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OCD Project No. 1532-A
(Final Report)

SHELTER EQUIPMENT PLANNING GUIDELINES

OFFICE OF CIVIL DEFENSE
DEPARTMENT OF ARMY-OSA

AD 602 124

Summary

of

Research Report

SHELTER EQUIPMENT PLANNING GUIDELINES

Prepared for

Office of Civil Defense

Department of Army - OSA

Under

Contract No. OCD-OS-62-195

Subtask 1532A

OCD REVIEW NOTICE

This summary of the report has been reviewed in the Office of Civil Defense and approved for publication as a working paper for limited distribution. Publication does not signify that its contents necessarily reflect views and policies of the Office of Civil Defense.

IIT RESEARCH INSTITUTE

Technology Center

Chicago 16, Illinois

June 1964

SCOPE OF THE CONTRACT WORK

The IIT Research Institute in conjunction and consultation with the Office of Civil Defense was to furnish the necessary facilities, personnel, and other services as required to develop planning guidelines for community shelter equipment and supply. The study was designed to determine the type of equipment and supplies that are necessary for human survival in habitations varying from austere to comfortable and to provide information on how the equipment and supplies should be maintained before and during shelter occupancy. The specific work and services were to include, but not necessarily be limited to, (1) identification of essential equipment, supplies, and facilities for use in different sizes of shelters; (2) analysis of the function and characteristics of the equipment, supplies, and facilities; (3) study and overall review of the operation and handling of the equipment, supplies, and facilities.

An analysis of the basic study data resulted in and provided for (1) development of a handbook format to be used by shelter planners; and (2) an overall review of the shelter equipment, supplies, and facilities for an adequate and realistic community shelter program.

APPROACH

The study material was developed in accordance with the current Office of Civil Defense doctrine regarding currently available equipment, supplies, and facilities. All equipment systems in the community shelters must be self-sustaining and capable of continuous operation for the anticipated period of shelter occupancy.

The equipment must be maintained properly to ensure that it is in a constant state of readiness and can be put into service with a minimum of start-up preparation. This can only be accomplished with a well-controlled maintenance program for each piece of equipment in the shelter.

Maintenance and operating data were developed from detailed descriptive literature published by several manufacturers supplying equipment in each of the categories of equipment required for shelters.

Interviews with application and design engineers were conducted to determine the logical guidelines for equipment selection, maintenance, and operation. These interviews revealed that the equipment must be operated periodically to keep it in a state of constant readiness. This information was expanded through extensive use of brochures that describe the specific equipment in detail. Standby maintenance and operating instructions thoroughly defined equipment requirements which were then incorporated into the study program and final report.

REPORT FORMAT

The report is composed of ten chapters and two supplements. General information concerning the report is contained in the introductory chapter. This chapter also contains the two supplements which cover general concepts of a preventive maintenance program and accepted color codes, symbols, and rules for marking and identifying equipment.

A single major equipment category is discussed in each of the succeeding nine chapters. The equipments described are those essential to human survival within a community shelter. The chapters are as follows:

2. Electrical Power Systems
3. Auxiliary Prime Mover Systems
4. Ventilation, Air Conditioning, and Air Revivification Systems
5. Water Supply, Waste Disposal, and Drainage Systems
6. Radiological Instrumentation Units
7. Communications Systems
8. Fire Protection Units
9. Noise Control Methods
10. Food, Medicine, and Sanitation Supplies and Facilities

STUDY RESULTS

The study culminated in a report which can be used by community shelter planners as a reference on how to equip shelters, maintain and operate shelter equipment, and prepare instruction manuals for maintenance of that equipment.

OCD Project No. 1532-A
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CONTENTS

CHAPTER 1

INTRODUCTION

INTRODUCTION

1. BACKGROUND

The Office of Civil Defense of the Department of Army is engaged in a program designed to strengthen every aspect of civilian protection against a thermonuclear attack on the United States.

One of the initial phases of this program was the identification and marking of numerous areas in buildings which could serve as austere group or community fallout shelters. The shelter identification, which has been completed, was carried out by the U.S. Army Corps of Engineers and the Navy, Bureau of Yards and Docks, under the direction of the Office of Civil Defense.

An important aspect of the national shelter system program is the development and implementation of effective shelter plans. This must be accomplished at the local level by community representatives. These plans must include the selection of equipment and supplies for each shelter (or a review of equipment now in existing shelters), the installation of additional equipment and supplies as required, the establishment of a maintenance program to ensure that each shelter is suitable for occupancy at any time, and the preparation of instruction manuals to be used by shelter occupants in operating and maintaining equipment and handling supplies.

Equipment considered for use in shelters is that equipment which is currently available from manufacturers. It is standard hardware and offers the advantages of completed designs, in-use testing, current design features, the latest technology, and the availability of servicing and parts from the manufacturer. Special equipment designs for shelter applications only were not considered because the equipment information is not readily available and working knowledge of equipment in this application is almost nonexistent.

The relationship of equipment costs to the number of shelter occupants was not examined because the parameters which affect the relative cost of the many different types of equipment differs from shelter to shelter. For example, the cost of auxiliary power generation equipment is contingent upon the size of the unit. The size is determined by the number of lights, the type of air conditioning system, the motor sizes associated with the water and sewerage pumps, and the communications installed in the shelter. In addition, the size of each type of equipment is directly related to the shelter's occupant capacity. Specific cost information must be related to a specific shelter having its own design requirements, and therefore a general review of equipment costs provides no meaningful information for application to particular shelter systems.

To aid local governments and community representatives in establishing these shelter plans, data had to be developed which established guidelines for equipping and maintaining community fallout shelters.

2. OBJECTIVE OF THIS STUDY

The objective of this study is to establish a series of guidelines for community shelter equipment and supply planning. Specifically, this study was designed to determine the type of equipment and supplies which are necessary for human survival within the protective area of a community fallout shelter and the manner in which the equipment and supplies should be maintained before and during shelter occupancy.

The material in Chapters Two through Ten covers the major shelter equipment categories. It is presented in the form of a handbook to show a format which might be used by the shelter planner responsible for preparing and writing the manuals to be used by shelter occupants.

3. SPECIFIC USES OF THE REPORT

This report is intended primarily for reference use by persons responsible for shelter equipment and supply planning.

1. It provides an overall review of the many shelter operational and maintenance requirements for an adequate and realistic community shelter program.

2. It presents guidelines for specifying or reviewing the adequacy of equipment and supplies for a community shelter in terms of the type of equipment and supplies needed, sizes, capacities, and capabilities of this equipment, system interrelationships, equipment installation, specific operating and maintenance requirements, and related details.

3. It acts as a sample of how to prepare an instruction manual which can be used in a shelter by shelter occupants, many of whom may be unfamiliar with the kinds of equipment in a shelter but who must operate and maintain this equipment and be prepared to deal with emergencies.

The information developed in the report for the maintenance and operation of the shelter equipment indicates a very important aspect of the overall shelter equipment guidelines. Because special equipment, designed for shelter use only, is not available all the equipment utilized in the shelters is of the type currently available and must be operated at specified maintenance intervals. These intervals, as specified by the equipment manufacturer, are based upon the operational history of the equipment. Operation is necessary, among other things, to keep lubrication systems functioning, reduce corrosion of the parts, and keep contacts and switches clean. Because use of the equipment is unpredictable, operation will keep the expensive equipment in top operational condition and also show problems which may have developed since the last operational check, such as a leaking fuel line.

It should be noted that much of the information contained in this report is necessarily technical in nature because of the kinds of equipment systems which are required in a community fallout shelter. As a result, technical knowledge such as that possessed by a plant engineer or mechanical engineer is required to properly interpret and utilize some of the detailed data contained in this handbook.

4. ORGANIZATION AND CONTENT OF THE REPORT

The report is divided into ten chapters and two supplements. The first chapter consists of the introduction and two supplements. These supplements provide definitions of terms used in shelter planning, general concepts of a preventive maintenance program, and generally accepted rules for equipment marking and identification. Each of the next eight chapters describes a major equipment system required in a community fallout shelter. The tenth and final chapter describes the supplies required within a shelter and presents detailed procedures for handling these supplies during shelter occupancy.

The equipment systems and supplies described in the report are those considered essential to human survival within the protective area of a community fallout shelter. In accordance with current Office of Civil Defense doctrine, it was assumed that the equipment systems must be self-sustaining and capable of twenty-four-hour operation for the anticipated period of shelter occupancy.

Chapters Two through Ten of the report describe the equipment systems and supply situations in the following sequence:

<u>Electrical Power Systems (Chapter 2)</u>

Electrical power systems are required in a shelter to transmit electrical power to light fixtures, communications equipment, and electric motor-driven fans, blowers, pumps, air conditioners, and other equipment. Two basic systems, normal and auxiliary, provide independent power sources for operation of necessary equipment under normal conditions and during temporary emergency periods respectively.

The essential systems described in this chapter are the following:

1. Single-phase power system
2. Three-phase power system

Electrical Power Systems (Chapter 2)

3. Dry cell system

4. Wet cell system

Auxiliary Prime Mover Systems (Chapter 3)

An auxiliary prime mover system must be readily available to drive electric generators in the event of complete disruption of public utility power supply during and following nuclear attack. Commercially available prime mover systems which are generally suitable to shelter requirements are included in this chapter.

The systems discussed in this chapter include the following:

1. Hand-operated prime mover and generator system

2. Foot-operated prime mover and generator system

3. Air-cooled gasoline engine system

4. Liquid-cooled gasoline engine system

5. Diesel engine system

Ventilation, Air Conditioning, and Air Revivification Systems (Chapter 4)

Ventilation, air conditioning, and air revivification systems are necessary because habitability depends on maintaining suitable environmental conditions within the shelter during the period of occupancy. Temperature, humidity, air purity, and air distribution must be maintained at levels consistent with reasonable human requirements.

Systems reviewed in this chapter include the following:

1. Manually operated ventilating system

2. Electric-powered ventilating system

Ventilation, Air Conditioning, and Air Revivification Systems (Chapter 4)

3. Mechanical air conditioning system

4. Absorption air conditioning system

5. Chlorate candle and screened chemical absorbent system

6. Oxygen cylinder and lithium hydroxide canister system

Water Supply, Waste Disposal, and Drainage Systems (Chapter 5)

Water supply, waste disposal, and possibly drainage systems are essential equipment to shelter survival. The water supply system provides the means for storing and distributing potable water to shelter inhabitants. Human waste is collected, transferred, and disposed of through the waste product disposal system. Should the shelter be subject to possible flooding, the drainage system provides the means for collecting and disposing of this water.

Specific systems described include the following:

1. OCD-supplied container water supply system

2. Gravity flow water supply system

3. Power flow water supply system

4. Combination power and gravity flow water supply system

5. OCD-supplied waste containers and kits

Radiological Instrumentation Units (Chapter 6)

Radiological instrumentation units are indispensable to shelter operations. The operation of such instruments will be required from the period shortly after a nuclear attack until the radiological hazard from fallout diminishes to the point that normal activities may be resumed without significant danger

Radiological Instrumentation Units (Chapter 6)

to the shelter inhabitants. The radiological monitoring requirements of the shelter will involve monitoring of personnel, food, water, and the areas within and outside the shelter. When the radiation intensity or dose rates have decreased to the extent that limited outside activities can be performed, the radiological instrument units can be mobilized to support operations of emergency services such as rescue, fire, and police.

Equipment discussed in this chapter includes the following:

1. Ratemeter
2. Dosimeter

Communications Systems (Chapter 7)

Communications systems within the shelter are needed to provide occupant control and information dissemination. Systems providing communication with sources outside the shelter are necessary for information receipt and exchange. The probability of shelter leaders making correct decisions will be increased by the amount of information available concerning outside conditions. Therefore, shelter communications systems should consist of an internal setup and a capability for providing communication with the outside environment.

The following equipment and systems are reviewed in this chapter:

1. Messenger and bulletin board systems
2. Signal light, horns, and buzzer systems
3. Sound-powered phone system
4. Portable power megaphone system

Communications Systems (Chapter 7)

5. Public address system
6. Intercommunication system
7. AM or FM radio systems
8. Telephone systems
9. Two-way radio system

Fire Protection Units (Chapter 8)

Fire protection equipment is required within the shelter to combat potential internal fires. A fire may be caused by human carelessness, defective electrical wiring, and overheated equipment, among other things.

Fire protection systems described include the following:

1. Sand pails
2. Portable fire extinguishers

Noise Control Methods (Chapter 9)

Control of internal noises is important in keeping the shelter habitable. Excessive noise can cause shelter occupants to experience discomfort. Methods for reducing or eliminating the source of these irritants by absorbing or blocking out the noise include the use of individual ear protective devices, soundproofing materials, and vibration isolators with equipment.

Specifically, this chapter reviews the following:

1. Ear-insert protective devices
2. Ear-covering protective devices
3. Soundproofing methods
4. Vibration isolators

Food, Medicine and Sanitation Supplies and Facilities (Chapter 10)

Adequate supplies and facilities are necessary to meet the shelter occupants' needs in three categories: the nutritional resources necessary for survival; the medical supplies required for at least first-aid-level treatment; and the sanitation items necessary to carry out a minimum sanitary program. The importance of supplies and facilities ranges from those required for minimum subsistence to those that are classified as comfort items. Supplies and facilities that are over and above the minimum requirements are desirable. Included are items such as special medicines for the chronically ill, sleeping accommodations, and supplemental foods. Supplies and facilities selected for shelters must have long shelf life, excellent storage characteristics, ease of use, and low cost.

Supplies selected for discussion in this chapter include the following:

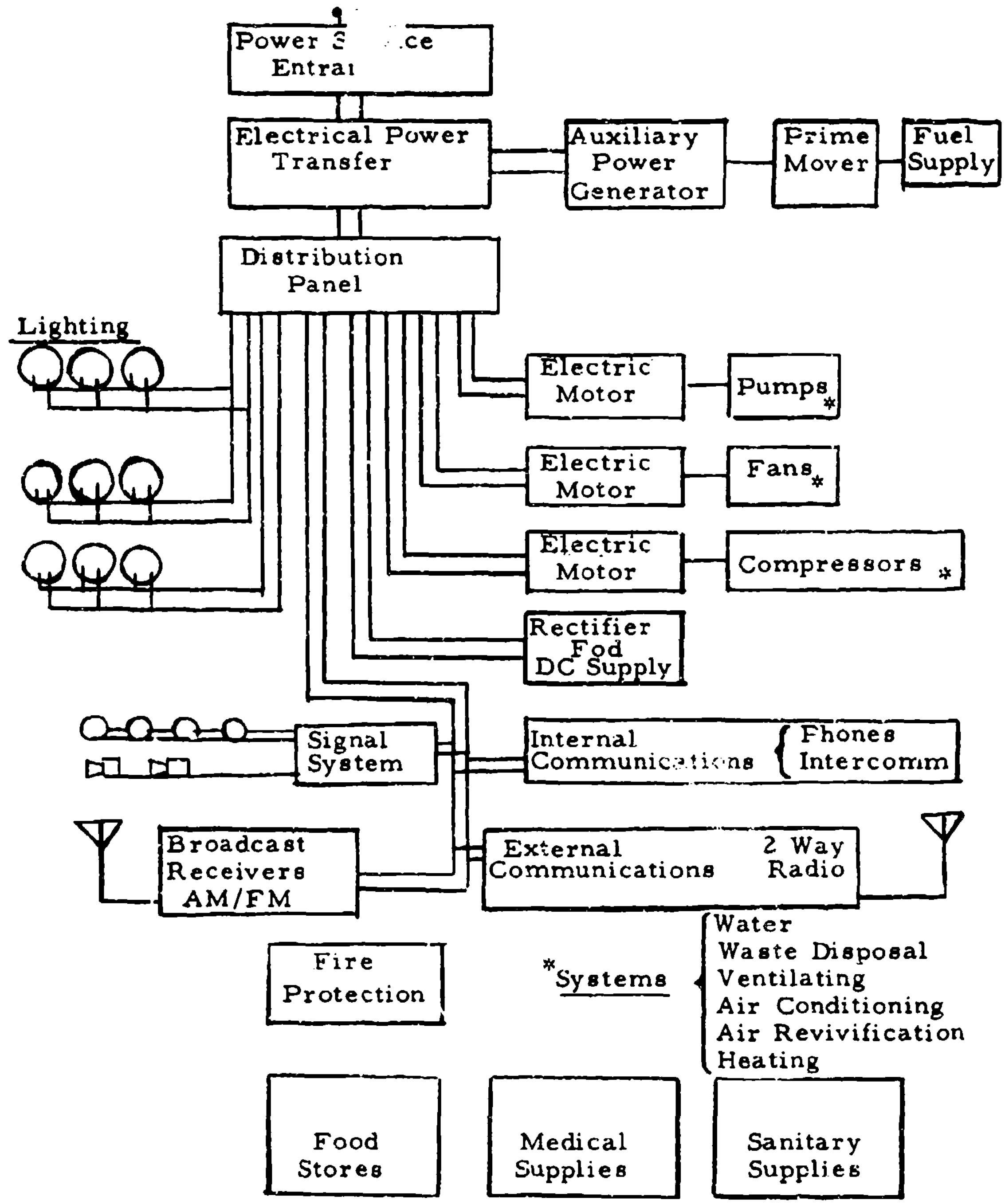
1. OCD-supplied food package supplies
2. Supplementary food supplies
3. OCD-supplied medical kits
4. Supplementary medical kits

* * * *

The reader is reminded that, although the major types of systems for community fallout shelters are described separately for clarity, they are strongly interdependent. Some of the more important of these interrelationships are described in Exhibit 1 on page 9.

Exhibit 1

INTERRELATIONSHIPS AMONG BASIC SHELTER EQUIPMENT SYSTEMS



5. FORMAT OF EACH CHAPTER IN THE REPORT

Each of the chapters in the report contains three major sections. The first section introduces the chapter and describes generally the subject types of equipment or supplies and indicates the availability of the typical equipment for various sizes of shelters.

The second section of each chapter is divided into three subsections, which contain specifications and applications data about the major components of the equipment system described in the first section. Specifically, the first subsection describes typical component designs; the second furnishes application data, such as component nomenclature, size and weight, shipping information, and related facts; and the third subsection presents the procedures which must be followed in selecting various components or equipment and includes appropriate tables, charts, and drawings.

The third section of each chapter identifies all of the essential elements to be covered in writing simple operating instructions for using the equipment described in the chapter. This section includes information relating to the scheduling of maintenance inspections while the shelter is unoccupied. In addition, it describes the procedures to be followed for starting up and shutting down the equipment, for determining the causes of equipment malfunction, and for performing standard repair operations. A listing of tools, spare parts, and methods for identifying and coding equipment parts and their location is also contained in this third and final section of each chapter.

6. USE OF THE REPORT TO PREPARE AN OPERATIONAL MANUAL

One of the primary purposes of the report is to provide an example of what an operational manual for use in a specific community fallout shelter should contain and how this information should be presented. While each manual will vary with the type of fallout shelter, for the overall shelter planning program within a community certain fundamental principles can and should be followed. These principles are outlined in the following paragraphs.

The planning of the shelter operations manual should start with the determination of tasks to be performed,[1] the identification of shelter equipment and supplies available and required, and a determination of the skill levels of the persons who will be using the manual so that its content can be tailored to the most likely and appropriate user. It should be noted that the specific data and information on equipment and supplies contained in each chapter of the handbook, while correct, are intended to be illustrative in nature. Thus, the person responsible for developing an operations manual for the equipment systems and supplies in a specific community fallout shelter can use the information in the handbook as a standard; but he must also analyze the particular equipment and supply requirements of the shelter with which he is concerned to ensure that he develops a plan tailored to his particular shelter size, configuration, personnel, and equipment situation.

The steps which should be followed in preparing an operational manual include the following:

1. Gather all data available from manufacturers and other sources concerning maintenance, storage, and operation of equipment and supplies.

2. Analyze the data to determine the number of operating personnel required so that people can be preassigned to given jobs. Make an outline of the elements of each task for both administrative and operational personnel.

3. Consult with competent engineering personnel to validate the sequence and completeness of equipment instructions.

4. Write the operations manual using a simple format. Use as few subdivisions as possible.

5. Present illustrations and photographs as follows:

   (1) Illustrations and photographs should be used to visually clarify equipment operation and maintenance and procedures. Illustrations and photographs should furnish immediate identification of specific parts and give a graphic explanation of instructions. Illustrations and photographs should be planned to keep text to a minimum.

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[1] The reader is referred to state and federal civil defense agencies for additional information on shelter personnel and management principles.

SUPPLEMENT A

CONCEPTS OF PREVENTIVE MAINTENANCE PROGRAM

(2) Illustrations must be clear and identifiable. Photographs must provide sharp detail, good contrast, and full tonal range of the subject. Short captions should be used for both illustrations and photographs.

(3) Use of symbols on illustrations and photographs in operations manuals should be minimal.

(4) Sequential illustrations should be used to show step-by-step instructions. Halftone photographs are particularly suitable for sectional views and cutaways to illustrate mechanical functions of equipment. Exploded views of the equipment to present greater detail are very useful.

CONCEPTS OF PREVENTIVE MAINTENANCE PROGRAM

GENERAL INFORMATION

1. Purpose - A preventive maintenance program is a planned and continuous effort, based upon inspections, adjustments, routine replacement, and proper lubrication, to minimize the possibility of equipment breakdown.

2. Advantages - Preventive maintenance has the following advantages:

   (1) It minimizes the premature replacement of shelter equipment.

   (2) It maximizes the probability that shelter equipment will be ready for use when needed.

   (3) It minimizes the amount of standby equipment required.

   (4) It minimizes maintenance and repair costs.

   (5) It minimizes the number of spare parts required.

PROGRAM DEVELOPMENT

1. Four major steps are fundamental to a proper preventive maintenance program:

   (1) List the pieces of equipment.

   (2) Prepare a chart for each piece of equipment specifying what is to be inspected, how it should be inspected, and when it is to be inspected.

   (3) Prepare an inspection report form which provides sufficient space for recording the name of the equipment inspected and the maintenance or repair work performed.

   (4) Prepare a permanent record card for each piece of equipment showing its specific location. Provide space on the card for repair entries.

CONCEPTS OF PREVENTIVE MAINTENANCE PROGRAM

PROGRAM DEVELOPMENT

2. Each preventive maintenance program must be tailored to the individual requirements of the equipment. Typically, the following shelter equipment should be included in a sound preventive maintenance program:

   (1) Engine-generator sets

   (2) Ventilation fans and blowers

   (3) Pumps

   (4) Air conditioning units

   (5) Electric motors

   (6) Batteries

   (7) Lighting

3. Manufacturers' service manuals are an excellent source for compiling the checklists that are a necessary part of the preventive maintenance program. The checklist itemizes for the inspector all the points to be checked on any one piece of equipment. Use of checklists ensures uniform and complete inspections, regardless of the user.

4. Inspection frequency must be determined on the basis of the following engineering considerations:

   (1) Age, condition, and value of the equipment

   (2) Severity of service

   (3) Safety requirements

   (4) Number of hours of operation

   (5) Susceptibility to wear from exposure to such things as dirt or corrosive atmospheres

   (6) Susceptibility to damage from being subjected to such things as vibration or overloading

CONCEPTS OF PREVENTIVE MAINTENANCE PROGRAM

PROGRAM DEVELOPMENT

(7) Susceptibility to damage resulting from disuse

5. The scheduling of preventive maintenance can be divided into the following three categories:

(1) Routine upkeep work done at regular intervals, such as adjusting, lubricating, and cleaning.

(2) Periodic inspections done at prescribed intervals, such as visual inspections, teardown inspections, and scheduled parts replacement.

(3) Contingent work done at irregular intervals when equipment is down for other reasons.

6. Schedules for preventive maintenance are of two main types:

(1) Overall charts listing all shelter equipment

(2) Individual charts for each piece of equipment

While the overall chart is the simpler approach, individual charts have the advantage of holding more detail on preventive maintenance requirements for a specific piece of equipment. The overall chart should be used as a control for checking that individual equipment maintenance is performed. These charts provide an effective control on maintenance when they are used in combination. Sample charts are noted on page 1-18. Consult manufacturers for service sheets for complete maintenance charts on individual equipment.

7. Maintenance Personnel - Personnel who maintain the shelter equipment should be capable people familiar with the specific equipment. These people may be local residents who perform these types of tasks during their normal

CONCEPTS OF PREVENTIVE MAINTENANCE PROGRAM

PROGRAM DEVELOPMENT

workday. For example, an electrician might maintain electrical motors, generators, etc., and an automobile engine mechanic might maintain prime mover equipment.

SUPPLEMENT B

ACCEPTABLE EQUIPMENT COLOR CODING, MARKING, AND CHARTING METHODS

CONCEPTS OF PREVENTIVE MAINTENANCE PROGRAM

MASTER MAINTENANCE SCHEDULE AND CONTROL FORM

Equipment	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
Pump 3421													
Fan 11604													
Air Con Mtr. 6740													

EQUIPMENT MAINTENANCE CONTROL FORM

Type of Equipment Exhaust Fan

Date Installed 4/1/64 By Air Equipment Co. Tel: 363-4000

Mfg. General Fan Model No. A3402 Serial No. 11604

Required Maintenance Schedule Every three months

Check Function	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
Pulley													
Mountings													
Fan Blade													
Oil Bearings													SAE No.
Belt													Goodyear 34012

Note also that most suppliers of business record systems have preprinted standard maintenance control forms available to fit their file cabinets.

Legend: Show initials of person performing maintenance in the square provided. Correlate initials with name by noting on back of card.

ACCEPTABLE EQUIPMENT COLOR CODING, MARKING, AND CHARTING METHODS

GENERAL PURPOSE

Proper equipment color coding, marking, and charting is important to shelter equipment identification and maintenance.

ACCEPTABLE EQUIPMENT COLOR CODING APPLICATIONS

Color	Category	Application
Red	Fire protection equipment and apparatus	Alarm boxes Buckets, pails Extinguishers Axes, shovels
	Danger-stop	Temporary danger areas Stop switches Shutoff valves Signs
Orange	Dangerous parts of equipment or machines	Gears Pulleys
Yellow	Caution	Signs Markers Unguarded platform edges Fixtures hanging from ceilings or walls Handrails Pillars and posts Waste containers
Green	Safety First aid	First-aid kits Bulletin boards Stretchers
Blue	Water	Valves Pumps Pipes
	Equipment warning	No start No use No movement

ACCEPTABLE EQUIPMENT COLOR CODING, MARKING, AND CHARTING METHODS

ACCEPTABLE EQUIPMENT COLOR CODING APPLICATIONS

Color	Category	Application
Blue	Equipment power sources	Electrical controls Valves
Black, White, Separately or in Combination	Traffic	Dead aisles Passageways Direction signs Aisle locations and widths Stairways' direction lines
Purple	Radiation hazards	Contaminated areas Disposal cans of contaminated materials Contaminated equipment

ACCEPTABLE EQUIPMENT TAG AND LABEL APPLICATIONS

Tags and labels used for making should be made of a permanent type material such as bakelite or plastic, so that they cannot be damaged by water, mildew, etc. Markings should be permanently affixed to the equipment or structure with wires, screws, or bolts and should be placed in a noticeable location.

Items	Category	Application	
Tags	Operating instructions	Start-up controls Shift-down controls Valve cutoffs Wires	
	Troubleshooting	Cause, remedy	
	Maintenance instructions	Routine operational maintenance procedure; preventive maintenance procedure	
Labels	Spare parts	Parent system or component	
	Specifications data	Machinery supplies	
	Piping	Steam Water Waste Electrical	*Pipes are marked by stenciling the name of the function on the pipe with a contrasting color of paint.

ACCEPTABLE EQUIPMENT COLOR CODING, MARKING, AND CHARTING METHODS

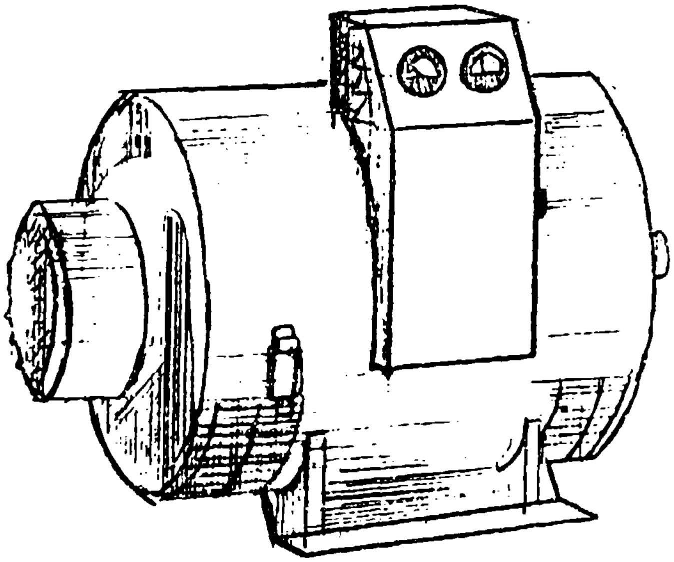
ACCEPTABLE EQUIPMENT CHARTING APPLICATIONS		
Type	Category	Application
Schematic	Administrative	Shelter layout showing equipment locations, supply storage, occupant space allocation, area locations, and entrances and exits
Schematic	Administrative	Shelter system layout for ventilation, electrical power supply, water and other liquids, lighting, switches, fuses, circuit breakers, and distribution system
Schematic	Occupant	Shelter space allocation, area locations for supplies issuance and medical treatment, and entrances and exits

SUGGESTED SAMPLE
DESIGN OF PAGE

SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 2

ELECTRICAL
POWER SYSTEMS
AND EQUIPMENT



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

SUGGESTED SAMPLE
DESIGN OF PAGE

Table of Contents	How to Use Guidelines

Use the Table of Contents given below to locate quickly key technical data pertaining to the selection and operation of electrical systems.

The Introduction Section provides all essential data regarding system requirements and typical system designs.

System component descriptions, application data, and selection procedures are given in the Component Selection Section.

The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions for relatively unskilled people.

NEED FOR ELECTRICAL POWER SYSTEMS

System Uses

Electrical power systems are used in a shelter to transmit electrical power to light fixtures, communication equipment, electric motor-driven fans, blowers, pumps, and other equipment. Two basic systems, normal and auxiliary, provide independent power sources for operation of necessary equipment under normal conditions and during temporary periods, respectively.

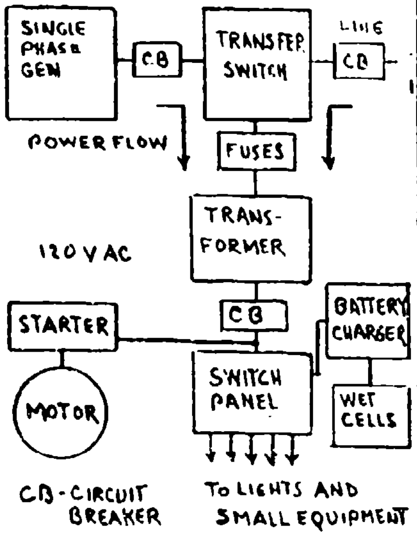
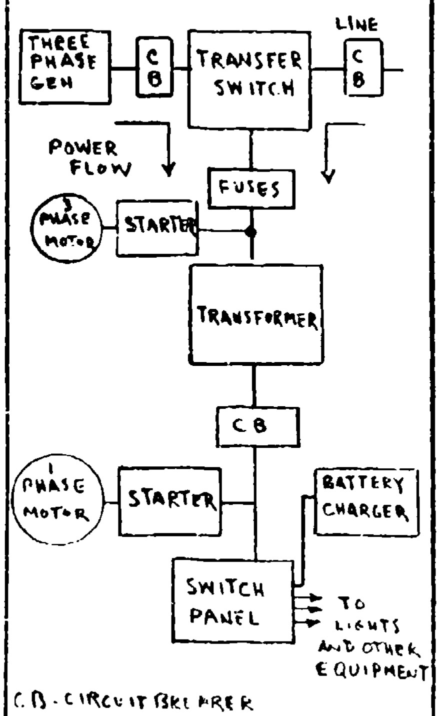
Normal Electrical Systems

Two types of normal electrical power systems can be applied to shelters, single-phase and three-phase. The single-phase system is used for smaller shelters where power requirements are moderate and no three-phase motors or other three-phase electrical apparatus are required. The three-phase system is used for larger shelters where power requirements are greater and the economies of space and operation justify the more expensive three-phase generator and distribution. Three-phase shelter power is also required in spaces which had existing three-phase systems or equipment prior to designation as a shelter.

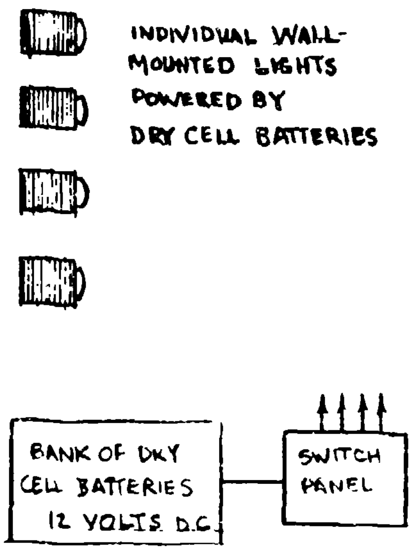
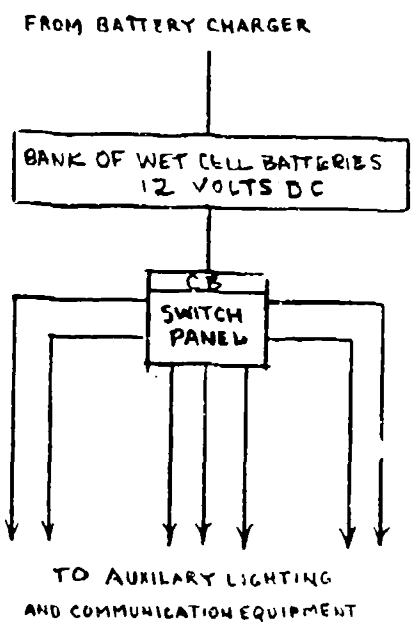
Secondary Electrical Systems

Two types of secondary electrical power systems can be applied to shelters: a dry cell battery system and a wet cell battery system, both of which are low voltage, low power D-C systems. The dry cell battery system is the simplest and least expensive type and is used for small shelters where minimum secondary lighting is needed. The wet cell battery system consists of rechargeable storage batteries which supply the power requirements necessary to operate auxiliary lighting and communication equipment in large shelters. In either case, the secondary system provides power for lighting and communications at times when the primary or normal system is out of service for maintenance, repair, or other reasons, and for electrical control functions at all times.

NORMAL ELECTRICAL POWER SYSTEMS

<table>
<tr><th>Type Designation</th><th>Typical Design</th><th>Description</th></tr>
<tr><td colspan="3">SINGLE-PHASE SYSTEM</td></tr>
<tr><td>Type I</td><td>
</td><td>This is a single-phase, 60-cycle-per-second, alternating-current system which supplies power for lighting, fan motors, and other equipment. A transformer becomes necessary whenever the incoming line voltage or the generator voltage is higher than 120 volts.</td></tr>
<tr><td colspan="3">THREE-PHASE SYSTEM</td></tr>
<tr><td>Type II</td><td>
</td><td>The three-phase, 60-cycle-per-second, alternating-current system supplies power for lighting, single-phase and three-phase motors and other equipment. A transformer is usually necessary to step down the generator and incoming line voltage to 120 volts.</td></tr>
</table>

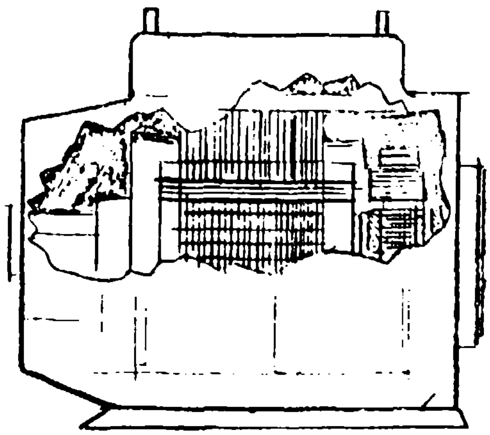
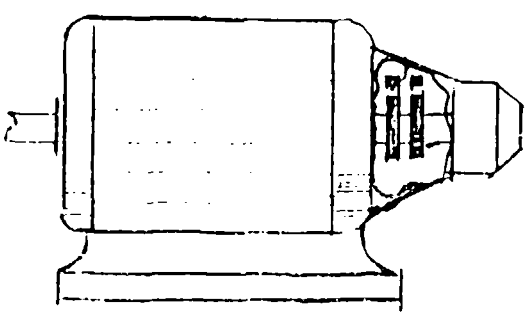
SECONDARY ELECTRICAL POWER SYSTEMS

Type Designation	Typical Design	Description
DRY CELL SYSTEM		
Type I		This system consists of a group of individual battery-powered lights and a bank of interconnected batteries to supply supplementary power to communications equipment and emergency lighting.
WET CELL SYSTEM		
Type II		The wet cell system consists of a bank of batteries supplying secondary power to lighting and certain communications equipment. The batteries are kept at full charge by a battery charger which is supplied from the normal power system. A 12-volt system is necessary to operate certain emergency or standby communications equipment, but 24, 48, or higher voltages can be used if needed for control functions or for higher power requirements.

SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	NORMAL ELECTRICAL SYSTEMS	SECONDARY ELECTRICAL SYSTEMS
ABOVEGROUND AND BELOWGROUND SHELTERS			
50 PEOPLE	Best	Type 1	Type 1
	Acceptable	Type 2	Type 2
100 PEOPLE	Best	Type 1	Type 2
	Acceptable	Type 2	Type 1
200 PEOPLE	Best	Type 1	Type 2
	Acceptable	Type 2	Type 1
300 PEOPLE	Best	Type 1	Type 2
	Acceptable	Type 2	Type 1
500 PEOPLE	Best	Type 1	Type 2
	Acceptable	Type 2	Type 1
1,000 PEOPLE	Best	Type 2	Type 2
	Acceptable	Type 1	Type 1
2,000 PEOPLE	Best	Type 2	Type 2
	Acceptable	Type 1	Type 1
3,000 PEOPLE	Best	Type 2	Type 2
	Acceptable	Type 1	Type 1
5,000 PEOPLE	Best	Type 2	Type 2
	Acceptable	Type 1	Type 1
10,000 PEOPLE	Best	Type 2	Type 2
	Acceptable	Type 1	Type 1

A-C GENERATORS

Typical Design	Description
	A-C Generator A totally enclosed, fan-cooled (TEFC) A-C generator
	**Brushless A-C Generator** The brushless A-C generator has a self-contained exciter winding and rotor on the same frame and shaft as the main generator windings. Rectifiers convert the exciter voltage to D-C for direct connection to the rotor (field) windings. This design eliminates the need for slip rings, commutators, and brushes.
	**A-C Generator with External Shaft-Mounted Exciter** This type of generator has the exciter mounted on the shaft of the generator rotor outside the stator. D-C voltage from the exciter is fed from its brushes and slip rings to the rotor field.

A-C GENERATORS

GENERAL INFORMATION

1. Characteristics - A-C generators are normally synchronous machines, called alternators, which operate at a constant number of revolutions per minute called the "synchronous speed." The A-C generator converts mechanical energy supplied by the prime mover into electrical energy. This energy conversion is accomplished utilizing the principle of induced voltage whereby a voltage is created in a conductor which moves through a magnetic field.

2. Construction - The alternator consists of two main parts, the stator and the rotor. The stator, or stationary section, contains the iron frame, laminations, and the stator windings. The rotor, or rotating section, is composed of the shaft, laminations, and the rotor windings. The rotor windings are also known as the field windings.

3. Classification - For shelter applications the brushless synchronous A-C generator is appropriate. This type requires a minimum of maintenance because it has no brushes, slip rings, or commutators.

   Where the brushless generator is not available in the particular size required, a standard slip ring type with external, shaft-mounted exciter can be used.

4. Applications - For smaller shelters, generators with a rated capacity of 4 kw to 40 kw will be needed. A single-phase generator and system will suffice for shelters with a capacity of 1000 people unless there is an existing three-phase system in the space to be used as a shelter. A generator control panel is necessary for each generator in order to provide for regulating voltage and power,

A-C GENERATORS

GENERAL INFORMATION

for opening and closing generator circuits, and for displaying meters and control lights associated with the operation of the generator. The control panel can be combined with the control panels for operating switching gear and lights to make one control center for all electrical equipment.

A-C GENERATORS

SHIPPING INFORMATION	1.	A-C generators are shipped assembled and complete with exciters when specified.
	2.	A-C generators are not shipped with auxiliary equipment such as voltmeters, ammeters, wattmeters, and control components unless it is specifically ordered.
RATINGS	1.	A-C generators are rated as to power, voltage, frequency at a rated speed, phases, and temperature rise.
	2.	The power rating, given in kilowatts, is the rated full load output of the generator when terminal voltage is that specified as the rated voltage.
	3.	For shelter planning purposes, 60 cps frequency is recommended.
	4.	The speed rating of a generator is the speed at which the machine must be operated in order to produce the 60 cps frequency at rated voltage.
	5.	For most shelters under 1000 spaces, single-phase generators are adequate. However, a three-phase generator and system may be required to conform to an existing power system.
	6.	The temperature rise specified is usually that which is to be expected of the machine when it is operating at rated conditions. This temperature rise is based upon a standard ambient temperature.
INSTALLATION INSTRUCTIONS		Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied.

A-C GENERATORS

INSTALLATION INSTRUCTIONS

1. Ensure that generator terminals are connected to the automatic transfer switch terminals correctly.

2. Ensure that the generator output rating is compatible with the commercial power source, and that the generator windings have been connected to provide the voltage specified.

3. Connect all control wiring according to the wiring diagrams provided by the designer or manufacturer.

4. Make wiring checks to determine that each wire is connected to the proper terminal.

5. Before connecting the generator to the transfer switch, test the windings for proper resistance according to the nameplate and check the resistance of the insulation to make sure it has not become wet or otherwise damaged.

A-C GENERATORS

STEP 1

Determine from manufacturer's rating plates whether three-phase or single-phase loads exist Select a generator and system in accord with the type of phase loads. Generator selection should be made in conjunction with the prime mover (see Chapter 3).

STEP 2

Determine the total kilowatt load by summing all individual loads connected to the system, , as follows:

(1) Lighting - Add the total wattage of all the lights to be used in the shelter. This must include the power requirements for all fluorescent and incandescent luminaires.

(2) Motors - Calculate the total power needed to operate all electrical motors, including fans, air-conditioning systems, and pumps. The power requirements are indicated on equipment marking plates. If the horsepower is indicated instead of the wattage, convert the horsepower figure to wattage by the following formula:

$$\text{Watts} = 746 \times \frac{\text{Horsepower}}{\text{Efficiency of motor} \times \text{Power factor of motor}}$$

Most small induction motors operate at about 90% efficiency and 80-90% power factor at full load.

A-C GENERATORS

STEP 2

(3) Batteries - Determine the watts required to maintain any wet cell batteries fully charged. In most cases power consumed by battery charging will be negligible compared to total system requirements.

(4) Communications equipment - Total the wattage required to operate all radios, signal systems, and other communications devices.

(5) Other electrical equipment - Add the wattages of any other electrical equipment.

Divide the total watt load by 1000 to obtain kilowatts. The generator rating should be 25% greater than the total kilowatt load computed to provide reserve power and to provide sufficient capacity for extreme conditions.

STEP 3

Determine the voltage system required. The circuits in the shelter for lighting and general use will be 120-volt. Circuits for heavy duty motors may use higher voltages (220-volt, 440-volt). Select the auxiliary generator and transfer panel to operate on the same voltage as the incoming line. If necessary, a transformer may be used to reduce the line voltage to 120-volt AC for the lighting, small motor, and general distribution circuits.

STEP 4

Though the generator was discussed independently of the prime mover, the prime mover is intrinsically connected to the generator both mechanically and controlwise. It is extremely advantageous to obtain the prime mover and all control components as a packaged unit. Select a generator with the proper voltage, number of phases, power, and frequency.

SINGLE-PHASE A-C MOTORS

GENERAL INFORMATION

1. Characteristics - The majority of A-C motors up to 1 hp operate on single-phase alternating current, although single-phase motors are available in ratings as high as 10 hp.

   Wide variations in starting and maximum torque requirements are encountered, so that many different types of single-phase motors are available to meet those needs.

2. Classification - Single-phase motors are classified according to the means used to provide the necessary starting torque. The classifications of single-phase induction motors are as follows: split-phase, resistance/capacitor start, capacitor, and shaped pole. All the starting methods create a rotating field which, when reacting with the squirrel-cage rotor, provides starting torque until the motor comes up to operating speed. The commutator types of single-phase motors are classified as series, repulsion, repulsion-induction, and repulsion-start induction run motors. The most common type of single-phase commutator motor is the series motor, since it can operate on both A-C and D-C current. These motors are fundamentally high-speed motors of from 1500 to 15000 RPM. Governor control is used for constant speed applications in some very small motors.

3. Applications - Single-phase motors are generally used with fractional horsepower drives and may be used where requirements are as high as 10 hp. Single-phase motors are widely used in small air conditioners, pumps, and fans. In large shelters where greater horsepower is needed, a three-phase system should be considered to handle the larger power requirements without undue current demands on the wiring system and motor.

SINGLE-PHASE A-C MOTORS

SHIPPING INFORMATION

1. Single-phase A-C motors are shipped complete and assembled.
2. Starters and fuses or circuit breakers must be ordered separately.

RATINGS

1. Single-phase A-C motors, both squirrel-cage and wound-rotor types, are rated according to horsepower, voltage, frequency, speed, and temperature rise.
2. The type of enclosure is also specified.

INSTALLATION INSTRUCTIONS

Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:

1. Ensure that the line voltage to the motor is the same as the motor's rated voltage and frequency.
2. Ensure that the motor is properly aligned with the driven element so that both shafts are in line.
3. If there are more than two terminals on the motor, be sure that the correct wires are connected to armature and field terminals. Wiring diagrams and instructions are usually on the name-plate of the motor.
4. Turn the rotor by hand before energizing the motor for the first time.

THREE-PHASE A-C INDUCTION MOTORS

GENERAL INFORMATION	1.	Characteristics - Three-phase A-C motors are used in applications that require high horsepower and constant speed.
	2.	Classification - The induction motor is classified as to types of rotor windings--squirrel-cage and wound-rotor. The ends of the wound-rotor circuit are brought out to insulated slip rings on the rotor shaft so that external resistance can be added to each phase of the rotor circuit, permitting speed variation and a heavier starting torque.
	3.	Application - For general applications requiring more than 10 hp, without speed regulation, the three-phase induction motor with squirrel-cage rotor possesses the greatest range of applicability. Where possible, shelter equipment requiring electric motors should be obtained from the manufacturer equipped with motors of the correct size, operational characteristics, and input voltage to meet the total requirements of the installation.
SHIPPING INFORMATION	1.	Except for very large or special-purpose motors, three-phase induction motors are shipped complete and assembled.
	2.	Controls must be ordered separately.
RATINGS	1.	Squirrel-cage and wound-rotor three-phase motors are rated as to horsepower, voltage, frequency speed, and temperature rise.
	2.	The type of frame is specified, such as totally enclosed, fan-cooled (TEFC), drip-proof, explosion-proof, or open.

THREE-PHASE A-C INDUCTION MOTORS

INSTALLATION INSTRUCTIONS

Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:

1. Ensure that the line voltage to the motor is the same as the motor's rated voltage and frequency.

2. Ensure that the motor is properly aligned with the driven element so that both shafts are in line.

3. Be sure that the correct wires are connected to the armature and field terminals. Wiring diagrams and instructions are usually on the motor nameplate.

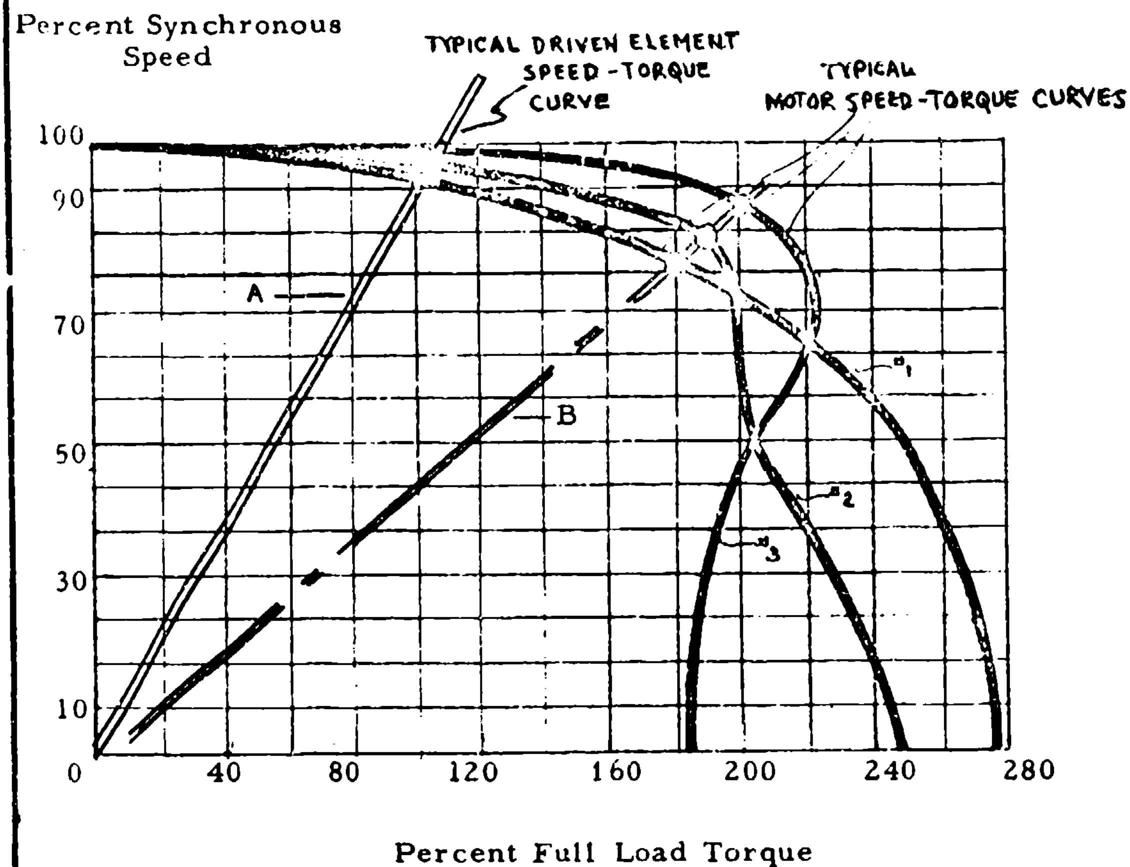
4. Turn the rotor by hand before energizing the motor for the first time.

A-C MOTORS

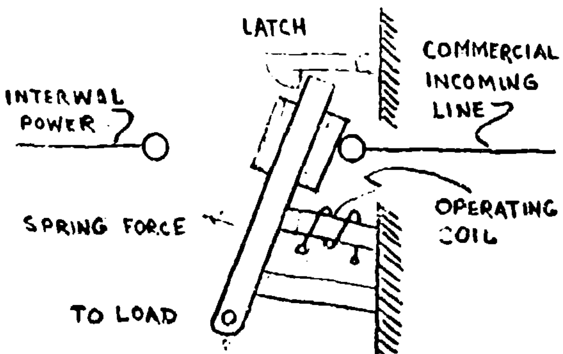
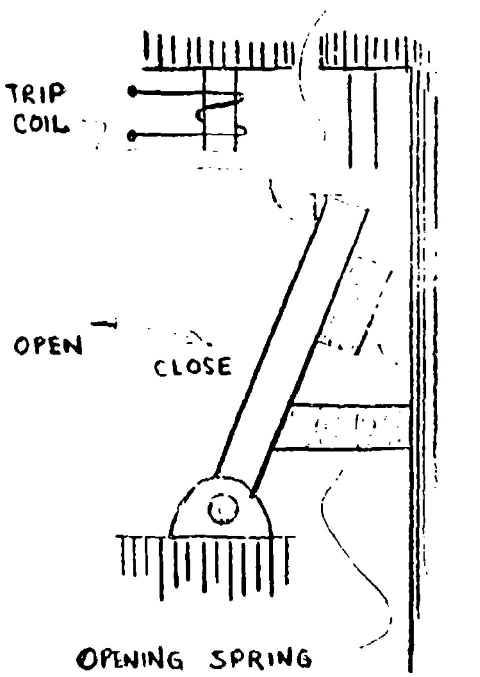
STEP 1	Determine the speed and horsepower required to operate the driven element from the manufacturer's instructions.
STEP 2	Determine the speed-torque requirements
STEP 3	Determine the speed (rpm), horsepower, and speed-torque requirements for the driven element from the manufacturer's instructions. An example of a typical driven element speed-torque curve is indicated by curve A in the chart on the following page.
STEP 4	Determine the speed-torque characteristics of motors that meet the horsepower and speed-torque requirements. Three typical motor curves are shown in the following chart.
STEP 5	Determine the voltage available at the location where the motor will be installed. Be sure that circuits will handle current requirements for motor operation.
STEP 6	Select an A-C motor based upon the driven element requirements for horsepower, speed-torque, speed, and voltage. For example, any of the three motors below will meet the requirements of the driven element shown in curve A. With the units operating in the area of 100% Full Load Torque and 90-100% Synchronous Speed, small changes in torque do not affect the speed, and efficient operation of the motor is obtained. However, if the driven element speed-torque curve were similar to curve B, erratic operation would result. The full load torque of the motor would be exceeded, causing overheating. Changes in the speed-torque requirements will cause sharp changes in the speed (rpm). Thus it can be seen that proper matching of the motor to the driven element is essential for troublefree operation.

A-C MOTORS

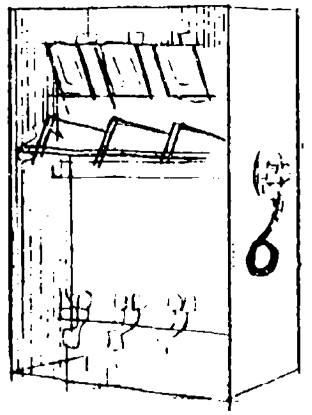
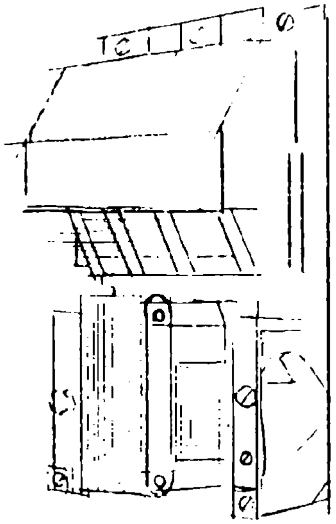
TYPICAL SPEED-TORQUE CURVES (3-PHASE, 5-HP, 4-POLE MOTORS AND TYPICAL DRIVEN ELEMENT)



SWITCH BREAKERS AND CONTROLS

Typical Design	Description
 SCHEMATIC REPRESENTATION OF DOUBLE THROW TRANSFER SWITCH	**Automatic Transfer Switch** Automatic transfer switches are devices which automatically transfer auxiliary power to the load circuit when a disruption in the normal commercial power source occurs. The device detects a loss of voltage on the incoming line and immediately switches power to the internal source.
 SCHEMATIC REPRESENTATION OF A CIRCUIT BREAKER	**A-C Circuit Breakers** A circuit breaker is a switching device which makes and breaks an electric circuit quickly with a minimum of arcing. The circuit breaker can be closed by an electromagnetic coil or by hand. The breaker is caused to operate automatically by a thermal or electrical overload device when short-circuit conditions occur, as well as normally by hand or tripping the switch. Circuit breakers are required as protection on the incoming line, at the generator, on the low voltage lines from the transformer, and on the switch panel for protecting individual lighting and equipment circuits. Fuses are used on the high voltage side of the transformer.

SWITCH BREAKERS AND CONTROLS

Typical Design	Description
 SAFETY SWITCH	**Standard Switch** The standard mechanical switch is a device which breaks or closes a circuit simply by disconnecting or connecting two separate contacts. Several types are available including safety switches, no-load disconnect switches, small toggle switches for lighting and small loads, and fused switches.
	**Motor Controls** The purpose of starters for A-C motors is to provide a safe, convenient means of switching a motor on and off. Most smaller motors are started by connecting the motor directly to the voltage source, while larger motors are commonly started with some current-limiting device to avoid the high starting currents (as high as ten times normal load current) drawn by induction motors. Normally included in the starter are a contactor, auxiliary contacts for control circuits, push buttons or operating handle, and some type of overload protection device.

ELECTRICAL SWITCHING GEAR

GENERAL INFORMATION

1. Types - The types of electric switching gear for shelter system use are automatic transfer switches, remote control switches, A-C circuit breakers, contactors and relays, motor starters, and circuit breakers.

2. Functions - Automatic transfer switches are designed to disconnect the commercial power supply and connect the internal power supply to the shelter circuits. Once the commercial power is restored, the transfer switch will return the load to the commercial power. The transfer switch also controls the start-up and shutdown of the internal power generator.

   There are three types of automatic transfer switches: double-throw magnetically held; double-throw mechanically held; and single-throw contactors and a relay. Double-throw magnetically held and double-throw mechanically transfer switches are preferable.

   Remote control switches operate electromagnetically. These switches are operated at convenient and accessible control stations by push buttons or automatically controlled time switches or relays.

   A-C circuit breakers are switches designed to open and close a circuit quickly and to quench the electric arc produced when opening a heavily loaded circuit. Contactors and relays are circuit opening and closing devices for controlling the operation of other electrical apparatus.

   Various types of electrical switching devices are used in electric motor starting. For three-phase induction motors, there are three common starting methods: across-the-line starting, compensator, and rotor rheostat starting. In across-the-line starting, the motor is started by connecting it to the line directly using a 3-pole knife switch or an automatic push button-operated contactor. Most small three-phase and single-phase

ELECTRICAL SWITCHING GEAR

GENERAL INFORMATION		induction motors utilize across-the-line starting.
		Starting compensators and roto-rheostat starters are used for larger motors to reduce the starting current. With high rheostat resistance, the starting current is kept low. As the motor comes up to speed, the resistance is reduced and finally taken completely out of the circuit.
SHIPPING INSTRUCTIONS	1.	Electric switching gear is shipped as a functionally complete item, normally encased in a protective housing.
RATINGS	1.	Switches are generally rated as to voltage, maximum interrupting current, and operating or steady-state current.
	2.	The type of enclosure, closing and opening devices, auxiliary contacts, and special features desired must also be specified.
INSTALLATION INSTRUCTIONS		Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:
	1.	Ensure that the switch is mechanically operative prior to installation. Inspect the contacts for alignment, proper closure, and good contact surfaces.
	2.	Ensure that the line and load conditions are not greater than the rated capacity of the switch.
	3.	Install the switch in the circuit.
	4.	Test the mechanical and electrical operation of the switch after installation.

ELECTRICAL SWITCHING GEAR

STEP 1	Determine whether the function of the switching gear is as a circuit breaker, no-load disconnect switch, transfer switch, remote control switch, or motor starter.
STEP 2	Determine the line voltage to be impressed across the switch terminals.
STEP 3	Determine the maximum starting current, maximum operating or steady-state current anticipated to flow through the switch, and then, in the case of circuit breakers, the maximum short-circuit current which the switch would need to break.
STEP 4	Determine the currents at which each circuit breaker should open and coordinate tripping times so that the circuit breaker nearest any short circuit or overload will trip first. These tripping times and currents are available in graph form from the manufacturers.
STEP 5	Select the switch based upon function, maximum voltage, maximum expected load current.

LIGHTING

GENERAL INFORMATION

1. Description - The function of lighting is to provide adequate illumination for the task to be performed. The two commercially available lighting mediums acceptable for shelter use are incandescent and fluorescent lights. Lights will be operated from the 110-volt A-C single-phase source available in the shelter. In some applications, a lighting system may be operated from 12 volts, D-C. Incandescent lamps are available in sizes ranging from 60 to 1500 watts. Silvered bowl lamps are available in 110-volt ratings, with capacities of 15 to 150 watts. Fluorescent lamps are available in sizes ranging from 4 watts to 215 watts. Fluorescent lamps are preferred for general lighting of shelter areas because their glare and heat dissipation is less than that of incandescent bulbs. Luminaires provide the mounting for the incandescent or the fluorescent lamp.

2. Design - The amount of lighting required in any shelter depends upon the amount of space needed for various types of tasks. In general, 80% of the space can be illuminated at the minimum level required for moving about and performing simple manual tasks. Approximately 15% of the space will require lighting for supply areas, equipment maintenance, while less than 5% of the space will require a relatively high illumination level for administrative and medical tasks. Recommended lighting levels are summarized in the following table.

RECOMMENDED LIGHTING LEVELS

5 Footcandles	Sufficient light for manual tasks and for assembly or movement of people within the shelter
10 Footcandles	Sufficient light for supply areas and areas around machinery where maintenance might be performed
30 Footcandles	Sufficient light for administrative and medical areas

LIGHTING

STEP 1 Determine the required level of illumination based on the type of task performed in each specific area.

STEP 2 Select the lighting system and luminaires. Both incandescent and fluorescent lighting are acceptable. Lighting systems are classified as:

(1) Direct
(2) Indirect
(3) Semidirect
(4) General diffuse or direct-indirect
(5) Semi-indirect

A guide for the general types of lighting systems is provided on the following page. For final selection of lighting luminaires, the manufacturers of lighting equipment should be consulted.

STEP 3 Determine the coefficient of utilization. This factor adjusts for absorption of light by other surfaces and spillage of light to nonuse areas.

STEP 4 Determine the maintenance factor. In general, a factor of 0.8 can be used.

STEP 5 Determine the number of lamps required using the following equation:

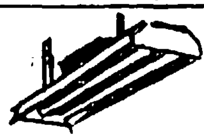
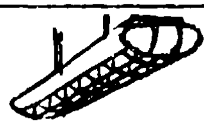
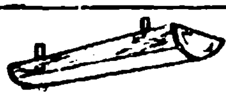
$$\text{Number of Lamps} = \frac{\text{Footcandles Req'd} \times \text{Area}}{\text{Lumens per lamp} \times \text{Coefficient of utilization} \times \text{Maintenance factor}}$$

STEP 6 Determine the number of luminaires required based on 110-volt lamps:

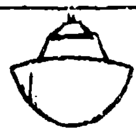
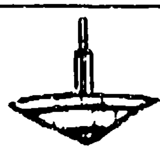
$$\text{Number of Luminaires} = \frac{\text{Number of Lamps}}{\text{Lamp per Luminary}}$$

GUIDE TO LIGHTING SYSTEMS

REPRESENTATIVE LIGHTING POWER LOAD - WATTS PER SQUARE FOOT

FLUORESCENT LUMINARIES 120 V 60 CPS		FOOTCANDLES 5	10	15	20	40	60	80	100
Direct		0.3	0.5	0.9	1.1	2.2	3.2	4.3	5.4
Direct		0.3	0.7	1.0	1.3	2.6	3.9	5.2	6.5
Direct-Indirect		0.4	0.7	1.1	1.4	2.8	4.2	5.6	7.0
Indirect		0.6	1.2	1.8	2.4	4.7	7.1	9.5	12.0

REPRESENTATIVE LIGHTING POWER LOAD - WATTS PER SQUARE FOOT

INCANDESCENT FIXTURES 120 V 60 CPS.		FOOTCANDLES 5	10	15	20	40	60	80	100
Direct		0.6	1.2	1.8	2.4	4.8	7.1	9.5	12.0
General Diffuse		0.8	1.6	2.4	3.2	6.4	9.6	13.0	16.0
Indirect		1.2	2.3	3.5	4.7	9.4	14.0	19.0	24.0

STORAGE BATTERIES

GENERAL INFORMATION

1. Application - Storage batteries are needed for starting operations of the power generator set and for other emergency functions, such as providing power for emergency lighting in case of normal power plant failure.

Wet Cell Batteries

2. Wet cell batteries are desirable in shelters because they generally have a greater storage capacity than dry cells. The wet cells can also be maintained in a fully charged condition or recharged when A-C power is available. The common usage of 12-volt D-C systems in equipment (prime mover starting systems and communications equipment) makes it desirable to employ this voltage for ease of maintenance and interchangeability. Several types of wet cells are available. The lead-acid type has been standard for many years, although the nickel-cadmium type is now gaining favor for applications requiring maximum life and performance. Certain precautions must be observed both in the design and operation of wet cell systems to avoid dangerous conditions. Gas fumes coming from the cells can be toxic and must therefore be vented to the outside of the shelter. In each case, the manufacturers should be consulted for information concerning their batteries and systems, including recommended safety equipment.

Dry Cell Batteries

3. Dry cell batteries will suffice for small shelters of 50 spaces due to the relatively low auxiliary power requirements. The dry cell system can consist of self-contained batteries and lights or both. Dry cells cannot be recharged, and whether used or not, they tend to age over a period of several months. The shelf life for useful power availability is approximately 24-30 months. This results in the need for constant checking and periodic replacement of the batteries.

STORAGE BATTERIES

SHIPPING INSTRUCTIONS	1.	Wet cell batteries, in some cases, are shipped dry with the electrolyte in a separate container. Normally when a bank of cells is required the complete system including battery charger, interconnecting hardware, supporting racks, and switching should be ordered as a package.
	2.	Dry cells are normally ordered as individual units or as part of emergency lighting units.
RATINGS	1.	Wet cells are rated on the basis of ampere-hour capacity and voltage.
	2.	The type of battery, lead-acid or nickel-cadmium, must be specified.
INSTALLATION INSTRUCTIONS		Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:
	1.	Check connections to ensure that anodes and cathodes are connected according to the wiring diagrams.
	2.	Check to see that the voltage is that which is specified.
	3.	Set the battery charger for the proper charging rate according to manufacturer's instructions.
	4.	If auxiliary lighting is turned on by automatic devices, test each device to see that the lights go on under the required conditions.
	5.	Be sure to consult with the manufacturer for instructions regarding proper installation of battery racks and vents to carry fumes from the batteries out of the shelter.

STORAGE BATTERIES

STEP 1

Determine the D-C voltage desired for the auxiliary equipment.

STEP 2

Determine the D-C voltage desired for the secondary electrical system. For dry cell systems, choose a voltage that allows batteries to be interchanged. For wet cell systems, choose a voltage that allows use of commercially available cells and associated charger.

STEP 3

Determine current (amperage) requirements by adding the amperages for each light on the secondary system, signaling equipment, and communications equipment supplied by the batteries. If the current (amps) is not noted on lights, calculate by use of the following formula:

$$I = \frac{W}{V} \qquad I = \frac{V}{R}$$

where

V	voltage
I	current (amps)
R	resistance
W	watts (power)

STEP 4

Determine the maximum time that the batteries will be needed without recharging.

STEP 5

Select D-C storage batteries based upon the (1) voltage, (2) current requirements, and (3) hours of operation required.

MAINTENANCE AND OPERATING DATA

GENERAL MAINTENANCE

ELECTRIC MOTORS AND GENERATORS

The maintenance and operation instructions for the shelter equipment should be carried out in accordance with a well-defined program. The unpredictability of the time when the equipment will be required makes it imperative that this program be followed in its entirety.

Rotating machines such as motors and generators require a program of combined maintenance and operation. The equipment must be lubricated and checked at specified intervals, as indicated by the manufacturer. In addition, the equipment must be operated at specified intervals to assure that oil distributes itself over all moving parts, control relays and associated circuits operate properly, and the equipment generally functions correctly.

Periodic operation and associated maintenance will provide the maintenance personnel with operating knowledge of the machines. For example, electric motors and generators must not be allowed to run at temperatures above their normal operating range. Equipment in operation has a normal temperature rise, and excessive temperature rise indicates an abnormal condition. Such a condition would be noticed by the maintenance personnel and corrected before the equipment is required in an emergency situation.

The maintenance and operating instructions prepared by the manufacturer for the specific equipment should be used as the guide for shelter equipment instructions. The manufacturer has years of equipment development and field testing experience and knows how his equipment must be used if it is to function at its best and longest. Therefore, the instructions and checklists he develops should be used conscientiously by the customer. In the absence of such instructions, the checklist which follows in this section should be consulted to assure minimum control of the inspection, operation, and maintenance of shelter equipment.

MAINTENANCE AND OPERATING DATA

GENERAL MAINTENANCE

COMMUTATORS AND SLIP RINGS	During normal operations, commutators and slip rings acquire a shiny protective gloss, which serves to reduce wear and thereby lengthens service life. The surface film generally contains copper oxide and graphite. Operating conditions, atmospheric conditions, and brush grade affect the makeup and color of this film, which may range from a light straw color to jet black. The color most common to a good surface film is chocolate brown. A raw copper surface may be caused by the wrong brush grade, some mechanical or electrical fault, or low current density at the brush surface brought on by consistently small loads. In the case of low current density, a minimum of 40 amps per square inch is usually necessary to maintain a good surface film and to minimize brush wear. This may be accomplished by removing one or more brushes from each group of brushes.
BRUSHES	Brush sparking can be a symptom of mechanical, electrical, or operating trouble and can be caused by a great variety of disorders. Most frequently the sparking is caused by dirty slip ring or commutator or by some mechanical fault. Mechanical unbalance, machine misalignment, slip ring or commutator eccentricity, and incorrect positioning of brushes are all detrimental to good current transfer and may cause sparking.
FUSES	Fuses of the correct type and size provide maximum dependability and protection. When fuses of the correct size and type are found to blow frequently, look for trouble within the circuit. Do not overfuse. A fuse larger than necessary will endanger the apparatus to be protected. Common causes of blown fuses, other than short circuits and sustained overloads, are loose fuse clips, poor contacts, extremely hot surroundings, and excessive vibration.

MAINTENANCE AND OPERATING DATA

GENERAL MAINTENANCE	
CONTROL EQUIPMENT	Control devices are essential to the successful control of electric motors. Failure of the control may result in poor performance, failure to start, and damage to the machine itself. Failure of an overload trip may result in a burned-out motor. Control equipment should be kept dry, clean, and in proper working condition. Excessive vibration of contacts should be corrected. Heavy copper contacts and cadmium-plated contacts should be inspected regularly and filed when they become badly pitted. Solid silver oxide, which forms on contact surfaces, should not be removed because it is almost as good a conductor as silver. When necessary, dress silver contacts with a fine cut file or a grade 0000 sandpaper. The welding of contacts is generally due to low contact pressure caused by low voltage or weak springs. Lubrication of controllers is normally not necessary and should only be performed at intervals recommended by the manufacturer.
RESISTORS	Failure of resistors may be caused by poor connections, excessive vibration, inadequate ventilation, overloads, defective insulation, or corrosion. Connections should be checked for proper banding. Loose connections cause excessive heating of terminals and wiring. Excessive vibrations of cast-grid type resistors will cause fractures to develop. Inadequate ventilation and overload may result in burned-out units.
LIGHTING	The components of a fluorescent lighting system are lamp, starter, and ballast. When a lamp fails to light the trouble may be in the lamp, starter, ballast, or supply circuit. The lamp is easily checked by substituting one which is known to be good. If a good lamp fails to light, the starter should be replaced.

MAINTENANCE AND OPERATING DATA

GENERAL MAINTENANCE	
CIRCUIT BREAKERS	All circuit breakers should be inspected and operated periodically to ensure proper functioning. Contacts, mechanism, wiring, and control devices should also be inspected. For larger breakers, the tripping system should be tested at least once a year by actually passing tripping current through the breaker or its control system, where practicable, or by simulating short circuit conditions. Most circuit breakers do not need lubrication, and oil or grease should never be put on contact surfaces.
STORAGE BATTERIES	Storage batteries require frequent, but simple maintenance. The terminals should be kept clean and the electrolyte maintained at the correct level. Pure petroleum jelly, when applied to the cable connections of both acid and alkaline batteries, will prevent their corrosion. Dirty battery connections may be cleaned by removing them and brushing them with a wire brush. Regular hydrometer checks will indicate whether or not the battery needs charging. These checks should be made monthly.
MISCELLANEOUS SPARE PARTS	One fuse for each fuse installed One spare operating coil of each type One pushbutton of each type One spare resistor of each type One set of spare contacts, springs, and arc chutes for each type of relay, contactor, and circuit breaker

MAINTENANCE AND OPERATING DATA

GENERAL MAINTENANCE	
GENERAL TROUBLE-SHOOTING AND EMERGENCY REPAIRS	Trouble in an electrical system is generally caused by grounds, shorts, or opens. A ground is an electrical connection between the wiring of the apparatus and its framework. A short circuit is unintentional contact between two or more parts of the circuit which by-passes part or all of the electric load. An open is a break in the continuity of the circuit. A ground or short circuit may cause one or more circuit breakers or fuses to open because of the high currents which result. The cause of a circuit breaker tripping should be determined and corrected prior to closing the breaker again. In some cases, a short circuit may have corrected itself by burning free, but the molten and burned material must be found and cleaned up. Electrical tape can be used to temporarily reinsulate bare wires. These wires should be replaced at the earliest possible time to prevent further hazard.

MAINTENANCE AND OPERATING DATA

A-C GENERATORS		
MONTHLY STANDBY INSPECTION	1.	Make a visual check of the generator for physical damage to windings, slip rings, brushes and brushholders, connections, bearings, commutators, couplings, and mountings. Ensure that no foreign bodies are lodged between stator and rotor.
	2.	Check insulation for dryness and resistance by using a megger, which is a meter of high resistance. A megger is used to measure insulation resistance between windings and between windings and frame.
	3.	Check all brushes to see that they are in place, move freely in their brushholders, and are held to the slip rings or commutator with proper spring tension. Replace brushes which have worn past half their original length.
	4.	Check the generator circuit breaker for physical damage, missing and broken parts, tight connections, contact alignment, and proper operation.
	5.	Check the generator and exciter field circuit breakers in the same manner.
	6.	Inspect all of the circuit breakers, wiring, controls, switches, and the generator itself for evidence of moisture or casual water.
	7.	If fuses are in any of the generator circuits, check for continuity and proper rating.
START-UP	1.	Ensure that the generator circuit breaker is open.
	2.	If an exciter field rheostat or generator field rheostat is used, set it at full high resistance.

MAINTENANCE AND OPERATING DATA

A-C GENERATORS

START-UP

3. Start the prime mover by going through the prime mover start-up procedure.

4. Gradually reduce exciter or generator field rheostat resistance until voltage builds up to rated no-load voltage.

5. Allow the generator to run at rated no-load voltage and rated speed (frequency) for several minutes.

6. Close the generator circuit breaker.

7. If the commercial incoming line is connected to the shelter system and it is desired to operate the shelter electrical system from generator power, switch the transfer switch to "auxiliary" from "incoming commercial line."

TROUBLESHOOTING

VOLTAGE DOES NOT BUILD UP

1. Check generator and/or exciter field rheostat for an open resistance. Short the rheostat terminals and if voltage then builds up, the rheostat is faulty.

2. Check brush contact pressure and slip ring and commutator surfaces.

3. Check for an open circuit in the field wiring and controls.

4. In brushless generators, check the rectifiers on the rotor shaft for connections, proper functioning, and physical appearance. An ohmmeter can be used to check for proper forward and inverse resistance.

MAINTENANCE AND OPERATING DATA

A-C GENERATORS

TROUBLESHOOTING

BRUSHES SPARK OR CHATTER EXCESSIVELY	1.	Check for proper number of brushes and that they all are in place.
	2.	Check spring pressure on each brush.
	3.	For light loads, lift some of the brushes from the slip rings or commutator to increase the current density above 40 amps per square inch.
BEARINGS TOO HOT	1.	Check lubrication and add lubricant if necessary. (Some bearings are permanently lubricated and sealed at the factory so that no further lubrication is needed.)
	2.	Listen with an ear pressed against the bearing housing to detect grinding or squealing noises. Such noises may indicate imminent bearing failure which would cause a shutdown and replacement of bearings, if feasible.
GENERATOR FRAME TOO HOT	1.	If the frame rises to above rated full-load temperature rise (above ambient temperature) check to see that the load is not excessive.
	2.	In three-phase generators, check all phases to ensure that equal current is flowing in each phase. A loose connection or high resistance connection may result in an unbalanced condition.
	3.	Check all ventilating and cooling passages to see that no obstructions are blocking cooling air.
	4.	Check brushes for proper contact

MAINTENANCE AND OPERATING DATA

A-C GENERATORS

TROUBLESHOOTING

VOLTAGE FREQUENCY IS WRONG OR ERRATIC	1.	Check operation of the speed control governor on the prime mover.
	2.	Check the speed control governor for proper setting (at rated generator speed).
SHUTDOWN	1.	Open the generator circuit breaker.
	2.	Reduce the voltage by means of exciter-field or generator-field rheostat.
	3.	Shut down the prime mover.
SPARE PARTS	1.	One complete set of brushes
	2.	Two individual brushholders
	3.	Two brushholder springs
	4.	One set of brushholder stud insulation
	5.	One set of bearings
	6.	One set of retainer rings for antifriction bearings
TOOLS	1.	Two screwdrivers
	2.	Set of wrenches to fit connection studs, mounting bolts, coupling bolts, bearing bolts and nuts
	3.	One portable ohmmeter
	4.	One portable AC-DC voltmeter

MAINTENANCE AND OPERATING DATA

A-C GENERATORS

TOOLS

5. One tong type ammeter
6. One megger (insulation tester)
7. One portable tachometer
8. Two or more industrial thermometers with a variety of ranges
9. Electrical insulating tape

IDENTIFICATION AND CODING

1. Mark phases A, B, or C for three-phase systems and 1 and 2 for single-phase systems.
2. Mark the generator circuit breaker as such and any other controls according to their function.
3. Keep manufacturer's name tags on each piece of apparatus intact and readable.
4. Locate manufacturer's instruction booklets for each piece of apparatus in a conspicuous, well-protected holder on or close to the piece of equipment.

MAINTENANCE AND OPERATING DATA

A-C MOTORS

MONTHLY STANDBY INSPECTION	1.	Make a visual check of the motor for physical damage to windings, slip rings, brushes and brush-holders, connections, bearings, couplings, and mountings. Ensure that no foreign bodies are lodged between stator and rotor.
	2.	Check insulation for dryness and resistance. A megger is used to measure insulation resistance between frame and windings and between windings in different phases.
	3.	Check the motor starter for physical damage, missing and broken parts, tight connections, contact alignment, and proper operation.
	4.	On single-phase motors having brushes, check for brush spring tension, free movement in brushholders, and excessive wear. Replace brushes which are worn over half their original length.
	5.	Inspect all wiring, controls, and equipment for evidence of moisture. Wipe off any moisture found.
	6.	If fuses are used in the circuit, check for continuity and proper rating.
START-UP	1.	Lower motor brushes, if previously lifted.
	2.	Turn the rotor by hand, if feasible, to ensure free movement.
	3.	Start the motor.

MAINTENANCE AND OPERATING DATA

A-C MOTORS

START-UP

4. Check visually to see that the motor and driven element are operating properly.

TROUBLESHOOTING

MOTOR DOES NOT START

1. Check fuses to see that they are not open.
2. Recheck the motor and driven element for obstructions.
3. Check the starter and control to see that the main contactor closes.
4. Check line voltage for rated value.
5. Check connections, brushes, and lubrication.
6. Check windings for an open circuit or short circuit.
7. Recheck to see that the starting load is not too great.

MOTOR RUNS SLOW

1. Check for proper line voltage.
2. Check for blown fuse in one phase of a three-phase motor starter, or for poor contacts in one phase of the main contactor.
3. Check for an overload condition caused by the driven element.
4. Check for proper line frequency due to improper generator speed.
5. Inspect windings for broken wires or evidence of physical damage.
6. Check the rotor for broken rotor bars.

MAINTENANCE AND OPERATING DATA

A-C MOTORS

TROUBLESHOOTING

MOTOR RUNS SLOW	7.	Check for equal current in each phase using a tong type ammeter.
MOTOR RUNS HOT	1.	Check fuses for continuity.
	2.	Check voltage and frequency.
	3.	Check insulation for physical damage, moisture, or charring.
	4.	Check the driven element to see that it is not causing an overload.
	5.	Check the supply circuit to make sure excessive resistance has not developed through poor connections, broken wire, or wiring too small for the rated current.
	6.	Check bearing lubrication and add lubricant if necessary.
MOTOR STOPS	1.	Check overload trip elements in the starter. Replace the elements if no reason can be found for their operation.
	2.	Check fuses and replace if blown and no reason can be found for their opening.
	3.	Check starter for contact pitting, stuck relays or contactor, open contactor coil, inadvertent stopping.
SHUTDOWN	1.	Stop the motor.

MAINTENANCE AND OPERATING DATA

A-C MOTORS

SHUTDOWN	2.	Lift the motor brushes, if any, if the motor will not be operated for more than a month. Lifting the brushes is a simple operation and involves raising the brushes off of the slip ring without removing them entirely. Indicate that the brushes have been lifted by placing a tag on control switch or motor.
SPARE PARTS	1.	Brushholders
	2.	Brushholder springs
	3.	Brushholder stud insulation
	4.	Brushes
	5.	Bearings
	6.	Oil rings
	7.	Retainer rings for antifriction bearings
TOOLS	1.	Two screwdrivers
	2.	Wrenches to fit all nuts and bolts on the control, motor, and connections
	3.	One portable ohmmeter
	4.	One portable A-C voltmeter
	5.	One portable tachometer
	6.	One megger (insulation tester)

MAINTENANCE AND OPERATING DATA

A-C MOTORS

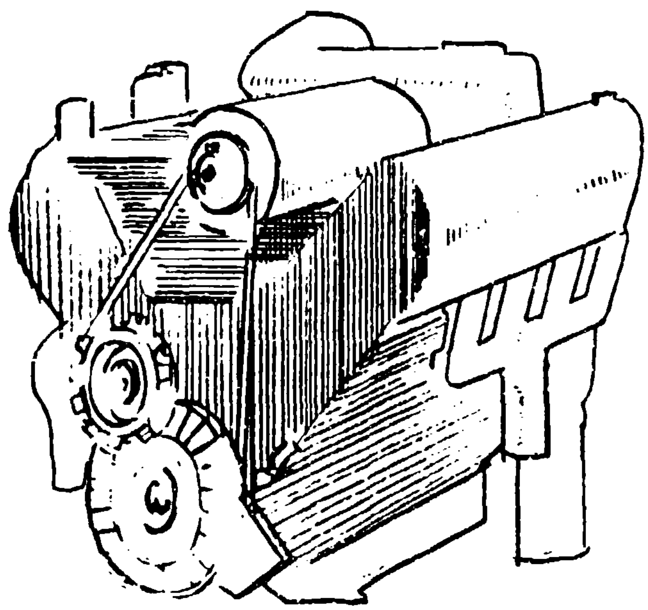
TOOLS	7.	One tong type ammeter
	8.	One industrial thermometer
	9.	Electrical insulating tape
	10.	Sandpaper, fine grades
	11.	Wiping rags and canvas
	12.	Soldering iron and solder
	13.	Fine file for smoothing contacts
IDENTIFICATION AND CODING	1.	Mark the phases to conform to generator phase markings.
	2.	Keep manufacturer's name tags on each piece of apparatus intact and readable.
	3.	Locate manufacturer's instructions for each piece of equipment in a convenient, conspicuous, and protected place.

SUGGESTED SAMPLE
DESIGN OF PAGE

SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 3

AUXILIARY
PRIME MOVER
SYSTEMS



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

SUGGESTED SAMPLE
DESIGN OF PAGE

Table of Contents	How to Use Guidelines

Use the Table of Contents given below to quickly locate key technical data pertaining to the selection and operation of manually operated prime mover and generator systems, gasoline engine prime mover systems, and diesel engine prime mover systems.

The Introduction Section provides all essential data regarding system requirements and typical system designs.

System component descriptions, application data, and selection procedures are given in the Component Selection Section.

The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions for relatively unskilled people.

NEED FOR AUXILIARY PRIME MOVER SYSTEMS

System Uses

An auxiliary prime mover system must be readily available to drive electric generators in the probable event of complete disruption of the public utility power supply during and following nuclear attack. Commercially available prime mover systems which are generally suitable to shelter requirements include manual, gasoline engine, and diesel engine systems.

Manual Drive Systems

Manual drive systems are suitable only for small horsepower requirements. Their primary use is for driving small 12 volt direct-current generators and their shelter applications are restricted to charging storage batteries and providing limited additional electric power for emergency lighting and communications needs.

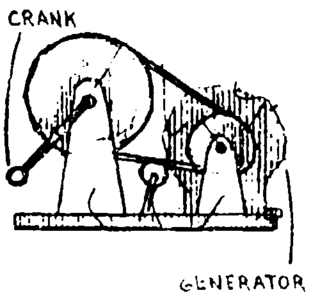
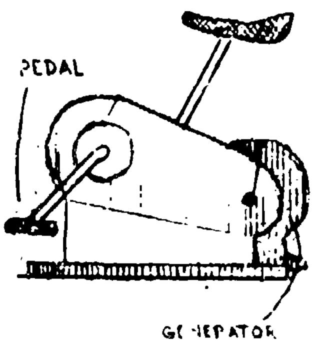
Gasoline Engine Systems

Gasoline engine systems are best suited to medium prime mover demands of 100 horsepower and below. Their primary shelter application is to drive an alternating-current generator which provides the electric power required for lighting, communications equipment, and electric motors in shelters ranging in size from 50 to 2000 occupants.

Diesel Engine Systems

Diesel engine systems are best suited to large prime mover demands of 100 horsepower. Their primary shelter application is to drive an alternating-current generator which provides the electric power required for lighting, communications equipment, and electric motors in shelters having over 1000 occupants.

MANUALLY OPERATED PRIME MOVER AND GENERATOR SYSTEMS

Type Designation	Typical Design	Description
HAND-OPERATED SYSTEM		
Type I		A typical hand-operated prime mover and generator system consists of a roller chain drive, a small direct-current generator, a mounting base, a hand crank, and a number of bearing supports and bearings. In some applications, a gear train is substituted for the roller chain drive. Mechanical power converted to electrical power by means of a 12-volt direct-current generator which is connected directly to the driven sprocket.
FOOT-OPERATED SYSTEM		
Type II		A typical foot-operated prime mover and generator system consists of the same basic components as the hand-operated system with the exception that a seat and some means of support or frame are added. Also, the crank projects from both sides of the large drive sprocket and has attached foot pedals to permit foot actuation of the drive. Mechanical power is converted to electrical power by means of a 12-volt direct-current generator connected directly to the driven sprocket.

GASOLINE ENGINE PRIME MOVER SYSTEMS

Type Designation	Typical Design	Description
AIR-COOLED GASOLINE ENGINE		
Type III	None	A typical air-cooled gasoline prime mover system consists of an air-cooled gasoline engine, a fuel source, an air intake system, and an exhaust system. The major segments of the gasoline engine include a cylinder block and crank-case assembly, a cylinder head assembly, and other attached unit subassemblies. In operation, gasoline flows from a storage tank to the carburetor where the fuel is mixed with filtered air obtained from the air intake component. The fuel mixture is then supplied to the engine and ignited by means of the ignition system thus creating heat energy which is converted to mechanical power by the crank-case assembly. The resulting products of combustion are removed by means of the exhaust component.
LIQUID-COOLED GASOLINE ENGINE		
Type IV	None	A typical liquid-cooled gasoline prime mover system consists of a gasoline engine, a fuel source, a liquid cooling system, and an air intake and exhaust component. The fuel flow and mixture with air, ignition, mechanical power generation, and exhaust actions are the same as those described above for the air-cooled gasoline engine. The liquid cooling system draws off engine heat by circulating water or other coolant between the engine and an air-cooled heat exchanger.

DIESEL ENGINE PRIME MOVER SYSTEMS

Type Designation	Typical Design	Description
LIQUID-COOLED DIESEL ENGINE		
Type V	None	A typical diesel prime mover system consists of a diesel engine, a fuel supply, a liquid cooling system, and an air intake and exhaust component. The major segments of the diesel engine include a block assembly, a head assembly, an auxiliary starting unit, a fuel pump and a lubrication unit. In operation, diesel oil flows from a storage tank to a fuel pump where the oil pressure is increased to the required injection pressure level. The diesel oil is then fed in measured quantities into the engine, together with filtered air obtained from the air intake system. Ignition is accomplished by means of compression, and the resultant heat energy is converted into mechanical power by the block assembly. The resultant products of combustion are then removed by means of the exhaust component. A fairly critical engine operating temperature is maintained by means of the liquid cooling system which circulates water or other coolant between the engine and a heat exchanger. The auxiliary starting unit provides the speed and high torque required to start the diesel engine.

SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	ENGINE-POWERED PRIME MOVER SYSTEM	MANUALLY OPERATED PRIME MOVER SYSTEM
BELOWGROUND AND ABOVEGROUND SHELTERS			
50 PEOPLE	Best	Type III	Type II
	Acceptable		Type I
100 PEOPLE	Best	Type IV	Type II
	Acceptable	Type III	Type I
200 PEOPLE	Best	Type IV	Type II
	Acceptable	Type V	Type I
300 PEOPLE	Best	Type IV	Type II
	Acceptable	Type V	Type I
500 PEOPLE	Best	Type IV	Type II
	Acceptable	Type V	Type I
1,000 PEOPLE	Best	Type V	Type II
	Acceptable	Type IV	Type I
2,000 PEOPLE	Best	Type V	Type II
	Acceptable	Type IV	Type I
3,000 PEOPLE	Best	Type V	Type II
	Acceptable		Type I
5,000 PEOPLE	Best	Type V	Type II
	Acceptable		Type I
10,000 PEOPLE	Best	Type V	Type II
	Acceptable		Type I

HAND- AND FOOT-OPERATED DIRECT-CURRENT GENERATORS

GENERAL TERMS

1. Roller Chain Drive - A mechanical drive which transmits power between a driver sprocket and a driven sprocket by means of roller chain.

2. Sprocket - A toothed metal disk which mounts on a shaft.

3. Roller Chain - A flexible steel rack composed of a series of alternately assembled roller links and pin links.

4. Gear Train Drive - A mechanical drive which transmits power between a driver gear and a driven gear by means of a series of intermediate gears.

5. Horsepower - A unit of mechanical power equivalent to the expenditure of 33,000 foot pounds of energy per minute.

6. Direct-Current Generator - A machine which converts mechanical energy into direct-current electrical energy.

7. Voltage Regulator - An electrical device used to regulate the output of the generator to ensure that the correct voltage is used to charge the batteries.

GENERAL INFORMATION

1. Characteristics - A hand- or foot-operated direct-current generator converts mechanical energy into electrical energy by means of a coupled mechanical drive and 12-volt direct-current generator.

2. Uses - The application of hand- or foot-operated direct-current generators is restricted to providing limited additional electrical power for emergency lighting, communications needs, and charging storage batteries.

3. Size and Weight - A hand- or foot-operated direct-current generator will weigh between 40 and 50 pounds and will require between 1 and 2 cubic feet of storage or operating space.

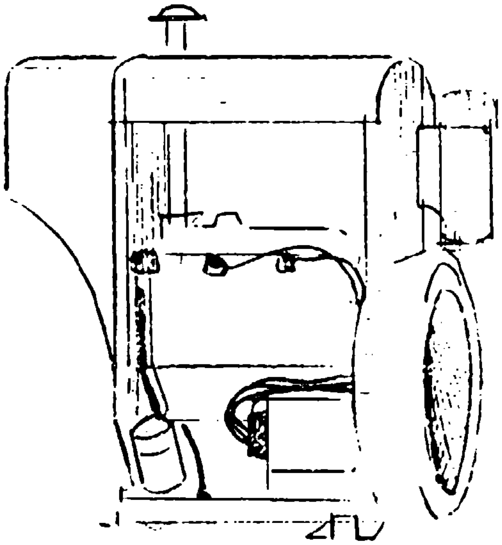
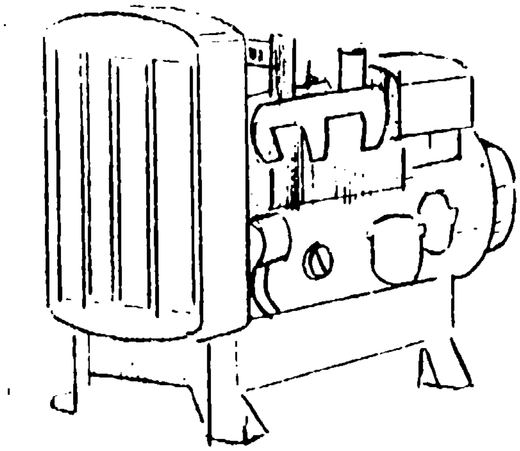
HAND- AND FOOT-OPERATED DIRECT-CURRENT GENERATORS

RATED GENERATOR CAPACITY	1.	Hand-operated 12-volt direct-current generators generally have rated capacities between 75 and 100 watts. Foot-operated units normally have somewhat higher rated capacities ranging between 100 and 125 watts.
INSTALLATION INSTRUCTIONS	1.	A hand- or foot-operated direct-current generator is normally shipped completely assembled and requires only connection to a voltage regulator to ready the unit for battery charging operations.

HAND- AND FOOT-OPERATED DIRECT-CURRENT GENERATORS

STEP 1	Determine the total wattage required to maintain the storage batteries fully charged when they are supplying the individual load requirements of emergency lighting and communications equipment. The combined load of the equipment and the charging current is thus supplied.
STEP 2	Determine the total rated capacity in watts required by dividing the sum determined in Step 1 by a factor of 0.8.
STEP 3	Determine from the manufacturers' catalogs the particular hand- or foot-operated direct-current generator to be used.
STEP 4	Determine the rated capacity of the selected hand- or foot-operated direct-current generator unit from the manufacturer's catalog.
STEP 5	Determine the number of generating units required by dividing the total rated capacity requirement in watts determined in Step 2 by the rated capacity in watts of the selected generator unit.

AIR-COOLED AND LIQUID-COOLED GASOLINE ENGINES

Typical Design	Description
	**Air-Cooled Gasoline Engine** An air-cooled gasoline engine consists of a cylinder block and crankcase assembly, a cylinder head assembly, and other attached unit subassemblies. The cylinder block and crankcase assembly is the major body section and includes cooling fins, the crankshaft, cylinders, pistons, connecting rods, and other important parts. The cylinder head assembly or upper part of the engine includes valves, rocker arms, spark plugs, and related parts. Exhaust and intake manifolds are bolted to the cylinder head and a governor, carburetor, and air cleaner assembly are bolted to the intake manifold. Unit subassemblies which are also attached to the complete engine assembly include a starting unit, an ignition unit, a fuel supply tank, a flywheel, and other items.
	**Water-Cooled Gasoline Engine** The major parts of a water-cooled gasoline engine are identical with those of an air-cooled gasoline engine and include a cylinder block and crankcase assembly, a cylinder head assembly, and other attached unit subassemblies. However, because of its larger size, the heat generated by the engine cannot be removed by air cooling but must be carried away by a liquid cooling unit which circulates water or other coolant between the engine and some form of air-cooled heat exchanger. While some cooling is achieved by heat loss to the air surrounding the engine, the major cooling task is performed by the liquid cooling unit.

AIR-COOLED AND LIQUID-COOLED GASOLINE ENGINES

GENERAL INFORMATION

1. Uses - The proper shelter application of a gasoline engine is to drive an alternating current generator which provides the electric power required for lighting, communications equipment, and electric motors. Air-cooled gasoline engines are best suited to shelter applications where the number of occupants is 100 people or less. Liquid-cooled gasoline engines effectively span the prime mover requirements for shelters ranging in size from 100 to 1000 occupants but can be used in multiples to meet the prime mover requirements of shelters ranging in size up to 2000 people.

2. Size and Weight - The size and weight of a gasoline engine will vary considerably depending on the horsepower rating of the engine. An air-cooled gasoline engine will be lighter and will occupy less space than a liquid-cooled engine. Air-cooled engines for stationary applications are available in various sizes ranging up to approximately 20 horsepower. Water-cooled units span the size range from 5 horsepower to about 100 horsepower.

INSTALLATION INSTRUCTIONS

Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:

1. A gasoline engine usually is shipped completely assembled and ready for installation on a level base.

2. After mounting on the base, connections are made to the air intake and exhaust ducts. Battery connections are made and fuel lines are connected, as required.

3. Fuel tanks are filled and checked to see that there are no leaks in the tanks, fittings, or the fuel lines.

AIR-COOLED AND LIQUID-COOLED GASOLINE ENGINES

INSTALLATION INSTRUCTIONS

4. Engine is now filled with lubricating oil, and with coolant if the engine is a liquid-cooled unit.

5. Engine is now ready for start-up. Allow engine to run until operating temperature is reached. Check for oil pressure, stable temperature and general smooth operating characteristics.

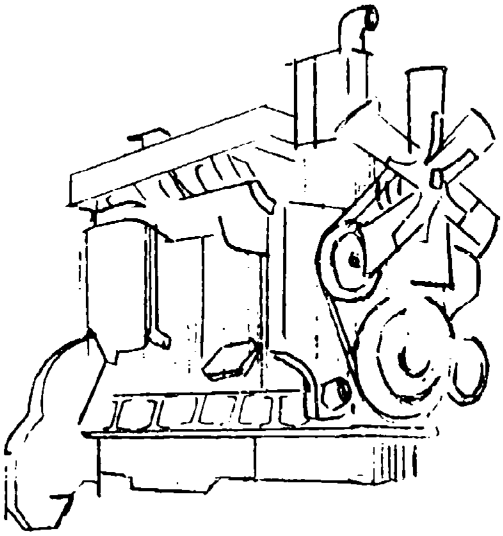
AIR-COOLED AND LIQUID-COOLED GASOLINE ENGINES

GENERAL NOTES	Although the generator selection is discussed independently of the prime mover selection, the two units are so closely interrelated that they should be selected as a packaged unit. All control circuits, metering, and transfer panel components and controls are designed into a balanced system to provide auxiliary power. This packaged unit gives the shelter planner a completely engineered auxiliary power system designed to meet the requirements of the installation.
STEP 1	Determine power requirements for the complete shelter as noted in Chapter 2, A-C Generators, Selection Procedure. Be sure to increase load requirements by 25% to assure extra capacity for expansion.
STEP 2	Determine the voltage and number of phases of the incoming commercial power service. The generator selected should match these requirements.
STEP 3	Determine the voltage of the incoming power. Determine the phase of the incoming power, single-phase (1) or three-phase (3).
STEP 4	Select the generator to meet the following requirements: Load - Total power required in kilowatts Voltage - 1-phase or 3-phase Frequency - 60 cps Starting - Remote or manual Transfer switch - To match voltage, load frequency, and phase noted above Housing - Outdoor housing if unit is to be installed outside shelter Radio suppression - Must be ordered

AIR-COOLED AND LIQUID-COOLED GASOLINE ENGINES

STEP 4	Equipment manuals and installation instructions Accessories - As required for special applications; list and descriptions available from manufacturers

DIESEL ENGINES

Typical Design	Description
	A diesel engine consists of a block assembly, a head assembly, and other attached subassemblies. The block assembly includes cylinders, pistons, crankshaft, connecting rods, and other important parts. The head assembly, or upper part of the engine, includes valves and valve parts, fuel injectors, a fuel pump, and related parts. Exhaust and intake manifolds are either bolted to or are an integral part of the head assembly. Unit subassemblies which are attached to the complete engine assembly include an auxiliary starting unit, a fuel supply, a flywheel, a liquid cooling unit, and other items.

DIESEL ENGINES

GENERAL INFORMATION

1. Uses - Diesel engines are best suited to shelter applications where the number of occupants is over 1000.

2. Size and Weight - Diesel engines are physically larger than gasoline engines of comparable horsepower. While smaller diesel engines are available, proper shelter applications of such units are for power demands in excess of 100 horsepower. The size and weight of diesel engines will vary considerably depending on the horsepower rating of the engine.

3. Manufacturers' catalogs and equipment manuals offer a very fine source of up-to-date information on the very latest equipment designs, installation drawings, and technical discussions about the subject equipment. These should be consulted in conjunction with other shelter guides.

INSTALLATION INSTRUCTIONS

Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:

1. A gasoline engine is usually shipped completely assembled and ready for installation on a level base.

2. After the engine is mounted on the base, connections are made to the air intake and exhaust ducts. Battery connections are made, and fuel lines are connected, as required.

3. Fuel tanks are filled and checked to see that there are no leaks in the tanks, the fittings, or the fuel lines.

4. The engine should be filled with lubricating oil and coolant for the cooling system.

5. The engine is now ready for start-up. Allow the engine to run until operating temperature is reached. Engine should

DIESEL ENGINES

INSTALLATION INSTRUCTIONS	have smooth operating characteristics. Observe the oil pressure during this period. Low oil pressure is a warning to shut engine down and look for cause of low pressure.

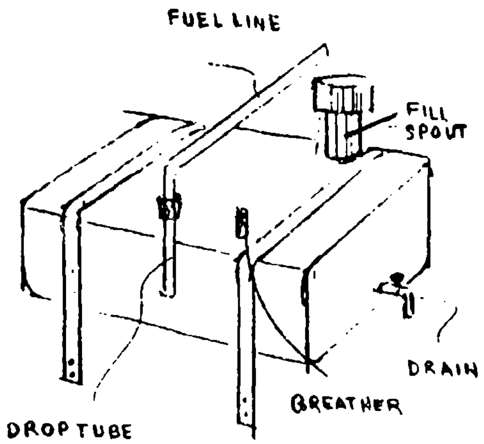
DIESEL ENGINES

GENERAL NOTES	Although the generator selection is discussed independently of the prime mover selection, the two units are so closely interrelated that they should be selected as a packaged unit. All control circuits, metering, and transfer panel components and controls are designed into a balanced system to provide auxiliary power. This packaged unit gives the shelter planner a completely engineered auxiliary power system designed to meet the requirements of the installation.
STEP 1	Determine power requirements for the complete shelter as noted in Chapter 2, A-C Generators, Selection Procedure. Be sure to increase load requirements by 25% to assure extra capacity for expansion.
STEP 2	Determine the voltage and number of phases of the incoming commercial power service. Generator selected should match these requirements.
STEP 3	Determine the voltage of the incoming power. Determine the phase of the incoming power, single-phase (1) or three-phase (3).
STEP 4	Select the generator to meet the following requirements: Load - Total power required in kilowatts Voltage - 1-phase or 3-phase Frequency - 60 cps Cooling system - Air-cooled or water-cooled Starting - Remote or manual Transfer switch - To match voltage, load frequency, and phase noted above Housing - Outdoor housing if unit is to be installed outside shelter

DIESEL ENGINES

STEP 4	Radio suppression - Must be ordered Equipment manuals and installation instructions Accessories - As required for special applications; list and descriptions available from manufacturers

GASOLINE AND DIESEL ENGINE FUEL SOURCES

<table>
<tr><th>Typical Design</th><th>Description</th></tr>
<tr><td>
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Gasoline and Diesel Engine Integral Fuel Tanks

Integral fuel tanks mount directly on the engine and consist of a cylindrical or rectangular tank, a fill spout and cap, a drain plug or drain pipe and valve, a fuel line, and several engine mounting brackets. Tank capacities vary from 1 to 25 gallons. A version of the integral tank, called a day tank, provides a small immediate fuel supply for the engine and is kept filled by a remote fuel storage tank. Day tanks vary in size from one quart to one gallon in the case of gasoline engines and from 8 to 60 gallons in the case of diesel engines.
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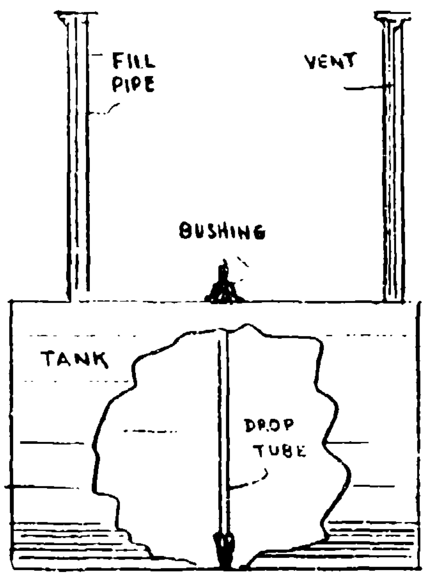
<tr><td>
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Gasoline and Diesel Engine Remote Fuel Tanks

Remote fuel tanks are normally buried underground adjacent to the shelter and consist of a cylindrical or rectangular tank, a fill pipe and cap, a vent pipe, a drop tube, and two fuel lines. An auxiliary fuel pump may or may not be required, depending on the relative location of the remote fuel tank. Remote fuel tanks are available in 55, 110, 285, and 560 gallon sizes.
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GASOLINE AND DIESEL ENGINE FUEL SOURCES

GENERAL INFORMATION

1. Nomenclature - The fuel storage tank consists of a metal tank, the outside of which has been specifically treated to withstand the weather for outside belowground installation or painted for integral tank indoor use. The fuel tank is equipped with fuel line fittings and connections such as fill pipe, vent pipe, suction and return lines, and coupling flanges, depending on the particular type of tank.

2. Capacity - The capacity of the fuel storage tank will vary with its specific function, such as a day tank, integral tank, or remote storage tank. Gasoline day tanks are less than one gallon in capacity, whereas integral gravity feed gasoline tanks are permitted up to 25 gallons for inside use. Day tanks for use on diesel engines will vary from 8 to 60 gallons. Remote storage tanks are large in capacity, ranging from 55 to 560 gallons and can be installed in groups of two, three or more units The capacity requirement is dependent upon the size of the prime mover and its fuel demand at full load for desired days continuous operation.

3. Size and Shape - The size of the tank will vary with its particular purpose and its required capacity. Integral tanks are designed to blend or nest with the engine's physical shape and size and are either rectangular or cylindrical in shape. Remote storage tanks are generally of cylindrical shape. A 55-gallon tank is about 26 inches in diameter and 24 inches long A 110-gallon tank is also 26 inches in diameter, but 48 inches long. Used in groups, they are placed side by side and piped together.

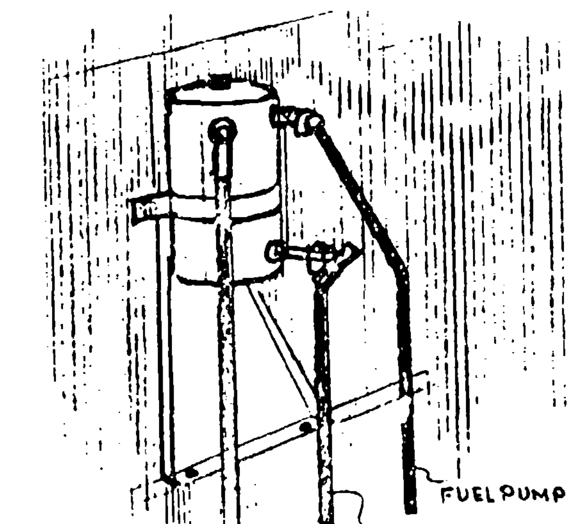
4. Weight - The fuel storage tank will vary in weight, depending on the material thickness congruous with its size and capacity.

GASOLINE AND DIESEL ENGINE FUEL SOURCES

DAY TANK APPLICATION INFORMATION

1. Gasoline and diesel engine installations which use a remote fuel tank must have some means of keeping the engine fuel system primed and ready for instant starting. A day tank mounted on or near the engine meets this requirement by providing a small supply of fuel for immediate use by the engine. Many gasoline engines have a one-quart day tank mounted close to the carburetor to replace the fuel which evaporates from the fuel bowl in the carburetor. Such day tanks vary in capacity from one quart to one gallon for gasoline engines. Diesel engine installations have day tanks ranging in capacity from 8 to 60 gallons.

TYPICAL DAY TANK INSTALLATION



AUXILIARY FUEL PUMP APPLICATION INFORMATION

1. The ability of a gasoline or diesel engine fuel pump to move fuel is limited to specific lateral and vertical distances. An auxiliary fuel pump can be used to overcome these limitations. In such applications, an electric booster fuel pump is installed close to the remote fuel supply to pump fuel to the day tank. The booster fuel pump is usually controlled by a float-actuated switch on the day tank.

GASOLINE AND DIESEL ENGINE FUEL SOURCES

INSTALLATION INSTRUCTIONS

Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:

1. Integral and day tanks are normally shipped mounted on and attached to the gasoline or diesel engine. Day tanks, however, must be connected to a fuel circuit to draw fuel from remote storage tanks. Remote fuel storage tanks must be located underground and outside the shelter at least one foot from any building foundation and three feet from any adjoining property lines. They must be so located that loads carried by foundations cannot be transferred to the tank.

2. Every effort should be made to keep stored fuel cool to limit vaporization. Gasoline engine fuel should be a regular grade. Highly leaded premium grades of gasoline should be avoided, since their use will require more frequent lead removal and valve or spark plug servicing. Gasoline should not be stored for periods longer than one year. Diesel fuel should be a No. 2 diesel oil or equivalent and can be stored for an indefinite period of time.

3. In determining how deep to bury the tank, definite consideration should be given to the capability of the fuel pump to lift the fuel from an underground tank. Fuel pumps on small engines can suck the fuel up about 4 feet, fuel pumps on medium-sized engines can lift the fuel about 8 feet, and large engine units are capable of about 12 feet of lift. Lifting capabilities are reduced by elbows and bends in the fuel line. Locating the tank a long distance from the engine also puts a heavier demand on the fuel pump, thus reducing the pump's lifting capability. The use of booster pumps and proper valving can augment the suction of lift capability of the engine's fuel pump.

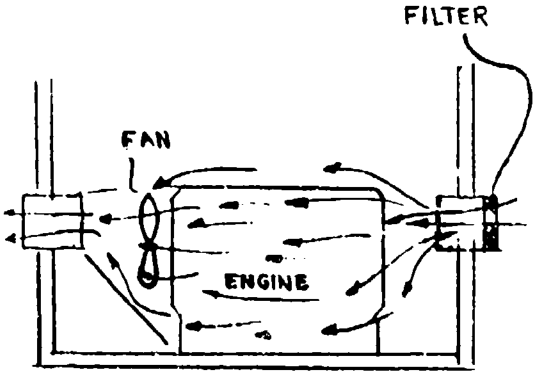
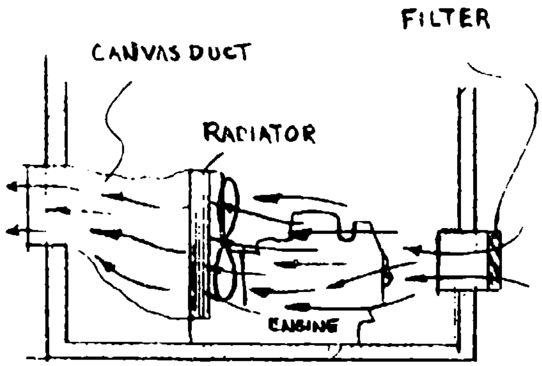
GASOLINE AND DIESEL ENGINE FUEL SOURCES

INSTALLATION INSTRUCTIONS	4.	Manufacturers' installation instructions and recommendations for fuel system installation should be consulted for current information related to particular models and types of fuel storage.

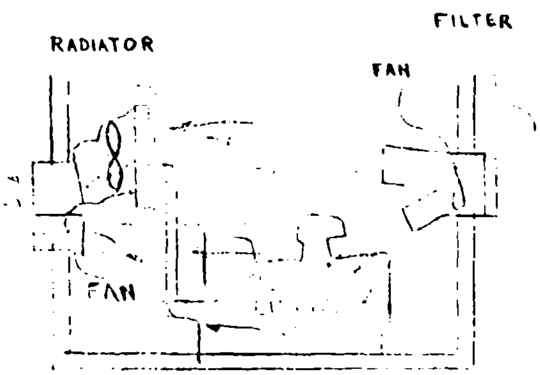
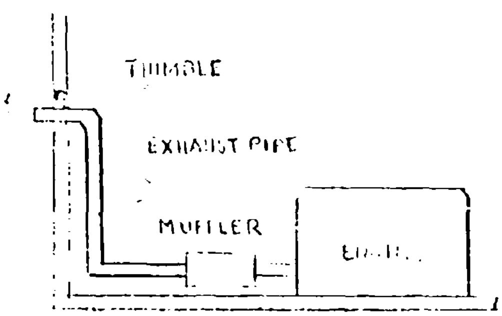
GASOLINE AND DIESEL ENGINE FUEL SOURCES

STEP 1	Determine the rated horsepower of the selected gasoline or diesel engine.
STEP 2	Determine the total required gasoline fuel supply by multiplying the total anticipated running hours by a factor of 0.512* and then multiplying the resultant product by the rated horsepower of the gasoline engine. OR Determine the total required diesel fuel supply by multiplying the total anticipated running hours by a factor of 0.437* and then multiplying the resultant product by the rated horsepower of the diesel engine. *The multiplying factors 0.512 for gasoline and 0.437 for diesel are determined from machine operating characteristics and are an average of these characteristics: gallons/hr/hp. OR Determine the total anticipated running hours and the average fuel consumption per hour of operation. The fuel consumption per hour must be based on the power load that the machine will be carrying during operation. Multiply the consumption per hour by the total hours to get the total capacity required.
STEP 3	From the catalogs of manufacturers select a fuel tank which has a rated capacity as close as possible to that determined in Step 2. Fuel tank must also be selected for belowground or aboveground installation.

GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

Typical Design	Description
	**Air-Cooled Gasoline Engine Ventilation Units** A typical air-cooled gasoline engine ventilation unit consists of a filter, an air intake duct, and an air exhaust duct. Outside air is pulled through the filter and into the air intake duct by the fan or blower. The airstream then passes around the engine, where it absorbs heat, and into the exhaust fan or blower, where it is forced out the exhaust duct. The airflow may be thermostatically controlled by means of automatic shutters.
	**Integral Radiator-Cooled Gasoline and Diesel Engine Ventilation Units** A typical integral radiator-cooled ventilation unit consists of a filter, an air intake duct with fan or blower, and an air exhaust duct with canvas connecting section. Outside air is pulled through the filter and into the air intake duct. The airstream then absorbs heat as it passes around the engine and is pushed through the radiator and into the exhaust duct by the radiator fan. The airflow may be thermostatically controlled by means of automatic shutters.

GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

Typical Design	Description
 	**Remote Radiator-Cooled Gasoline and Diesel Engine Ventilation Units** A typical remote radiator-cooled ventilation unit consists of a filter, a double brand air intake duct with fan or blower, and a double brand air exhaust duct with one canvas connecting section. Outside air is pulled through the filter and into the air intake duct by the fan or blower. The airstream then passes from the smaller branch of the intake duct around the engine, where it absorbs heat, and into the exhaust duct, where it is forced out of the shelter by the exhaust fan or blower. The airstream from the larger brand of the intake duct absorbs heat as it is pushed through the radiator and into the exhaust duct by the radiator fan. The airflow in both cases is controlled by means of automatic shutters.
 	**Gasoline and Diesel Engine Exhaust Units** A typical gasoline or diesel engine exhaust unit consists of an exhaust pipe, a muffler assembly, a thimble, and a number of necessary supports. The muffler serves to minimize engine exhaust noise. The exhaust pipe carries the fuel combustion gases from the engine through the muffler to the air exhaust duct or to a point of discharge outside the shelter. The thimble serves to isolate the hot exhaust pipe from combustible wall materials.

GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

GENERAL EXPLANATION

1. An independent ventilation unit must be provided to furnish enough fresh air at the engine for efficient cooling. The basic need for air circulation is common to all gasoline and diesel engines, but there are application differences in the way each need is satisfied. Air-cooled gasoline engines depend entirely on air circulation around the engine for cooling. Water-cooled engines, on the other hand, use air circulation around the engine for some limited cooling effect, but rely primarily on a fan-cooled radiator for their major cooling requirement.

2. An exhaust unit is also essential in confined areas, as in a shelter, to remove the poisonous exhaust gases generated by engine combustion. For this reason, the exhaust gases must be piped outside the shelter so that they cannot find their way back into the air intake duct.

AXIAL FLOW ENGINE FAN GENERAL INFORMATION

1. Characteristics - Integral- and remote-mounted engine fans are normally axial-flow propeller type fans. Propeller fans customarily are used for free delivery applications or against low resistance. As such, they are particularly suitable for radiator cooling but are limited in their duct applications by the static pressure inherent in such systems.

2. Nomenclature - A propeller fan consists of a four-bladed propeller mounted within a ring or plate. The fan either is integrally mounted and driven by the engine or remotely mounted and driven by an electric motor.

3. Size - The capacity of a propeller type fan to move air varies with its diameter, blade design, and speed. For engine applications, propeller fans vary from 15 to 42 inches in diameter, depending upon the engine size. This type of fan requires very large frontal areas but little depth for mounting.

GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

CENTRIFUGAL FAN GENERAL INFORMATION

1. Characteristics - Centrifugal fans are used primarily for moving air through duct systems because of their pressure-building capability. They also are used to move air through and around closely spaced cooling fins on air-cooled gasoline engines.

2. Nomenclature - A centrifugal fan consists of a fan rotor or wheel within a scroll type housing. The fan rotor is composed of a large number of curved rectangular blades arranged to form a slotted cylindrical shell. The blower scroll acts as a housing around the cage. In operation, the fan rotor rotates and sucks air into the fan where it is compressed by centrifugal force and discharged at right angles to the air intake area.

3. Size - Centrifugal fans are available in sizes that span 200 to 500,000 cubic feet per minute in capacity and are capable of working against static heads that range from 1 to 15 inches of water column.

DUCT SYSTEM GENERAL INFORMATION

1. Nomenclature - A duct system is constructed of heavy gauge sheet metal and can be either rectangular or cylindrical in cross section. An intake exhaust system also includes a filter for removing dust and dirt particles. All duct systems include a necessary number of supports and elbows.

2. Size - Ductwork is sized to equal or exceed the centrifugal fan inlet or outlet cross-sectional area. The cross-sectional area of the duct is increased when the airflow is restricted by bends, long runs, filters, or dampers.

GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

ENGINE EXHAUST GENERAL INFORMATION	1.	Nomenclature - An engine exhaust unit consists of a necessary length of steel exhaust pipe, a muffler, and a thimble. Engine noise is minimized by the integral muffler construction which baffles and diffuses the exhaust gases. The thimble serves to isolate the hot exhaust pipe from combustible wall materials.
	2.	Size - Steel exhaust pipe varies in diameter from 1/2 to 4 inches. Mufflers are cylindrical or oval in shape and range from 3 inches in diameter and 12 inches in length to 24 inches in diameter and 108 inches in length.
VENTILATION UNIT INSTALLATION INSTRUCTIONS	1.	Ventilation ducts should be located as a function of the prevailing wind direction, ambient air temperatures, and other factors that influence airflow and circulation. Air intake and exhaust ducts must be arranged so that air passes through the immediate area of the engine. Ideally, the exhaust duct should be connected directly to the engine radiator by a canvas shroud. The exhaust duct outlet should be located slightly higher than the air intake duct inlet.
ENGINE EXHAUST INSTALLATION INSTRUCTIONS	1.	Engine exhaust pipes must not terminate near air intake ducts nor combustible materials. Similarly, the interior shelter sections of the exhaust pipes must not come closer than 9 inches to combustible materials. Walls and partitions through which the exhaust pipe passes must be protected by a thimble. The exhaust pipe either should be pitched slightly downward or have a condensate trap installed at the point where a rise in the exhaust pipe begins. Sharp bends should be avoided and the pipe diameter should be increased one size for each ten feet in span beyond the first ten feet.

GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

GENERAL

Many packaged units (generator and engine sets) have an engine fan which will move a sufficient quantity of air to meet the cooling requirements for the engine. This would be part of the packaged unit. If this ventilation system is not utilized, a separate system must be designed, as indicated in the following steps.

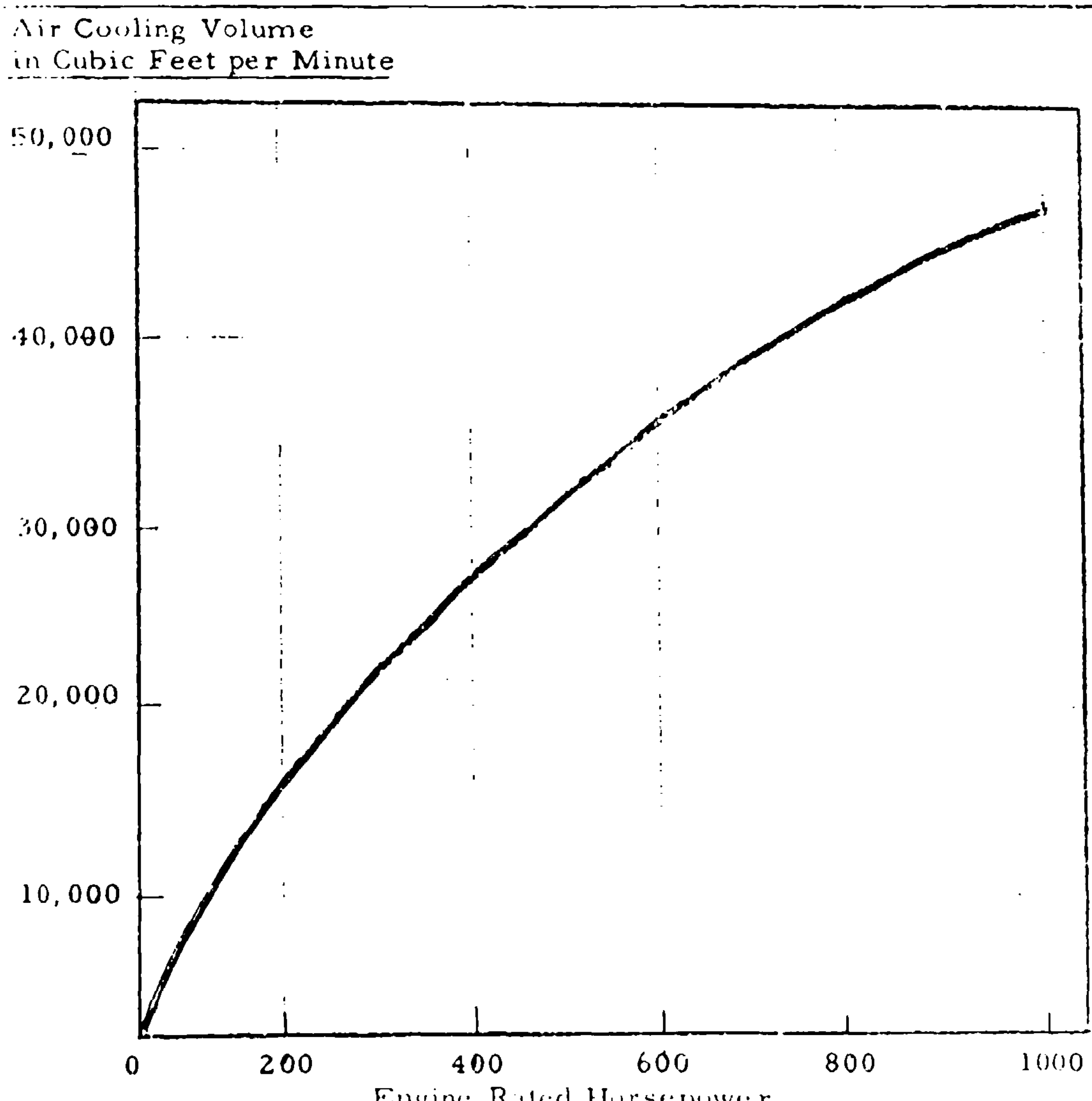
STEP 1

Determine the rated horsepower of the selected gasoline or diesel engine.

STEP 2

Determine the required air cooling volume in cubic feet per minute from the selection chart shown below.

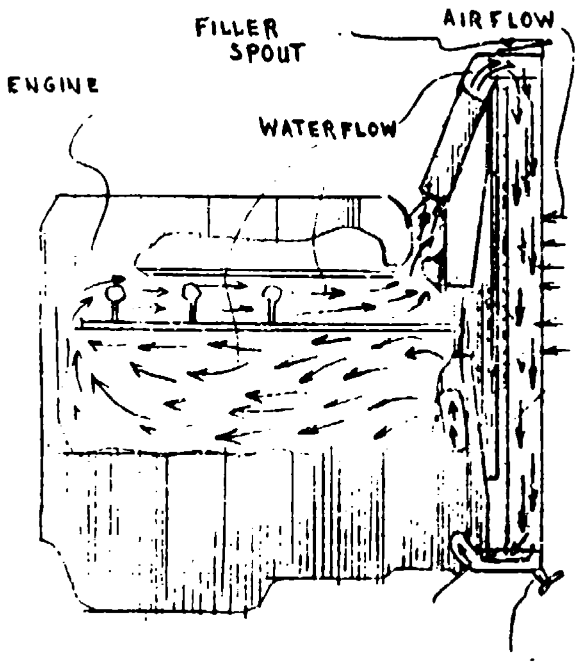
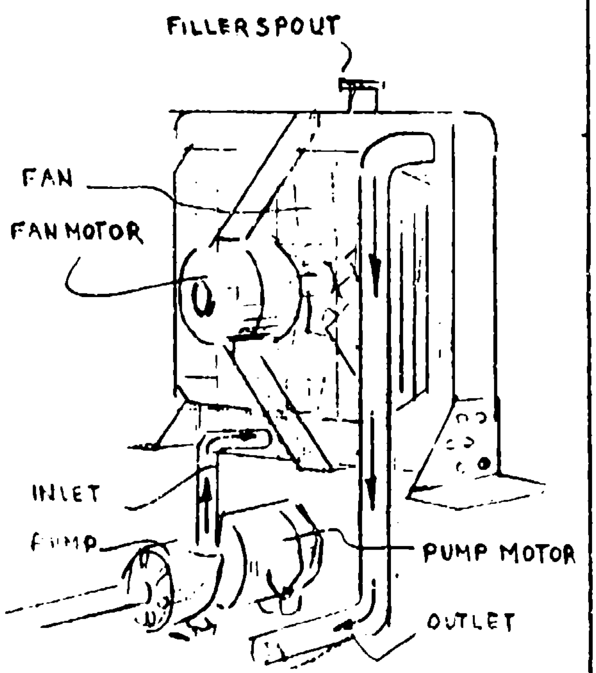
GASOLINE AND DIESEL ENGINE AIR COOLING VOLUMES



GASOLINE AND DIESEL ENGINE VENTILATION AND EXHAUST UNITS

STEP 3	Select a centrifugal fan that delivers the required air intake volume in cubic feet per minute at the selected engine speed and against the system resistance.
STEP 4	Size the air intake duct so that it is at least as large in cross section as the centrifugal fan intake area. Minimize the number of bends and length of run of the duct or increase the cross-sectional area of the duct.
STEP 5	Select a filter from manufacturers' catalogs which is capable of removing dust and dirt particles and can be fitted into the air intake duct.
STEP 6	Select for the exhaust system a centrifugal fan that is slightly larger than the fan used for the intake system. This will allow for increased volume of air caused by a rise in temperature and accumulation from inputs other than the intake system.
STEP 7	Size the air exhaust duct so that it is at least as large in cross section as the blower or fan discharge opening. Minimize the number of bends and length of run of the duct or increase the cross-sectional area of the duct.
STEP 8	Design the exhaust system for the engine gas in accordance with the manufacturer's recommendations. The exhaust gas system must be large enough to minimize back pressure caused by system resistance. Exhaust piping should not exit from the building near any air intake systems.

GASOLINE AND DIESEL ENGINE COOLING UNITS

Typical Design	Description
	**Gasoline Engine Integral Radiator Units** A gasoline engine integral radiator is mounted directly on the engine and consists of a rectangularly shaped radiator, an engine-driven fan, a filling spout and pressure cap, a drain plug, inlet and outlet connections, and two hoses or coolant lines which connect the radiator inlet and outlet connections to the engine. The radiator is usually 2 to 6 inches thick, made of copper, and constructed of inter-connected and ribbed tubes.
	**Gasoline and Diesel Engine Remote Radiator Units** A remote radiator unit consists of a steel frame, a rectangularly shaped radiator, an electric motor-driven fan, a fan shroud and guard, a filler neck and pressure cap, a drain plug, an inlet and outlet connection, and coolant hoses or lines which connect the inlet and outlet connections to the engine. A booster pump and pressure relief tank may also be required, depending on the relative location of the remote radiator in relation to the engine.

GASOLINE AND DIESEL ENGINE COOLING UNITS

GENERAL EXPLANATION	1.	Water-cooled gasoline and diesel engines have jackets or chambers surrounding each cylinder. A liquid coolant enters the water jacket under pressure and on its way to the outlet absorbs heat from the cylinders. At the outlet, the coolant is circulated through a radiator, where the heat is released and recirculated back through the gasoline or diesel engine.
INTEGRAL RADIATOR GENERAL INFORMATION	1.	Characteristics - An integral radiator liquid cooling system is designed to maintain the engine heat at the temperature which will produce the most efficient and economical operation of the engine. Heated water from the engine is circulated through the engine radiator, where it is cooled and recirculated back through the engine. The engine radiator is comprised of small finned tubes through which the engine coolant passes. These tubes provide a relatively large surface area for transfer of heat from the coolant to the airstream. The airstream is produced by a radiator fan which is driven off the engine crankshaft.
	2.	Capacity - The capacity of an integral radiator unit will vary, depending on the size of the engine, and will range from 3 to 12 gallons. Similarly, the size of a radiator will vary between 1 and 20 square feet in area and 2 to 6 inches in depth.
	3.	Weight - The weight of an integral engine radiator unit will vary from 2 to 200 pounds, depending on its size and capacity.
REMOTE RADIATOR GENERAL INFORMATION	1.	Characteristics - A remote radiator unit is designed to maintain the engine heat at the temperature which will produce the most efficient and economical operation of a gasoline or diesel engine. Heated water from the engine is pumped to the remote radiator unit, where it is cooled

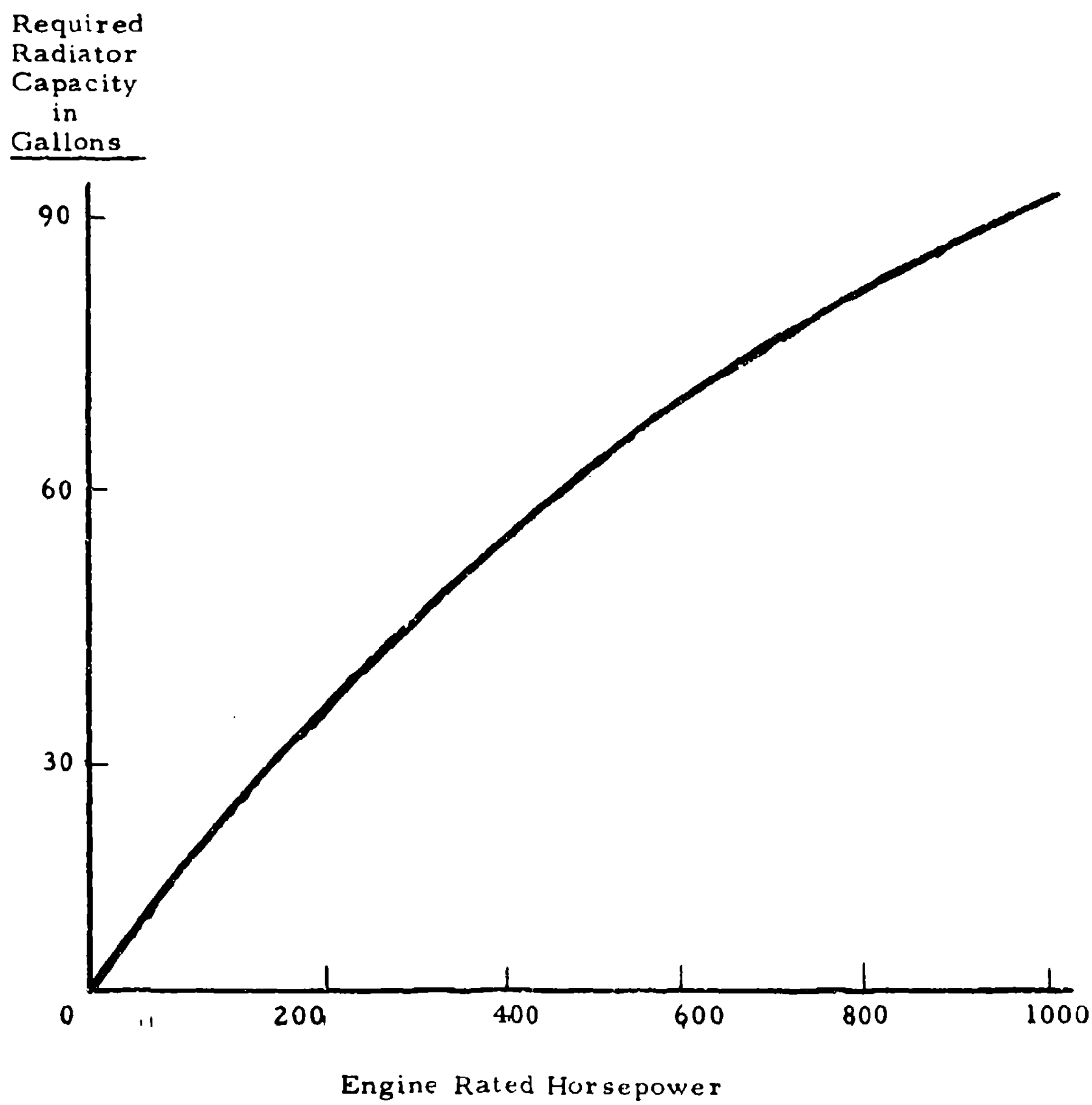
GASOLINE AND DIESEL ENGINE COOLING UNITS

REMOTE RADIATOR GENERAL INFORMATION		and recirculated back through the engine. The remote radiator unit cools the heated water by forced draft provided by a motor-driven fan.
	2.	Capacity - The capacity of a remote radiator unit will vary, depending on the size of the engine, but normally will range from 10 to 60 gallons.
	3.	Size and Shape - Typical remote radiator units are normally rectangular in shape and range from 4 to 60 square feet in area and from 2 to 6 inches in depth.
	4.	Weight - The weight of a remote radiator unit will vary from 50 to 300 pounds, depending on its size and capacity.
INTEGRAL RADIATOR INSTALLATION INSTRUCTIONS	1.	Integral radiator units are shipped mounted and attached to the gasoline engine. Their size and capacity are determined by the manufacturer. Installation merely requires removing the radiator cap, filling the radiator with coolant, and replacing the radiator cap. A check should be made to ensure that no leaks exist at the draincock or cylinder block drain.
REMOTE RADIATOR INSTALLATION INSTRUCTIONS	1.	Remote radiator units are normally shipped completely assembled and ready for connection to the gasoline or diesel engine. If the remote radiator is installed more than 15 feet above the engine, both a booster pump and a pressure relief tank must be incorporated into the cooling circuit. Installation requires mounting the remote radiator unit on a solid base, connecting the unit to the engine, filling the unit with coolant, and checking for coolant leaks.

GASOLINE AND DIESEL ENGINE REMOTE RADIATORS

STEP 1	Determine the rated horsepower of the selected gasoline or diesel engine.
STEP 2	Determine the required radiator capacity in gallons from the selection chart shown below.

REMOTE ENGINE RADIATORS

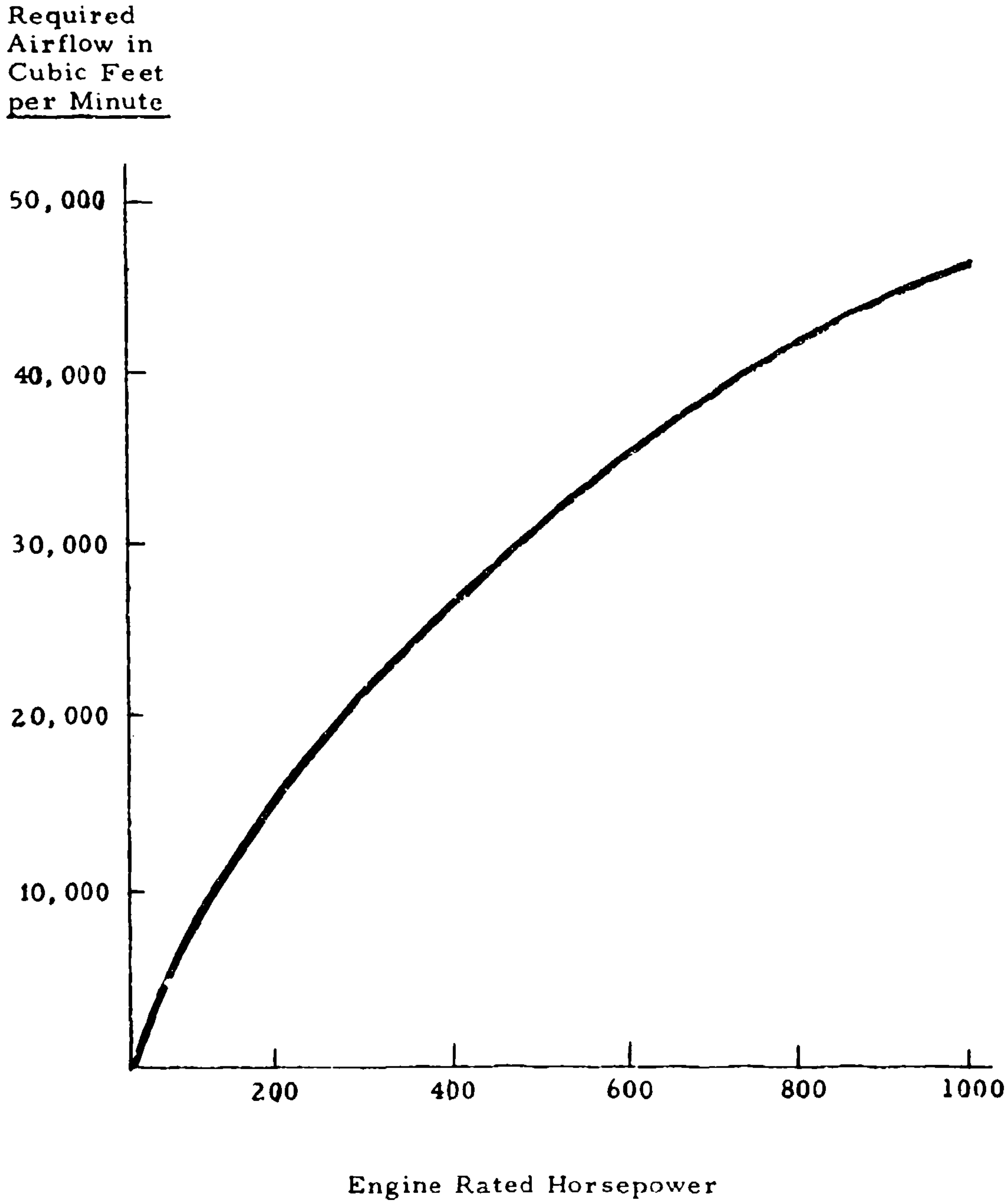


GASOLINE AND DIESEL ENGINE REMOTE RADIATORS

STEP 3

Determine the airflow required through the radiator in cubic feet per minute from the selection chart shown below.

REMOTE ENGINE RADIATORS

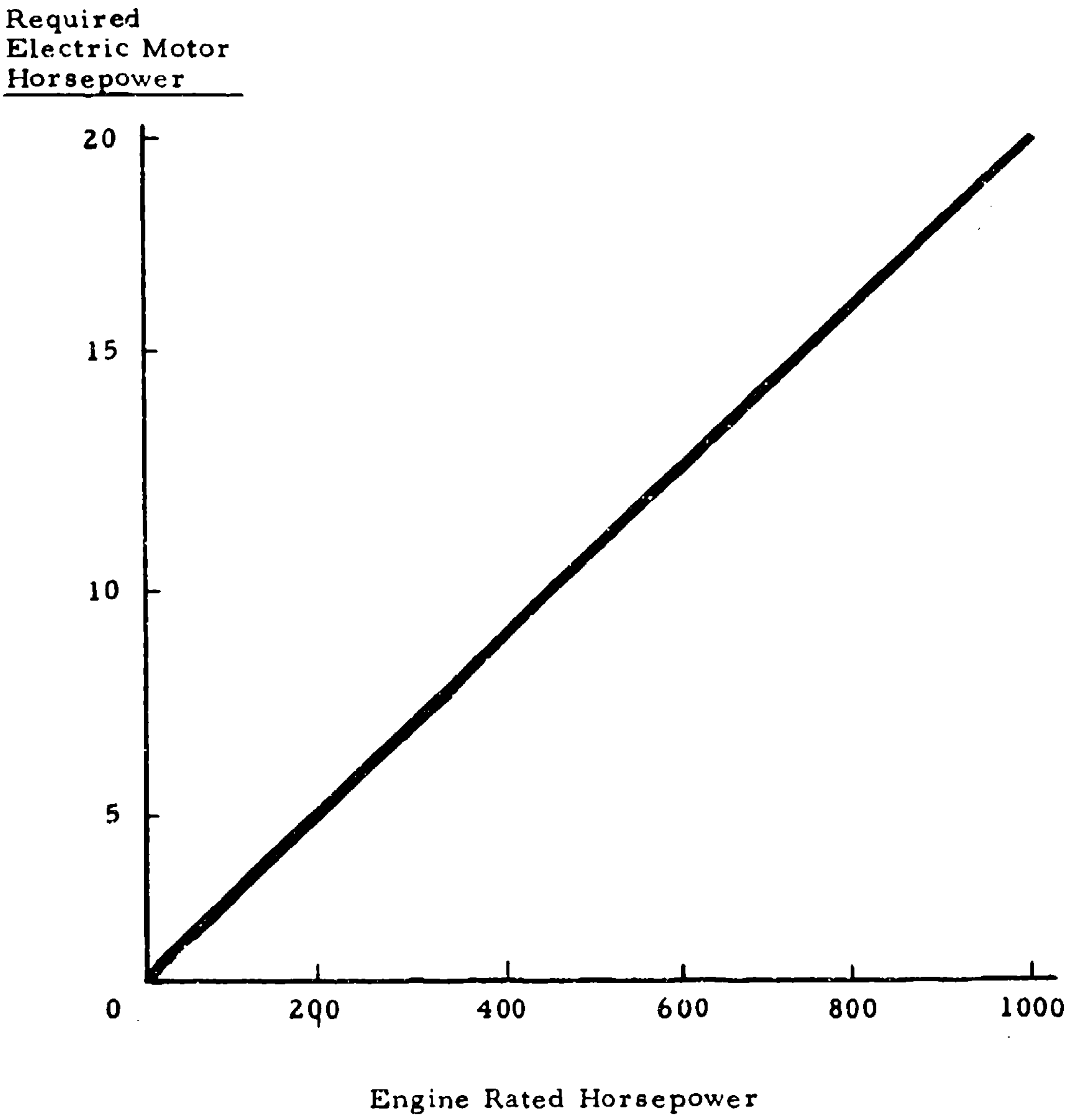


GASOLINE AND DIESEL ENGINE REMOTE RADIATORS

STEP 4 Determine the electric motor horsepower required to drive the radiator fan from the selection chart shown below.

STEP 5 Select a remote radiator assembly from a manufacturer's catalog which closely approximates the capacity, airflow and fan motor criteria established in the preceding steps.

REMOTE ENGINE RADIATORS



MAINTENANCE AND OPERATING DATA

The maintenance and operation of the shelter equipment should be carried out in accordance with the instructions prepared by the manufacturer of the equipment. In the absence of such instructions, the following checklist should be followed to assure minimum control of the inspection, operation, and maintenance of the shelter equipment.

MONTHLY STANDBY INSPECTION AND START-UP

1. Make a visual check for damage and oil leaks. Tighten gasket bolts to eliminate leaks.
2. Check the oil level in the gear box on gear train type drives. For grease-lubricated units, ensure that the gears are greased. Change dirty oil as required.
3. Grease all fittings.
4. Lubricate the roller chain on roller chain type drives.
5. Hand crank or pedal the unit to ensure free and easy operation and check the voltage output of the generator with a voltmeter to ensure that it is delivering 12 volts.

SHUTDOWN

1. Store unit in a safe, dry place.

TROUBLESHOOTING

PRIME MOVER WILL NOT CRANK PROPERLY

1. Check the bearings for tightness. Lubricate the bearings. Remove, clean, repack, and reassemble as necessary.
2. Check the chain tightness on chain-driven models. Slacken up slightly on the chain tightener.
3. Check the alignment of the chain-driven sprockets. Align the sprockets to eliminate binding.

MAINTENANCE AND OPERATING DATA

TROUBLESHOOTING		
GENERATOR WILL NOT DELIVER 12 VOLTS	1.	Replace the generator.
SPARE PARTS	1.	Lubricating oil
	2.	Lubricating grease
	3.	Grease gun
	4.	Extra drive chain
	5.	Set of bearings
	6.	Set of gaskets
	7.	Gasket compound
	8.	Gallon of cleaning compound
TOOLS	1.	Pliers
	2.	Funnel
	3.	Screwdrivers
	4.	Set of adjustable wrenches
	5.	Hammer
	6.	File
	7.	Metal saw
	8.	Emery paper
	9.	Wire brush
	10.	Flashlight

MAINTENANCE AND OPERATING DATA

GENERAL

The maintenance and operation of the prime mover system for the shelter auxiliary power is based on a completely integrated program for the machines. This program consists of the monthly standby inspection, the start-up and operate procedures, and troubleshooting information.

Monthly standby inspections are designed to keep the equipment in top running condition through systematic inspection of the machines. This inspection points out possible problem areas by noting telltale signs of trouble.

Start-up and operate procedures provide an additional means of checking the operation of the equipment under actual running conditions. Monthly start-up procedures are a necessary part of the preventive maintenance procedure to ensure that engine lubrication, cooling, and other systems are functioning normally. Failure due to rust and corrosion of engine parts will be minimized if a good preventive maintenance program is followed. These procedures also provide the person who is unfamiliar with the engine with a reference for starting the engine in case of an emergency.

Troubleshooting information indicates some of the major problems to be encountered with the operation of engines of this type. The symptoms and possible immediate corrective actions are noted. If the corrective action is not successful, an experienced maintenance mechanic should be employed to correct the faulty operation.

MAINTENANCE AND OPERATING DATA

MONTHLY STANDBY INSPECTION	1.	Visually inspect the engine and surrounding floor area. Look for water, fuel, and oil leaks.
	2.	Clean the engine surface by wiping the exposed surfaces with a lightly oiled rag to remove lint and grime accumulations.
	3.	Check the bearings in the clutch assembly and lubricate if necessary.
	4.	Inspect battery and ensure that the fluid covers the top of the plates. If the fluid level is low, add distilled water until the water rises above the top of the plates.
	5.	Read the fuel supply gauge to determine the quantity of gasoline in the tank. If the gasoline supply is low, fill the tank within one inch of the top of the filler pipe.
	6.	Check level of oil in engine and determine whether oil should be added to the engine. Add any required quantity of appropriate oil.
	7.	Remove the oil filter and clean out sludge and deposits from body of oil filter. Replace oil filter element if required.
	8.	Check the operation of the fan belt. Correct adjustment if it is required.
	9.	Check for and tighten any loose wiring connections.
START-UP	1.	Check the engine oil level and add oil if required.
	2.	Check the radiator liquid level and add water or other coolant if required.
	3.	Check the gasoline supply level and ensure that an adequate supply of gasoline is available.

MAINTENANCE AND OPERATING DATA

START-UP	4.	Open the gasoline shutoff valve.
	5.	Set the choke and throttle.
	6.	Hold the start and stop switch at the start position which starts the engine if it is electrically cranked.
	7.	Move the start and stop switch to the start position if the engine is manually cranked. Work the fuel pump primary lever about fifteen strokes and disengage. Engage the crank and crank the engine with quick upward pulls on the crank handle. Remove the crank as soon as the engine starts.
	8.	Let the engine run at fast idle speed for 30 minutes to bring it up to normal operating temperature.
SHUTDOWN	1.	Move the start and stop switch to the stop position.
	2.	Close the gasoline shutoff valve.
TROUBLESHOOTING		
ENGINE WILL NOT TURN OVER	1.	Ensure that battery is not discharged by inserting a hydrometer into a battery cell. Read the scale on the hydrometer. If the reading is less than 1.10, replace the battery.
	2.	Check for loose or corroded battery terminal connections. Tighten connections to be certain of positive contact. If terminals are corroded, clean with a wire brush.
	3.	Check for defective starting circuit. This circuit consists of the battery, starting motor, and the necessary wiring to connect the battery to the starter switch and from the starter switch to the starter. All wires and connections should be checked to make certain that they are not loose or damaged.

MAINTENANCE AND OPERATING DATA

ENGINE WILL NOT TURN OVER	4.	Check for defective starting switch. If defective, replace the switch.
	5.	Check for damaged or defective starter motor. Remove and replace a damaged or defective starter motor with a new starter motor.
ENGINE TURNS OVER TOO STIFFLY	1.	Ensure that the crankcase oil is not heavier than that specified for the engine. If the oil is too heavy, drain the engine crankcase and fill with proper oil.
	2.	Check cables leading from battery through relay to starter. Look for broken strands of wire and cracked, peeled, or deteriorated insulation. Replace cable if required or add extra wire from battery to starter to aid in carrying current.
	3.	Reduce or disconnect the load from the engine and start the engine. Determine why load was too great for engine and correct problem. Increase or reconnect load.
ENGINE WILL NOT START WHEN CRANKED	1.	Read the fuel supply gauge to ensure that there is sufficient gasoline in the fuel tank.
	2.	Disconnect the fuel line in front of the fuel pump. Place the end of the fuel line in a container and create pressure in the fuel tank. Fuel should flow freely from the fuel line. If it does not, the line is clogged and must be cleaned with a long stiff wire. Reconnect the fuel line to the fuel pump.
	3.	Disconnect the fuel line at the carburetor. Crank the engine several times and ensure that fuel spurts out of the line. If it does not, the fuel pump is defective and must be replaced. Reconnect the fuel line to the carburetor.

MAINTENANCE AND OPERATING DATA

ENGINE WILL NOT START WHEN CRANKED	4.	Ensure that the carburetor choke setting is correct. To adjust the choke for a richer mixture, pull the lever up. To adjust for a leaner mixture, push the lever downward. Check to see that when the level is lifted up to the limit of its travel that the carburetor choke is completely closed, and when the lever is pushed down that the carburetor choke is wide open.
	5.	Check the cylinder head gasket for damage or leakage. If the gasket appears to be leaking, tighten the cylinder head bolts or replace gasket if leak persists.
	6.	Ensure that the spark plugs are properly seated and tightened down securely. Remove and replace any defective spark plugs.
	7.	Check the distributor for faulty operation. If the distributor is found to be defective, remove and replace with a new distributor.
	8.	Inspect the ignition coil and replace if it is weak or defective.
ENGINE IDLES ROUGHLY	1.	Check the carburetor idling setting and adjust if required.
	2.	Check the carburetor for faulty operation and remove and replace the carburetor if required.
	3.	Inspect the carburetor-to-manifold gasket for leaks. Tighten the carburetor-to-manifold bolts or replace the gasket, if tightening the bolts does not stop leakage.
	4.	Inspect the manifold-to-cylinder head gasket. Tighten the manifold-to-head bolts or replace the gasket, if tightening the bolts does not stop the leakage.

MAINTENANCE AND OPERATING DATA

ENGINE MISSES WHEN APPLYING LOAD OR ACCELERATING

1. Check for normal fuel delivery to the carburetor. Disconnect the fuel line at the carburetor and crank the engine. Good fuel flow indicates that blockage exists in the carburetor. Remove the carburetor and replace.

2. Check the ignition system. Remove and check the spark plugs. Clean, adjust, or replace the spark plugs as needed. Look for faulty ignition wiring. Replace any bad wiring. Remove the distributor cap to examine the distributor points for improper adjustment or poor or faulty condition. Replace the distributor if required. Remove and replace the coil if inspection indicates a weak coil exists.

ENGINE STOPS UNEXPECTEDLY

1. Check the fuel gauge for an empty fuel tank. Fill tank with good grade gasoline if the fuel tank is empty.

2. Check for fuel pump failure. Disconnect the fuel line between the carburetor and the fuel pump. Crank the engine. Little or no fuel delivery at the open connection will require replacement of the fuel pump.

3. Inspect the engine temperature gauge for overheating or a hot engine. Proceed as instructed in section entitled Engine Overheating. Uusual faults are radiator obstruction, poor coolant circulation, dirty cooling system, low coolant level, deficient air circulation, broken or loose fan belt, defective thermostat, defective water pump, light or diluted oil, clogged air cleaner, lean fuel mixture, overloaded engine, and exhaust system restriction. Check and correct as necessary.

4. Check for low oil level. Stop the engine, remove the dipstick, and

MAINTENANCE AND OPERATING DATA

ENGINE STOPS UNEXPECTEDLY		observe the oil level. Add oil to the engine to full level indicated on the dipstick.
	5.	Check for a defective distributor. Remove and replace the distributor if necessary. Check the connecting wires from the distributor to the coil and connect any loose wires.
ENGINE LACKS POWER	1.	Check the distributor and ignition timing. Poor adjustment will require resetting.
	2.	Check the engine temperature for signs of overheating or a hot engine. Proceed as instructed under Troubleshooting - Engine Overheating. Check and correct items listed, as is necessary.
	3.	Check the engine temperature for unusually low engine temperature. If low temperature is indicated, remove and replace thermostat.
	4.	Check for a fuel-starved engine. Proceed as indicated when Engine Will Not Start When Cranked. Typical causes are clogged fuel lines, clogged or dirty carburetor, dirty air cleaner, defective fuel pump, or leaking fuel system connections and lines. Proceed to eliminate each cause by cleaning, or replacement as necessary.
ENGINE MISFIRES AT ALL LOADS	1.	Remove the spark plugs and check for fouled or defective condition. Replace defective plugs with new plugs and plug washers.
	2.	Look for defective ignition wires. Repair or replace poor wiring.
	3.	Check the distributor. Remove the distributor cap and look for

MAINTENANCE AND OPERATING DATA

ENGINE MISFIRES AT ALL LOADS		improper adjustment or defective parts, including the breaker points and condenser. Replace the distributor if it is found to be defective.
ENGINE MISFIRES AT LIGHT LOADS	1.	Check the spark plugs. Regap the plugs to their proper setting. Install the plugs, plug sealing washers, and reconnect the ignition wires.
	2.	Listen for air leaks around the intake manifold and carburetor. Tighten the manifold bolts to squeeze the sealing gaskets if required. Defective and damaged gaskets must be removed and replaced.
	3.	Check the ignition system for faulty operation and improper timing. Proceed to time the engine if timing is out of phase.
	4.	Check the carburetor for improper adjustment or blockage. Adjust the carburetor or remove and replace with a new carburetor.
ENGINE MISFIRES AT HEAVY LOADS	1.	Remove and check the spark plugs. Regap the plugs if they are in good condition. Install the plugs after regapping. Replace with new plugs as necessary. Install plug washers before replacing the plugs into the engine. Tighten the plugs and connect the wires.
	2.	Check the spark plug wires for defective insulation and terminal corrosion. Repair any reparable wires or replace poor wiring with new wires.

MAINTENANCE AND OPERATING DATA

ENGINE MISFIRES AT HEAVY LOADS	3.	Look for ignition faults. These include the condition of the wiring and the condition of the distributor and the distributor parts. Replace the distributor if required.
	4.	Look for carburetor and fuel screen clogging. Remove the fuel screen from the carburetor and clean if required. Replace the carburetor if necessary.
ENGINE BACKFIRES AT CARBURETOR	1.	Inspect the fuel mixture setting for a lean mixture. Adjust the setting for a richer mixture until condition is eliminated.
	2.	Check the fuel screen for blockage. Remove, clean, and reinstall the screen.
	3.	Check the engine timing for late firing. Loosen the distributor clamp bolt and rotate the distributor counterclockwise to advance the spark one division. Hold the distributor in this position and tighten the clamp bolt. Repeat if necessary.
	4.	Check the engine for a leaky valve. Remove the spark plugs, insert and seat a compression gauge into a spark plug hole, and crank the engine. A low reading indicates a leaking or sticking valve. Repeat for each cylinder. Attempt to loosen sticking valves with engine oil additives. Install the plugs and their sealing washers and connect the wires.
	5.	Inspect the ignition wire hookup from the distributor to the spark plugs for crossed wires. Compare to a firing order chart and reconnect properly as indicated by the chart.

MAINTENANCE AND OPERATING DATA

ENGINE BACKFIRES AT CARBURETOR	6.	Listen for air leaks around the intake manifold and carburetor. Tighten the bolts to squeeze sealing gaskets. Defective or damaged gaskets must be removed and replaced with new gaskets.
ENGINE RACES	1.	Inspect the throttle for a stuck condition. Free the throttle for easy operation.
	2.	Examine the governor for proper setting. Reset to a lower speed position.
	3.	Check the governor for sticking parts. Remove, repair, and replace the governor.
ENGINE OIL PRESSURE IS LOW	1.	Check the oil pressure gauge and verify that it is in good working condition. Remove and replace a defective gauge with a new gauge.
	2.	Examine the engine temperature gauge for any signs of engine overheating. Proceed as instructed in Engine Overheating. Eliminate overheating causes by making the necessary corrections outlined.
	3.	Inspect the oil pressure gauge reading. A low reading indicates oil dilution, lightweight grade oil, or low oil level. Drain the oil if diluted or the grade is too light. Add oil to full level, as indicated on the dipstick.
	4.	If changing oil does not correct problem, engine bearings are probably worn and replacement will be necessary.

MAINTENANCE AND OPERATING DATA

ENGINE OIL PRESSURE IS HIGH	1.	Check the oil pressure gauge and verify that it is in good working condition. Remove and replace a defective gauge with a new gauge.
	2.	Inspect the oil pressure gauge reading. A high reading indicates a heavyweight grade of oil is being used. Drain the oil and fill to level indicated on the dipstick with correct oil grade.
ENGINE OVERHEATING	1.	Examine the vicinity of the radiator for airflow obstruction or insufficient clearances for proper air distribution. Clear the area for better air movement.
	2.	Check the radiator. Carefully and slowly remove the radiator cap and inspect the coolant level. Add coolant as needed.
	3.	Inspect the fan belt for looseness and slipping, wear, oil-soaked or broken condition. Tighten the belt takeup or remove the defective belt and replace with a new belt, whichever is required.
	4.	Check the thermostat. Remove from the engine to test. Replace a defective or sticking unit with a new thermostat.
	5.	Check the water circulation. Carefully and slowly remove the radiator cap and observe if water is circulating. No circulation indicates a broken water pump. Stop the engine, drain the coolant, remove the defective pump, and install a new unit. Refill the cooling system with coolant.

MAINTENANCE AND OPERATING DATA

ENGINE OVERHEATING

6. Check for adequate lubrication. Verify good working condition of the oil pressure gauge. Remove and replace a defective gauge. A low reading indicates oil dilution, lightweight grade oil, or a low oil level. Change the oil if it is diluted or the grade is too light.

7. Check for ignition and valve timing error. Attach the neon timing light to number one spark plug circuit. Start the engine and allow the engine to attain normal operating temperature, as indicated on the temperature gauge. Run at idling speed with the light aimed at the flywheel housing opening. Loosen the distributor clamp bolt and rotate the distributor in either direction until the timing marks appear to line up under the flashing neon light. Hold the distributor in this position and tighten the clamp bolt. Remove the timing light and reconnect the spark plug wire.

8. Inspect the air cleaner for dirty or clogged condition. Remove from engine and clean if necessary.

9. Check the carburetor setting for a lean fuel mixture delivery at the carburetor. Adjust the setting for a richer mixture until the condition is eliminated. Allow ample time between setting increases for the engine to assume a normal temperature.

10. Verify that the engine is not overloaded. Reduce the demand on the engine to ease its load and eventually its temperature.

MAINTENANCE AND OPERATING DATA

ENGINE OVERHEATING	11.	Examine the exhaust system. Look for obstructions or restrictions. Repair or replace damaged or defective parts, such as the muffler and exhaust pipe.
SPARK PLUG FOULING	1.	Remove the spark plugs from the engine. Regap, install with plug washers. Replace plugs if necessary. Tighten and connect the wires.
	2.	Check the carburetor setting for a rich fuel mixture delivery. Adjust the setting to yield a leaner mixture.
	3.	Inspect the air cleaner for dirty and clogged condition. Remove the air cleaner from the engine and clean in gasoline or kerosene.
EXCESSIVE OIL CONSUMPTION	1.	Check for oil leaks. Tighten gasket bolts and leaking drain plugs.
	2.	Check the weight grade of the oil in the engine. Too light an oil must be drained and the crankcase must be refilled with proper oil to the level indicated on the dipstick.
	3.	Check for high oil level. Open the drain plug and remove any excess oil. Install and tighten the drain plug when the oil level has been lowered.

MAINTENANCE AND OPERATING DATA

EXCESSIVE OIL CONSUMPTION	4.	Examine the oil pressure gauge for a high reading. Proceed as outlined in Troubleshooting section entitled Engine Oil Pressure Is High. Make corrections as necessary.
	5.	Check for faulty ignition and fouled plugs. Correct ignition faults. Replace fouled plugs.
	6.	Check for continued operation at light loads. Oil loss will be eliminated upon operation at heavier engine loads.
EXCESSIVE FUEL CONSUMPTION	1.	Check the carburetor setting for a rich fuel mixture delivery. Adjust the setting for a leaner mixture.
	2.	Check the choke to ensure free operation and nonsticking. Clean, adjust, or replace as warranted.
	3.	Inspect the air cleaner for a dirty or clogged condition. Remove from the engine and clean in gasoline or kerosene.
	4.	Check the crankcase breathers for a clogged condition resulting in a high crankcase pressure. Remove the breather, clean in gasoline or kerosene, and install properly.

MAINTENANCE AND OPERATING DATA

OIL DILUTION	1.	Check the spark plugs for fouling. Disconnect the plug wires. Unscrew the plugs and inspect. Replace with new plugs as necessary.
	2.	Check for carburetor leaks. Tighten the gasket bolts. Remove the carburetor and replace the gaskets if necessary.
OIL LOSS	1.	Look for oil leaks around seals and gaskets. Tighten the bolts. Replace seals and gaskets which cannot be serviced adequately to stop leakage.
	2.	Inspect the engine for loose or lost oil cap. Install the cap.
	3.	Check the breather. Remove and clean the breather in gasoline or kerosene. Install after cleaning.
SPARE PARTS	1.	Extra engine battery
	2.	Engine battery charging generator
	3.	Battery cables
	4.	Distilled water for battery
	5.	Fuses
	6.	Fuel pump
	7.	Fuel filter
	8.	Fuel screen
	9.	Gasoline additives
	10.	Wire for opening fuel lines
	11.	Copper tubing for fuel lines
	12.	Carburetor

MAINTENANCE AND OPERATING DATA

SPARE PARTS

13. Carburetor kit
14. Set of spark plugs
15. Spark plug washers
16. Spark plug wires
17. Fan belt
18. Thermostat
19. Radiator hoses and clamp
20. Radiator rust preventative
21. Radiator cleaner
22. Water pump
23. Water pump lubricant
24. Oil filter
25. Engine oil additives
26. Crankcase (or engine) oil
27. Oil pump
28. Ignition coil
29. Ignition wires
30. Distributor
31. Distributor kit (points & condenser)
32. Cylinder head gasket
33. Manifold gasket
34. Gasket compound
35. Starter
36. Starter brushes
37. Starter solenoid

MAINTENANCE AND OPERATING DATA

SPARE PARTS	38.	Starter relay
	39.	Starter switch
	40.	Governor
	41.	Exhaust pipe
	42.	Muffler
	43.	Gallon of engine cleaning compound
	44.	Engine parts (valves, valve springs, valve guide, piston rings, etc.)
TOOLS	1.	Complete large set of socket wrenches
	2.	Pliers
	3.	Funnel
	4.	Timing light
	5.	Ignition tool kit
	6.	Spark plug wrench
	7.	Feeler gauge
	8.	Hydrometer
	9.	Tube cutting & flaring kit
	10.	Screwdriver
	11.	Set of adjustable wrenches
	12.	Hammer
	13.	File
	14.	Metal saw
	15.	Emery paper

MAINTENANCE AND OPERATING DATA

TOOLS	16.	Wire brush
	17.	Flashlight
	18.	Tachometer
IDENTIFICATION	1.	Keep manufacturers' name tags on each piece of apparatus intact and readable.
	2.	Locate manufacturers' instructions for each piece of equipment in a convenient, conspicuous, and protected place.

MAINTENANCE AND OPERATING DATA

GENERAL

The maintenance and operation of the prime mover system for the shelter auxiliary power is based on a completely integrated program for the machines. This program consists of the monthly standby inspection, the start-up and operate procedures, and troubleshooting information.

Monthly standby inspections are designed to keep the equipment in top running condition through systematic inspection of the machines. This inspection points out possible problem areas by noting telltale signs of trouble.

Start-up and operate procedures provide an additional means of checking the operation of the equipment under actual running conditions. Monthly start-up procedures are a necessary part of the preventive maintenance procedure to ensure that engine lubrication, cooling, and other systems are functioning normally. Failure due to rust and corrosion of engine parts will be minimized if a good preventive maintenance program is followed. These procedures also provide the person who is unfamiliar with the engine with a reference for starting the engine in case of an emergency.

Troubleshooting information indicates some of the major problems to be encountered with the operation of engines of this type. The symptoms and possible immediate corrective actions are noted. If the corrective action is not successful, an experienced maintenance mechanic should be employed to correct the faulty operation.

MAINTENANCE AND OPERATING DATA

MONTHLY STANDBY INSPECTION	1.	Visually check the lubricating oil level. If the oil level is at or below the low level mark, add enough oil to raise the level to the full level mark. Check the condition of the oil and change the oil as required.
	2.	Check for evidence of external oil leakage. Tighten capscrews, fittings, connections, or replace gaskets as necessary to correct.
	3.	Check the fuel gauge and fill the fuel tank as required.
	4.	Check for evidence of external fuel leakage. Tighten capscrews, fittings, and connections, or replace gaskets as necessary to correct. Also check for air leaks in the fuel system by placing a sight gauge in the line between the fuel filter and the pump. Bubbles over one-half inch long or milky in appearance indicate an air leak. Find any such leaks and correct.
	5.	Check the level of the oil in the hydraulic governor sump if the fuel pump has a hydraulic governor. Oil level should be maintained half-way up on an inspection glass or to the high-level on a dipstick gauge.
	6.	Check the coolant level to ensure that the cooling system is completely filled. Investigate for the cause of any coolant loss and make necessary corrections.
	7.	Check belt tension by pressing straight down on belt with index finger. Force applied should be approximately 13 pounds. Belt deflection should be equal to the thickness of belt for each foot of the distance between the pulley centers. If excessive or insufficient deflection is indicated, adjust belt to desired tension by

MAINTENANCE AND OPERATING DATA

MONTHLY STANDBY INSPECTION

varying the distance between the pulleys.

8. Check the fan hub and drive pulley to ensure that they are securely mounted.

9. Check the engine coolant for pH value and chromate concentration. If the tests indicate that the coolant has a pH value below 8.5 or that the chromate concentration is below 1700 parts per million, an adjustment should be made immediately to prevent corrosion.

10. Check oil level in the oil bath air cleaner to ensure that level is at indicated mark. Add oil if necessary.

11. Check all air and vapor lines and connections from the compressor, supercharger, rocker housing cover, and cylinder heads and correct as needed.

12. Check the battery fluid level. Check the battery charge with a hydrometer. Fill the battery with distilled water or recharge as required.

13. Lubricate all engine fittings as required. Wipe excess grease from all fittings after greasing.

14. Clean the engine surfaces with a lightly oiled rag.

15. Check and clean the air cleaner as necessary. Remove from the engine and clean in a bath of gasoline or kerosene.

MAINTENANCE AND OPERATING DATA

MONTHLY STANDBY INSPECTION	16.	Blow dust from cranking motor. Dust and dirt, if allowed to accumulate in the cranking motor, will cause excessive wear of bearings, brushes, and commutator. Remove the cover band and blow out the dust and dirt with a compressed air jet.
	17.	Check, clean, and tighten all electrical connections.
START-UP	1.	Check the fuel gauge to ensure that sufficient fuel is available.
	2.	Check the oil level gauge or dipstick to ensure that the oil pan is filled to the high level mark. Add oil as required
	3.	Check the coolant level to ensure that the cooling system is completely filled. Add coolant as required.
	4.	Check the air cleaner and service if necessary.
	5.	Check for loose connections, loose nuts, bolts or capscrews and leaking oil, fuel, or air lines. Make required corrections.
	6.	Open the fuel shutoff valve.
	7.	Open the throttle to 2/3 open position.
	8.	Move the control switch to the start position to engage the starting motor. Move the switch to the run position immediately when the engine starts. If the engine fails to start within 30 seconds, allow the starting motor to cool for two minutes before it is used again.

MAINTENANCE AND OPERATING DATA

START-UP

9. After the engine starts, observe the oil pressure gauge. If no oil pressure is indicated within 10 seconds, stop the engine, find the cause, and correct.

10. Run the engine at approximately half speed until the water temperature starts to register on the temperature gauge.

11. Engage load and adjust throttle to normal operating position. Run engine for fifteen minutes.

SHUTDOWN

1. Disengage the load and run the engine at low idle speed for approximately five minutes to dissipate the heat from the combustion chambers.

2. Move the control switch to the stop position.

3. Close the fuel shutoff valve.

TROUBLESHOOTING

ENGINE STARTS HARD

1. Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all restricted or defective fuel lines.

2. Check for air leaks on suction side of the system. Make necessary corrections.

3. Check for worn or broken transfer pump blades. Replace transfer pump if defective.

4. Check for loose or leaking delivery valve retainer screw. Tighten retainer screw if loose and replace delivery valve if defective.

MAINTENANCE ND OPERATING DATA

ENGINE STARTS HARD	5.	Check that end plate regulating piston is not sticking in the prime position. Disassemble piston, remove any burrs or corrosion, and reassemble.
	6.	Check for sticking plungers. Disassemble, remove any burrs or corrosion, and reassemble.
	7.	Check for sticking or closed metering valve. Remove any foreign matter or burrs and correct any binding in the governor linkage.
	8.	Check for low cranking speed and charge or replace batteries if necessary.
	9.	Check for correct oil grade in the crankcase. Drain any heavyweight oil from the crankcase and replace with lighter oil specified for the engine.
	10.	Check to ensure that engine is not engaged with load. If the engine is connected to the load. disengage the load.
	11.	Check for faulty or sticking nozzles. Replace or correct any defective nozzles.
	12.	Check for low intake air temperature Provide starting aids if required.
	13.	Check to ensure that pump is timed correctly to engine. Correct timing if required.
	14.	Check for excessive fuel leakage past plungers. Replace rotor and hydraulic head assembly if required.
	15.	Check for faulty transfer pump. Replace transfer pump if defective.

MAINTENANCE AND OPERATING DATA

ENGINE STARTS HARD	16.	Check for clogged filters or inlet strainer. Remove and replace clogged elements if necessary. Clean strainer if required.
	17.	Check for worn cam, shoes, or rollers. Remove and replace if necessary.
	18.	Check for faulty automatic advance. Remove and replace if required.
	19.	Check to ensure that governor linkage is not out of adjustment. Make necessary corrections.
	20.	Check for inoperative governor. Correct any binding parts and replace governor if necessary.
	21.	Check that maximum fuel setting is not set too low. Reset to pump specifications if required.
	22.	Check for restricted return oil line or fittings. Remove line, blow clean, and reassemble if restricted. Replace if damaged.
	23.	Check to ensure that shutoff device is not interfering with governor linkage. Adjust governor linkage dimension if required.
	24.	Check to ensure that torque screw is correctly adjusted. Adjust to specification if necessary.
	25.	Check for badly scored rotor. Replace hydraulic head and rotor assembly if necessary.
ENGINE STARTS AND STOPS	1.	Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all restricted and defective fuel lines.

MAINTENANCE AND OPERATING DATA

MONTHLY STANDBY INSPECTION	16.	Blow dust from cranking motor. Dust and dirt, if allowed to accumulate in the cranking motor, will cause excessive wear of bearings, brushes, and commutator. Remove the cover band and blow out the dust and dirt with a compressed air jet.
	17.	Check, clean, and tighten all electrical connections.
START-UP	1.	Check the fuel gauge to ensure that sufficient fuel is available.
	2.	Check the oil level gauge or dipstick to ensure that the oil pan is filled to the high level mark. Add oil as required.
	3.	Check the coolant level to ensure that the cooling system is completely filled. Add coolant as required.
	4.	Check the air cleaner and service if necessary.
	5.	Check for loose connections, loose nuts, bolts or capscrews and leaking oil, fuel, or air lines. Make required corrections.
	6.	Open the fuel shutoff valve.
	7.	Open the throttle to 2/3 open position.
	8.	Move the control switch to the start position to engage the starting motor. Move the switch to the run position immediately when the engine starts. If the engine fails to start within 30 seconds, allow the starting motor to cool for two minutes before it is used again.

MAINTENANCE AND OPERATING DATA

ERRATIC ENGINE OPERATION	2.	Check for air leaks on suction side of the system. Make necessary corrections.
	3.	Check for worn or broken transfer pump blades. Replace transfer pump if defective.
	4.	Check for loose or leaking delivery valve retainer screw. Tighten retainer screw if loose and replace delivery valve if defective.
	5.	Check for sticking plungers. Disassemble, remove any burrs or corrosion, and reassemble.
	6.	Check for sticking or closed metering valve. Remove any foreign matter or burrs and correct any binding in the governor linkage.
	7.	Check for worn or broken governor spring. Remove and replace if defective.
	8.	Check for sticking cam roller shoes. Remove, eliminate any burrs, and reassemble.
	9.	Check for faulty or sticking nozzles. Replace or correct any defective nozzles.
	10.	Check to ensure that pump is timed correctly to engine. Correct timing if necessary.
	11.	Check for faulty transfer pump. Replace transfer pump if defective.
	12.	Check for clogged filters or inlet strainer. Remove and replace clogged elements if necessary Clean strainer if required.
	13.	Check for faulty automatic advance. Remove and replace if required.

MAINTENANCE AND OPERATING DATA

ERRATIC ENGINE OPERATION	14.	Check to ensure that governor linkage is not out of adjustment. Make necessary corrections.
	15.	Check for inoperative governor. Correct any binding parts and replace governor if necessary.
	16.	Check for restricted return oil line or fittings. Remove line, blow clean, and reassemble if restricted. Replace if damaged.
	17.	Check for clogged nozzle return lines. Remove lines, blow out, inspect, and reassemble.
	18.	Check for worn tang drive. Remove and install new head and rotor assembly and drive shaft as necessary.
	19.	Check that governor sleeve is not binding on drive shaft. Disassemble remove any burrs or dirt, and reassemble.
	20.	Check for sticking end plate regulating piston. Remove piston and sleeve. eliminate burrs, and reassemble.
	21.	Check for faulty variable speed droop device. Replace if defective.
ENGINE IDLES IMPERFECTLY	1.	Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all restricted and defective fuel lines.
	2.	Check for air leaks on suction side of the system. Make necessary corrections.
	3.	Check for worn or broken transfer pump blades. Replace transfer pump if defective.

MAINTENANCE AND OPERATING DATA

ENGINE IDLES IMPERFECTLY	4.	Check for sticking plungers. Disassemble, remove any burrs or corrosion, and reassemble.
	5.	Check for sticking or closed metering valve. Remove any foreign matter or burrs and correct any binding in the governor linkage.
	6.	Check for worn or broken governor spring. Remove and replace if defective.
	7.	Check for broken governor linkage. Remove and replace if defective.
	8.	Check for faulty or sticking nozzles. Replace or correct any defective nozzles.
	9.	Check to ensure that pump is timed correctly to engine. Correct timing if necessary.
	10.	Check for excessive fuel leakage past plungers. Replace rotor and hydraulic head assembly if required.
	11.	Check for faulty automatic advance. Remove and replace if required.
	12.	Check to ensure that governor linkage is not out of adjustment. Make necessary corrections.
	13.	Check for inoperative governor. Correct any binding parts and replace governor if necessary.
	14.	Check for restricted return oil line or fittings. Remove line, blow clean, and reassemble if restricted. Replace if damaged.
	15.	Check for sticking end plate regulating piston. Remove piston and sleeve, eliminate burrs, and reassemble.

MAINTENANCE AND OPERATING DATA

ENGINE DOES NOT DEVELOP FULL POWER OR SPEED	1.	Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all defective fuel lines.
	2.	Check for air leaks on suction side of the system. Make necessary corrections.
	3.	Check for worn or broken transfer pump blades. Replace transfer pump if defective.
	4.	Check for loose or leaking delivery valve retainer screw. Tighten retainer screw if loose and replace delivery valve if defective.
	5.	Check for sticking plungers. Disassemble, remove any burrs or corrosion, and reassemble.
	6.	Check for sticking or closed metering valve. Remove any foreign matter or burrs and correct any binding in the governor linkage.
	7.	Check to ensure that pump is timed correctly to engine. Correct timing if required.
	8.	Check for excessive fuel leakage past plungers. Replace rotor and hydraulic head assembly if required.
	9.	Check for faulty transfer pump. Replace transfer pump if defective.
	10.	Check for clogged filters or inlet strainer. Remove and replace clogged elements if necessary. Clean strainer if required.
	11.	Check for worn cam, shoes, or rollers. Remove and replace if necessary.
	12.	Check for faulty automatic advance. Remove and replace if required.

MAINTENANCE AND OPERATING DATA

ENGINE DOES NOT DEVELOP FULL POWER OR SPEED	13.	Check to ensure that governor linkage is not out of adjustment. Make necessary corrections.
	14.	Check for inoperative governor. Correct any binding parts and replace governor if necessary.
	15.	Check that maximum fuel setting is not set too low. Reset to pump specifications if required.
	16.	Check for restricted return oil line or fittings. Remove line, blow clean, and reassemble if restricted. Replace if damaged.
	17.	Check for restricted air intake. Make necessary corrections.
	18.	Check for worn tang drive. Remove and install new head and rotor assembly and drive shaft as necessary.
	19.	Check to ensure that shutoff device is not interfering with governor linkage. Adjust governor linkage dimension if required.
	20.	Check for incorrect governor high idle adjustment. Adjust to pump specifications if necessary.
	21.	Check to ensure that torque screw is correctly adjusted. Adjust to specification if necessary.
	22.	Check for insufficient throttle arm travel. Adjust throttle linkage if required.
	23.	Check for badly scored rotor. Replace hydraulic head and rotor assembly if necessary.

MAINTENANCE AND OPERATING DATA

FUEL NOT REACHING PUMP	1.	Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all restricted or defective fuel lines.
	2.	Check for air leaks on suction side of the system. Make necessary corrections.
	3.	Check for worn or broken transfer pump blades. Replace transfer pump if defective.
	4.	Check that end plate regulating piston is not sticking in the prime position. Disassemble piston and remove any burrs or corrosion.
	5.	Check for closed tank valve and open if valve is closed.
	6.	Check for clogged inlet strainer or filters. Remove and replace clogged elements if necessary. Clean strainer if required.
FUEL DELIVERED FROM TRANSFER PUMP BUT NOT TO NOZZLES	1.	Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all restricted or defective fuel lines.
	2.	Check that the governor stop lever is not stuck in the shutoff or stop position. Locate and correct the cause of any sticking by the stop lever.
	3.	Check for sticking plungers. Disassemble, remove any burrs or corrosion, and reassemble.
	4.	Check for sticking or closed metering valve. Remove any foreign matter or burrs and correct any binding in the governor linkage.

MAINTENANCE AND OPERATING DATA

FUEL DELIVERED FROM TRANSFER PUMP BUT NOT TO NOZZLES	5.	Check whether the passage from the transfer pump to the metering valve is clogged with foreign matter. If the passage is clogged, disassemble and flush out hydraulic head.
	6.	Check for worn or broken governor spring. Remove and replace if defective.
	7.	Check for broken governor linkage. Remove and replace if defective.
	8.	Check for sticking cam roller shoes. Remove, eliminate any burrs, and reassemble.
	9.	Check for inoperative governor. Correct any binding parts and replace governor if necessary.
	10.	Check for incorrectly adjusted torque screw and adjust to specifications if required.
	11.	Check for badly scored rotor. Replace hydraulic head and rotor assembly if necessary.
FUEL REACHING NOZZLES BUT ENGINE WON'T START	1.	Check for clogged or restricted fuel supply lines. Blow out all clogged fuel lines. Remove and replace all restricted or defective fuel lines.
	2.	Check for low cranking speed and charge or replace batteries if necessary
	3.	Check for correct oil grade in the crankcase. Drain any heavyweight oil from the crankcase and replace with lighter oil specified for the engine.
	4.	Check to ensure that engine is not engaged with load. If the engine is connected to the load, disengage the load.

MAINTENANCE AND OPERATING DATA

FUEL REACHING NOZZLES BUT ENGINE WON'T START	5.	Check for faulty or sticking nozzles. Replace or correct any defective nozzles.
	6.	Check for low intake air temperature. Provide starting aids if required.
	7.	Check to ensure that pump is timed correctly to engine. Correct timing if required.
	8.	Check for excessive fuel leakage past the plungers. Replace rotor and hydraulic head assembly if required.
	9.	Check for worn cam, shoes, or rollers. Remove and replace if necessary.
	10.	Check for faulty automatic advance. Remove and replace if required.
	11.	Check that maximum fuel setting is not set too low. Reset to pump specifications if required.
	12.	Check to ensure that shutoff device is not interfering with governor linkage. Adjust governor linkage dimension if required.
	13.	Check to ensure that the torque screw is correctly adjusted. Adjust to specifications if necessary.
	14.	Check for insufficient throttle arm travel. Adjust throttle linkage if required.
	15.	Check for badly scored rotor. Replace hydraulic head and rotor assembly if necessary.
ENGINE SMOKES BLACK	1.	Check for faulty or sticking nozzles. Replace or correct any defective nozzles.

MAINTENANCE AND OPERATING DATA

ENGINE SMOKES BLACK	2.	Check to ensure that pump is timed correctly to engine. Correct timing if required.
	3.	Check for worn cam, shoes, or rollers. Remove and replace if necessary.
	4.	Check for faulty automatic advance. Remove and replace if required.
	5.	Check for restricted air intake. Make necessary corrections.
	6.	Check to ensure that torque screw is correctly adjusted. Adjust to specifications if necessary.
	7.	Check whether maximum fuel setting is too high. If so, reset to pump specifications.
	8.	Check for overheating engine. Look for a clogged radiator or other restriction in the cooling system. Also check for a loose or broken fan belt. Make the necessary corrections.
	9.	Check whether load exceeds engine rating. If so, reduce the load on the engine.
ENGINE SMOKES BLUE OR WHITE	1.	Check for low cranking speed and charge or replace batteries if necessary.
	2.	Check to ensure that pump is timed correctly to engine. Correct timing if required.
	3.	Check for faulty automatic advance. Remove and replace if required.
	4.	Check for worn tang drive. Remove and install new head and rotor assembly and drive shaft as necessary.

MAINTENANCE AND OPERATING DATA

ENGINE SMOKES BLUE OR WHITE	5.	Check for excess oil in engine air cleaner. Reduce oil quantity to specified level if oil level is excessive.
SPARE PARTS	1.	Extra engine starting batteries
	2.	Engine battery charging generator
	3.	Battery cables
	4.	Distilled water for battery
	5.	Fuses
	6.	Fuel pump
	7.	Fuel filter
	8.	Fuel strainer
	9.	Fuel injection pump
	10.	Wire for opening fuel lines
	11.	Copper tubing for fuel lines
	12.	Set of fuel injection nozzles
	13.	Fan belt
	14.	Thermostat
	15.	Radiator rust preventative
	16.	Radiator cleaner
	17.	Radiator hoses and clamps
	18.	Water pump
	19.	Water pump lubricant
	20.	Oil filter for both fuel and lub-oil
	21.	Engine oil additives
	22.	Crankcase or engine oil

MAINTENANCE AND OPERATING DATA

SPARE PARTS	23.	Grease gun
	24.	Grease
	25.	Cylinder head gasket
	26.	Manifold gasket
	27.	Set of other engine gaskets
	28.	Gasket compound
	29.	Starter
	30.	Starter brushes
	31	Starter solenoid
	32.	Starter relay
	33.	Starter switch
	34.	Governor
	35.	Exhaust pipe
	36.	Muffler
	37.	Gallon of engine cleaning compound
	38.	Engine parts (valves valve springs valve guide piston rings etc.)
TOOLS	1.	Complete large set of socket wrenches
	2.	Pliers
	3.	Funnel
	4.	Nozzle wrench
	5.	Feeler gauge
	6.	Hydrometer
	7.	Tube cutting & flaring kit

MAINTENANCE AND OPERATING DATA

TOOLS

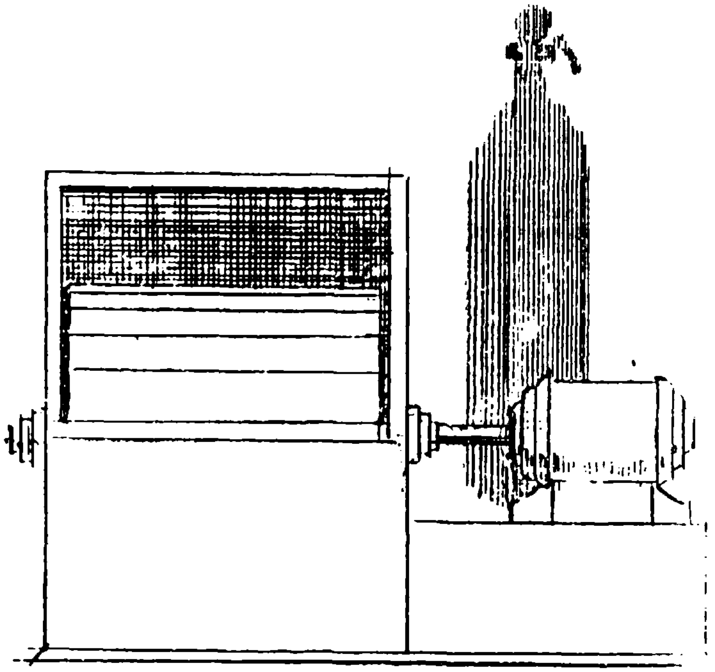
8. Screwdriver
9. Set of adjustable wrenches
10. Hammer
11. File
12. Metal saw
13. Emery paper
14. Wire brush
15. Flashlight

SUGGESTED SAMPLE
DESIGN OF PAGE

SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 4

VENTILATION, AIR CONDITIONING, AND AIR REVIVIFICATION SYSTEMS



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

SUGGESTED SAMPLE
DESIGN OF PAGE

Table of Contents	How to Use Guidelines

Use the Table of Contents given below to locate quickly key technical data pertaining to the selection and operation of ventilation, air conditioning, and air revivification systems.

The Introduction Section provides all essential data regarding system requirements and typical system designs.

System component descriptions, application data, and selection procedures data are given in the Component Selection Section.

The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions for relatively unskilled people.

NEED FOR VENTILATION, AIR CONDITIONING AND AIR REVIVIFICATION SYSTEMS

System Uses

Shelter habitability depends on the maintenance of suitable internal environmental conditions during the period of occupancy. Temperature, humidity, air composition, and air motion must be maintained at levels consistent with reasonable human requirements.

Certain minimal environmental criteria have been established as applicable to shelter design. Experience has shown that a maximum effective temperature between 90°F and 93°F is the critical level above which heat exhaustion can occur. As a result, the effective temperature must be kept below this level. A maximum effective temperature of 85°F should not be exceeded, and the 85°F temperature should not be allowed to persist in a fully occupied shelter for more than four hours in any twenty-four hour period. Similar standards apply to air composition. Carbon dioxide levels should be kept below 3% and oxygen content above 14% in shelter applications. Slightly higher percentages of carbon dioxide and lower oxygen contents can be tolerated for short periods if there is some reduction in the amount of activity for people.

Experimentation indicates that the oxygen and carbon dioxide requirements can be met with an outdoor air ventilation rate of approximately 3 cfm per person. An outdoor air rate above 3 cfm is required to dilute odors, smoke density, or other nontoxic conditions.

Ventilation, air conditioning, and air revivification systems provide the means for controlling internal environmental conditions within a shelter. Each or a combination of all three systems may be required, depending upon the shelter design considerations.

NEED FOR VENTILATION, AIR CONDITIONING AND AIR REVIVIFICATION SYSTEMS

Ventilation Systems

Ventilation is an effective means of removing the contaminated air in a shelter by dilution. In this process, the vitiated air containing carbon dioxide is replaced by clean outdoor air. In its simplest form ventilation results from the effect of winds upon buildings or from the natural levity of heated air. Air blown horizontally against a shelter creates a small pressure to windward and a small vacuum to leeward. This pressure difference will cause a ventilating current to flow through openings in the shelter. Similarly, natural ventilation can be secured in the absence of atmospheric motion by providing roof ventilators and air shafts so that cool air may displace warm air upwards and out of the vents.

Mechanical systems of ventilation are more adaptable to the continuous positive control of airflow. The vitalizing airflow of these systems is usually created by a centrifugal fan, although propeller fans are sometimes used. Sheet metal ducts are utilized to carry the air to and from the space to be ventilated in most larger installations.

Air Conditioning Systems

Air conditioning is the only means for precisely controlling the temperature, relative humidity, ventilation, and cleaning of the air within an enclosure like a shelter. As such, a complete air conditioner system consists of a ventilating system for giving motion and circulation to the air, a refrigerator or cooler to lower the air temperature when required, a dehumidifier, and a filter.

Experience has shown that the most practical refrigeration method for shelter air conditioning applications is the vapor compression system. Other methods such as an air refrigerating system or an absorption system are either relatively inefficient or require a heat source.

NEED FOR VENTILATION, AIR CONDITIONING AND AIR REVIVIFICATION SYSTEMS

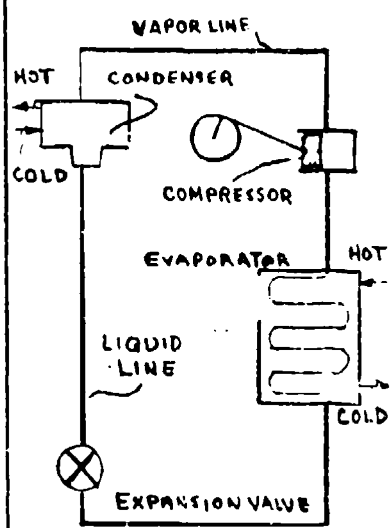
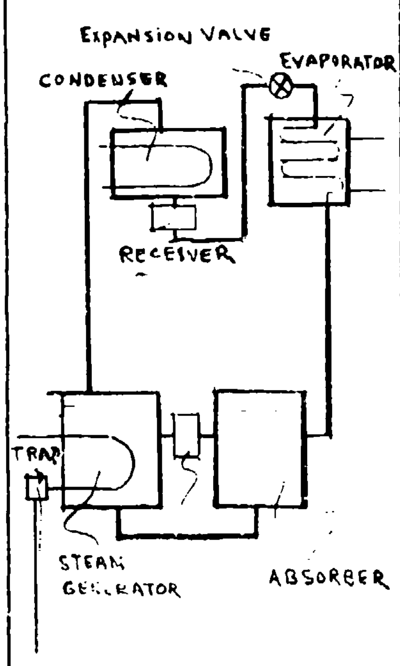
Air Revivification Systems

Air revivification is the only means for regenerating air within a closed shelter. For example, exterior fires create a condition that makes closure necessary.

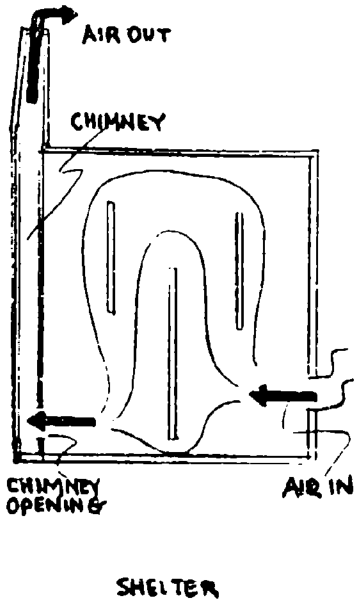
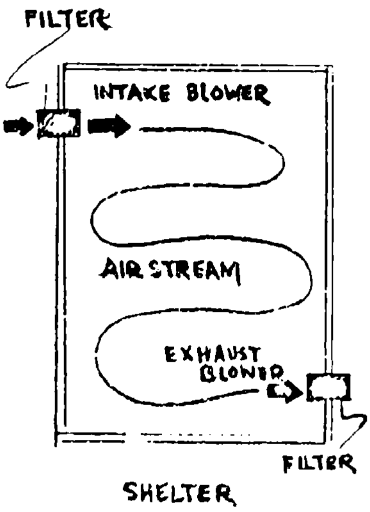
When the shelter is shut off from outside air for extended periods, air revivification equipment provides the means for maintaining the oxygen content above 14% and the carbon dioxide level below 3%.

Air revivification equipment includes oxygen cylinders or chlorate candles and one or two types of absorbent chemicals. During shelter closure, the occupants should restrict their physical activity in order to reduce their oxygen requirements and carbon dioxide generation.

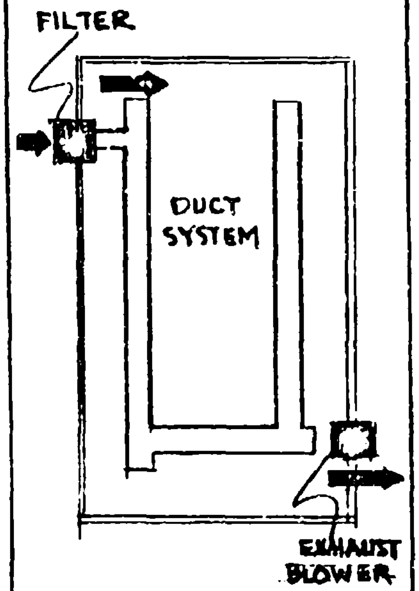
AIR CONDITIONING SYSTEMS

Type Designation	Typical Design	Description
MECHANICAL		
Type I		The components of a vapor compression system are the compressor, the evaporator, the expansion valve, and the condenser. The most common refrigerant used is freon. For large applications, several mechanical systems may be required.
ABSORPTION		
Type II		The components of an absorption system are stationary heat exchangers. The only moving parts are the solution, the refrigerant, and the chilled water pumps. Units are available having one or more shells and auxiliary vessels. The refrigerant is a combination of water and lithium bromide. These units require steam and condenser water for operation. Packaged units are available.

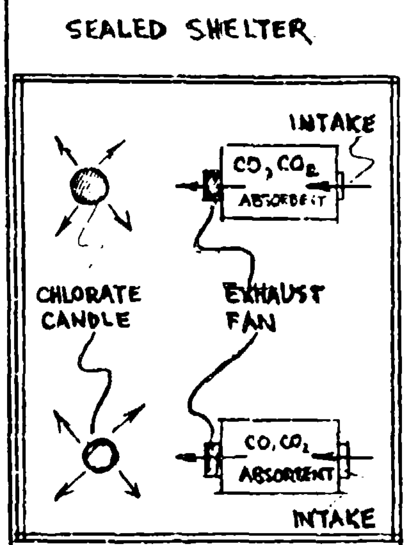
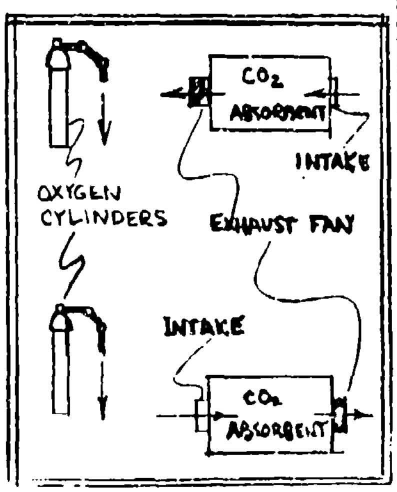
VENTILATION SYSTEMS

<table>
<tr><th>Type Designation</th><th>Typical Design</th><th>Description</th></tr>
<tr><td colspan="3">NATURAL AIR CURRENTS</td></tr>
<tr><td>Type I</td><td>
</td><td>This system may be used for smaller shelters if conditions permit. Care must be taken to prohibit entrance of contaminants. This type of system is not adequate where the consumption of air is high. A large opening must be left clear in the shelter in order to create a chimney effect and cause air circulation by moving air through a multiplicity of other small openings. This is the least desirable method of achieving the ventilation that is necessary for survival.</td></tr>
<tr><td colspan="3">MANUALLY OPERATED SYSTEM</td></tr>
<tr><td>Type II</td><td>
</td><td>The manually operated ventilation system consists of a blower connected to the exterior of the shelter. This blower is turned by a hand crank or connected to a foot-pedaled bicycle wheel. Operators must be changed regularly, probably every half hour. A second blower must be used to provide the exhaust for the shelter. If only one blower is to be provided, it should be used to exhaust air from the shelter.</td></tr>
</table>

VENTILATION SYSTEMS

Type Designation	Typical Design	Description
ELECTRIC-POWERED SYSTEM		
Type III		An electric-powered blower can be used for shelters of any size. It can be operated continually or intermittently. The blower is driven by a motor coupled to the shaft directly or through a belt. In either case, electric power is required for the shelter power system.

AIR REVIVIFICATION SYSTEMS

Type Designation	Typical Design	Description
CHLORATE CANDLES, SCREENED CHEMICAL ABSORBENTS		
Type I		Air regeneration in a closed shelter can be achieved by combining an oxygen supply source and a carbon dioxide-carbon monoxide absorbent. The two elements shown here are the chlorate candle for oxygen supply and the carbon dioxide absorbent baralyme. Air is drawn through the screen containing the absorbent. Carbon dioxide is removed from the air by chemical action. At the same time, additional oxygen for respiration is introduced into the shelter air by burning the chlorate candles. Burning of chlorate candles introduces heat and a hazard into the shelter and should be handled with due caution.
OXYGEN CYLINDERS, LITHIUM HYDROXIDE CANISTERS		
Type II		A second method for regenerating the air in a closed shelter is the use of oxygen cylinders and the carbon dioxide-carbon monoxide absorbent lithium hydroxide. The principles are the same as in Type I. The flow of air currents within the sealed shelter is an important consideration when locating the components of the air revivification system.

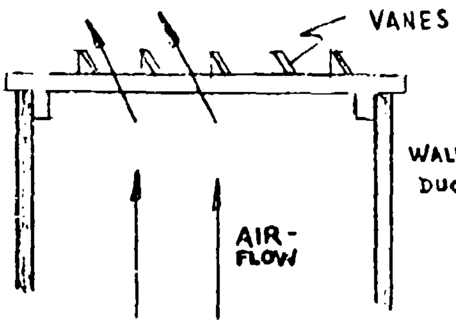
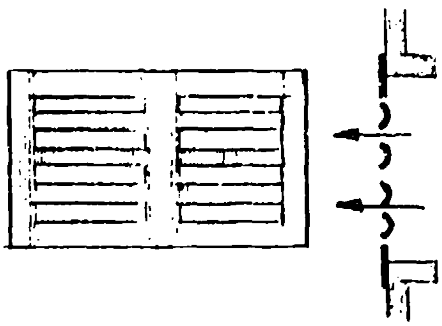
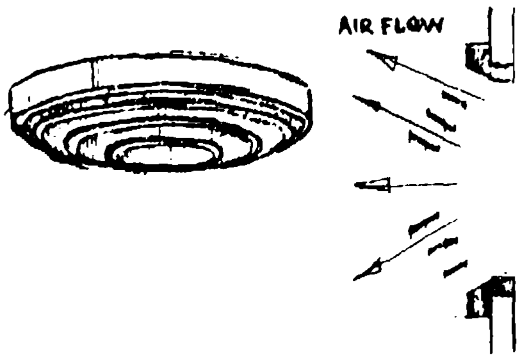
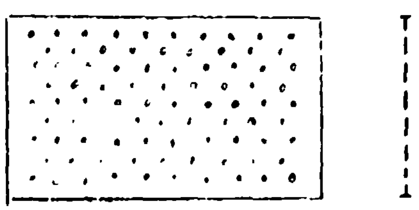
SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	VENTILATION SYSTEM	AIR CONDITIONING SYSTEM	AIR REVIVIFICATION SYSTEM
ABOVEGROUND AND BELOWGROUND SHELTERS				
50 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable	Type 2		Type 1
100 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable	Type 2		Type 1
200 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable	Type 2		Type 1
300 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable	Type 2		Type 1
500 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable			Type 1
1,000 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable			Type 1
2,000 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable			Type 1
3,000 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable		Type 2	Type 1
5,000 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable		Type 2	Type 1
10,000 PEOPLE	Best	Type 3	Type 1	Type 2
	Acceptable		Type 2	Type 1

DUCTWORK

Typical Design	Description
None	**Ducts** Ducts are necessary for the distribution of the ventilating air. They direct the flow of air from a source to the several areas being ventilated. Ducts which have square, rectangular, or circular cross sections are available. If the ducts are imbedded or buried, they should be made of galvanized material or black pipe coated with coal tar or bituminous paint. Sheet metal may be used for ductwork within the shelter. Ducts should be as small as possible, but they must be able to carry the required airflow. Small ducts are possible for high velocity systems. In shelters that are yet to be built, ductwork may be obtained inside and as part of the precast concrete forms that are used in the construction of ceilings and walls.

GRILLS AND DIFFUSERS

Typical Design	Description
	**Directional Vanes** Directional vanes may be fixed or adjustable to direct the airflow as required. Vanes may be used in both the horizontal and vertical directions.
	**Injection Airflow Vanes** Injection airflow vanes are designed to create maximum secondary circulation. They are very useful where it is necessary to introduce air at temperatures considerably below the comfort level.
	**Concentric Rings** Concentric ring diffusers are arranged so that air is directed at some definite angle relative to the airflow in the duct. They provide for a uniform delivery of air and are obtainable for both wall and ceiling mounting.
	**Perforated Panels** Perforated panels are used principally in low-ceiling rooms where the three previous types of grills and diffusers would not be satisfactory. They provide for a uniform air distribution without objectionable drafts.

GRILLS AND DIFFUSERS

GENERAL INFORMATION

1. Characteristics - Grills and diffusers are an architecturally acceptable mask for the end of the supply duct and provide for control of the airflow as it issues from the duct.

2. Location - The choice of location of the exhaust grills is less critical than that for the supply outlets.

INSTALLATION INSTRUCTIONS

Installations should be supervised by competent specialists who are part of the staff of the manufacturer or his representatives in that area of the country. The following precautionary measures should be applied:

1. Inlet or supply grills may be installed in either walls or ceilings.

2. Exhaust grills are generally installed in walls, but may be placed in ceilings at locations where warm air accumulates.

3. Inlet grills must be located so that objectionable drafts do not blow directly onto occupants.

4. Outlet grills located in the low sidewalls should not be placed closer than 5 feet to an area normally occupied by people who are seated.

5. Placement of exhaust grills in a floor should be avoided because of the resulting accumulation of dirt and moisture.

DUCTS

STEP 1 Determine the length of duct required and the number of openings needed.

STEP 2 Determine the quantity of air in cubic feet per minute to be circulated by multiplying the number of people to be housed in the shelter by the factor of 3 cubic feet per minute.

STEP 3 Determine the required duct size by dividing the quantity of air to be circulated in cubic feet per minute by a factor of 1000 feet per minute. Similarly, size any branch ducts and risers by dividing by factors of 850 and 725 respectively. Convert the resultant cross-sectional areas to equivalent square or circular ducts by referring to the table below.

CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION

Side Rectangular Duct	4	5	6	7	8	9	10	11	12
8	6.1	6.9	7.6	8.2	8.8				
9	6.5	7.3	8.0	8.7	9.3	9.9			
10	6.8	7.7	8.4	9.2	9.8	10.4	11.0		
11	7.1	8.0	8.8	9.6	10.2	10.9	11.5	12.1	
12	7.4	8.3	9.2	10.0	10.7	11.4	12.0	12.6	13.2
13	7.6	8.7	9.6	10.4	11.1	11.8	12.5	13.1	13.7
14	7.9	8.9	9.9	10.8	11.5	12.3	12.9	13.6	14.3
15	8.2	9.2	10.2	11.1	11.9	12.7	13.4	14.1	14.7
16	8.4	9.5	10.5	11.4	12.3	13.1	13.8	14.5	15.2
17	8.6	9.8	10.8	11.8	12.6	13.5	14.2	15.0	15.7
18	8.9	10.0	11.1	12.1	13.0	13.8	14.6	15.4	16.1
19	9.1	10.3	11.4	12.4	13.3	14.2	15.0	15.8	16.5
20	9.3	10.5	11.6	12.7	13.6	14.5	15.4	16.2	17.0
22	9.7	11.0	12.1	13.2	14.2	15.2	16.1	16.9	17.8
24	10.0	11.4	12.6	13.8	14.8	15.8	16.8	17.6	18.5
26	10.4	11.8	13.1	14.3	15.4	16.4	17.3	18.3	19.2

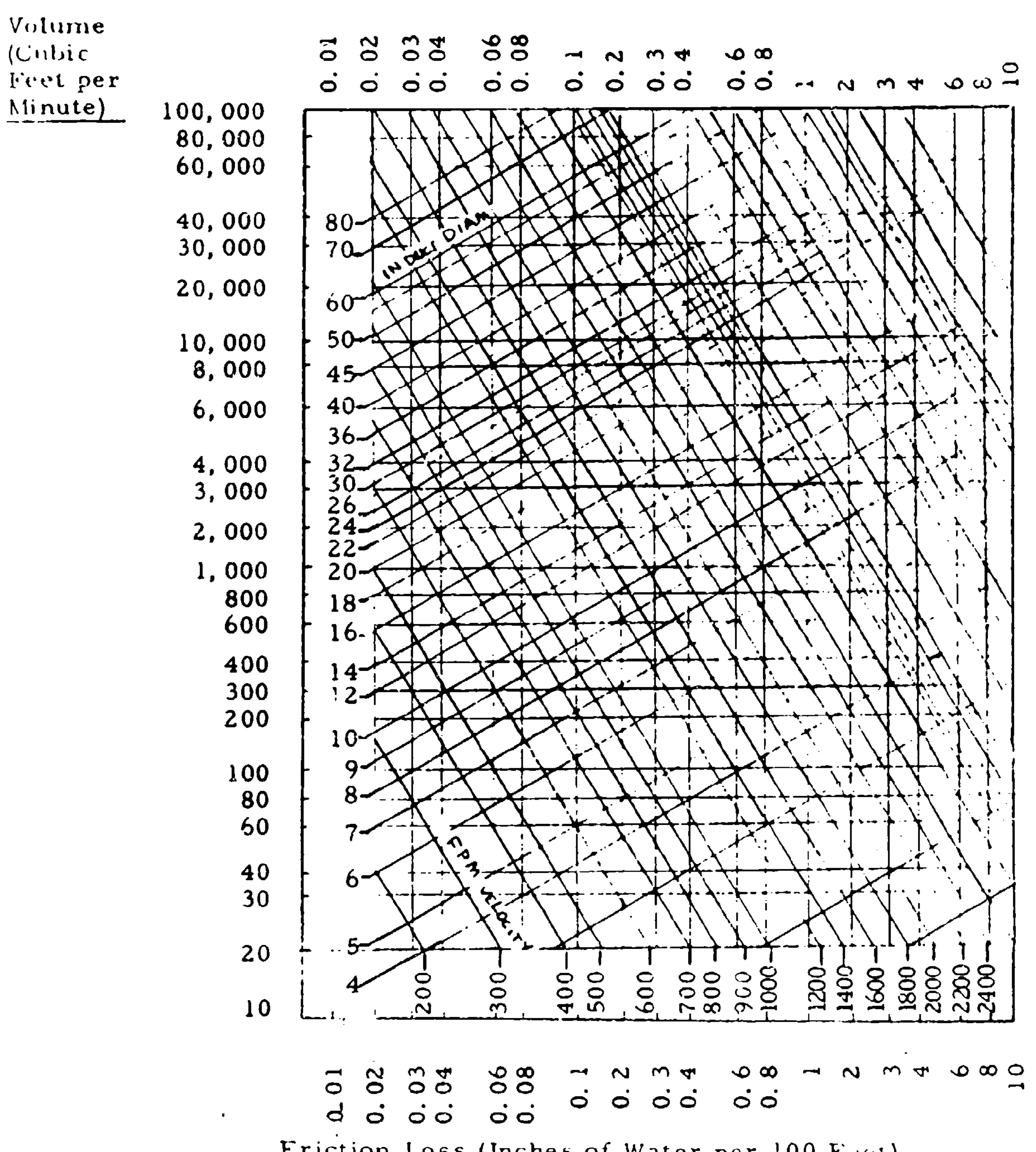
Inches

DUCTS

STEP 4

Determine the friction losses in inches of water pressure per hundred feet for the equivalent circular duct from the chart below.

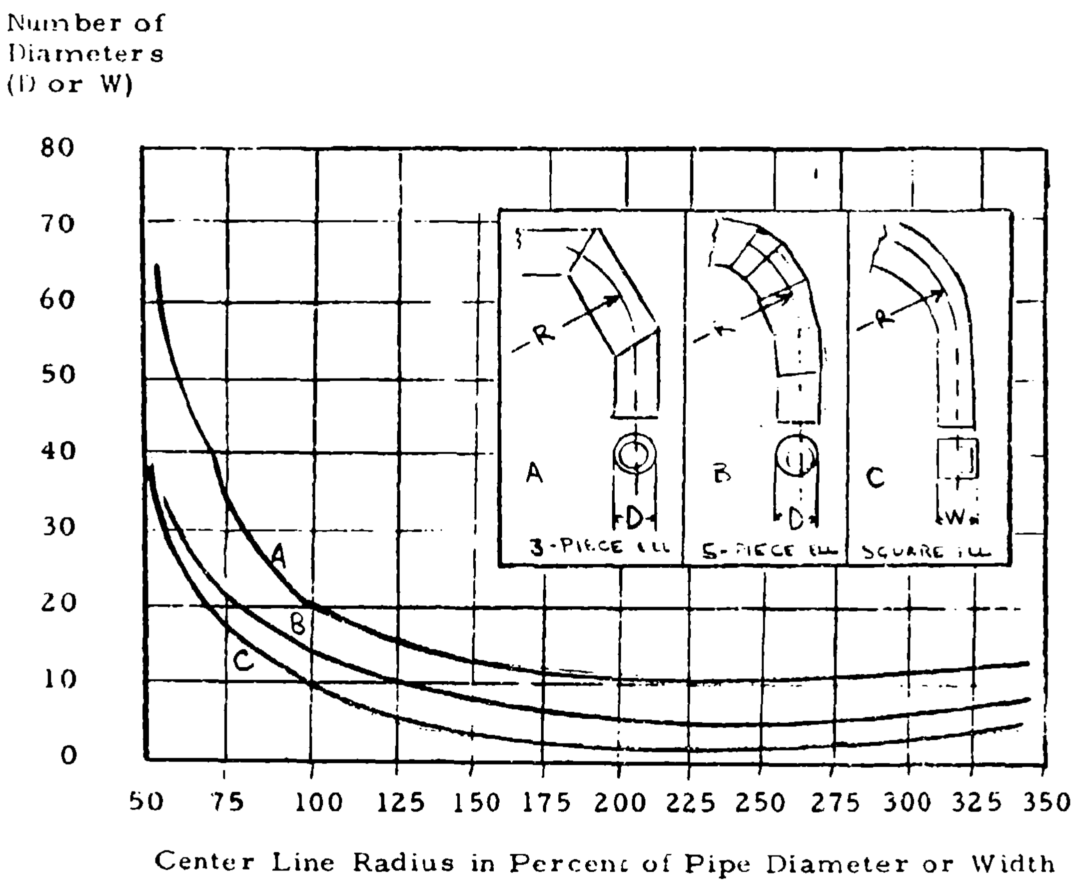
DUCT FRICTION



DUCTS

STEP 5 Determine the friction losses in equivalent length of pipe for the elbows and vanes from the following charts.

STRAIGHT PIPE EQUIVALENTS OF ELBOWS FOR EQUAL FRICTION LOSSES



DUCTS

EFFECT OF VANES ON PRESSURE LOSS OF 7-IN. SQ. VENTILATING DUCT EXPRESSED IN FEET OF TOTAL EQUIVALENT LENGTH OF DUCT (ELD)

Square miter elbow

Radius Ratio $\frac{R1}{W}$	0.0	0.2	0.4	0.6	0.8	1.0
ELD, ft	41.1	30.5	27.5	30.1	37.7	38.5

Radius Ratio $R1/W$	0.0	0.2	0.3
Radius Ratio $R2/W$	0.0	0.4	0.5
ELD, ft	41.1	23.5	23.3

Radius Ratio $R1/W$	0.0	0.2	0.3
Radius Ratio $R2/W$	0.0	0.4	0.5
Radius Ratio $R3/W$	0.0	0.6	0.7
ELD, ft	41.1	20.7	22.2

Vane	A	B	C	D
ELD, ft	21.8	17.0	17.9	17.8

Standard elbows with various radii

Radius Ratio $\frac{R1}{W}$	0.0	0.2	0.4	0.6	0.8	1.0
ELD, ft	39.7	23.3	22.0	25.7	28.9	39.7

Radius Ratio $R1/W$	0.0	0.2	0.3	0.4	0.5	0.6
Radius Ratio $R2/W$	0.0	0.4	0.5	0.6	0.7	0.8
ELD, ft	39.7	20.0	22.0	23.0	23.8	25.7

Radius Ratio $\frac{R1}{W}$	0.0	0.4	0.6	0.8	1.0	1.2
ELD, ft	25.3	17.7	16.5	18.7	23.5	25.6

Radius Ratio $\frac{R1}{W}$	0.0	0.7	0.8	0.9	1.0	1.2
ELD, ft	14.2	13.3	13.0	12.7	12.5	12.7

DUCTS

STEP 6	Convert the data from step 5 into losses in inches of water by referring to the chart in step 4.
STEP 7	Add the results of steps 4 and 6 to obtain the static pressure in inches of water that the ventilation fan must operate against. Using this information, select the fan or fans to be used for ventilation.

GRILLS AND DIFFUSERS

Inlet Grills

STEP 1 — Size inlet grills to the size of the ventilation supply ducts.

STEP 2 — Select the style depending on the location of inlet and air discharge velocities.

Outlet Grills

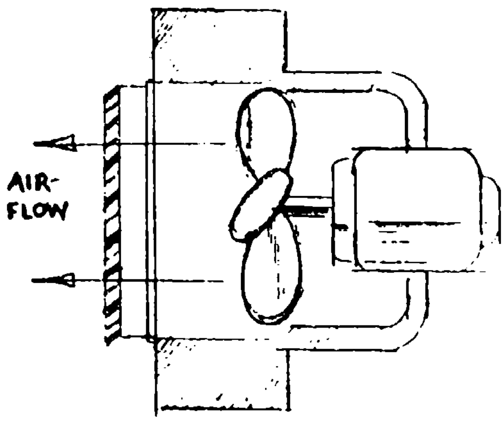
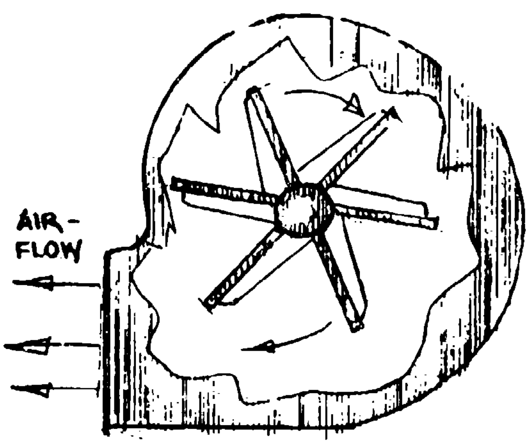
STEP 1 — Determine the amount of air being introduced into the shelter.

STEP 2 — Determine the location and number of outlets desired.

STEP 3 — Divide the inlet air quantity expressed in cfm by 800 to obtain an approximate outlet area.

STEP 4 — Select outlet grills accordingly.

FANS AND BLOWERS

Typical Design	Description
	**Propeller** A propeller fan consists of a multi-bladed wheel driven by an electric motor. The blades extend outward radially from the hub and are set at an angle with the longitudinal axis of the wheel shaft.
	**Centrifugal Fan** A centrifugal fan consists of a rotating impeller or wheel that draws air in at its center of rotation and accelerates the air radially. A housing or case around the impeller catches the air and directs it to the outlet. These units generally have better operating characteristics than propeller fans have.

FANS

GENERAL INFORMATION

1. Characteristics - Fans and blowers are an important requirement for shelter ventilation systems. They are usually electrically driven. For small shelters they may be manually driven. In considering manually driven fans, the planner must recognize that human beings are not able to deliver any substantial horsepower for an extended period of time. Operators cranking fans should be relieved at least every half hour.

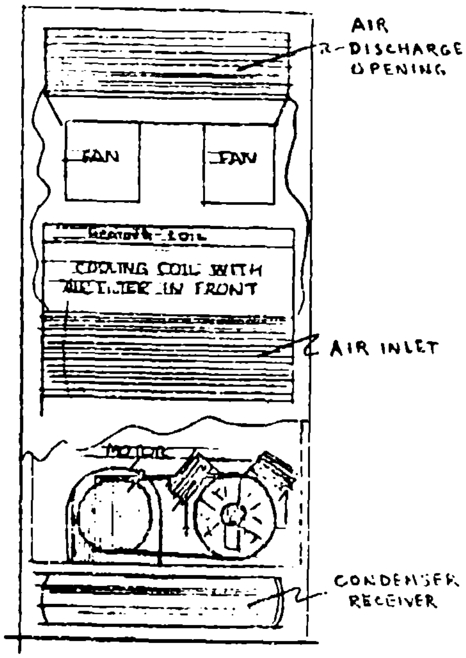
2. Uses - Propeller and centrifugal fans are generally used for moving large quantities of air against low static pressures. Centrifugal fans are generally quieter than propeller fans. If propeller fans are used, they should be of the axial flow type in order to obtain good operating characteristics, including low vibration, low noise levels, and good airflow for the power input.

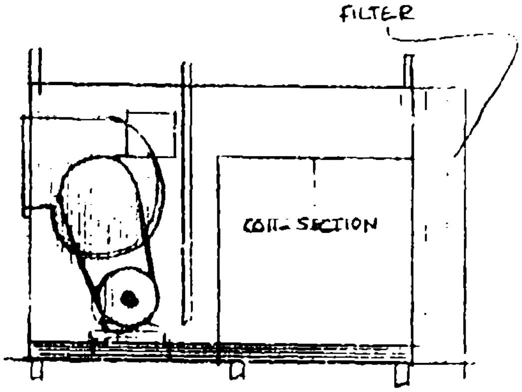
FANS

STEP 1*	Determine the number of people to be housed in the shelter.
STEP 2	Calculate the fan capacity in cubic feet per minute by multiplying the number of people to be housed in the shelter by the factor of 3 cubic feet per minute.
STEP 3	Refer to the static pressure calculated for the system in the preceding section.
STEP 4	Select a fan having the proper output rating for the static pressure established for the air distribution system.

*The steps indicate a method which the planner may use as an expedient. Ventilation system design requires much more engineering analysis than this discussion will allow.

MECHANICAL AIR CONDITIONING

<table>
<tr><th>Typical Design</th><th>Description</th></tr>
<tr><td>
</td><td><u>Packaged Air Conditioning Unit</u>

The packaged air conditioning unit is a complete system including the refrigeration equipment. Units can be obtained with air-cooled condensers or water-cooled condensers. The sizes range from 5-ton units to 20-ton units. Several units may be used for larger air conditioning loads.</td></tr>
<tr><td>
</td><td><u>Unit Air Conditioner</u>

Basically, the unit air conditioner is a unit that provides all six phases of air conditioning. It heats and cools, extracts or adds moisture to the air, filters dust and dirt from the air, and distributes conditioned air. These units require access to air outside the shelter for proper operation.</td></tr>
</table>

PACKAGED AIR CONDITIONING UNIT

GENERAL INFORMATION

1. Nomenclature - The packaged air conditioning system consists of a fan, a cooling coil, a refrigerating system with either a water- or air-cooled condenser, and filters. Condenser water must be supplied to units with a water-cooled condenser. Air must be supplied to units with air-cooled condensers. Most packaged air conditioners are provided with hermetic compressors. Little maintenance is required. Filter changing may be the major task.

2. Size and Weight - The table below indicates the relationships between the capacity in tons and the size and the weight.

Nominal Tonnage	Unit Volume in Cubic Feet	Unit Weight in Pounds
5	60	1150
7.5	90	1600
10	120	2800
15	150	3600
20	180	4200

UNIT AIR CONDITIONER

GENERAL INFORMATION

1. Nomenclature - Unit air conditioners consist of a casing that houses the fans, cooling and heating coils, filters, and humidification devices. The casing has convenient access doors for maintenance requirements. Air from the conditioned space is drawn into the unit by the fan. The air passes through the filters for cleaning, then through a heating coil, and finally through the cooling coils. Fan motors are mounted outside the casing for easy adjustability.

2. Capacity - Capacities of these units range from 500 cfm to 40,000 cfm. They are available in vertical and horizontal arrangements and can be floor-, ceiling-, or wall-mounted. The use of several units in different locations eliminates the need for large spaces, which would be required for ductwork from a central system.

3. Size and Weight - The table below indicates the relationships between the capacity in cubic feet per minute and the size and weight of the corresponding unit required to produce that capacity.

Nominal Cubic Feet per Minute of Cool Air	Unit Volume in Cubic Feet	Unit Weight in Pounds
2000	60	1000
3000	60	1200
4000	80	1400
5000	100	1600
7500	150	1800
10000	200	2000
15000	300	3000
20000	400	4000
30000	500	5000
40000	650	6000

COOLING LOADS

GENERAL INFORMATION

1. A heat gain calculation is made to determine what cooling capacity is needed to do a satisfactory air conditioning job.

2. There are five different sources of heat gain within a shelter: heat transmitted through the building structure; solar heat transmission; heat produced by occupants; heat produced from the lights; and heat produced from prime movers, generators, motors, and other heat-producing sources.

3. A complete heat gain calculation involves not only the independent calculation of each of the five components, but also the proper addition of these components to determine the correct maximum heat gain for the shelter. The underlying principles are fundamentally simple, and in fact the whole process of calculating each component and adding it in proper relationship to the others has been so organized and simplified that it may be carried out with a minimum of effort, as shown in subsequent sections.

4. Heat gain is composed of two separate but important factors. The first is called the sensible heat gain, because it is associated with a change in temperature of the air and may be sensed by that temperature change. The second factor is called the latent heat gain, because it is unaccompanied by any temperature changes and involves simply an increase of the moisture content of the air. In this sense, the heat is latent or hidden. Since the elimination of excessive moisture by an air conditioning system requires the removal of heat from the air, this moisture gain represents a gain of heat.

COOLING LOADS

FACTOR 1	DESIGN CONDITIONS
STEP 1	From a winter and summer climatic conditions table, select the design outdoor dry bulb and wet bulb temperatures recommended for the appropriate geographical location. An example of such a table prepared for a few cities is shown on the following page.

Climatic Conditions

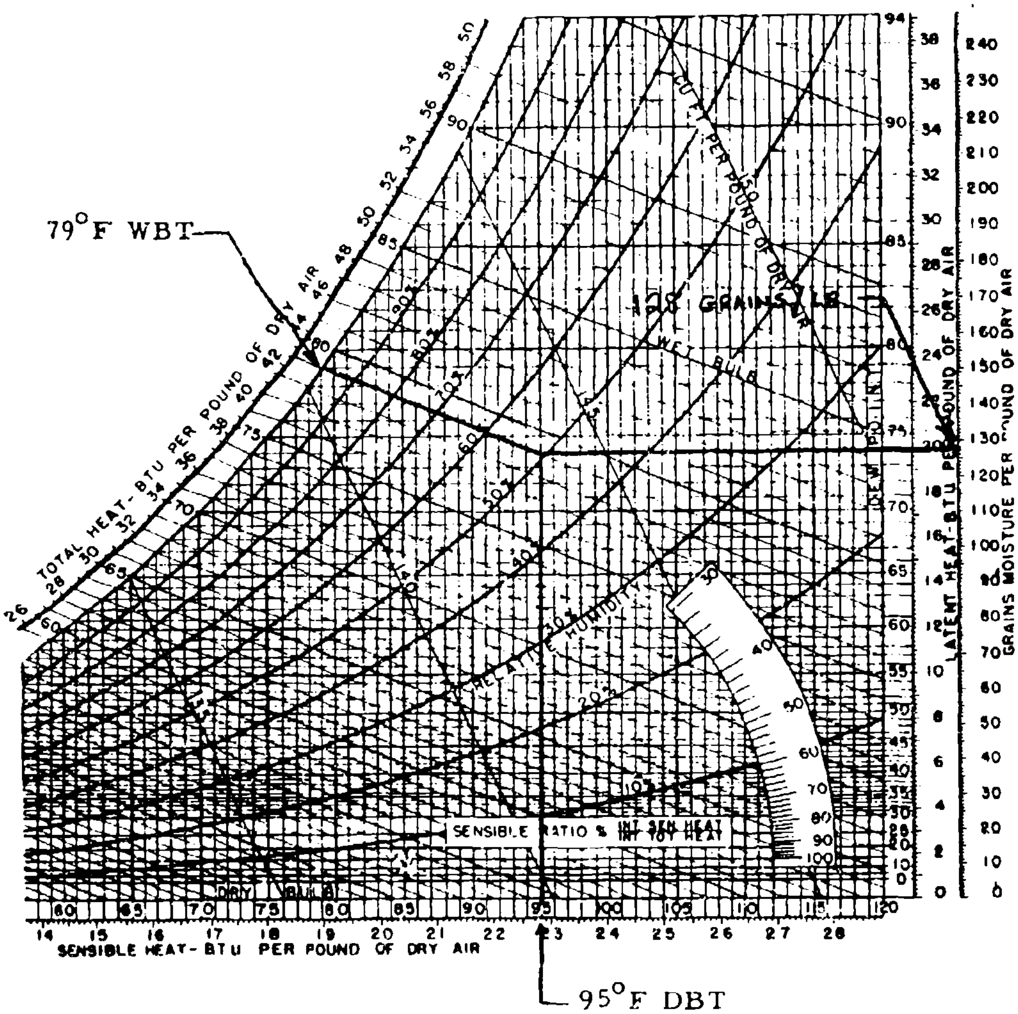
State	City	Elevation, ft.	Latitude, deg.	Winter: Design temp* dry bulb	Winter: Lowest recorded temp, dry bulb	Summer: Design temp Dry Bulb	Summer: Design temp Wet Bulb	Summer: Highest recorded temp Dry Bulb	Summer: Highest recorded temp Wet Bulb	Summer: No. days per year exceeds design temp Dry Bulb	Summer: No. days per year exceeds design temp Wet Bulb	Wind velocity, mph Winter	Wind velocity, mph Summer	Prevailing summer wind direction
Ala.	Anniston	733	34	5	-10	95	78	105						
	Birmingham	711	33	10	-10	95	78	107	81	1	8	8.0	5.4	S
	Mobile	143	31	15	- 1	95	80	103	81	1	4	9.9	8.0	SW
	Montgomery	293	32	10	- 5	95	78	107				7.5		
Ariz.	Flagstaff	6,957	35	-10	-25	90	65	93				7.7		
	Kingman	3,473	35	22	8	99		103				8.6		
	Phoenix	1,122	33	25	16	105	76	118	78	2	2	5.4	6.0	W
	Tucson	2,561	32	25	6	105	72	112				5.2		
	Winslow	4,853	35	-10	-19	100	70	107						
	Yuma	146	33	30	22	110	78	120				6.7		
Ark.	Fort Smith	545	35	10	-15	95	76	113				8.3	6.1	
	Little Rock	451	35	5	-12	95	78	110	81	1	10	8.3	6.2	NE
Calif.	Bakersfield	499	35	25	19	105	70	113				5.6		
	Burbank	740	34	35	21	94		110				4.9		
	Daggett	1,925	35	27		104		113				8.5		

*All temperatures are in degrees Fahrenheit

COOLING LOADS

STEP 2

Determine the absolute humidity of the outdoor air in grains of moisture per pound of dry air from a psychrometric chart (see the example below).



COOLING LOADS

STEP 3	Establish the inside design temperatures as 95°F dry bulb and 79°F wet bulb. This is an effective temperature of 85°F, maximum, and it should not be allowed to exist in a fully occupied shelter for more than four hours in any 24-hour period.
STEP 4	Establish the absolute humidity of the indoor air as 128 grains of moisture per pound of dry air. This is the correct absolute humidity reading for 95°F dry bulb and 79°F wet bulb temperatures.
STEP 5	Calculate the design temperature difference by subtracting the design indoor dry bulb temperature from the design outdoor dry bulb temperature.
STEP 6	Calculate the design humidity difference by subtracting the absolute humidity of the design indoor air from that of the design outside air.
STEP 7	Calculate the required amount of ventilation air by multiplying the number of shelter occupants by a factor of 3 cubic feet.
STEP 8	Calculate the volume of the room in cubic feet by multiplying the width in feet by the height in feet by the depth in feet.

COOLING LOADS

STEP 9

Calculate the rate of infiltration in cubic feet per minute by multiplying the volume of the room in cubic feet by the number of air changes per hour and dividing the resultant product by 60. Select the applicable air change rate from the table shown below. Next, calculate the total amount of outside air required by multiplying the number of shelter occupants by a factor of 3 cubic feet per minute. Use the larger of the two figures determined above.

NATURAL INFILTRATION RATES FOR VARIOUS TYPES OF ROOMS

Kind of Shelter	Number of Complete Air Changes Per Hour
Shelter with one side exposed	1.0
Shelter with two sides exposed	1.5
Shelter with three sides exposed	2.0
Shelter with four sides exposed	2.0
Shelter with no windows or outside doors	0.6

STEP 10

Determine the probable time of maximum heat gain applicable to the type of shelter from the following table. Both occupancy and appliances are neglected in this table and must be considered independently if significant to the decision.

COOLING LOADS

TIME OF DAY WHEN MAXIMUM COOLING LOAD OCCURS IN ROOMS WITH DIFFERENT TYPES OF EXPOSURE

Number of Walls Exposed	Direction of Exposed Wall or Walls	Shaded Windows: Occupied Space Above	Shaded Windows: Roof or Attic Above	Nonshaded Windows: Occupied Space Above	Nonshaded Windows: Roof or Attic Above
1	N	-	-	2	2
	NE	-	-	2	2
	E	2	2	9	9
	SE	1	1	10	10
	S	2	1	1	1
	SW	3	2	4	3
	W	3	3	4	4
	NW	4	3	5	4
2	N E	2	2	9	9
	NE SE	2	1	9	9
	E S	2	1	10	10
	SE SW	3	2	3	3
	S W	3	2	3	3
	SW NW	3	3	4	4
	W N	3	3	4	4
	NW NE	4	3	5	5
3	W N E	4	3	4	4
	NW NE SE	3	3	4	4
	N E S	2	2	10	10
	NE SE SW	3	2	3	3
	E S W	3	2	3	3
	SE SW NW	3	3	4	4
	S W N	3	3	4	4
	SW NW NE	4	3	4	4
4	S W N E	3	2	3	3
	SW NW NE SE	3	2	4	4
None		-	-	2	2

All times of day are pm, except 9 and 10, which are am

COOLING LOADS

STEP 11	Calculate the net area in square feet for the ceiling or roof, the walls, and all glass areas.
FACTOR 2 SENSIBLE HEAT GAIN	
STEP 1	Determine the proper heat transmission coefficients for the ceiling or roof, the floor, the walls, and all glass areas from an American Society of Heating and Ventilating Engineers handbook.
STEP 2	Calculate the conduction through the ceiling or roof, the floor, and the walls by multiplying the area of each in square feet by the design dry bulb temperature in degrees Fahrenheit and by its heat transmission coefficient expressed as a decimal.
STEP 3	Calculate the radiation coefficient at that time when the total load is maximum for each outside wall and the roof by multiplying the intensity of solar radiation in Btu per hour for each by its absorption coefficient expressed as a decimal and by a factor that is the equivalent of its heat transmission coefficient expressed as a decimal multiplied by 0.167. From the following tables, select the proper intensity of solar radiation and absorption coefficient. Select the proper heat transmission coefficient from an American Society of Heating and Ventilating Engineers handbook.

COOLING LOADS

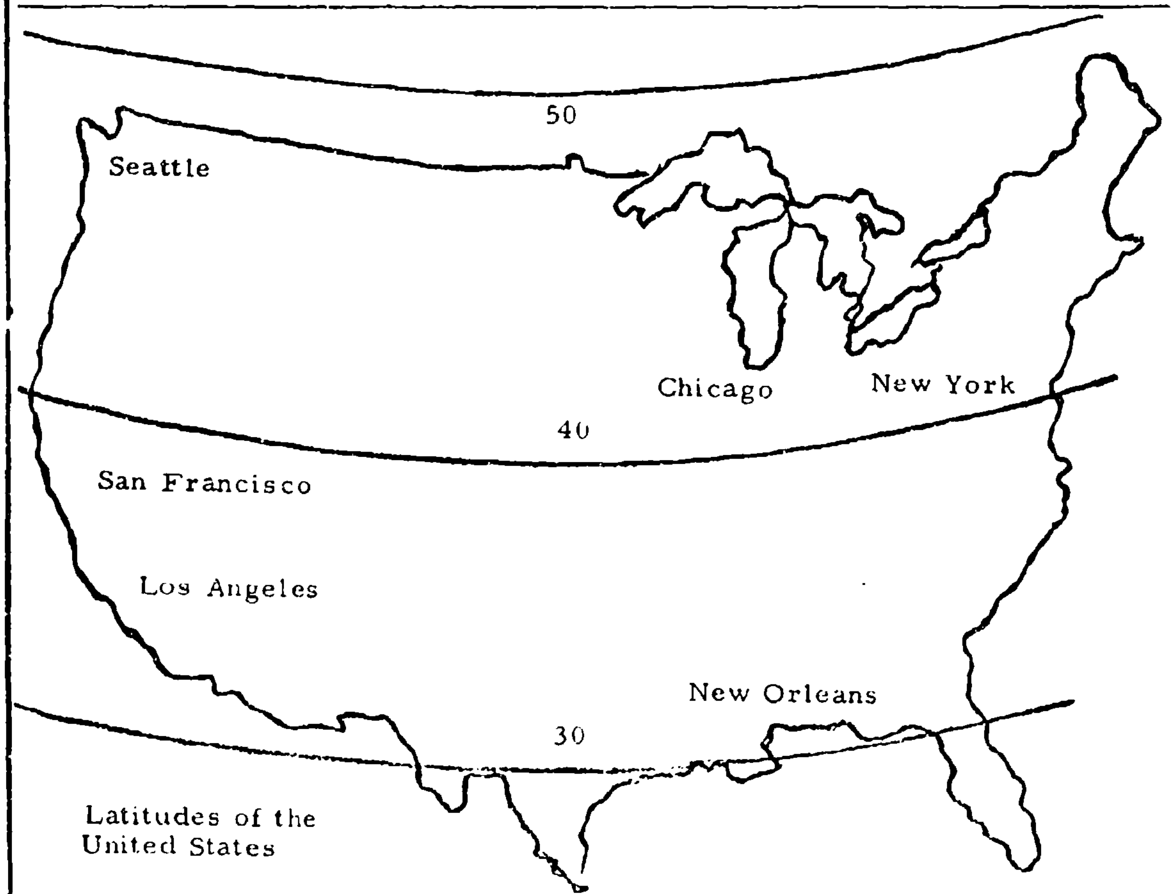
SOLAR RADIATION ON WALLS AND ROOFS

Degrees North Latitude	Time of Day	NE	E	SE	S	SW	W	NW	Horizontal Surface
		Value of I in Btu per hour striking 1 sq ft							
	6	37	47	23	5	5	5	5	11
	7	119	145	91	11	11	11	11	64
	8	153	207	149	17	17	17	17	147
	9	130	194	158	35	21	21	21	213
	10	86	152	143	63	24	24	24	262
	11	35	94	85	80	26	24	26	290
30	Noon	26	26	65	85	65	26	26	300
	1	26	26	26	80	85	94	35	290
	2	24	24	24	63	143	152	86	262
	3	21	21	21	35	158	194	130	213
	4	17	17	17	17	149	207	153	147
	5	11	11	11	11	91	145	119	64
	6	5	5	5	5	23	47	37	11
	6	43	49	27	5	5	5	5	13
	7	121	151	97	11	11	11	11	72
	8	147	207	155	25	17	17	17	151
	9	120	194	169	49	21	21	21	213
	10	71	152	156	83	24	24	24	245
	11	28	94	129	103	26	26	26	288
35	Noon	26	26	84	109	84	26	26	298
	1	26	26	26	103	129	94	28	288
	2	24	24	24	83	156	152	71	245
	3	21	21	21	49	169	194	120	213
	4	17	17	17	25	155	207	147	151
	5	11	11	11	11	97	151	121	72
	6	5	5	5	5	27	49	43	13
	6	49	56	32	5	5	5	5	20
	7	123	162	109	11	11	11	11	85
	8	137	211	166	29	17	17	17	160
	9	102	195	181	74	21	21	21	212
	10	54	152	171	103	24	24	24	244
	11	28	94	144	124	41	26	26	281
40	Noon	26	26	98	128	98	26	26	290
	1	26	26	41	124	144	94	28	281
	2	24	24	24	103	171	152	54	244
	3	21	21	21	74	181	195	102	212
	4	17	17	17	29	166	211	137	160
	5	11	11	11	11	109	162	123	85
	6	5	5	5	5	32	56	49	20

COOLING LOADS

SOLAR RADIATION ON WALLS AND ROOFS

Degrees North Latitude	Time of Day	NE	E	SE	S	SW	W	NW	Horizontal Surface
		Value of I in Btu per hour striking 1 sq ft							
	6	87	99	56	6	6	6	6	27
	7	151	192	134	12	12	12	12	89
	8	144	237	188	48	17	17	17	156
	9	100	199	197	93	21	21	21	205
	10	46	153	184	121	24	24	24	243
	11	28	94	158	146	63	26	26	259
45	Noon	26	26	116	156	116	26	26	281
	1	26	26	63	146	158	94	28	259
	2	24	24	24	121	184	153	46	243
	3	21	21	21	93	197	199	100	205
	4	17	17	17	48	188	237	144	156
	5	12	12	12	12	134	192	151	89
	6	6	6	6	6	56	99	87	27



Latitudes of the United States

COOLING LOADS

SOLAR ABSORPTION COEFFICIENTS FOR VARIOUS BUILDING MATERIALS

Type Surface	Absorption Coefficient a
Very light colored surfaces as	
White stone	0.4
Very light colored cement	
White or light cream colored paint	
Medium dark surfaces as	
Asbestos shingles	
Unpainted wood	
Brown stone	0.7
Brick and red tile	
Dark colored cement	
Stucco	
Red, green, or grey paint	
Very dark colored surfaces as	
Slate roofing	
Tar roofing materials	0.9
Very dark paints	

COOLING LOADS

STEP 4 From the following table, select the glass radiation coefficient for the time of day when the total load is maximum.

SOLAR RADIATION ON WINDOWS AND SKYLIGHTS

Degrees North Latitude	Time of Day	Direction Wall Faces: Value of R_g in Btu per hour striking 1 sq ft of single glass. Multiply by 0.9 for double glass.							Horizontal Surface
		NE	E	SE	S	SW	W	NE	
	6	31	40	15	3	3	3	3	7
	7	95	123	63	8	8	8	8	47
	8	112	174	104	12	12	12	12	122
	9	81	154	108	16	15	15	15	190
	10	44	101	92	29	16	16	16	236
	11	19	51	50	41	18	18	18	263
30	Noon	18	18	32	43	32	18	18	272
	1	18	18	18	41	50	51	19	263
	2	16	16	16	29	92	101	44	236
	3	15	15	15	16	108	154	81	190
	4	12	12	12	12	104	174	112	122
	5	8	8	8	8	63	123	95	47
	6	3	3	3	3	15	40	31	7
	6	36	42	18	3	3	3	3	8
	7	96	129	68	8	8	8	8	54
	8	104	174	112	12	12	12	13	126
	9	71	153	121	22	15	15	15	190
	10	34	101	105	42	16	16	16	220
	11	18	51	79	57	18	18	18	261
35	Noon	18	18	43	62	43	18	18	270
	1	18	18	18	57	79	51	18	261
	2	16	16	16	42	105	101	34	220
	3	15	15	15	22	121	153	71	190
	4	13	12	12	12	112	174	104	126
	5	8	8	8	8	68	129	96	54
	6	3	3	3	3	18	42	36	8

COOLING LOADS

SOLAR RADIATION ON WINDOWS AND SKYLIGHTS

Degrees North Latitude	Time of Day	Direction Wall Faces: Value of R_g in Btu per hour striking 1 sq ft of single glass. Multiply by 0.9 for double glass.							Horizontal Surface
		NE	E	SE	S	SW	W	NE	
	6	41	48	21	3	3	3	3	13
	7	96	138	78	8	8	8	8	64
	8	93	176	124	12	12	12	12	133
	9	58	153	135	35	15	15	15	188
	10	25	112	121	56	16	16	16	219
	11	18	50	93	74	21	18	18	254
40	Noon	18	18	53	79	53	18	18	263
	1	18	18	21	74	93	50	18	254
	2	16	16	16	56	121	112	25	219
	3	15	15	15	35	135	153	58	188
	4	12	12	12	12	124	176	93	133
	5	8	8	8	8	78	138	96	64
	6	3	3	3	3	21	48	41	13
	6	72	85	37	3	3	3	3	18
	7	116	165	98	8	8	8	8	67
	8	94	198	144	18	12	12	12	129
	9	58	155	151	47	15	15	15	181
	10	19	100	137	71	16	16	16	219
	11	18	50	106	93	30	18	18	234
45	Noon	18	18	66	104	66	18	18	254
	1	18	18	30	93	106	50	18	234
	2	16	16	16	71	137	100	19	219
	3	15	15	15	47	151	155	58	181
	4	12	12	12	18	144	198	94	129
	5	8	8	8	8	98	165	116	67
	6	3	3	3	3	37	85	72	18

COOLING LOADS

STEP 5	Calculate the total sun effect in Btu per hour for each outside wall and the roof by multiplying the radiation coefficient for each expressed as a decimal by its net area in square feet.
STEP 6	Calculate the total sun effect in Btu per hour for each glassed area by multiplying the radiation coefficient for each expressed as a decimal by its net area in square feet.
STEP 7	Determine the total heat gain from conduction by adding together the individual totals determined in step 2 above.
STEP 8	Determine the total heat gain from sun effect by adding together the individual totals determined in step 6 above.
STEP 9	Calculate the heat gain from shelter occupants by multiplying the number of shelter occupants by a factor of 220 Btu per hour.
STEP 10	Calculate the heat gain from lights and equipment by multiplying the total electrical power load in watts by a factor of 3.4.
STEP 11	Calculate the total shelter sensible heat gain in Btu per hour by adding together the individual totals determined in steps 7-10 above.

COOLING LOADS

FACTOR 3 LATENT HEAT GAIN	
STEP 1	Calculate the latent heat gain from ventilation air in Btu per hour by multiplying the ventilation air rate in cubic feet per minute by the difference in absolute humidity in grains of moisture per pound of dry air between the outdoor and indoor air and then by a factor of 0.68.
STEP 2	Calculate the latent heat gain from shelter occupants by multiplying the number of shelter occupants by a factor of 180 Btu per hour.
STEP 3	Calculate the total latent heat gain in Btu per hour by adding together the individual totals determined in steps 1 and 2 above.
FACTOR 4 TOTAL HEAT GAIN	
STEP 1	Calculate the total heat gain in Btu per hour by adding together the total latent heat gain and the total sensible heat gain.
STEP 2	Convert the total heat gain in Btu per hour to tons of cooling required by dividing by a factor of 12,000.

PACKAGE AIR CONDITIONING UNIT

STEP 1

Determine the design capacity in tons of air conditioning from the cooling load analysis.

STEP 2

Select the package air conditioners from the rating table shown below. Multiple units may be desirable.

TYPICAL PACKAGE AIR CONDITIONERS

Cooling Load Requirement in Tons	Nominal Capacity in Tons
3.0 - 5.0	5.0
5.0 - 7.5	7.5
7.5 - 10	10
10 - 15	15
15 - 20	

UNIT AIR CONDITIONERS

STEP 1 — Determine the temperature factor cooling load in tons from the air conditioning cooling load analysis.

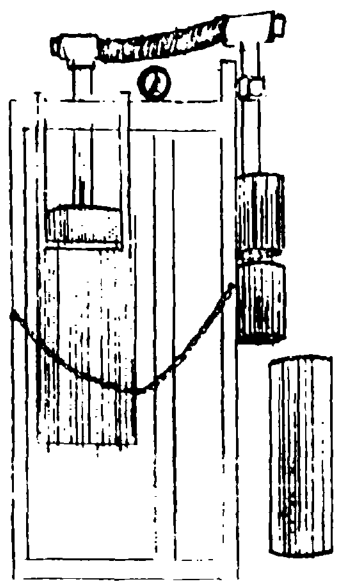
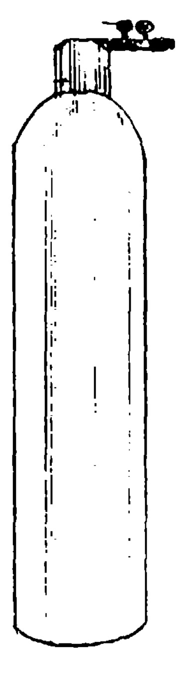
STEP 2 — Determine the cfm of air required to absorb the cooling load.

STEP 3 — From the manufacturer's rating tables, select a casing adequate for a 70-degree rise in chilled air temperature. A typical rating table is shown below.

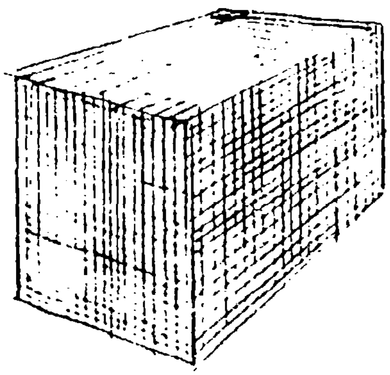
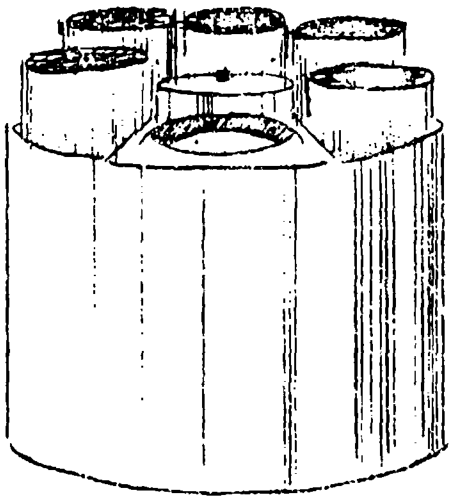
UNIT FAN AND COIL DATA

Manufacturer's Type	Standard Coil Cfm Range
No. 1	1967 - 4215
No. 2	2625 - 5625
No. 3	3279 - 7027
No. 4	4091 - 8767
No. 5	4812 - 10312
No. 6	5908 - 12660
No. 7	7217 - 15465
No. 8	8421 - 18045
No. 9	10717 - 22965
No. 10	12250 - 26250
No. 11	14175 - 30375
No. 12	17325 - 37125
No. 13	22050 - 47250

OXYGEN SUPPLY

Typical Design	Description
	**Chlorate Candle** A chlorate candle consists of a candle, ignition system, and filters. The candle is ignited at the upper end, causing decomposition of chlorate and the accompanying release of oxygen. The candle must be burned in a container made for this purpose. A typical candle of 6" x 12" dimensions will provide about 100 cubic feet of oxygen at a rate of approximately 108 cubic feet per hour. The rate of burning cannot be controlled. Once ignited, it is best to allow the candle to burn itself out. The candle will generate heat and introduce a possible hazard into the shelter when it is burning. Due caution should therefore be observed.
	**Oxygen Cylinders** A good source of oxygen is compressed oxygen in cylinders. Commercial cylinders will provide about 1600 cubic feet of oxygen, which can be released in measured quantities through use of a pressure regulator. Regulators can be attached directly to the oxygen cylinder.

CHEMICAL ABSORBENTS

Typical Design	Description
	**Baralyme** One method of carbon dioxide absorption uses a chemical called baralyme. The baralyme granules are placed in a screened container. Air is drawn through the container, and the carbon dioxide is removed. By changing color from pink to blue, the baralyme indicates when it should be discarded and/or replaced. The air is drawn through the screened container by a fan.
	**Lithium Hydroxide** Another method of carbon dioxide absorption consists of chemical granules contained in a canister that has lids on both ends. The canister is placed in a manifold after both lids have been removed, and air is drawn through it by a fan. The canister must be replaced after the lithium hydroxide has been expended.

CHLORATE CANDLE

GENERAL INFORMATION

1. Characteristics - Chlorate candles contain a mixture of sodium chlorate, about 10% powdered iron, and small percentages of other ingredients. The mixture is pressed or cast into the shape of a cylinder of dimensions suitable for its intended use. Most of the oxygen in the candle is available for external use, which in this case is for breathing. A small part combines with some of the iron, producing heat and causing additional chlorate to decompose.

2. Size and Weight - The greater the diameter of the candle, the greater the rate of oxygen production. A 6" x 12" candle weighs 28 pounds.

INSTALLATION INSTRUCTIONS

1. Chlorate candles are packed in polyethylene bags and stored in individual tin cans until needed for use. The can should be kept clean and dry.

2. The candle will store reliably for up to 20 years, if cared for properly.

3. A furnace, in which the candles can be burned, must be available. The furnace is specially built for this purpose.

4. The candle mixture is not susceptible to spontaneous ignition.

5. The amount of space required per candle is approximately one-half cubic foot.

OXYGEN CYLINDER

GENERAL INFORMATION	1.	Characteristics - Oxygen cylinders with regulators and controls are commercially available. A means must be devised for distributing the air throughout the shelter and reducing the fire hazard of high oxygen concentration in a given area.
	2.	Size and Weight - Commercially available tanks are under 100 psi pressure and contain 200 cubic feet of air. This tank would supply oxygen at a rate of about 1600 cubic feet per minute.
INSTALLATION INSTRUCTIONS	1.	Handle the cylinders with care. Make sure that valves are closed and that there are no leaks.
	2.	The cylinders should be stored in an area not subject to high temperatures.
	3.	The required storage space for a typical tank is about 5 cubic feet.
	4.	Store the cylinders where they will not have to be moved until exhausted.

CHLORATE CANDLE

STEP 1	Determine the number of shelter occupants.
STEP 2	Determine the number of chlorate candles required for a two-day closure period by calculating the number of shelter occupants.

OXYGEN CYLINDER

STEP 1	Determine the number of shelter occupants.
STEP 2	Calculate the shelter oxygen requirement for a two-day closure period by multiplying the number of shelter occupants by a factor of 48 cubic feet.
STEP 3	Calculate the number of 244-cubic-feet-capacity oxygen cylinders required by dividing the shelter oxygen requirement for a two-day closure period, determined in step 2 above, by a factor of 244 cubic feet.
STEP 4	Calculate the number of 1500-cubic-feet-capacity oxygen cylinders required by dividing the shelter oxygen requirement for a two-day closure period, determined in step 2 above, by a factor of 1500 cubic feet.

BARALYME AND SODA LIME

STEP 1	Determine the number of shelter occupants.
STEP 2	Calculate the number of pounds of either baralyme or soda lime required for a two-day closure period by multiplying the number of shelter occupants by a factor of 16 pounds.

MAINTENANCE AND OPERATING DATA

FANS AND BLOWERS		
GENERAL INSTRUCTIONS FOR VENTILATION SYSTEMS		The maintenance and operation of the shelter equipment should be carried out in accordance with the instructions prepared by the manufacturer of the equipment. In the absence of such instructions, the following checklist should be followed to assure minimum control of the inspection, operation, and maintenance of the shelter equipment.
MONTHLY STANDBY INSPECTION	1.	Make visual check for damage.
	2.	Run blower momentarily.
	3.	Lubricate bearings if necessary.
	4.	Check drive belts if used.
START-UP	1.	Open filter cover.
	2.	Turn on blower.
TROUBLESHOOTING		
INSUFFICIENT AIR INTAKE	1.	Loose or bent blades
	2.	Dirt or accumulation on blades
	3.	Shaft bent
	4.	Bearings worn
	5.	Loose mounting bolts
MOTOR WON'T RUN	1.	Blown fuse
	2.	Loose or broken wire connection
FAN SQUEAKS	1.	Needs lubrication
	2.	Belt tight or dirty
FAN OPERATES PROPERLY BUT CIRCULATION IS LOW	1.	Filter dirty
	2.	Vent or diffuser clogged
	3.	Leaks at air inlet

MAINTENANCE AND OPERATING DATA

FANS AND BLOWERS		
SHUTDOWN	1.	Shut off fan.
	2.	Release filter cover.
SPARE PARTS	1.	Spare bearing
	2.	Spare drive belts if used
	3.	Motor fuses
TOOLS	1.	Adjustable wrench
	2.	Screwdriver
	3.	Pliers
	4.	Hammer
IDENTIFICATION AND CODING	1.	Attach tags to motor switch.
	2.	Keep manufacturer's name tags on each piece of apparatus intact and readable.
	3.	Locate manufacturer's instructions for each piece of equipment in a convenient, conspicuous, and protected place.
FILTERS		
MONTHLY INSPECTION	1.	Visually check for moisture accumulation, dirt, or deterioration.
	2.	Check operation of rolls.
SPARE PARTS	1.	Replacement filters
TOOLS	1.	Pliers
	2.	Screwdriver
	3.	Knife

MAINTENANCE AND OPERATING DATA

FILTERS		
IDENTIFICATION AND CODING	1.	Attach tag to filter to identify purpose and size.
	2.	Attach tag with instructions for replacement of filter.
	3.	Locate manufacturer's instructions for filter in a convenient, conspicuous, and protected place.
DUCT SYSTEM		
MONTHLY STANDBY INSPECTION	1.	Inspect ducts for leaks by running fans.
TROUBLESHOOTING		
DIRECT LEAKS	1.	Repair leak by taping seams or patching with cardboard.
SPARE PARTS	1.	Cardboard
	2.	Adhesive
TOOLS	1.	Pliers
	2.	Screwdriver
	3.	Hammer
	4.	Adjustable wrench
GRILLS AND DIFFUSERS		
MONTHLY STANDBY INSPECTION	1.	Inspect for damage.
	2.	Check for blocking or obstructions.

MAINTENANCE AND OPERATING DATA

GRILLS AND DIFFUSERS

TROUBLESHOOTING

LITTLE OR NO AIRFLOW	1.	Check for obstruction in grill. Remove obstruction.
TOOLS	1.	Pliers
	2.	Screwdrivers

MAINTENANCE AND OPERATING DATA

PACKAGED AIR CONDITIONING UNITS		
MONTHLY STANDBY INSPECTION		
INSPECT FILTERS	1.	Filters should be inspected every two months. Dirty filters should be replaced as they cause serious loss of capacity because of reduced air-flow over the cooling coil.
LUBRICATION	1.	Motor sleeve bearings should be inspected and grease added when necessary. Overlubrication should be avoided.
	2.	Fan shaft sleeve bearings should be oiled with a high grade of SAE 30 machine oil if they are not sealed bearings.
COMPRESSOR-MOTOR COUPLING	1.	For open compressors the drive coupling should be checked to make sure the compressor and motor are in perfect alignment.
BELTS	1.	Inspect belts.
START-UP	1.	Set thermostat for air temperature.
	2.	Turn UNIT switch to ON position.
	3.	Push START button on control.
TROUBLESHOOTING		
UNIT FAILS TO START	1.	Power failure: test lamp shows no current on line side of motor starter. Check for blown fuse or broken lead.

MAINTENANCE AND OPERATING DATA

PACKAGED AIR CONDITIONING UNITS

TROUBLESHOOTING

UNIT FAILS TO START	2.	Low voltage: test lamp glows but not at full brilliance. Check power generator.
	3.	Inoperative motor starter: burned-out coil or faulty contacts. Determine cause and repair

SHUTDOWN	1.	Push STOP button on control.
	2.	Turn UNIT switch to OFF position.
SPARE PARTS	1.	Filters
	2.	Belts
	3.	Condenser automatic control valve
	4.	Fuses
	5.	Gauges
	6.	Sight glass
	7.	Thermal expansion valve
	8.	Oil pressure cutout
	9.	Dual pressure control
	10.	Relay
	11.	Solenoid valve

TOOLS

VISES	1.	Machinist--mounted on a portable table and tool rack
	2.	Pipe--mounted on above portable table and tool rack

MAINTENANCE AND OPERATING DATA

PACKAGED AIR CONDITIONING UNITS

TOOLS

HAMMERS	1.	Claw--16 oz
	2.	Ball peen
SCREWDRIVERS	1.	Square shank--3/16" to 3/4"
	2.	Phillips
WRENCHES	1.	Monkey
	2.	Adjustable
	3.	Pipe
	4.	Open end
	5.	Box
	6.	Socket
	7.	Allen
DRILLS	1.	Portable electric
	2.	Hand
	3.	Twist--number, letter, and fractional sizes
	4.	Center
	5.	Star
OTHER	1.	Test lamp

MAINTENANCE AND OPERATING DATA

PACKAGED AIR CONDITIONING UNITS		
IDENTIFICATION AND CODING	1.	Keep manufacturer's name tags on each piece of apparatus intact and readable.
	2.	Locate manufacturer's instructions for each piece of equipment in a convenient, conspicuous, and protected place.
UNIT AIR CONDITIONERS		
MONTHLY STANDBY INSPECTION		
INSPECT FILTERS	1.	Access doors are provided on both sides in all units for filter removal for inspection.
	2.	Cleanable filters may be washed with hot water, oiled, and then replaced.
LUBRICATE FAN BEARINGS	1.	If possible, use permanently sealed, prelubricated flange type bearings that require no lubrication.
	2.	Grease line extensions are provided for bearings that require lubrication. Grease should be pumped slowly to the bearings until a slight bead appears around the seal.
INSPECT BEARINGS	1.	If bearings are noisy, remove and replace. Loosen the two knurled cup point setscrews which hold the bearing race to the fan shaft. Remove the bearing mounting bolts and pull the bearing off the end of the shaft.

MAINTENANCE AND OPERATING DATA

UNIT AIR CONDITIONERS		
INSPECT FAN BELT	1.	Belt tension should be such that light pressure applied with one finger will depress the belt about one inch.
	2.	Always replace worn belts as a set.
LUBRICATE FAN MOTOR	1.	Some motors require a good grade of mineral oil.
	2.	Some motors will have grease cups that require a good grade of semi-smooth, high temperature, soda soap grease.
START-UP	1.	Turn UNIT switch to ON position.
	2.	Push START button on control.
TROUBLESHOOTING		
UNIT FAILS TO START	1.	Low voltage: test lamp glows but not with full brilliance. Check power generator.
	2.	Power failure: test lamp shows no current on line side of motor starter. Check for blown fuse or broken lead.
	3.	Inoperative motor starter: burned-out coil or faulty contacts. Determine cause and repair.
SHUTDOWN	1.	Push STOP button on control.
	2.	Turn UNIT switch to OFF position.
SPARE PARTS	1.	Filters
	2.	Belts
	3.	Bearings

MAINTENANCE AND OPERATING DATA

UNIT AIR CONDITIONERS		
SPARE PARTS	4.	Expansion valve for direct expansion coils
	5.	Solenoid valve
	6.	Water control valve for water coil
	7.	Air vent
	8.	Fuses
TOOLS		
VISES	1.	Machinist--mounted on a portable table and tool rack
	2.	Pipe--mounted on above portable table and tool rack
HAMMERS	1.	Claw--16 oz
	2.	Ball peen
SCREWDRIVERS	1.	Square shank--3/16" to 3/4"
	2.	Phillips
	3.	Automatic with 3/16" to 3/4" bits
WRENCHES	1.	Monkey
	2.	Adjustable
	3.	Pipe
	4.	Open end
	5.	Box
	6.	Socket
	7.	Allen

MAINTENANCE AND OPERATING DATA

UNIT AIR CONDITIONERS		
DRILLS	1.	Portable electric
	2.	Hand
	3.	Twist--number, letter, and fractional sizes
	4.	Center
	5.	Star
PLIERS	1.	Combination
	2.	Side cutting
	3.	Round nose
	4.	Long chain nose
CHISELS AND PUNCHES	1.	Chisels
	2.	Center punch
	3.	Starting punch
	4.	Pin punch
GENERAL	1.	Ripping bar
	2.	Glass cutter
	3.	Hacksaw--14, 18, 24, 32 teeth per inch
	4.	Files and file card
	5.	Soldering iron
	6.	"C" clamps
	7.	Tin snips
	8.	Feeler gauge
	9.	Rules--folding, steel

MAINTENANCE AND OPERATING DATA

UNIT AIR CONDITIONERS

GENERAL	10.	Combination square
	11.	Calipers--Vernier, outside, inside
	12.	Scriber
IDENTIFICATION AND CODING	1.	Keep manufacturer's name tags on each piece of apparatus intact and readable.
	2.	Locate manufacturer's instructions for each piece of equipment in a convenient, conspicuous, and protected place.

MAINTENANCE AND OPERATING DATA

CHLORATE CANDLES		
MONTHLY STANDBY INSPECTION	1.	Check containers for visible damage.
START-UP (for actual shelter use only)	1.	Ignite candle by closing head and striking prime.
SHUTDOWN (for actual shelter use only)	1.	Allow candle to burn itself out. Do not extinguish with water as this will cause a large amount of smoke and toxic gas. Remove clinker of iron oxides from furnace.
IDENTIFICATION AND CODING	1.	Keep manufacturer's name tags on each piece of apparatus intact and readable.
	2.	Locate manufacturer's instructions for each piece of equipment in a convenient, conspicuous, and protected place.
OXYGEN CYLINDERS		
MONTHLY STANDBY INSPECTION	1.	Check for proper storage.
	2.	Spot-check cylinders for pressure.
	3.	Check regulator and gauge for proper operation.
START-UP	1.	Attach regulator to cylinder.
	2.	Open cylinder valve.
	3.	Adjust pressure to required amount.
	4.	Open oxygen supply valve.

MAINTENANCE AND OPERATING DATA

OXYGEN CYLINDERS		
TROUBLESHOOTING		
NO OXYGEN FLOW	1.	Cylinder valve closed
	2.	Defective regulator
	3.	Regulator not adjusted
	4.	Oxygen supply valve closed
	5.	Cylinder empty
TOO MUCH OXYGEN FLOW	1.	Regulator adjustment
SHUTDOWN	1.	Close oxygen supply valve.
	2.	Close cylinder valve.
SPARE PARTS	1.	Regulator gaskets
	2.	Regulator blowout disks
TOOLS	1.	Adjustable wrench
	2.	Pliers
	3.	Screwdrivers
IDENTIFICATION AND CODING	1.	Keep manufacturer's name tags on each cylinder intact and readable.
	2.	Locate manufacturer's instructions for the cylinders in a convenient conspicuous, and protected place.

CO_2 ABSORBENT CHEMICALS		
MONTHLY STANDBY INSPECTION	1.	Check for proper storage.
	2.	Visually check for broken containers and moisture.

MAINTENANCE AND OPERATING DATA

CO_2 ABSORBENT CHEMICALS

START-UP (for actual shelter use only)	1.	Fill canisters or screens as required.
	2.	Place near fan where fan will draw air over chemical.
	3.	Turn on fan.
TROUBLESHOOTING		
CO_2 CONTENT OF ROOM HIGH	1.	Change chemicals.
SHUTDOWN (for actual shelter use only)	1.	Empty canisters and screens.
TOOLS	1.	Pipe wrench
	2.	Adjustable wrench
	3.	Pliers
	4.	Screwdrivers
IDENTIFICATION AND CODING	1.	Keep manufacturer's name tags on each container of absorbents intact and readable.
	2.	Locate manufacturer's instructions for the absorbents in a convenient, conspicuous, and protected place.

Use the Table of Contents given below to quickly locate key technical data pertaining to the selection and operation of water supply, waste disposal, and drainage systems.

The Introduction Section provides all essential data regarding system requirements and typical system designs.

System component descriptions, application data, and selection procedures are given in the Component Selection Section.

The Manual Preparation Section identifies all of the essential elements and includes material to be covered in writing simple operating instructions for relatively unskilled people.

NEED FOR WATER SUPPLY DISPOSAL, AND DRAINAGE SYSTEMS

System Uses

Water supply, waste disposal, and possibly drainage systems are essential equipment to shelter survival. The water supply system provides the means for storing and distributing potable water to shelter inhabitants. Human waste is collected, transferred, and disposed of through the waste disposal system. Should the shelter be subject to possible flooding, the drainage system provides the means for collecting and disposing of this water.

Water Supply Systems

From the standpoint of human survival, potable water is more important than food to the shelter inhabitants. Water must be available for drinking and medical purposes. Since it is highly possible that the community water distribution system will be rendered inoperable as the result of nuclear attack, the shelter must have its own water supply system.

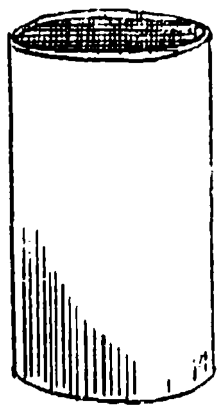
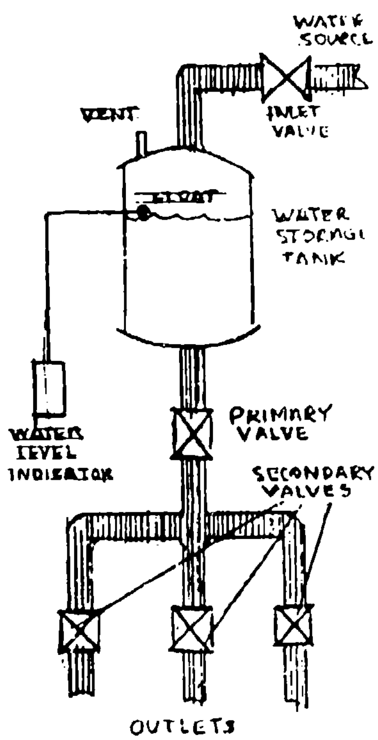
Waste Disposal Systems

An effective means of waste disposal is essential to minimize offensive odors and to eliminate the possibility of the waste becoming a breeding area for bacteria, which condition would create a serious health problem. Again, due to the probability that community systems will be rendered inoperable, the shelter must have its own waste disposal system.

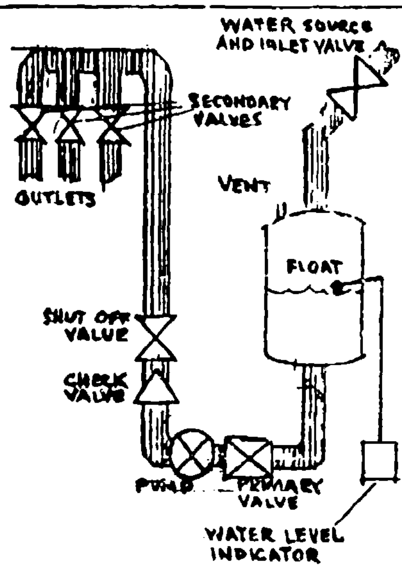
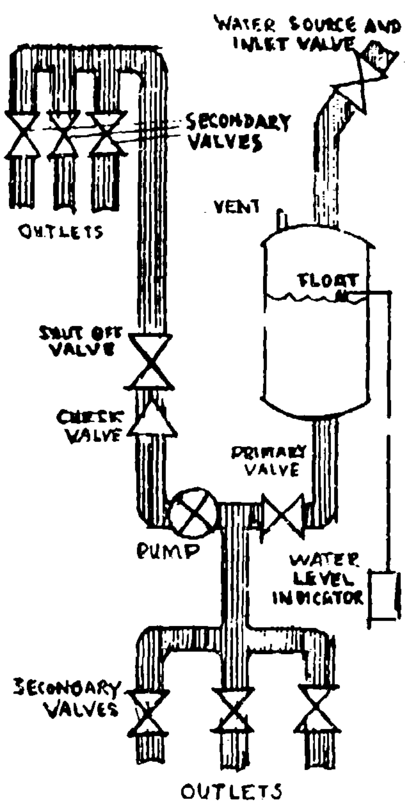
Drainage Systems

Drainage systems are particularly important considerations in belowground shelters. Potential flooding conditions as well as moisture accumulation could cause damage to supplies or equipment and in extreme cases cause the shelter to become uninhabitable. As a result, any shelter subject to potential flooding or excessive moisture accumulation must have its own drainage system.

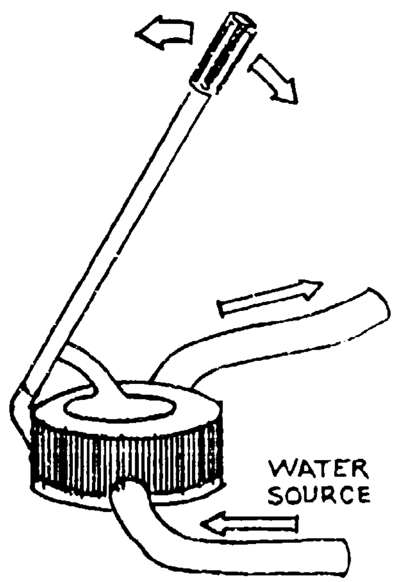
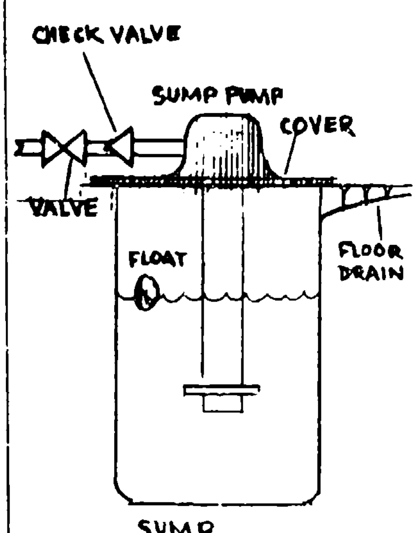
WATER SUPPLY SYSTEMS

Type Designation	Typical Design	Description
OCD-SUPPLIED WATER CONTAINER		
Type I		The water container consists of a metal drum in which water is stored in a polyethylene double bag liner. Water is dispensed from the container by means of a siphon tube which is inserted through the spout of the inner bag. Water dispensed in this way is limited to filling individual cups at slow rates of flow.
GRAVITY FLOW SYSTEM		
Type II		A typical gravity flow system consists of a water source, a large storage tank, and a required number of valves and length of piping. Water is either pumped or flows by means of gravity from a community wa[illegible] supply system through an inlet valve into a water storage tank. The tank water level is registered by a water level indicator. Water flow from the tank is by gravity and is controlled by both primary and secondary valves.

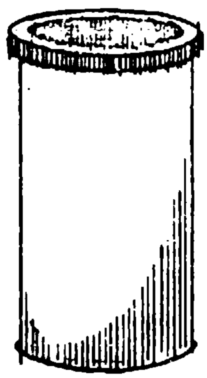
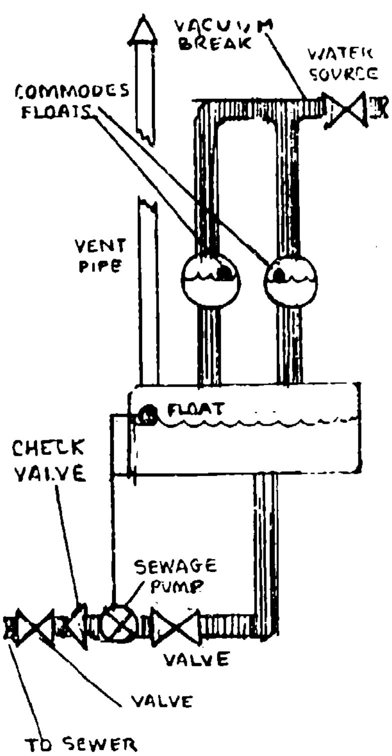
WATER SUPPLY SYSTEMS

<table>
<tr><th>Type Designation</th><th>Typical Design</th><th>Description</th></tr>
<tr><td colspan="3">POWER FLOW SYSTEM</td></tr>
<tr><td>Type III</td><td>
</td><td>A typical power flow system consists of a water source, a large storage tank, a pump, and a required number of valves and length of piping. Water is either pumped or flows by means of gravity from a community water supply system or shelter well through an inlet valve into a water storage tank. The water is then elevated from the tank to a higher level by means of a pump and is controlled by both primary and secondary valves.</td></tr>
<tr><td colspan="3">COMBINATION POWER AND GRAVITY FLOW SYSTEM</td></tr>
<tr><td>Type IV</td><td>
</td><td>A typical combination power and gravity flow system uses gravity feed where possible and power feed where necessary. Such systems consist of a water source, a large storage tank, a pump, and a required number of valves and length of piping. Water is either pumped or flows by means of gravity from a community water supply system or shelter well through an inlet valve into a water storage tank. The water then flows from the tank by gravity where suitable and is elevated to a higher level by means of a pump. In both cases the water flow is controlled by both primary and secondary valves.</td></tr>
</table>

SUMP AND DRAINAGE SYSTEMS

Type Designation	Typical Design	Description
MANUAL SYSTEM		
Type I		The manually operated system consists of a self-priming flexible diaphragm type pump with required lengths of inlet and outlet hoses. Since this type of pump has no packing or valves subject to clogging, it also can be used for handling the various liquid wastes in shelter systems. While extremely flexible and portable, this type of pump has a relatively low rate of flow.
POWER FEED SYSTEM		
Type II		A typical power feed drainage system consists of a sump, a sump pump, a suitable number of floor drains, and a required length of connecting sewer pipe. Water flows into the floor drains and through the sewer pipe to the sump by gravity. The sump pump is activated when the water in the sump reaches a maximum level and pumps the water out of the sump. The pump shuts off automatically when the water reaches a minimum level

WASTE DISPOSAL SYSTEM

Type Designation	Typical Design	Description
OCD-SUPPLIED CHEMICAL TOILET		
Type I		Chemical toilets consist of metal drums and fiberboard drums, plastic bag liners, commode seats, and required commode chemicals and supplies. The chemicals and supplies, as well as the commode and seat, are packed as a unit within the fiberboard drums as sanitation kits in 25- and 50-person sizes. The fiberboard drum serves as a commode. As the metal water drum is emptied of water, it also is used as a commode. Thus, both the fiberboard drum and the metal water drum serve dual purposes.
COMBINATION POWER AND GRAVITY FLOW SYSTEM		
Type II		A typical power and gravity flow system consists of a water source, a necessary number of commodes, a tank, a sewage pump, and a required number of valves and length of piping. Water is either pumped or flows by means of gravity from a community water supply system or shelter well through an inlet valve and into the float-actuated commode water tank. Waste products are then water-flushed into the tank. When the tank fills to the maximum allowable level, the float actuates the sewage pump and the waste products are pumped out of the tank.

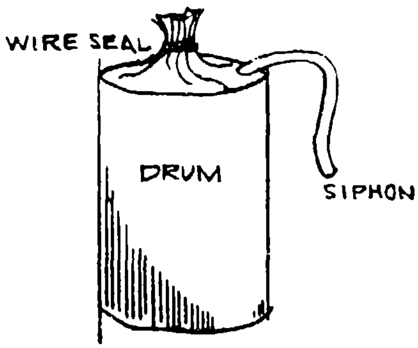
SHELTER SYSTEM REQUIREMENTS

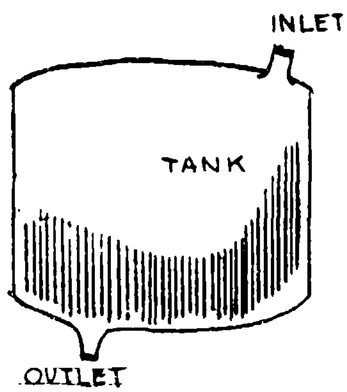
Shelter Size	System Rating	Water Supply System	Waste Disposal System	Drainage System
BELOWGROUND SHELTERS				
50 PEOPLE	Best	Type I	Type I	Type I
	Acceptable			
100 PEOPLE	Best	Type I	Type I	Type I
	Acceptable			
200 PEOPLE	Best	Type I	Type I	Type I
	Acceptable			
300 PEOPLE	Best	Type I	Type II	Type I
	Acceptable		Type I	
500 PEOPLE	Best	Type II	Type II	Type I
	Acceptable	Type I	Type I	
1,000 PEOPLE	Best	Type II	Type II	Type II
	Acceptable	Type I	Type I	Type I
2,000 PEOPLE	Best	Type II	Type II	Type II
	Acceptable	Type I		Type I
3,000 PEOPLE	Best	Type IV	Type II	Type II
	Acceptable	Type I		Type I
5,000 PEOPLE	Best	Type IV	Type II	Type II
	Acceptable	Type I		Type I
10,000 PEOPLE	Best	Type IV	Type II	Type II
	Acceptable	Type III		Type I

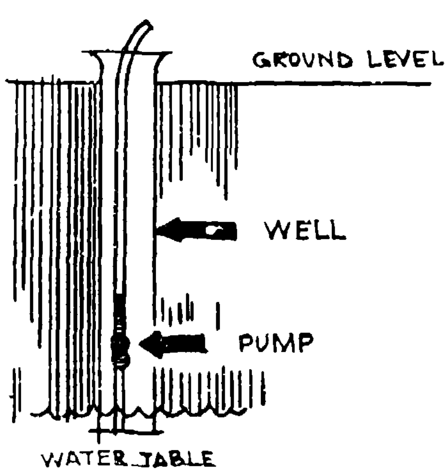
SHELTER SYSTEM REQUIREMENTS

Shelter Size	System Rating	Water Supply System	Waste Disposal System	Drainage System
ABOVEGROUND SHELTERS				
50 PEOPLE	Best	Type I	Type I	Not Required
	Acceptable			
100 PEOPLE	Best	Type I	Type I	Not Required
	Acceptable			
200 PEOPLE	Best	Type I	Type I	Not Required
	Acceptable			
300 PEOPLE	Best	Type I	Type II	Not Required
	Acceptable		Type I	
500 PEOPLE	Best	Type II	Type II	Not Required
	Acceptable	Type I	Type I	
1,000 PEOPLE	Best	Type II	Type II	Not Required
	Acceptable	Type I		
2,000 PEOPLE	Best	Type II	Type II	Not Required
	Acceptable	Type I		
3,000 PEOPLE	Best	Type IV	Type II	Not Required
	Acceptable	Type I		
5,000 PEOPLE	Best	Type IV	Type II	Not Required
	Acceptable	Type I		
10,000 PEOPLE	Best	Type IV	Type II	Not Required
	Acceptable	Type III		

CONTAINERS, TANKS AND WELLS

<table>
<tr><th>Typical Design</th><th>Description</th></tr>
<tr><td>
</td><td><u>OCD-Supplied Water Container</u>

The OCD-supplied water container consists of a metal drum with removable cover. Inside the water container is a plastic bag assembly consisting of an inner and outer bag which contains 70 quarts or 17-1/2 gallons of water. The plastic bag is sealed by a wire tie. After the water is consumed, the drum is converted to use as a chemical toilet.</td></tr>
<tr><td>
</td><td><u>Water Storage Tank</u>

Water storage tanks are made of steel with a protective inner coating. A float inside the tank protects against overflow, and an outside gauge indicates the tank water level. The number of occupants determines the gallons of water required to be stored.</td></tr>
<tr><td>
</td><td><u>Water Well</u>

Well water can be either pumped directly to the outlets or be pumped into a storage tank and then flow by gravity or be pumped to the outlets.</td></tr>
</table>

OCD-SUPPLIED WATER CONTAINER

GENERAL INFORMATION	1.	Nomenclature - The water container consists of a metal drum and a 4-mil double bag liner made of polyethylene which is inserted in the drum at the time of filling.
	2.	Container Capacity - The plastic bag assembly contains 70 quarts or 17-1/2 gallons of water.
	3.	Size and Weight - The metal drum diameter will vary from 15-3/8 inches to 16 inches. With the diameter 15-1/2 inches or less, the drum will be 23-1/4 inches in height. With the diameter over 15-1/2 inches, the drum will be 21-3/4 inches in height. The weight will be approximately 10 pounds empty and 156 pounds when filled with water.
SHIPPING INFORMATION	1.	The metal drums are shipped as individual units. The double polyethylene plastic bag liners are packed in fiberboard panel folders, having approximate dimensions of 42 inches by 28 inches by 1 inch. Each folder will contain twenty sets of bag liners and will have a gross weight of 15-1/4 pounds. Twenty-five folders will be utilized in a heavy duty, triple wall fiberboard box. Plastic wire ties for closing the bag liners after they have been filled and detailed instructions for filling the water storage containers are included in each folder containing twenty sets of bag liners.
FILLING AND DISPENSING INSTRUCTIONS	1.	Remove the water purification tablets, iodine, from the Medical Kit. Remove the dispensing spout, plastic cups and lids from the Sanitation Kit.
	2.	Remove drum cover.
	3.	Unfasten wire ties on both outer and inner bag-liners and drop 10 water purification tablets into the spout of the inner bag.
	4.	Replace drum cover and wait five minutes.

OCD-SUPPLIED WATER CONTAINER

FILLING AND DISPENSING INSTRUCTIONS

5. Remove drum cover and insert siphon tube about 3/4 of its length through the spout of the inner bag. Agitate water with siphon tube for 30 seconds.

6. Fasten tube in place by wrapping spout and tube with wire tie and replace drum cover.

7. Wait 20 minutes.

8. Remove drum cover, unfasten wire tie, pinch end of siphon tube and pull down about 18 inches. This will start the flow of water when the pinch pressure is released.

9. Start filling individual cups.

10. If the water in the first cups filled has noticeably strong color, pour back through spout, pinch end of tube to avoid loss of siphoning action and agitate water with tube in drum for 30 seconds.

11. Resume filling individual cups.

WATER STORAGE TANK

GENERAL INFORMATION	1.	Nomenclature - The water storage tank consists of a metal tank with a protective inner lining.
	2.	Storage Tank Capacity - The storage tank capacity requirement depends on the number of shelter occupants. Minimum capacity must account for 3.5 gallons of drinking water per person.
	3.	Size and Shape - The storage tank will range in size, based upon the required capacity. The shape of the container can be either rectangular or cylindrical, as best fits the space available.
	4.	Weight - Storage tanks will vary in weight according to the materials used in their construction and the required tank capacity.
INSTALLATION INSTRUCTIONS	1.	Water storage tanks must be placed where they cannot be damaged or, if damaged, cause shelter flooding.
	2.	Water storage tanks that are connected directly to municipal water supply systems or other water sources subject to potential radioactive contamination or blast must have a control valve located between the tank and the water source such that it is readily accessible to the shelter inhabitants.
	3.	All water storage tanks must have a water level gauge located within the confines of the shelter.
	4.	Consideration should be given to the use of multiple tanks when the required capacity exceeds 3500 gallons.

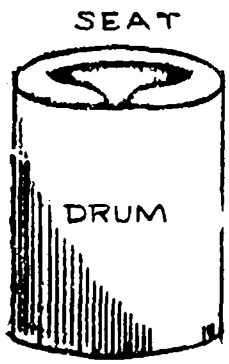
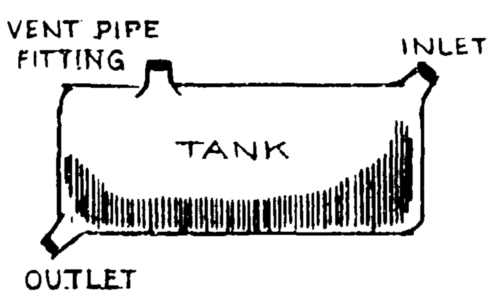
OCD-SUPPLIED WATER CONTAINER

STEP 1	Determine the number of people to be maintained in the shelter.
STEP 2	Determine the total gallons of water required to sustain this number of people by multiplying the figure from step 1 by 3.5, the minimum number of gallons of drinking water per person.
STEP 3	Determine the required number of water containers by dividing the total gallons of water required by 17-1/2. Each container requires approximately 2.4 cubic feet of storage space.

WATER STORAGE TANK

STEP 1	Determine the number of people to be maintained in the shelter.
STEP 2	Determine the total gallons of water required to sustain this number of people by multiplying the figure from step 1 by 3.5, the minimum number of gallons of drinking water per person.
STEP 3	Determine the required size in cubic feet of the water storage tank.
STEP 4	Determine the approximate required cylindrical tank length by multiplying the square of the desired tank radius in feet by 3.14 and then dividing this resultant product into the required tank capacity in cubic feet.
STEP 5	Determine the approximate required rectangular tank length by multiplying the desired width by the desired height in feet and then dividing this resultant product into the required tank capacity in cubic feet.

CHEMICAL TOILETS AND STORAGE TANKS

Typical Design	Description
	<u>OCD-Supplied Chemical Toilet</u> The OCD-supplied chemical toilet consists of a drum, plastic seat, and polyethylene liner. The toilet capacity is approximately 17 gallons of waste. Necessary odor control chemicals and supplies are included and are shipped as a kit. When full, the polyethylene bag is tied with a wire band and the drum and bag are replaced.
	<u>Special Commercial Flushing Toilet</u> Typical special commercial flushing toilets consist of a porcelain water closet, a built-in primary sewage treatment unit, and water supply and drain connections. Such toilets operate on a power flush principle. Inlet water flow is controlled by a valve and the required water pressure is provided by either manual or electric pumps. Outlet waste product flow is by gravity into a septic tank.
	<u>Storage Tank</u> Storage tanks are made of concrete, ceramic materials, or steel lined with a plastic material. Such tanks are commercially available in a large number of different sizes. A float inside the tank prevents the tank from overflowing by activating a sewage pump. The float must be purchased separately.

OCD-SUPPLIED CHEMICAL TOILET

GENERAL INFORMATION

1. Nomenclature - The chemical toilet consists of a fiberboard drum, a kit containing chemicals and supplies, and a bag liner made of polyethylene which is inserted in the drum prior to use. A plastic commode seat is included and is placed on top of the drum at the time of use.

2. Container Capacity - The plastic bag will hold about 17 gallons of waste products.

3. Size and Weight - The fiberboard drum diameter is 16 inches. The drum height is 21-3/4 inches. The weight will be between 18 and 23 pounds in storage and about 150 pounds when filled with waste products.

SHIPPING INFORMATION

1. The fiberboard drums are shipped as individual units. Each drum serves as the container for a sanitation kit consisting of the following items: toilet tissue, plastic commode seat, sanitary napkins, hand cleaner, polyethylene gloves, tie wires, one double polyethylene bag liner for the start-up commode, and an instruction sheet. Other items included are a can opener and a water dispensing spout and drinking cups and lids.

PREPARATION INSTRUCTIONS

1. Remove the entire contents from the fiberboard drum and set aside. Open the polyethylene bag liner and insert it into the drum. Spread mouth of bags over and down around the top of the drum about four inches. Add the commode chemical as directed on the container. Fix the plastic seat on the drum. Place the drum cover in an inverted position over the commode seat when commode is not in use. Remove the cover before use. Drums in which drinking water is stored also serve as commodes after the drinking water is used. The drum is prepared for use as a commode by first cutting the

OCD-SUPPLIED CHEMICAL TOILET

PREPARATION INSTRUCTIONS	top seam of the inner bag for the full width of the drum, so that the top is completely open. The mouths of the inner and outer bags are then spread over and down around the top of the drum about four inches. The remaining preparatory steps are the same as mentioned above for preparing the fiberboard drum.

SPECIAL COMMERCIAL FLUSHING TOILET

GENERAL INFORMATION	1.	Nomenclature - The special commercial flushing toilet consists of a porcelain water closet, a primary sewage treatment unit, and water supply and drainage connections. Such units operate on a power flush principle provided by either valve-controlled manual or electric pumps. Gravity flow is then utilized to move the waste product from the toilet to the storage tank.
	2.	Size and Weight - These special commercial flushing toilets are available in both standard and smaller sizes. Bowl heights range between 15-1/2 inches and 9-1/4 inches, with commensurate shipping weights that vary between 37 and 22 pounds.
WATER QUANTITY REQUIREMENTS	1.	Water requirements average one-half gallon per flush when used as a toilet, and one-third pint per flush when used as a urinal. The average person living under shelter conditions will require approximately 3.6 gallons of water for toilet purposes during a fourteen-day period.
WATER PRESSURE REQUIREMENTS	1.	The minimum water pressure requirements for proper power flushing action should exceed 8 pounds per square inch.
SHIPPING INFORMATION	1.	The special commercial flushing toilet is shipped completely assembled and ready for connection to the water inlet supply system and drain outlet.
INSTALLATION INSTRUCTIONS	1.	The special commercial flushing toilet is floor-mounted on an ordinary closet flange and connected to the storage tank by means of iron pipe on copper tube. The water valve and pump combination are connected by copper tubing to both the water source and the inlet fitting of the special commercial flushing toilet.

STORAGE TANK

GENERAL INFORMATION	1.	Nomenclature - The sewage tank is a cylindrically or rectangularly shaped vessel constructed of protectively lined steel, concrete, or ceramic tile. The tank is equipped with pipe fittings so that auxiliary items such as vent pipes, inlet sewage lines, and outlet sewage lines can readily be connected during tank installation.
	2.	Size and Capacity - The tank is commercially available in a variety of sizes. The capacity of the sewage tank is to be sized on the basis of being able to handle approximately 1 quart of waste products per person per day. If the flush toilet is used, the amount of flush water will need to be included when determining the tank volume needed.
	3.	Auxiliary Equipment - The sewage tank is equipped with a float control mechanism which activates the sewage discharge pump.
FABRICATION	1.	Steel storage tanks come with protective liners installed. Storage tanks are also constructed of cylindrical precast concrete segments or are fabricated on-site of ceramic bricks. The general design includes pipe fittings for pipe vents and inlet and outlet sewage lines.
INSTALLATION INSTRUCTIONS	1.	Storage tanks should be located below the shelter floor level or buried underground adjacent to the shelter. At the time of installation, the tank should be thoroughly checked for leaks and the vent pipe and inlet and outlet lines inspected for possible blockage. At the same time, the waste product level control device should be checked to ensure that it activates the waste disposal pump when the waste product level reaches the control point.

OCD-SUPPLIED CHEMICAL TOILET

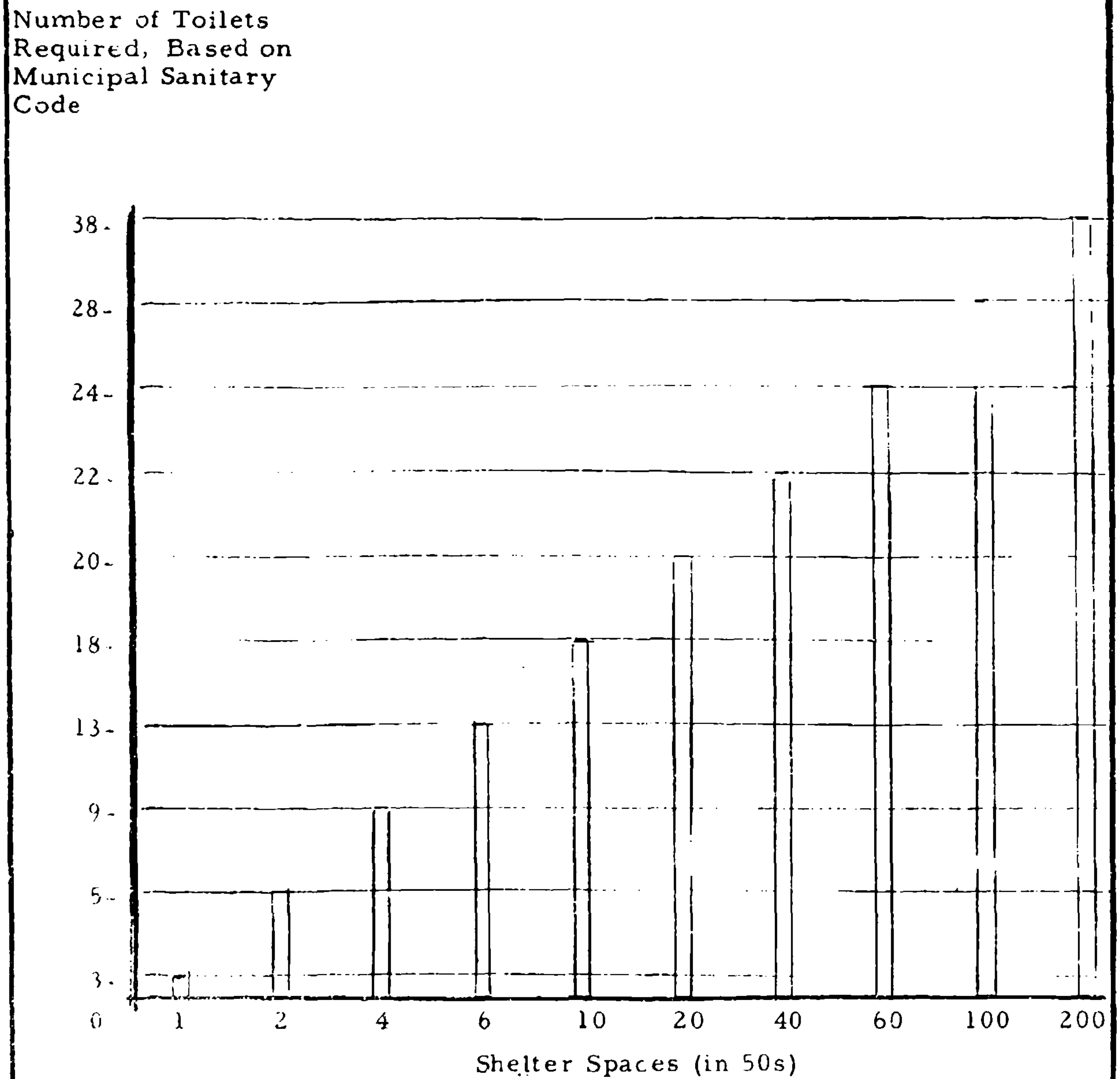
STEP 1	Determine the number of people to be maintained in the shelter.
STEP 2	Determine the total gallons of waste products this number of people will excrete. The OCD-supplied drums are designed to provide for somewhat more than 1 quart of waste per person per day.
STEP 3	Determine the required number of chemical toilets by dividing the total gallons of waste products by 17. By using the emptied, OCD-supplied water containers as toilets, the initial number of toilets ordered can be reduced on a one-for-one basis.

SPECIAL COMMERCIAL FLUSHING TOILET

STEP 1 — Determine the number of people to be maintained in the shelter.

STEP 2 — Determine the total number of special flushing toilets required from the selection chart below.

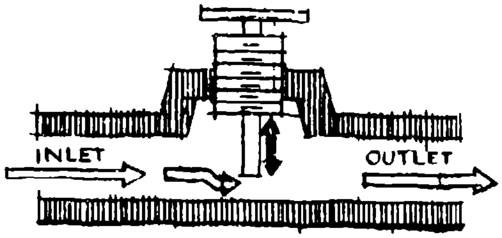
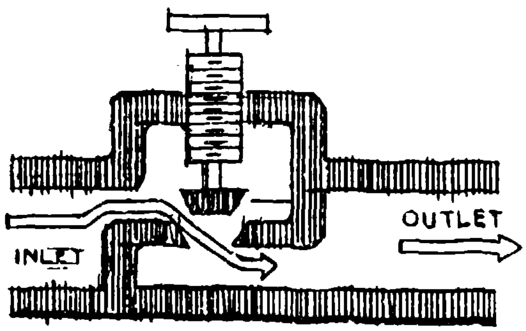
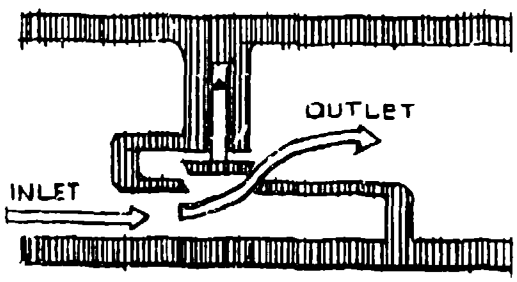
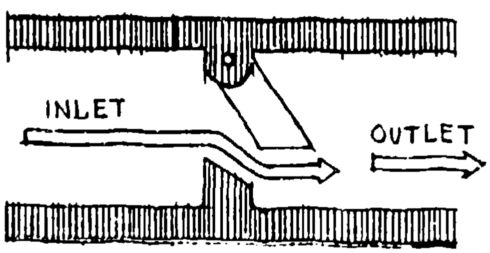
SPECIAL COMMERCIAL FLUSHING TOILET



STORAGE TANK

STEP 1	Determine the number of shelter occupants to be serviced.
STEP 2	Determine the approximate total amount of waste products the given number of people will excrete by multiplying the figure from step 1 by 1, the number of quarts of waste per person per day. If a substantial amount of food is planned as intake, a higher figure of waste per person per day should be planned for.
STEP 3	Determine the required tank capacity in cubic feet to hold this amount of waste.
STEP 4	Determine the total cubic feet available for placement of the waste disposal tank.

GATE, GLOBE, AND CHECK VALVES

Typical Design	Description
	**Gate Valve** A gate valve is a device which uses an orifice blocking gate to control the flow.
	**Globe Valve** A globe valve utilizes an adjustable valve and valve seat arrangement, oriented perpendicular to the flow, as the flow control mechanism.
	**Lift Check Valve** A lift check valve is a device used to prevent reversal of flow direction. The valve stem is oriented perpendicular to the flow and is raised by means of upstream pressure. A change in pressure direction closes the valve.
	**Swing Check Valve** A swing check valve prohibits flow reversal by means of a flapper which is opened by upstream pressure and closed by a reversal in flow direction.

GATE, GLOBE, AND CHECK VALVES

Globe Valve

GENERAL INFORMATION

1. Characteristics: The globe valve, which utilizes an adjustable valve orientated perpendicular to the flow, is used extensively for throttling of pressure lines and where close regulation of volume of flow of liquids is necessary. In general, the design requires two changes of direction of flow which causes some loss of pressure in the system. All globe valves are of the rising stem type. Ample space must be provided for operation to open completely.

2. Advantages: Globe valves have the capability of flow control and also are less expensive than gate valves.

3. Applications: These valves are used where flow regulation is required.

Gate Valve

GENERAL INFORMATION

1. Characteristics: The gate valve, when opened, offers little restriction to straight line flow. If the design is such that the gate moves out of the body of the valve with the stem, it is called a rising stem valve. If the gate moves out of the body of the valve along the stem, it is called a nonrising stem valve. Consideration of the mechanics of these two styles of gate valves is important. The rising stem type requires more space for stem clearance than does the nonrising type. An open or closed position of the gate is clearly indicated by the stem position.

2. Application: The gate valves are commonly used on lines conveying water and other liquids. These valves should not be used for throttling or volume flow control devices.

GATE, GLOBE, AND CHECK VALVES

Lift Check Valves

GENERAL INFORMATION

1. Characteristics: The lift check valve prohibits reversal of flow by means of a lift valve orientated perpendicular to the flow. Downstream flow forces the valve up out of its seat and permits the fluid to flow. Reversal of the flow direction causes the valve to seat and blocks the valve passage. In general, these valves require two changes in flow direction and therefore some friction losses are incurred.

2. Application: These valves are used to check or prohibit reversal of fluid flow.

Swing Check Valve

GENERAL INFORMATION

1. Characteristics: A swing check valve prohibits flow reversal by means of a flapper. Upstream pressure unseats the valve and permits the fluid to flow in a selected direction. A flow reversal causes the flapper to seat, thus checking the flow.

2. Application: These valves are used to check or prohibit reversal of fluid flow and where valve frictional losses are required to be minimized.

INSTALLATION INSTRUCTIONS

1. Prior to installation, ensure that the valve operates mechanically. Next, close the valve and fill the valve chamber through the inlet port. Check to determine whether the valve properly seats itself. For check valves, ensure that the valve is installed in the proper direction of the flow.

GATE, GLOBE, AND CHECK VALVES

STEP 1	Determine the function of the valve. For example, for general fluid transmission lines, use gate valves; for throttling or flow control, use globe valves; and for prevention of flow reversal, use lift or swing check valves. The use of swing check valves is indicated in a system which contains large pipe friction losses.
STEP 2	Determine the size of the valve inlet and outlet ports by matching them with their respective size fluid transmission lines.
STEP 3	Determine the type of fluid, whether corrosive or noncorrosive, to be transported. Select a valve which is made of materials appropriate for the conditions.
STEP 4	Ensure that the rated flow capacity of the valve is equal to or greater than the required flow rate through the outlet transmission lines.

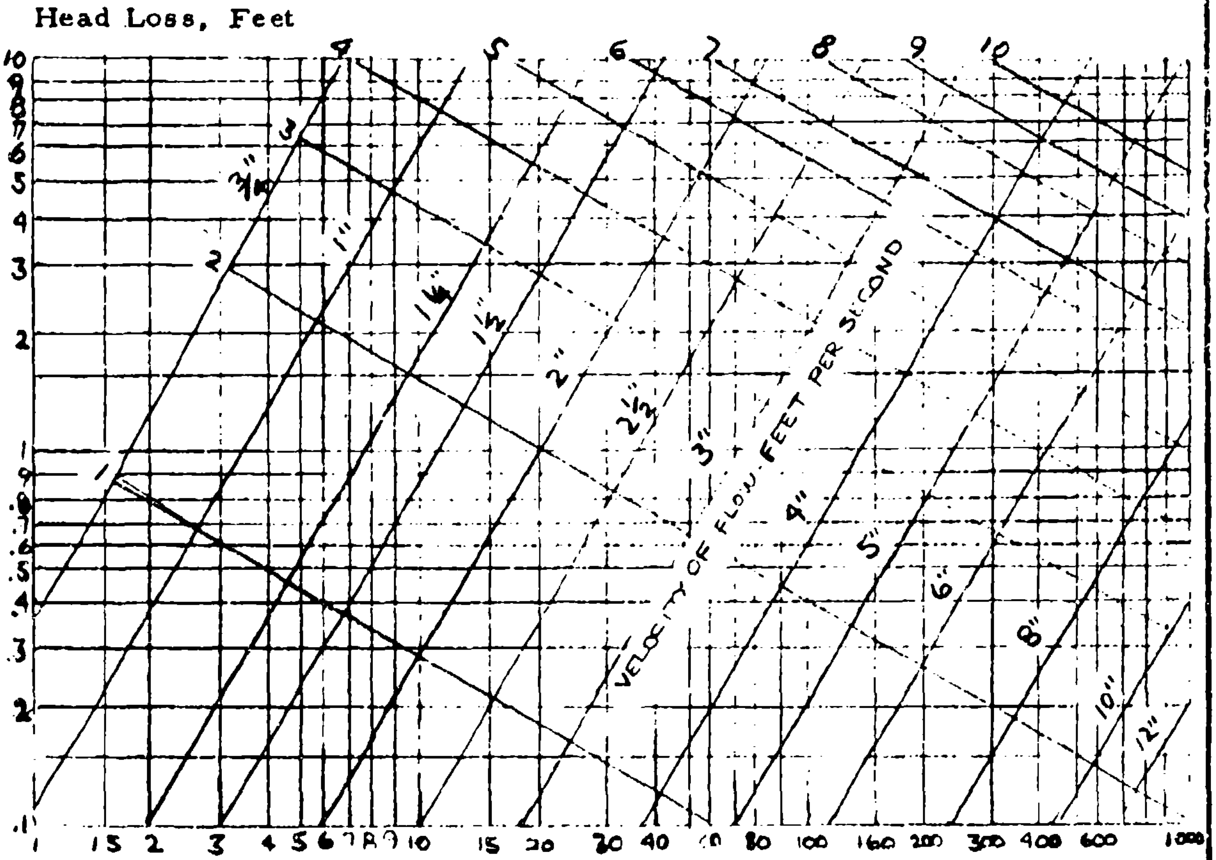
PIPING

GENERAL EXPLANATION	1.	Pipe Materials - The most common types of materials used for piping are iron, steel, brass, copper, lead, and their alloys.
	2.	Pipe Sizes - Cast iron pipe is available in a wide range of sizes, from 1-1/4 to 12 inches in diameter, and in two weights called regular and extra strong. Copper water tubing is available in sizes ranging from 1/8 inch to 12 inches in diameter. Its wall thickness is considerably less than that of most other piping.
APPLICATION INFORMATION	1.	Pipe size should be sufficient to keep head loss due to friction at a minimum. Inlet lines should be chosen large enough to reduce vacuum created at the pump, thus reducing the danger of air being drawn into the system. Similarly, inlet lines should be simple, with as few elbows, bends, valves, and other restrictions as possible. Long lengths of tubing or small diameter pipe should be especially avoided. Outlet lines of sufficient size will decrease the pump operating head, with a resultant increase in the pump discharge volume.

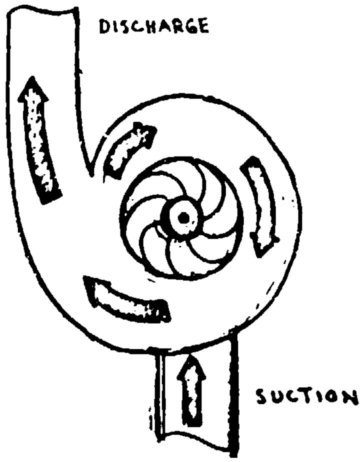
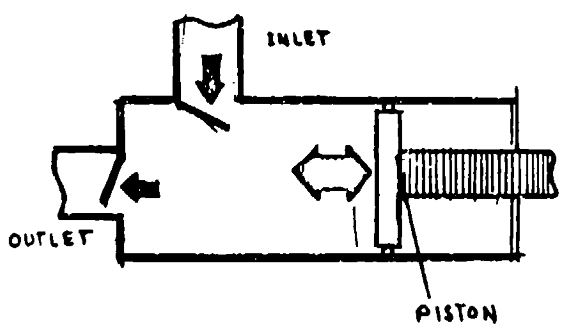
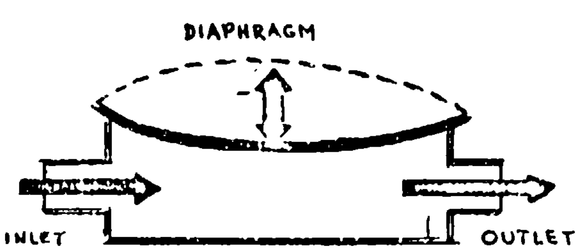
PIPING

STEP 1	Determine the equivalent length of pipe represented by the required number of fittings and valves from the conversion chart shown on the following page.
STEP 2	Determine the required length of connecting pipe and add it to the total previously determined in step 1.
STEP 3	Determine the required rate of flow in gallons per minute.
STEP 4	Select pipe size to minimize friction losses from the water friction loss chart shown on the page following the conversion chart. The friction loss values shown on the chart are for new pipe and should be multiplied by 1.8 to determine friction losses for old pipe. If liquids other than water or waste products are to be transported, then it will be necessary to obtain similar friction loss charts for these specific liquids.

FRICTION LOSS FOR WATER IN FEET PER 100 FEET OF NEW PIPE



WASTE SUPPLY, WASTE DISPOSAL, AND DRAINAGE PUMPS

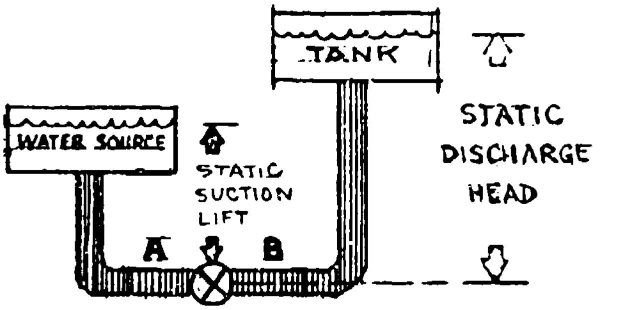
Typical Design	Description
	**Centrifugal Pump** A centrifugal pump consists basically of an impeller rotating within a casing. The impeller is made up of a number of blades mounted on a shaft which projects outside the casing. In operation, the impeller imparts a pressure to the fluid being pumped, and the casing guides the fluid to and from the impeller.
	**Piston Pump** A piston or reciprocating pump consists of a piston, a cylinder, and valves for inlet and discharge of the liquid being pumped. Motion is imparted to the liquid by the piston moving back and forth in the cylinder. The operation of the inlet and discharge valves is related in a definite manner to the motion of the piston.
	**Diaphragm Pump** A diaphragm pump is another form of reciprocating pump. In this type of pump, a flexible diaphragm separates the suction chamber from the discharge chamber. The diaphragm moves up and down through the action of a yoke or rod, and a discharge valve forces the liquid from the suction chamber into the discharge pipe.

WATER SUPPLY, WASTE DISPOSAL, AND DRAINAGE PUMPS

GENERAL TERMS	1. Capacity - The volume of liquid in gallons per minute handled by a pump.
	2. Friction Head - The hydraulic pressure in pounds per square inch or feet of water required to overcome frictional resistance of the valve and piping system.
	3. Static Suction Lift - The hydraulic pressure in pounds per square inch or feet of water below atmosphere at the intake port with the liquid at rest.
	4. Total Suction Lift - The sum of the static suction lift and the friction head of the suction valves and piping.
	5. Total Suction Head - The sum of the difference between the static suction lift and the friction head of the suction valves and piping.
	6. Static Discharge Head - The hydraulic pressure in pounds per square inch or feet of water exerted at the pump discharge by the liquid at rest.
	7. Total Discharge Head - The sum of the static discharge head and the friction head of the discharge valves and piping.
	8. Total Pumping Head - The sum of the total discharge head and the total suction lift or the difference between the total discharge head and the total suction head.

WATER SUPPLY, WASTE DISPOSAL, AND DRAINAGE PUMPS

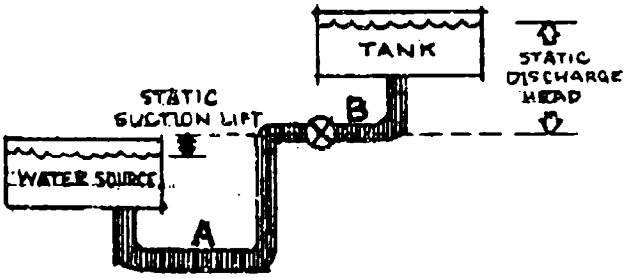
GENERAL EXAMPLES



Total Suction Lift = Static Suction Lift + Friction Head A

Total Discharge Head = Static Discharge Head + Friction Head B

Total Pumping Head = Total Suction Lift + Total Discharge Head



Total Suction Head = Static Suction Head - Friction Head A

Total Discharge Head = Static Discharge Head + Friction Head B

Total Pumping Head = Total Discharge Head - Total Suction Head

CENTRIFUGAL PUMP GENERAL INFORMATION

1. Centrifugal pumps are the most widely used pumps for transferring liquids of all types. They are available in a variety of capacities, from 2 or 3 gallons per minute up to 100,000 gallons per minute. Discharge pressure capabilities vary from a few feet up to 3000 pounds per square inch. Advantages of

WATER SUPPLY, WASTE DISPOSAL, AND DRAINAGE PUMPS

CENTRIFUGAL PUMP GENERAL INFORMATION

this type of pump include lower initial cost, smaller floor area requirement, quiet operation, uniform pumping rate, and high efficiency.

PISTON PUMP GENERAL INFORMATION

1. The cylinder and piston method of moving fluids is commonly used in both hand pumps and motor-driven pumps. The advantages of this type of pump over those of a centrifugal pump include greater flexibility and capacity for the same physical size, more head acceptance, and greater flexibility of speed. Disadvantages include high initial cost, greater floor space requirement, and noisier operation.

DIAPHRAGM PUMP GENERAL INFORMATION

1. The diaphragm pump is normally a manually driven pump and is used for emptying tanks and sumps. The range of capacities and discharge pressures available with this type of pump is limited.

PUMP HORSEPOWER REQUIREMENTS

1. To determine the actual or brake horsepower requirement for a given pump application, it is necessary to know the volume in gallons per minute, the total pumping head in feet, the specific gravity of the liquid being pumped, and the efficiency of the given pump. The pump horsepower requirement is then determined by means of the following formula:

$$HP = \frac{GPM \times H \times S}{3,960 \times E}$$

where

HP = Pump horsepower requirement,
GPM = Volume in gallons per minute,
H = Total pumping head,
S = Specific gravity of the liquid,
E = Pump efficiency expressed as a decimal.

WATER SUPPLY, WASTE DISPOSAL, AND DRAINAGE PUMPS

STEP 1

Determine the required rate of flow in gallons per minute.

STEP 2

Determine the total discharge head in feet of water or other liquid. The specific steps normally involved are the following:

(1) Determine the total required length of discharge pipe.

(2) Convert the required number of fittings and valves into equivalent lengths of pipe using a conversion chart like the one shown in the Piping Selection Procedure section.

(3) Calculate the total equivalent length of pipe in feet by adding the total determined in step 1 to that determined in step 2.

(4) Select the friction loss factor per 100 feet for the type of condition and size of pipe to be used from a friction loss chart like the one shown in the Piping Selection Procedure section.

(5) Calculate the total friction discharge head in feet by multiplying the total equivalent length of pipe in feet calculated in step 3 by the friction loss factor selected in step 4, and then dividing this product by 100.

(6) Determine the total static discharge head in feet by measuring the distance between the center line of the pump outlet and the maximum level to which the water or other liquid is to be pumped.

(7) Calculate the total discharge head in feet by adding the total friction discharge head calculated in step 5, to the total static discharge head, calculated in step 6.

STEP 3

Determine the total suction head or lift in feet of water or other liquid.

(1) Determine the total required length of suction pipe.

(2) Convert the required number of fittings and valves into equivalent lengths of pipe using a conversion chart like the one

WATER SUPPLY, WASTE DISPOSAL, AND DRAINAGE PUMPS

shown in the Piping Selection Procedure section.

(3) Calculate the total equivalent length of pipe in feet by adding the total determined in step 1 to that determined in step 2.

(4) Select the friction loss factor per 100 feet for the type, condition, and size of pipe to be used from a friction loss chart like the one shown in the Piping Selection Procedure section.

(5) Calculate the total friction suction head in feet by multiplying the total equivalent length of pipe in feet calculated in step 3 by the friction loss factor selected in step 4, and then dividing this product by 100.

(6) Determine the total static suction head in teet by measuring the distance between the center line of the pump inlet and the water level of the water supply.

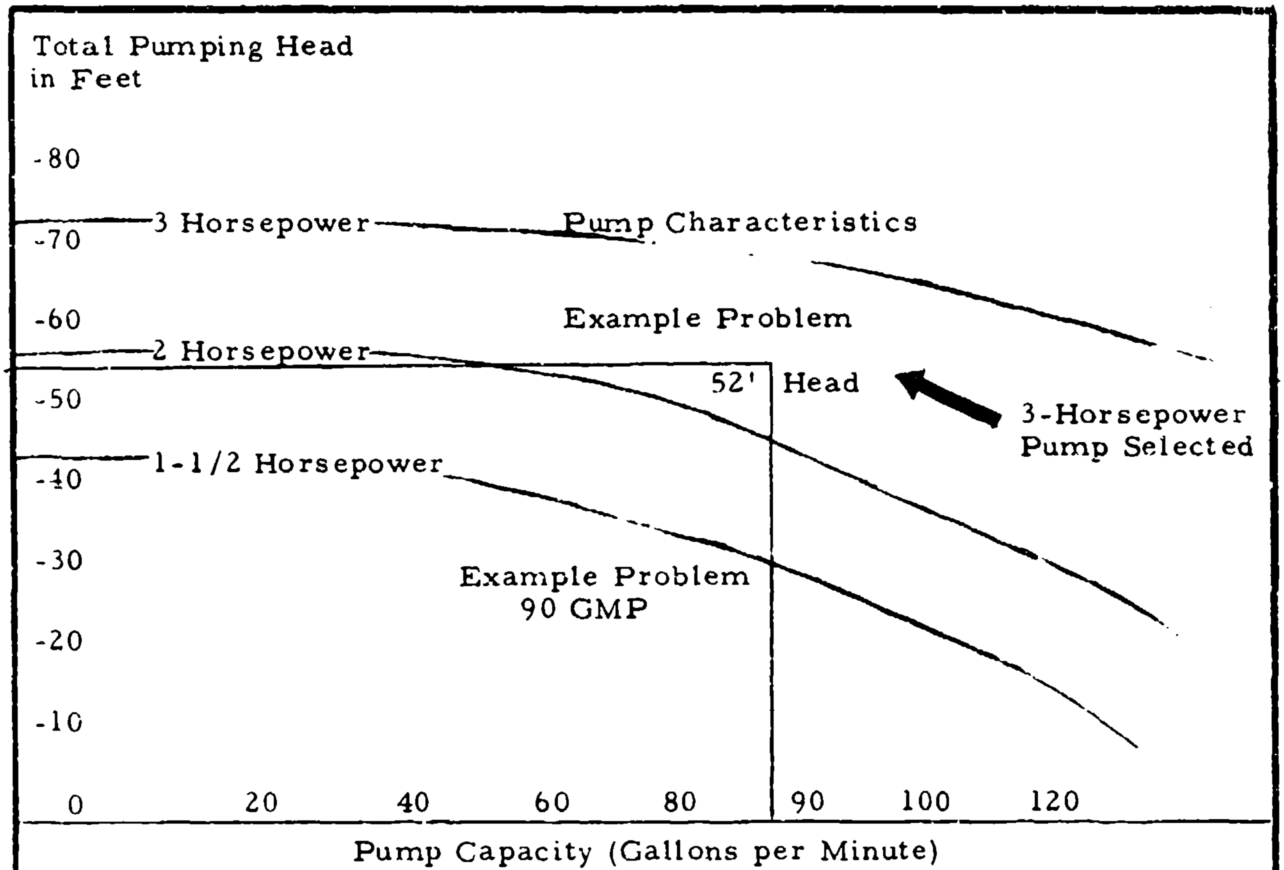
(7) Calculate the total suction head in feet, if the pump is located above the water source, by subtracting the total friction suction head calculated in step 5 from the total static suction head calculated in step 6.

(8) Calculate the total suction lift in feet, if the pump is located below the water source, by adding the total friction suction head calculated in step 5 to the total static suction head calculated in step 6.

STEP 4 — Determine the total pumping head in feet of water or other liquid by either adding the total discharge head and total suction lift or subtracting the total suction head from the total discharge head.

STEP 5 — Select the proper size pump and motor horsepower requirements from a manufacturer's catalog on the basis of the predetermined rate of flow and total pumping head. See the chart on the following page for an example of a typical manufacturer's pump performance curves and characteristics.

TYPICAL PERFORMANCE CURVES FOR A CENTRIFUGAL PUMP



MAINTENANCE AND OPERATING DATA

GRAVITY-FEED SYSTEMS		
MONTHLY STANDBY INSPECTION	1.	Make visual check for system damage or leaks.
	2.	Check tank water level gauge to ensure tank is filled.
	3.	Lubricate all exposed valve moving parts.
	4.	Open master and secondary outlet valves and check rate of water flow.
START-UP	1.	Ensure that master and secondary outlet valves are closed.
	2.	Check tank water level gauge to ensure that tank is filled.
	3.	Close tank inlet valve.
	4.	Check system for damage or leaks.
TROUBLESHOOTING	1.	Check inlet strainer for blockage.
NO DISCHARGE OF WATER INTO TANK	2.	Check inlet valve for blockage and remove any obstruction
NO DISCHARGE OF WATER FROM TANK	1.	Check master outlet valve for blockage and remove any obstruction.
	2.	Check secondary outlet valves for blockage and remove any obstructions.
LEAK IN VALVE	1.	Tighten stuffing boxes.
	2.	Replace packing if leakage continues.
LEAK IN THREADED PIPE COUPLING	1	Tighten threaded pipe coupling.
	2.	Spread sealer around leaky joint and wrap soft wire around cement at the leak if leakage continues.

MAINTENANCE AND OPERATING DATA

GRAVITY-FEED SYSTEMS

TROUBLESHOOTING	1.	Tighten bolts in flanged coupling.
LEAK IN FLANGED PIPE COUPLING	2.	Remove all bolts around the flange and insert a piece of rope around the flange inside the circle of bolt holes if leakage continues. Tighten bolts and plug any opening by filling with iron cement.
SHUTDOWN	1.	Make visual check for system damage or leaks.
	2.	Ensure that master and secondary outlet valves are closed.
SPARE PARTS	1.	Valve packings
	2.	Valve and pipe gaskets
	3.	Soft copper wire
	4.	Rope
	5.	Pipe sealer
	6.	Solder
TOOLS	1.	Pipe wrenches
	2.	Soldering iron
	3.	Blowtorch
	4.	Pliers
	5.	Hammer
	6.	Sandpaper or emery cloth
	7.	Flashlight

MAINTENANCE AND OPERATING DATA

GRAVITY-FEED SYSTEMS		
IDENTIFICATION AND CODING	1.	Paint all water supply tanks, valves, and piping blue for easy identification.
	2.	Prepare and attach tags specifying purpose and use to all valves.
POWER-FEED SYSTEM		
MONTHLY STANDBY INSPECTION	1.	Make visual check for system damage or leaks.
	2.	Check tank water level gauge to ensure tank is filled.
	3.	Lubricate all exposed valve moving parts.
	4.	Run pump a few minutes and check for discharge.
START-UP	1.	Ensure that all pump discharge valves are closed.
	2.	Check pump for prime.
	3.	Close switch to start pump.
TROUBLESHOOTING		
NO DISCHARGE OF WATER INTO TANK	1.	Check pump for priming.
	2.	Check for plugged or obstructed strainers or piping.
NO DISCHARGE OF WATER FROM TANKS	1.	Ensure that pump is running in right direction.
	2.	Check direction pump impeller for damage.
	3.	Check for blown fuse.

MAINTENANCE AND OPERATING DATA

POWER-FEED SYSTEM		
TROUBLESHOOTING		
NO DISCHARGE OF WATER FROM TANKS	4.	Check for tripped circuit breaker.
	5.	Check for loose connections.
LEAK IN VALVE	1.	Tighten stuffing boxes.
	2.	Replace packing if leakage continues.
LEAK IN THREADED PIPE COUPLING	1.	Tighten threaded pipe coupling.
	2.	Spread sealer around leaky joint and wrap soft wire around cement at the leak if leakage continues.
LEAK IN FLANGED PIPE COUPLING	1.	Tighten bolts in flanged coupling.
	2.	Remove all bolts around the flange and insert a piece of rope around the flange inside the circle of bolt holes if leakage continues. Tighten bolts and plug any openings by filling with iron cement.
SHUTDOWN	1.	Make visual check for system damage or leaks.
	2.	Ensure that master and secondary outlet valves are closed.
	3.	Open electric switch.

MAINTENANCE AND OPERATING DATA

POWER-FEED SYSTEM

SPARE PARTS	1.	Valve packings
	2.	Valve and pipe gaskets
	3.	Soft copper wire
	4.	Rope
	5.	Pipe sealer
	6.	Solder
	7.	Pump packings and gaskets
	8.	Fuses
TOOLS	1.	Pipe wrenches
	2.	Soldering iron
	3.	Blowtorch
	4.	Pliers
	5.	Hammer
	6.	Sandpaper or emery cloth
	7.	Flashlight
	8.	Adjustable wrench
	9.	Various socket wrenches
IDENTIFICATION AND CODING	1.	Paint all water supply tanks, valves, and piping blue for easy identification.
	2.	Prepare and attach tags specifying purpose and use to all valves.
	3.	Prepare and attach tags to all electric switches

MAINTENANCE AND OPERATING DATA

POWER- AND GRAVITY-FEED TANK SYSTEMS		
MONTHLY STANDBY INSPECTION	1.	Make visual checks for damage or leaks.
	2.	Check water source for proper operation.
	3.	Check sewage pump for operation.
START-UP	1.	Open water supply valve.
	2.	Turn on electricity to sewage pump.
	3.	Open sewage discharge valve.
TROUBLESHOOTING		
COMMODES WILL NOT FLUSH	1.	Check to ensure that water source valve is open.
	2.	Check commode float valves.
SEWAGE PUMP NOT WORKING OR SEPTIC TANK NOT EMPTYING	1.	Check for blown fuse.
	2.	Ensure that switch is not turned off.
	3.	Ensure that float valve is not stuck or defective.
	4.	Check for closed or plugged sewer discharge valve.
SHUTDOWN	1.	Close water supply and discharge valves.
	2.	Turn off electricity supply to pump.

MAINTENANCE AND OPERATING DATA

POWER- AND GRAVITY-FEED TANK SYSTEMS

MAINTENANCE	1.	Check float valves, clean and lubricate as necessary.
	2.	Check valve packing, tighten glands as necessary.
	3.	Check pump seals for leakage and replace as necessary.
SPARE PARTS	1.	Gaskets and seals
	2.	Valve and float packing
	3.	Fuses
TOOLS	1.	Pipe wrench
	2.	Adjustable wrench
	3.	Pliers
	4.	Hammer
	5.	Screwdriver
IDENTIFICATION AND CODING	1.	Paint sewage discharge piping yellow.
	2.	Tag all valves and switches as to purpose and use.

MAINTENANCE AND OPERATING DATA

OCD-SUPPLIED CHEMICAL TOILET

MONTHLY STANDBY INSPECTION	1.	Ensure that the sanitation kit drums are not stacked more than six high.
	2.	Check storage area for dampness.
	3.	Ensure that kits remain sealed.
PREPARATION FOR USE	1.	Remove entire contents from sanitation kit.
	2.	Remove the commode chemical box.
	3.	Carefully place plastic bag liner in drum seating base of bag in the base of the drum. Spread mouth of bag over and around top of drum about four inches. Add the chemical kit as directed on the container. Place commode seat on drum, making sure that plastic bag is securely in place.
	4.	Place toilet tissue in close proximity.
AFTER USE	1.	Between uses, place drum cover in an inverted position over the commode seat.
DISPOSITION	1.	When waste reaches level of the sanitary fill line on drum, remove the commode seat.
	2.	Take tie wire, gather the top of the plastic bag assembly together, and tie securely.
	3.	Do not remove bag from drum.
	4.	Replace drum cover and move drum to storage.

MAINTENANCE AND OPERATING DATA

MANUAL SYSTEM		
MONTHLY STANDBY INSPECTION	1.	Operate pump several strokes and check performance.
	2.	Make visual checks for system damage or leaks.
START-UP	1.	Open supply and discharge valves.
	2.	Begin manual pumping.
TROUBLESHOOTING		
NO DISCHARGE OF SEWAGE	1.	Check for closure of inlet valve.
	2.	Check for closure of discharge valve.
	3.	If diaphragm type pump, inspect diaphragm for breakage.
	4.	Check lines and piping for plugged lines.
	5.	Check inlet pipe for split or leaks, causing loss of prime.
SHUTDOWN	1.	Stop pumping.
	2.	Close inlet and discharge valves.
SPARE PARTS	1.	Pump diaphragms
	2.	Gaskets and packing

MAINTENANCE AND OPERATING DATA

AUTOMATIC SUMP PUMP		
MONTHLY STANDBY INSPECTION	1.	Operate pump several minutes.
	2.	Check system for proper operation of float valve.
START-UP	1.	Open discharge valve.
	2.	Turn on pump.
TROUBLESHOOTING		
PUMP DOES NOT RUN	1.	Check for blown fuse.
	2.	Check for defective motor.
	3.	Ensure that float valve is not stuck.
WATER DOES NOT EMPTY FROM SUMP	1.	Check for defective pump motor.
	2.	Ensure that discharge valve is closed.
	3.	Check discharge pipe to see if plugged or otherwise obstructed.
SHUTDOWN	1.	Shut off electricity.
	2.	Close discharge valve.
SPARE PARTS	1.	Pump seals
	2.	Gaskets
	3.	Float switch

MAINTENANCE AND OPERATING DATA

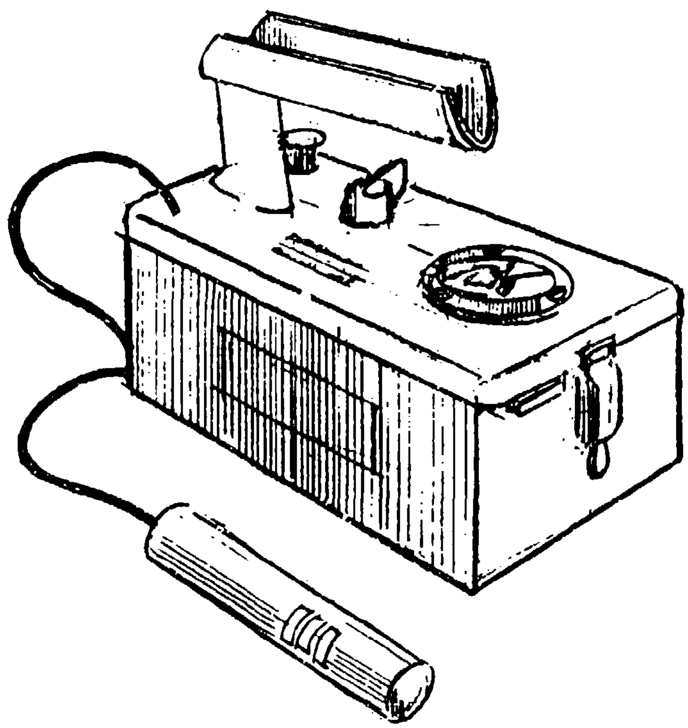
AUTOMATIC SUMP PUMP	
TOOLS	1. Hammer 2. Screwdriver 3. Pipe wrench 4. Adjustable wrench 5. Pliers
CODING AND IDENTIFICATION	1. Paint discharge piping yellow. 2. Tag valves and switches as to purpose or use.

SUGGESTED SAMPLE
DESIGN OF PAGE

SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 6

RADIOLOGICAL INSTRUMENTATION UNITS



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

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Table of Contents	How to Use Guidelines

Use the Table of Contents given below to locate quickly key technical data pertaining to the selection and operation of Radiological Instrumentation Units.

The Introduction and Component Selection provides all essential data regarding unit requirements and typical unit designs. Unit component descriptions and application data are also given in this section.

The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions for relatively unskilled people.

NEED FOR RADIOLOGICAL INSTRUMENTATION UNITS

Unit Uses

Radiological instrumentation units are indispensable to shelter operations. The operation of such instruments will be required from the period shortly after a nuclear attack until the radiological hazard from fallout diminishes to the point that normal activities may be resumed without significant danger to the shelter inhabitants.

The radiological requirements of shelter inhabitants will involve monitoring personnel and food and water, as well as monitoring areas within and probably without the shelter. When the radiation intensity or dose rates have decreased to the extent that limited outside activities can be performed, the radiological instrument units can be mobilized to support operations of emergency services such as rescue, fire, and police.

Radiological instrument units divide logically by type into ratemeters and dosimeters.

Ratemeters

Ratemeters are required to measure the intensity of gamma ray radiation in roentgens per hour or milliroentgens per hour. The primary use of the instrument is for measurement of the rate at which gamma radiation is being received in a particular area.

Dosimeters

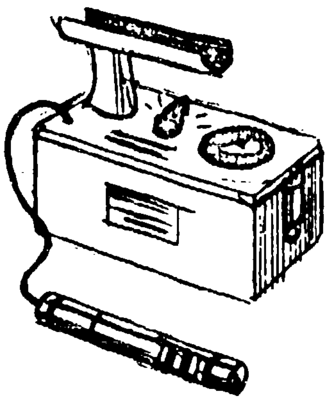
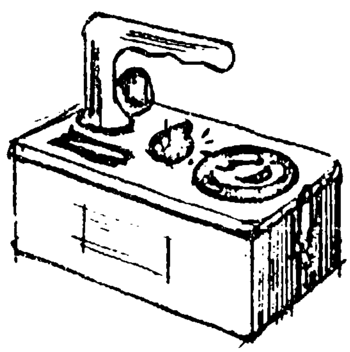
Dosimeters are required to measure the total amount of gamma radiation to which a shelter occupant has been exposed during a specific period of time.

Note: For additional information on this subject refer to the Handbook for Radiological Monitors, FG-E-5.9, available from your local civil defense organization.

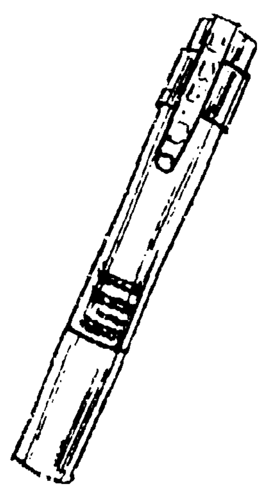
SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	RATEMETERS PERSONNEL MONITORING	RATEMETERS AREA MONITORING	DOSIMETERS
ABOVEGROUND AND BELOWGROUND SHELTERS				
50 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
100 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
200 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
300 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
500 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
1,000 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
2,000 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
3,000 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
5,000 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	
10,000 PEOPLE	Best	Type I		Type I
	Acceptable		Type II	

ACCEPTABLE RADIOLOGICAL INSTRUMENTATION UNITS

Type Designation	Typical Design	Description
RATEMETERS		
Type I		CD V-700 Ratemeter The CD V-700 ratemeter is a low-range instrument that measures gamma ray dose rates and detects the presence of beta particles. The unit consists of a probe, the monitoring instrument itself, and a set of headphones. This unit can be used in long-term cleanup and decontamination operations, for personnel monitoring, and for monitoring the degree of radioactive contamination of food and water.
Type II		CD V-715 Ratemeter The CD V-715 ratemeter is a high-range instrument that measures gamma ray dose rates but has no beta detection capability. The CD V-717 ratemeter is a modification of the CD V-715 unit to the extent that it is equipped with a removable ionization chamber and 25 feet of cable which attaches to the CD V-715 ratemeter. These units can be used for ground survey, in fallout monitoring stations, and in community shelters. Note: These items are OCD-supplied as part of the shelter-stocking program.

ACCEPTABLE RADIOLOGOCAL INSTRUMENTATION UNITS

Type Designation	Typical Design	Description
DOSIMETERS		
Type I		**CD V-742 Dosimeter** The CD V-742 dosimeter is an instrument that measures the total amount of gamma ray radiation to which the instrument has been exposed from a given point in time. It records a running total of all gamma ray radiation it receives from the instant that it is exposed to radiation, regardless of the rate of radiation. The unit consists of the monitoring instrument itself and a CD V-750 charger which zeros the dosimeter prior to use. Note: This item is OCD-supplied as part of the shelter-stocking program

RADIOLOGICAL INSTRUMENTATION UNITS

GENERAL TERMS

1. Radiation - Nuclear radiation. Energy and particles emitted from the nuclei of radioactive atoms. The important nuclear radiations from radioactive fallout are beta particles and gamma rays.

2. Radioactivity - The spontaneous break-down of nuclei of unstable atoms with the resulting emission of nuclear radiation, generally alpha or beta particles, often accompanied by gamma rays.

3. Fallout - The process of the fallback to the earth's surface of particles contaminated with radioactive bomb fragments from a nuclear explosion.

4. Alpha Particles - Particles emitted from the nuclei of heavy radioactive atoms such as radium, uranium, or plutonium. Alpha particles do not penetrate the skin and, thus, are not an external hazard. If emitted inside the body, they can cause severe damage in the tissue very close to the source. It is unlikely that fallout from efficient nuclear explosions will emit significant amounts of alpha radiation.

5. Beta Particles - Particles emitted from the nuclei of some types of radioactive atoms. When heavy atoms are split in a nuclear detonation the fragments formed are usually beta emitters. Beta radiation has sufficient penetrating power to burn the skin if a high concentration of fallout particles remains in contact for several hours. If fission products are taken into the body, beta radiation can be an internal hazard

6. Gamma Rays - Nuclear radiation of high energy originating in atomic nuclei and accompanying many beta particles as they are emitted from the fragments of heavy atoms split in a nuclear detonation. Physically, gamma rays are identical with x-rays of high energy. Gamma rays are very penetrating and for practical shielding considerable amounts of dense material are usually employed.

RADIOLOGICAL INSTRUMENTATION UNITS

GENERAL TERMS

7. Roentgen - A unit of measure for gamma radiation exposure.

8. Milliroentgen - 1/1000 of a roentgen. 1000 milliroentgens equal one roentgen.

9. Dose - Accumulated or total exposure to gamma radiation, commonly expressed in roentgens.

10. Dose Rate - The rate or dose per unit time of exposure to gamma radiation, commonly expressed in roentgens per hour, or milliroentgens per hour.

11. Calibration - Determination of variation in accuracy of radiological instruments. Radioactive sources are used to produce known dose rates. The variation in accuracy of a radiological instrument can be determined by measuring these known dose rates

CD V-700 RATEMETER

GENERAL INFORMATION

1. Uses - The CD V-700 ratemeter is a low-range radiological instrument that measures gamma dose rates between zero and 50 milliroentgens per hour as well as detects the presence of beta. Its principal use is for personnel monitoring and indicating the degree of radioactive contamination in food and water. Since the instrument is designed for low-level measurements, it has limited usefulness in areas of high contamination.

2. Controls - The instrument has only one control, a selector switch, which can be moved between the off position and three ranges labeled X100, X10 and X1. When the selector switch is set on the X1 range, the measured dose rate is read directly from the meter. When set on either the X10 or X100 ranges, the meter readings must be multiplied by 10 and 100, respectively, to obtain the measured dose rate.

RADIOLOGICAL INSTRUMENTATION UNITS

CD V-700 RATEMETER

GENERAL INFORMATION	3.	Response Time - The instrument requires approximately 30 seconds for warm-up prior to being placed into operation.
INSTALLATION INSTRUCTIONS	1.	Required Additional Components - The instrument incorporates a probe and headphone jack as integral parts of the basic instrument. The two additional components required to place the instrument in operation are a battery and a standard headphone. The headphone is not needed for visual reading.
	2.	The instrument is shipped calibrated and completely assembled from the factory, ready for connection to a headphone and battery. Reference should be made to the manufacturer's instruction manual for the proper battery installation. Particular attention should be given to correct battery polarity during installation. With proper batteries, the instrument should operate continuously for between 100 and 150 hours.
INSTRUMENT	1.	Radiation dose rates from 50 milliroentgens per hour to 1 roentgen per hour will produce off-scale instrument readings. Should the dose rates materially exceed 1 roentgen per hour, the instrument may saturate and read zero or less than full scale.

CD V-715 RATEMETER

GENERAL INFORMATION	1.	Uses - The CD V-715 ratemeter is a high range radiological instrument that measures gamma dose rates between zero and 500 roentgens per hour. Unlike the CD V-700 ratemeter, this instrument has no capability for beta detection.

RADIOLOGICAL INSTRUMENTATION UNITS

CD V-715 RATEMETER

GENERAL INFORMATION

Its principal use is for internal shelter measurement of high gamma dose rates, although the instrument can be used for certain external shelter area monitoring applications. Limitations on external measurement are human in nature since the instrument must be handcarried outside the shelter for external monitoring.

2. Controls - The instrument has two controls, a selector switch and a zero control switch. The selector switch has seven positions including circuit check, off, zero, X100 range, X10 range, X1 range and X0.1 range. When the selection switch is set on the X1 range, the measured dose rate is read directly from the meter. When set on the X0.1, X10, and X100 ranges, the ratemeter must be multiplied by a factor of 0.1, 10, or 100 respectively in order to obtain the measured dose rate.

   The second control, the zero control switch, is used to adjust the ratemeter reading to zero during operational checks and to adjust for zero drift during long periods of operation.

3. Response Time - The instrument requires approximately two minutes for warm-up prior to being placed into operation.

INSTALLATION INSTRUCTIONS

1. The instrument is shipped calibrated and completely assembled from the factory. Reference should be made to the manufacturer's instruction manual for the proper battery installation. Particular attention should be given to correct battery polarity during installation. With proper batteries, the instrument should operate continuously for between 100 and 150 hours.

RADIOLOGICAL INSTRUMENTATION UNITS

CD V-717 RATEMETER

GENERAL INFORMATION	1.	Uses - The CD V-717 ratemeter is a modification of the CD V-715 ratemeter and measures gamma dose rates between zero and 500 roentgens per hour. Like the CD V-715 ratemeter, this instrument has no capability for beta detection. Its principal use is for external shelter measurement of high gamma dose rates, although the unit can be used for any internal shelter area monitoring applications.
	2.	Nomenclature - The instrument consists of a CD V-715 ratemeter equipped with a removable ionization chamber attached to 25 feet of cable.
	3.	Controls - The instrument's controls are identical with those previously described for the CD V-715 ratemeter.
INSTALLATION INSTRUCTIONS	1.	The CD V-715 instrument and the removable ionization chamber are both shipped completely assembled and calibrated from the manufacturer.
	2.	Installation of the instrument requires placement of the ionization chamber outside the shelter at any height above the ground and about 20 feet from the shelter and connection of the battery and the ionization chamber cable to the instrument.

RADIOLOGICAL INSTRUMENTATION UNITS

CD V-742 DOSIMETER AND CD V-750 DOSIMETER CHARGER		
GENERAL INFORMATION	1.	Uses - The CD V-742 dosimeter is an instrument designed for measuring accumulated exposure doses of gamma radiation in the range between zero and 200 roentgens. The CD V-750 dosimeter charger is used to zero and to read the dosimeter when no light source is available.
	2.	Controls - The CD V-742 dosimeter has no controls since it is zeroed by pressing the instrument down on the charging contact of the CD V-750 dosimeter charger and holding it there until the meter indicates zero. The CD V-750 dosimeter charger has a variable voltage control. The charging action is initiated by pressing the CD V-742 dosimeter down on the charging contact of the charger. Similarly, charging action is stopped by removing the dosimeter from the charger.
INSTALLATION INSTRUCTIONS	1.	The CD V-742 dosimeter and CD V-750 dosimeter charger are both shipped completely assembled and calibrated by the manufacturer. Reference should be made to the manufacturer's instruction manual for proper installation of batteries in the dosimeter charger. Particular attention should be given to correct battery polarity during installation.
STORAGE INFORMATION	1.	The CD V-742 dosimeter will probably require a charging prior to use, if placed in long-term storage in an uncharged condition. A second charging may also be required. When dosimeters are not in use, they should be charged and stored in a dry place.

CD V-700, CD V-715, AND CD V-717 RATEMETERS
CD V-742 DOSIMETERS AND CD V-750 DOSIMETER CHARGER

STEP 1	OCD supplies one set of these units per shelter.
STEP 2	Additional units may be desirable supplementary to the initial issue or because the shelter is very large. For example, several dosimeters and two ratemeters may be sought for a shelter having several hundred spaces.

MAINTENANCE AND OPERATING DATA

CD V-700 RATEMETER

ANNUAL STANDBY MAINTENANCE

1. Ensure that the instrument is calibrated annually or sooner if required.

2. Replace the instrument batteries annually or sooner if required.

BI-MONTHLY STANDBY INSPECTION

1. Install batteries and make an operational check of the instrument as follows:

   (1) Turn the selector switch to the X10 range and allow at least 30 seconds for warm-up.

   (2) Rotate the shield on the probe to the fully open position.

   (3) Place the open area of the probe as close as possible to the operational check source located on the instrument case.

   (4) Check to see that the meter reads between 1.5 and 2.5 milliroentgens per hour.

2. Enter the results of the operational check on an instrument inspection, maintenance and calibration log as follows:

   (1) Enter the date that the operational check was performed.

   (2) Indicate the action taken stating either inspected or the corrective action taken such as out for repair or batteries replaced.

   (3) Enter any pertinent remarks such as instrument operates properly or the identification number of the instrument if it requires corrective action.

MAINTENANCE AND OPERATING DATA

CD V-700 RATEMETER

BI-MONTHLY STANDBY INSPECTION	(4)	Enter the name of the individual who made the operational check.
START-UP AND PERSONNEL MONITORING OPERATIONS	1.	Insert the headphone plug into the jack on the instrument.
	2.	Check the operability of the instrument following the procedures previously described.
	3.	Place the probe in a light plastic bag or similar cover of lightweight material.
	4.	Put on the headphone if audio monitoring.
	5.	Hold the probe approximately two inches away from individuals and one inch away from food or water and search for possible contamination.
	6.	Initiate standard decontamination procedures for shelter occupants found to be contaminated
	7.	Decontaminate food or water found to be contaminated or place in storage and recheck for possible consumption after contamination has decreased due to radioactivity decay. Foods such as fruits and vegetables should be decontamination by washing, brushing, or peeling. Water should be decontaminated by either filtering or allowing any particles to settle out.
SHUTDOWN	1.	Take off the headphone.
	2.	Turn the instrument selector switch to the off position

MAINTENANCE AND OPERATING DATA

CD V-700 RATEMETER		
SHUTDOWN	3.	Remove the headphone plug from the jack on the instrument and store the headphone near the instrument.
	4.	Remove the batteries from the instrument and store in a cool dry place.
TROUBLESHOOTING		
OPERATIONAL CHECK INDICATES THAT INSTRUMENT REQUIRES CALIBRATION	1.	Return instrument to manufacturer for corrective maintenance, which can be adequately performed only by specially trained personnel using specialized equipment.
INSTRUMENT DOES NOT OPERATE	1.	Check batteries' contacts and clear, if required, or replace batteries.
	2.	Make operational check. If instrument still fails to operate, return it to the manufacturer for corrective maintenance.
TOOLS	1.	Soft cleaning cloth
	2.	Steel wool
	3.	Fine sandpaper
	4.	Screwdriver
SPARE PARTS	1.	Batteries
	2.	Light bulbs

MAINTENANCE AND OPERATING DATA

CD V-715 AND CD V-717 RATEMETERS		
ANNUAL STANDBY MAINTENANCE	1.	Ensure that the instrument is calibrated annually or sooner if required.
	2.	Replace the instrument batteries annually or sooner if required.
BI-MONTHLY STANDBY MAINTENANCE	1.	Install batteries and make an operational check of the instrument as follows: (1) Turn the selector switch to the zero position and allow at least two minutes for warm-up. (2) Adjust the zero control to make the meter read zero. (3) Turn the selector switch to the circuit check position. (4) Check to see that the instrument reads within the red band marked circuit check. (5) Recheck the zero setting as the selector switch is turned to the X100 range, the X10 range, the X1 range and the X0.1 range.
	2.	Enter the results of the operational check on an instrument inspection, maintenance and calibration log as follows: (1) Enter the date that the operational check was performed. (2) Indicate the action taken stating either inspected or the corrective action taken such as out for repair or batteries replaced.

MAINTENANCE AND OPERATING DATA

CD V-715 AND CD V-717 RATEMETERS

BI-MONTHLY STANDBY MAINTENANCE

(3) Enter any pertinent remarks such as instrument operates properly or the identification number of the instrument if it requires corrective action.

(4) Enter the name of the individual who made the operational check.

START-UP AND SHELTER AREA MONITORING OPERATIONS

1. Check the operability of the instrument following the procedures previously described.
2. Hold the instrument approximately 3 feet above the ground.
3. Take readings at selected locations throughout the shelter.
4. Record these readings on a sketch of the shelter area.
5. Recommend occupation of shelter areas with dose rates below 2 roentgens per hour preferably or otherwise those areas with lowest dose rates.

START-UP AND UNSHELTERED MONITORING OPERATIONS WITH A CD V-715 RATEMETER

1. Check the operability of the instrument following the procedures previously described.
2. Take a dose rate reading at a specific location in the shelter. This should be done as soon as the dose rate reaches or exceeds 0.05 roentgens per hour.
3. Go outside to a preplanned location in a reasonably flat area, which is preferably unpaved and at least 25 feet away from buildings, and take an outside reading within 3 minutes of the above reading taken in step 2 above.

MAINTENANCE AND OPERATING DATA

CD V-715 AND CD V-717 RATEMETERS

START-UP AND UNSHELTERED MONITORING OPERATIONS WITH A CD V-715 RATEMETER

4. Calculate the protection factor of the shelter by dividing the outside dose rate by the inside dose rate.

5. Multiply future inside dose rate readings by the protection factor at the selected location to obtain the outside dose rate.

6. Recalculate the protection factor at least once every 24 hours during the first few postattack days, unless the outside dose rate is estimated to be above 100 roentgens per hour.

7. Record and report the dose rate measurements.

8. Take all dose rate measurements outside after the unsheltered dose rate has decreased to 25 roentgens per hour.

START-UP AND UNSHELTERED MONITORING OPERATIONS WITH A CD V-717 RATEMETER

1. Check the operability of the instrument following the procedures previously described.

2. Place the removable ionization chamber 3 feet above the ground in a reasonably flat area and at least 20 feet from the shelter, preferably this should be done prior to fallout arrival.

3. Cover the ionization chamber with a light plastic bag or other lightweight material.

4. Observe the outside dose rates directly on the instrument meter.

5. Record and report the dose rate measurements.

MAINTENANCE AND OPERATING DATA

CD V-715 AND CD V-717 RATEMETERS		
SHUTDOWN FOR A CD V-715 RATE-METER	1.	Turn the instrument selector switch to the off position.
	2.	Remove the batteries from the instrument and store in a cool dry place.
SHUTDOWN FOR A CD V-717 RATE-METER	1.	Turn the instrument selector switch to the off switch.
	2.	Disconnect the removable ionization chamber from the instrument and store near the instrument.
	3.	Remove the batteries from the instrument and store in a cool dry place.
TROUBLESHOOTING		
OPERATIONAL CHECK INDICATES THAT INSTRUMENT REQUIRES CALIBRATION	1.	Return instrument to manufacturer for corrective maintenance,which can be adequately performed only by specially trained personnel using specialized equipment.
METER LIGHT DOES NOT OPERATE	1.	Replace light bulb.
INSTRUMENT DOES NOT OPERATE	1.	Check battery contacts and clean, if required, or replace batteries.
	2.	Make operational check. If instrument still fails to operate, return it to the manufacturer for corrective maintenance.

MAINTENANCE AND OPERATING DATA

CD V-715 AND CD V-717 RATEMETERS		
TOOLS	1.	Soft cleaning cloth
	2.	Steel wool
	3.	Fine sandpaper
	4.	Screwdriver
SPARE PARTS	1.	Batteries
	2.	Light bulbs
CD V-742 DOSIMETER		
ANNUAL STANDBY MAINTENANCE	1.	Ensure that the instrument is calibrated annually or sooner if required.
	2.	Replace the instrument batteries annually or sooner if required.
BI-MONTHLY STANDBY INSPECTION	1.	Install batteries and zero the instrument using the CD V-750 dosimeter charger.
	2.	Check instrument leakage characteristics by placing it in a radiation-free area for 4 days. If the leakage rate exceeds 5 percent of full scale per 4 days, then the instrument should be returned to the manufacturer for corrective maintenance.
	3.	Enter the results of the operational check on an instrument inspection, maintenance and calibration log as follows: (1) Enter the date that the operational check was performed.

MAINTENANCE AND OPERATING DATA

CD V-742 DOSIMETER

BI-MONTHLY STANDBY INSPECTION

(2) Indicate the action taken stating either inspected or the corrective action taken such as out for repair or batteries replaced.

(3) Enter any pertinent remarks such as instrument operates properly or the identification number of the instrument if it requires corrective action.

(4) Enter the name of the individual who made the operational check.

START-UP AND PERSONNEL MONITORING OPERATIONS

1. Install batteries and zero the instrument using the CD V-750 dosimeter charger.

2. Position the dosimeter so that representative shelter exposures will be measured by the instrument. If representative readings are to be obtained, the location of the instruments must correspond to shelter population density.

3. Ensure that shelter occupants record their individual doses on their radiation exposure record as follows:

   (1) Enter date of exposure.

   (2) Enter daily dose exposure in roentgens.

   (3) Enter cumulative total dose exposure in roentgens.

START-UP AND UNSHELTERED MONITORING OPERATIONS

1. Install batteries and zero the instrument using the CD-750 dosimeter charger.

MAINTENANCE AND OPERATING DATA

CD V-742 DOSIMETER

START-UP AND UNSHELTERED MONITORING OPERATIONS

2. Go outside to a preplanned location in a reasonably flat area, which is preferably unpaved and at least 25 feet away from buildings, and make an outside dose measurement.

3. Select an inside shelter location where the dose rate is approximately one-tenth to one-twentieth of the unsheltered dose rate and position the CD V-742 at this location.

4. Take a dose measurement at this location.

5. Calculate the protection factor for this location by dividing the outside dose measurement by the inside dose measurement.

6. Read the instrument daily. If the daily dose at this location could exceed 200 roentgens, estimate the time required for a 150-roentgen exposure.

7. Record this reading and rezero the instrument using the CD V-750 dosimeter charger.

8. Determine the daily unsheltered dose by multiplying the daily dose at this location by the protection factor and record these readings.

SHUTDOWN

1. Zero the instrument using the CD V-750 dosimeter charger.

2. Store the instrument in a dry place.

MAINTENANCE AND OPERATING DATA

CD V-742 DOSIMETER

TROUBLESHOOTING

LIGHT IS WEAK OR FAILS TO OPERATE WHEN CHARGING CONTACT IS DEPRESSED ON CD V-750 DOSIMETER CHARGER	1.	Check the battery and light contacts. If they are dirty or corroded, clean the contacts.
	2.	Check the light bulb. If it is loose, tighten the bulb. If it is burned-out, replace the bulb.
	3.	Depress the charging contact and, if the light is still weak or fails to operate, replace the battery.
SHADOWS APPEAR ON DOSIMETER SCALE	1.	Check the charging contact. If it is dirty, clean it.
	2.	Check both ends of the dosimeter. If either is dirty, clean it.
	3.	Check the outer aluminum sleeve of the charging contact. If it is making poor contact with the dosimeter, clean the sleeve or bend the contacts.
	4.	Check the end of the dosimeter or charging contact. If they are dirty or moist, clean and dry the end of the dosimeter.
	5.	Check the light switch spring contacts. If they are dirty, clean them.

TOOLS

1. Soft cleaning cloth
2. Steel wool
3. Fine sandpaper
4. Screwdriver

MAINTENANCE AND OPERATING DATA

CD V-742 DOSIMETER

SPARE PARTS	1.	Batteries
	2.	Light bulbs

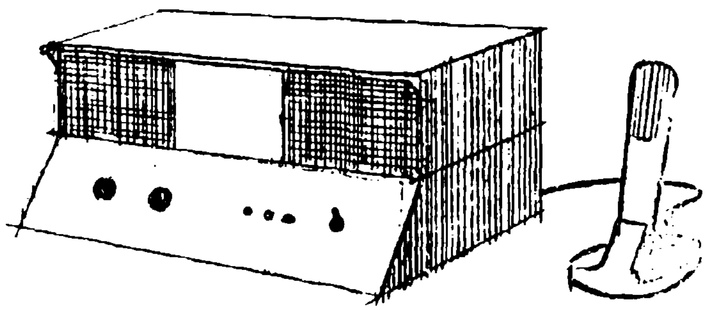
SUGGESTED SAMPLE

DESIGN OF PAGE

SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 7

COMMUNICATION
SYSTEMS



PARTMENT OF DEFENSE
ICE OF CIVIL DEFENSE

SUGGESTED SAMPLE
DESIGN OF PAGE

Table of Contents	How to Use Guidelines

Use the Table of Contents given below to locate quickly key technical data pertaining to the selection and operation of internal and external communications systems.

The Introduction Section provides all essential data regarding system requirements and typical system designs.

System component descriptions, application data, and selection procedures are given in the Component Selection Section.

The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions for relatively unskilled people.

System Uses

Communications systems within the shelter are needed to provide occupant control and information dissemination. Systems providing communication with sources outside the shelter are necessary for information receipt and exchange. The probability of shelter leaders making correct decisions will be increased by the amount of information available concerning outside conditions. Therefore, shelter communications systems should consist of an internal setup and a capability for providing communication with the outside environment.

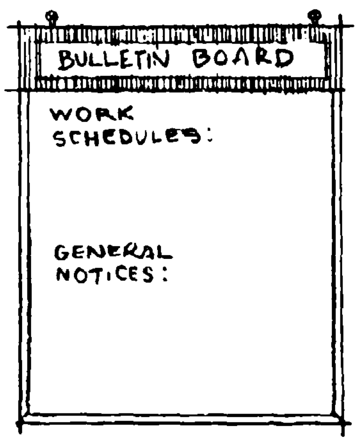
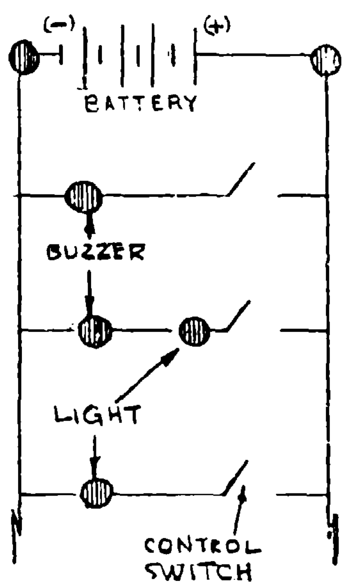
Internal Systems

Internal shelter communications systems are used for the dissemination of information to the shelter occupants and for the gathering of information by the shelter management. These systems provide shelter management with a partial means of operational control of the shelter.

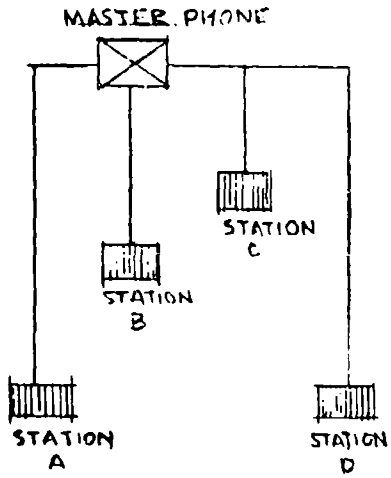
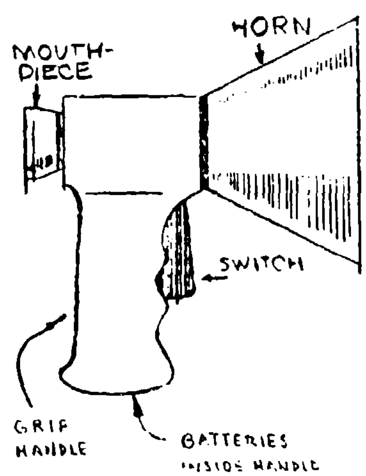
External Systems

External shelter communications systems are used as a vehicle for the receipt of important information and for the exchange of necessary messages between the shelter occupants and other shelters or local authorities. These systems provide shelter management with input data upon which critical decisions can be based relating to shelter use times, etc.

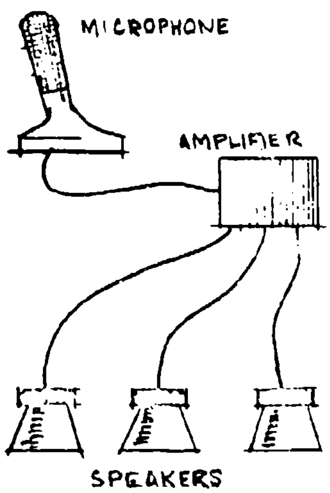
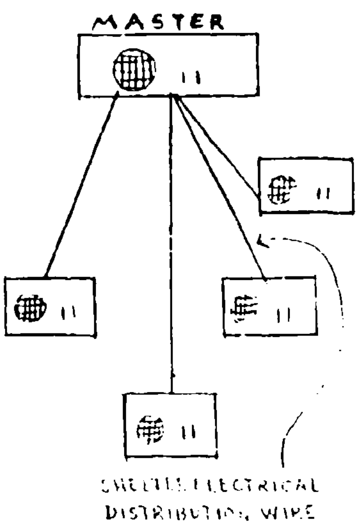
INTERNAL COMMUNICATIONS

Type Designation	Typical Design	Description
MESSENGERS, BULLETIN BOARDS		
Type I		Messengers should be used for carrying messages to key personnel. They should also be assigned the task of posting work schedules, assignments, and other notices of interest to the shelter occupants. The notices should be posted on strategically placed bulletin boards throughout the shelter. Bulletin boards can be fabricated out of cork panels, wood, or similar materials that effectively hold thumbtacks or pins.
SIGNAL LIGHTS, HORNS AND BUZZERS		
Type II		Visual and audible systems composed of lights, horns and buzzers are valuable for signalling key personnel. Signals should be prearranged to insure recognition and clear understanding. These same systems could double as alarm systems when dangerous situations arise such as fires.

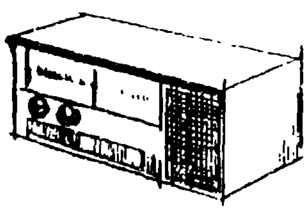
INTERNAL COMMUNICATIONS

Type Designation	Typical Design	Description
SOUND-POWERED PHONES		
Type III		Sound-powered phone systems consist of a master phone and up to twelve stations. These units operate on the current generated from voice sound. The master phone can be used to communicate with any station. The separate stations can communicate with each other by going through the master unit.
PORTABLE POWER MEGAPHONES		
Type IV		Megaphones are battery operated units capable of amplifying and transmitting sound. The units are portable, making them employable for such diverse tasks as the dissemination of information, the delivering of instructions, and the controlling of emergency situations within the shelter.

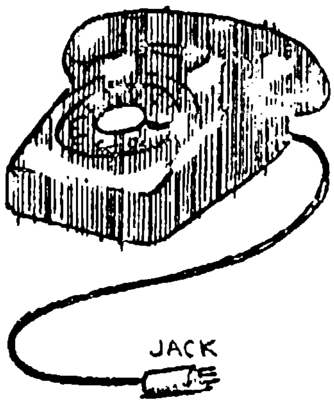
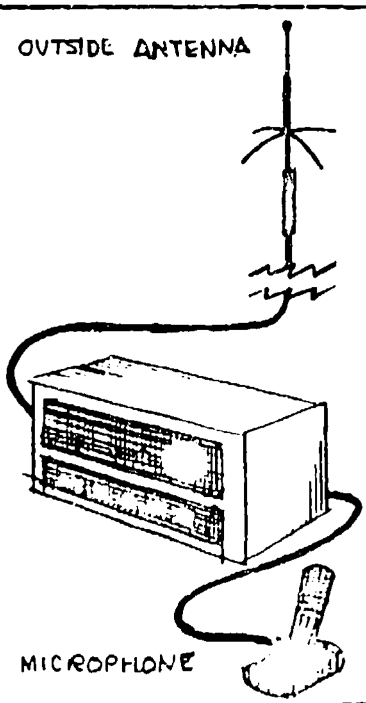
INTERNAL COMMUNICATIONS

Type Designation	Typical Design	Description
PUBLIC ADDRESS SYSTEMS		
Type V		The public address system consists of a microphone, amplifier, and speakers. Electric power is necessary to operate this type of system. This system can be used for such tasks as dissemination of information and overall shelter control.
INTERCOMMUNICATIONS SYSTEMS		
Type VI		The intercommunication system consists of a series of interconnected master and substation sets. Master sets can receive and transmit from other master sets, singly or in combination. Substation sets are capable of receiving and transmitting with the master set to which they are connected. Transistorized sets are available. These sets operate on 110-VAC and/or battery-supplied power.

EXTERNAL COMMUNICATIONS

Type Designation	Typical Design	Description
COURIERS		
Type I	None	Couriers provide an emergency source for obtaining and exchanging information with sources outside the shelter. Many limitations are involved in courier use. Radiation intensity, travel time, area knowledge, and other factors cause the use of couriers to qualify as a last resort effort to obtain or send information.
AM OR FM RADIOS		
Type II		AM or FM radios provide a means for receiving news broadcasts by local and federal agencies. These radios require electrical power or can be battery operated.

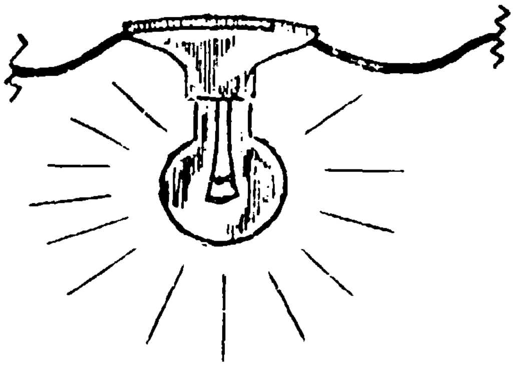
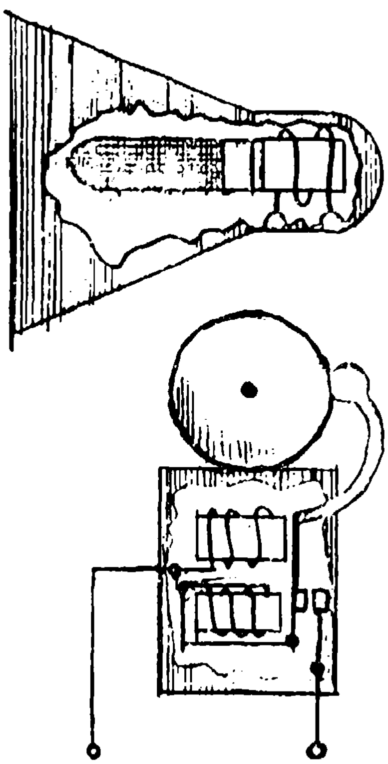
EXTERNAL COMMUNICATIONS

Type Designation	Typical Design	Description
TELEPHONE SYSTEMS		
Type III		The telephone is readily accessible in many installations. It provides a fairly stable source of information. Telephones in shelters should have a jack type connection. In belowground shelters, jacks should be well above the baseboard level.
TWO-WAY RADIO SYSTEMS		
Type IV		Powered transmit/receive sets such as the citizens band radios and amateur band radios provide a good means for external communications. Citizens band radios are usually low output units, have a relatively short range, and require an outside antenna. Transceivers are usually higher power units, having a longer range, and require an antenna. Both types of units are available in transistorized models.

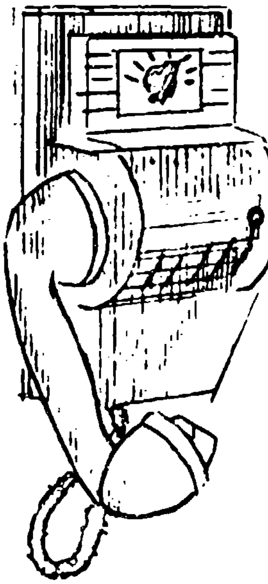
SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	INTERNAL COMMUNICATIONS	EXTERNAL COMMUNICATIONS
ABOVEGROUND AND BELOWGROUND SHELTERS			
50 PEOPLE	Best	Type 1	Type 2
	Acceptable		Type 3
100 PEOPLE	Best	Type 4	Type 2
	Acceptable	Type 1	Type 3
200 PEOPLE	Best	Type 4	Type 2
	Acceptable	Type 1	Type 3
300 PEOPLE	Best	Type 3	Type 4
	Acceptable	Type 4	Type 3
500 PEOPLE	Best	Type 5	Type 4
	Acceptable	Type 4	Type 3
1,000 PEOPLE	Best	Type 5	Type 4
	Acceptable	Type 2	Type 3
2,000 PEOPLE	Best	Type 6	Type 4
	Acceptable	Type 5	Type 3
3,000 PEOPLE	Best	Type 6	Type 4
	Acceptable	Type 5	Type 3
5,000 PEOPLE	Best	Type 6	Type 4
	Acceptable	Type 5	Type 3
10,000 PEOPLE	Best	Type 6	Type 4
	Acceptable	Type 5	Type 3

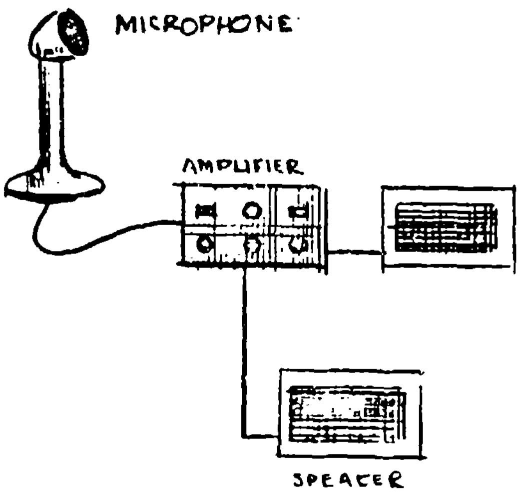
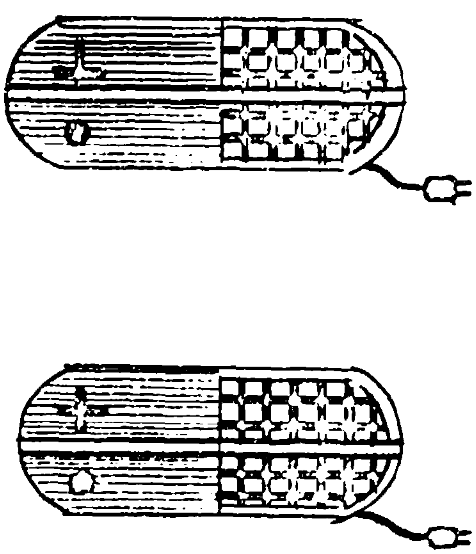
HORNS, BUZZERS OR LIGHTS

Typical Design	Description
	**Light Bulbs** Low wattage light bulbs are best for signal systems. These bulbs are wired together in series and are operated by closing the circuit with a switch. Breaking and closing the circuit a specific number of times can signal an individual who has been assigned that number of flashes. Bulbs should be of different colors for easy identification.
	**Horns and Buzzers** Horns and buzzers for signalling are usually reliable. The horns and buzzers should be pitched to a low, distinguishable sound. These signals are usually wired in parallel. The signal is caused by opening and closing the circuit a number of specified times. The number of signals corresponds to that assigned to a given individual.

POWERED PHONES

Typical Design	Description
	**Sound-Powered Phones** Sound-powered phones are completely self-contained handsets. They do not require any batteries for an external power source, as the voice of the person using the phone supplies the needed power. As many as 12 units may be connected in parallel. Two-conductor cable is required for the connections.
	**Portable Power Megaphones** Megaphones are completely self-contained transistorized units. Batteries are contained within the handle. A unit consists of an amplifier, microphone, speaker, and batteries. This type of unit is portable, which permits its use in various locations.

MULTIPLE POWERED UNITS

Typical Design	Description
	**Public Address Units** A typical public address system consists of a microphone, an amplifier, speakers, and connecting cable. Transistorized units are available. These are preferable since they use very little power. One or more speakers may be plugged into the amplifier depending on the coverage desired.
	**Intercommunication Unit** A typical unit consists of a speaker-microphone, transmitter, receiver, and amplifier. These units may be placed within an area as desired because they do not require connecting wiring. They require external power in order to operate. The power line into which the units are plugged doubles as the transmission connecting line between units.

COMBINATION SOUND-POWERED PHONE AND SIGNAL SYSTEM

GENERAL INFORMATION

1. Nomenclature - The sound-powered phone consists of a master phone, phone stations, and a connecting 2-wire cable. Signal systems consisting of horns, buzzers or lights can be used in conjunction with the phones. The sound of the user's voice generates the current necessary for the phone to operate. Dry cell batteries or 110 VAC are required to furnish power for the signal system.

2. Size and Weight - Sound-powered phones are comparable in size to home phones. These units weigh approximately 7 pounds.

3. Effective Distance - Sound-powered phones will satisfactorily transmit over several miles of cable. Signal units can be installed with the sound-powered phones, thus providing a dual system.

SHIPPING INSTRUCTIONS

1. Sound-powered phones are shipped as complete units. Small lengths of cable with clip leads are attached. Connecting cable for the units must be acquired separately.

2. Signal units are shipped separately as components. These components are buzzers, light holders, horns, wire or cable, batteries, and switches.

3. Phone units should be stored in their original containers until ready to be put into use.

INSTALLATION INSTRUCTIONS

1. Place the phone units in selected locations.

2. Wire all the phone units to the master phone unit.

3. Install signal units near the phone units and wire to 110 VAC or battery power.

PORTABLE POWER MEGAPHONES

GENERAL INFORMATION

1. Nomenclature - Portable power megaphones are complete units. Batteries are housed in the handle. These units offer flexibility because of their portability and self-contained power source.

2. Size and Weight - These megaphones weigh approximately 3.5 pounds. The dimensions are 10 inches in diameter for the horn and 16-1/2 inches in overall length. Six flashlight batteries are required.

3. Effective Distance - Megaphones will satisfactorily transmit up to a distance of 300 yards.

4. Battery Life - Six flashlight batteries provide six months of power when the megaphone is used intermittently.

SHIPPING INSTRUCTIONS

1. The megaphone is shipped as a complete unit, less batteries.

2. Units should be stored in their shipping containers until needed. Batteries should be stored separately, preferably in a cool, dry place. The shelf life for useful power availability is approximately 24-30 months, and therefore the batteries should be replaced at this interval.

PUBLIC ADDRESS UNITS

GENERAL INFORMATION

1. Nomenclature - Public Address Units consist of a microphone, speakers, an amplifier, and cable. The number of speakers required depends upon the shelter size and configuration. Shelters having large open areas require fewer speakers than the comparable size shelters having passageways, small rooms, or are in other ways segmented. Low power public address units require batteries as a power source. Large units require a 110-VAC power source. Transistorized models are preferable in all sizes. Microphones are available in crystal, ceramic, or high-impedance dynamic types. The third type is preferable.

2. Size and Weight - Microphones weigh about 3 pounds and stands weigh about 4 pounds. Amplifiers in the 35-watt range weigh approximately 30 pounds. Speakers in the 15-watt range weigh approximately 8 pounds.

INSTALLATION INSTRUCTIONS

1. Place speakers in selected locations.

2. Place amplifier and microphone in administration or communications area.

3. AM or FM radios may be tied into the systems as additional speakers, provided they are sized correctly.

INTERCOMMUNICATION UNITS

GENERAL INFORMATION

1. Nomenclature - Intercommunication sets consist of master units and substation units. These master units can originate calls to any other unit while substation units can only originate calls to master units. Intercommunication sets are powered by plugging them directly into 110-VAC outlets. Switches are available for master units to convert them into private line operations.

2. Size and Weight - Master units weigh approximately 12 pounds. They are 8 inches wide, 11 inches long, and 6 inches high. Substations weigh approximately 5 pounds. These units are smaller, being 4 inches wide, 8 inches long, and 6 inches high.

3. Effective Distance - The intercommunication units use the 110-VAC supply for transmission. No additional wire or cable is necessary. The units will transmit the length of the 110-VAC wiring line.

SHIPPING INSTRUCTIONS

1. Intercommunication units are shipped as complete units, ready for use.

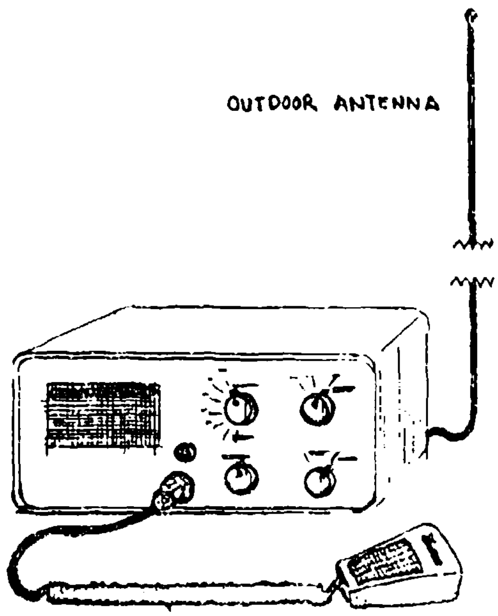
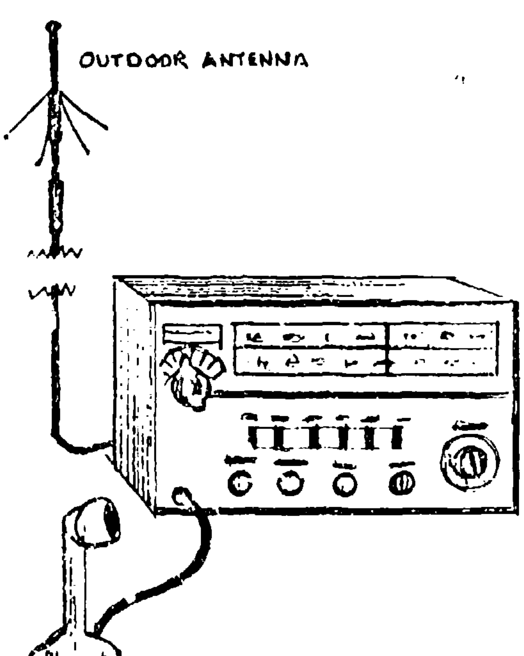
PORTABLE AND FIXED UNITS

STEP 1	Determine the number of key locations where communications outlets are required.
STEP 2	Determine the type of units necessary for the kind of coverage desired for each area from the chart on the following page. Combinations of units may be desirable.
STEP 3	Determine the number of feet of cable or wire required for connecting wired units. Determine the number of receptacles needed for units using electric power outlets.
STEP 4	Determine the amount cf power required to operate the units selected.

PORTABLE AND FIXED UNITS

Use and Area Coverage Desired	Messengers and Bulletin Boards	Horns, Buzzers or Lights	Sound-Powered Phones	Public Address	Inter-communications	Portable Power Megaphones
Mainte-nance Area			X		X	X
Medical Area			X		X	
Supply Area	X					X
Shelter Information Dissemina-tion	X		X	X	X	X
Radiological Monitoring			X		X	
Specific Shelter Signals		X		X		
Fire Services			X		X	X

TWO-WAY RADIOS

Typical Design	Description
	**Citizens Band Radio Units** The Citizens Band Radio combination transmitter and receiver operates in a single band of frequencies. The sets are often transistorized and are generally of low output. Citizens Band Radios require little skill for operation. No license is necessary for use of these units. However, operation must be in conformance with FCC rules.
	**Amateur Band Radio Units** An Amateur Band Radio is a combination transmitter and receiver which covers all amateur bands. A license is required to operate these units. Some degree of knowledge and skill in radio communication is also necessary.

TWO-WAY RADIOS

Citizens Band Radios

GENERAL INFORMATION

1. Nomenclature - Citizens Band Radios consist of a transmitter, a receiver, a microphone and an antenna. These sets may be battery-powered or may be plugged into a 110-VAC outlet. Citizens Band Radios are usually low power output frequencies available for transmission and receipt.

2. Size and Weight - Typical Citizens Band Radios are 6 inches wide, 11 inches long, and 7 inches high. They weigh approximately 12 pounds. The hand microphone weighs approximately 2 pounds. The antenna is 9 feet high, and weighs 6 pounds.

3. Effective Distance - The transmitting range of these sets depends on the set wattage. A 100-milliwatt set has a range of about 1 mile. A 5-watt set has a range of up to 15 miles. Local CD officials should be consulted for CD frequency information.

Amateur Band Radios

1. Nomenclature - Amateur Band Radios consist of a transmitter, a receiver, a microphone, and an antenna. These sets can be battery-powered or plugged directly into a 110-VAC outlet. Transceivers are high power output sets. They cover the entire amateur frequency band. Skill and knowledge of radio fundamentals is required for an operator to be competent.

TWO-WAY RADIOS

Amateur Band Radios

GENERAL INFORMATION

2. Size and Weight - Typical Amateur Band Radios are 5 inches wide, 12 inches long, and 7 inches high. These units weigh approximately 14 pounds. The hand microphone weighs 2 pounds. The external antenna is 9 feet high and weighs 6 pounds.

3. Effective Distance - Sets are available with various transmitting ranges. Local CD officials should be consulted for CD frequency information

INSTALLATION INSTRUCTIONS

1. The desired broadcast and receiving frequencies should be preset on the unit dials.

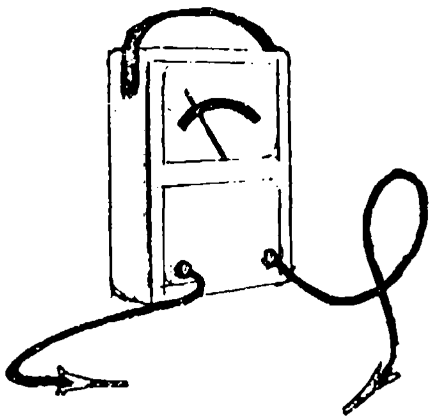
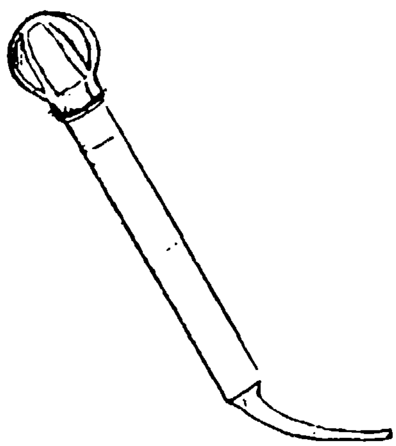
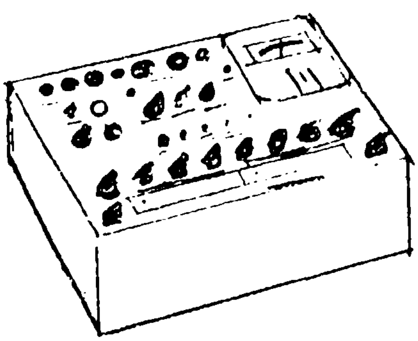
2. The cable to the external antenna must be plugged into the set. The power should be off prior to connecting antenna.

3. The set should be plugged into the 110 VAC or connected to batteries if they are the power source.

FIXED UNITS

STEP 1	Determine the maximum range to the outside location(s) with which communication is desired.
STEP 2	Determine the frequency needs.
STEP 3	Determine the type of units having the appropriate frequencies and power capacity required.
STEP 4	Determine the amount of power required to operate the units selected.
STEP 5	Determine an appropriate location for the antenna.

BATTERIES AND TUBES

Typical Design	Description
	**D.C. Voltmeter** A measuring device to indicate the electrical potential difference between two points. For battery testing, place a test lead on each battery terminal positive to positive and negative to negative. Positive leads are normally red and negative leads are normally black.
	**Hydrometer** A measuring device to indicate the specific gravity of the battery electrolyte. Hydrometer is calibrated along its glass body. The calibration indicates the specific gravity of the liquid measured and indicates the electrolyte condition.
	**Tube Tester** An electronic measuring device to indicate the operational condition of vacuum electron tubes. NOTE: The three test items listed above should be stored with the communications equipment. Their use is limited to communications equipment operators and to people engaged in maintaining that equipment.

MAINTENANCE AND OPERATING DATA

HORNS, BUZZERS OR LIGHTS

GENERAL INSTRUCTIONS FOR INTERNAL COMMUNICATIONS UNITS		The maintenance and operation of the shelter equipment should be carried out in accordance with the instructions prepared by the manufacturer of the equipment. In the absence of such instructions, the following checklist should be followed to assure minimum control of the inspection, operation, and maintenance of the shelter equipment.
MONTHLY STANDBY INSPECTIONS	1.	Check for visual damage.
	2.	Check the power supply.
	3.	Check the batteries.
	4.	Operate for a few seconds.
TROUBLESHOOTING		
SYSTEM DOES NOT OPERATE	1.	Check the incoming power supply.
	2.	Check the fuses.
	3.	Check the batteries
	4.	Check for burned-out bulbs.
	5.	Check for loose connections and broken wires.
SPARE PARTS	1.	Bulbs
	2.	Batteries
	3.	Fuses
TOOLS	1.	Screwdriver
	2.	Pliers
	3.	Voltmeter

MAINTENANCE AND OPERATING DATA

SOUND-POWERED PHONES

MONTHLY STANDBY INSPECTIONS	1.	Check for visual damage.
	2.	Operate for a few seconds.
TROUBLESHOOTING		
PHONES DO NOT OPERATE	1.	Check for broken wires or loose connections.
		NOTE: If the above procedure does not locate the trouble, it will be necessary to enlist the services of a qualified electronic technician.
TOOLS	1.	Pliers
	2.	Screwdriver

MAINTENANCE AND OPERATING DATA

PORTABLE POWER MEGAPHONES

MONTHLY STANDBY INSPECTION	1.	Check for visual damage.
	2.	Check the batteries.
	3.	Operate for a few seconds.
TROUBLESHOOTING		
MEGAPHONE DOES NOT OPERATE	1.	Check the battery.
		NOTE: If the above procedure does not locate the trouble, it will be necessary to enlist the services of a qualified electronic technician.
SPARE PARTS	1.	Battery
TOOLS	1.	Screwdriver
	2.	Pliers

MAINTENANCE AND OPERATING DATA

PUBLIC ADDRESS SETS

MONTHLY STANDBY INSPECTION

1. Check for visual damage.
2. Check the power supplies.
3. Check the batteries if used.
4. Turn on, allow one minute warm-up, voice test for operation.

START-UP

1. Turn on the switch
2. Adjust the controls in accordance with the manufacturer's instructions.

TROUBLESHOOTING

SYSTEM NOT OPERATING

1. Check the incoming power supply.
2. Check the batteries if used.
3. Check the fuses.
4. Check control and dial positions.

NOTE: If the above procedures do not locate the trouble, it will be necessary to enlist the services of a qualified electronic technic[illegible]

SPARE PARTS

1. Fuses
2. Batteries

TOOLS

1. Screwdriver
2. Pliers
3. DC Voltmeter
4. Tube tester

MAINTENANCE AND OPERATING DATA

INTERCOMMUNICATION SETS

MONTHLY STANDBY INSPECTION	1.	Check for visual damage.
	2.	Check the power supply.
	3.	Turn on, allow one minute for warm-up, voice test for operation.
START-UP	1.	Turn on the switch.
	2.	Adjust the controls in accordance with the manufacturer's instructions
TROUBLESHOOTING		
SET NOT OPERATING	1.	Check the incoming power supply.
	2.	Check the fuses.
	3.	Check the control and dial positions.
		NOTE: If the above procedures do not locate the trouble, it will be necessary to enlist the services of a qualified electronic technician.
SPARE PARTS	1.	Fuses
TOOLS	1.	Pliers
	2.	Screwdriver
	3.	DC Voltmeter
	4.	Hydrometer
	5.	Tube Tester

MAINTENANCE AND OPERATING DATA

CITIZENS BAND RADIOS

MONTHLY STANDBY INSPECTION	1.	Check for visual damage.
	2.	Check battery and power supply.
	3.	Turn on, allow one minute warm-up, voice test for operation.
START-UP	1.	Turn on the switch
	2.	Adjust the controls in accordance with manufacturer's instructions.
TROUBLESHOOTING		
NO TRANSMISSION OR RECEPTION	1.	Check the incoming power supply.
	2.	Check the fuses.
	3.	Check the batteries.
	4.	Check control and dial positions.
		NOTE: If the above procedures do not locate the trouble, it will be necessary to enlist the services of a qualified electronic technician.
SPARE PARTS	1.	Fuses
	2.	Batteries
	3.	Tubes
TOOLS	1.	Screwdriver
	2.	Pliers
	3.	DC Voltmeter
	4.	Hydrometer
	5.	Tube Tester

MAINTENANCE AND OPERATING DATA

TRANSCEIVERS

MONTHLY STANDBY INSPECTION	1.	Check for visual damage.
	2.	Check battery and power supply.
	3.	Turn on, allow one minute warm-up, voice test for operation.
START-UP	1.	Turn on the switch.
	2.	Adjust the controls in accordance with manufacturer's instructions.
TROUBLESHOOTING		
NO TRANSMISSION OR RECEPTION	1.	Check the incoming power supply.
	2.	Check fuses.
	3.	Check batteries if used.
	4.	Check control and dial position.
		NOTE: If the above procedures do not locate the trouble, it will be necessary to enlist the services of a qualified electronic technician.
SPARE PARTS	1.	Fuses
	2.	Batteries
TOOLS	1.	Screwdriver
	2.	Pliers
	3.	DC Voltmeter
	4.	Hydrometer
	5.	Tube tester

SUGGESTED SAMPLE
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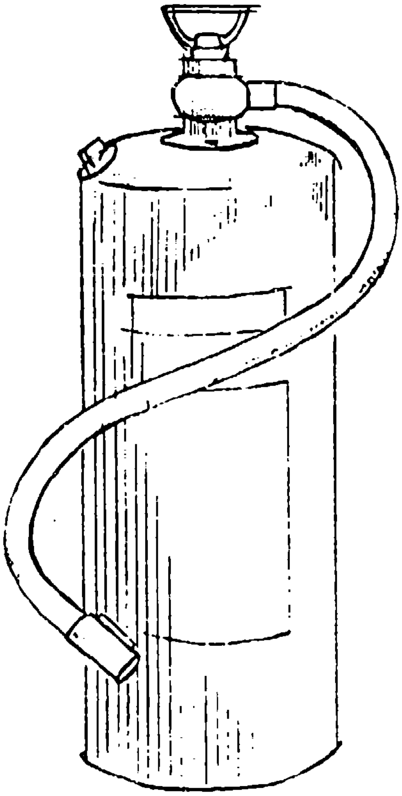
SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 8

FIRE PROTECTION
UNITS



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

SUGGESTED SAMPLE
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Use the Table of Contents given below to locate quickly key technical data pertaining to the selection and operation of manual fire extinguishers.

The Introduction Section provides all essential data regarding extinguisher requirements and typical extinguisher designs.

System component descriptions, application data, and selection procedure are given in the Component Selection Section.

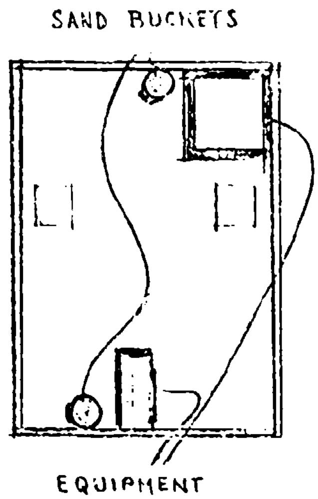
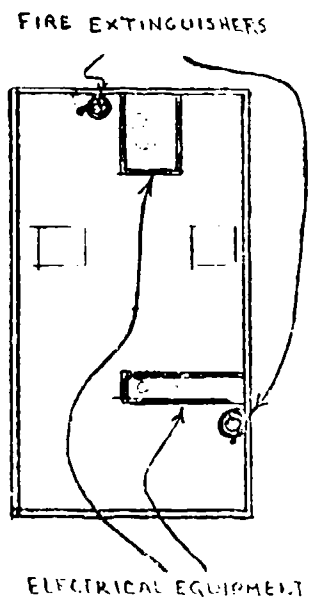
The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions for relatively unskilled people.

NEED FOR FIRE PROTECTION SYSTEMS

System Uses

Fire protection equipment is required within the shelter to combat potential internal fires. A fire may be caused by human carelessness, defective electrical wiring, overheated equipment, or other causes. Fire protection systems consist of fire extinguisher units and accessory equipment.

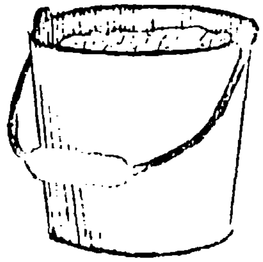
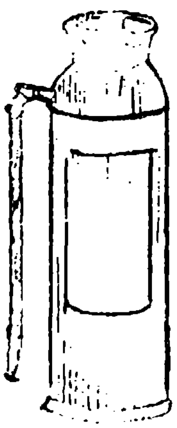
FIRE PROTECTION SYSTEMS

Type Designation	Typical Design	Description
SAND PAILS		
Type I		This type of system consists of buckets of sand, shovels, protective masks, and asbestos gloves. It is used to combat small local fires that are readily extinguished by smothering.
PORTABLE EXTINGUISHER SYSTEMS		
Type II		Portable fire extinguishers may be of several types. They may be filled with plain water, water with chemicals added, foam, or dry chemicals. They are either pressure- or hand-operated. Protective face masks, shovels and asbestos gloves complete the system. Large, heavy extinguishers may be mounted on wheeled carts for easier handling and to facilitate maneuverability.

SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	FIRE PROTECTION SYSTEM
ABOVEGROUND AND BELOWGROUND SHELTERS		
50 PEOPLE	Best	Type 1
	Acceptable	
100 PEOPLE	Best	Type 2
	Acceptable	Type 1
200 PEOPLE	Best	Type 2
	Acceptable	Type 1
300 PEOPLE	Best	Type 2
500 PEOPLE	Best	Type 2
1,000 PEOPLE	Best	Type 2
2,000 PEOPLE	Best	Type 2
3,000 PEOPLE	Best	Type 2
5,000 PEOPLE	Best	Type 2
10,000 PEOPLE	Best	Type 2

PORTABLE FIRE EXTINGUISHERS

Typical Design	Description
	**Fire Pails** Fire pails are conical shaped and should be painted red. The pails are filled with sand used to smother fires.
	**Water Extinguishers** Water-filled fire extinguishers are actuated by a hand pump, air or gas. These extinguishers are reliable and are effective against all but electrical fires. Extinguishers of this type must be protected against freezing.
	**Chemical Extinguishers** Chemical-filled extinguishers are either manually or pressure-actuated. They may be filled with either dry chemicals or foam. The dry chemical extinguisher and the foam extinguisher smother fires by excluding the oxygen necessary for continuance of the fire. The dry chemical extinguishers are of particular value in combating electrical fires.

SAND PAILS

GENERAL INFORMATION	1.	Nomenclature - Fire pails consist of a pail and ring holder. The pail is filled with sand and should be covered. Pails should be painted red to denote their use. The standard container is made of galvanized steel.
	2.	Container Capacity - The standard fire pail will hold about 45 pounds of sand. This is enough to cover an area of approximately 3 square feet with a layer of 2 inches of sand.
	3.	Size and Weight - The standard fire pail is 8-5/8 inches high and 12-5/8 inches in diameter at the top. The bottom is 11-3/8 inches in diameter. The container will weigh 3 pounds 13 ounces when empty and 48 pounds 13 ounces when filled with sand.
INSTALLATION INSTRUCTIONS	1.	Fire pails should be located throughout the shelter. They should be placed next to potential fire sources such as electrical switch boxes, supply storage areas, and similar areas.
	2.	A long-handled scoop or shovel, a pair of asbestos gloves, and a protective face mask should be placed near each pail at the time of shelter occupancy.

PORTABLE WATER EXTINGUISHERS

GENERAL INFORMATION

1. Nomenclature - The portable water fire extinguisher is available in two models. The hand pump-operated model provides a water stream approximately 5 feet in length. The pressure-activated model is of two types--air or gas. The air pressure extinguisher is pressurized by means of an air inlet valve. It operates for about 1 minute and is activated by squeezing a lever. A 45-foot water stream is produced. The gas cartridge-activated extinguisher is operated by turning it upside down and bumping it against the floor. The shock releases the gas in the cartridge, thereby forming internal pressure.

2. Extinguisher Capacity - Liquid extinguishers range in capacity from 1-1/2 gallons to 5 gallons. The 2-1/2 gallon size liquid extinguisher covers an area of approximately 2,000 square feet.

3. Size and Weight - Charged and ready to use, liquid extinguishers range in weight from 20 pounds to 70 pounds.

INSTALLATION INSTRUCTIONS

1. Portable fire extinguishers should be placed throughout the shelter. At least one extinguisher is required for every 2,500 square feet of floor area.

2. Units should be located no more than 100 feet from each potential fire hazard. Units should be wall-mounted.

3. The area immediately around the extinguisher should be painted red.

PORTABLE CHEMICAL EXTINGUISHERS

GENERAL INFORMATION

1. Nomenclature - The portable chemical fire extinguisher is available filled with dry chemicals or foam. Dry chemical extinguishers are air pressure-actuated. The expelled powder smothers the fire. Foam extinguishers are activated when turned upside down. About 20 gallons of foam are produced which smother the fire.

2. Extinguisher Capacity - Dry chemical extinguishers range in capacity from 5 pounds to 30 pounds. The usage of these extinguishers depends on the type of fire encountered. Foam extinguishers range in capacity from 1-1/2 gallons to 5 gallons. Foam from the 2-1/2 gallon extinguisher will cover about 1500 square feet.

3. Size and Weight - Dry chemical extinguishers, ready to use, weigh from 10 pounds to 65 pounds. Foam extinguishers range in weight from 20 pounds to 70 pounds.

INSTALLATION INSTRUCTIONS

1. Portable fire extinguishers should be placed throughout the shelter. At least one extinguisher is required for every 2500 square feet of floor area.

2. Units should be located no more than 100 feet from each potential fire hazard. Units should be wall-mounted.

3. The area immediately around the extinguisher should be painted red.

SAND PAILS, PORTABLE WATER EXTINGUISHERS AND PORTABLE CHEMICAL EXTINGUISHERS

STEP 1 — Determine the total shelter area in square feet.

STEP 2 — Determine the location of potential fire hazards such as machinery, flammable supplies, fuel lines, and electrical switch boxes.

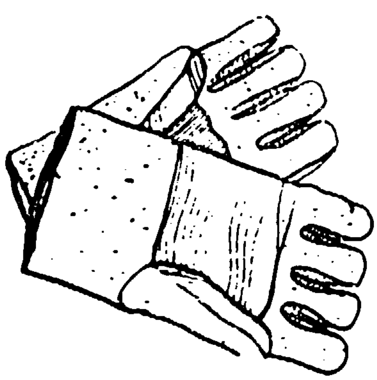
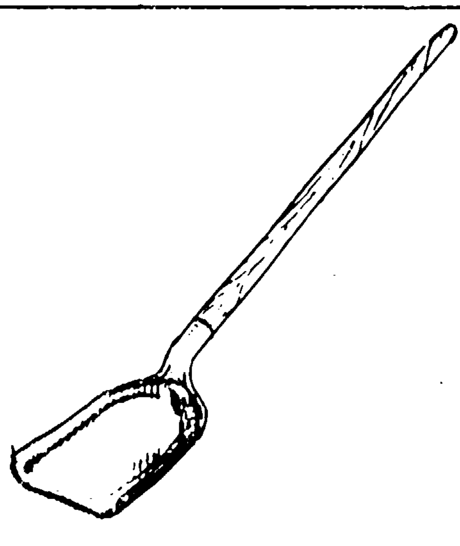
STEP 3 — Divide the total square footage of the shelter by 2500 to obtain the number of units required. Add to this sum the additional extinguishers required for potential fire hazards.

STEP 4 — Determine the type of extinguisher required to fight the kind of fire possible in each area. Use the chart below.

Extinguisher Selection Data

Kind of Fire	Type of Extinguisher			
	Sand Pail	Water Extinguisher	Dry Chemical Extinguisher	Foam Extinguisher
Textile	X	X	X	X
Oil	X		X	X
Gasoline	X		X	X
Paper	X	X	X	X
Grease	X		X	X
Paint	X		X	X
Electrical			X	
Wood	X	X	X	X

FACE MASKS, ASBESTOS GLOVES, AND SHOVELS

Typical Design	Description
	**Face Masks** Face masks are worn for protection against smoke, fumes, and gases. They are individual,,self-contained units.
	**Asbestos Gloves** Asbestos gloves are worn to protect the fire fighters' hands from burns.
	**Shovels** Shovels or scoops should have extra long handles. The fire fighter can spread the sand over the fire from a distance of several feet. The shovel or scoop should have curved sides and be made of metal.

FACE MASKS AND ASBESTOS GLOVES

Face Masks

GENERAL INFORMATION	1.	Nomenclature - A face mask consists of a hood having eye protective pieces and a filter. The filter cartridge is replaceable.
	2.	Filter Capacity - Filter capacity varies according to different mask models. The filter is measured by the size of microns it screens. A typical commercially available filter will screen 0.3 microns.
	3.	Size and Weight - A typical commercially available mask weighs about 6 pounds.
STORAGE INSTRUCTIONS	1.	The face masks should be stored in their original shipping containers until needed.

Asbestos Gloves

GENERAL INFORMATION	1.	Nomenclature - Gloves can be made of asbestos and cloth, asbestos and leather, or aluminized asbestos and leather. The inside of the gloves may be lined or unlined. The gloves are heat resistant. Mitts are also available made of the same materials.
	2.	Size and Weight - Asbestos gloves are available in small, medium, and large sizes. The gloves weigh about 1.5 pounds.
STORAGE INSTRUCTIONS	1.	The asbestos gloves or mitts should be stored in their original shipping containers until needed.

FACE MASKS, ASBESTOS GLOVES, AND SHOVELS

STEP 1	Determine the number of shelter occupants to be assigned fire protection duties.
STEP 2	Determine the number of face masks, asbestos gloves, and shovels required based on the issuance of one face mask and one pair of asbestos gloves for every three people assigned to fire protection duties. Base the shovel requirements on one shovel for every sand pail or one shovel for every six people assigned to fire protection duties.

MAINTENANCE AND OPERATING DATA

SAND PAILS		
MONTHLY STANDBY INSPECTION	1.	Make a visual check to ensure that the pails are filled, covered, and in their proper locations.
USE	1.	Remove the cover from the pail.
	2.	Spread the sand evenly over the fire using a shovel or scoop.
	3.	Reclaim as much of the sand as possible after the fire is out.
	4.	Refill the pail and replace the cover.
IDENTIFICATION AND CODING	1.	Paint all sand pails red. Letter with a white "F" or the word "FIRE."
	2.	Paint the immediate area around the pail red, or paint a red circle around said area.

MAINTENANCE AND OPERATING DATA

PORTABLE EXTINGUISHERS		
MONTHLY STANDBY INSPECTION	1.	Make a visual check to ensure that all extinguishers are in their proper location and properly mounted.
	2.	Check each extinguisher for liquid level, damage, discharge, and leaks.
YEARLY INSPECTION	1.	Discharge and refill any water pump-operated extinguishers.
	2.	Weigh the cartridge in any water-filled and cartridge-actuated extinguishers.
	3.	Check the visual gauge on any water-filled and pressure-operated extinguishers.
	4.	Discharge and recharge any soda and acid type extinguishers.
	5.	Discharge and refill any foam type extinguishers.
	6.	Weigh any dry chemical type extinguishers.
OPERATING INSTRUCTIONS	1.	Remove the seal.
	2.	Point the nozzle in the direction of the fire.
	3.	Operate the hand pump, squeeze the lever, or turn the extinguisher upside down, depending upon the type of extinguisher.
SPARE PARTS	1.	Refill units for cartridge-operated extinguishers and for dry extinguishers
	2.	Extinguisher seals

MAINTENANCE AND OPERATING DATA

PORTABLE EXTINGUISHERS		
TOOLS	1.	Adjustable wrench
	2.	Screwdrivei
	3.	Pliers
IDENTIFICATION AND CODING	1.	Paint the immediate area around the extinguisher red, or paint a red circle around said area.
	2.	Tag each type of extinguisher, stating the types of fires for which each specific extinguisher is applicable.

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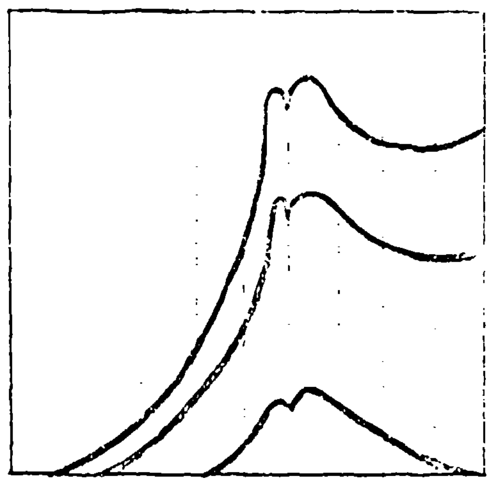
SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 9

NOISE CONTROL METHODS



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

SUGGESTED SAMPLE
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Use the Table of Contents given below to locate quickly key data pertaining to the application and selection of noise control methods and materials.

The Introduction Section provides all essential data regarding typical methods design and typical requirements.

Component descriptions, application data, and selection procedures are given in the Component Selection Section.

NEED FOR NOISE CONTROL METHODS

Method Uses

Control of internal noise is important in keeping the shelter habitable. Excessive amounts of noise cause discomfort. Methods for reducing or eliminating the source causing this discomfort through absorbing c blocking out the noise are the employment of individual ear protective devices, the use of soundproofing materials, and the use of vibration isolators with equipment.

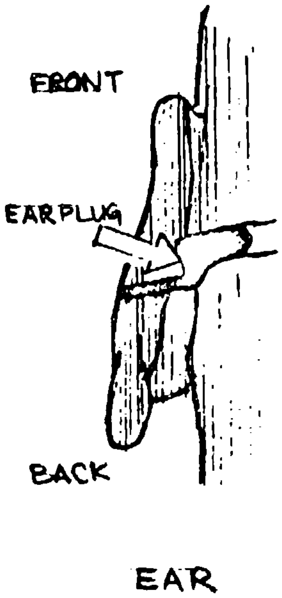
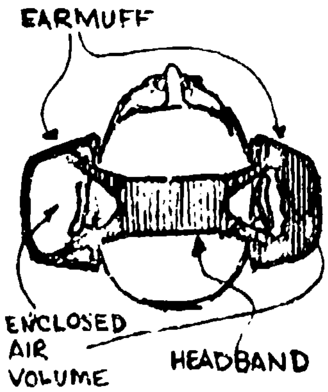
Ear Protective Devices

Ear protective devices are used by the individual shelter occupants. These devices will block out noise. They act as a barrier between the noise source and the ear and in effect insulate the ear from the noise source. Use of earplugs allows the wearer to discriminate between background noise and normal conversation.

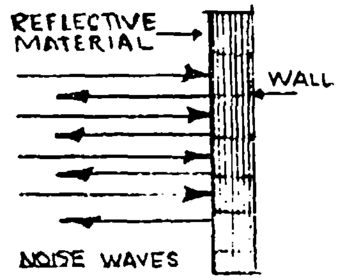
Soundproofing Methods

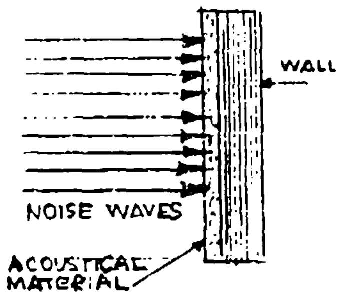
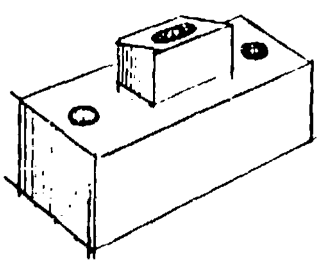
Soundproofing is the reduction of noise by breaking up sound waves and absorbing them. Both isolation of the noise source and insulation from it can help reduce the level of noise. Various conventional and improvised methods can be used for this purpose. Among the conventional methods are baffles and acoustical materials surrounding noise-creating equipment, and the use of acoustical ceilings and floors. An improvised method is the use of blankets or other sound-absorbing materials hung on walls and from ceilings.

NOISE CONTROL METHODS

Type Designation	Typical Design	Description
EAR INSERT PROTECTIVE DEVICES		
Type I		Ear insert protective devices consist of cotton balls, earplugs, and semi-inserts. These devices block out noise to varying degrees before it reaches the ear membrane.
EAR COVERING PROTECTIVE DEVICE		
Type II		Earmuffs protect the ear from noise by providing an enclosed air volume around the ear. The muffs are usually joined together by an adjustable headband.

NOISE CONTROL METHODS

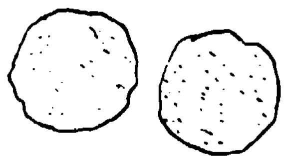
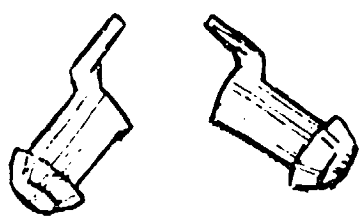
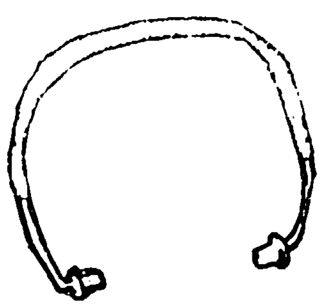
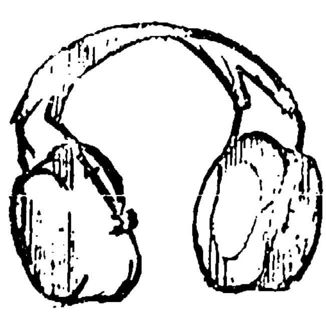
<table>
<tr><th>Type Designation</th><th>Typical Design</th><th>Description</th></tr>
<tr><td colspan="3">SOUNDPROOFING METHODS</td></tr>
<tr><td>Type I</td><td>


</td><td>One method of soundproofing is the use of construction materials that will reflect noise such as brick, stone, or masonry. A second method is the use of acoustical material to absorb the noise.</td></tr>
<tr><td colspan="3">VIBRATION ISOLATORS</td></tr>
<tr><td>Type II</td><td></td><td>Vibration isolators are equipment mountings. These special mountings dampen the vibration caused by the operation of the equipment. The vibration received by the floor, wall, or ceiling to which the equipment is mounted is substantially reduced. Isolators vary in materials of construction and design.</td></tr>
</table>

SHELTER SYSTEM REQUIREMENTS

SHELTER SIZE	METHOD RATING	EAR PROTECTIVE DEVICES	SOUND-PROOFING METHODS
50 PEOPLE	Best	Type 1	Type 1
	Acceptable	Type 2	Type 2
100 PEOPLE	Best	Type 1	Type 1
	Acceptable	Type 2	Type 2
200 PEOPLE	Best	Type 1	Type 1
	Acceptable	Type 2	Type 2
300 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	
500 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	
1,000 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	
2,000 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	
3,000 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	
5,000 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	
10,000 PEOPLE	Best	Type 2	Type 1 & 2
	Acceptable	Type 1	

EAR INSERT PROTECTIVE DEVICES

Typical Design	Description
	**Cotton Balls** Cotton balls are partially effective in blocking out noise. Their use is an expedient.
	**Earplugs** Earplugs are designed to fit comfortably in the ear auditory canal. They are effective in blocking out noise.
	**Semi-Inserts** Semi-inserts fit partially into the ear. They require a support which fits over the wearer's head. They are effective in blocking out noise.
EAR COVERING PROTECTIVE DEVICE	
	**Earmuffs** Earmuffs cover the outside of the ear and insulate the ear with an enclosed air pocket. They are effective in blocking out noise.

EAR PROTECTIVE DEVICES

Earplugs

GENERAL INFORMATION

1. Characteristics - Earplugs are made of plastic or synthetic rubber. They are inserted into the ear auditory canal. They form a barrier between the noise and the middle ear. There is no discomfort to the wearer. Earplugs permit the wearer to discriminate between background noises and speech. Earplugs will remain in the auditory canal without additional support.

2. Size and Weight - Earplugs are formed to fit the ear auditory canal. A pair weighs approximately 10 grams.

Semi-Inserts

GENERAL INFORMATION

1. Characteristics - Semi-inserts are made of plastic or synthetic rubber and are attached to a headband. They close the entrance to the ear canal without being actually inserted into the canal. The headband generally provides a comfortable fit.

2. Size and Weight - Semi-inserts fit the entrance of the ear auditory canal. A pair weighs approximately 30 grams.

Earmuffs

GENERAL INFORMATION

1. Characteristics - Earmuffs consist of plastic cups with foam, plastic, or rubber edges. They cover the entire outer ear. The air pocket trapped inside each muff insulates the ear. The muffs are attached to a headband which usually is adjustable.

2. Size and Weight - Earmuffs come in one size and are large enough to cover the entire ear. A pair weighs approximately 400 grams.

EAR PROTECTIVE DEVICES

ADVANTAGES

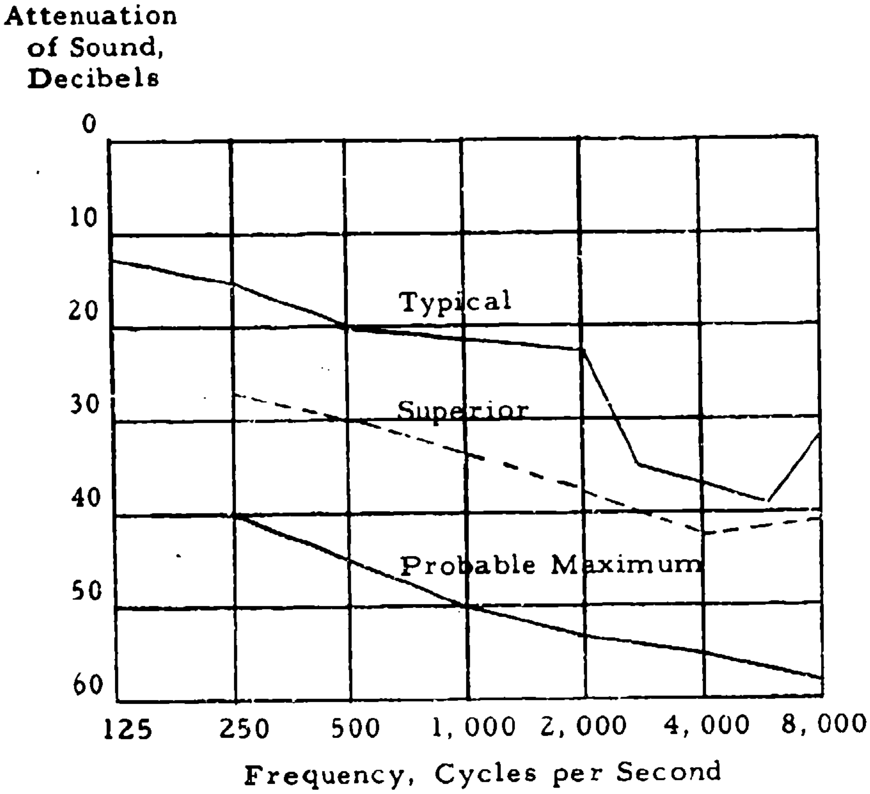
1. Application - Ear protectors are valuable when it is not practical or economical to reduce noise below hazard or annoyance levels.

2. Cost - Most ear protectors are inexpensive and provide high noise reduction when used correctly.

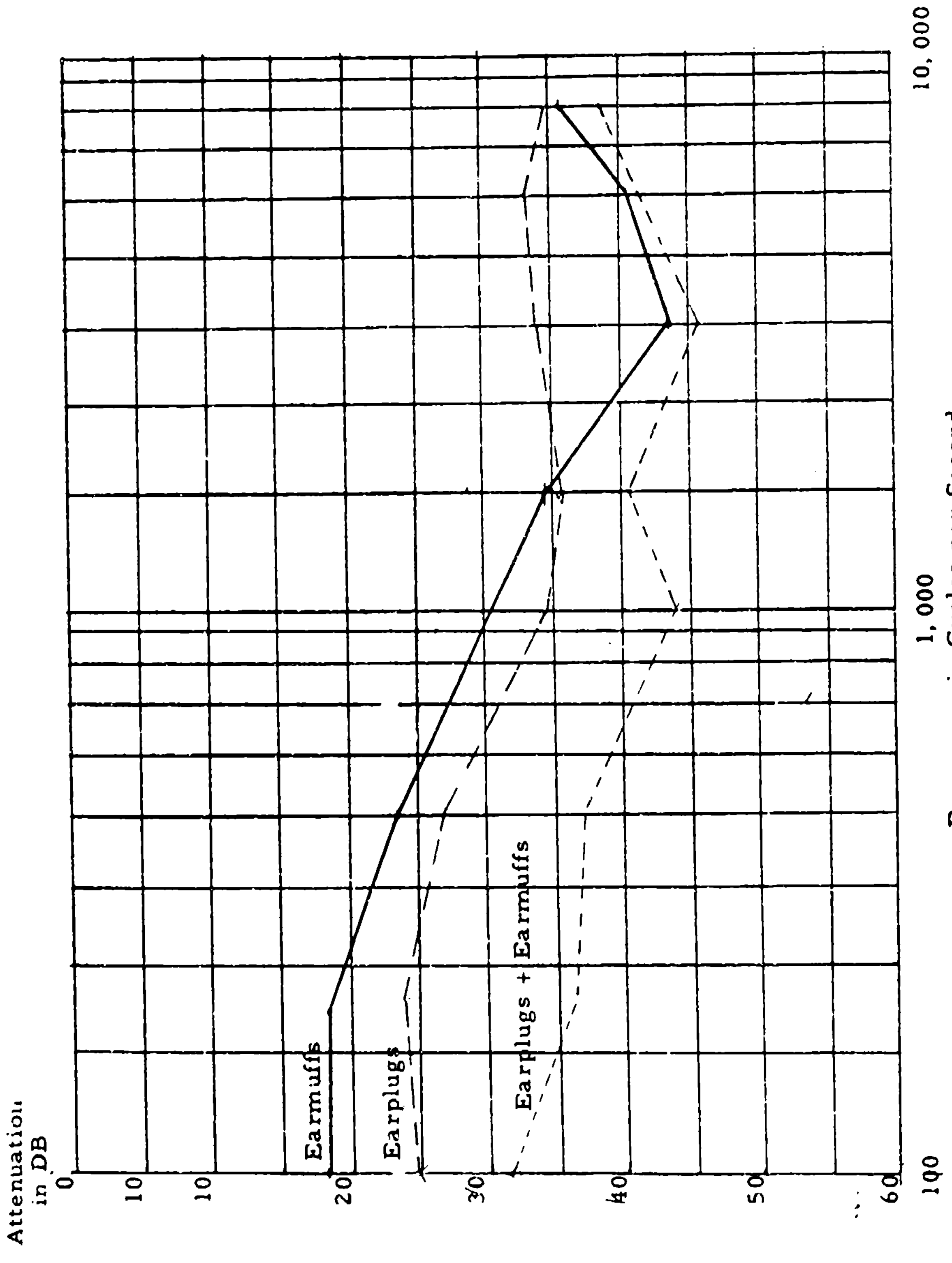
3. Comfort - Ear protectors are comfortable to wear. They do not interfere with other activities.

4. Capabilities - Noise attenuation achieved by the use of ear protective devices is shown below. The typical line represents the usual degree of attenuation and the superior line shows the degree attenuation when the protective device is well-fitted.

ATTENUATION OF SOUNDS USING EAR PROTECTORS



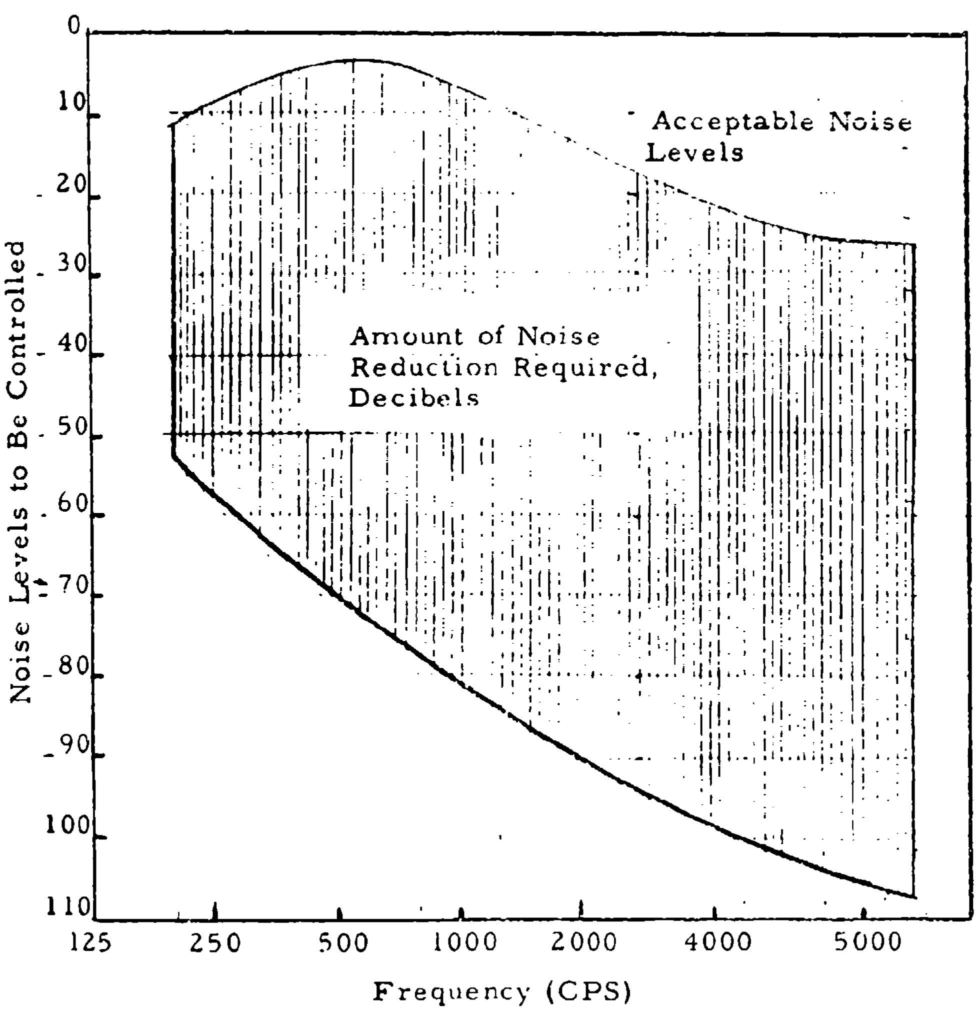
MEASURED ATTENUATION CURVES FOR EAR PROTECTIVE DEVICES



EAR PROTECTIVE DEVICES

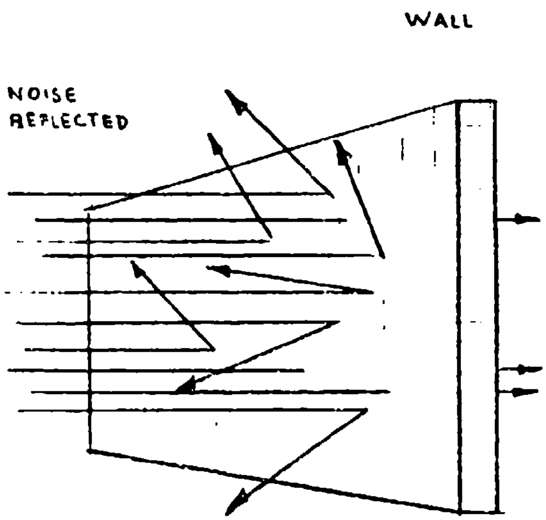
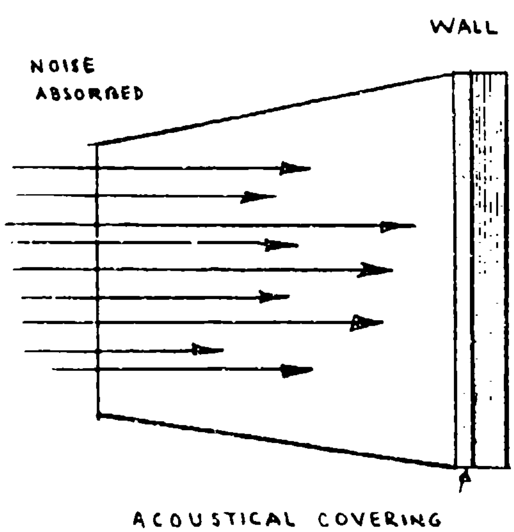
STEP 1	Determine the potential noise level of the shelter.
STEP 2	Determine the number of occupants in the shelter requiring ear protective devices.
STEP 3	Determine the amount of noise reduction required as is illustrated in the chart below.
STEP 4	Determine the kind of ear protective devices required for each shelter occupant needing such a device.

DETERMINATION OF NOISE-REDUCTION REQUIREMENTS

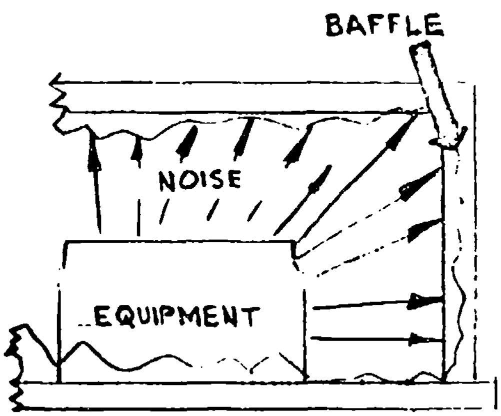
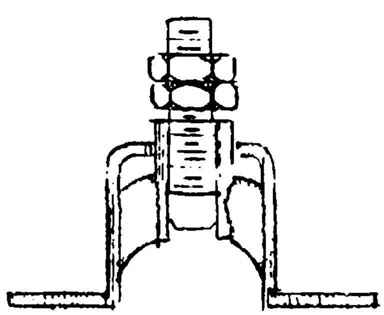
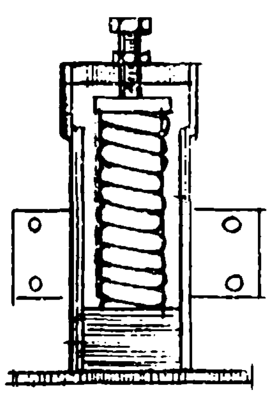


The lower curve represents the present noise level of a hypothetical situation and the upper represents the acceptable level. The difference represents the noise reduction requirements.

SOUNDPROOFING METHODS

Typical Design	Description
	**Sound-Reflecting Materials** Brick, stone, and masonry walls are reflectors of noise waves. Some noise waves will penetrate, but there is a substantial reduction. Wood and fiberboard are partially effective as noise reflectors. They also are partial sound-deadeners.
	**Sound-Absorbing Materials** Acoustical materials are sound-deadening or sound-absorbing. They are generally compositions of cork, perforated fiberboard, or plaster and tile. Soft goods such as burlap and blankets can be used as expedients. Acoustical materials are mounted in various ways and the method of mounting influences the amount of noise reduction.

SOUNDPROOFING METHODS

Typical Design	Description
	**Baffles** Baffles are sound-reflective or sound-absorbing enclosures around equipment. They reduce or eliminate the noise levels emanating from the operation of the enclosed equipment. Baffles can be rigid enclosures, acoustical enclosures, or a combination of these two.
 	**Vibration Isolators** Vibration isolators are equipment mountings which dampen the vibrations resulting from equipment operation. These mountings allow the equipment to move freely. They are made of rubber, plastic, steel spring, metal mesh, or wire, rope and cable.

GENERAL INFORMATION

GENERAL TERMS

1. Noise - Unwanted sound.
2. Noise Source - The element creating the noise, such as equipment from which noise originates.
3. Noise Path - The means by which the noise reaches the ear, such as through the air, ductwork, and similar means.
4. Noise Receiver - The person affected by the noise.
5. Noise Control - The means of obtaining a tolerable noise level.
6. Noise Reduction - A definite decrease in the noise level.
7. Absorption Coefficient - The ratio of absorbed noise to the original total noise.
8. Acoustics - The science of sound, including its production, transmission, and effects.
9. Cycles per Second (cps) - A unit of frequency.
10. Decibel (db) - The smallest change in loudness the human ear can detect, a measurement of loudness.

LOUDNESS OF SOUNDS

1. 1 db - Smallest sound a human ear can detect
2. 10 db - Whisper
3. 60 db - Normal speaking voice
4. 90 db - Loud music
5. 120 db - Airplane at 10 feet
6. 140 db - Threshold of pain

The intensity and loudness of sound increase at an equal rate.

GENERAL INFORMATION

GENERAL TERMS

1. Frequency - The number of vibrations per unit of time, as in cycles per second (cps).

2. Intensity - The amount of energy in the sound waves.

3. Phon - The term used to denote the measure of intensity of sound.

4. Pitch - The frequency with which the air vibrates. Rapid vibrations produce high-pitched sounds. Slow vibrations produce low-pitched sounds.

5. Reverberation - The sound that persists at a given point after direct reception from the source has stopped.

6. Reverberation Time - The time required for the average sound pressure level to decrease 60 db after the source is stopped.

7. Sabin - A measure of the sound absorption of a surface. It is the equivalent of 1 sq. ft. of perfectly absorptive surface.

8. Sone - A unit of loudness. A simple tone of 1000 cps frequency and 40 db above a listener's threshold produces a loudness of 1 sone.

9. Sound Absorption - The process by which sound energy is diminished.

10. Threshold of Audibility - The level at which sounds approach the limit of hearing.

11. Threshold of Feeling - The level at which sound is painful to the ear.

12. Transmission Loss - The reduction of some sound characteristic. The noise level loss is expressed in decibels.

SOUNDPROOFING METHODS

Sound-Reflecting Materials

GENERAL INFORMATION

1. Characteristics - Sound-reflecting materials are brick, stone, masonry, and other materials which are nonsound-transmitting. Combinations of materials such as plastered brick or plastered slab concrete are very effective in yielding a high transmission loss. Painting surfaces increases the reflecting capability of the material used.

2. Application - The use of sound-reflecting materials does not permit much noise to pass through the barrier. However, the higher the reflecting capability the lower the noise-absorption capacity. Sound-reflecting materials are used when the requirement is to reduce the transmission of noise from one chamber to another.

Sound-Absorbing Materials

GENERAL INFORMATION

1. Characteristics - Sound-absorbing materials are generally acoustical tiles fabricated for this purpose. Each type of material absorbs different amounts of noise. Also, each type of material reduces different frequencies to different levels.

2. Application - The use of sound-absorbing materials does not permit sound noise to pass through the absorber. The higher the degree of absorption, the lower the noise-reflecting capacity. The reduction of noise is generally greater in the higher frequencies than in the lower frequencies. Sound-absorbing materials are used when the requirement is to absorb or deaden the noise within a chamber. Sound-absorbing materials have the advantage of being adaptable to both new and existing shelters.

SOUNDPROOFING METHODS

Baffles

GENERAL INFORMATION

1. Characteristics - Baffles are sound-absorbing or sound-reflecting enclosures surrounding noise-creating equipment. There are various designs for baffles. These various designs provide different degrees of noise reduction. Some baffles have ventilation openings necessitated by the type of equipment enclosed. Baffles may have double walls with the acoustical material on the inside, an air pocket in the center, and a rigid covering on the outside. Baffles constructed of nonsound-transmitting materials trap noise within the enclosure.

2. Application - Baffles are generally used to reduce noise levels resulting from equipment operation. The various kinds of baffles available for use offer flexibility to achieve a particular result or end.

EFFICIENCIES

1. The efficiency of sound-reflecting materials is determined by the amount of sound that strikes the surface compared to the amount of sound that passes through the surface. The density of the reflecting materials is very important.

2. The efficiency of sound-absorbing materials is measured by the ratio of sound absorbed to the total amount of sound that strikes the material surface.

Vibration Isolators

GENERAL INFORMATION

1. Characteristics - Vibration isolators are generally of two kinds--cable isolators and cup type or block isolators. Cable isolators are made of combinations of cable and metal mesh, or wire and rope and cable, or springs and cable. Cup type or block isolators are made of rubber or plastics. A third group of vibration isolators are pads made of cork or felt. Vibration isolators are basically resilient supports for equipment. They

SOUNDPROOFING METHODS

Vibration Isolators

GENERAL INFORMATION

reduce the amount of vibration transmitted from the equipment to the supporting structure. The overall size and weight of a vibration isolator increases as the load carrying capacity increases.

SHIPPING/ INSTALLATION INFORMATION

1. Small vibration isolators are shipped boxed as sets. Large units may be individually boxed.
2. Padding comes in bulky foam. Small pads are cut from the bulk piece to meet the particular application.
3. Some machinery comes with the vibration isolators built in. Generally, all the installation work required is the bolting of the vibration isolators to the mounting surface.

COMPARISON OF CABLE AND CUP TYPE ISOLATORS

Category	Cable Isolators	Cup Type Isolators
Load Range	100 to 1	2-to-1 maximum
Resonant Amplification	Low	Moderate
Natural Frequency	Adjustable, by spacing, stacking, cable cutting, etc.	Fixed
Load Variations	Adjustable, as above	Fixed rating
Attitude	Flexible	Vertical compression
Isolation	Shock and vibration	Vibration only
Mass Overload	Continues to isolate vibration	"Bottoms Out"
Weights	3, 7, and 10 ounces	2.2, 5, and 8 ounces
Shelf Life	Durable	Semi-durable, fail at extreme temperatures

SOUNDPROOFING METHODS

Materials

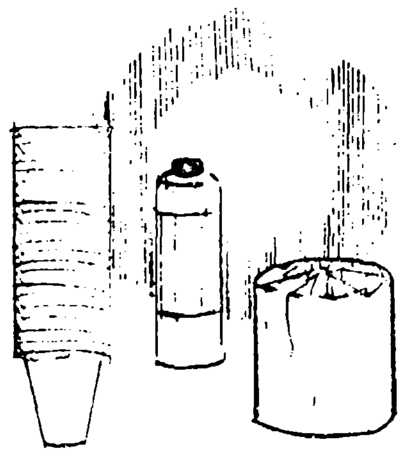
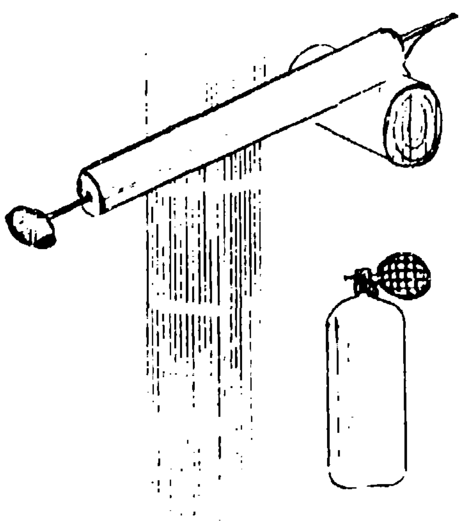
STEP 1	Determine the potential noise sources and noise levels of the shelter.
STEP 2	Determine the locations needing soundproofing and the type of soundproofing necessary--reflective or absorbent.
STEP 3	Determine the kind of materials of each type of soundproofing that are applicable for the required noise reduction. Select materials that are durable, flame-resistant, and light-reflecting.
STEP 4	Determine the number of square feet to be covered by each kind of material.
STEP 5	Determine the additional supplies required for applying, mounting, and supporting the soundproofing materials.
STEP 6	Determine where baffles are required and the type of baffle best fitting the need.

SOUNDPROOFING METHODS

Isolation Vibrators

STEP 1	Determine the weight of the equipment to be supported.
STEP 2	Determine the number of isolators required to properly support the load magnitude. Determine this for each isolator in its particular position and/or location. For loads equally distributed among the isolators, divide the total weight of the load by the number of isolators. The quotient is the load per isolator. For loads having weight that is not uniformly distributed, several different kinds of isolators may be required.
STEP 3	Determine the nature of the forcing vibration by defining its frequency, magnitudes, and the directions of applied forces.
STEP 4	Determine the greatest natural frequency for coupled vibration in the varying modes.
STEP 5	Determine the required stiffness of the isolators.

SANITATION KITS

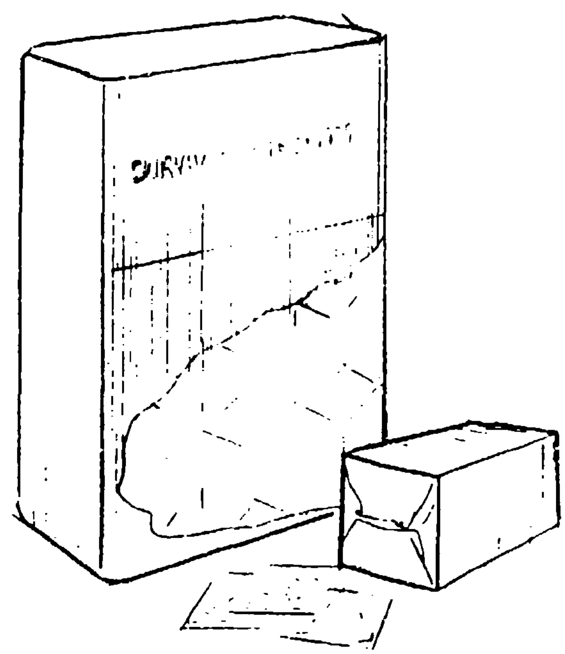
Typical Design	Description
	**OCD-Supplied Sanitation Kit** The OCD-supplied sanitation kit consists of sanitary items such as toilet tissue and hand cleaner. Plastic cups for drinking and the water dispensing tube for the OCD-supplied water drum are included. These kits are issued in fiberboard drums containing supplies for either 25 persons or 50 persons.
	**Supplemental Sanitation Supplies** A wide variety of sanitation items are available for shelter stocking. Included in this group are chemical deodorants, insect sprays, chemical toilets, and additional toilet tissue rolls. These items are adjuncts to the OCD-supplied sanitation kit.

SUGGESTED SAMPLE
DESIGN OF PAGE

SHELTER EQUIPMENT PLANNING GUIDELINES

CHAPTER 10

FOOD, MEDICINE AND SANITATION SUPPLIES AND FACILITIES



DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

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Use the Table of Contents given below to locate quickly key data pertaining to the selection, storage, and inventory of shelter supplies and facilities.

The Introduction Section provides all essential data regarding feeding supplies, medical supplies, sanitary supplies, and general facilities requirements.

Supply and facility component descriptions, application data, and selection procedures are given in the Component Selection Section.

The Manual Preparation Section identifies all of the essential elements to be covered in writing simple operating instructions.

NEED FOR FOODS, MEDICINES, SANITATION SUPPLIES AND FACILITIES

Supplies and Facilities Uses

Supplies and facilities are necessary items that must be adequate to meet the shelter occupants' needs in three categories.These categories are the nutritional resources necessary to survival,the medical supplies required for at least first-aid level treatment, and the sanitation items necessary to carry out a minimum sanitary program. All supplies and facilities can be placed in categories ranging from those required for minimum subsistence to those that are classified as comfort items. Supplies and facilities that are beyond the minimum requirements are desirable. Included are items such as special medicines for the chronically ill, sleeping accommodations, and supplemental foods. Supplies and facilities selected for shelters must have long shelf life, excellent storage characteristics, ease of use, and low cost.

Nutritional Supplies

The shelter occupants' capacities to do work and maintain the shelter will in part depend upon their nutritional intake during shelter stay. It is necessary to stock potable water and food within the shelter. The order of importance of nutritional supplies is first, potable water, and second, foods. It is possible for people to exist without water for brief periods--a few days. It is possible for people to exist without food for a more extensive period. The subsistence level desired will dictate the kinds and types of nutritional supplies stocked. Nutritional supplies as a system involve storage, maintenance, distribution, and control.

Medical Supplies

Medical supplies should be available within a shelter for use in treating persons who are suffering from injuries resulting from the aftereffects of an attack and the rigors of shelter living. The degree of sophistication of the medical supplies stored must depend on the assumed kind and level of treatment that will be required. Medical supplies as a system involve storage, maintenance, use, and control.

NEED FOR FOODS, MEDICINES, SANITATION SUPPLIES AND FACILITIES

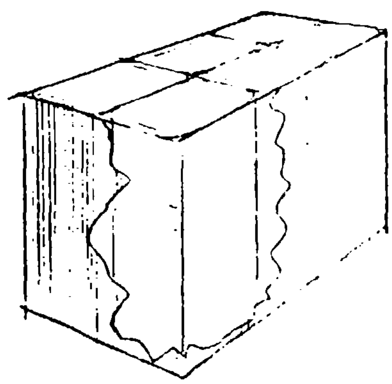
Sanitary Supplies

A sanitation program is an important factor in keeping the shelter habitable and its occupants healthy. The essential parts of this program are the control of communicable disease and the maintenance of at least the minimum level of personal hygiene. The effectiveness of the shelter sanitary program will depend upon the supplies available for carrying out the program objective. Sanitary supplies as a system involve storage, maintenance, distribution, and control.

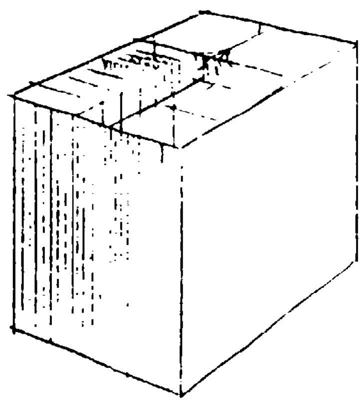
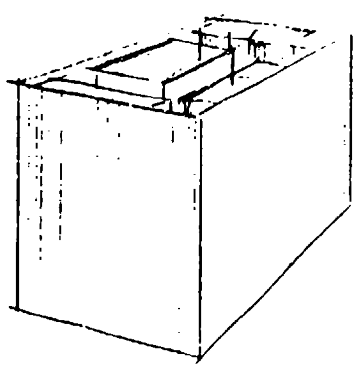
General Facilities

General facilities are that group of items which will, when added to a shelter, provide the shelter inhabitants with a level of comfort above that of austerity. The general facilities include bunks, brooms, blankets, clothing, utensils, furnishings, and recreational materials. General facilities as a system involve storage, maintenance, and use.

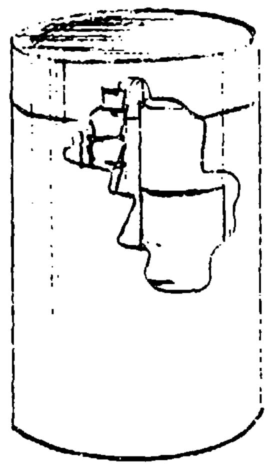
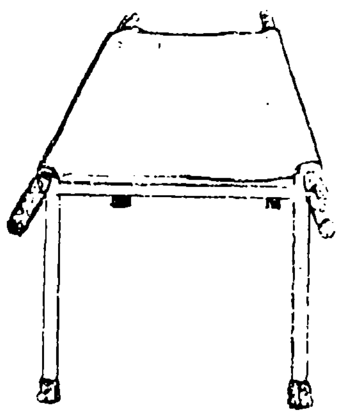
FOOD SUPPLIES

Type Designation	Typical Design	Description
OCD-SUPPLIED FOOD PACKAGE		
Type I		The food package consists of survival biscuits or crackers stored in either 5-gallon or 2-1/2-gallon cans. The cans are in cases, two per case and six per case, respectively. The cans are opened by using a can opener.
SUPPLEMENTARY FOODS		
Type II		Typical supplemental or adjunct foods must be compatible with the survival biscuits or crackers, be prepared easily, and have long shelf life. Generally, dry mixtures of dehydrated foods are best suited for the shelter selection. These foods are available in metal and/or carton storage containers. If planning includes stocking supplies for pregnant women, infants, and/or aged people, high protein foods are required for their diets.

MEDICAL SUPPLIES

Type Designation	Typical Design	Description
OCD-SUPPLIED MEDICAL KIT		
Type I		The medical kit consists of medications, dressings, and accessories such as scissors, forceps, and cotton applications. The kit is available in two different sizes of packages. The packages provide supplies for approximately 50-65 people and 300-325 people, respectively. Both packages are contained in weather-resistant, corrugated fiberboard boxes.
SUPPLEMENTARY MEDICAL KITS		
Type II		Typical supplemental medicines and accessories are those required for seriously injured persons, chronically and/or congenitally ill persons, for very young persons, and for infirm persons. Certain of the medicines required for persons in these groups require special storage procedures.

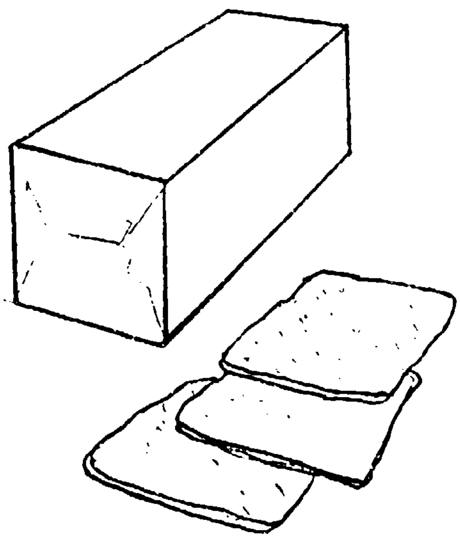
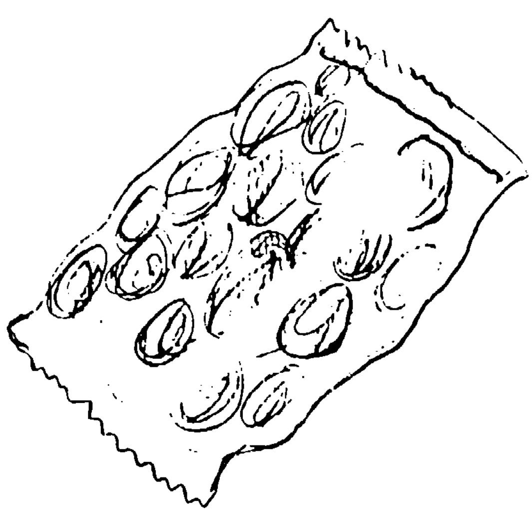
SANITARY SUPPLIES

Type Designation	Typical Design	Description
OCD-SUPPLIED SANITARY KIT		
Type I		The sanitation kit consists of various sanitary items such as toilet tissue, hand cleaner, and a commode seat. This kit also contains plastic drinking cups and the water dispensing spout used with the OCD-supplied container. The kit is available in two different sizes of packages. The packages provide supplies for approximately 25 persons and 50 persons, respectively. Both kits are packaged in fiberboard drums. This drum as well as the water storage drums forms the shell for OCD-supplied chemical toilet.
GENERAL FACILITIES		
Type I		The general facilities within the shelter consist of all items not previously categorized. The types of items selected for this group are wholly dependent upon the level of living desired for the shelter occupants. Included in this group are such items as furniture, clothing, recreational materials, and utensils.

SHELTER UNIT REQUIREMENTS

SHELTER SIZE	SYSTEM RATING	FOOD SUPPLY UNITS	MEDICAL SUPPLY UNITS	SANITATION SUPPLY UNITS
ABOVEGROUND AND BELOWGROUND SHELTERS				
50 PEOPLE	Best	Type I & II	Type I & II	Type I
	Acceptable	Type I	Type I	Type I
100 PEOPLE	Best	Type I & II	Type I & II	Type I
	Acceptable	Type I	Type I	Type I
200 PEOPLE	Best	Type I & II	Type I & II	Type I
	Acceptable			
300 PEOPLE	Best	Type I & II	Type I	Type I
	Acceptable	Type I		
500 PEOPLE	Best	Type I & II	Type II	Type I
	Acceptable	Type I	Type I	
1,000 PEOPLE	Best	Type I & II	Type II	Type I
	Acceptable	Type I	Type I	
2,000 PEOPLE	Best	Type I & II	Type II	Type I
	Acceptable	Type I	Type I	
3,000 PEOPLE	Best	Type I & II	Type II	Type I
	Acceptable	Type I	Type I	
5,000 PEOPLE	Best	Type I & II	Type II	Type I
	Acceptable	Type I	Type I	
10,000 PEOPLE	Best	Type I & II	Type II	Type I
	Acceptable	Type I	Type I	

FOOD PACKAGES

Typical Design	Description
	**OCD-Supplied Food Container** The OCD-supplied food packages consist of survival biscuits or crackers. These are somewhat similar in taste either to graham or animal crackers. The packages are issued in cases containing two 5-gallon cans or six 2-1/2-gallon cans.
	**Supplemental Food Package** A wide variety of supplemental foods are available for shelter stocking. These foods could be used as adjuncts to the main food which is the survival biscuit or cracker. Additional foods, specially suitable for pregnant women, infants, aged and infirm people would be very desirable.

OCD-SUPPLIED FOOD PACKAGE

GENERAL INFORMATION

1. Nomenclature - The food package consists of biscuits or crackers in two 5-gallon cans packed in a case. The contents of this case will provide 10,000 calories per person for 5 persons. The food package that consists of biscuits or crackers in six 2-1/2-gallon cans packed in a case will provide 10,000 calories per person for 7 persons. The biscuits or crackers contained in both of these food packages have a taste similar to graham crackers.

2. Size and Weight - The two-can fiberboard case measures approximately 19" x 9-5/8" x 14-5/8". This case weighs approximately 31 pounds. The six-can fiberboard case measures approximately 26-1/8"x 11-1/2" x 13". This case weighs approximately 47 pounds.

3. Biscuits and Crackers - The individual biscuits and crackers are in either of two sizes, 2" x 2" and 2-1/2" x 2-1/2". The 2" x 2" size biscuit or cracker contains about 22 calories. Ninety-two of these biscuits or crackers equal one pound. The 2-1/2" x 2-1/2" size biscuit or cracker contains about 30 calories. Sixty-five of these biscuits or crackers equal one pound.

STORAGE INFORMATION

1. The food packages are shipped ready for storage. The two 5-gallon can case requires 1.52 cubic feet of space. The six 2-1/2-gallon can case requires 2.26 cubic feet of space.

2. These food packages should be stored inside in a dry area.

3. A chart should be prominently displayed showing the location of the area where food supplies are stored.

4. An itemized list of the contents of each package should be posted in the storage area.

OCD-SUPPLIED FOOD PACKAGE

STORAGE INFORMATION	5.	Preplanned menus and shelter occupant ration cards should be stored with the food supplies in separate labeled packages. These items are then available for use as guides prior to opening the food containers.
	6.	Issuing instructions containing food handling methods, suggested feeding time, and other pertinent data should be stored with the food items.
	7.	Heavy loads should not be placed on top of the food packages. There is no limit on stackability of these packages.

SUPPLEMENTAL FOOD PACKAGES

GENERAL INFORMATION

1. Nomenclature - Commercially available supplemental food packages suitable for shelter stocking consist of dry mixtures of dehydrated foods. Most of these foods require the addition of water. Some of the foods available require the addition of hot water. Those foods which do not require the addition of hot water are preferable.

2. Typical Foods - The following typical foods can be selected as adjuncts to the OCD-supplied biscuit or cracker. These selections should require no heating.

   (1) Chocolate pudding
   (2) Apple, apricot, wild cherry, orange, grape, peach, raspberry, pineapple, strawberry, lemon, vanilla, and butterscotch toppings
   (3) Chocolate icing
   (4) Nonfat dry milk
   (5) Jellies
   (6) Raisins
   (7) Dehydrated soups
   (8) Gravies
   (9) Instant coffee, tea
   (10) Peanut butter
   (11) Dehydrated vegetables
   (12) Infant formulas and cereals
   (13) Vitamins
   (14) Dehydrated meats

STORAGE INFORMATION

1. The food packages should be as compact as possible and stored in master containers. Typical available containers are 55-gallon steel drums, 5-gallon hermetically sealed cans, and lined fiberboard drums.

2. These food packages and containers should be stored inside a dry area.

3. Heavy loads should not be placed on top of the food packages.

SUPPLEMENTAL FOOD PACKAGES

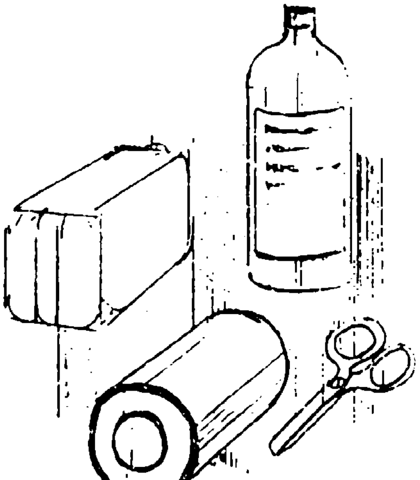
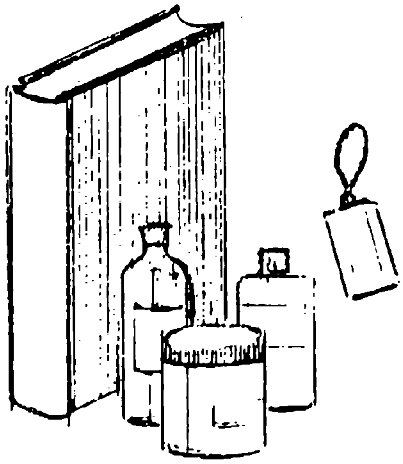
STEP 1	Determine the number of people by group to be maintained.
STEP 2	Determine, from the table below, the daily desired caloric intake rate required for individual people. Multiply the number of people in each group by the calories required. Multiply this number by the number of days of planned shelter occupancy.
STEP 3	Determine the caloric content of each food package.
STEP 4	Determine the number of food packages needed by dividing the caloric content of one standard food package into the total number of calories required as determined in step 2.

SUGGESTED AND/OR RECOMMENDED DAILY CALORIC REQUIREMENTS SELECTION TABLE

I. Healthy Nutritional Grouping	Calories	II. Diseased Nutritional Grouping	Calories
1-2 years	1300	Cardiovascular	2100
3-5	1600	Diabetes	
6-9	2000	Adults	2400
10	2500	Children	2300
Mature male (25)	3200	Gall Bladder	2100
Aged male (65)	2600	Ulcerative colitis	2300
Mature female	2300	Liver disease	
Aged female	1800	Low protein	2000
Pregnant female	2400	Moderate protein	2100
		High protein	3100
		Ulcer	2400
		Allergy	2100

The above daily caloric requirements are based upon estimates by trained dieticians. They may be in excess of what the planner wants to or can provide.

MEDICAL KITS

Typical Design	Description
	**OCD-Supplied Medical Kit** The OCD-supplied medical kit consists of first-aid level medical items including medications and dressings. These kits are issued in boxes containing supplies for approximately either 50-65 persons or 300-325 persons.
	**Supplemental Medical Kit** A wide variety of medical kits are available for shelter stocking. Supplemental kits are necessary for use in the treating of serious or chronic illnesses. Items in these kits should be used by medically trained personnel.

OCD-SUPPLIED MEDICAL KIT

GENERAL INFORMATION

1. Nomenclature - The medical kit consists of medications, dressings, and accessory supplies. Two kits are available. One kit contains enough supplies for 50-65 persons. One kit contains enough supplies for 300-325 persons. The kits contain instructions for use of the contents.

2. Size and Weight - The kit for 50-65 persons measures 15-1/2" x 12-3/4" x 8-1/2". This kit weighs 21 pounds. The kit for 300-325 persons measures 29-1/2" x 19-1/2" x 15". This kit weighs 104 pounds.

3. Contents - The contents of each of the two kits are shown in the table below.

Item & Number	Unit	50-65 Persons - Kit A	300-325 Persons - Kit B
Medication			
Aspirin, 500's	Bottle	1	
Aspirin, 1000's	Bottle		3
Laxative, 100's	Bottle	1	6
Toothache remedy 1 oz	Bottle	1	1
Eye, ear, nose drops, 1/2 oz	Bottle	3	18
Concentrated rubbing alcohol, 1 qt	Can	1	6
Diarrhea medicine, 1 qt	Bottle	1	6
Petroleum jelly, 1 lb	Can	1	3
Antiseptic soap, 1-3/4 oz	Cake	6	36
Baking soda, 1 lb	Can	1	2
Table salt, 1 lb	Bottle	1	2
Water purification tablets, 50's	Bottle	2	12

OCD-SUPPLIED MEDICAL KIT

Item & Number	Unit	65 Persons - Kit A	325 Persons - Kit B
Professional Items			
Penicillin tablets, 100's	Bottle	2	12
Phenobarbital tablets, 500's	Bottle	1	
Phenobarbital tablets, 1000's	Bottle		3
Sulfadiazine tablets, 500's	Bottle	1	
Sulfadiazine tablets, 1000's	Bottle		3
Dressings			
Roll gauze bandage, 2" x 6 yd, 12's	Package	1	6
Muslin triangular bandage, 37" x 37" x 52"	Each	1	6
Purified cotton, 1 lb	Package	1	3
Surgical pads gauze 4" x 4", 200's	Package	1	6
Other			
Cotton-tipped wood applicators, 1/2" x 6", 100's	Package	1	6
Wood tongue depressors, 100's	Box	1	3
Tweezer forceps, 3-1/2"	Each	1	1
Safety pins, 1-1/2" 12's	Package	3	12
Double blunt straight scissors, 4"	Each	1	3
Plastic fountain syringe	Each	1	1
Oral thermometer	Each	1	1

OCD-SUPPLIED MEDICAL KIT

STORAGE INFORMATION

1. The medical kits are shipped ready for storage. The 50-65-person kit requires 1.0 cubic feet of space. The 300-325-person kit requires 5.2 cubic feet of space.
2. These medical kits should be stored inside in a secure and dry area.
3. A chart should be prominently displayed showing the location of the area where medical supplies are stored. This area should be secured, not open.
4. An itemized list of the contents of each package should be posted in the storage area.
5. Dispensing instructions, shelter occupants' treatment cards and other pertinent data should be stored with the medical supplies.
6. There is no limit on stackability for kits of the same type.

Component Selection	Medical Supply Application Data

SUPPLEMENTAL MEDICAL KITS

GENERAL INFORMATION

1. Nomenclature - Commercially available medical kits suitable for shelter storage consist of supplies for treating the chronically ill, infirm, congenitally ill, and very young persons. Kits can be made up based upon the capacity desired to treat various diseases. The degree of knowledge and skill required to use these supplemental items must be considered.

2. Typical Medical Items - The following typical medical items may be selected as adjuncts to OCD-supplied medical kits.

(1) Accident report cards
(2) Adult-child plastic pharyngeal airway
(3) Aluminum hydroxide gel dried tablets
(4) Ammonia inhalants
(5) Anatomical charts
(6) Bismuth subcarbonate tablets
(7) Calamine lotion
(8) Cascara sagrada extract tablets
(9) Catgut sutures
(10) Compress bandages
(11) Dextran injection
(12) Dissecting scissors
(13) Elixer Terpin Hydrate
(14) Eye dressing packets
(15) Eye droppers
(16) Eye ointment
(17) Hemostatic forceps
(18) Insulin tablets
(19) Iodine swabs
(20) Liquid antiseptic analgesic dressings
(21) Medical books
(22) Medical tags for patients
(23) Needle holder
(24) Nitroglycerine tablets
(25) Portable resuscitators or oxygen administrators
(26) Rescue breathing tubes
(27) Rubber urethral catheter
(28) Sanitary belts
(29) Skin sutures and needle
(30) Small sterilizer
(31) Stretchers
(32) Tissue forceps
(33) Tourniquets
(34) Tracheotomy size 5 cannula
(35) Transfusion apparatus
(36) Wire Splints

SUPPLEMENTAL MEDICAL KITS

GENERAL INFORMATION

3. Package Size - Packaged kits for 25 persons is the recommended container size for supplemental medical items.

4. Typical Medical Card - An example of a typical medical card that may be used for recording treatment of shelter occupants is shown below.

TYPICAL MEDICAL CARD

Name ______________ Date ____________

Address ____________ Blood Type ________

Nature of Injuries ____________________

____

____

Treatment ____________________________

____

____

Disposition ___________________________

____

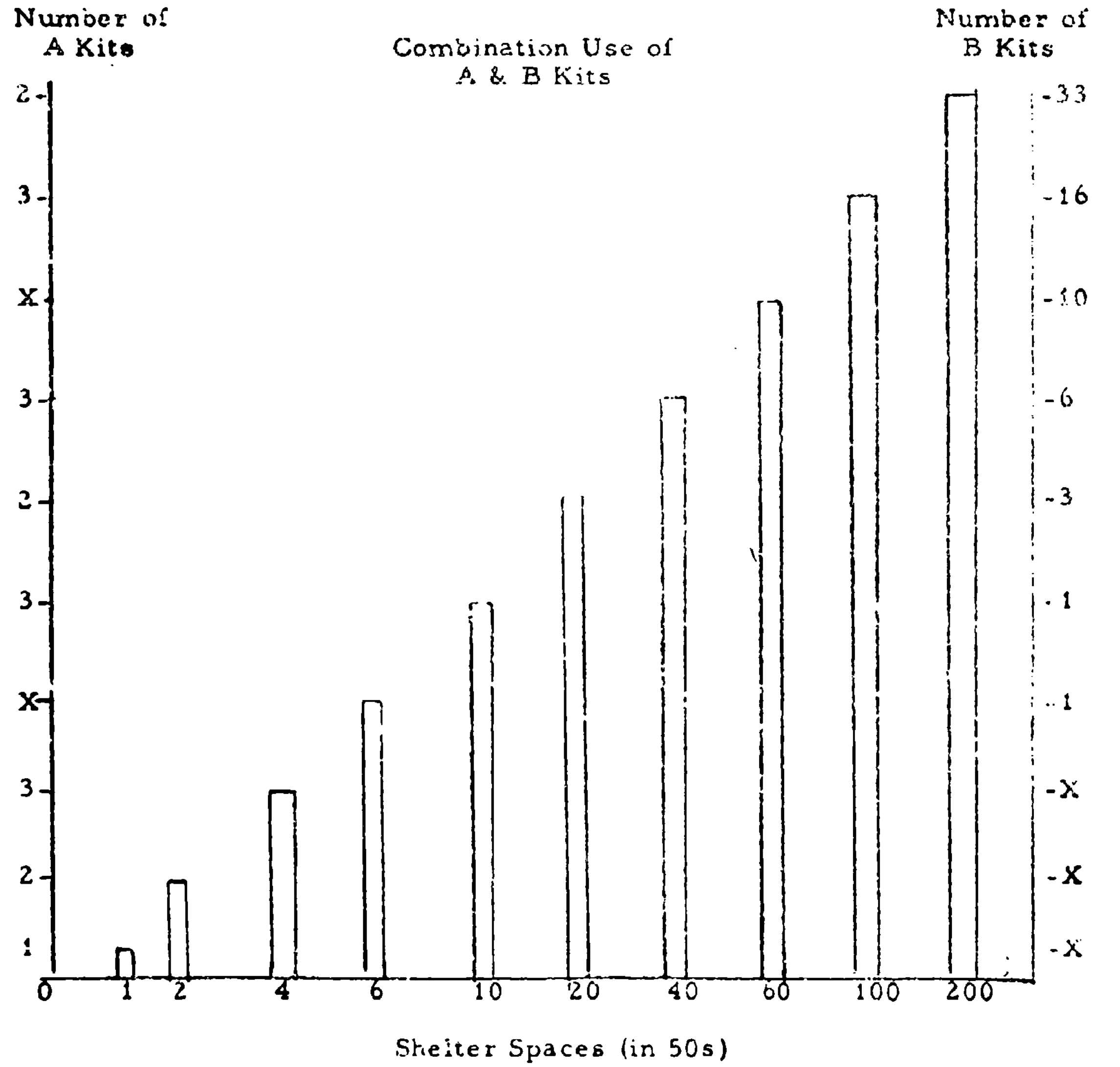
____

Signature of Attendant _________________

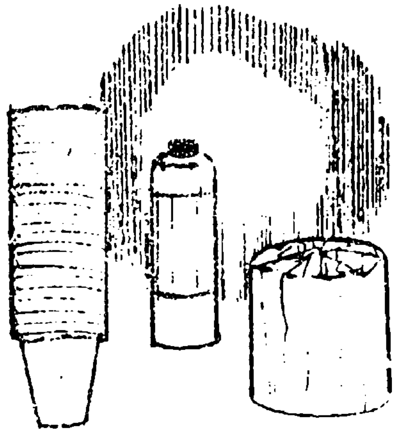
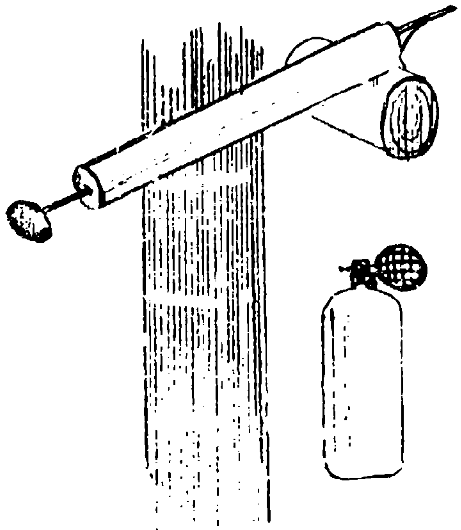
MEDICAL KITS

STEP 1	Determine the number of people to be maintained in the shelter. OCD medical kits are issued according to shelter capacity.
STEP 2	Determine the type of medical treatment desired and the degree of knowledge and skills required to provide that treatment.
STEP 3	Select the medical kits that meet the requirements determined in step 2.

OCD-SUPPLIED MEDICAL KITS



SANITATION KITS

Typical Design	Description
	**OCD-Supplied Sanitation Kit** The OCD-supplied sanitation kit consists of sanitary items such as toilet tissue and hand cleaner. Plastic cups for drinking and the water dispensing tube for the OCD-supplied water drum are included. These kits are issued in fiberboard drums containing supplies for either 25 persons or 50 persons.
	**Supplemental Sanitation Supplies** A wide variety of sanitation items are available for shelter stocking. Included in this group are chemical deodorants, insect sprays, chemical toilets, and additional toilet tissue rolls. These items are adjuncts to the OCD-supplied sanitation kit.

OCD-SUPPLIED SANITATION KIT

GENERAL INFORMATION

1. Nomenclature - The sanitation kit consists of the necessary sanitation materials and supplies for use with the OCD-supplied water drum. Two kits are available. One kit contains enough supplies for 25 persons. One kit contains enough supplies for 50 persons.

2. Size and Weight - Both kits are stored in a fiberboard drum which measures 16-1/4" in diameter and 21-3/4" in height. The kit for 25 persons weighs 18 pounds. The kit for 50 persons weighs 23 pounds.

3. Contents - The contents of each of the two kits are shown on the table below.

Item	Unit	Kit III	Kit IV
Toilet tissue	Rolls	5	10
Plastic commode seat	Each	1	1
Hand can opener	Each	1	1
Sanitary pads, Heavy Duty	Dozen	1	2
Sanitary pads, Regular	Dozen	2	3
Hand cleaner	Can	1	1
Polyethylene gloves	Pair	1	1
Water dispensing spout	Each	1	1
Plastic cup and lids	Each	40	80
Chemical commode	Each	1	1
Polyethylene bag liner	Each	1	1

OCD-SUPPLIED SANITATION KIT

STORAGE INFORMATION

1. The sanitation kits are shipped ready for storage. Each kit requires 3.36 cubic feet of space.

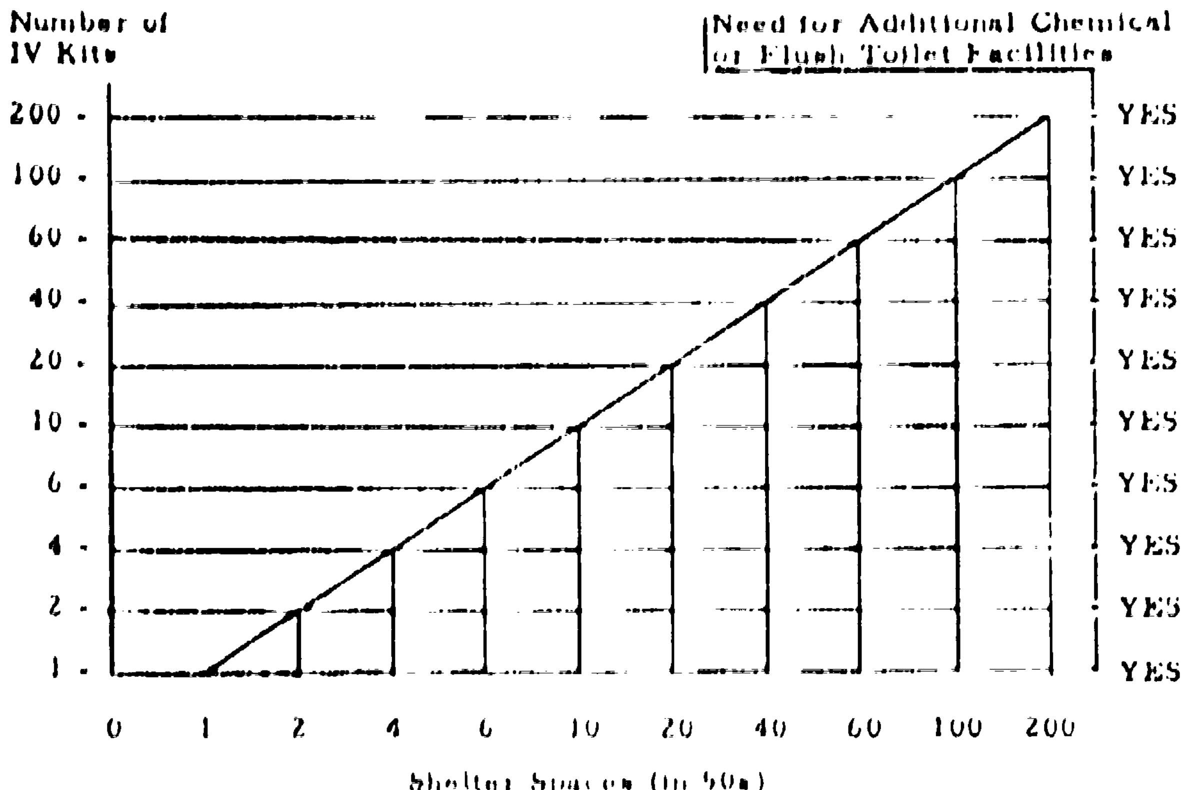
2. These kits should be stored inside in a dry area.

3. The sanitation kits should be stacked no more than six high.

OCD-SUPPLIED SANITATION KITS

STEP 1	Determine the number of people to be maintained. OCD-sanitation kits are issued according to shelter capacity.
STEP 2	Determine from the chart below the number of sanitation kits required.

OCD-SUPPLIED SANITATION KITS



ACCESSORY ITEMS AND FURNITURE

Typical Design	Description
None	**Accessory Items** Accessory items for the shelter consist of cleaning materials, food preparation and serving materials, recreational materials, and miscellaneous materials. The presence of these items contributes to a shelter occupancy level above that which is needed for subsistence.
None	**Furniture** Furniture items for the shelter consist of chairs, tables, and sleeping units. The presence of these items contributes to a shelter occupancy level above that which is needed for subsistence.

ACCESSORY ITEMS

GENERAL INFORMATION

1. Cleaning Materials - The chart below is a list of typical items.

Item	Unit	Number of Units per Each 50 Persons
Concentrated all-purpose cleaner	Gallon	2
Rubber or plastic gloves	Pair	2
Dustpan	Each	2
Sponge	Each	4
Plastic trash bag	Each	10
10-quart bucket	Each	2
Packaged paper towels	Each	10
Mop	Each	2
Broom	Each	2
Brush	Each	2

2. Food Preparation and Serving Utensils - The chart below is a list of typical items.

Item	Unit	Number of Units per Each 50 Persons
Electric coffee urn	Gallon	2
Plastic cup	Each	60
Plastic knife	Each	60
Plastic spoon	Each	60
Electric hot table	Each	2
Measuring spoon	Each	2
Plastic dish	Each	60

ACCESSORY ITEMS

3. Recreational Materials - The chart below is a list of typical items.

Item	Unit	Number of Units per Each 50 Persons
Playing cards	Deck	8
Checkers	Set	5
Scrabble	Set	5
Paperback books	Each	10
Pencil or pen	Each	10
Paper pad	Each	20
Bingo	Set	3

4. Miscellaneous Materials - The chart below is a list of typical items.

Item	Unit	Number of Units per Each 50 Persons
Stepladder	Each	1
Plastic mirror	Each	10
Religious services kit	Each	1
Blankets	Each	100
Electric razor	Each	2
Safety razor	Kit	5
Ashtrays	Each	5
Axe	Each	2
Shovel	Each	2
Pocket flashlight	Each	2
Foot powder	Can	5
Toothpaste	Tube	5
Coveralls	Pair	5
Chewing gum	Package	10
Logbook	Each	1
Records book	Each	1

ACCESSORY ITEMS AND FURNITURE

STORAGE INFORMATION

1. All accessory items and furniture should be stored in the general storage area.

2. These items should be stored in master containers.

3. A chart should be prominently displayed showing the location of the area where the general supplies and facilities are stored.

4. An itemized list of the contents of each package should be posted in the storage area.

FURNITURE

GENERAL INFORMATION

1. Nomenclature - Chairs and tables for shelter use may be constructed of corrugated cardboard, molded plastic, metal, or wood and canvas construction. Bunks may be metal frame and mesh, metal frame and canvas, or metal frame and spring combinations.

2. Form - For storage purposes chairs should be stackable and tables should have folding legs. Bunks should be tiered and rigid. They must incorporate dismantling features so that they can be stored in a minimum amount of space. Serviceability will depend on the proper design, construction, and materials.

3. Use - Plans should include the use of these facilities on a shift basis. When one-half of the shelter occupants are using the sleeping facilities, the remaining one-half should be working and/or having access to the furniture.

MAINTENANCE AND INVENTORY DATA

SEMI-MONTHLY STANDBY INSPECTION

1. Inspect containers for physical and/or moisture damage.
2. Visually audit the number of containers.
3. Prepare a status of inventory list.

TYPICAL FOOD INVENTORY LIST

SHELTER SUPPLIES

Food Inventory List

Item	Inventory Interval	Last Inventory	Rotation Date	Passed	Failed	Remedial Action	
						Repair	Replace

MAINTENANCE AND INVENTORY DATA

SEMI-MONTHLY STANDBY INSPECTION

1. Inspect containers for physical and/or moisture damage.
2. Visually audit the number of containers.
3. Prepare a status of inventory list.

TYPICAL MEDICAL INVENTORY LIST

SHELTER SUPPLIES

Inventory List Location

Item	Inventory Interval	Last Inventory	Passed	Failed	Remedial Action	
					Repair	Replace

MAINTENANCE AND INVENTORY DATA

QUARTERLY STANDBY INSPECTION

1. Inspect containers for physical and/or moisture damage.
2. Visually audit the number of containers.
3. Prepare a status of inventory list.

TYPICAL GENERAL SUPPLY AND FACILITY INVENTORY LIST

SHELTER SUPPLIES AND FACILITIES

General Item Inventory List — Location

Item	Inventory Interval	Last Inventory	Passed	Failed	Remedial Action	
					Repair	Replace

APPENDIX

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The bibliography information in the Appendix is essentially a listing of the references used by the study team on this project. These references are grouped by kind of publication as follows:

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