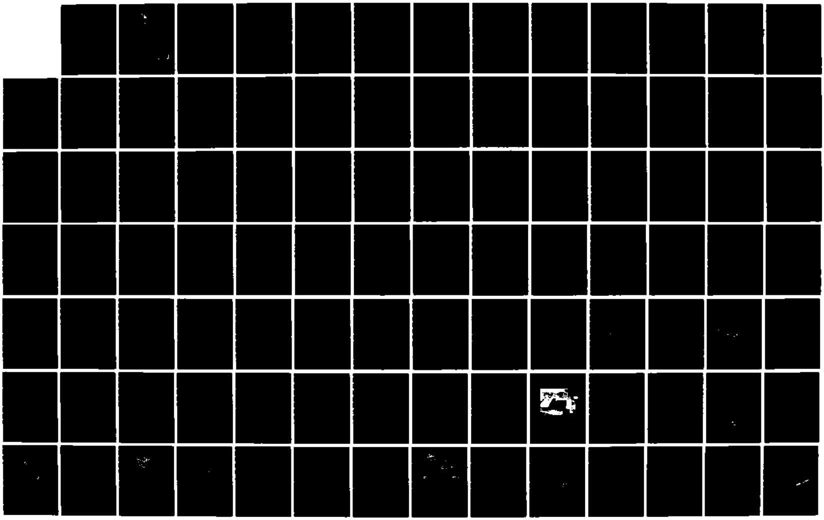
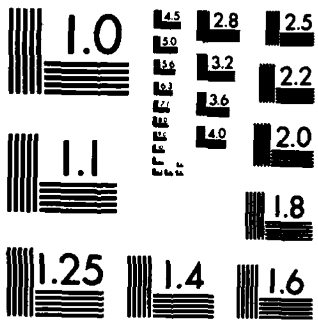
AD-A146 892 A COMPREHENSIVE EXPEDIENT METHODS FIELD MANUAL(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYSTEMS AND LOGISTICS R V BOUSQUET SEP 84 1/2

UNCLASSIFIED AFIT/GEM/LSM/84S-3 F/G 13/2 NL

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A COMPREHENSIVE EXPEDIENT METHODS

FIELD MANUAL

THESIS

Roy V. Bousquet
Captain, USAF

AFIT/GEM/LSM/84S-3



DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

# AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GEM/LSM/84

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

AD-A146892

## REPORT DOCUMENTATION PAGE

**1a. REPORT SECURITY CLASSIFICATION:** UNCLASSIFIED

**1b. RESTRICTIVE MARKINGS**

**2a. SECURITY CLASSIFICATION AUTHORITY**

**2b. DECLASSIFICATION/DOWNGRADING SCHEDULE**

**3. DISTRIBUTION/AVAILABILITY OF REPORT:** Approved for public release; distribution unlimited.

**4. PERFORMING ORGANIZATION REPORT NUMBER(S):** AFIT/GEM/LSM/84S-3

**5. MONITORING ORGANIZATION REPORT NUMBER(S)**

**6a. NAME OF PERFORMING ORGANIZATION:** School of Systems and Logistics

**6b. OFFICE SYMBOL (If applicable):** AFIT/LS

**7a. NAME OF MONITORING ORGANIZATION**

**6c. ADDRESS (City, State and ZIP Code):**
Air Force Institute of Technology
Wright-Patterson AFB, Ohio 45433

**7b. ADDRESS (City, State and ZIP Code)**

**8a. NAME OF FUNDING/SPONSORING ORGANIZATION**

**8b. OFFICE SYMBOL (If applicable)**

**9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER**

**8c. ADDRESS (City, State and ZIP Code)**

**10. SOURCE OF FUNDING NOS.**

| PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. | WORK UNIT NO. |
|---|---|---|---|
| | | | |

**11. TITLE (Include Security Classification):** See Box 19

**12. PERSONAL AUTHOR(S):** Roy V. Bousquet, Capt, USAF

**13a. TYPE OF REPORT:** MS Thesis

**13b. TIME COVERED:** FROM ________ TO ________

**14. DATE OF REPORT (Yr., Mo., Day):** 1984 September

**15. PAGE COUNT:** 160

**16. SUPPLEMENTARY NOTATION**

Approved for public release: IAW AFR 190-17.
Lynn E. WOLAVER 14 Sep 84
Dean for Research and Professional Development
Air Force Institute of Technology (ATC)
Wright-Patterson AFB OH 45433

**17. COSATI CODES**

| FIELD | GROUP | SUB. GR. |
|---|---|---|
| 13 | 02 | |
| | | |

**18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number):** Bare Bases, Bomb Damage, Civil Engineering, Deployment, Military Facilities

**19. ABSTRACT (Continue on reverse if necessary and identify by block number)**

Title: A COMPREHENSIVE EXPEDIENT METHODS FIELD MANUAL

Thesis Advisor: Jeffrey S. Thomas, Captain, USAF

**20. DISTRIBUTION/AVAILABILITY OF ABSTRACT:** UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐

**21. ABSTRACT SECURITY CLASSIFICATION:** UNCLASSIFIED

**22a. NAME OF RESPONSIBLE INDIVIDUAL:** Jeffrey S. Thomas, Captain, USAF

**22b. TELEPHONE NUMBER (Include Area Code):** 513-255-4552

**22c. OFFICE SYMBOL:** AFIT/DET

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

This investigation uncovers expedient methods for use by Air Force Civil Engineers during contingencies or contingency training. A literature review of magazine articles, course handouts, pamphlets, regulations, and manuals was conducted to find published expedient methods. Unpublished expedient methods were found by surveying Civil Engineering officers, enlisted personnel and civilians stationed in the CONUS. A total of 70 expedient methods were uncovered to supplement AFM 88-34, Field Engineering Handbook: Expedient Methods, to form a comprehensive expedient methods field manual.

AFIT/GEM/LSM/84S-3

# A COMPREHENSIVE EXPEDIENT METHODS FIELD MANUAL

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Masters of Science in Engineering Management

Roy V. Bousquet, B.S.

Captain, USAF

September 1984

# Preface

This study developed a comprehensive expedient methods field manual by combining published and unpublished expedient methods to supplement AFM 88-34, Field Engineering Handbook: Expedient Methods. The published expedient methods were found after an extensive literature review. A survey of Civil Engineering personnel was used to find unpublished expedient methods. The final product provides a valuable guide for Civil Engineers for home station training and during actual contingencies.

In gathering the expedient methods and designing the supplement to AFM 88-34, I received a great deal of help from some very special people. I am deeply indebted to my thesis advisor, Capt Jeffrey S. Thomas, for his wisdom and guidance throughout this research effort. I would also like to thank Maj Charles E. Beck for his valuable assistance in editing this study. Finally, I extend my deepest gratitude to my wife Corinne for her patience and understanding during the many nights that I was consumed with work and confined to my desk.

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## Abstract

This investigation uncovers expedient methods for use by Air Force Civil Engineers during contingencies or contingency training. A literature review of magazine articles, course handouts, pamphlets, regulations, and manuals was conducted to find published expedient methods. Unpublished expedient methods were found by surveying Civil Engineering officers, enlisted personnel and civilians stationed in the CONUS. A total of 70 expedient methods were uncovered to supplement AFM 88-34, Field Engineering Handbook: Expedient Methods, to form a comprehensive expedient methods field manual.

# A COMPREHENSIVE EXPEDIENT METHODS FIELD MANUAL

## I. Introduction

### Overview

This thesis identifies expedient methods which supplement AFM 88-34, Field Engineering Handbook: Expedient Methods. The result is a comprehensive expedient methods field manual for use during contingencies. A literature review is used to uncover published expedient methods that are not included in AFM 88-34, while a survey of all Air Force bases in the continental United States (CONUS) is used to discover unpublished methods. The published and unpublished expedient methods are then combined to supplement AFM 88-34 to form a more comprehensive field manual.

This chapter discusses the need for a comprehensive expedient methods field manual. This discussion begins with a general background of the Civil Engineering mission during contingencies, and is followed by an examination of the specific areas of work expected of Civil Engineers to complete their mission. The research problem relating to accomplishing these specific areas of work during contingencies is then discussed. This chapter also includes the research objectives, assumptions, and the scope and limitations of this thesis.

Issue

The Department of Defense Directive 1315.6, "Responsibilities for Military Troop Construction Support of the Air Force Overseas," identifies the mission of Civil Engineering in a contingency environment (15:6). This directive identifies the following tasks that Civil Engineers can expect to perform during war [15:6]:

a. emergency repair of war damage to air bases,
b. force beddown of Air Force units and weapons systems,
c. operations and maintenance of Air Force facilities and installations,
d. crash rescue and fire suppression, and
e. construction management of emergency repairs of war damage and force beddown.

Although Defense Directive 1315.6 identifies the Civil Engineering mission during wartime contingencies, other contingencies exist in addition to war. Military exercises and natural disasters also constitute contingencies. During contingencies, Air Force Civil Engineering forces must use expedient methods (i.e., quick and temporary forms of construction, maintenance, and repair) to keep base facilities operational. Such methods cover the 16 areas of work expected of Civil Engineers during contingencies [41]:

1. Building systems
2. Non-airfield pavements
3. Airfield pavements
4. Aircraft arresting systems
5. Airfield Lighting systems
6. Electrical power production
7. Overhead and underground electrical distribution systems
8. Interior wiring systems for buildings
9. Water wells
10. Potable water distribution systems

11. Sanitary distribution systems
12. Sewage treatment plants
13. Plumbing
14. Liquid fuel systems
15. Heating systems
16. Refrigeration and air-conditioning systems

Problem Statement

The last extended contingency in which Civil Engineering forces used expedient methods to perform their mission was the Vietnam conflict nearly a decade ago. Because of this time span, the majority of today's Civil Engineering members have never operated in a wartime contingency. Their knowledge in expedient methods can only come from actual peacetime contingencies or expedient methods training.

Since peacetime contingencies are not very common, expedient methods experience must come from home station training. Chapter 3 in AFR 93-3 identifies the need for home station training. This regulation states that every Base Civil Engineer, Air National Guard and United States Air Force Reserve Civil Engineering Unit Commander must ensure that home station training is "designed and executed to achieve a high state of readiness [8:15]." This same regulation also identifies expedient methods as one of the home station training requirements (8:16). The specific words are as follows:

> A great deal of simulation will be necessary in this [expedient methods] type of annual training. Realistic training scenarios should be developed to best derive the learning experience desired [8:16].

The need for home station expedient methods training is also emphasized at the Contingency Engineering Course at the Air Force Institute of Technology, School of Civil Engineering at Wright-Patterson AFB, Ohio. A draft Prime BEEF Managers Handbook served as a course handout during the February 1982 class. The handout provides the following guidance:

> The most likely time to encounter the need of expedient repair methods is during the bomb damage repair (BDR) phase of a base recovery operation. Therefore, training should concentrate heavily on the types and peculiarities of the facilities and utility systems found in friendly foreign countries. The prime concern is to get bases operational as safely and expeditiously as possible. A great deal of simulation will be necessary in this type [of] training. Realistic training scenarios should be developed to best drive the learning experience desired [12:23].

Although realistic scenarios are recommended for expedient methods training, a 1982 Functional Management Inspection team found many Air Force installations lacking in "hands-on" training for expedient methods (13:4). The inspection team identified this training as critical for "supporting Civil Engineering contingency readiness to meet worldwide combat support roles [13:1]." Furthermore, it is the author's opinion, based on five years of experience within the Civil Engineering (CE) organization at base level, that only senior CE officers and noncommissioned officers who served in Vietnam, and CE personnel who have peacetime contingency experience have any practical knowledge of expedient methods. Few of these procedures are published in existing pamphlets, manuals, training guides, and handbooks. Therefore, very little of this practical knowledge of expedient methods is available to the inexperienced CE personnel. As the experienced senior CE members retire from active duty, much of their valuable expedient methods knowledge is lost.

Finally, AFM 88-34 contains only some of the known expedient methods that are useful to Civil Engineers during contingencies. Numerous other expedient methods have been tried and reported since AFM 88-34 was published in 1967. The other published expedient methods are scattered among numerous Air Force and Army pamphlets, manuals, training guides, and handbooks. Therefore, no single field manual exists that includes all the expedient methods for each of the 16 areas of work required by Civil Engineers during contingencies.

## Statement of Purpose/Objectives

The purpose of this thesis is to provide expedient methods information for Civil Engineers deployed to contingency environments. This purpose is accomplished by fulfilling three objectives:

1. Identification of published expedient methods not included in AFM 88-34 that would be useful to Civil Engineers for completing the 16 areas of work expected of them during contingencies.

2. Collection of additional expedient methods for these

16 areas of work from Civil Engineers who have had past contingency experience but have never had their expedient methods procedures published.

3. Design of a supplement to AFM 88-34 that combines the published and unpublished expedient methods and provides a comprehensive expedient methods field manual for rapid use in contingency environments.

Assumptions

This thesis assumes Civil Engineers will be deployed to the worst possible location, namely a bare base in a hostile environment. The following factors will be applicable in this "worst-case" scenario:

1. The base will have few supporting facilities, utilities, and equipment that can be utilized by the deployed forces.

2. Some of the deployed equipment, utilities, and/or facilities will become useless due to normal wear-and-tear, or by hostile enemy action.

3. Replacements for the damaged equipment, utilities, and facilities will not always be readily available.

4. The deployed Civil Engineers with prior contingency experience will be very busy with their own work and will not always be available to give guidance to the less experienced personnel.

Even though this thesis assumes Civil Engineers are deployed to a bare base, less severe deployments are also possible. Both the worst-case and these less severe deployments would require expedient construction, maintenance, and repair procedures to keep the equipment, utilities, and facilities operational. However, the assumption of a worst-case scenario identifies expedient methods that would not otherwise be identified.

## Scope and Limitations

Since Civil Engineers can be deployed worldwide (8:5), this thesis examines expedient methods for widely contrasting environments. The environments considered include desert, arctic, and jungle regions. These regions present the most hostile weather conditions for the deployed Civil Engineering forces and their equipment.

No classified information is used in this thesis. The basic sources include military regulations and manuals, training guides, private authors, guest lecturers, and personal interviews.

## Organization of This Report

This report is organized to meet the academic requirements of a Master's thesis. However, it is also designed to provide the practical requirements of an expedient methods field manual.

The usual thesis documentation is included in this report. Chapter 2 is the literature review that uncovers published expedient methods not included in AFM 88-34. Chapter 3 gives the methodology for completing the literature review and the survey that uncovers unpublished expedient methods. Chapter 3 also explains how the published and unpublished expedient methods are combined to form the supplement to AFM 88-34. Chapter 4 summarizes the results of the literature review and survey. It also provides recommendations based on these results. Appendix A is an exhibit of the survey package and Appendix B is the actual supplement to AFM 88-34. Appendix B can be removed from this report, added to AFM 88-34, and used during deployments as a guide for completing required expedient methods.

## II. General Background to Expedient Methods

### Chapter Overview

This chapter provides information about the role of Civil Engineering during contingencies. Readers familiar with AFM 88-34 or expedient methods should skip this chapter. The discussion begins with definitions, a brief history of Civil Engineering mobilization, and an explanation of the importance of expedient methods for deployed Civil Engineers. The final portion of the chapter provides a literature review of expedient methods. This review introduces the primary areas to be included in the supplement to AFM 88-34. The actual supplement, found in Appendix B, presents each of these areas in a form similar to that found in AFM 88-34.

### Definitions

The following alphabetical list of terms provides a reference for material presented in this chapter:

> Bare base. A base having a runway, taxiway, parking areas adequate for the deployed force, and possessing an adequate source of water that can be made potable [40:29].
>
> Contingency. An uncertain future event sufficiently within the realm of possibility to warrant advance planning. Includes potential military operations, civilian or military emergencies, natural disaster relief [40:29].
>
> Deploy. To relocate a unit, or an element of it, to an area of operations or to a staging area. Deployment begins when the first aircraft, personnel, or items of equipment leave the home base. The force is deployed after the last

component of the unit has departed [40:29].

Expedient methods. The field construction, repair, and maintenance techniques used during contingencies. It is work performed in an innovative manner (often without the proper tools, materials, equipment, replacement parts, or personnel), yet sufficient to provide, restore, and maintain critical facilities, utilities, and equipment in an operational state without creating serious safety hazards (8:16).

Force beddown. The immediate beddown of mission forces and the operation of critical facilities and utilities. The force can be bedded in various types of facilities that make up Harvest Eagle and Harvest Bare sets, or they can be bedded by renovation/converting existing facilities on standby bases or colocated operating bases [2:16].

Harvest Bare. Nickname given to a bare base system. Harvest Bare is a concept in mobility which offers deployment of all supporting buildings to a bare or fixed base. These buildings are of light modular design and may serve as containers for those items used in the building when set up. Harvest Bare consists of shelters, utilities, and base maintenance equipment and support subsystems. Harvest Bare assets are designed to support 4500 personnel in various increments and are designated as War Reserve Materials (WRM) and maintained in a ready status [8:29].

Harvest Eagle. A nickname given to a selected package of essential items of equipment and supplies required to support forces/personnel under bare base conditions. It is an air transportable housekeeping package designed to support activities deployed to remote areas where it is not feasible to pre-position assets. Harvest Eagle sets are designed to support 1100 personnel, and are designated as War Reserve Materials (WRM) and maintained in a ready to deploy status [8:29].

Prime Base Engineer Emergency Force (BEEF). An Air Force, major command, and base level program that organizes the civil engineering force for worldwide direct and indirect combat support roles. It identifies and postures both civilian and military authorizations and skills for the dual role of performing peacetime real property maintenance and wartime engineering requirements. The Prime BEEF program includes all military civil engineering personnel at all levels of command [8:5].

## The Concept of Expedient Methods

During contingencies, Prime BEEF teams are tasked with force beddown, emergency repairs, and operations and maintenance functions (15:6). These functions are all accomplished by using expedient methods, quick and temporary forms of construction, maintenance, and repair.

Expedient methods of construction are used during base build-up. Harvest Bare and Harvest Eagle sets "provide all the support facilities, utilities, and equipment required to turn a runway into an operable airfield [39:28]." Expedient maintenance is the work that keeps facilities, utilities, and equipment operational often without the proper tools, materials, replacement parts, and personnel (8:16). "Expedient repair methods provide for minimum essential restoration of a facility or system to useful operation in the least time, with the least effort and often without the benefit of the best material or equipment... The prime objective is to make operational repairs as safely and expeditiously as possible [8:16]."

One method of performing expedient repairs involves the cannibalization of other equipment. "Cannibalization - the removal of serviceable items from one item of equipment for use on another - is an issue closely related to forward support... Cannibalization may be used when parts are not available from the supply system and an item of equipment can be repaired using parts from other unserviceable equipment [38:4]."

Many other examples of expedient methods have been used in past deployments. As support requirements change, the deployment kits are modernized. New forms of expedient methods must then be developed to install and service the new equipment, facilities, and utilities included in the modernized deployment kits.

Therefore, to perform their mission effectively, CE personnel must be familiar with both past and current expedient methods of accomplishing construction, maintenance, and repair. This work may also have to be done under the most hostile conditions. Shortages of food and water, inadequate tools and equipment, inclement weather, and enemy action must be dealt with so the overall mission can continue.

## The Evolution of Civil Engineering Mobilization

Since the development of modern air warfare, Civil Engineers have used expedient methods to make air base facilities, utilities, and equipment operational. During World War II, advancing ground forces were required to establish forward operating bases; air units also advanced to provide air support for these advancing ground troops. These forward air units could either build required base facilities or operate in the open (46:24).

During the 1950s, techniques were developed to prepackage needed equipment for shipment to forward bases. This initial deployment kit was nicknamed Grey Eagle. It included tents, field kitchens, medical facilities, power generators, administrative supplies, and various equipment. All items of the Grey Eagle kit were installed, repaired, and maintained with expedient methods. Unfortunately, this early kit was heavy, bulky, and required many hours to erect (46:24).

By the late 1960s, deployment kits were designed to be light, modular, and C-130 transportable. Some shelters were their own containers. The new concept was to provide everything to support a deployed force in any environment. Hardware included equipment to support weapons systems plus transportation, housing, mess, aircraft maintenance, airfield lighting, electrical power, water, sewage, heating, cooling, medical, and civil engineering facilities (46:24).

Today's concept of deployment has remained basically unchanged since the late 1960s. The idea is to "rapidly deploy a force, complete with shelters and support facilities, capable of independently supporting and launching sustained combat operations with the same independence as fixed theater installations. The assumption is that tactical forces will continue to have a bare base requirement to conduct sustained air operations on a worldwide basis in support of national policy [46:25]."

Harvest Eagle and Harvest Bare kits provide the equipment necessary to establish an operating bare base for, respectively, short term and long term deployments. Expedient methods are used not only to erect the equipment, facilities, and utilities provided in these kits, but to keep them operational. As these deployment kits are modernized, new expedient methods must be developed to erect, repair, and maintain them.

## Engineering Needs

Civil Engineers must be familiar with various expedient methods to operate effectively in hostile environments. The purpose of this chapter is to uncover expedient methods that were used in past deployments and can be used to guide expedient methods in future contingencies.

The expedient methods to be examined cover the 16 areas of work required by Civil Engineers during contingencies. The work requiring expedient construction, maintenance, and repair have been divided into three major categories: (1) facilities, (2) pavement surfaces and support systems, and (3) utility systems. Facilities includes shelters, field-fortifications, and facility hardening. Pavement surfaces and support systems includes non-airfield pavements, airfield pavements, aircraft arresting systems, and airfield lighting systems. Utility systems includes electrical power production, overhead and underground electrical distribution systems, interior wiring systems for buildings, water wells, potable water distribution systems, sanitary distribution systems, sewage treatment plants, plumbing, liquid fuel systems, heating systems, and refrigeration/air-conditioning systems.

Since many of these work areas are provided by the Harvest Bare and Harvest Eagle deployment kits, these kits are discussed in detail. However, many useful and perhaps critical items are not included in either deployment kit. Expedient methods that provide and service these "nonstandard" deployment items are also examined.

## Facilities

General. Shelters protect airmen, equipment, and supplies from enemy assault and the weather. "The best shelter is usually the one that will provide the most protection with the least amount of effort [20:3.1]." Therefore, existing facilities should be fully used. Also, natural shelters such as caves, mines, or tunnels should be used before artificial shelters are constructed (20:3.1). Constructing shelters consumes valuable time that can be used elsewhere in making a base operational.

There are basically three classifications of shelters. Surface shelters, the first type, are built above ground elevation. The surface shelter requires "the least amount of labor to construct, but it is hard to conceal and requires a large amount of cover and revetting material [20:3.1]." Most shelters in contingency environments are surface shelters due to their expediency of construction.

The second type, underground shelters, are labor and time intensive to construct but "provide good protection against radiation because the surrounding earth and overhead cover are effective shields against nuclear radiation [18:3.1]." Cut-and-cover shelters, the third type, are dug partly into the ground and are covered with a thick layer of rock, logs, sod, and excavated backfill. The cut-and-cover shelters are also time consuming to construct but "provide excellent protection from weather and enemy action [20:3.1]."

During contingencies, facilities should be constructed as soon as possible. Therefore, surface shelters are usually built first. The other classes of shelters are built if there is sufficient time. Because the surface shelters offer little protection against enemy action, they must be hardened. Proper siting of surface shelters reduces the need for immediate hardening. "Wherever possible, shelters should be sited on reverse slopes, in woods, or in some form of natural defilade such as ravines, valleys, and other hollows or depressions in the terrain... All shelters must be camouflaged or concealed [20:3.1]."

Deployed Shelters. Since deployed forces must operate in extremely hot or extremely cold areas of the world, the Harvest Bare and Harvest Eagle deployment kits provide surface shelters that offer protection against the elements. These kits contain modular, expandable, and canvas shelters. "Modular and expandable shelters and canvas tents provide all the structures needed on a bare base to provide billeting, shops, hangars, and storage. All expandable and general purpose shelters can be set up for immediate use or packaged for redeployment by the same people who will use them [1:8.1]."

Hasty Shelters. In a deployment, the shelters provided in the Harvest Bare and Harvest Eagle kits may be destroyed. They can be destroyed during transport to the site, or weather and enemy action can destroy the shelters after they have been set up. If no replacements are immediately available, some hasty (expedient) shelters must be constructed until the replacements arrive.

> Hasty shelters are constructed with a minimum expenditure of time and labor using available materials. They are ordinarily built above ground or dug in deep snow. Shelters that are completely above ground offer protection against the weather and supplement or replace shelter tents which do not provide room for movement [20:3.1].

Field Fortifications. Although shelter from the weather is important to keep the deployed forces healthy and able to perform their mission, shelter against enemy action is also necessary if the deployed forces are to survive in contingency environments. Therefore, Civil Engineers must be familiar with the various expedient field fortifications they can construct to increase the probability of individual and base survival.

Field fortifications include numerous types of passive measures to better ensure the air base's survivability. The most common types are emplacements, revetments, bunkers, bomb shelters, and obstacles (17:85,93,96,105). Emplacements (i.e., foxholes) are simply and hastily constructed defensive positions that are camouflaged, concealed, and "permit each individual to accomplish assigned fire missions [17:85]."

Revetments are retaining walls that prevent unstable soils from collapsing in defensive structures. "Revetments may be constructed of sandbags, sod blocks, and other expedients [17:93]."

Bunkers are emplacements with overhead protective cover. "The protective cover and roof of a bunker should be designed so that it moves freely but is rigid enough to displace as a unit. It must also be able to absorb the shock of an exploding shell [17:96]."

Bomb shelters are totally passive structures because they protect personnel and equipment from the enemy and have no openings for effectively returning fire. "The most effective shelters are underground cut-and-cover [17:96]."

Obstacles are structures that prevent or hinder enemy forces from advancing to the air base. Antipersonnel obstacles include "wire obstacles constructed with barbed wire and tape...[and] expedient obstacles constructed from locally available material... Antivehicular obstacles are both deliberate and expedient types of obstacles designed to delay or stop the progress of all types of vehicles [17:123]."

Hardening Facilities. Whereas perimeter defense fortifications protect the base defensive forces, other base facilities must be hardened to protect deployed aircraft, munition storage areas, support personnel, and critical equipment and utilities. "Even small-caliber rifle of automatic weapons fire against many existing air base facilities could produce high numbers of casualties among facility occupants [7:1]." The threat is even greater from mortors, large-caliber projectiles, rockets, and bombs.

Hardening the exterior walls, roofs, windows, and doors can protect facilities from enemy action. Exterior walls can be protected by filling hollow spaces, attaching protective overlays, placing loose soil or sandbags against the walls, erecting revetments, or constructing interior shelters (7:14-19,22,23). Roofs can be protected by adding concrete or sandbag overlays. Windows can be protected by permanently sealing window openings or by adding a removable protective cover panel. Finally, doorways can be protected with protective panels or revetments, or replaced with blast and penetration resistant doors (7:20-24).

## Pavement Surfaces and Support Systems

Non-airfield Pavement Surfaces. Although expedient shelters and other base buildings are required to support the deployed forces, efficient routes of transportion are required to minimize travel time between facilities. Adequate parking areas should also be provided so the roads can remain open to traffic.

Roads and parking areas are quite satisfactory in many nations. Europe, for instance, has many roads equal to those in the United States. Unfortunately, many other nations have few paved roads, if any at all. For example, roads in desert Arab countries are generally underdeveloped (35:187). Generally, underdeveloped nations are marked by "a lack of investment capital [24:255]." Since local roads are administered and financed by local governments and highways are financed by national governments (25:901), it is reasonable to assume that undeveloped areas lack the investment capital to construct effective road systems. Therefore, forces deployed to undeveloped, third world nations can expect inadequate roads.

Deployed CE forces may find it necessary to expeditiously construct, maintain, and repair the non-airfield pavement surfaces to ensure a totally operational base. Since CE forces can be deployed worldwide, they must be familiar with expedient methods of providing roads and parking areas in both wet and dry areas.

Expedient surfaces in wet, muddy areas "must be structurally strong and spread the load over a wide area of the subgrade [17:247]." Graded and compacted areas without some load-bearing surface are totally inadequate in muddy areas. Three different expedient loadbearing surfaces can be constructed to provide the necessary roads and parking areas in the deployed location. These surfaces are (1) chespaling roads, (2) corduroy roads, and (3) tread roads

(17:250-254). These expedient road surfaces are shown in Appendix B.

In contrast to road surfaces in wet areas which are built to distribute loads over a greater area, expedient road surfaces in dry, sandy areas attempt to stabilize the sand so it can support necessary loads (17:254). Numerous expedient methods can be used to stabilize sand so it can be used for non-airfield pavement surfaces. For example, chicken wire, expanded metal lath, and chain link wire mesh (cyclone fence) can be used to stabilize sand (17:254). Other expedients include lowering tire pressure, stabilizing sand with portland cement or oil, grading the road until firmer soil is found, and placing building rubble in the ruts (43:7.19).

In some instances, airfield landing mats can provide non-airfield pavement surfaces. "Airfield landing mats can be used to form an expedient road surface over either mud or sand [17:255]." In either case, airfield landing mats should be used for non-airfield pavement surfaces only if there are sufficient quantities to meet both the non-airfield surface needs and the airfield bomb damage repair needs.

Airfield Pavements. The flightline area contains some of the most critical facilities on a base. Included are the airfield pavements (i.e., the runways, taxiways, and ramps) and the systems required to support these pavement areas. These supporting systems include the runway/taxiway lighting system and aircraft arresting system. These pavement facilities and support systems are critical because the flying mission cannot effectively be conducted without them.

During the early 1960s, Air Force strategic planners believed that enemy weapon systems would be aimed at the softer targets, namely, the aircraft (5:2). Aircraft are especially vulnerable on the ground due to "their delicate structure, fuel contents and associate high-explosive ordnance [5:2]."

However, this view has changed with the advent of hardened aircraft shelters and improved aircraft performance and support systems (5:2). Today, airfield pavements are the primary target on airbases (5:3). Therefore, airfield pavements are a major concern for Civil Engineering forces in contingency environments.

In contingency environments, Civil Engineering's airfield pavement work is classified as Rapid Runway Repair (RRR). "Following an enemy attack, the BCE must be capable of rapidly restoring damaged runways, taxiways, aircraft parking areas and other airfield pavements. Consequently, RRR is a priority mission for the Prime BEEF contingency force (CF) teams [8:15]."

Chapter 5 of AFR 93.2 outlines eight major steps for this RRR procedure after all unexploded ordinance has been removed by Explosive Ordinance Disposal personnel. These steps consist of [14:5.2]:

a. Identifying craters for repair and establishing a new temporary runway center line;

b. Delivering, stockpiling, and placing select fill material;

c. Cleaning and sweeping the new runway;

d. Assembling the AM-2 matting;

e. Positioning AM-2 matting over the crater;

f. Anchoring AM-2 matting; and

g. Painting new runway center line.

Since the early 1960s, the objective has been to provide at least a minimum operating strip (MOS). The MOS is "a 50 foot wide, 5,000 foot long area clear of all debris and structurally capable of withstanding the weight of a fully loaded fighter aircraft for the number of passes necessary for launch and recovery of all assigned aircraft. This objective had to be accomplished within a four hour period for any anticipated damage from three 750 - pound bomb craters [5:3]."

AM-2 matting met the RRR requirements for the wartime scenario specified in the early 1960s. However, the Soviet Union has greatly improved its Air Force.

> Since 1973, they have phased a new generation of aircraft into the inventory; including improvements to the MIG-21 FISHBED aircraft (the J, K, and L models); and newer aircraft - the Su-17 FITTER C, the MIG-23 FLOGGER and the Su-19 FENCER are fully employed... The FENCER A, an aircraft designed with air-to-ground weapons (against airfields; specifically runways) appears to be the first Soviet fighter designed for ground attack, and was doubled in Frontal aviation capability by the end of 1976 [5:8].

These modernization efforts by the Soviet Union have resulted in a change from a position of defense to one capable of successful offensive action (5:9). Therefore, the current practice of repairing three large craters in four hours with AM-2 matting is no longer realistic (5:13,14).

New, faster methods of repairing craters must be found.

Arresting Systems. During wartime, aircraft often must make emergency landings. Furthermore, the runways themselves may be severly damaged from enemy action. Expedient repair work may not be completed or the MOS may be too short for the emergency landing. In these cases, aircraft arresting systems become crucial for safe landings.

Although many arresting systems exist, "the BAK-12 is the only expeditionary aircraft arresting barrier system. The other arresting systems, the BAK-9, 11, 13 and 14, were designed for permanent installation [42]." In contrast, the BAK-12 can be "installed as an expeditionary semi-permanent, or permanent runway facility or may be used in conjunction with other engaging devices [10:3326]." It can be fixed on-grade to a concrete pad, below grade in a concrete pit, or expeditiously installed with earth anchors in about 100 manhours (1:4.9). Finally, "the BAK-12 can be readily installed anywhere in the world [1:4.9]."

Airfield Lighting. While arresting systems are critical for emergency landings and to ensure landing aircraft do not exceed the MOS, airfield lighting becomes critical for night landings. The need for airfield lighting is especially critical in contingency environments where the MOS may be only 50 feet wide by 5,000 feet long. The surrounding area may be dangerously marred by unrepaired bomb craters.

Both the Harvest Bare and Harvest Eagle kits contain portable airfield lighting sets that can be installed by Prime BEEF forces (1:4.1). Both kits contain components that are "identical to those items currently being used at both military and civilian airports around the world and are highly reliable [1:4.5,4.6]."

## Utility Systems

Electrical Power Production. Electrical power during contingencies is needed to operate the runway lighting system and critical base facilities. A reliable source of power is becoming increasingly important to the Air Force mission as more defense systems and support functions rely on electrical power for their operation. Sources of electrical power become even more critical during contingency situations in which the enemy targets the electrical power sources in an attempt to disrupt the Air Force mission (40:1,2). Electrical power systems are "used during expedient construction and operation of air base facilities for contingency force beddown and expedient post-attack recovery of vital base facilities [40:1]."

Electrical generators are the primary source of electrical power for Air Force operations in contingency environments. Generators also serve as a backup "to provide exigent operation of air base facilities and functions (including surveillance) during commercial electric power disruptions or outages caused by accident, sabotage, vandalism, and/or attack in the CONUS and the overseas theaters [40:1]." This section examines expedient methods, as they pertain to the installation, repair, and maintenance of electrical generators at Air Force installations during contingencies.

Preparing electrical power can be accomplished by using the generator sets available in the Harvest Bare and Harvest Eagle kits. The generators that make up these kits have been developed after extensive study of the problems encountered with electrical generators during the build-up of the Vietnam conflict (27).

At present, the second generation standard family of generators is still under development, and many of the interim family of generators are still being u[illegible]d. The vast majority of generators in the current Air Force inventory is the first generation standard family. These are the generators included in the Harvest Bare and Harvest Eagle kits. During contingencies, expedient methods would be used to keep the generators found in these kits operational. Expedient methods would also be used on the interim family of generator sets that still exist (32).

<u>Electrical Distribution</u>. Electrical power is useless unless the power can be transmitted from the power source to the facilities requiring electricity. Host nation power and distribution lines should be used whenever possible. However, in many countries such as those in Southwest Asia, standardized power does not exist (1:5.1). "Frequency and voltage may vary from location to location. Their

distribution networks are limited and those that do exist may be deteriorated and unreliable [1:5.1,5.2]."

Therefore, Air Force Civil Engineers may have to provide their own electrical distribution systems. The Harvest Bare deployment kit contains an expedient electrical distribution system. Harvest Bare kits contain both primary and secondary distribution systems to supplement the Harvest Bare generator sets (1:5.2,5.3).

Interior Electrical Wiring. Procedures for wiring the interior of facilities are given in AFM 91.17 and AFP 85.1. These procedures vary little during contingencies. Any variation to these procedures simply adds to the already hazardous conditions with the threat of electrical fires. However, insulated wiring can be expediently mounted on the surfaces of interior walls, ceilings, and floors. Furthermore, expedient methods can be used to determine the required wire size for a specific load when no other method is available (17:351). This method of expediently sizing interior wiring is found in Appendix B.

Water Supply. Water is perhaps the most critical resource required by the human body to stay alive. This is especially true in desert environments where sparse rainfall produces very few rivers and only intermittent streams (1:6.1). If deployed forces do not have adequate sources of potable water, the body's natural cooling system brakes down. Dehydration takes place, followed by incapacitation, heat stroke, and possibly death (1:6.3).

> Heat and lack of water will be the greatest threat against combat forces. Casualty stories indicate the problem of water is critical. Fifty percent of the Egyptian army's 20,000 casualties were caused by heatstroke in the six day war in 1967, between Israel and Egypt... During the Kuwait Intervention, British forces suffered dehydration rates of almost ten percent. Water will quickly become a killer. As temperatures rise to 120 to 125 degrees farenheit, such as in an armored personnel carrier or other tracked vehicle, water consumption rates will need to increase. The Surgeon General has stated that a loss of two quarts of body fluid decreases efficiency by 25 percent, and a loss of fluid equal to fifteen percent of the body weight is usually fatal [28:1].

Due to its critical nature, water consumption must be carefully planned during contingencies. Consumers of potable water include individuals, mess operations, and hospitals (1:6.4). Nonpotable water use for laundry operations, construction, and grave registration must also be considered (1:6.4). Finally, demineralized water must be planned for thrust augmentation for many heavy aircraft (1:6.5).

Water Treatment. Fortunately, other than desert areas, water is usually readily available. Also, seawater and brackish water can be used for most nonpotable requirements, although it should be disinfected if it is to come in contact with human skin. Furthermore, seawater and brackish water can be made potable when treated with the reverse osmosis water purification unit (ROWPU). However, water with small amounts of dissolved solids can be purified with the Erdlator (1:6.1,6.2).

Water Storage. Once the water has been located it should be stored for latter use. Water can be stored in "flexible bladders ranging in sizes up to 50,000 gallon capacity, 1,500 gallon water distribution trucks and 400 gallon distribution trailers, 3,000-gallon onion or stave tanks, 36-gallon lyster bags, and 5-and 10-gallon igloo water coolers [1:6.7]." The bladders can be used to store both potable and nonpotable water. The onion or stave tanks store the brine water from the ROWPUs. The distribution trucks, distribution trailers, and igloo coolers transport water as required. The lyster bags provide water in the billeting and work areas. Considerable water is also stored in the water pipelines, themselves (1:6.7).

Expedient water containers can be constructed from available matter if the conventional storage containers are destroyed from normal wear and tear or by enemy action (11:16). Examples of expedient water containers include cleaned fuel storage cans (11:16,17) and lumber or excavated basins lined with a membrane sheeting (43:5.43-5.45).

Water Distribution. Water must be transported from its source for treatment and storage. Once in storage, the water must be distributed to the deployed forces. Although water trailers can be used to distribute water, they are labor intensive. There is also the potential problem of improperly segregating the storage vessels. If this occurs, nonpotable water may be used for potable purposes and vice versa (34:5.15). Although the containers can be color coded to reduce confusion, pipelines are much more efficient.

Pipes can distribute greater quantities of water to numerous locations in the deployed location.

Pumps. Typically, pumps are used to drive the water through the pipes from the water storage bladders to the user locations. Pumps are classified as either raw water pumps, fire transfer pumps, or potable water booster pumps (1:6.6). Raw water pumps "pump water from remote sources to various water treatment stations and to raw water storage bladders [1:6.6]." The diesel-driven fire transfer pumps are used to fill the fire vehicles. The fire vehicles can be filled from the water source, the raw water bladders, or the potable water bladders (1:6.6). The potable water booster pumps are "used to pressurize the potable water distribution system [1:6.6]."

Water Distribution Problems. Although pipelines are effective in distributing water, problems can occur. For example, surface or near-surface distribution lines collect heat during the day. Also, plastic pipes can degrade from ultraviolet light if left uncovered in hot environments. Finally, pipelines expand and contract and tend to leak during great temperature variations. Desert pipelines often leak due to the wide temperature variation between day and night (34:5.15).

Field Sanitation. In contrast to water which must be acquired, purified and distributed to the deployed forces, waste must be kept away from the deployed forces. "The total weight of wastes of all kinds, including liquid wastes, produced under field conditions approaches 100 pounds per person per day. If this material is not removed promptly and thoroughly, a bare base installation would soon become unhealthy and unsightly. Prompt and thorough removal of this material in such a manner that will not contaminate local water sources, air, or the land is a must [1:7.1]."

Latrines. During contingencies, human waste must be disposed of to prevent disease and the appearance of vermin. The method of disposal can vary greatly, depending upon where the forces are deployed (1:7.1). Modern sewage systems may not always be available. Furthermore, the Harvest Bare portable chemical toilets and human waste incinerators may not always be in operational condition. Therefore, expedient latrine facilities may have to be constructed.

Garbage Disposal. Garbage is caused by the kitchen and mess activities. Both wet and dry forms of garbage must be removed from the kitchen and mess areas before offensive odors are generated and flies and rats are attracted. The usual practice is to collect the garbage in cans outside the kitchen and then dispose it by burial (20:242).

Since liquid wastes contain particles of food, grease, and soap, it must be treated before it is buried (1:7.3). Treatment involves either soakage pits or grease traps. "Soakage pits act as reservoirs from which water is gradually absorbed by the surrounding ground [1:7.3]." Grease traps "prevent greases from slogging the soil's ability to absorb the waste water [1:7.3]." Expedient soakage pits and grease traps can be constructed during contingencies.

Dry garbage is divided into two classes - combustible and noncombustible (1:7.5). Although noncombustible dry garbage can be buried directly, the combustible dry garbage should be burned to reduce its volume. It can be burned in either an open incinerator or an inclined plane incinerator (11:30). The burned garbage can then be buried or placed in a sanitary fill with the noncombustible garbage. Care should be taken to properly bury the garbage. Improper burial of garbage "creates breeding/feeding grounds for all types of disease carriers (rats, flies, etc.) [1:7.5]."

The Sanitary Collection System. Sewage systems carry waste away from the deployed forces to reduce disease and improve the living conditions of the deployed forces (1:7.6). The sewage system at a deployed location is made up of Harvest Bare pipes, couplings, and valves. However, commercial pumps and controls, sewage lagoons, and expediently made items are also used (1:7.6,7.9). The entire system must be capable of handling 14 gallons of sewage per day for each person (1:7.7).

The collection system is made up of "a series of lateral, branch, main, and outfall sewers leading from shelter connections, together with such devices as grease traps, wet-well sumps, and sewage lagoons [1:7.7]." The lateral sewers collect the sewage from the shelter connections and empties it into the branch lines. The branch lines connect to the mains and the mains bring the sewage to the lagoons.

Liquid Fuels. Liquid fuels are needed to power numerous pieces of equipment required by CE forces during contingencies. Heaters, incinerators, pieces of equipment with internal combustion engines require liquid fuels. Furthermore, any piece of equipment which runs on electrical power relies on liquid fuels since electrical generator engines operate on liquid fuels (1:1.7).

Providing and Storing Liquid Fuels. The most efficient way to provide liquid fuel is to transport the fuel through pipelines from a major storage complex to the deployed forces. However, a fuel pipeline may not always be available. Furthermore, pipeline systems are especially vulnerable to sabotage (45). Since pipelines are usually buried, the most susceptible pipeline facilities and locations are actually "pump stations, input stations, river crossings, intersections with other systems, and centralized computers which remotely control operations [45:iii]." If damaged, these critical pipeline facilities "could require up to 6 months or more for repair [45:iii]."

During contingencies, an alternate procedure of supplying deployed forces with liquid fuel, other than for sortie generation, is flying the fuel to the deployed site in fuel transport planes or helicopters. The fuel can then be off-loaded into fuel transport vehicles and transported to storage facilities. Fuel storage facilities can be existing steel tanks, deployed fuel bladders, or expediently used storage such as 55-gallon drums (33).

Special Fuel Dispensing Problems. At extremely low arctic temperatures, special problems are encountered which affect fuel dispensing systems. Pumps and other equipment are difficult to start and operate when the temperature drops to -60 degrees F. Fuel bladders and other elastomeric materials become brittle and useless at these low temperatures (30:vi). Therefore, fuel dispensing equipment, batteries, and elastomerics must be developed to withstand the extremely cold temperatures of the arctic (30:viii).

Heating. Liquid fuels provide a primary source of heat for deployed forces during contingencies. However, liquid fuels are not the only sources of heat. In fact, anything that burns can be used to provide heat. No matter what the fuel, an adequate heat source can be critical for deployments to cold regions.

Estimating Heat Requirements. Properly sized heating units are important for conserving fuel. Undersized heaters must operate continuously during long, cold winter deployments. Therefore, the smaller heaters may actually consume more fuel then the larger units. Unfortunately, the larger heater are more expensive. However, slightly oversized heaters may actually "be beneficial in overcoming heat loss because of doors opening and also for bringing an unused shelter up to the desired temperature more quickly before sensitive equipment is turned on [31:II.5]."

Expedient Heating. Wood is perhaps the best expedient fuel for creating fire and heat. Wood must be fine, dry, and loosely arranged before it will begin to burn (4:289). Once these conditions are met, wood produces an excellent expedient heat source.

Air Conditioning. While heaters are required during cold weather, air conditioning is required when forces are deployed to hot areas of the world. Serious heat related health problems such as heat exhaustion and heat stroke can result if cooling is not provided (19:190; 22:51). Since both health problems are incapacitating, and heat stroke can be fatal, adequate air conditioning can be critical for both individual health and overall mission accomplishment.

Selecting the proper cooling unit is also important for fuel conservation and to ensure adequate dehumidification (31:II.5). Smaller cooling units use less fuel and ensures fuel for cooling during long hot spells. Smaller cooling units also ensure proper dehumidification. A smaller unit "will cool more slowly and, because its capacity is close to the requirement, will cool almost constantly; it therefore will be also constantly dehumidifying the shelter [31:II.5]." Oversized cooling units may cool the shelter more quickly, but it switches off more often. "While in the non-cooling mode, it is not dehumidifying the shelter [31:II.5]."

## Summary

This chapter provided a general background to expedient methods. After defining terms closely associated with expedient methods, it presented a brief history of Civil Engineering mobilization and explained the concept of expedient methods and its importance to Civil Engineers. A literature review of expedient methods was then presented. The literature review gave a brief insight to the numerous areas of work in which Civil Engineers utilize expedient methods during contingencies.

The following pages develop these areas of work into a workable guide for performing expedient methods. The final product, found in Appendix B, supplements AFM 88-34 to form a comprehensive expedient methods field manual.

# III. Methodology

## Chapter Overview

This chapter restates the research objectives identified in Chapter 1 and describes their method of accomplishment. Justification for the research approach and specific aspects of data collection is also presented.

## Research Steps for Objective #1

Research Objective #1. The first objective of this thesis was to identify published expedient methods not included in AFM 88-34 but useful to Civil Engineers deployed to contingency environments. The expedient methods considered useful were those that involved the 16 areas of work expected of Civil Engineers during contingencies. These 16 areas of work were categorized into three major groups and redefined as follows:

1. Facilities
    a. Expedient Shelters
    b. Expedient Field-fortifications
    c. Expedient Facility Hardening
2. Pavement Surfaces and Support Systems
    a. Non-airfield Pavements
    b. Airfield Pavements
    c. Aircraft Arresting Systems
    d. Airfield Lighting Systems
3. Utility Systems

a. Electrical Power Production

b. Electrical Distribution

c. Interior Electrical Wiring

d. Water Supply

e. Water Distribution

f. Field Sanitation

g. Liquid Fuels

h. Heating

i. Air Conditioning

Method of Approach. A literature review of magazine articles, course handouts, pamphlets, regulations, and manuals was used to find published expedient methods useful to Civil Engineers. These published expedient methods were compared to those in AFM 88-34. Any expedient methods not included in AFM 88-34 were used to develop the supplement to AFM 88-34.

Justification of Approach. The literature review was required to find expedient methods that were already available to Civil Engineers. This review served as a base for evaluating the unpublished methods identified in objective #2.

Aspects of Data Collection. All expedient methods that were uncovered by the literature review but already included in AFM 88-34 were disregarded. Those expedient methods that were not found in AFM 88-34 were retained and included in the supplement.

The next step in data collection was to make a list of key words that related to the topic of expedient methods. This list was, in fact, provided by the School of Civil Engineering at the Air Force Institute of Technology (AFIT), Wright-Patterson AFB OH, at the onset of this research effort (41). The 16 areas of work that Civil Engineers are expected to perform during contingencies provided the necessary key words.

These key words were used to begin the actual literature review effort. A request for unclassified Air Force and Army reports for each of the work areas identified by the key words was submitted to the Defense Technical Information Center (DTIC), Defense Logistics Agency, Cameron Station, Alexandria, VA.

The key words were then used to find appropriate articles listed in the Air University Index to Military Periodicals. Microfiche slides of these articles were located at the AFIT Engineering (EN) Library. The microfiche slides were reviewed to locate data pertinent to this thesis. Articles with no relevant data were immediately discarded. Articles with only a few pages of pertinent data were saved and paper copies of these pages were made. Articles that were needed in their entirety were identified and complete copies were obtained from DTIC.

Other sources of expedient methods information were the course handouts offered by the AFIT School of Civil Engineering in their short course, ENG 485, "Contingency Engineering"; Army field manuals; and Navy Seabee engineering manuals. All of these sources contained additional, valuable information that was used to complete objective #1.

All sources uncovered by the literature review contained expedient methods that could be applied by Civil Engineers during contingencies. General information of the expedient methods provided by these sources was presented in Chapter 2 of this thesis. The detailed methods were used to complete the supplement to AFM 88-34.

## Research Steps for Objective #2

Research Objective #2. The second objective of this thesis was to obtain the unpublished expedient methods actually used by Civil Engineers during past contingencies. Since these expedient methods were developed, used, and found effective during actual contingencies, they would be a valuable source of information for future contingencies. Therefore, these expedient methods would be included in the supplement to AFM 88-34.

Method of Approach. The only practical means of obtaining unpublished expedient methods was by a survey. Those surveyed included all Air Force Civil Engineering officers, enlisted personnel, and civilians stationed in the Continental United States (CONUS). Responses were expected only from those members who performed the Civil Engineering mission in a contingency environment and actually used expedient methods not found in any publication. The responses in this case contained the detailed, step-by-step procedures for accomplishing the expedient methods. Since the survey was actually a request for expedient methods instructions, the survey could be sent directly to the CONUS Air Force Civil Engineers without the approval required for typical surveys (16:1.3).

## Aspects of Data Collection

The first step in collecting the expedient methods instructions was to design the survey cover letter, instructions, and forms. The survey cover letter was critical to this thesis, for an adequate number of pertinent responses depended entirely upon the motivation of the respondees. The author felt that many respondees could be motivated directly by stressing the benefits that their inputs would have on the less experienced Civil Engineering personnel. However, other respondees had to be motivated by their Base Civil Engineers (BCEs). Therefore, the survey forms were sent directly to each BCE with a clear and concise cover letter. The cover letter explained the importance of this thesis and requested their assistance and support. The BCE could then direct their branch chiefs to complete the survey forms and to solicit responses from other military and civilian personnel who have had any contingency experience.

The BCE letter contained another letter to the branch chiefs which provided concise instructions for properly completing the survey forms. The survey instructions stated the purpose of the survey, defined the terms "expedient methods" and "contingencies," and identified the survey respondees.

To ensure pertinent expedient methods procedures from the respondees, the survey forms were made as simple as possible. This was extremely important since the respondees had to write detailed procedures instead of the simple responses typical of most surveys.

The survey forms contained a completed sample to demonstrate the proper way of completing the forms. The survey forms asked each respondee to enter expedient methods procedures along with the respondee's name, rank, and phone number. This biographical information provided a means to contact the respondees for clarification of their procedures. Also, by providing their names, the respondees received full credit for their expedient methods when these procedures were published in the new field manual.

The survey forms also required the respondees to state the time, place, and situation that the expedient methods procedures were used if this information was unclassified. This information provided historical realism to the procedures and would give future readers the means to compare their contingency situation with those provided by the respondees.

The second step was to test the survey before sending the survey package to the BCEs to eliminate any ambiguity that may have existed in the cover letter, survey instructions, or survey forms. Twenty-two Civil Engineering graduate students enrolled in the Graduate Engineering Management Program at the AFIT were selected to perform the test survey. Responses to the test survey revealed no need for improving the survey cover letter, instructions, and survey forms.

The third and final step was to send the survey package (i.e., the cover letter, survey instruction letter to the branch chiefs, and approximately 80 survey forms) to the BCEs at each CONUS Air Force Base. A copy of the cover letter, instructions letter, and survey form was placed in Appendix A of this thesis for reference. The responses to the survey provided expedient methods actually used during contingencies. This information was then assembled with the information found from the literature review to form the supplement to AFM 88-34.

### Research Steps for Objective #3

Research Objective #3. The third objective of this thesis was to design the supplement to AFM 88-34 from the information obtained from objectives #1 and #2.

Method of Approach. The supplement was kept in the same basic format of AFM 88-34 so the pages could be inserted without impairing the effectiveness of the manual. The supplement was also kept clear and concise so the information could be easily located and used during contingencies.

Aspects of Supplement Design. The first step in designing the supplement to AFM 88-34 was to discard duplicate expedient methods as discussed in the Methods of Approach section. The remaining expedient methods were then grouped into similar categories. These categories were identified by the 16 key words discussed previously. Expedient methods that did not fall in any of these categories were grouped in a category labled "Miscellaneous Expedient Methods." These 17 categories formed the body of the supplement to AFM 88-34 and can be found in Appendix B of this thesis.

The next step was to design the instructions for inserting the pages of the supplement into AFM 88-34. This was accomplished by locating sections in AFM 88-34 that paralleled each of the 17 categories of the supplement. The pages of each category were then placed in the appropriate section of AFM 88-34. Care was taken that the inserted pages did not interrupt the logical presentation of AFM 88-34.

The instructions were then written. The instructions direct the reader to insert a given page of the supplement before or behind a given page in AFM 88-34. The final step was to construct a revised Table of Contents for AFM 88-34 to account for the inserted pages of the supplement. This Table of Contents is also found in Appendix B.

# IV. Results and Recommendations

## Chapter Overview

This chapter gives the results for each of the research objectives discussed in the first two chapters. Recommendations based on these results are presented to improve the comprehensive expedient methods field manual developed in the thesis.

## Research Results

Results of Research Objective #1. The literature review disclosed 41 published sources that were pertinent to this thesis. These sources were sited in both the main body of this thesis and in the Appendices. Fourteen sources contained expedient methods instructions that were not published in AFM 88-34. These sources were used to develop the supplement to AFM 88-34.

Results of Research Objective #2. All 84 CONUS Air Force bases were surveyed to obtain previously unpublished expedient methods instructions. Of these bases, 18 submitted responses. These responses contained a total of 65 expedient methods, 22 of which were never before published. These unpublished expedient methods were added to those discovered in the literature review to form the supplement to AFM 88-34.

Results of Research Objective #3. The actual supplement to AFM 88-34 was then developed. This supplement can be found in Appendix B, along with instructions for inserting the pages into AFM 88-34.

## Recommendations

Although this thesis provided 70 additional expedient methods to supplement AFM 88-34, it also uncovered areas in which expedient methods are lacking. These areas are listed below:

1. Expedient repair of aircraft arresting systems
2. Expedient wiring of facilities
3. Expedient plumbing techniques
4. Expedient liquid fuels distribution systems
5. Expedient air conditioning systems

Therefore, it is recommended that additional research be conducted to uncover and/or develop expedient methods in these areas. Additional expedient methods can be uncovered by additional surveys and a more extensive literature review. A survey should be conducted for each of the areas to which information is missing. Each survey should be sent directly to those Air Force Civil Engineers whose wartime duties would include expedient methods in the area of concern. Additional information could be found by surveying Civil Engineering personnel attending the AFIT short courses, stationed overseas, in the Air National Guard, and in the other branches of the military. Retired Civil Engineers should also be surveyed.

Additional expedient methods can also be uncovered by conducting a second literature review. This second literature should include Air Force trip reports and other published documents not researched in this thesis. The literature review should focus only on those areas which are weak in expedient methods.

If the additional surveys and literature review fails to uncover sufficient expedient methods for all of the areas presented above, it is recommended that research be conducted to develop expedient methods for the remaining weak areas. The Engineering and Services Laboratory at the Air Force Engineering and Services Center (AFESC), Tyndall AFB FL or Civil Engineering graduate students at the Air Force Institute of Technology, Wright-Patterson AFB OH would be best qualified to conduct this research.

A copy of of this thesis has been sent to the Directorate of Engineering and Services (HQ USAF/LEEE) since the O-2 to AFM 88-34 identifies LEEE as the office of primary responsibility for any changes made to the manual. This office can then revise AFM 88-34 by including the supplemental information found in Appendix B. This revised AFM 88-34 should then be made available to all Air Force Civil Engineers. Also, any follow-on research efforts should send the results to HQ USAF/LEEE.

## Appendix A: Survey Package

**DEPARTMENT OF THE AIR FORCE**
**AIR FORCE INSTITUTE OF TECHNOLOGY (AU)**
**WRIGHT-PATTERSON AIR FORCE BASE, OH 45433**

REPLY TO ATTN OF: LS

SUBJECT: Expedient Methods Field Manual

TO:

1. One of our graduate students, Captain Roy V. Bousquet, is developing a new field manual on expedient methods. The manual will contain actual methods of performing quick and temporary forms of construction, maintenance, and repair that have proved useful for CE during past contingencies. In addition to combining the numerous published sources on expedient methods, including AFM 88-34, the comprehensive manual will include previously unpublished techniques in expedient methods.

2. Many civilian and military personnel have performed their CE mission in wartime, during military exercises, or after natural disasters. Unfortunately, many of the innovative techniques used during these crises were never recorded. We want to gather this wealth of information to help younger officers and enlisted personnel who have never operated in a contingency environment. This information would also be useful in your expedient methods training program, providing realistic, "hands-on" contingency training. The new manual should be a useful guide in this training.

3. Please sign the attached letter and send copies of the letter and some survey forms to your branch chiefs. Your branch chiefs most likely possess the information needed. They can also find other experienced personnel who have actually used expedient methods during contingencies. Please have these personnel complete the enclosed forms and return them to your administrative office for mailing. A return envelope is included.

4. I realize that your people are very busy with their day-to-day duties. Many will not be willing to take the time to draw sketches and write brief directions that explain their expedient method experiences. However, the information that they possess will be valuable for many other Air Force Civil Engineers. Your support would be greatly appreciated.

Larry L. Smith

LARRY L. SMITH, Colonel, USAF
Dean
School of Systems and Logistics

2 Atch
1. Letter for Branches
2. Survey Forms

AIR FORCE—A GREAT WAY OF LIFE

REPLY TO
ATTN OF:
SUBJECT: Expedient Methods Field Manual
TO:

1. We have a chance to help write a manual of expedient methods to help us in future contingencies. Expedient methods are quick and temporary forms of construction, maintenance, and repair that are performed during contingencies to keep a base operational. A graduate student at the Air Force Institute of Technology (AFIT) is developing a new, comprehensive field manual on expedient methods. This manual will assist in our expedient methods training as well as providing a valuable source of information for our less experienced officers and enlisted personnel who have never operated in a contingency environment.

2. If you have ever been in an actual contingency such as a war, military exercise, or natural disaster, you probably have experience in using expedient methods. You may have used expedient methods during base build-up (providing electrical power, sanitation, shelter, etc.), for expedient maintenance/repair of existing facilities, or for making substitute tools. The procedures you used would be valuable additions to the new expedient methods manual.

3. Please take the time to fill out the four sections of the following form. Give copies of the form and this cover letter to anybody else in your branch who has information that can be added to the manual. Then return all the forms within 2 weeks to your Admin Office for mailing. You will receive full credit for any expedient methods procedure that you provide.

Thank you very much.

2 Atch
1. Survey Form
2. Example Sketch

SURVEY FORM

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

*SECTION 1- BIOGRAPHICAL INFORMATION:*

**NAME/RANK:** ______________________________________

**JOB TITLE:** ______________________________________

**CURRENT BASE:** ___________________________________

**AV PHONE NO:** ____________________________________

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

*SECTION 2- BACKGROUND INFORMATION:*

**BASE/COUNTRY/YEAR WHERE EXPEDIENT METHOD WAS USED** (if unclassified): ______________________________________

*EXAMPLE:*

PHU-CAT / VIETNAM / 1967

**WHAT WORK DID YOU DO USING EXPEDIENT METHODS?:**

______________________________________

______________________________________

______________________________________

*EXAMPLE:*

SET UP TEMPORARY SHOWER UNITS UNTIL PERMANENT UNITS COULD BE CONSTRUCTED

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

*SECTION 3- STEP-BY-STEP PROCEDURE (if sketch on back side is not self-explanatory:)*

××××××××××××××××××××××××××××××××××××××××××××××××××××××××××××××××××

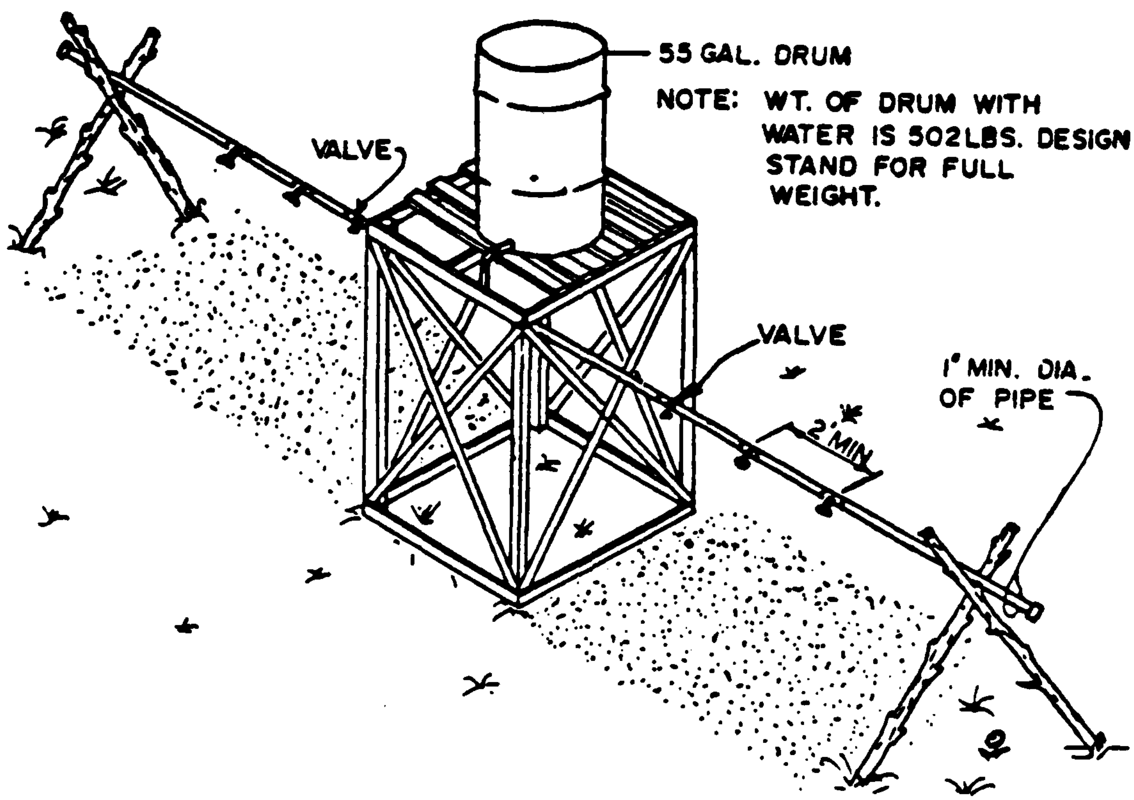
SECTION 4— SKETCH OF EXPEDIENT METHODS:

EXAMPLE SKETCH

"EXPEDIENT SHOWER UNIT"

Submitted by TSGT John E. Doe

As used in Vietnam, 1967



## Appendix B: Supplement to AFM 88-34

### Revised Table of Contents for AFM 88-34

CHAPTER 15 - MISCELLANEOUS TOOL AND AIDS

Instructions for Inserting Pages into AFM 88-34

1. Insert pages 61 and 62 after page 12-25 in AFM 88-34.

2. Insert pages 63 through 67 after page 6-26 in AFM 88-34.

3. Create a new chapter in AFM 88-34 entitled "Fortifications." Locate this new chapter between existing chapters 12 and 13. Insert pages 68 through 86 in this new chapter.

4. Insert pages 87 and 88 after page 1-3 in AFM 88-34.

5. Create a new chapter in AFM 88-34 entitled "Airfield Pavements and Support Systems." Locate this new chapter before the current Chapter 1. Insert pages 89 through 101 in this new chapter.

6. Insert pages 102 through 106 before page 9-1 in AFM 88-34.

7. Insert pages 107 through 112 after page 9-8 in AFM 88-34.

8. Insert pages 113 and 114 after page 9-33 in AFM 88-34.

9. Insert pages 115 and 116 before page 9-1 in AFM 88-34 but after the pages inserted in step 6.

10. Insert page 117 after page 9-4 in AFM 88-34.

11. Insert pages 118 through 120 after page 5-21 in AFM 88-34.

12. Insert page 121 after page 5-7 in AFM 88-34.

13. Insert pages 122 through 126 after page 5-21 in AFM 88-34 and behind the pages inserted in step 11.

14. Insert page 127 before page 4-1 in AFM 88-34.

15. Insert pages 128 through 130 after page 4-2 in AFM 88-34.

16. Insert pages 131 and 132 after page 4-4 in AFM 88-34.

17. Insert page 133 after page 1-2 in AFM 88-34.

18. Insert pages 134 through 136 after page 8-1 in AFM 88-34.

19. Insert page 137 after page 13-6 in AFM 88-34.

20. Insert pages 138 and 139 before page 13-1 in AFM 88-34.

21., Insert pages 140 through 142 after page 11-1 in AFM 88-34.

## Supplemental Expedient Methods

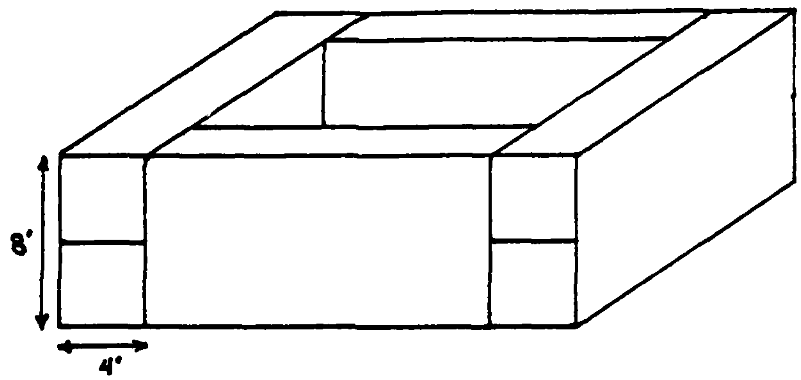



Figure 1. Expedient Shelter: Revetment Command Post

As Used in Ben Hoe, Vietnam

Submitted by MSgt Daniel Bermudez

Use 8 Republic Revement sections to form the command post walls. Use 2"x4"s and plywood or just tree limbs tied together with rope for the roof.

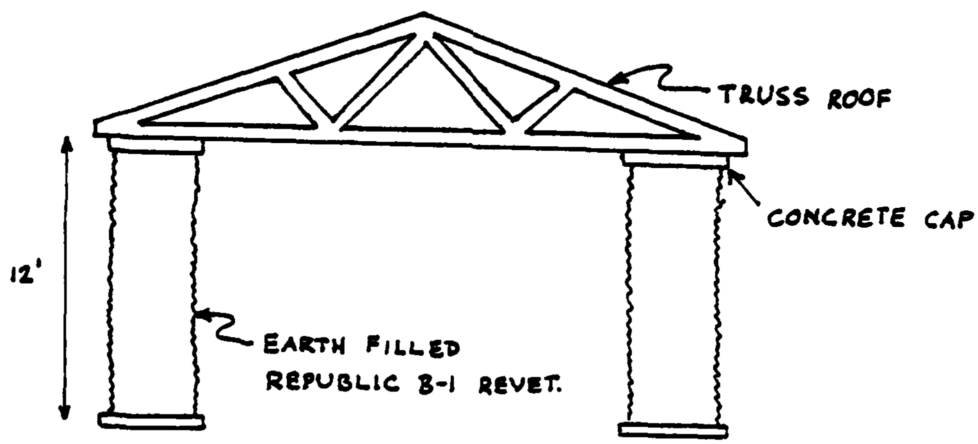



Figure 2. Expedient Shelter: "Singapore" Shelter

As Used in Korea

Submitted by Capt James T. Ryburn

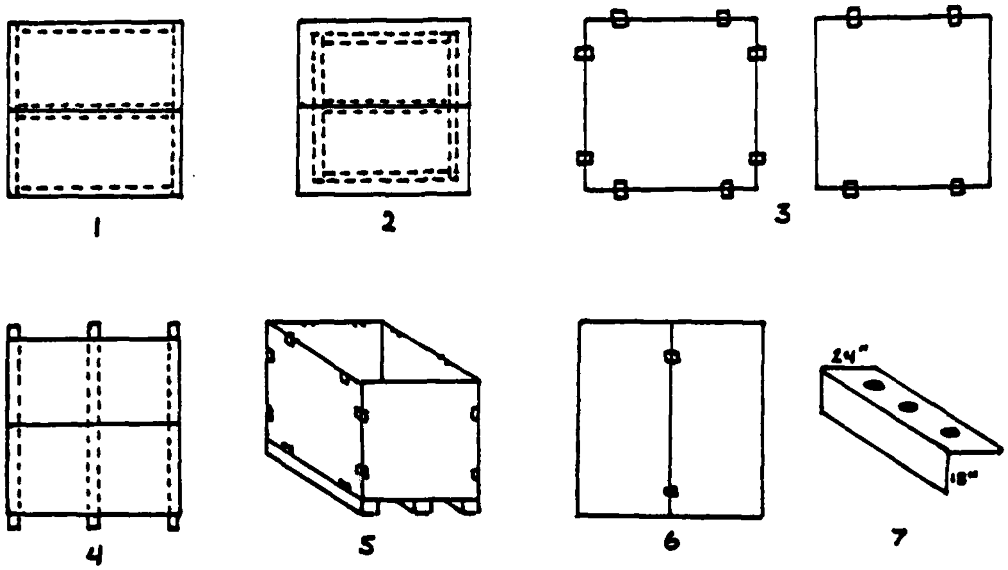



Figure 3. Expedient Shelter: Making a Portable Building

As Used in Project "Bright Star"

Submitted by SSgt William J. Ferris

Step 1. Frame 2 pieces of plywood with 2"x4" to make a 6'x6' wall. Make 2 of these.
Step 2. Frame 2 more 6'x6' walls. Allow for joining 4 walls.
Step 3. Attach 2 hinges on each of the 4 sides on 2 walls, and 2 hinges on the top & bottom of the other walls.
Step 4. Nail 2 pieces of 3'x6' plywood to the 4"x4"s to make a floor.
Step 5. Connect walls to each other and to the floor.
Step 6. Connect 2 pieces of 3'2"x6'2" plywood with hinges to form a 6'4"x6'2" roof. Attach roof to top hinges. Cut holes for windows and door. Make door from 4'x8' plywood sheet.
Step 7. If used as a latrine, the back 2' of floor must be removed and a bench seat can be installed.

NOTE: To disassemble, pull hinge pins, fold roof, and put shelter sections on a pallet.

MATERIALS:
- 2 pieces of 3'2"x6'2"x3/4" plywood
- 10 pieces of 3'x6'x3/4" plywood
- 1 additional sheet of 3/4" plywood
- 10 - 2x4s, 6' long
- 26 - 4" hinges (butt)
- 3 - 4x4s, 6'2" long

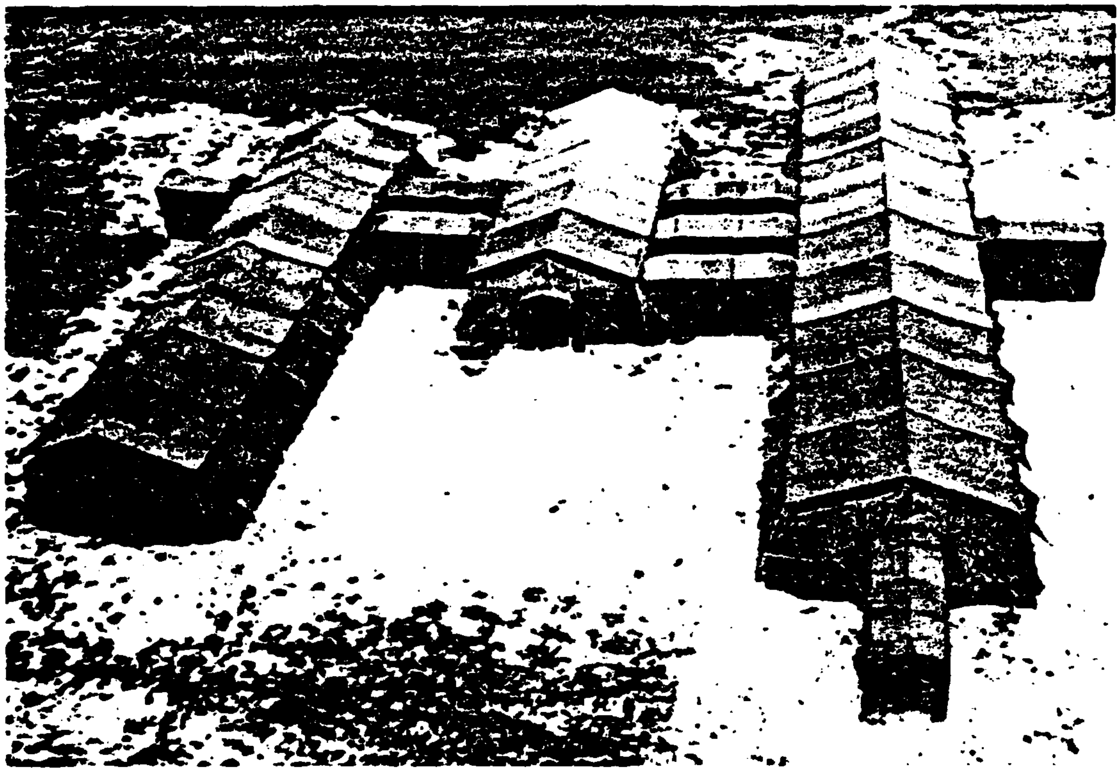


Figure 4. Expedient Shelter: TEMPER Complex

Reprinted from 44:i

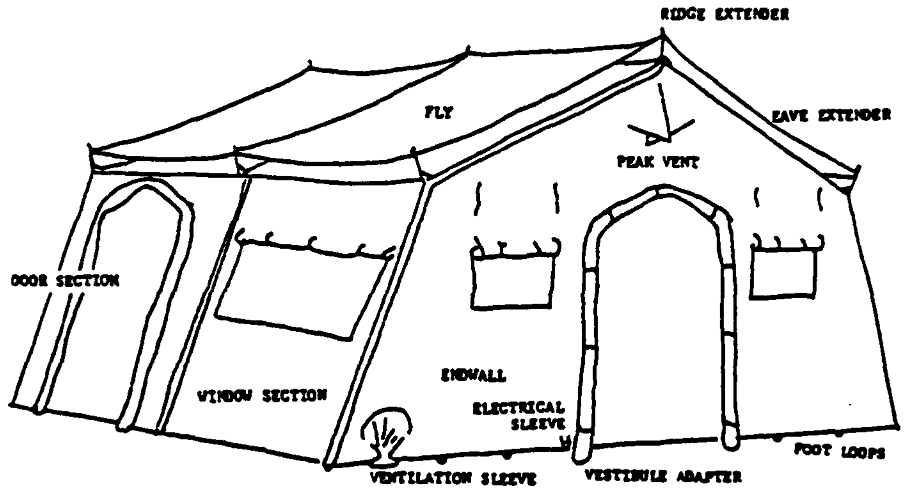



Figure 5. TEMPER Coverings

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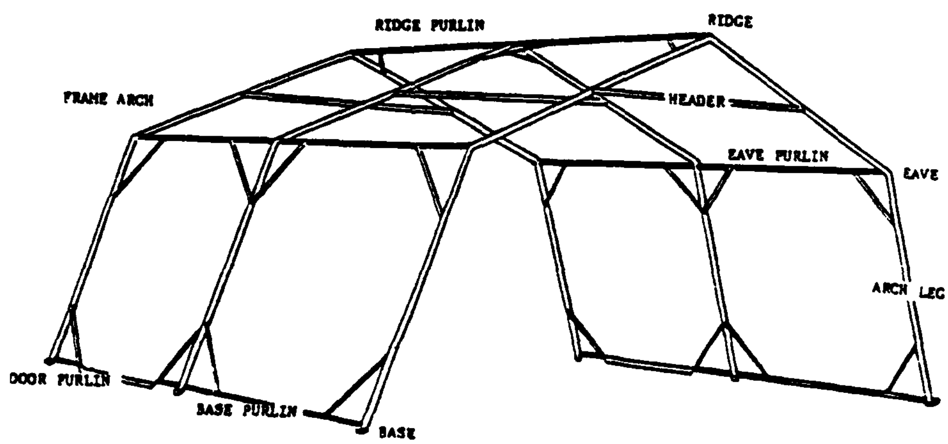


Figure 6. TEMPER Frame

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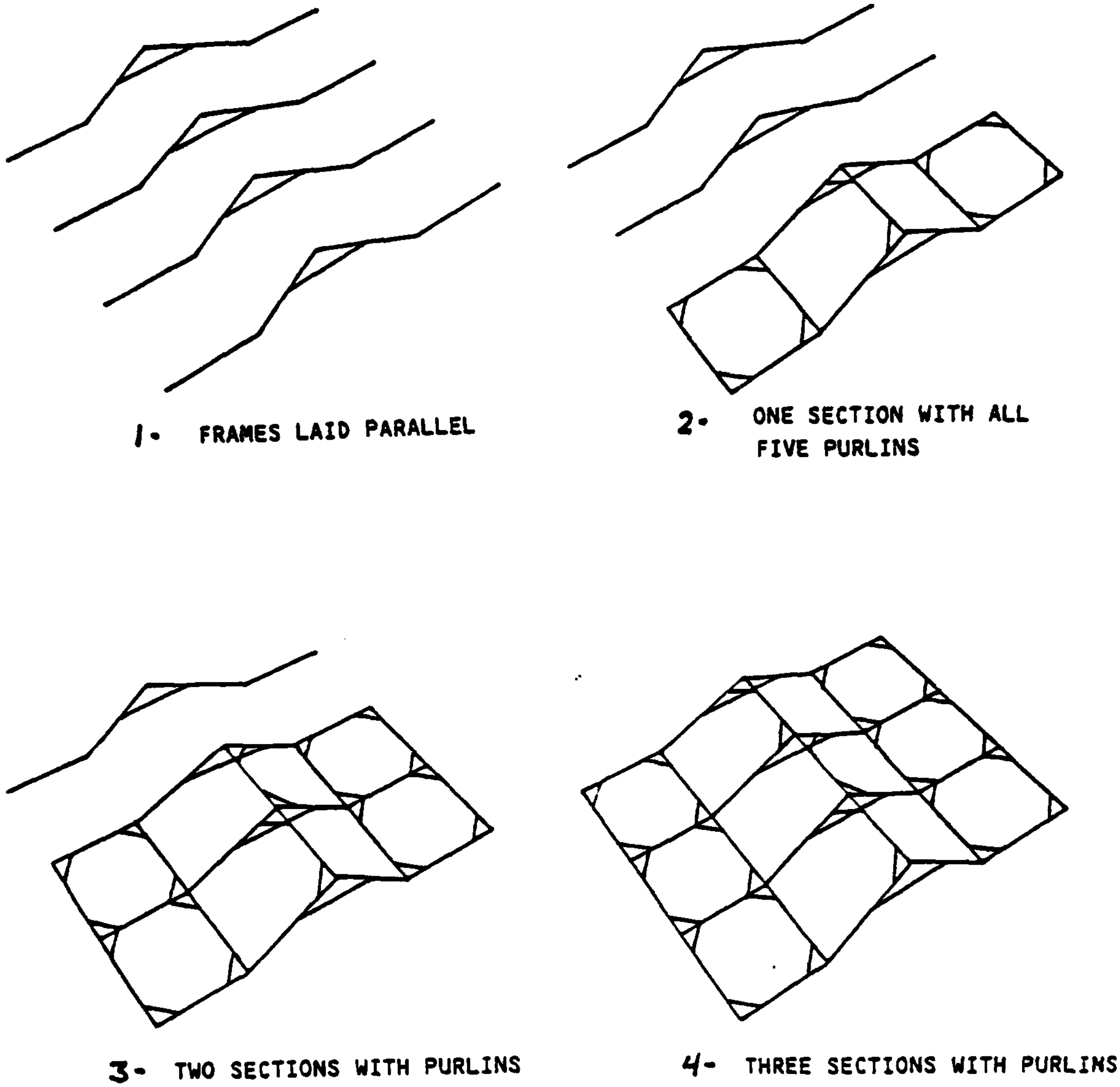


Figure 7. Steps in Assembling TEMPER Frames

Adapted from 44:25

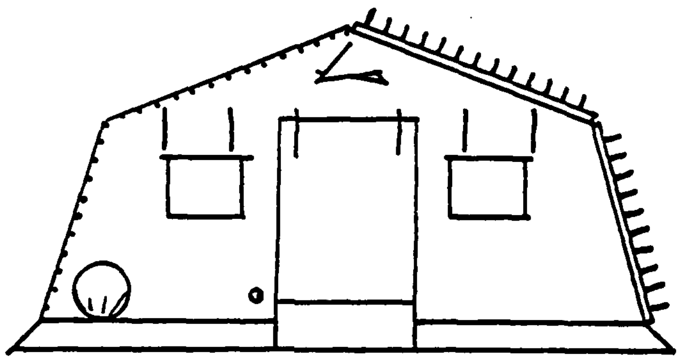

Figure 8. TEMPER Endwall Fabric

Reprinted from 44:27

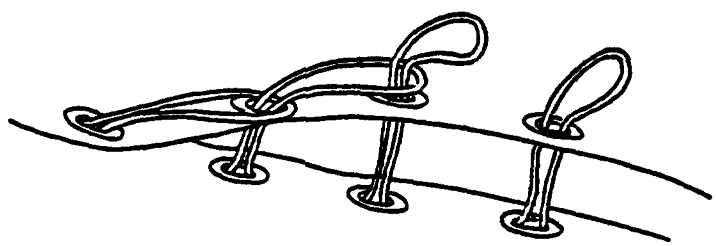

Figure 9. TEMPER Lacing Procedure

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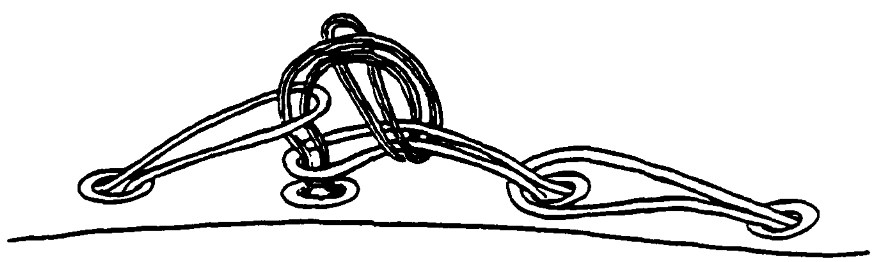


Figure 10. TEMPER Lacing Tie Off Procedure

Reprinted from 44:28

TABLE I

Parts Required to Assemble the TEMPER

The TEMPER tent is erected in lengths of 8 ft. To erect a two section tent of 16'x20' floor area, you would need the following parts:

| | |
|---|---|
| FRAME: | 3 Arches |
| | 3 Headers |
| | 10 Purlins |
| | 6 Eave Extenders |
| | 3 Ridge Extenders |
| COVERINGS: | 2 Roof Sections |
| | 1 16' Fly |
| | 2 End Sections |
| | 2 End Section Liners |
| | 1 Endwall Plenum |
| COMPONENTS | 26 Steel Pins |
| | 10 Wooden Stakes |

To add one section to a two section tent:

| | |
|---|---|
| FRAME: | 1 Arch |
| | 1 Header |
| | 5 Purlins |
| | 2 Eave Entenders |
| | 1 Ridge Extender |
| COVERINGS: | 1 Roof Section |
| | 1 8' Fly |
| | 1 Liner Section |
| | 1 16' Plenum |
| COMPONENTS: | 6 Steel Pins |
| | 2 Wooden Guy Line Stakes |

Adapted from 44:19

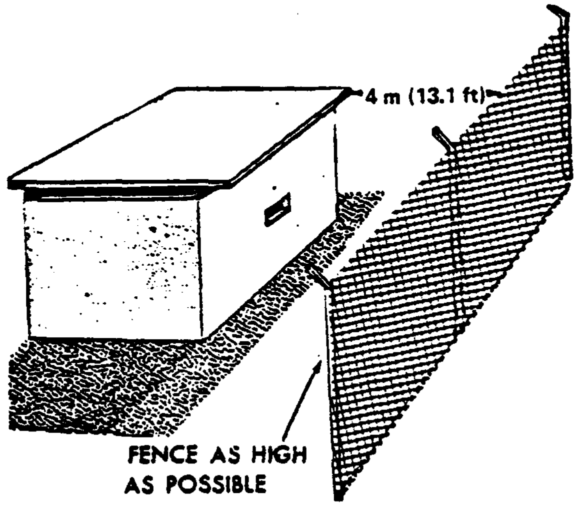



Figure 11. Fortifications: Fence Standoff

Reprinted from 18:3.12

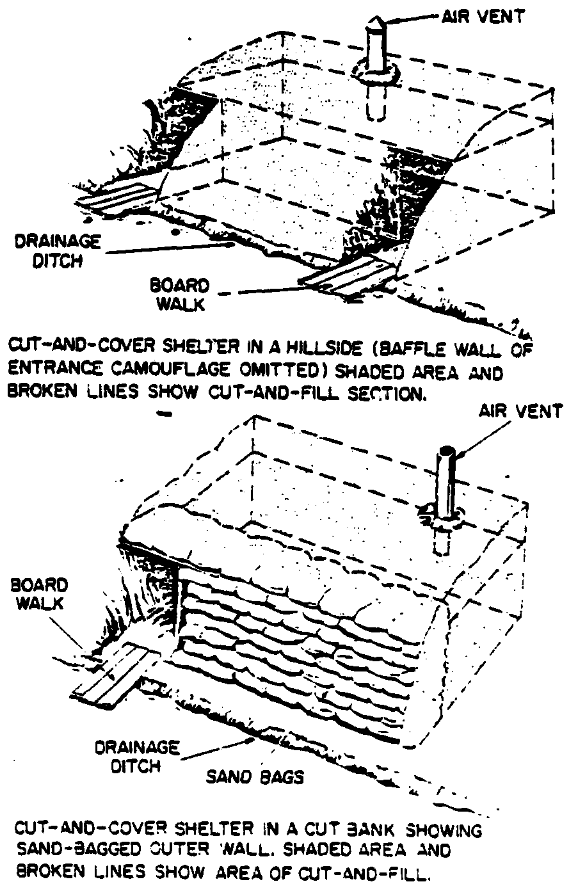



Figure 12. Fortifications: Cut-and-cover Shelter

Reprinted from 18:3.12

TABLE II

Minimum Thickness of Protective Material Required to Resist Penetration

No Standoff - Material in Inches

| Types of ammo | Soil W | Soil D | Sand W | Sand D | Clay W | Clay D | Soil cement (BC) | C | T | A | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .30 cal ball | 36 | 24 | 36 | 24 | 44 | 30 | 18 | 9 | 60 | 2.6 | 1.3 |
| .50 cal ball | 54 | 36 | 45 | 30 | 80 | 54 | 18 | 9 | 120 | 4.4 | 2.2 |
| 57-mm recoil-less rifle | 18 | 12 | 18 | 12 | 36 | 24 | 20 | 10 | 20 | 9.0 | 5.0 |
| 82-mm recoil-less rifle | 40 | 27 | 41 | 27 | 80 | 54 | 42 | 22 | 48 | 21.0 | 12.5 |
| 90-mm recoil-less rifle | 60 | 40 | 63 | 42 | 120 | 80 | 66 | 33 | 75 | 32.2 | 19.5 |
| 107-mm recoil-less rifle | 72 | 48 | 70 | 48 | 144 | 96 | 84 | 42 | 88 | 40.0 | 22.5 |
| 60-mm mortor | 72 | 48 | 45 | 30 | 100 | 64 | 20 | 10 | 20 | 2.8 | 1.0 |
| 81-mm mortor | 90 | 60 | 63 | 42 | 136 | 90 | 26 | 13 | 27 | 3.7 | 1.3 |
| 120-mm mortor | 103 | 70 | 70 | 48 | 180 | 120 | 32 | 16 | 36 | 4.7 | 1.7 |

1/4" Steel or 1/2" Timber Standoff

| Types of ammo | Soil W | Soil D | Sand W | Sand D | Clay W | Clay D | Soil cement (BC) | C | T | A | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .30 cal ball | 18 | 12 | 18 | 12 | 22 | 15 | 9 | 6 | 30 | 1.3 | 0.6 |
| .50 cal ball | 27 | 18 | 26 | 15 | 40 | 27 | 9 | 6 | 60 | 2.2 | 1.1 |
| 57-mm recoil-less rifle | 9 | 6 | 9 | 6 | 18 | 12 | 10 | 6 | 10 | 4.5 | 2.5 |
| 82-mm recoil-less rifle | 20 | 13 | 21 | 13 | 40 | 27 | 21 | 11 | 24 | 10.5 | 6.3 |
| 90-mm recoil-less rifle | 30 | 20 | 30 | 21 | 59 | 40 | 33 | 17 | 38 | 16.0 | 9.8 |
| 107-mm recoil-less rifle | 36 | 24 | 35 | 24 | 71 | 48 | 42 | 21 | 44 | 20.0 | 11.3 |
| 60-mm mortor | 36 | 24 | 22 | 15 | 50 | 32 | 10 | 5 | 10 | 1.4 | 0.5 |
| 81-mm mortor | 45 | 30 | 31 | 21 | 66 | 45 | 13 | 7 | 14 | 1.9 | 0.6 |
| 120-mm mortor | 52 | 35 | 35 | 24 | 90 | 60 | 16 | 8 | 18 | 2.4 | 0.8 |

"W" = wet
"D" = dry
"BC" = bituminous concrete
"C" = concrete
"T" = timber
"A" = aluminum
"S" = steel

Adapted from 19:110

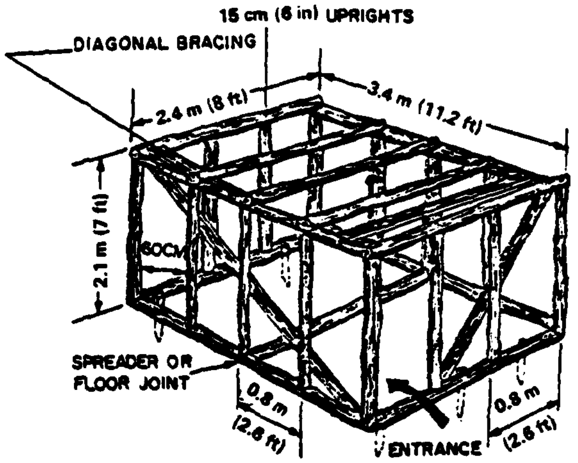



Figure 13. Fortifications: Log Framed Shelter

Reprinted from 18:3.6

TABLE III

Size of Roof Supports

| Size of timber (diam.) | Maximum span when used to support 18" of earth |
|---|---|
| 4 in. | 4 ft. |
| 5 in. | 5 ft. |
| 6 in. | 7 ft. |
| 7 in. | 9 ft. |
| 8 in. | 11 ft. |
| 9 in. | 13 ft. |

Adapted from 18:3.6

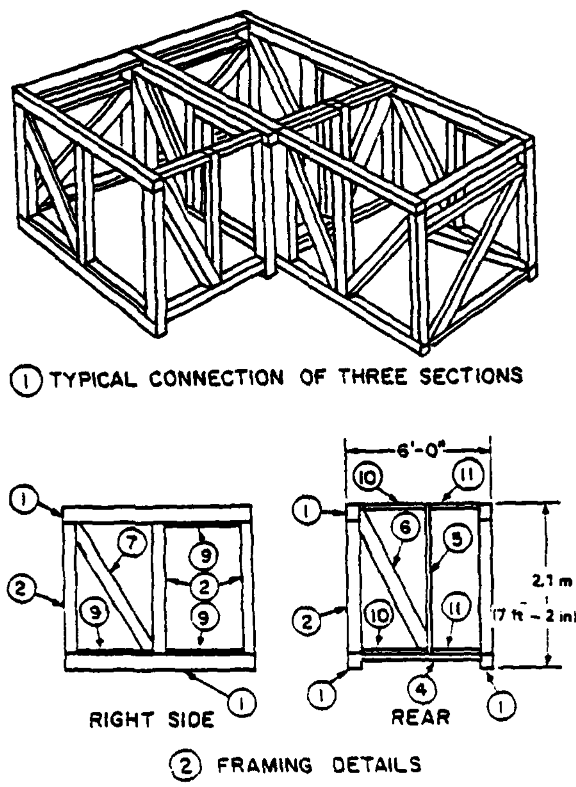
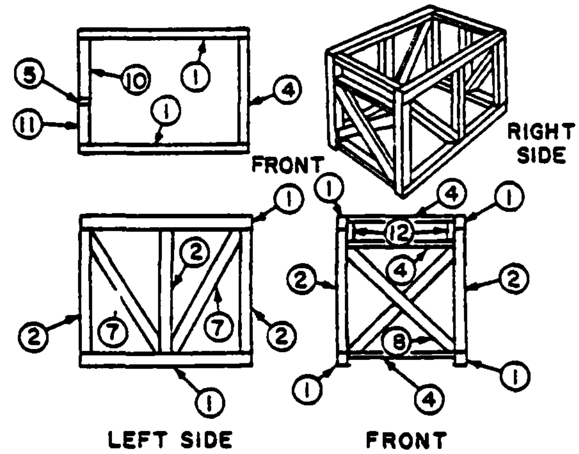
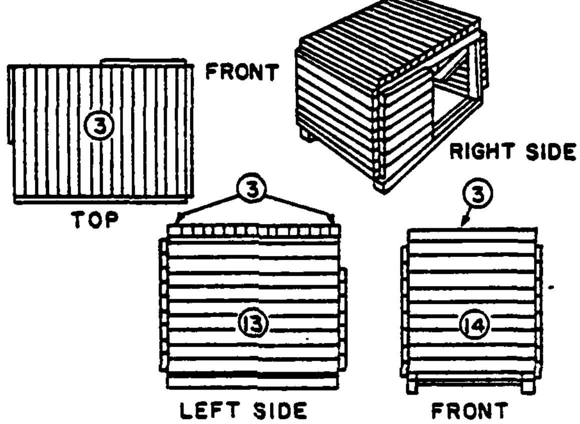



Figure 14. Fortifications: Sectional Shelters

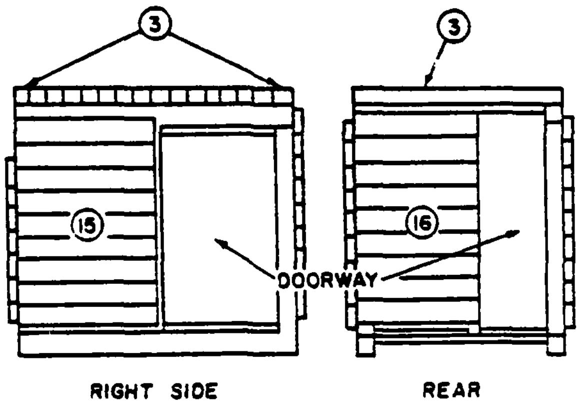
Reprinted from 18:3.6




③ FRAMING DETAILS




④ SHEATHING DETAILS




⑤ SHEATHING DETAILS

Figure 14 - continued

Reprinted from 18:3.7

TABLE IV

Bill of Materials for One 6'x8' Sectional Shelter With Post, Cap and Stringer Construction - Dimensional Timber

| No. | Material size<br>Nomenclature | Rough size | Quantities<br>Roof | Front | Right | Left | Rear |
|---|---|---|---|---|---|---|---|
| 1 | Cap or sill | 6"x8"x8'0" | - | - | 2 | 2 | - |
| 2 | Post | 6"x6"x5'10" | - | - | 3 | 3 | - |
| 3 | Stringer ** | 6"x6"x6'0" | 16 | - | - | - | - |
| 4 | Spreader | 3"x6"x5'0" | - | 2 | - | - | 1 |
| 5 | Post, door | 3"x6"x6'6" | - | - | - | - | 1 |
| 6 | Brace | * 3"x6"x7'0" | - | - | - | - | 1 |
| 7 | Brace | * 3"x6"x6'10" | - | - | 1 | 2 | - |
| 8 | Brace | * 3"x6"x8'0" | - | 2 | - | - | - |
| 9 | Spreader | 2"x6"x3'3" | - | - | 3 | - | - |
| 10 | Spreader | 2"x6"x2'9" | - | - | - | - | 2 |
| 11 | Spreader | 2"x6"x2'0" | - | - | - | - | 2 |
| 12 | Scab | 3"x6"x2'0" | - | - | - | - | - |
| 13 | Siding | 3"xRWx8'0" | - | - | - | 41 1/3SF | - |
| 14 | Siding | 3"xRWx6'0" | - | 36SF | - | - | - |
| 15 | Siding | 3"xRWx4'0" | - | - | 24SF | - | - |
| 16 | Siding | 3"xRWx3'6" | - | - | - | - | 21SF |
| 17 | Roll roofing | 100 sq ft roll | 6 | - | - | - | - |
| 18 | Driftpin | 1/2"x14" | 32 | - | 6 | 6 | - |
| 19 | Nails | 60d | - | 8 lb | 8 lb | 8 lb | 8 lb |

* Allowance for double out ends of braces is included in overall length as shown under rough size.
** Laminated wood roof may be substituted if desired.

Adapted from 18:3.8

TABLE V

Comparison of Rectangular and Round Timber

| Size or rectangular timber | Size or round timber required to equal (in inches) |
|---|---|
| 6x6 | 7 |
| 6x8 | 8 |
| 8x8 | 10 |
| 8x10 | 11 |
| 10x10 | 12 |
| 10x12 | 13 |
| 12x12 | 14 |

Adapted from 18:3.8

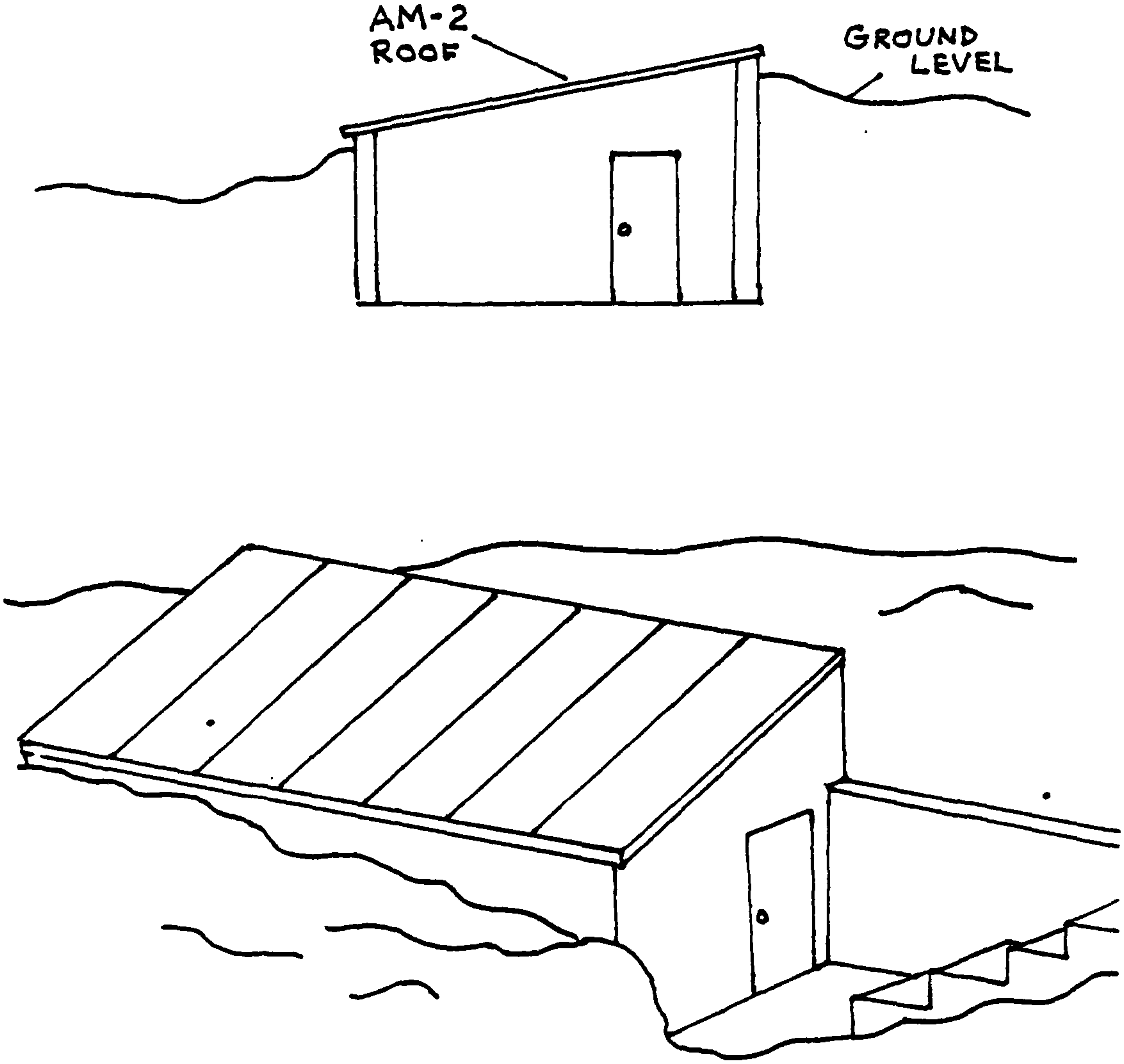



Figure 15. Fortifications: Underground Command Bunker

As Used During an AFLC Inspection

Submitted by 1Lt Jared Astin

## TABLE VI

## Material and Labor Requirements for 300-Meter (984-foot) Sections of Various Barbed Wire Entanglements

| Type of entanglement | Pickets: Extra long | Pickets: Long | Pickets: Medium | Pickets: Short | Barbed wire No. of 400 m, 41.5 kg reels [1] | No. of concertinas [4] | Staples | Kg of materials per lin m of entanglement [2] | Lb of materials per lin m of entanglement [2] | Man-hours to erect 300 m of entanglement [3] |
|---|---|---|---|---|---|---|---|---|---|---|
| Double-apron, 4- and 2-pace | -------- | 100 | -------- | 200 | 14–15(19) [5] | -------- | -------- | 4.6(3.5) [6] | 10 (7.7) [6] | 59 |
| Double-apron, 6- and 3-pace | -------- | 66 | -------- | 132 | 13–14(18) [5] | -------- | -------- | 3.6(2.6) [6] | 8 (5.7) [6] | 49 |
| High wire (less guy wires) | -------- | 198 | -------- | -------- | 17–19(24) [5] | -------- | -------- | 5.3(4.0) [6] | 11.6(8.8) [6] | 79 |
| Low wire, 4- and 2-pace | -------- | -------- | 100 | 200 | 11(15) [5] | -------- | -------- | 3.6(2.8) [6] | 7.9(6.1) [6] | 49 |
| 4-strand fence | -------- | 100 | -------- | 2 | 5–6(7) [5] | -------- | -------- | 2.2(1.8) [6] | 4.8(3.9) [6] | 20 |
| Double expedient concertina | -------- | 101 | -------- | 4 | 3 | 100 | 295 | 6.9 | 15.1 | 40 |
| Triple expedient concertina | 51 | 101 | -------- | 7 | 4 | 148 | 295 | 10.4 | 22.8 | 99 |
| Triple standard concertina | -------- | 160 | -------- | 4 | 3(4) [5] | 59 | 317 | 7.9(5.4) [6] | 17.3(11.8) [6] | 30 |

[1] Lower number of reels applies when screw pickets are used: high number when U-shaped pickets are used. Add difference between the two to the higher number when wood pickets are used.
[2] Average weight when any issue metal pickets are used.
[3] Man-hours are based on the use of screw pickets. With the exception of the triple-standard concertinas, add 20 percent to the man-hours when driven pickets are used. With experienced troops, reduce man-hours by one-third. Increase man-hours by 50 percent for nightwork.
[4] Based on concertinas being made up in rear areas and ready for issue. Once expedient concertina opens to 19.7 ft length, as compared with 15 meters for a standard concertina; it requires 302 feet of standard barbed wire, also small quantities of No. 16 smooth wire for ties.
[5] Number of 984 ft, 14.5 kg barbed tape carrying cases required if barbed tape is used in place of barbed wire.
[6] Kgs of materials required per linear meter of entanglement if barbed tape is used in place of barbed wire and barbed tape concertina is used in place of standard barbed wire concertina.

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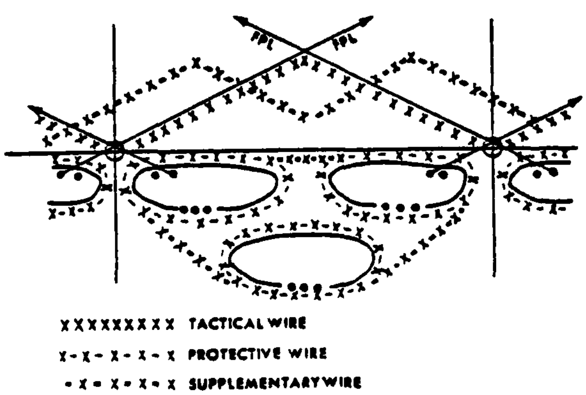


Figure 16. Obstacles: Classification of Wire by Use

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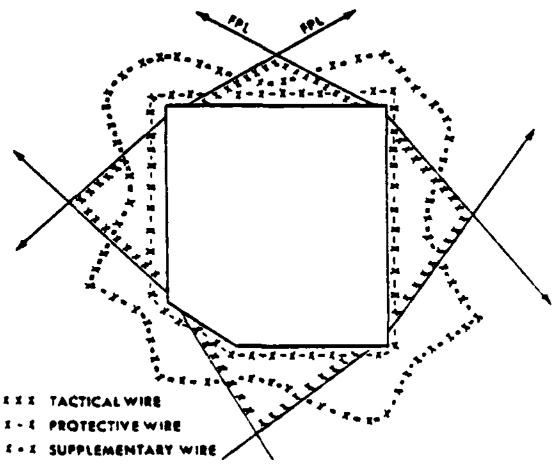


Figure 17. Obstacles: Perimeter Defense Wire

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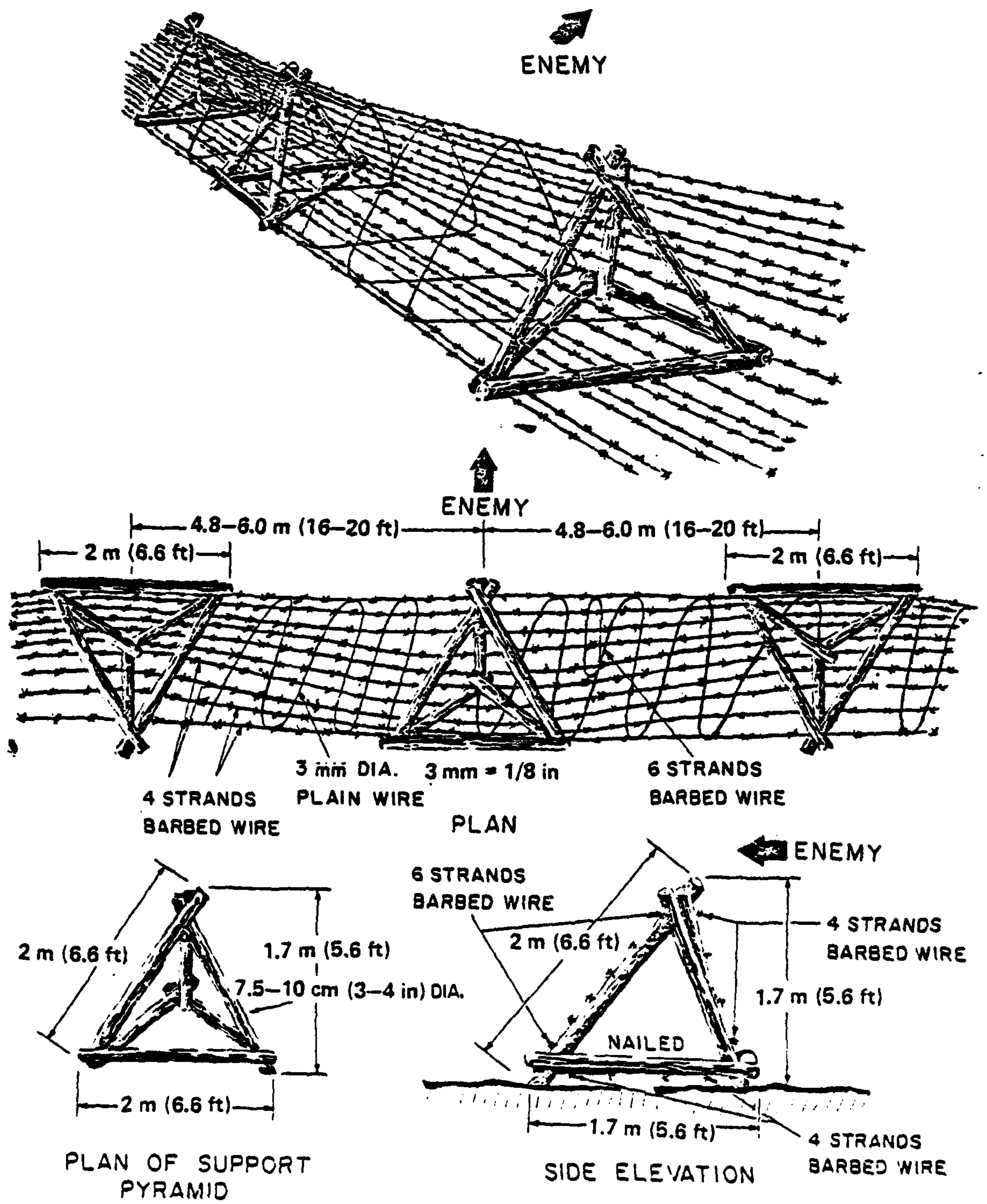


Figure 18. Obstacles: Lapland Fence

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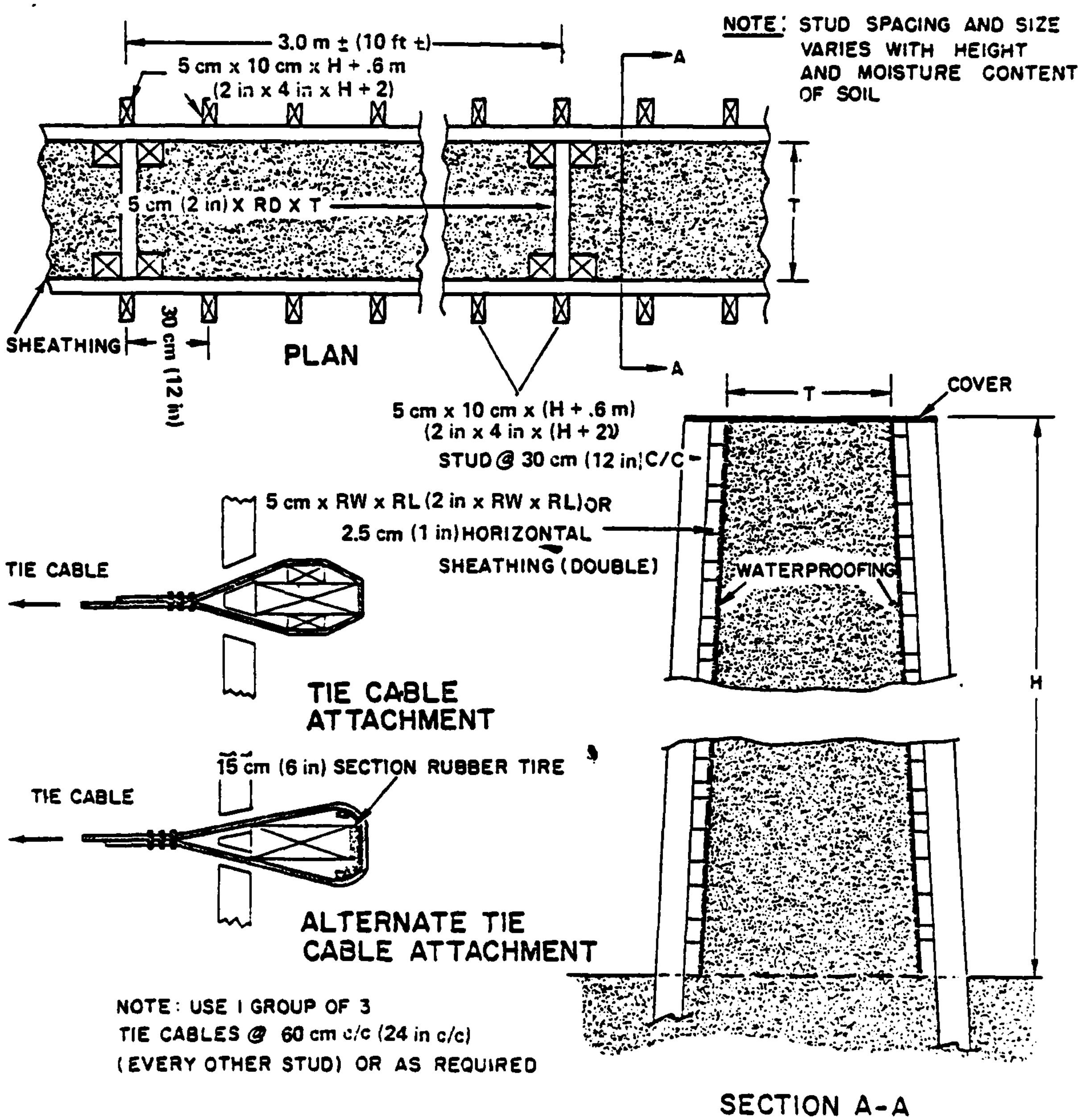


Figure 19. Hardening: Dimensional Timber (Soil Bin) Revetment

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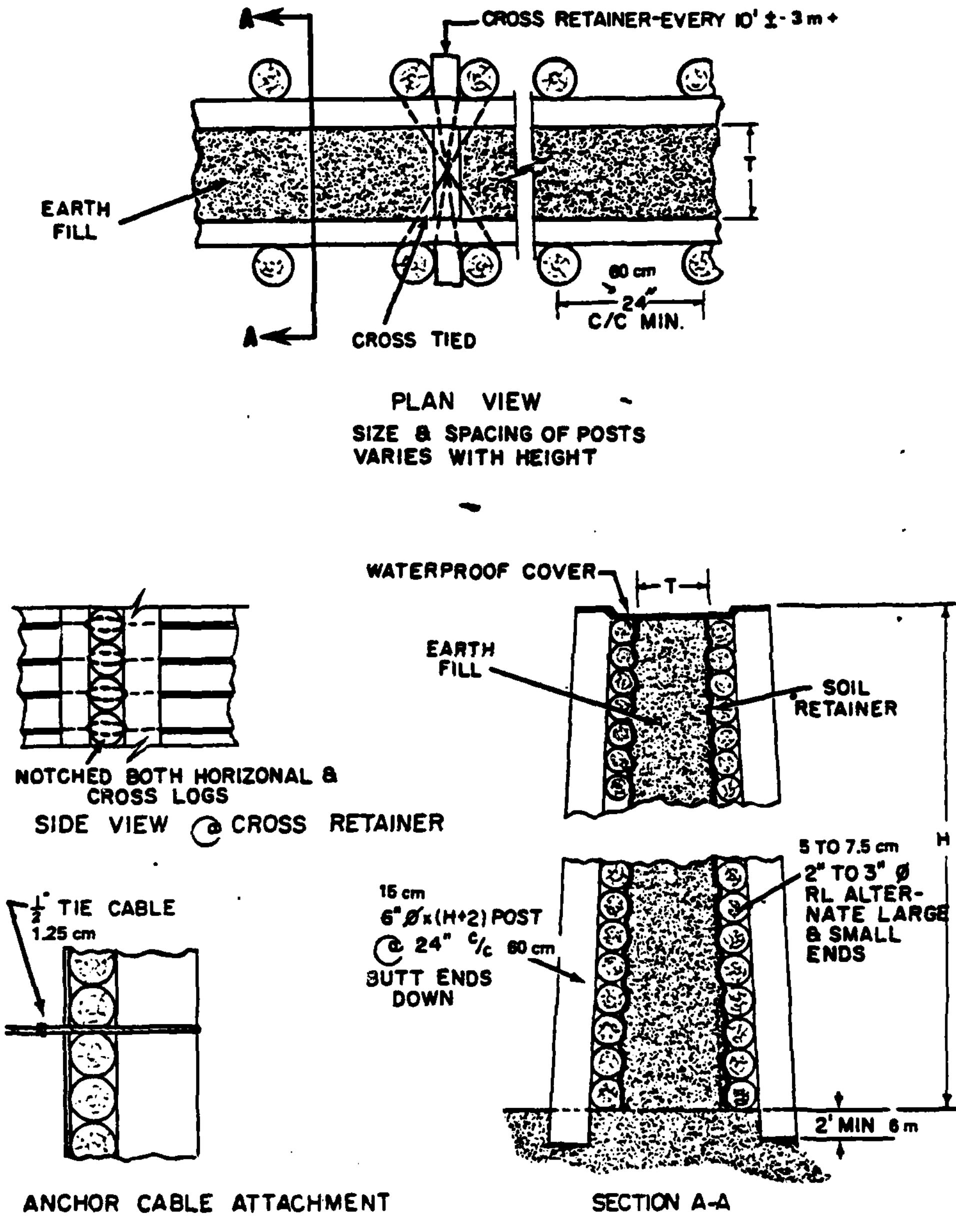


Figure 20. Hardening: Log Bulkhead (Soil Bin) Revetment

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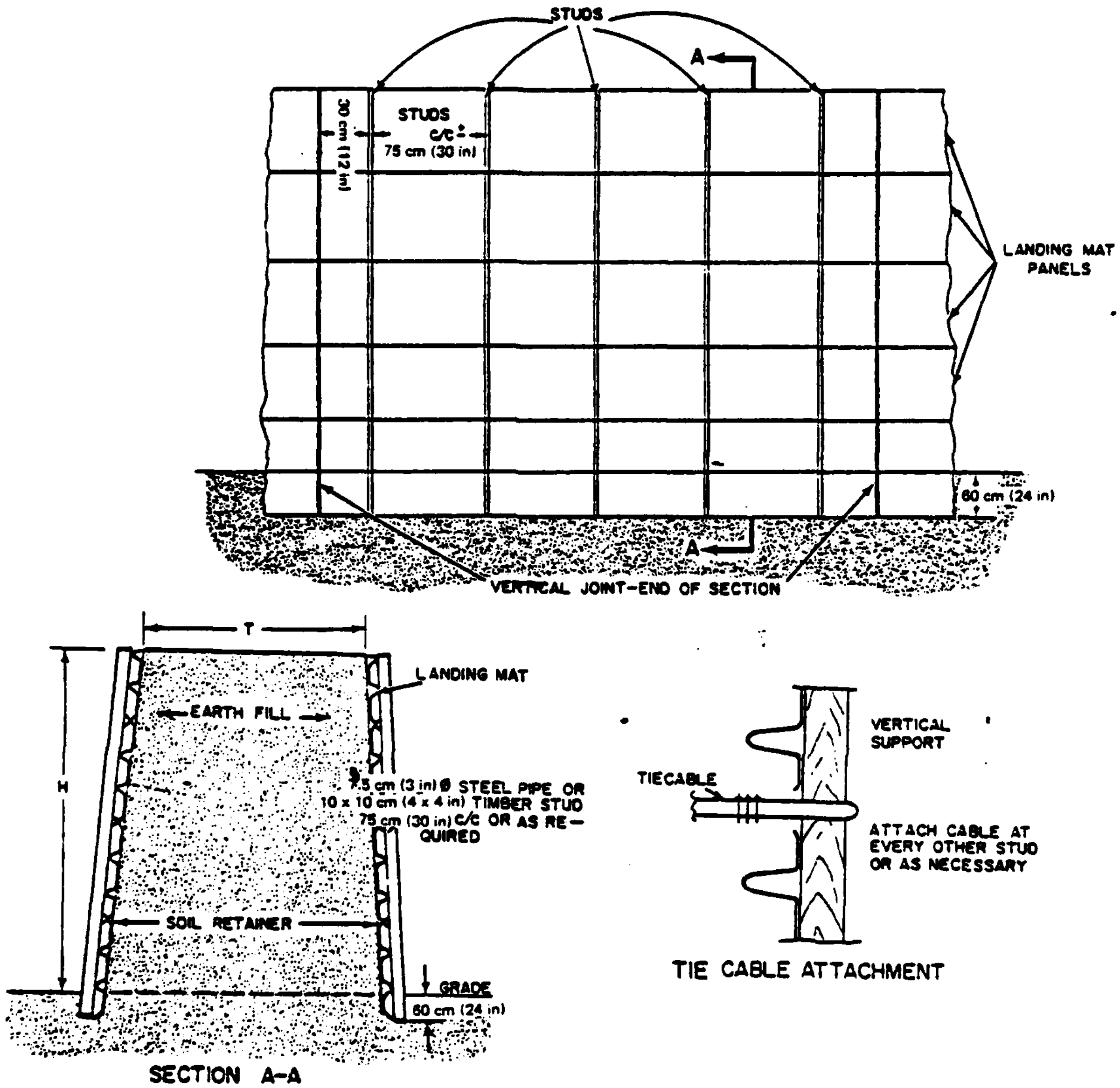



Figure 21. Hardening: Landing Mat Bulkhead
(Soil Bin) Revetment

Reprinted from 18:E.6

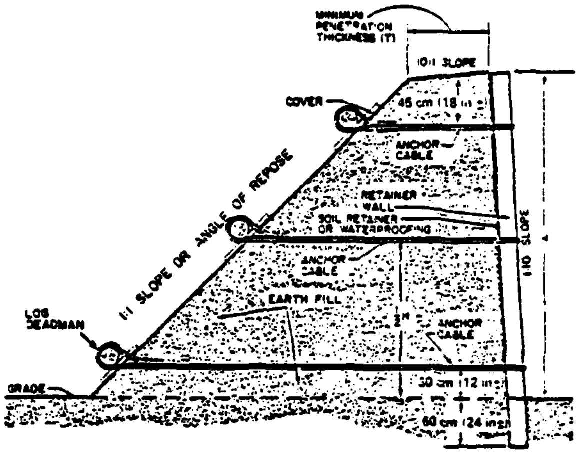



Figure 22. Hardening: Gravity Revetment

Reprinted from 18:E.9

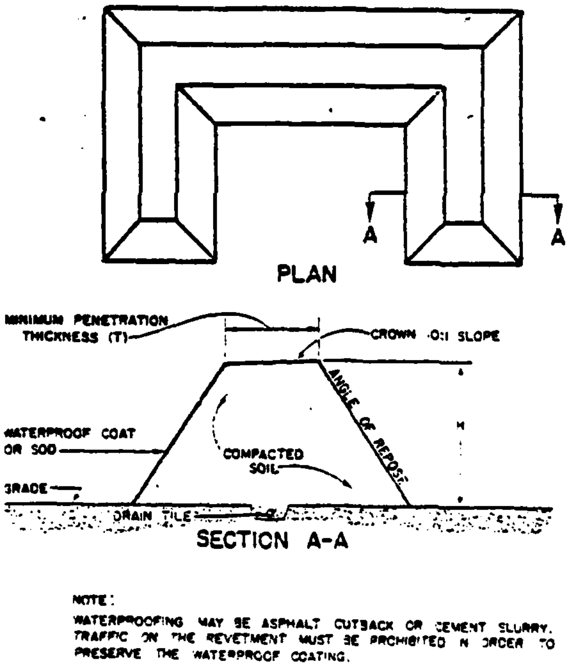



Figure 23. Hardening: Earth Revetment

Reprinted from 18:E.9

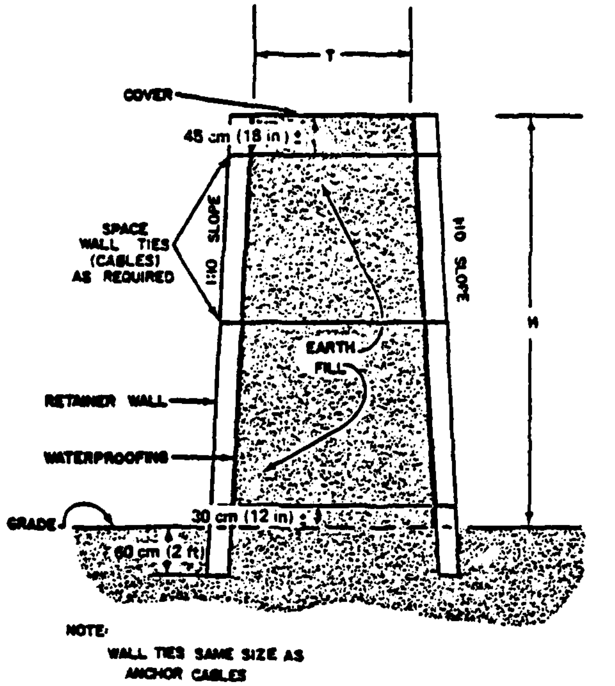



Figure 24. Hardening: Bulkhead Revetment

Reprinted from 18:E.10

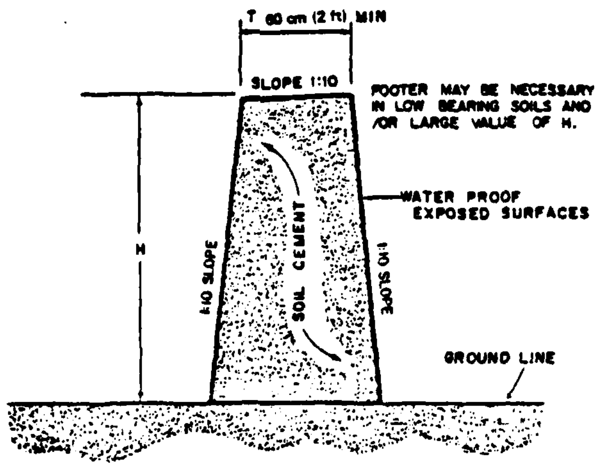



Figure 25. Hardening: Freestanding Wall, Soil-cement Revetment

Reprinted from 18:E.10

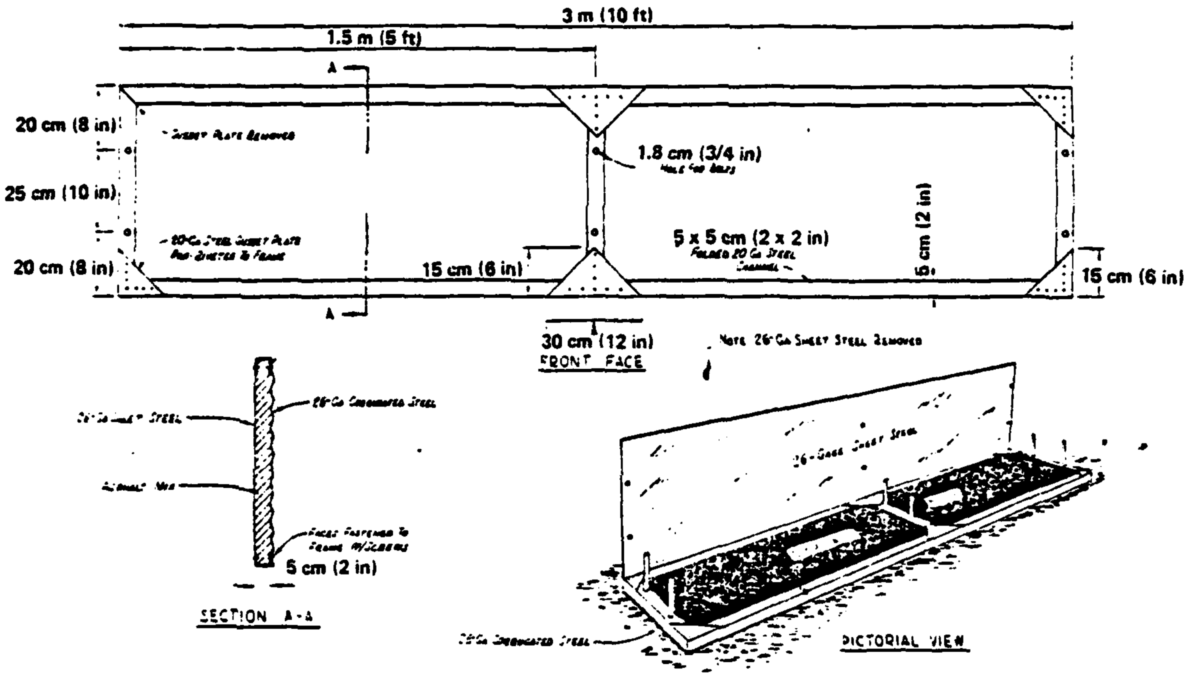
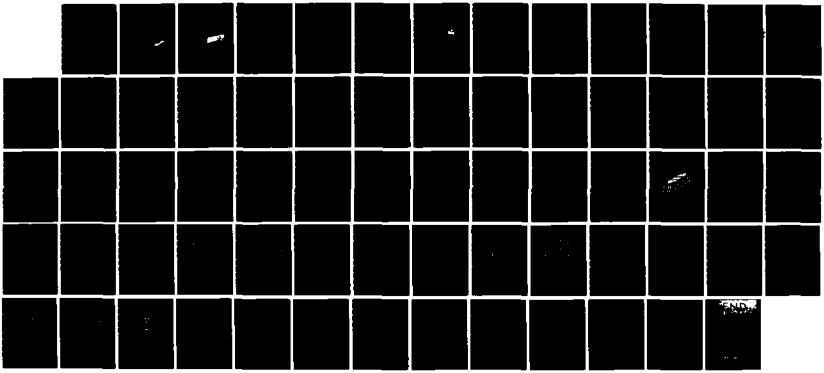


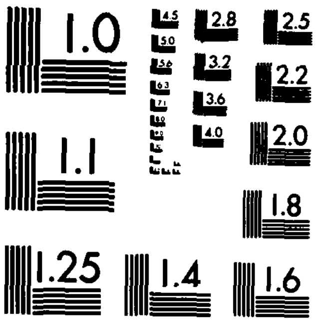

Figure 26. Hardening: Plastic Armor Panel
(Sheet Steel With Metal Frame)

Reprinted from 18:E.12

AD-A146 892 A COMPREHENSIVE EXPEDIENT METHODS FIELD MANUAL(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYSTEMS AND LOGISTICS R V BOUSQUET SEP 84 2/2

UNCLASSIFIED AFIT/GEM/LSM/84S-3 F/G 13/2 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3

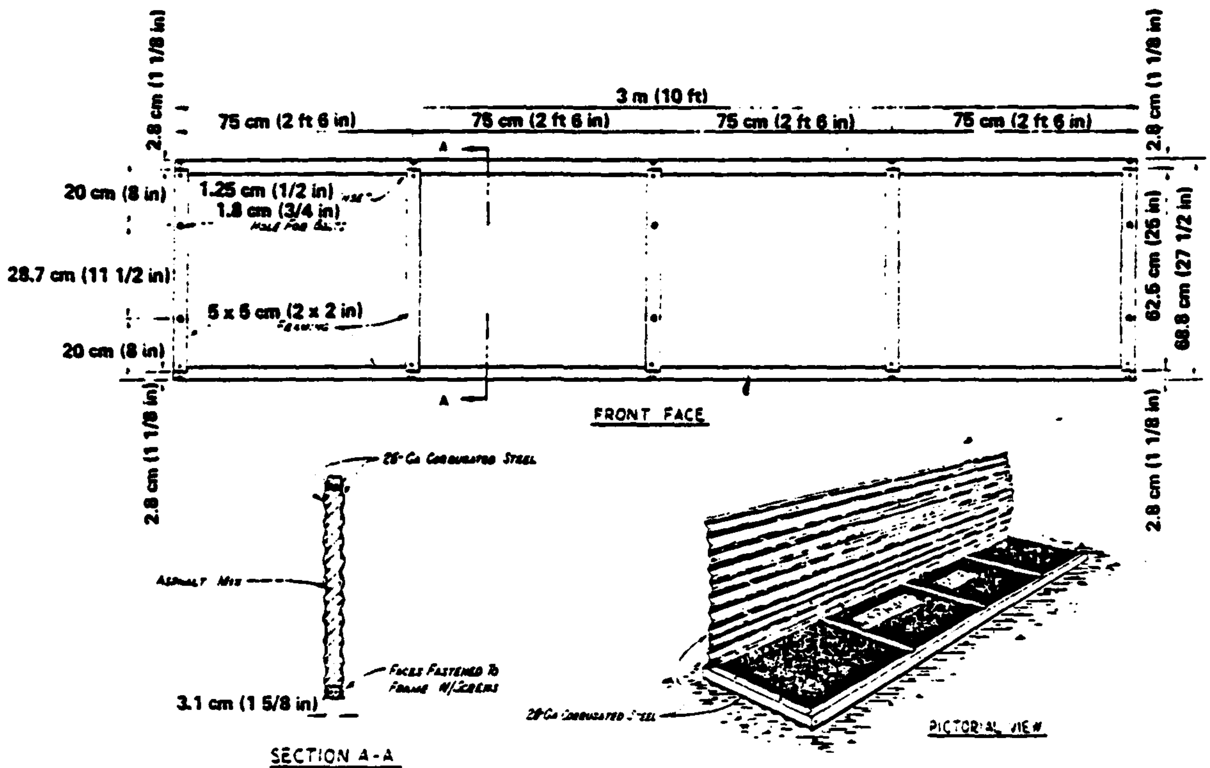



Figure 27. Hardening: Plastic Armor Panel
(Double Corrugated Metal)

Reprinted from 19:E.13

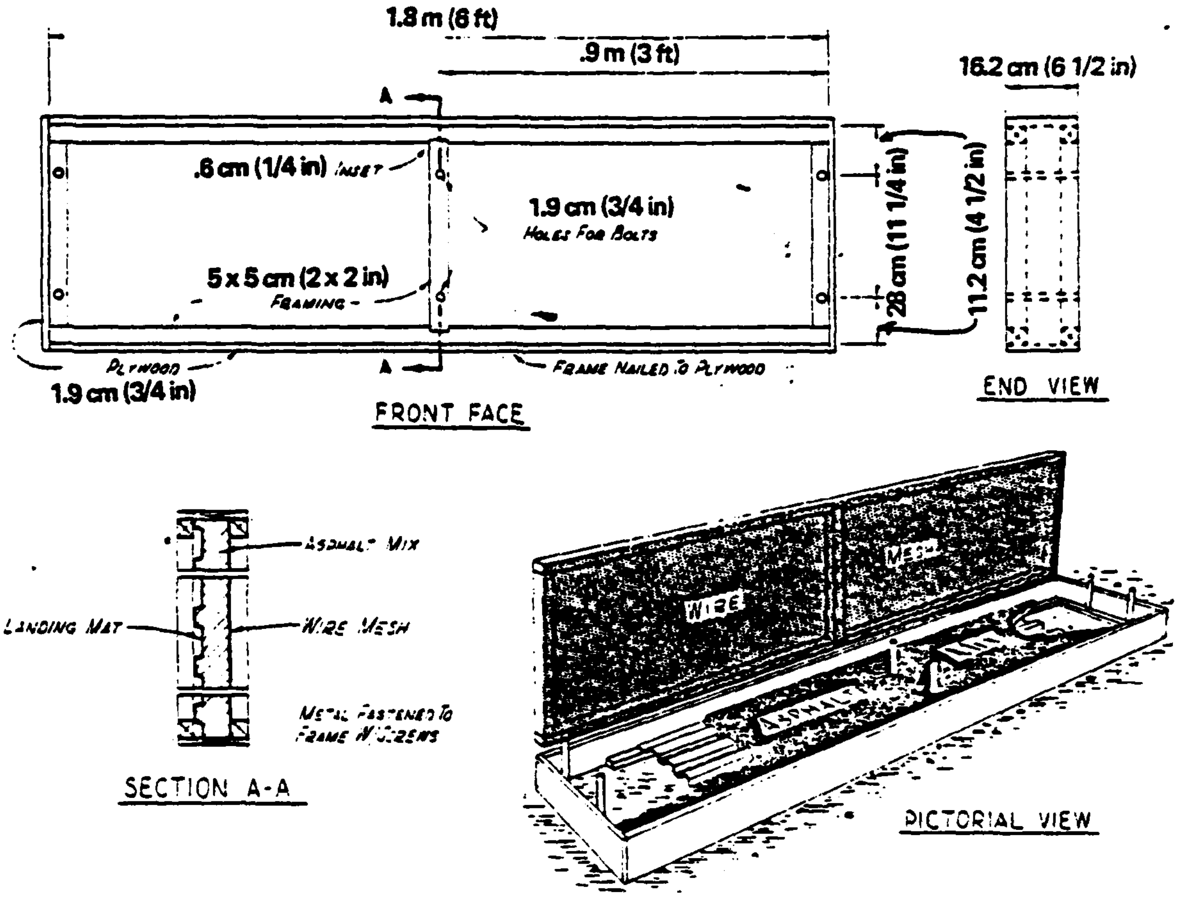



Figure 28. Hardening: Plastic Armor Panel
(M8A1 Mat With Wire Mesh)

Reprinted from 18:E.14

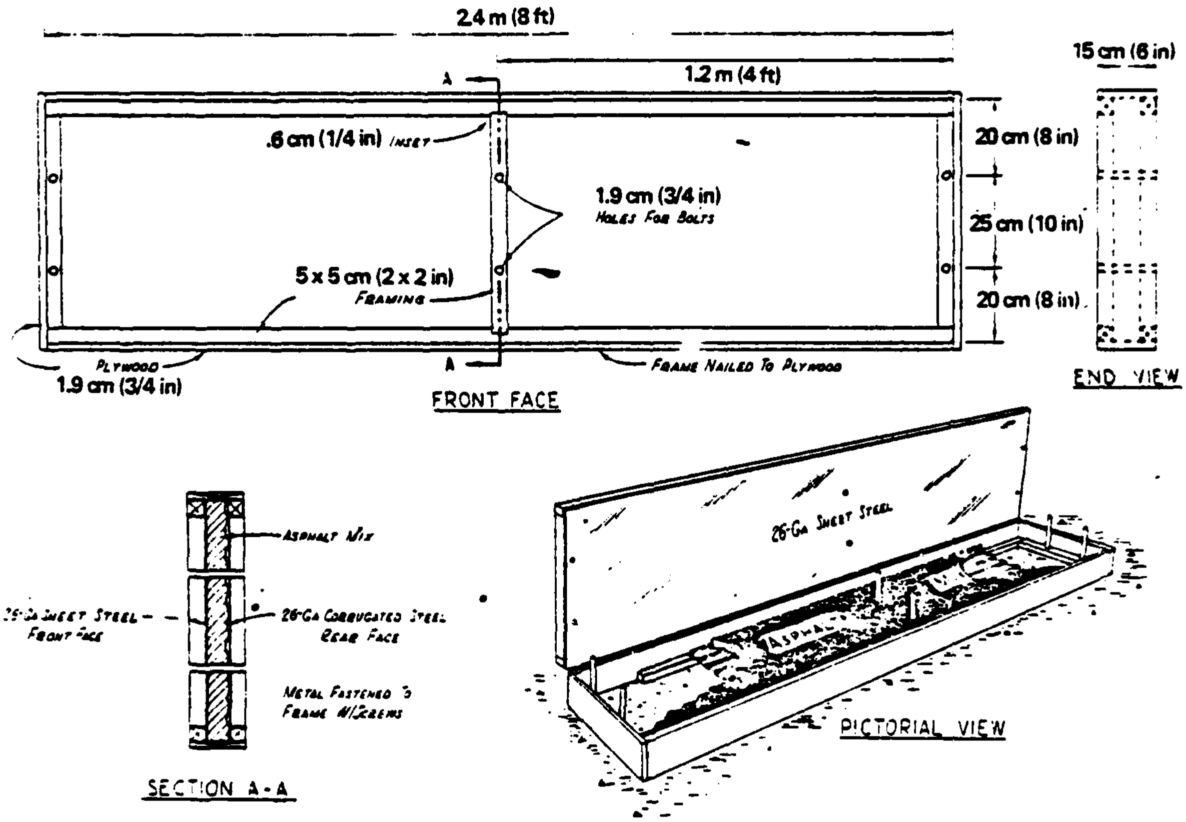



Figure 29. Hardening: Plastic Armor Panel (Corrugated and Sheet Metal with Plywood)

Reprinted from 18:E.15

## TABLE VII

### Hot Asphalt Mixes for Revetment Construction

| Sieve size[a] | Percent used | Percent passing indicated sieve sizes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | ¾ | ½ | ⅜ | 4 | 10 | 20 | 40 | 80 | 200 |
| **A. Mix 1—Coarse Mix[b]:** | | | | | | | | | | | |
| 3/4–1/2 | 22.2 | 22.2 | 21.8 | 1.5 | 0.0 | | | | | | |
| 1/2–3/8 | 22.2 | 22.2 | 22.2 | 21.8 | 4.9 | 0.0 | | | | | |
| 3/8–4 | 22.2 | 22.2 | 22.2 | 22.2 | 22.0 | 2.0 | 0.0 | | | | |
| LSD | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 | 33.3 | 33.0 | 31.6 | 25.3 |
| Blend | 100.0 | 100.0 | 99.6 | 78.9 | 60.3 | 35.4 | 33.4 | 33.3 | 33.0 | 31.6 | 25.8 |
| **B. Mix 2—Sand Mix[b]:** | | | | | | | | | | | |
| Sand | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 85.1 | 83.0 | 66.2 | 10.8 | 4.7 |
| LSD | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 13.8 | 13.2 | 10.5 |
| Blend | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 99.1 | 97.0 | 80.0 | 24.0 | 15.5 |
| **C. Mix 3—G11A Well Graded Mix[b]:** | | | | | | | | | | | |
| 3/4–1/2 | 11.6 | 11.6 | 11.4 | 0.8 | 0.0 | | | | | | |
| 1/2–3/8 | 7.3 | 7.3 | 7.3 | 7.2 | 1.6 | 0.1 | | | | | |
| 3/8–4 | 15.9 | 15.9 | 15.9 | 15.9 | 15.8 | 1.4 | | | | | |
| 4–10 | 16.8 | 16.8 | 16.8 | 16.8 | 16.8 | 16.7 | 1.6 | 0.3 | 0.2 | 0.2 | 0.2 |
| 10–20 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 1.8 | 0.1 | 0.0 | |
| 20–40 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 8.7 | 1.1 | 0.1 | 0.1 |
| 40–80 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 1.4 | 0.3 |
| TVS | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.4 | 13.3 | 10.7 | 1.9 |
| LSD | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.5 | 2.1 |
| Blend | 100.0 | 100.0 | 99.8 | 89.1 | 82.6 | 66.5 | 50.0 | 36.0 | 26.0 | 14.9 | 4.6 |

[a] Sizes 1, ¾, ½, and ⅜ are in inches; all others are standard sieve sizes. LSD and TVS are limestone dust and Tennessee Valley sand, respectively.
[b] Mix 1 contained Alabama limestone aggregate and 7.5 percent asphalt binder; Mix 2 contained Cook's Bayou sand and 7.5 percent asphalt binder. Mix 3 contained Alabama limestone and Tennessee Valley sand and 5.3 percent asphalt binder. The binder used in all three mixes was 85–100 penetration asphalt.

Reprinted from 18:E.16

## TABLE VIII

### Field Expedient Mixes for Revetment Construction

| Mix designation | Binder | Aggregate |
|---|---|---|
| 1-A, rapid-cure asphalt mix | 8.5 percent asphalt (percentage of total aggregate weight); RC-2 rapid cure (70 percent asphalt content); binder mixed cold. | Same as hot Mix 1: Limestone dust filler, 33.4 percent; Alabama limestone, 66.6 percent. |
| 1-B, hot-cold mix | 7.5 percent 85–100 penetration asphalt, binder mixed hot. | Same as hot Mix 1: Total aggregate soaked with 2.2 percent (percentage of total aggregate weight) diesel fuel prior to mixing with binder. |
| 1-C, Peneprime mix | 6.5 percent Peneprime (60 percent asphalt content); binder mixed cold | Same as hot Mix 1 |
| No. 4, commercial hot-cold mix. | 6 percent AC-8 cutback asphalt, binder mixed hot. | 10 percent fine river sand; 30 percent concrete sand; 60 percent No. 87 Birmingham slag. Aggregate sprayed with kerosene, then mixed with hot asphalt. |

*Gradation of Alabama Limestone* (Mix 1-A)

| Sieve size | Percent passing |
|---|---|
| 3/4 inch | 100 |
| 1/2 inch | 66 |
| 3/8 inch | 33 |
| No. 4 | 0 |

*Gradation of No. 87 Birmingham Slag* (Mix No. 4)

| Sieve size | Percent passing |
|---|---|
| 1/2 inch | 100 |
| 3/8 inch | 99 |
| No. 4 | 90 |
| No. 10 | 48 |
| No. 40 | 24 |
| No. 100 | 8 |
| No. 200 | 2 |

Reprinted from 18:E.17

## TABLE IX

### Concrete Mixes

| | Mix 5 (Standard 3,000-psi mix) | Mix 6 (sand grout mix) |
|---|---|---|
| Water ratio (weight of water/weight of cement) | 0.78 | 0.56 |
| Density, pcf | 153.3 | 140.4 |
| 28-day unconfined compressive strength, psi | 2,580 | 2,100 |
| Aggregate | 43.2 percent limestone sand 56.8 percent coarse Alabama limestone.[a] | 100 percent Cook's Bayou sand |

[a] Limestone comprised equal portions (by weight) as follows: [illegible] to [illegible]-inch, [illegible] to [illegible]-inch, and [illegible]-inch to No. 4 sieve sizes.

Reprinted from 18:E.17

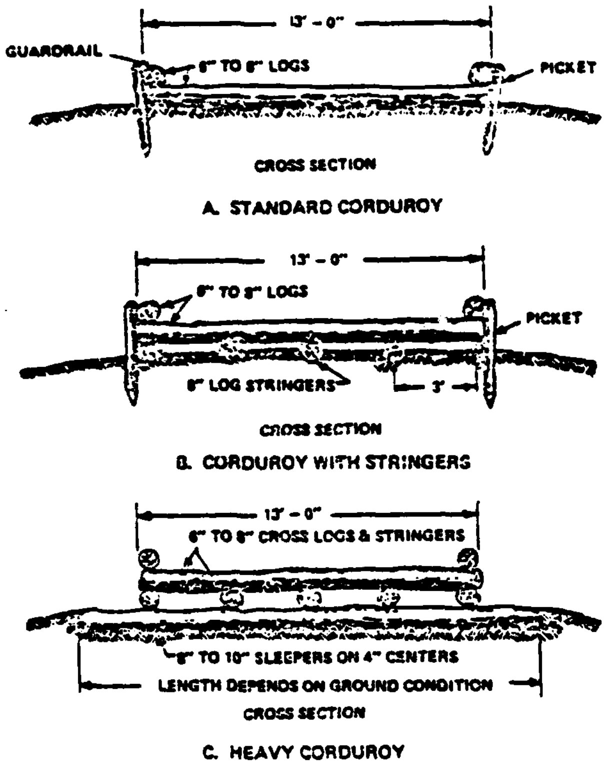



Figure 30. Non-airfield Pavements: Corduroy Roads

Reprinted from 15:252

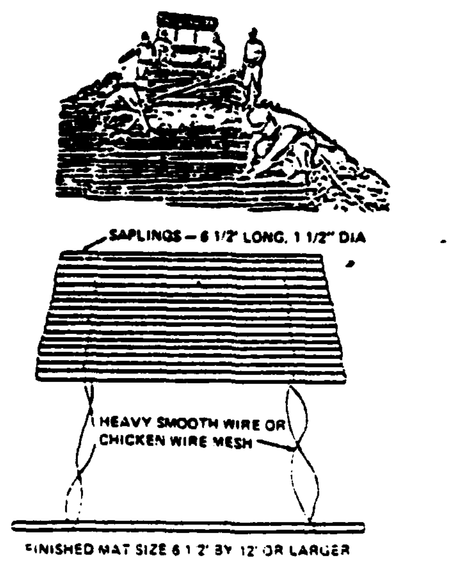



Figure 31. Non-airfield Pavements: Chespaling Road

Reprinted from 15:250

Vehicular Transportation in Sandy Areas. Additional expedients for driving over sandy areas are given below [43:7.19,7.20]:

1. Use lighter traffic loads and reduce tire pressures. A general rule of thumb is to lower tire pressure so that tire deflection is increased by 50 percent.

2. Sand stabilization using portland cement is a well-established method for constructing pavement base layers.

3. Mix available local ground or soils with the sand to inprove trafficability.

4. If a firmer material lies ar shallow depths, keep blading loose sands off the roadway.

5. Place building rubble in the ruts.

6. Use crude oil, if available, for stabilizing the sand.

Airfield Pavement Repair. The following procedures should be followed when using polymer-concrete (PC) for repairing spalls on airfield pavements (26:180):

1. Spall Repairs: The In-line Mixing System

   a. Remove any standing water that may be present.

   b. Place 50:50, sand-gravel mixture in the repair until it is level with the pavement surface.

   c. Push an in-line mixing gun into the surface and fill the spall with the polymer mixture.

   d. Add sand and polymethyl methacrylate (PMMA) to the surface and strike off until it is level with the pavement surface.

2. Spall Repairs: The Modified Concrete Method

   a. Remove any standing water that may be present.

   b. Fill the spall with PC; some vibration or rodding may be necessary to completely fill the voids.

   c. Strike off level with the pavement surface.

Airfield Lighting. Some airfield lighting expedients are given below (12:88):

1. Use bean bag lights.

2. Use kerosene smudge pots.

3. Light fixtures can be mounted on stakes placed at the shoulders of the runway surface.

4. Single conductor airfield lighting cable can be run along the ground and used to connect the isolation transformers in series with the C-3 regulator.

5. The MB-17 or EMU-15 generators can be used to power the C-3.

## TABLE X

### Aircraft Characteristics – Dimensions in British (Feet)

| AIRCRAFT DESIGNATION | WINGSPAN | LENGTH | HEIGHT | VERTICAL * CLEARANCE | TREAD * | WHEEL * BASE | PIVOT POINT | TURNING RADIUS | CONTROLLING GEAR | 180°TURN DIAMETER | AFR 93-5 GROUP INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C-123K | 110.0 | 76.2 | 34.5 | 18.0 | 150.0 | 288.0 | 15.3 | 29.0 | Nose | 70.0 | 1 |
| O-2A | 38.0 | 29.2 | 9.4 | | 98.0 | | | | | | 2 |
| F-4C | 38.6 | 58.3 | 16.4 | 6.0 | 215.0 | 279.0 | 8.9 | 24.8 | Nose | 57.7 | 2 |
| RF-4C | 38.4 | 63.0 | 16.4 | 6.0 | 215.0 | 279.0 | 8.9 | 24.8 | Nose | 76.7 | 2 |
| F-4D | 38.4 | 63.0 | 16.4 | 6.0 | 215.0 | 279.0 | 8.9 | 24.8 | Nose | 57.7 | 2 |
| F-4E/G | 38.4 | 63.0 | 16.4 | 6.0 | 215.0 | 279.0 | 8.9 | 24.8 | Nose | 76.8 | 2 |
| F-5E | 28.0 | 48.2 | 13.4 | 38.8 | 150.0 | 204.0 | 31.3 | 37.0 | Nose | 73.9 | 2 |
| F-5F | 28.0 | 51.7 | 13.2 | 32.3 | 150.0 | 254.0 | 26.5 | 43.0 | Nose | 85.7 | 2 |
| A-7D | 38.73 | 46.13 | 16.06 | 15.50 | 113.9 | 188.18 | 4.75 | 10.24 | Nose | 58.0 | 2 |
| A-7K | 38.72 | 48.69 | 16.30 | 15.50 | 113.9 | 188.18 | 4.75 | 10.24 | Nose | 58.0 | 2 |
| A-10 | 57.48 | 53.33 | 14.66 | 60.0 | 206.6 | 212.8 | 14.5 | 22.2 | Nose | 87.0 | 2 |
| OV-10A | 40.0 | 39.7 | 15.1 | | 178.0 | | | 22.7 | Nose | 72.0 | 2 |
| C-12A | 54.5 | 43.8 | 15.0 | 14.5 | 206.0 | 180.0 | 12.7 | 19.5 | Main | 79.7 | 2 |
| F-14 | 64.1 | 61.98 | 16.0 | | 192.0 | 276.5 | | | | | 2 |
| F-15A/B | 42.8 | 63.8 | 18.8 | 12.0 | 107.0 | 210.0 | 25.0 | 25.0 | Nose | 83.0 | 2 |
| F-15C/D | 42.8 | 63.8 | 18.8 | 12.0 | 107.0 | 210.0 | | | Nose | | 2 |
| F-16A/B | 32.8 | 49.6 | 16.7 | 18.4 | 93.0 | 158.0 | 21.5 | 25.0 | Nose | 78.0 | 2 |

* GIVEN IN INCHES    NOTE: REFERENCE FIGURES 1 THRU 10 FOR GENERAL AIRCRAFT CONFIGURATION

Reprinted from 36:10

## TABLE X - Continued

### Aircraft Characteristics - Dimensions in British (Feet)

| AIRCRAFT DESIGNATION | WINGSPAN | LENGTH | HEIGHT | VERTICAL * CLEARANCE | TREAD * | WHEEL * BASE | PIVOT POINT | TURNING RADIUS | CONTROLLING GEAR | 180° TURN DIAMETER | AFR 93-5 GROUP INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T-33A | 38.9 | 37.8 | 11.7 | 20.0 | 105.0 | 169.9 | 10.4 | 19.9 | Main | 78.6 | 2 |
| A-37B | 38.3 | 31.8 | 9.5 | | 164.0 | 94.0 | | 14.1 | Nose | | 2 |
| OA-37 | 38.3 | 31.8 | 9.5 | | 164.0 | 94.0 | | 14.1 | Nose | 63.1 | 2 |
| T-37B | 33.8 | 29.3 | 9.2 | 6.0 | 168.0 | 93.0 | 6.9 | 10.5 | Nose | 48.9 | 2 |
| T-38 | 25.3 | 46.4 | 12.9 | 39.0 | 129.0 | 233.4 | 15.3 | 33.0 | Nose | 66.0 | 2 |
| T-39A/B | 44.4 | 43.8 | 16.0 | 30.0 | 86.0 | 174.0 | 20.7 | 25.3 | Nose | 87.0 | 2 |
| EB-57 | 122.5 | 68.3 | 20.5 | | 189.0 | 171.0 | | 24.0 | Main | | 2 |
| F-100 | 38.8 | 57.6 | 16.2 | 31.0 | 152.4 | 176.0 | 21.1 | 24.9 | Nose | 84.3 | 2 |
| F-101B | 39.7 | 66.9 | 17.25 | 34.0 | 239.0 | 257.0 | 25.3 | 32.8 | Nose | 92.0 | 2 |
| F-104G | 21.9 | 54.8 | 13.5 | 18.0 | 106.0 | 181.0 | 32.3 | 35.6 | Nose | 96.2 | 2 |
| F-105D | 34.9 | 67.5 | 19.7 | 29.0 | 207.0 | 253.0 | 25.2 | 32.8 | Nose | 100.0 | 2 |
| F-105F/G | 34.9 | 69.9 | 20.5 | 29.0 | 207.0 | 285.0 | 27.6 | 36.0 | Nose | 103.6 | 2 |
| F-106A/B | 38.3 | 70.8 | 20.3 | 12.0 | 184.0 | 290.0 | 7.6 | 25.4 | Nose | 93.6 | 2 |
| F-111A | 63.0 | 75.5 | 17.1 | 14.0 | 120.0 | 288.0 | 28.7 | 23.6 | Nose | 120.3 | 3 |
| F-111D | 63.0 | 75.5 | 17.1 | 14.0 | 120.0 | 288.0 | 28.7 | 23.6 | Nose | 120.3 | 3 |
| F-111E | 63.0 | 75.5 | 17.1 | 14.0 | 120.0 | 288.0 | 28.7 | 23.6 | Nose | 120.3 | 3 |
| F-111F | 63.0 | 75.5 | 17.1 | 14.0 | 120.0 | 288.0 | 28.7 | 23.6 | Nose | 120.3 | 3 |

* GIVEN IN INCHES    NOTE: REFERENCE FIGURES 1 THRU 10 FOR GENERAL AIRCRAFT CONFIGURATION

Reprinted from 36:11

## TABLE X – Continued

### Aircraft Characteristics – Dimensions in British (Feet)

| AIRCRAFT DESIGNATION | WINGSPAN | LENGTH | HEIGHT | VERTICAL * CLEARANCE | TREAD * | WHEEL * BASE | PIVOT POINT | TURNING RADIUS | CONTROLLING GEAR | 180° TURN DIAMETER | AFR 93-5 GROUP INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FB-111A | 70.0 | 75.7 | 17.4 | 14.0 | 120.0 | 288.0 | 28.7 | 23.7 | Nose | 127.3 | 3 |
| EF-111A | 63.0 | 75.5 | 17.1 | 14.0 | 120.0 | 288.0 | 28.7 | 23.6 | Nose | 120.3 | 3 |
| C-130B | 132.6 | 97.8 | 38.5 | | 171.0 | 388.0 | 19.2 | 37.0 | Nose | 170.0 | 4 |
| C-130E | 132.6 | 97.8 | 38.4 | | 171.0 | 388.0 | 19.2 | 37.0 | Nose | 170.0 | 4 |
| C-130H | 132.6 | 97.5 | 37.9 | | 171.0 | 388.0 | 19.2 | 37.0 | Nose | 170.0 | 4 |
| AC-130A/H | 132.6 | | | | 172.0 | 388.0 | 19.2 | 37.0 | Nose | 170.0 | 4 |
| EC-130E | 132.6 | | | | 172.0 | 388.0 | 19.2 | 37.0 | Nose | 170.0 | 4 |
| HC-130H | 132.6 | 111.9 | 38.4 | | 172.0 | 388.0 | 19.2 | 37.0 | Nose | 170.0 | 4 |
| C-7A | 95.6 | 72.6 | 31.8 | 21.0 | 277.0 | 251.0 | 11.6 | 29.0 | Nose | 59.4 | 5 |
| C-9A | 93.3 | 119.3 | 27.5 | 35.0 | 197.0 | 638.0 | 18.1 | 54.0 | Nose | 128.2 | 5 |
| C-9C | 93.3 | 119.3 | 27.5 | 35.0 | 197.0 | 638.0 | 18.1 | 54.0 | Nose | 128.2 | 5 |
| DC-9-30 | 93.3 | 133.5 | 28.0 | | 198.0 | 731.0 | 9.1 | 141.3 | | | 5 |
| C-5A | 117.5 | 94.5 | 27.9 | 13.0 | 296.0 | | 27.7 | 40.0 | Outer | 172.9 | 5 |
| C-140A | 53.7 | 60.5 | 20.5 | | 148.0 | 248.0 | | 26.0 | Nose | | 5 |
| T-43A | 93.0 | 100.0 | 37.0 | 22.0 | 206.0 | 447.0 | 9.8 | 56.7 | Nose | 115.0 | 6 |
| B-737-200 | 93.0 | 100.0 | 37.0 | | 206.0 | 447.0 | 9.8 | 57.7 | | 115.0 | 6 |
| B-727 | 108.0 | 153.6 | 34.0 | | 225.0 | 760.0 | 10.7 | | | 161.0 | 7 |

* GIVEN IN INCHES NOTE: REFERENCE FIGURES 1 THRU 10 FOR GENERAL AIRCRAFT CONFIGURATION

Reprinted from 36:12

## TABLE X - Continued

### Aircraft Characteristics - Dimensions in British (Feet)

| AIRCRAFT DESIGNATION | WINGSPAN | LENGTH | HEIGHT | VERTICAL * CLEARANCE | TREAD * | WHEEL * BASE | PIVOT POINT | TURNING RADIUS | CONTROLLING GEAR | 180°TURN DIAMETER | AFR 93-5 GROUP INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E-3A | 145.8 | 152.9 | 41.8 | 40.0 | 265.0 | 708.0 | 45.6 | 23.5 | Nose | 288.0 | 8 |
| C-135A | 130.8 | 134.5 | 41.7 | 31.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| C-135B/C/E | 130.8 | 134.5 | 41.7 | 26.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| EC-135A/G/L | 130.8 | 134.5 | 41.7 | 31.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| EC-135B/E | 130.8 | 141.5 | 41.7 | 26.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| EC-135C/J | 130.8 | 136.2 | 41.7 | 24.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| EC-135H/K/P | 130.8 | 134.5 | 41.7 | 26.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| EC-135N | 130.8 | 141.5 | 41.7 | 31.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| KC-135A/D/Q | 130.8 | 136.2 | 41.7 | 31.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| KC-135E | 130.8 | 136.2 | 41.7 | 26.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| KC-135R | 136.2 | 136.2 | 41.7 | 22.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 288.0 | 8 |
| M/S/ RC-135T/W | 130.8 | 140.0 | 41.7 | 26.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| RC-135U | 135.1 | 136.0 | 41.7 | 24.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| RC-135V | 130.8 | 140.5 | 41.7 | 24.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| WC-135B | 134.5 | 141.5 | 41.7 | 26.0 | 265.0 | 548.0 | 45.7 | 65.0 | Nose | 228.0 | 8 |
| C-137B | 130.8 | 144.5 | 41.3 | 27.0 | 265.0 | 628.0 | 45.7 | 62.0 | Nose | 210.0 | 8 |
| C-137C | 145.8 | 152.9 | 41.8 | 33.0 | 265.0 | 708.0 | 45.7 | 69.0 | Nose | 230.0 | 8 |
| A-300 | 147.1 | 175.9 | 54.2 | | 372.0 | 732.0 | | | | | 8 |

* GIVEN IN INCHES    NOTE: REFERENCE FIGURES 1 THRU 10 FOR GENERAL AIRCRAFT CONFIGURATION

Reprinted from 36:13

## TABLE X – Continued

### Aircraft Characteristics – Dimensions in British (Feet)

| AIRCRAFT DESIGNATION | WINGSPAN | LENGTH | HEIGHT | VERTICAL * CLEARANCE | TREAD * | WHEEL * BASE | PIVOT POINT | TURNING RADIUS | CONTROLLING GEAR | 180° TURN DIAMETER | AFR 93-5 GROUP INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-707-120 | 145.8 | 152.9 | 42.4 | | 265.0 | 708.0 | 34.5 | | | | 8 |
| B-707-320 | 145.9 | 152.9 | 52.4 | | 265.0 | 708.0 | 34.5 | | | | 8 |
| B-1B | 136.68 | 151.08 | 33.6 | 51.27 | 174.0 | 677.75 | | | | | 9 |
| C-141A | 160.0 | 145.0 | 39.3 | 8.0 | 210.0 | 636.0 | 38.3 | 63.5 | Nose | 226 | 9 |
| C-141B | 160.0 | 168.3 | 39.3 | 8.0 | 210.0 | 796.0 | 38.3 | 76.5 | Nose | 240 | 9 |
| C-5 | 222.7 | 247.8 | 65.1 | 12.0 | 432.0 | 980.0 | 46.0 | 72.5 | Nose | 189.5 | 10 |
| DC-10-10 | 155.3 | 181.4 | 57.5 | 34.0 | 420.0 | 869.0 | 39.0 | 121.6 | | | 11 |
| DC-10-30 | 165.3 | 181.4 | 57.6 | 35.0 | 420.0 | 869.0 | 37.1 | 125.2 | | | 11 |
| DC-10-40 | 165.3 | 182.4 | 58.1 | 35.0 | 420.0 | 869.0 | 29.5 | 125.2 | | | 11 |
| KC-10A | 165.3 | 182.3 | 58.1 | 35.0 | 416.0 | 869.0 | 37.1 | 125.2 | | | 11 |
| L-1011 | 155.3 | 177.8 | 55.3 | | 432.0 | 840.0 | 38.8 | 242.5 | | | 11 |
| E-4A | 195.67 | 231.83 | 63.42 | 33.0 | 434.0 | 1008.0 | 32.0 | 14.0 | Nose | 292 | 12 |
| E-4B | 195.67 | 321.34 | 63.42 | 33.0 | 434.0 | 1008.0 | 32.0 | 14.0 | Nose | 292 | 12 |
| L-500 | 155.3 | 164.2 | 55.3 | | 432.0 | 840.0 | 38.8 | 242.5 | | | 11 |
| B-747 | 195.7 | 231.3 | 63.4 | | 434.0 | 1008.0 | 47.0 | 75.0 | | 312 | 12 |
| B-52D | 185.0 | 156.6 | 48.3 | 21.6 | 136.0 | 597.0 | 39.0 | 114.0 | Outer | 264.6 | 13 |
| B-52G | 185.0 | 162.0 | 40.7 | 44.5 | 136.0 | 597.0 | 39.0 | 114.0 | Outer | 264.6 | 13 |

* GIVEN IN INCHES    NOTE: REFERENCE FIGURES 1 THRU 10 FOR GENERAL AIRCRAFT CONFIGURATION

Reprinted from 36:14

## TABLE X - Continued

### Aircraft Characteristics - Dimensions in British (Feet)

| AIRCRAFT DESIGNATION | WINGSPAN | LENGTH | HEIGHT | VERTICAL * CLEARANCE | TREAD * | WHEEL * BASE | PIVOT POINT | TURNING RADIUS | CONTROLLING GEAR | 180°TURN DIAMETER | AFR 93-5 GROUP INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-52H | 185.0 | 160.4 | 40.7 | 44.5 | 136 | 597 | 39.0 | 114.0 | Outer | 264.6 | 13 |
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* GIVEN IN INCHES     NOTE: REFERENCE FIGURES 1 THRU 10 FOR GENERAL AIRCRAFT CONFIGURATION

Reprinted from 36:15

## TABLE XI

### Aircraft Characteristics - Gross Weights * and Performance ** in British Units

| AIRCRAFT DESIGNATION | BASIC EMPTY WEIGHT | BASIC MISSION T/O | MAXIMUM TAKE-OFF | BASIC MISSION LANDING | MAXIMUM LANDING | TAKE-OFF DISTANCE | TAKE-OFF (50') | LANDING DISTANCE | LANDING (50') |
|---|---|---|---|---|---|---|---|---|---|
| C-123K | 35.37 | 60.0 | 60.0 | 37.4 | 60.0 | 1810 | 2802 | 1539 | 2446 |
| O-2A | 3.26 | 4.85 | 4.85 | 3.73 | 4.85 | 1055 | 1680 | 480 | 1170 |
| F-4C | 31.8 | 58.0 | 58.0 | 36.8 | 46.0 | 3520 | 4850 | 3520 | 5430 |
| RF-4C | 29.5 | 52.8 | 58.0 | 33.6 | 46.0 | 3220 | 3970 | 2430 | 3490 |
| F-4D | 31.8 | 58.0 | 58.0 | 36.8 | 46.0 | 3760 | 5840 | 3760 | 5670 |
| F-4E/D | 31.9 | 53.8 | 58.0 | 37.8 | 46.0 | 3780 | 5880 | 3780 | 5690 |
| F-5E | 9.7 | 15.8 | 24.7 | 11.9 | 21.8 | 2160 | 2900 | 2425 | 4100 |
| F-5F | 10.5 | 16.0 | 25.2 | 12.1 | 25.2 | 2110 | 3270 | 2415 | 3860 |
| A-7D | 21.8 | 38.984 | 42.0 | 23.777 | 37.088 | 6250 | 9200 | 3950 | 5405 |
| A-7K | 21.856 | 38.984 | 42.0 | 23.777 | 37.088 | 6250 | 9200 | 3950 | 5405 |
| A-10 | 25.0 | 47.3 | 50.0 | 27.1 | 50.0 | 4000 | 4850 | 1500 | 3200 |
| OV-10A | 8.03 | 10.53 | 14.40 | 8.78 | 14.40 | 1050 | 1450 | 660 | 1090 |
| C-12A | 7.8 | 12.5 | 12.5 | 12.5 | 12.5 | 2200 | 2950 | 1150 | 2000 |
| F-14 | 39.31 | 58.54 | 74.35 | 51.83 | | 1200 | | 1600 | |
| F-15A/B | 27.5 | 50.0 | 54.0 | 34.0 | 39.0 | 2500 | 3500 | 3600 | 4400 |
| F-15C/D | 28.2 | 52.0 | 59.4 | | | | | | |
| F-16A/B | 16.37 | 31.8 | 35.4 | 21.12 | 27.500 | 3225 | 5000 | 3200 | 4590 |

* IN KIPS
** IN FEET

Reprinted from 36:16

## TABLE XI - Continued

### Aircraft Characteristics - Gross Weights * and Performance ** in British Units

| AIRCRAFT DESIGNATION | BASIC EMPTY WEIGHT | BASIC MISSION T/O | MAXIMUM TAKE-OFF | BASIC MISSION LANDING | MAXIMUM LANDING | TAKE-OFF DISTANCE | TAKE-OFF (50') | LANDING DISTANCE | LANDING (50') |
|---|---|---|---|---|---|---|---|---|---|
| T-33A | 9.1 | 16.3 | 16.3 | 12.2 | 16.3 | 3800 | 6000 | 3200 | 4200 |
| A-37B | 6.5 | 12.0 | 14.0 | 5.2 | 14.0 | 1590 | 3000 | 2000 | 4000 |
| OA-37 | 6.5 | 12.0 | 14.0 | 5.1 | 14.0 | 1590 | 3000 | 2000 | 4000 |
| T-37B | 4.2 | 6.6 | 6.6 | 5.0 | 6.0 | 1500 | 2250 | 1450 | 2800 |
| T-38 | 7.1 | 12.1 | 12.1 | 8.1 | 12.1 | 2800 | 4000 | 3400 | 5000 |
| T-39A/B | 10.0 | 18.7 | 18.7 | 13.2 | 17.5 | 2750 | 4050 | 1700 | 2800 |
| EB-57 | 37.0 | 63.0 | 63.0 | 42.6 | 63.0 | 5000 | 6200 | 2350 | 3100 |
| F-100 | 23.0 | 36.8 | 41.5 | 25.3 | 41.5 | 4500 | 6800 | 4300 | 5990 |
| F-101B | 28.8 | 45.5 | 52.4 | 33.6 | 35.5 | 2600 | 3400 | 6110 | 7250 |
| F-104G | 14.4 | 22.0 | 25.2 | 16.2 | 25.2 | 3200 | 5100 | 2500 | 4800 |
| F-105D | 28.2 | 44.3 | 52.8 | 31.1 | 52.8 | 4200 | 5700 | 2500 | 4000 |
| F-105F/G | 29.1 | 45.1 | 54.6 | 32.0 | 54.6 | 4370 | 6070 | 2800 | 4300 |
| F-106A/B | 24.9 | 35.2 | 39.6 | 28.4 | 36.8 | 4300 | 6200 | 4800 | 6200 |
| F-111A | 48.4 | 92.7 | 100.0 | 51.6 | 82.5 | 4600 | 5630 | 1480 | 2380 |
| F-111D | 49.7 | 82.4 | 100.0 | 51.2 | 82.5 | 2490 | 3250 | 1480 | 2400 |
| F-111E | 49.4 | 93.7 | 100.0 | 52.6 | 82.5 | 4700 | 5750 | 1500 | 2410 |
| F-111F | 51.0 | 93.1 | 100.0 | 53.0 | 82.5 | 3350 | 4540 | 1590 | 2430 |

* IN KIPS
** IN FEET

Reprinted from 36:17

## TABLE XI – Continued

### Aircraft Characteristics – Gross Weights * and Performance ** in British Units

| AIRCRAFT DESIGNATION | BASIC EMPTY WEIGHT | BASIC MISSION T/O | MAXIMUM TAKE-OFF | BASIC MISSION LANDING | MAXIMUM LANDING | TAKE-OFF DISTANCE | TAKE-OFF (50') | LANDING DISTANCE | LANDING (50') |
|---|---|---|---|---|---|---|---|---|---|
| FB-111A | 49.6 | 110.1 | 119.2 | 53.2 | 109.0 | 5280 | 6600 | 1720 | 2740 |
| EF-111A | 53.4 | 72.8 | 87.5 | 58.7 | 80.0 | 3250 | 4100 | 1770 | 2800 |
| C-130B | 72.3 | 135.0 | 135.0 | 119 | 135.0 | 2750 | 4100 | 1875 | 3320 |
| C-130E | 72.0 | 152.4 | 175.0 | 133.3 | 175.0 | 3690 | 5410 | 2980 | 4650 |
| C-130H | 75.3 | | 175.0 | | | | | | |
| HC-130H | 81.8 | 147.9 | 175.0 | 91.3 | 175.0 | 3230 | 4430 | 1846 | 2922 |
| C-7A | 18.5 | 28.5 | 28.5 | 27.1 | 28.5 | 1390 | 1765 | 825 | 1770 |
| C-9A<br>C-9C | 62.2<br>57.2 | 108.0<br>85.3 | 108.0<br>110.0 | 92.5<br>92.5 | 99.0<br>110.0 | 4380<br>4380 | 5360<br>5530 | 1756<br>1756 | 2690<br>4680 |
| DC-9 | 61.8 | | 121.0 | | 110.0 | | 6850 | | 4880 |
| C-54 | 38.7 | 62.0 | 82.5 | 82.5 | 82.5 | 915 | 1615 | 1158 | 2012 |
| C-140A | 21.5 | 40.5 | 40.5 | 26.1 | 30.0 | 3670 | 5150 | 2050 | 2980 |
| T-43A | 60.5 | 98.0 | 115.0 | | 103.0 | 4400 | 6800 | 3900 | 4400 |
| B-737 | 60.5 | 115.5 | 125.0 | | 103.0 | | 6800 | | 4400 |
| B-727 | 101.5 | | 209.5 | | 154.0 | | 10300 | | 4690 |
| E-3A | 195.0 | 325.0 | 325.0 | 250.0 | 325.0 | 8400 | 11300 | 4950 | 8150 |
| DC-8 | | | 358.0 | | 245.0 | | | | |
| C-135A | 109.0 | 270.0 | 301.6 | 200.0 | 297.0 | 10600 | 14750 | 3800 | 5700 |

* IN KIPS
** IN FEET

Reprinted from 36:18

## TABLE XI - Continued

### Aircraft Characteristics - Gross Weights * and Performance ** in British Units

| AIRCRAFT DESIGNATION | BASIC EMPTY WEIGHT | BASIC MISSION T/O | MAXIMUM TAKE-OFF | BASIC MISSION LANDING | MAXIMUM LANDING | TAKE-OFF DISTANCE | TAKE-OFF (50') | LANDING DISTANCE | LANDING (50') |
|---|---|---|---|---|---|---|---|---|---|
| C-135B | 116.8 | 274.0 | 301.6 | 200.0 | 297.0 | 9700 | 13100 | 4000 | 6100 |
| C-135C | 121.0 | 274.0 | 301.6 | 132.0 | 297.0 | 9700 | 13100 | 2500 | 4300 |
| C-135E | 123.0 | 274.0 | 301.6 | 134.0 | 297.0 | 9500 | 13200 | 2400 | 4200 |
| EC-135A | 119.3 | 297.0 | 301.6 | 132.6 | 297.0 | 13500 | 18500 | 2800 | 4400 |
| EC-135B/E | 116.0 | 299.0 | 301.6 | 128.8 | 297.0 | 11700 | 16200 | 2400 | 4200 |
| EC-135C | 135.6 | 299.0 | 301.6 | 149.9 | 297.0 | 11400 | 15900 | 2600 | 4300 |
| EC-135G | 122.8 | 297.0 | 301.6 | 136.1 | 297.0 | 13500 | 18400 | 3000 | 4700 |
| EC-135H | 139.4 | 299.0 | 301.6 | 155.6 | 297.0 | 11700 | 16600 | 2700 | 4600 |
| EC-135J | 138.1 | 299.0 | 301.6 | 157.1 | 297.0 | 11400 | 15900 | 2700 | 4400 |
| EC-135K | 123.4 | 299.0 | 301.6 | 134.4 | 297.0 | 11700 | 16350 | 2300 | 4100 |
| EC-135L | 112.8 | 297.0 | 301.6 | 124.4 | 297.0 | 13500 | 18400 | 2500 | 4000 |
| EC-135N | 124.0 | 297.0 | 301.6 | 136.8 | 297.0 | 13500 | 18400 | 3000 | 4700 |
| EC-135P | 134.1 | 299.0 | 301.6 | 148.5 | 297.0 | 11700 | 16400 | 2600 | 4400 |
| KC-135A | 104.3 | 297.0 | 301.6 | 115.3 | 297.0 | 13500 | 18400 | 2200 | 3700 |
| KC-135D | 107.6 | 297.0 | 301.6 | 118.6 | 297.0 | 13500 | 18400 | 2400 | 3900 |
| KC-135E | 112.1 | 299.0 | 301.6 | 123.1 | 297.0 | 11700 | 16200 | 2300 | 4100 |
| KC-135Q | 105.5 | 297.0 | 301.6 | 116.5 | 297.0 | 13500 | 18400 | 2300 | 3800 |

* IN KIPS
** IN FEET

Reprinted from 36:19

## TABLE XI - Continued

### Aircraft Characteristics - Gross Weights * and Performance ** in British Units

| AIRCRAFT DESIGNATION | BASIC EMPTY WEIGHT | BASIC MISSION T/O | MAXIMUM TAKE-OFF | BASIC MISSION LANDING | MAXIMUM LANDING | TAKE-OFF DISTANCE | TAKE-OFF (50') | LANDING DISTANCE | LANDING (50') |
|---|---|---|---|---|---|---|---|---|---|
| KC-135R | 117.0 | 319.7 | 322.5 | 128.0 | 297.0 | 10300 | 14800 | 2200 | 5300 |
| RC-135M | 130.1 | 299.0 | 301.6 | 146.1 | 297.0 | 11650 | 16200 | 2600 | 4400 |
| RC-135S | 141.6 | 299.0 | 301.6 | 157.0 | 297.0 | 11650 | 16250 | 2700 | 4600 |
| RC-135T | 110.1 | 299.0 | 301.6 | 121.1 | 297.0 | 11700 | 16800 | 2200 | 3900 |
| RC-135U | 150.6 | 299.0 | 301.6 | 167.4 | 297.0 | 11500 | 16200 | 2900 | 4700 |
| RC-135V | 139.0 | 299.0 | 301.6 | 153.3 | 297.0 | 11500 | 16100 | 2700 | 4500 |
| RC-135W | 141.0 | 299.0 | 301.6 | 157.0 | 297.0 | 11650 | 16300 | 2700 | 4600 |
| WC-135B | 117.0 | 299.0 | 301.6 | 128.7 | 297.0 | 11700 | 16100 | 2400 | 4200 |
| C-137B | 135.6 | 258.0 | 260.0 | 180.0 | 190.0 | 8100 | 8860 | 3100 | 6500 |
| C-137C | 151.7 | 326.0 | 336.0 | 205.5 | 247.0 | 10550 | 11950 | 2000 | 5400 |
| A-300 | 197.8 | | 363.7 | | 295.4 | | 9845 | | |
| B-707-120 | 146.4 | | 258.0 | | 207.0 | | | | |
| B-707-320 | 146.4 | | 333.6 | | 247.0 | | 10020 | | 6250 |
| B-1B | 189.0 | | 477.0 | | | | | | |
| C-141A | 136.9 | 271.03 | 323.1 | 239.175 | 323.1 | 3400 | 4050 | 1925 | 3600 |
| C-141B | 218.7 | 323.1 | 344.9 | 257.5 | 323.0 | | | | |
| C-5 | 324.3 | 706.6 | 769.0 | 641.0 | 728.0 | 7200 | 8600 | 2420 | 3900 |

* IN KIPS
** IN FEET

Reprinted from 36:20

## TABLE XI - Continued

### Aircraft Characteristics - Gross Weights * and Performance ** in British Units

| AIRCRAFT DESIGNATION | BASIC EMPTY WEIGHT | BASIC MISSION T/O | MAXIMUM TAKE-OFF | BASIC MISSION LANDING | MAXIMUM LANDING | TAKE-OFF DISTANCE | TAKE-OFF (50') | LANDING DISTANCE | LANDING (50') |
|---|---|---|---|---|---|---|---|---|---|
| DC-10-10 | 241.0 | | 455.0 | | 363.5 | | 11500 | | 5830 |
| DC-10-30 | 266.5 | | 572.0 | | 403.0 | | 11750 | | 5960 |
| DC-10-40 | 270.6 | 116.0 | 572.0 | | 403.0 | | 12250 | | 5840 |
| KC-10A | 240.0 | | 590.0 | | | | | | |
| L-1011 | 249.1 | | 450.0 | | 368.0 | | | 6420 | |
| E-4A | 363.1 | 778.0 | 778.0 | 507.0 | 564.0 | 10000 | 11500 | 6000 | 8000 |
| E-4B | 440.0 | 803.0 | 803.0 | 507.0 | 585.0 | 9200 | 10800 | 5640 | 7500 |
| L-500 | | | 861.0 | | 368.0 | | | | |
| B-747 | 363.0 | | 778.0 | | 564.0 | | 10500 | 6170 | |
| B-52D | 187.0 | 450.0 | 450.0 | 195.0 | 450.0 | 8800 | 11200 | 3300 | 5500 |
| B-52G | 179.3 | 488.0 | 488.0 | 187.3 | 450.0 | 8200 | 10450 | 3100 | 5450 |
| B-52H | 183.4 | 488.0 | 488.0 | 191.4 | 450.0 | 7700 | 9750 | 3600 | 6400 |

* IN KIPS
** IN FEET

Reprinted from 36:21

Electrical Power Safety Measures. The following electrical power safety measures should be followed during contingencies:

1. The generator should be thoroughly inspected prior to installation. The power production personnel should "look for broken or loose electrical and hose connections, loose bolts and cap screws, and see that the ground plate is properly grounded [3:10]."

2. Once the generator is installed, the wiring diagrams should be checked to make sure all connections are correct (3:10).

3. The load cable should also be checked to make sure it is sized properly, since an undersized cable is a fire hazard (3:10,11).

4. The generator ground should be carefully inspected because expedience has shown "that by far the most prevalent fault to which generators are subjected is a short-circuit to ground [29:4490]."

5. For additional power, generators can be set in parallel. However, it is not recommended to parallel generators of 100KW or less unless absolutely necessary, since they are not designed for parallel operation. It is sager to use a single smaller unit for each facility (3:12,13).

Derating Generators. Generators are rated under the standard conditions of zero to 2,000 feet above sea level and an 80 degrees Fahrenheit (F) ambient temperature. Generators must be derated when used in areas that vary from these standard conditions. The following guidelines should be followed when derating generators (32):

| | |
|---|---|
| Gas-turbine Generators: | Derated 5-1/2% for every 10 degrees F above 80 degrees F, and 4-1/2% for every 1,000 ft above 2,000 feet. |
| Diesel & Gasoline Generators: | Derated 1% every 10 degrees F above 80 degrees F, and 2 to 3% for every 1,000 feet above 2,000 feet. |

Dormant Generators. Generators perform more efficiently when allowed to operate over long periods of time (6:22,23). Therefore, standby generators, if left dormant for any length of time, may not start properly when power is interrupted. Power production personnel must exercise the standby generators once a month to ensure that the generators will perform when needed.

Generators in Hot Climates. When installing generators in tropical climates, the following precausions should be made (3:14,15):

1. The cooling systems must be cleaned and flushed at regular intervals and the coolant level checked frequently.

2. Soft water and rust inhibitors can be used in the radiator to prevent rust and scale.

3. The radiator fan motor should be checked frequently, as should the thermostats.

Generators in Cold Climates. When installing generators in extremely low temperatures, difficulties may arise in lubrication, electrical stability, and overall maintenance. To reduce these problems, the following precautions can be used (3:13,14):

1. Remove the moisture from the equipment that may cause condensation, since moisture may corrode or damage the equipment when it is energized.

2. Check the specific gravity of the storage batteries so they will not freeze.

3. Apply cold weather lubricants or graphite to rotating points (winterizing kits may or may not be available).

4. When the generators are shut down for any length of time in subzero temperatures (degrees F), drain the hot engine and fill the crankcase to the low livel with SAE 10W oil. Run the engine without any electrical load. When the engine is warmed up, put regular oil back in.

5. Prevent water from entering the fuel lines, since it will turn to ice and clog the lines. This can be prevented by keeping the fuel tank full. Also, flush the cooling system and check all hoses, lines and fittings regularly for tightness and serviceability.

6. Since wires become brittle in extreme cold, touch them as little as plssible. When installing new wire, warm it up before bending or twisting it.

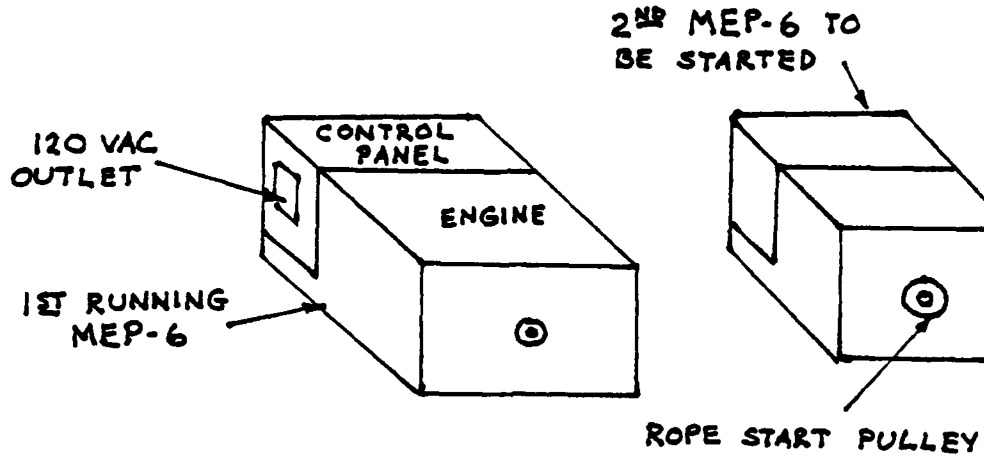


Figure 32. Electrical Power: Quick Start Method
for MEP-6 Portable Generators

As Used at Homestead AFB

Submitted by TSgt Dennis L. Becchelli

1. Using a rope, start one MEP-16 generator to give a 120 volt source of AC power.

2. Obtain a 1/2" portable electrical drill, a 1/2" drive - 1/2" socket, and a 5" long - 1/2" drive extension from the mobility team kit.

3. Place the socket on the rope pulley bolt head of the second MEP-16 to be started.

4. Start the second MEP-16 with the drill. CAUTION: Due to the high torque of the drill, a firm grip is required to prevent injury and/or damage to the bolt head. The second generator should start within one minute after starting the drill.

Guidelines for Expedient Electrical Distribution Lines. The following guidelines should be followed when providing electrical power distribution lines in contingencies:

1. Areas with a high ambient temperature have reduced current carrying ability because the heat buildup in the wires cannot effectively dissipate into the surrounding atmosphere. Therefore, cables must be derated at temperatures greater than 86 degrees F (1:5.4).

2. Cables should be protected from direct sunlight by burying the primary distribution lines at least 18 inches and secondary lines at least 8 inches, limiting loads during the hottest part of the day, using high temperature rated insulation, and not using cables above their rated current (1:5.4; 34:4.5).

3. Low voltage distribution cables, wired directly into the generator's output terminals, can be run short distances on top of the ground to provide the necessary power. When distribution transformers become available, the system can be made more efficient by converting to high voltage [12:83].

4. Distribution cables can be placed in trenches carrying water and sanitary pipelines to save time and energy (1: 5.4).

5. Electrical devices should be covered with weatherproof enclosures whenever possible to provide more environmental protection (1:5.5).

6. Transformers can be protected in desert climates by using extra creep bushings and by cleaning oil and other contamination from the bushings (34:4.11).

7. Electrical grounding is critical for systems of 25 ohms or less for generators, CCCs, transformers, and shelters (1:5.5). Therefore, all personnel concerned with power distribution must be aware of the potential problems of grounding in areas of poor soil conductivity and be careful around electrical systems (34:4.13).

8. In an emergency installation, time is the important factor. It may be necessary to use trees, pilings, four-by-fours or other temporary line supports to complete the installation [3:11].

TABLE XII

American/German Wire Gage Size Conversions for Insulated Wire at 25 Degrees C Ambient

| American Wire Gage (AWG) Size | Conductor Area | Next Standard German Size | Up to Three Conductors in Conduit | | Multi-Conductor | | Separate Conductor | |
|---|---|---|---|---|---|---|---|---|
| | | | Amp-acity | Fuse Size | Amp-acity | Fuse Size | Amp-acity | Fuse Size |
| | Sq. mm | Sq. mm | A | A | A | A | A | A |
| 18 | 0.82 | 1. | 12 | 10 | 16 | 16 | 20 | 20 |
| 16 | 1.13 | 1.5 | 16 | 16 | 20 | 20 | 25 | 25 |
| 14 | 2.08 | 2.5 | 21 | 20 | 27 | 25 | 34 | 36 |
| 12 | 3.31 | 4. | 27 | 25 | 36 | 26 | 45 | 50 |
| 10 | 5.26 | 6. | 36 | 36 | 47 | 50 | 57 | 63 |
| 8 | 8.37 | 10. | 48 | 50 | 65 | 63 | 78 | 80 |
| 6 | 13.30 | 16. | 65 | 63 | 87 | 80 | 104 | 100 |
| 4 | 21.15 | 25. | 88 | 80 | 115 | 100 | 137 | 125 |
| 2 | 33.62 | 35. | 110 | 100 | 143 | 125 | 168 | 160 |
| 0 | 53.52 | 50. | 140 | 125 | 178 | 160 | 210 | 200 |
| 00 | 67.43 | 70. | 170 | 160 | 220 | 224 | 260 | 250 |
| 000 | 85.01 | 96. | 210 | 200 | 265 | 250 | 310 | 300 |
| 0000 | 170.21 | 120. | 260 | 250 | 310 | 300 | 365 | 355 |

Adapted from 9:1112

TABLE XIII

Wire Ampacity: Load Capacity of Insulated Conductors

| Nominal cross-section (square mm) | Permitted permanent load capacity in A | | | | | |
|---|---|---|---|---|---|---|
| | Group 1 | | Group 2 | | Group 3 | |
| | Cu | Al | Cu | Al | Cu | Al |
| 0.75 | - | - | 13 | - | 16 | - |
| 1 | 12 | - | 16 | - | 20 | - |
| 1.5 | 16 | - | 20 | - | 25 | - |
| 2.5 | 21 | 16 | 27 | 21 | 34 | 27 |
| 4 | 27 | 21 | 36 | 29 | 45 | 35 |
| 6 | 35 | 27 | 47 | 37 | 57 | 45 |
| 10 | 48 | 38 | 65 | 51 | 78 | 61 |
| 16 | 65 | 51 | 87 | 68 | 104 | 82 |
| 25 | 88 | 69 | 115 | 90 | 137 | 107 |
| 35 | 110 | 86 | 143 | 112 | 168 | 132 |
| 50 | 140 | 110 | 178 | 140 | 210 | 165 |
| 70 | 175 | - | 220 | 173 | 260 | 205 |
| 95 | 210 | - | 265 | 210 | 310 | 245 |
| 120 | 250 | - | 310 | 245 | 365 | 285 |
| 150 | - | - | 355 | 280 | 415 | 330 |
| 185 | - | - | 405 | 320 | 475 | 375 |
| 240 | - | - | 480 | 380 | 560 | 440 |

Group classification:

Group 1: One or more single-core conductors laid in a conduit (e.g., NYA)

Group 2: Multiple-core conductors, ( e.g., sheathed conductors, conduit wires, lead sheath conductors, flat conductors, movable conductors)

Group 3: Single-core conductors with spacing of at least their own diameter, laid in free air, also single-conductor wiring in switch and distribution equipment, and bus bar distributions.

The values apply to an ambient temperature of 25 degrees C. Permissible loadings for temperatures between 25 and 55 degrees C are given below:

| Ambient temperature up to Degrees C | | 30 | 35 | 40 | 45 | 50 | 55 |
|---|---|---|---|---|---|---|---|
| Permissible loading: | | | | | | | |
| with rubber insulation | % | 92 | 85 | 75 | 65 | 53 | 38 |
| with plastic insulation | % | 94 | 88 | 82 | 75 | 67 | 58 |

Adapted from 9:2113

TABLE XIV

Fuse or Circuit Breaker Protection

| Nominal copper conductor (square mm) | Nominal rating of overload protection device | | |
|---|---|---|---|
| | Group 1 (A) | Group 2 (A) | Group 3 (A) |
| 0.75 | - | 10 | 16 |
| 1 | 10 | 16 | 20 |
| 1.5 | 16 | 20 | 25 |
| 2.5 | 20 | 25 | 35 |
| 4 | 25 | 35 | 50 |
| 6 | 35 | 50 | 63 |
| 10 | 50 | 63 | 80 |
| 16 | 63 | 80 | 100 |
| 25 | 80 | 100 | 125 |
| 35 | 100 | 125 | 160 |
| 50 | 125 | 160 | 200 |
| 70 | 160 | 224 | 250 |
| 95 | 200 | 250 | 300 |
| 120 | 250 | 300 | 355 |
| 150 | - | 355 | 425 |
| 185 | - | 355 | 425 |
| 240 | - | 425 | 500 |

For ambient temperatures above 25 degrees C, the nominal rating of the protective device must be reduced by the percentage given Table XII; the next lower nominal current rating to that of the overload device should be used.

Adapted from 9:2113

TABLE XV

Power Cable Loading for Air-suspended Cables at 30 Degrees C

Three-core cable — Three-core cable with single-core sheaths — Single-core cables, laid up together

| Nominal cross section | PROTODUR cable | | | | | | PROTOTHEN | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Y cable | | X cable | | Y cable | |
| | 0.6/1 kV | | 3.5/6 kV | | 5.8/10 kV | | 5.8/10 to 17.3/30 kV | | | | 5.8/10 kV | |
| | Current rating in A | | | | | | | | | | | |
| sq. mm | Cu | Al | Cu | Al | Cu | Al | Cu | Al | Cu | Al | Cu | Al |
| 1.5 | 18 | – | – | – | – | – | – | – | – | – | – | – |
| 2.5 | 25 | – | – | – | – | – | – | – | – | – | – | – |
| 4 | 34 | 26 | – | – | – | – | – | – | – | – | – | – |
| 6 | 43 | 34 | – | – | – | – | – | – | – | – | – | – |
| 10 | 60 | 46 | – | – | – | – | – | – | – | – | – | – |
| 16 | 80 | 62 | – | – | – | – | – | – | – | – | – | – |
| 25 | 106 | 83 | 105 | 82 | 115 | 88 | 135 | – | 165 | – | – | – |
| 35 | 132 | 102 | 130 | 100 | 135 | 105 | 165 | 125 | 200 | 155 | 145 | 110 |
| 50 | 160 | 124 | 155 | 120 | 165 | 125 | 195 | 150 | 240 | 185 | 170 | 130 |
| 70 | 202 | 158 | 195 | 155 | 205 | 160 | 245 | 190 | 295 | 230 | 210 | 165 |
| 95 | 244 | 191 | 240 | 185 | 250 | 190 | 295 | 230 | 360 | 280 | 260 | 200 |
| 120 | 283 | 221 | 275 | 215 | 285 | 220 | 340 | 265 | 410 | 320 | 295 | 230 |
| 150 | 325 | 253 | 315 | 245 | 320 | 250 | 385 | 300 | 465 | 365 | 340 | 260 |
| 185 | 372 | 289 | 360 | 285 | 365 | 285 | 440 | 340 | 530 | 415 | 385 | 300 |
| 240 | 437 | 340 | 430 | 335 | 430 | 335 | 520 | 405 | 630 | 495 | 455 | 355 |
| 300 | 500 | 391 | 490 | 385 | 490 | 385 | 590 | 465 | 710 | 560 | – | – |

Adapted from 9:2114

TABLE XVI

Reduction Factors for Air-suspended Cables

Deviating Ambient Temperatures:

| Ambient temperature degree C | | | 25 | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|---|---|
| PROTODUR cable | up to | 5.8/10kV | 1.06 | 1.0 | .94 | .87 | .79 | .71 |
| PROTOTHEN Y cable | up to | 17.3/30kV | 1.06 | 1.0 | .94 | .87 | .79 | .71 |
| PROTOTHEN X cable | up to | 17.3/30kV | 1.04 | 1.0 | .96 | .91 | .87 | .82 |

Bunching:

| Number or 3-core cables per trench | 1 | 2 | 3 | 6 | 9 |
|---|---|---|---|---|---|
| Laid side by side: | | | | | |
| touching | 0.95 | 0.84 | 0.80 | 0.75 | 0.73 |
| spacing (1 to 2 cable diameters) | 0.95 | 0.90 | 0.88 | 0.85 | 0.84 |
| Laid one above the other: | | | | | |
| touching | 0.95 | 0.78 | 0.73 | 0.68 | 0.66 |
| spacing (1 cable diameter) | 1.00 | 0.93 | 0.90 | 0.87 | 0.86 |

Adapted from 9:2114

TABLE XVII

Electrical Parameters for Long-span Overhead Lines

| Nominal voltage | kV | 20 | | 30 | 60 | 110 | | 220 | | 380 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal cross-section (Al) | sq. mm | 35 | 150 | 150 | 240 | 185 | 300 | 435 | Layup 2x240 | Layup 4x240 | Layup 2x564 |
| Cable diameter | mm | 3.1 | 17.1 | 17.1 | 21.9 | 19 | 24.5 | 28.8 | 2x21.9 | 4x21.9 | 2x32 |
| Limit, thermal loading | MVA | 5 | 16 | 24 | 67 | 100 | 140 | 350 | 490 | 1700 | 1380 |
| Effective resistance at 20 degrees C | ohms/km | 0.87 | 0.20 | 0.20 | 0.13 | 0.16 | 0.10 | 0.17 | 0.062 | 0.031 | 0.027 |
| Inductive resistance at 50 degrees C | ohms/km | 0.39 | 0.34 | 0.35 | 0.37 | 0.41 | 0.38 | 0.4 | 0.32 | 0.26 | 0.30 |
| Mutual capacitance | nF/km | 9.7 | 11.2 | 10.9 | 10.3 | 9.3 | 10 | 9.4 | 11.5 | 14.4 | 12.1 |
| Capacitance to earth | nF/km | 3.4 | 3.6 | 3.7 | 4.0 | 4.0 | 4.2 | 4.8 | 6.3 | 6.5 | 5.7 |
| Charging power | kVA/km | 1.2 | 1.4 | 3.1 | 12 | 35 | 38 | 145 | 175 | 650 | 550 |
| Earth leakage current | A/km | 0.04 | 0.04 | 0.06 | 0.13 | 0.25 | 0.25 | (.58) | (.76) | (1.35) | (1.18) |
| Characteristic impedance | ohms | 360 | 310 | 320 | 340 | 375 | 350 | 365 | 300 | 240 | 280 |
| Surge impedance loading | MW | | | | 11 | 32 | 35 | 135 | 160 | 600 | 515 |

Adapted from 9:2114

General guidelines for using 60 HZ electrical equipment on 50 HZ power sources are given below:

> Resistive Loads. Incandescent lighting, electric ranges, ovens, and other equipment which convert electric energy directly to heat energy perform equally well on either 50 HZ or 60 HZ source frequency... [However], lamps will not burn as brightly, ovens will not be as hot, etc [9:2109].
>
> Static Induction Devices. Distribution transformers, electric discherge lighting ballasts, series lighting current regulators, and other static inductive equipment induce magnetic energy fields in iron as part of normal operation... [The magnetic flux density] is directly proportional to the volts/hertz ratio of the power source... If equipment designed for 60 HZ operation is to be connected to a 50 HZ power source, the voltage must be reduced proportionately to maintain the volts/hertz ratio at the design point [9:2109].
>
> Induction Motors. Induction motors rated for 60 HZ operation will run at about 5/6 of. rated speed when connected to a 50 HZ source... Motor current varies inversely with both source frequency and voltage. As the 50 HZ source voltage is reduced, motor current heating the windings increases while iron loss heating decreases. No amount of voltage reduction can compensate for both heating effects simultaneously. However, induction motors rated [at] 120V, 60HZ will operate successfully at about 110V, 50 HZ if the speed reduction can be toperated [9:2110].

Remedies to three major electrical problems are given below [9:2110]:

A. INCREASED MOTOR HEATING DUE TO SATURATION OF IRON

REMEDY: Motor geometry establishes a design volts/hertz ratio. If the motor is to be operated at less than design frequency then the voltage must be reduced proportionately (5/6) to maintain the volts/hertz ratio at or below the design limit.

B. REDUCED MOTOR SHAFT SPEED

REMEDY: Shaft speed is a function of source frequency and motor configuration. The coupling to the driven load often involves belts, pulleys, chains, or gears. A change in drive ratios could correct the speed. However, many loads operate adequately at 5/6 of design speed.

C. INCREASED HEAT BUILD-UP DUE TO REDUCED INTERNAL AIR-FLOW

REMEDY: Motor heating is attributed to several factors: Iron losses, frictional losses, and copper losses. In 50 HZ design voltage, iron losses will remain about equal. Frictional losses will be slightly reduced due to decreased shaft speed. Copper losses vary roughly as the square of the *load torque. Hence the 50-HZ HP rating of the motor* is limited to about 5/6 of the 60-HZ HP rating. Otherwise, heat build-up would accelerate aging of motor insulation and possibly cause burnout.

An expedient method of installing temporary tent lighting and electrical outlets was developed during a training exercise at Holloman AFB NM and submitted by TSgt Mark Gunter. This method is presented below:

1. Use a pre-wired, wall mount, power outlet connected to the generator units.

2. Connect the pre-wired 50 ft or 100 ft interconnecting cable sets to energize the portable power boxes.

3. These power boxes provide power for the pre-wired, interconnecting stringer light cables.

4. Each spider box contains enough outlets to supply each tent with at least two power receptacles.

5. All equipment is assembled by using the twist type plugs on the cables.

6. All cables, boxes, light systems, etc. can be stored in a large wooden container and labled "For Prime BEEF Only."

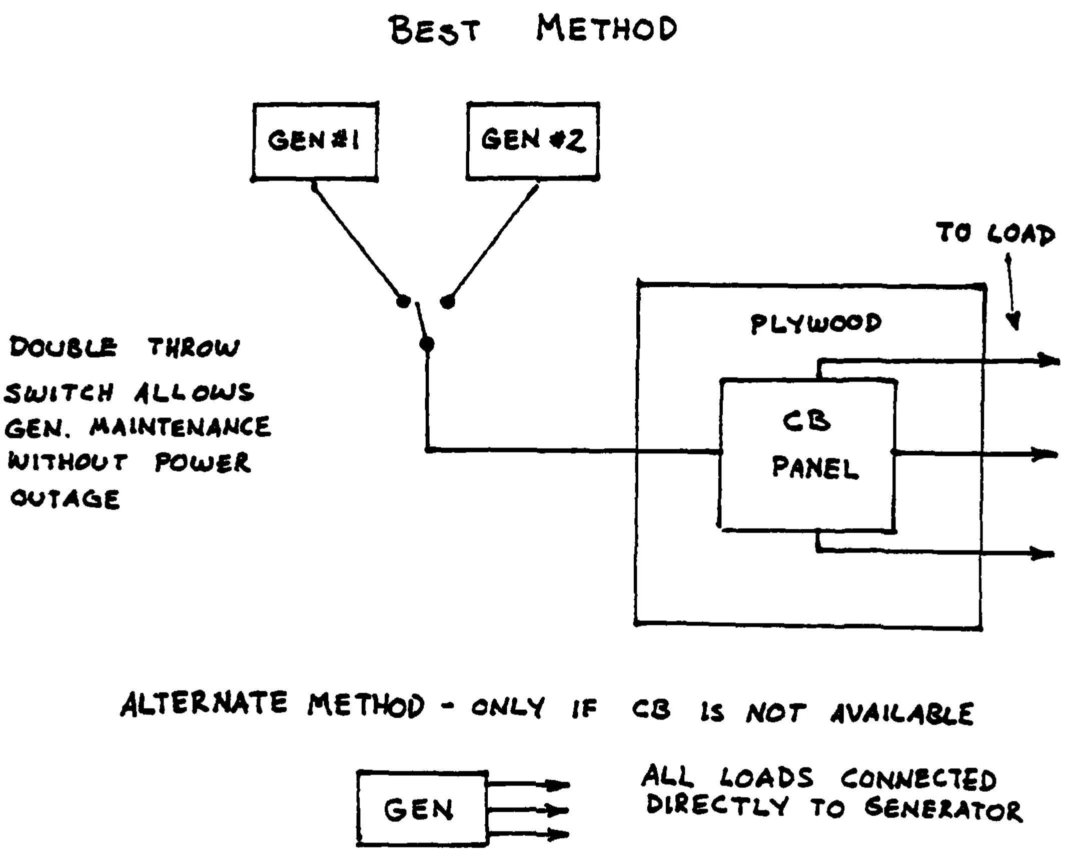


Figure 33. Electrical Distribution: Power Panels

As Used in Egypt to Connect Power to Tents, Lights, & Pumps

Submitted by CMSgt Jimmy Chestnutt

The following expedient methods can be used to determine the required wire size for a specific load when no other method is available (15:351):

1. Convert electrical load into amperes by using one of the following equations:

   a. Amperes = Total watts to be serviced / voltage

   b. Amperes = Voltage / resistance (ohms)

   c. Amperes = 745.7 x Horsepower / voltage

2. Using the calculated amperage and length of wire required, use Table XVII or XVIII to determine the wire size needed.

TABLE XVIII

Wire Sizes for 110-Volt Single Phase Circuits

10—ALUMINUM WIRE
12—COPPER WIRE

| LOAD IN AMPS | FOR 110V CIRCUIT DISTANCE TO LOAD IN FEET | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 75 | 100 | 125 | 150 | 200 | 250 | 300 | 400 | 500 |
| 15 | 10 / 12 | 8 / 10 | 8 / 10 | 6 / 8 | 6 / 8 | 4 / 6 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 |
| 20 | 10 / 12 | 8 / 10 | 6 / 8 | 6 / 8 | 4 / 6 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 0 / 2 |
| 25 | 8 / 10 | 6 / 8 | 6 / 8 | 4 / 6 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 |
| 30 | 8 / 10 | 6 / 8 | 4 / 6 | 4 / 6 | 2 / 4 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 1 |
| 40 | 6 / 8 | 4 / 6 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 |
| 50 | 4 / 6 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 300 / 3/0 |
| 60 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 250 / 3/0 | 350 / 4/0 |
| 70 | 4 / 6 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 250 / 3/0 | 300 / 4/0 | 400 / 250 |
| 80 | 4 / 6 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 250 / 3/0 | 350 / 4/0 | 500 / 250 |
| 90 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 1 | 4/0 / 2/0 | 250 / 3/0 | 300 / 3/0 | 400 / 250 | 500 / 300 |
| 100 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 300 / 3/0 | 350 / 4/0 | 500 / 250 | 600 / 350 |

Reprinted from 15:353

TABLE XIX

Wire Sizes for 220-Volt Three Phase Circuits

10—ALUMINUM WIRE
12—COPPER WIRE

| LOAD IN AMPS | FOR 220V CIRCUIT DISTANCE TO LOAD IN FEET | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| 15 | 12 / 12 | 8 / 10 | 6 / 8 | 4 / 6 | 4 / 6 | 2 / 4 | 2 / 4 | 2 / 4 | 1 / 2 | 1 / 3 |
| 20 | 10 / 12 | 6 / 8 | 4 / 6 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 1 / 3 | 0 / 2 | 0 / 2 |
| 25 | 8 / 10 | 6 / 8 | 4 / 6 | 3 / 4 | 2 / 4 | 1 / 3 | 0 / 3 | 0 / 2 | 2/0 / 1 | [illegible] |
| 30 | 6 / 10 | 4 / 6 | 2 / 4 | 2 / 4 | 1 / 2 | 0 / 2 | 2/0 / 2 | 2/0 / 1 | 3/0 / 0 | [illegible] |
| 40 | 4 / 8 | 4 / 6 | 2 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 3/0 / 0 | 4/0 / 2/0 | [illegible] |
| 50 | 4 / 8 | 3 / 4 | 1 / 3 | 0 / 2 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 4/0 / 2/0 | 250 / 3/0 | [illegible] |
| 60 | 4 / 6 | 2 / 4 | 0 / 2 | 2/0 / 1 | 2/0 / 0 | 4/0 / 3/0 | 250 / 2/0 | 250 / 3/0 | 300 / 4/0 | [illegible] |
| 70 | 4 / 6 | 1 / 3 | 2/0 / 2 | 3/0 / 0 | 4/0 / 2/0 | 250 / [illegible] | 300 / 3/0 | 350 / 4/0 | 350 / 4/0 | [illegible] |
| 80 | 4 / 6 | 1 / 3 | 2/0 / 1 | 3/0 / 0 | 4/0 / 2/0 | 250 / 3/0 | 300 / 4/0 | 350 / 4/0 | 400 / 250 | [illegible] / 250 |
| 90 | 2 / 4 | 0 / 2 | 3/0 / 0 | 4/0 / 2/0 | 250 / 3/0 | [illegible] / 4/0 | 350 / 4/0 | 400 / 250 | 500 / 300 | [illegible] / 350 |
| 100 | 2 / 4 | 1 / 2 | 3/0 / 3 | 4/0 / 2/0 | 300 / 2/0 | 350 / 4/0 | 400 / 250 | 500 / 350 | 500 / 300 | 600 / 350 |

Reprinted from 15:354

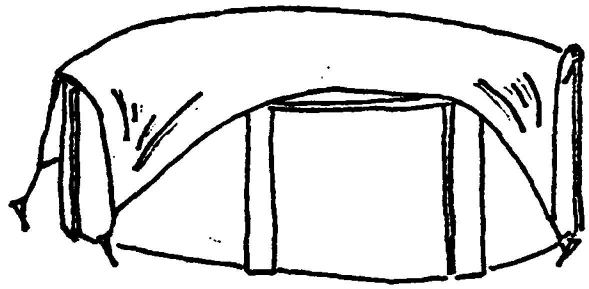

Figure 34. Water Storage: Rubber Tank With Protective Tarp

As Used in Vietnam 1966-1967

Submitted by MSgt James D. Carroll

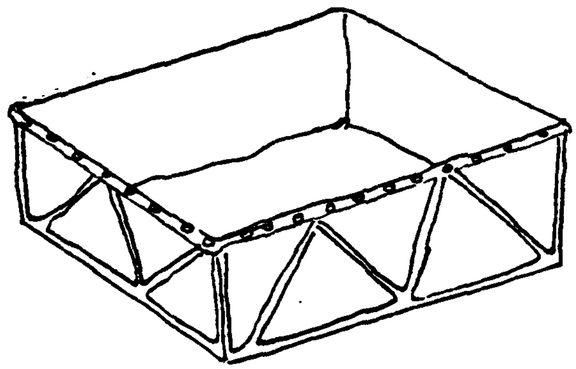

Figure 35. Water Storage: Tarp Lining in Aluminum/Wood Frame

As Used in Vietnam, 1966-1967

Submitted by MSgt James D. Carroll

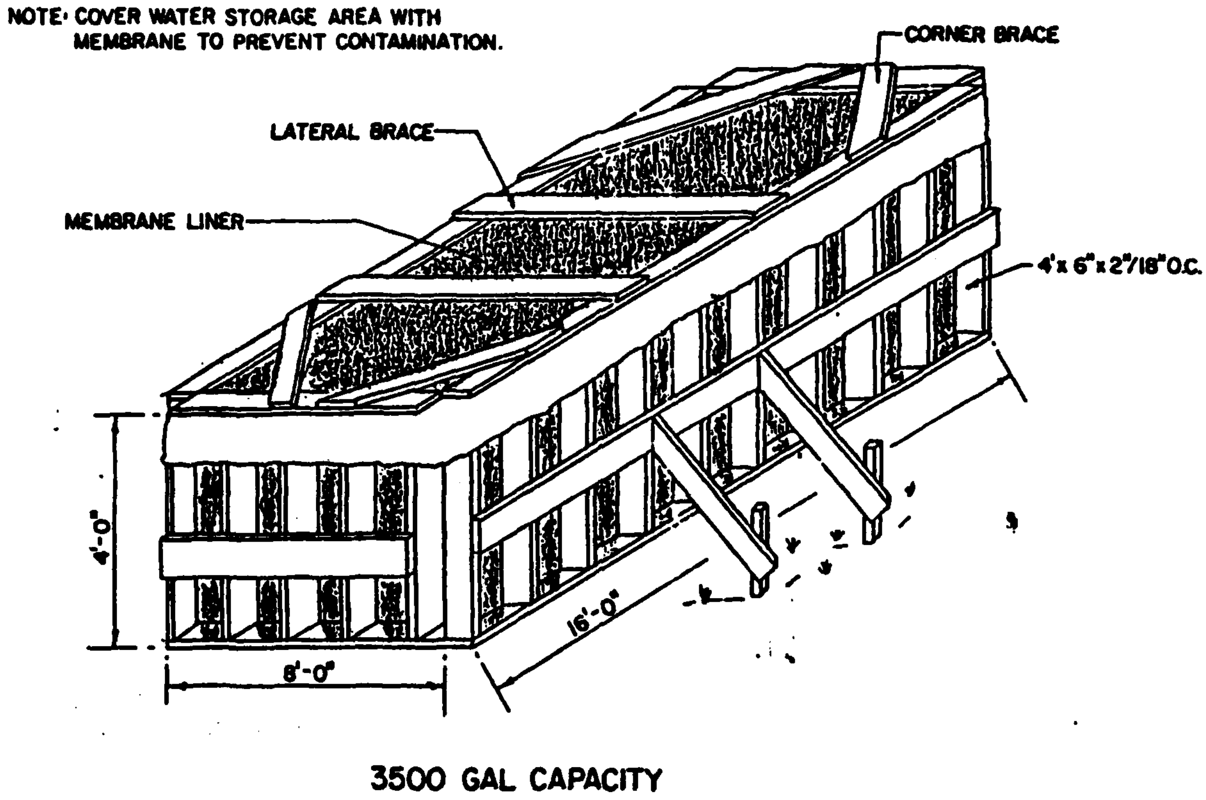


Figure 36. Water Storage: Wood Framed Container

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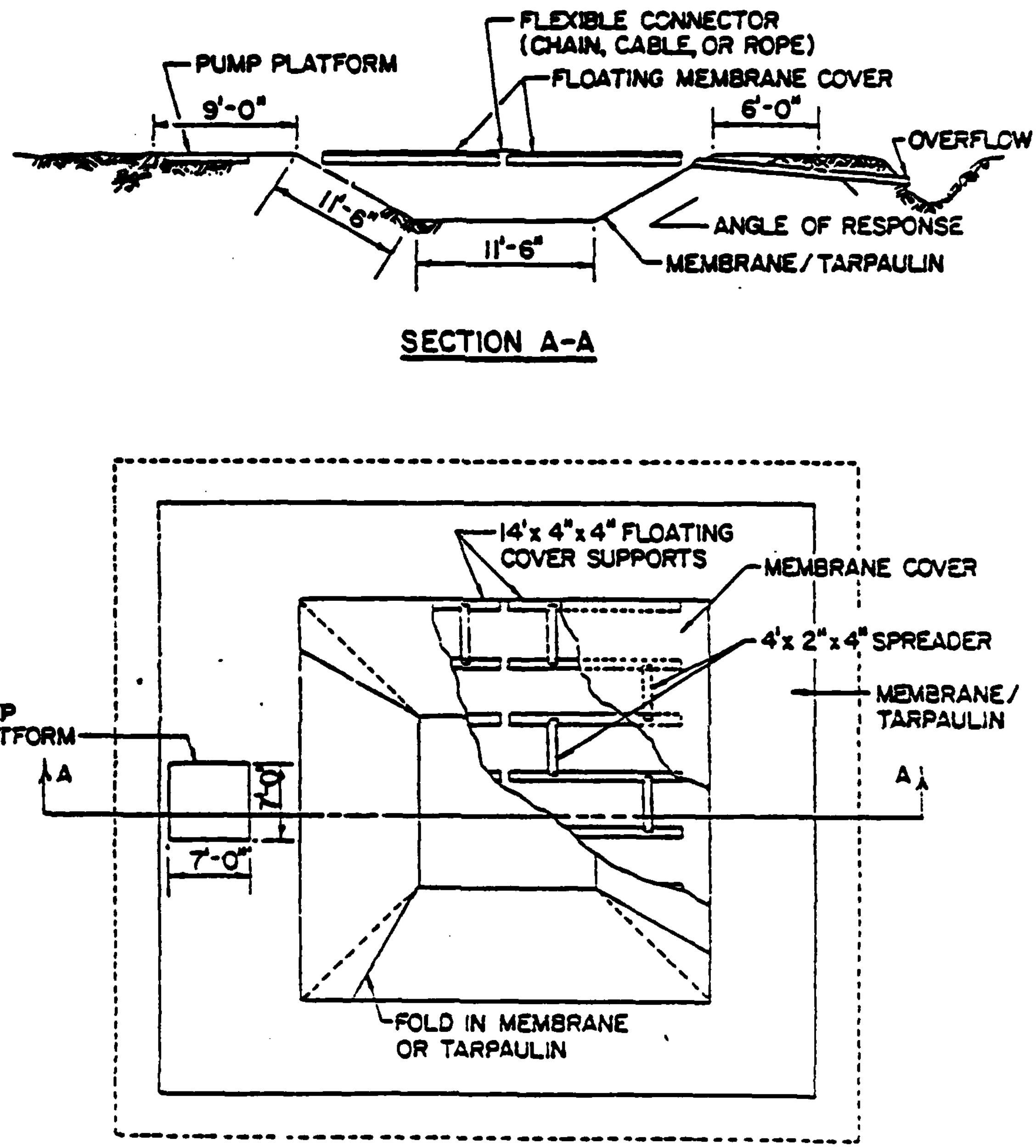


Figure 37. Water Storage: Basin Container

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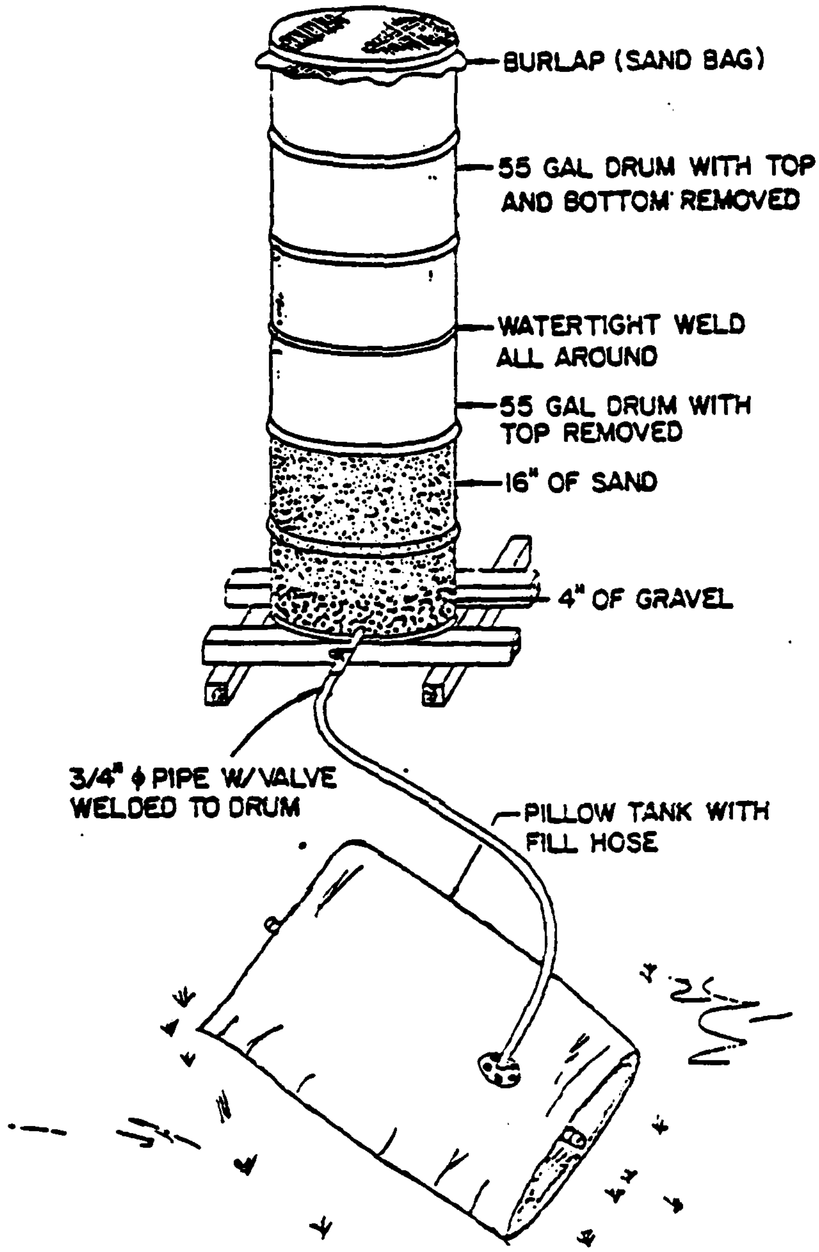



Figure 38. Water Purification: Sand Filter

Reprinted from 43:5.31

## TABLE XX

### Water Borne Disease

| DISEASE | CAUSATIVE ORGANISMS | INCUBATION PERIOD | IMMUNITY | PREVENTIVE TREATMENT | SYMPTOMS |
|---|---|---|---|---|---|
| 1. Typhoid | Bacillus Typhosus Eberthella Typhus | 10 to 14 avg<br>7 to 25 | Yes<br>Vaccine | Field $Cl_2$ | a) High fever ( 4 weeks)<br>b) Rose colored skin eruptions<br>c) Loose bowel movements<br>d) Enlargement of Spleen |
| 2. Paratyphoid | Bacillus Paratyphosus | 7 to 10 avg<br>4 to 14 | Yes<br>Vaccine | Field $Cl_2$ | Similar to Typhoid |
| 3. Bacillary Dysentary | Bacillus Shigella | 2 to 3 days | None | Field $Cl_2$ | a) Frequent bloody mucous filled bowel movements<br>b) Vomiting<br>c) Cramps and pains |
| 4. Amoebic Dysentary | Endamoeba Histolytica | 10 days to several months | None | Resistant to $Cl_2$<br>Drying kills cyst<br>Diatomite Filter | a) Similar to Bacillary Dysentary<br>b) Lesions in colon<br>c) Eats blood corpuseles |
| 5. Cholera | Vibro Comma (Comma shaped bacillus or Vibrio) | 2 days avg<br>2 hours to 6 days | Vaccins (3 to 6 mo)<br>Survival (3 to 6 mo) | Field $Cl_2$ | a) Profuse painless diarrhea<br>b) Dehydration of soft body tissue<br>c) Muscular cramps<br>d) Rapid collapse followed by subnormal temperature and severe prostration |
| 6. Schistoso-miasis | Cercarise of Schistosomes | 2 days | None | Resists $Cl_2$<br>Diatomite Filter<br>Remove fresh water snails | a) Cough, general pains<br>b) Fever<br>c) Anemia<br>d) Nausea<br>e) Diarrhea<br>f) Painful, bloody urination<br>g) Bloating of the abdomen<br>h) Liver enlarges<br>i) Ulceration (Cancer)<br>j) Tissues thicken<br>k) Constipation<br>l) Muscles stiffen<br>m) Liver shrinks<br>n) Spleen enlarges |

Reprinted from 16:12

## TABLE XXI

## Poisons in Water

| Poison | Symbol | Detection | Poisonous effect in water | Treatment | Remarks |
|---|---|---|---|---|---|
| Blister gases | | | | | |
| Nitrogen mustard | HN | Mustard test, Arsenic test | Highly poisonous | Remove by A.C.* | Readily soluble in water. Requires several days to decompose in water. Water containing nitrogen mustard is odorless and tasteless. |
| Lewisite | L | Arsenic test, Chlorine demand test | Highly poisonous | Remove by A.C. | Quite soluble in water. Decomposes rapidly in water but remains poisonous. |
| Ethyldichlorarsine | ED | Chlorine demand test | Highly poisonous | Remove by A.C. | Quite soluble in water. Decomposes rapidly in water but remains poisonous. |
| Mustard | H | Mustard test | Fairly poisonous | Remove by A.C. | Fairly soluble, but harmless several hours after decompositions. |
| Choking gases | | | | | |
| Chloropicrin | PS | Taste and odor | May be poisonous | May be removed by A.C. but with difficulty | Gives water objectionable taste and odor. |
| Phosgene | CG | Low pH | Harmless | None necessary | Soluble in water. Decomposes into harmless products. |
| Diphosgene | DP | Low pH | Harmless | None necessary | Soluble in water. Decomposes into harmless products. |
| Tear gases | | | | | |
| Chloracetophenone | CN | Taste and odor | May be poisonous | Remove by A.C. | Only slightly soluble. Gives water objectionable taste and odor. |
| Brombenzylcyanide | BBC | Taste and odor | May be poisonous | Remove by A.C. | Only slightly soluble. Gives water objectionable taste and odor. |
| Vomiting gases | | | | | |
| Adamisite | DM | Arsenic test | May be poisonous | Remove by A.C | Slightly soluble in water. |
| Diphenylchlorarsine | DA | Arsenic test | May be poisonous | Remove by A.C. | Slightly soluble in water. |
| Blood poisons | | | | | |
| Cyanogen chloride | CC | Cyanogen chloride test | Highly poisonous | Reduced by aeration, A.C. and chlorination | Decomposes slowly in water. |
| Nerve gases | G-agents | G-agent test | Highly poisonous | Hydrolysis by soda ash followed by coagulation | Variable rate of decomposition in water. |
| Physiologically active organic substances | | Chlorine demand test | Poisonous | Generally removed by A.C. | |
| Organic arsenicals | | Arsenic test | Poisonous | Generally removed by A.C. | |
| Inorganic arsenic compounds | | Arsenic test | Poisonous | Not removed by A.C. | |
| Cyanides | | Cyanide test | Poisonous | Treat with soluble iron salts and coagulate | Not removed by A.C. |
| Heavy metal salts | | Heavy metal test | Slightly poisonous | Not removed by A.C. | |
| Bone and fish oil | | Taste and odor | Poisonous | Large amounts of A.C. | |

NOTE: A.C. Activated Carbon

Reprinted from 16:13

Water Distribution. The expansion and contraction of pipes in hot climates causes leaks. This problem can be reduced by the following methods (34:5.15):

1. Painting pipelines a light color reflects heat and provides better camouflage in some areas.

2. Storing pipes in shady areas and burying distribution lines prevents degradation of plastic pipes.

3. Full-time maintenance crews or burying pipelines at least 18 inches also reduces leaks in hot areas.

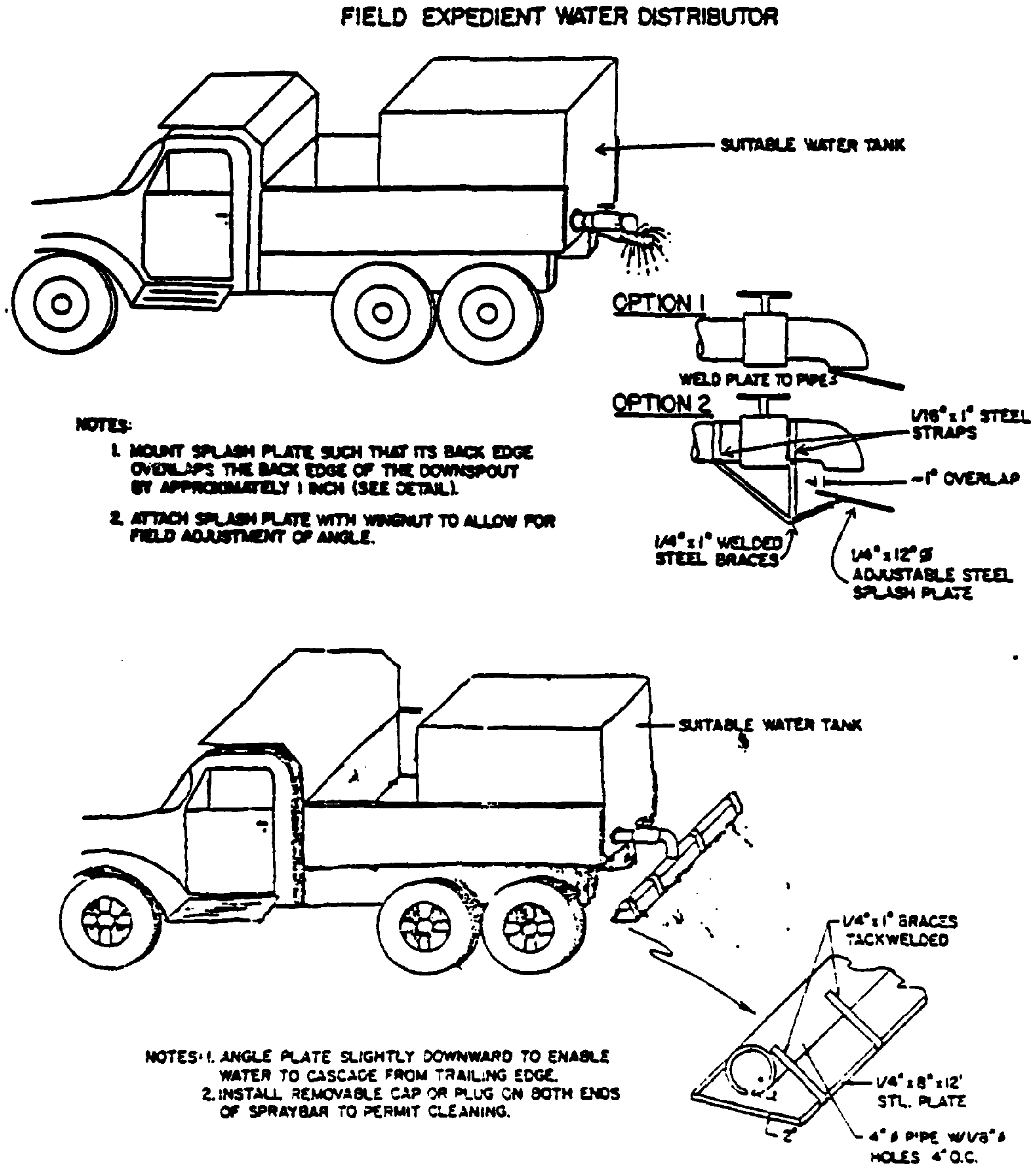



Figure 39. Water Distribution: Vehicular Transport

Reprinted from 43:5.33

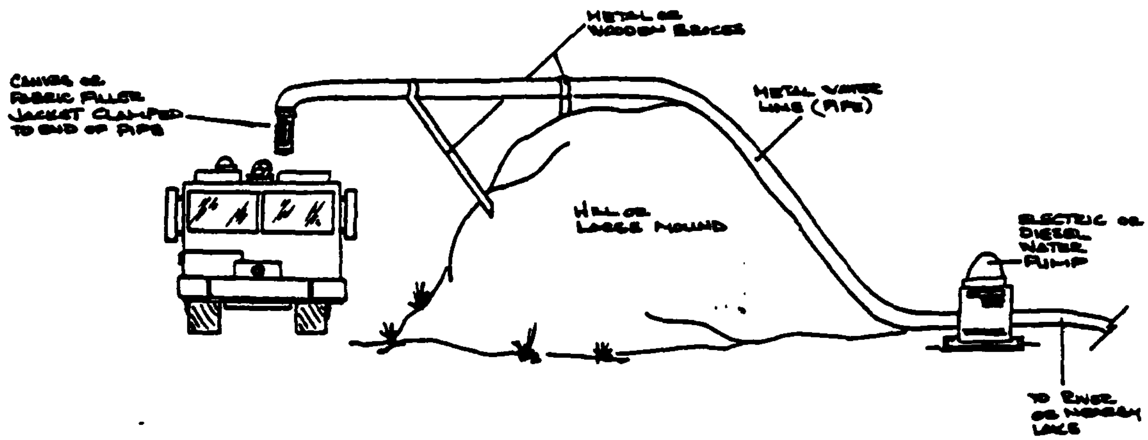



Figure 40. Water Distribution: Quick Crash Truck

As Used in Bien Hoa AB, Vietnam 1964-1965

Submitted by Fire Chief A. W. Baumgardner

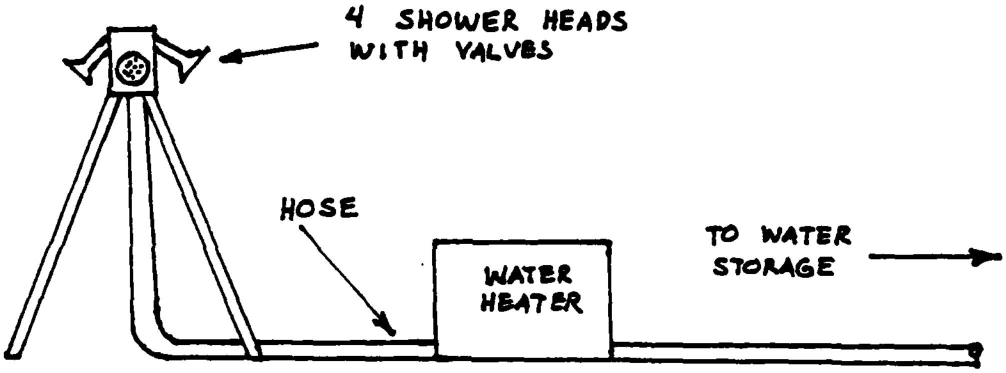



Figure 41. Sanitation: Shower Unit

As Used in Cairo West, Egypt 1980

Submitted by SSgt Tod C. Peabody

Hot Shower Unit. A temporary hot shower unit was used during the "Jack Frost Exercise" in Alaska in January 1979. Temperatures averaged 45 degrees F during this exercise. This expedient hot shower, submitted by CMSgt Donald L. Neels, can be constructed by following the guidelines given below.

1. Construct a plywood shower box with a 4'x8' base, 8'x8' back wall, 4'x8' end walls, and a 2'-high x 8'-long front wall. This box is used only to collect water to prevent flooding the tent floor area. This box can be drained by bucket from a hose attached to the base of one end wall. Also, construct a duct board resting on 4"x4" boards so occupants will not stand in water.

2. Install two 2x4s with 16 penny nails driven approximately 1 ft apart to hang clothes. These 2x4s can be tied with rope to vertical tent poles.

3. Drill a 1-1/4" hole through each end wall, centered and approximately 8" down. Connect 3 sections of 3-ft long, 3/4" galvanized pipe as follows: (1) At the end of one section, install a 3/4"x3/4"x1/2" tee; (2) install a second section of 3/4" pipe and install a second 3/4"x3/4"x1/2" tee; (3) install the third section of pipe and install a 3/4" cap on the end of this section; (4) on the branch side of the two tees, install a 1/2"x2" nipple, 1/2" valve, 1/2"x2" nipple and showerhead; (5) place this completed shower ficture into one hole of the shower end wall and pull it back into the other end hole until the unit is self hang ng; and (6) connect one end of a garden hose onto the exposed threading of the pipe and the other end of the hose to a submergible pump.

4. Fill a 32-gallon water can with water.

5. Insert a field unit immersion heater.

6. Insert a low pressure submergible pump with a garden hose attached.

7. Heat the water to the desired temperature of approximately 130 degrees F. The operator can monitor the water temperature with a refrigerator

type thermometer and probe, and controll the temperature by adjusting the fuel to the heater.

8. When the desired water temperature is reached, the operator can connect the plug from the water pump to the power source and add water to the storage can to control any overheat condition.

9. Two men can shower at a time to conserve water. Approximately 2 gallons per man is sufficient. Showering the Navy style (i.e., wetdown, shut off water, soap, scrub, and then rinse) is suggested to conserve water.

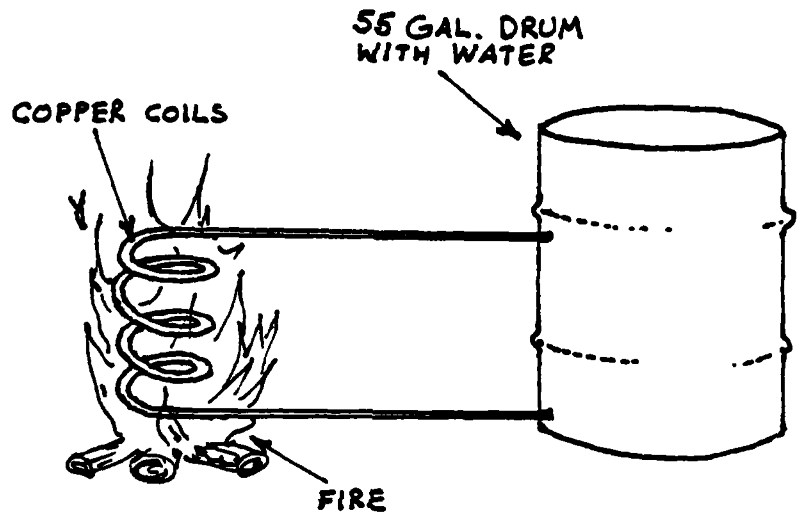



Figure 42. Sanitation: Hot Water Heater

As Used in Boy Scouts

Submitted by A1C Keith Runquist

Attach both ends of some copper tubing to a 55-gallon drum. Fill the drum up with water. Make some coils in the tubing and place the coils over a fire. The fire heats the water in the coils and in the drum.

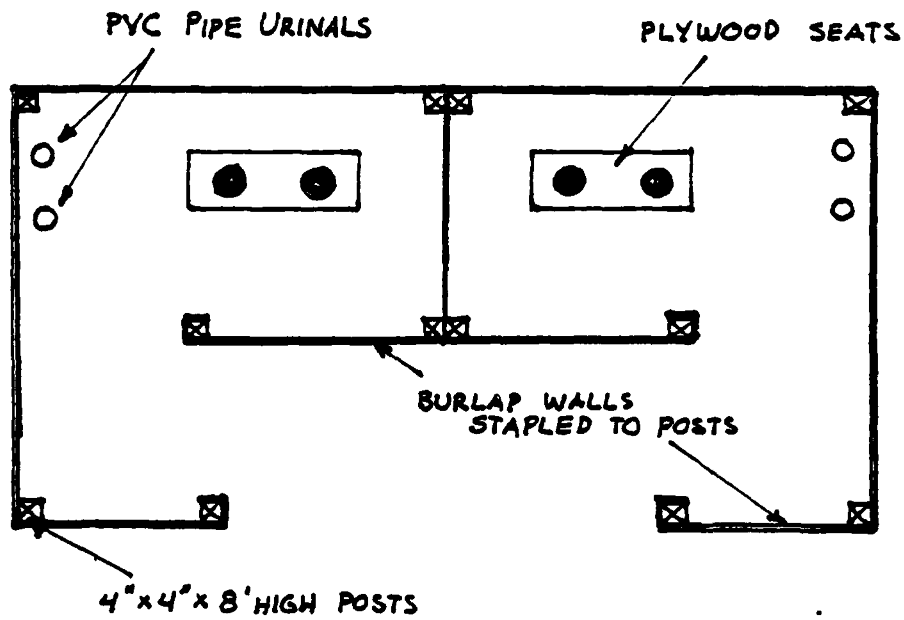



Figure 43. Sanitation: Outdoor Latrine

As Used in Oman, 1982

Submitted by Capt James C. Konyha

Use a few posts and burlap to form the walls in a maze effect. The top is left open.

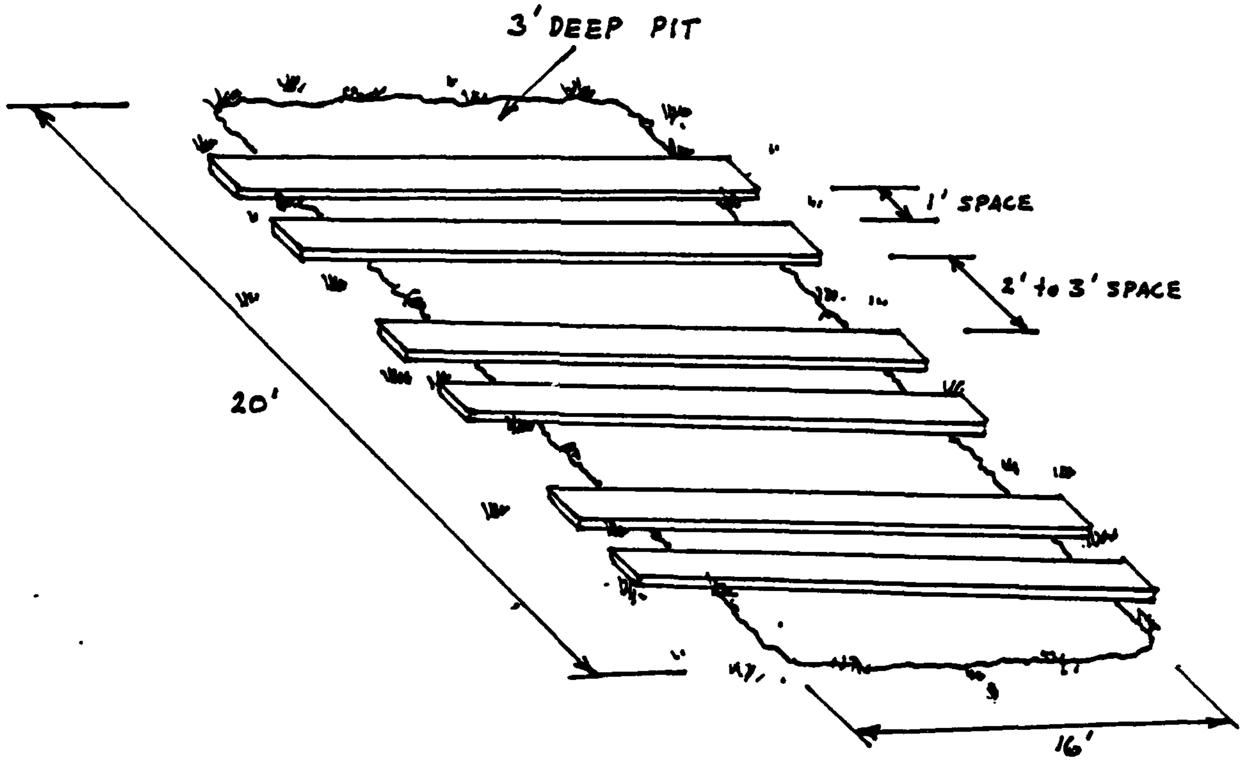



Figure 44. Sanitation: Straddle Pit Latrine

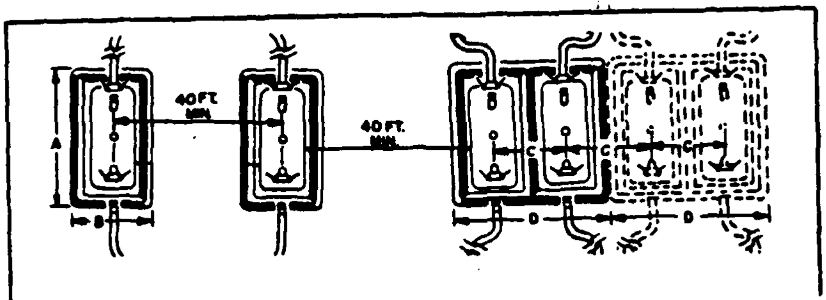
As Used at Eglin, Tyndall, and Bergstrom AFBs

Submitted by TSgt James G. Caraway

1. Use a backhoe to dig a 20'Lx16'Wx3'D hole.
2. Lay six 2"x8"x20' planks across the width of the hole to form three walks as shown in the figure.
3. Two feet at each end of the planking should lay firmly on the ground for stability.

## TABLE XXII

## Typical Fuel Tank Layout




| Capacity | Berm Dimensions A | | Berm Dimensions B | | | | Tank Dimensions Empty | | | | Tank Dimensions Full | | C | D | Weight Dry (Approximate) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gallons | Length Ft. | In. | Width Ft. | In. | Height Ft. | In. | Length Ft. | In. | Width Ft. | In. | Height Ft. | In. | Width Ft. | Width Ft. | Pounds |
| 500 | 11 | 0 | 12 | 0 | 3 | 6 | 7 | 0 | 8 | 0 | 2 | 6 | 12 | 24 | 40 |
| 750 | 12 | 0 | 12 | 0 | 3 | 6 | 8 | 0 | 8 | 0 | 3 | 0 | 12 | 24 | 50 |
| 900 | 15 | 2 | 12 | 0 | 3 | 6 | 11 | 1 | 8 | 0 | 2 | 6 | 12 | 24 | 65 |
| 1500 | 14 | 0 | 14 | 0 | 3 | 6 | 10 | 0 | 10 | 0 | 3 | 3 | 14 | 28 | 70 |
| 2000 | 16 | 0 | 16 | 0 | 3 | 6 | 12 | 0 | 12 | 0 | 3 | 7 | 18 | 32 | 95 |
| 3000 | 17 | 0 | 17 | 0 | 3 | 6 | 13 | 0 | 13 | 0 | 4 | 0 | 17 | 34 | 120 |
| 3000 | 23 | 7 | 14 | 0 | 3 | 6 | 19 | 7 | 10 | 0 | 3 | 0 | 14 | 28 | 130 |
| 4000 | 18 | 0 | 18 | 0 | 3 | 6 | 14 | 0 | 14 | 0 | 4 | 3 | 18 | 36 | 135 |
| 5000 | 19 | 0 | 19 | 0 | 3 | 6 | 15 | 0 | 15 | 0 | 4 | 4 | 19 | 38 | 150 |
| 6000 | 20 | 0 | 20 | 0 | 3 | 6 | 16 | 0 | 16 | 0 | 4 | 6 | 20 | 40 | 170 |
| 6000 | 29 | 4 | 16 | 0 | 3 | 6 | 25 | 4 | 12 | 0 | 4 | 0 | 16 | 32 | 185 |
| 7500 | 22 | 0 | 22 | 0 | 3 | 6 | 18 | 0 | 18 | 0 | 4 | 9 | 22 | 44 | 200 |
| 10,000 | 26 | 0 | 26 | 0 | 3 | 6 | 22 | 0 | 22 | 0 | 4 | 0 | 26 | 52 | 280 |
| 10,000 | 46 | 0 | 16 | 0 | 3 | 6 | 42 | 0 | 12 | 0 | 4 | 0 | 16 | 32 | 290 |
| 12,000 | 54 | 0 | 16 | 0 | 4 | 0 | 50 | 0 | 12 | 0 | 4 | 0 | 16 | 32 | 335 |
| 15,000 | 28 | 0 | 28 | 0 | 4 | 0 | 24 | 0 | 24 | 0 | 5 | 0 | 28 | 56 | 350 |
| 20,000 | 32 | 0 | 28 | 0 | 4 | 0 | 28 | 0 | 24 | 0 | 5 | 2 | 28 | 56 | 400 |
| 25,000 | 38 | 0 | 28 | 0 | 4 | 0 | 34 | 0 | 24 | 0 | 5 | 6 | 28 | 56 | 480 |
| 40,000 | 54 | 0 | 28 | 0 | 4 | 0 | 50 | 0 | 24 | 0 | 5 | 6 | 28 | 56 | 700 |
| 50,000 | 69 | 0 | 28 | 0 | 4 | 0 | 65 | 0 | 24 | 0 | 5 | 7 | 30 | 56 | 960 |
| 50,000 | 69 | 0 | 28 | 0 | 4 | 0 | 65 | 0 | 24 | 0 | 5 | 7 | 30 | 56 | 1400 |
| 75,000 | 93 | 0 | 28 | 0 | 5 | 0 | 89 | 0 | 24 | 0 | 6 | 0 | 30 | 56 | 1300 |
| 80,000 | 100 | 0 | 28 | 0 | 5 | 0 | 96 | 0 | 24 | 0 | 6 | 0 | 30 | 56 | 1410 |
| 100,000 | 80 | 0 | 42 | 0 | 5 | 0 | 76 | 0 | 42 | 0 | 5 | 8 | 48 | 84 | 1950 |
| 210,000 | 102 | 0 | 52 | 0 | 6 | 0 | 98 | 0 | 48 | 0 | 6 | 0 | 54 | 102 | 2850 |

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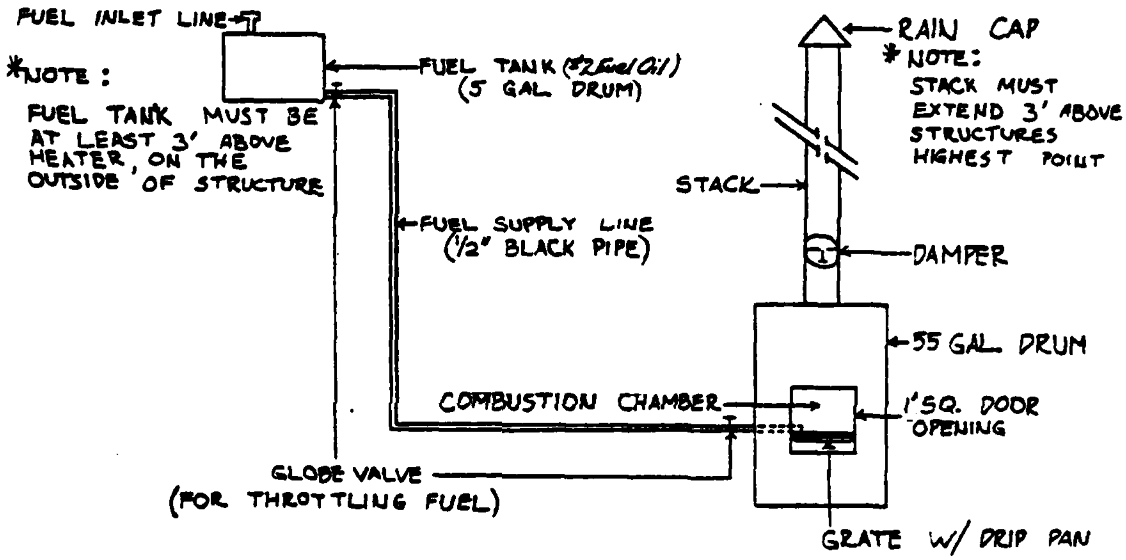


Figure 45. Heating: Semi-permanent Heating Unit

As Used in Vietnam, 1969

Submitted by MSgt Donald Tuttle

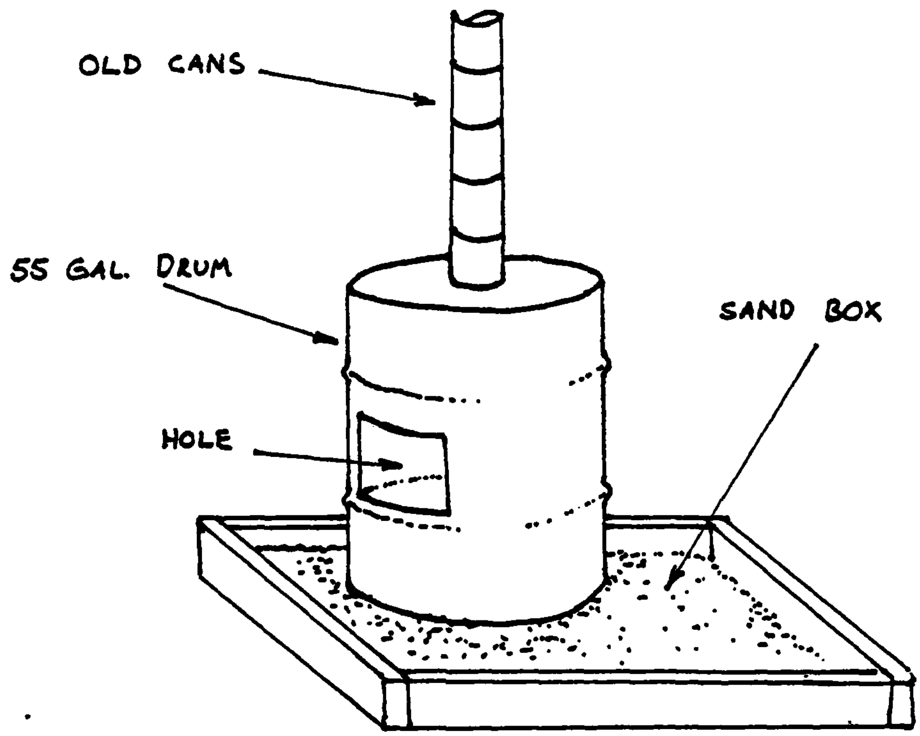


Figure 46. Heating: Tent Heater

Submitted by SSgt Lawrence W. Hopkins

1. Construct a sand box.
2. Place a 55-gallon steel drum in the sand box.
3. Cut a hole in a 55-gallon drum in the top and in the side.
4. Remove both ends from old coffee cans or fruit cans.
5. Stack these cans to form a smoke stack and place into the hole on the top of the drum.
6. Place wood in the hole on the side of the drum for fuel.

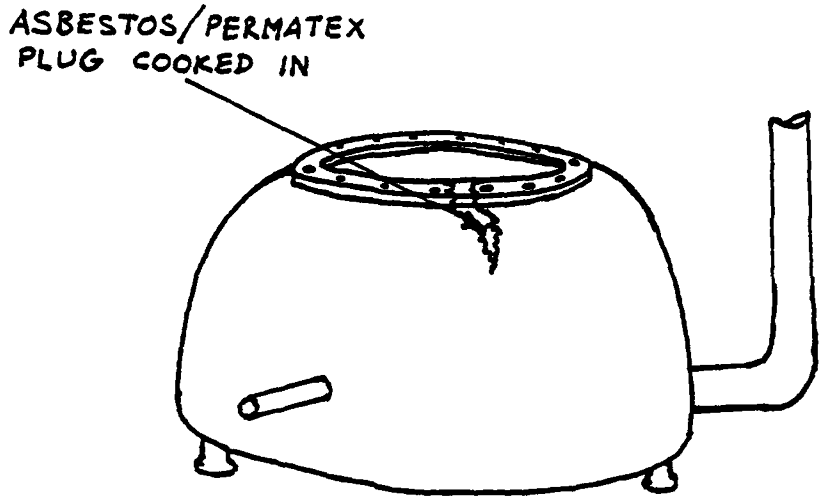


Figure 47. Heating: Expedient Repair of Turbine Block

As Used on a Ship's Engine Room, 1954

Submitted by Mr. Troy W. Franklin

1. Saw into the housing where the steam cut is located.
2. Mix powdered asbestos and permatex and pack into the cut.
3. Reinstall the nozzle block and cook the mixture with the steam.
4. Test before using.

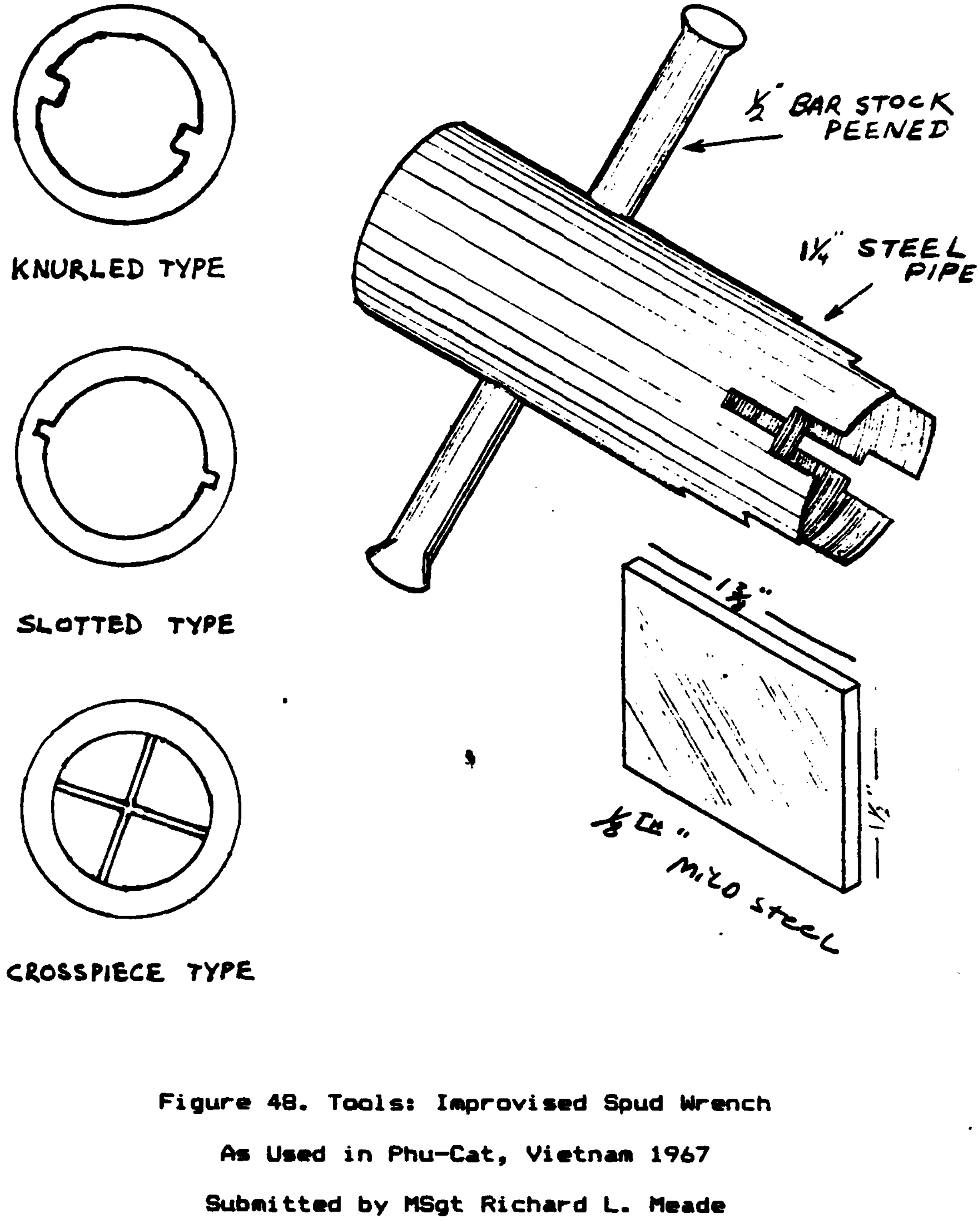


Figure 48. Tools: Improvised Spud Wrench

As Used in Phu-Cat, Vietnam 1967

Submitted by MSgt Richard L. Meade

Wrench can be made of appropriate sized steel pipe/conduit. 1-1/4" pipe is fairly standard for commodes and maintenance service sinks. The 1/8" plate is required so the wrench will remove slotted spuds. It will also remove spuds with knurls and P/O plugs with cross pieces.

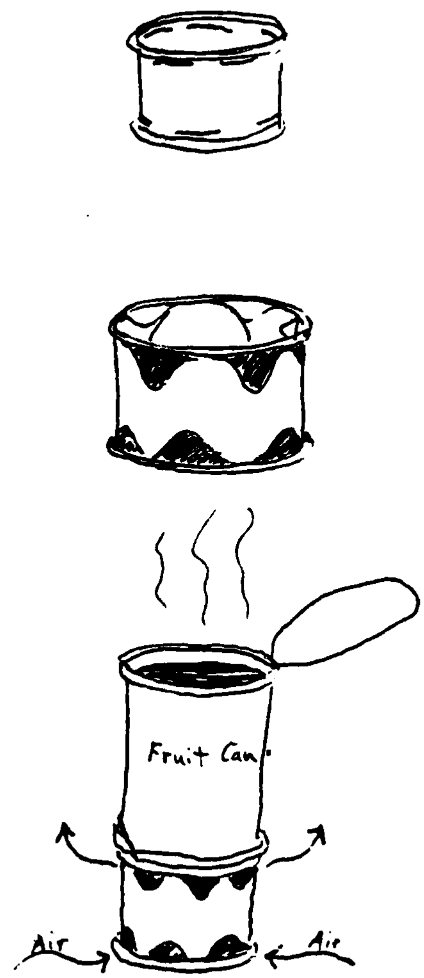


Figure 49. Tools: Portable Stove

Submitted by Mr. Richard Wilson

To make a portable stove to heat C Rations, use a dedium size cracker can. Cut slits around the top and bottom of the can on the outside. Push in the sides of the can so air will circulate from the bottom to the top. Place a heating tab or small ball of C-4 in the middle of the can and light it.

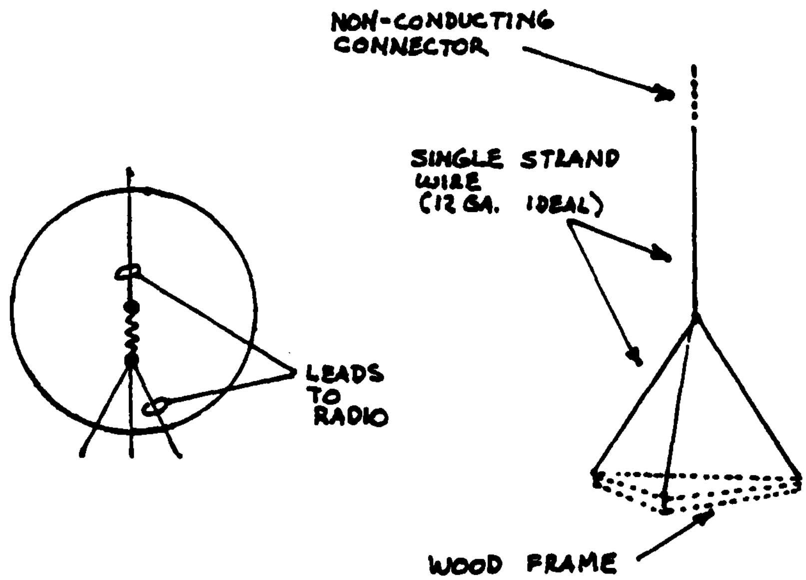


Figure 50. Tools: Long Range Radio/TV Antenna

As Used in Oklahoma

Submitted by 1Lt Jon L. Muller

1. All four wires to be same length (about 3 to 4 feet long).
2. Insulation need not be removed.
3. Can be tied to a tree or any other support.
4. Turn for directional capability.
5. Triples the range of reception.

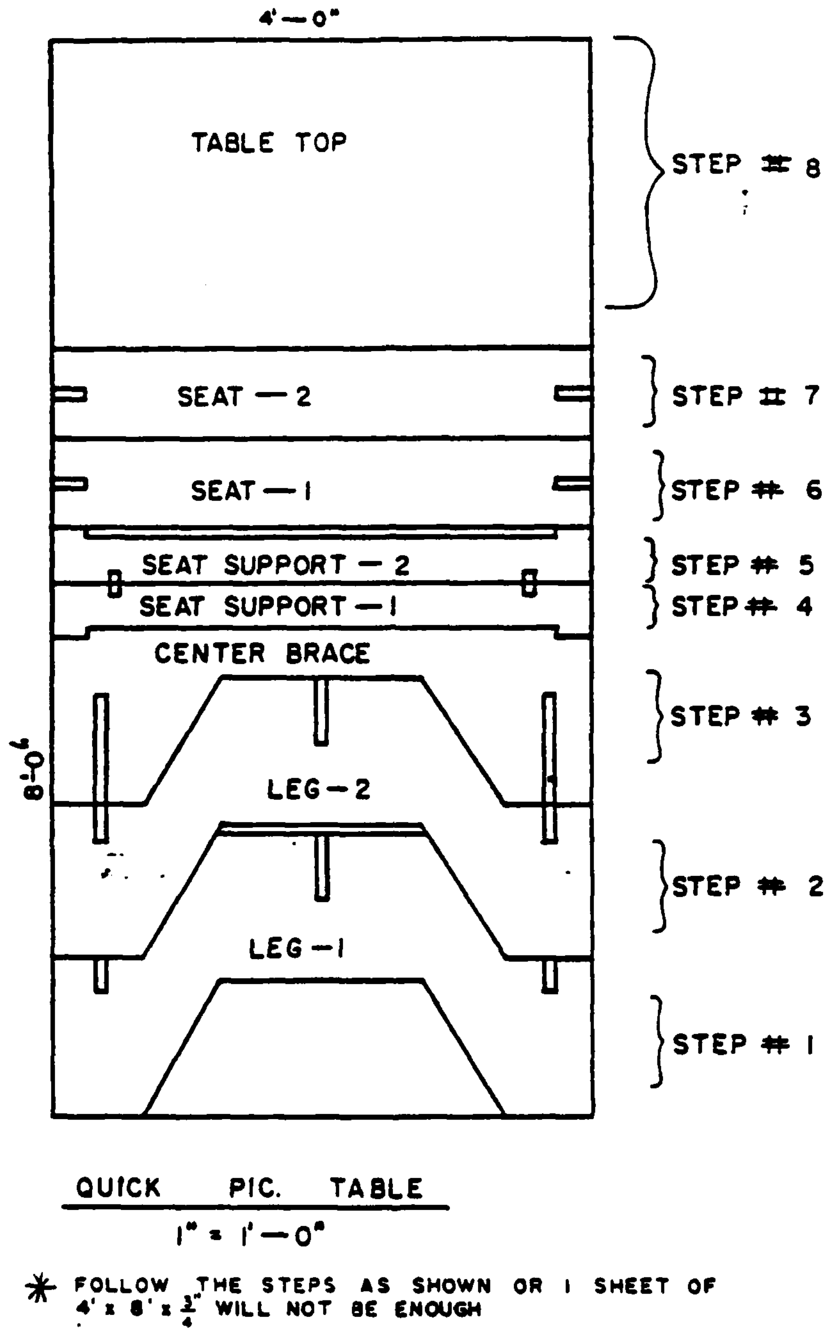


Figure 51. Furniture: Table and Benches

As Used in Mtn Home AFB ID

Submitted by 2Lt Bruce L. Steely

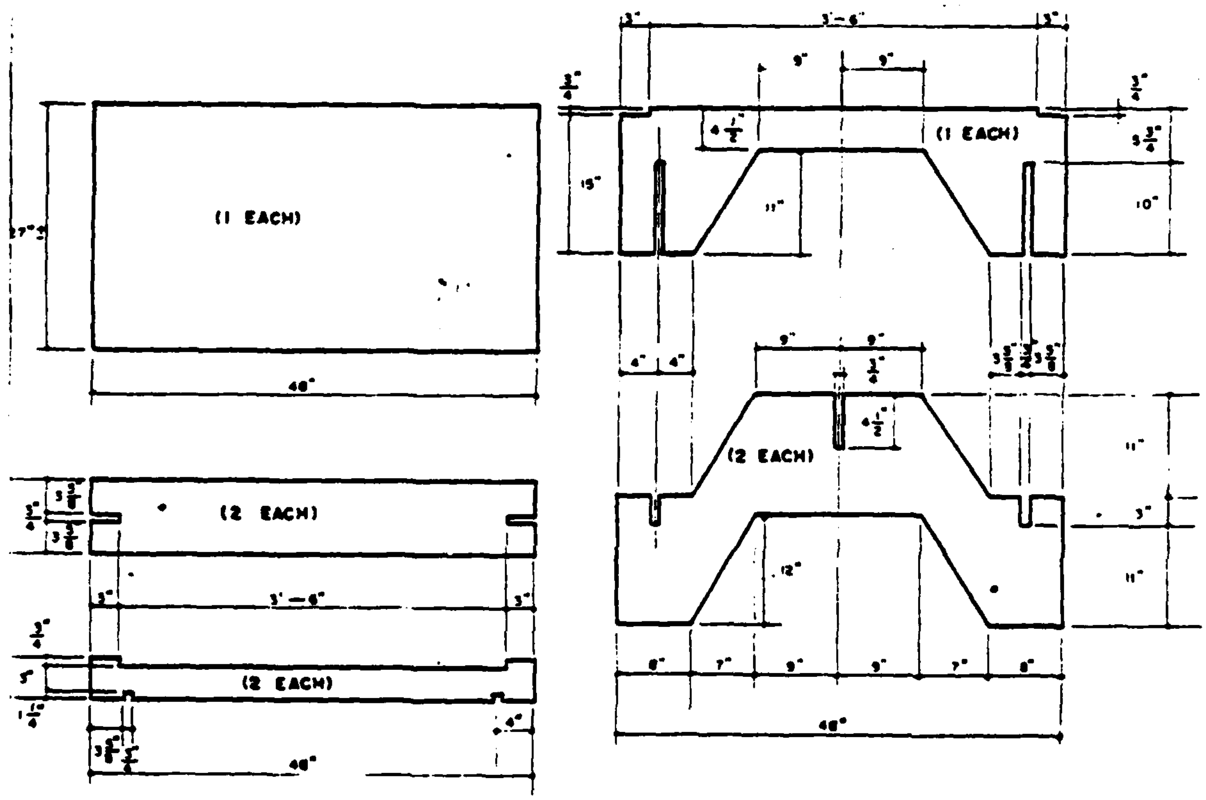


Figure 51. - continued

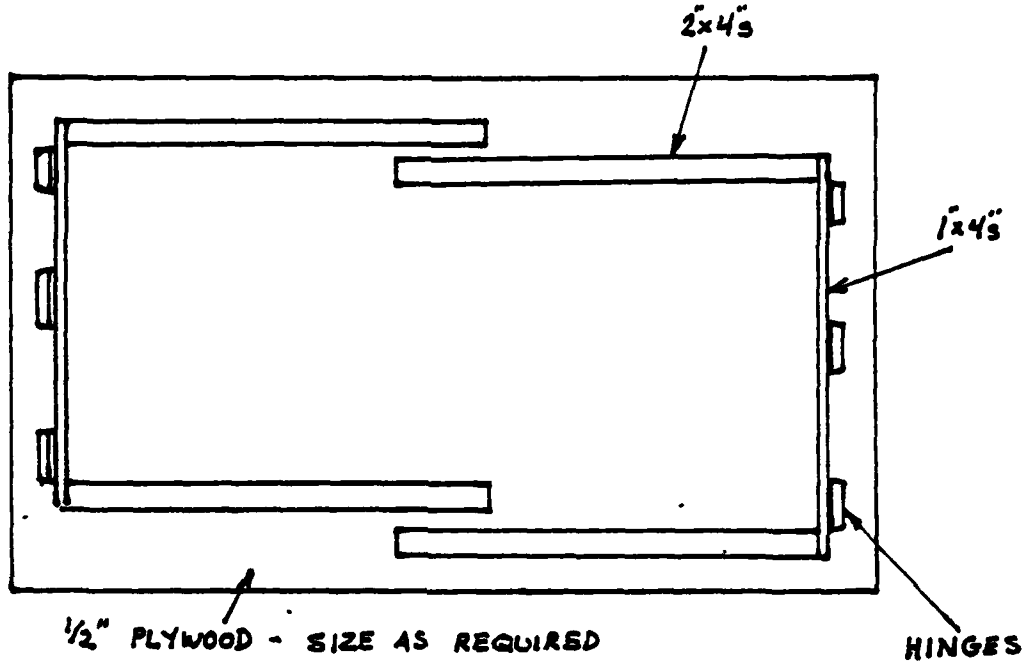


Figure 52. Furniture: Folding Table

As Used During "Team Spirit" in Osan AFB, Korea 1982

Submitted by Capt Mellerski

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