ADA134626

TECHNICAL REPORT
NATICK/TR/8D/D33

MARINE CORPS SHELTERIZED EXPEDITIONARY FOOD SERVICE SYSTEM

by

Norman D. Roberts
Arthur L. Murphy Jr.
Robert J. Buffone

August 198D

APPRDVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT LABORATORIES
NATICK, MASSACHUSETTS 01760

OPERATIONS RESEARCH/SYSTEMS ANALYSIS OFFICE

equipment in quantity and variety sufficient to provide a battalion-sized unit with three A Ration type meals per day. This complex can be separated into two independently operating food service systems capable of supporting 500 men and 200 men, respectively. The system employs disposables for shipboard operations. Hot water is supplied by remote fuel fired water heaters.

The hardware cost (shelters plus kitchen/sanitation equipment plus water heaters) is estimated to be $159,000; the power requirement is estimated to be 170kW. This report also contains estimates of water and fuel consumption rates, food storage requirements, and personnel requirements.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NATICK/TR-80/033	2. GOVT ACCESSION NO.: AD-A134 626
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): MARINE CORPS SHELTERIZED EXPEDITIONARY FOOD SERVICE SYSTEM	5. TYPE OF REPORT & PERIOD COVERED: Technical Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Norman D. Roberts, Arthur L. Murphy, Jr., Robert J. Buffone	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Natick Research and Development Laboratories, Operations Research and Systems Analysis Office, Natick, MA 01760	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 6.2 1L162724 AH99A, 054 035, 079
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Natick Research and Development Laboratories, Operations Research and Systems Analysis Office, Natick, MA 01760	12. REPORT DATE: August 1980
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Military Service Requirement: JSR AM 3-1, Appendix I1, Field Feeding System for the Marine Corps in the Field.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

FOOD SERVICE	GALLEY	SHELTERIZED
COMBAT FEEDING	SANITATION	MESS
FIELD FEEDING	MILITARY EQUIPMENT	EXPEDITIONARY SHELTER SYSTEM
RATIONS	SHELTERS	
KITCHENS	HARD SHELTERS	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Marine Corps requires a food service system that can be housed, for portability, within the 8 by 8 by 20 foot shelters of the Marine Corps Expeditionary Shelter System. This food service system is intended for use aboard container ships when such ships are used for troops transport. After the troops disembark, the food service unit will be used for base camp feeding.

This report contains a design concept for such a food service system. It consists of a seven-shelter complex containing electric, commercially available

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

Development of a Marine Corps Shelterized Expeditionary Food Service System (JSR AM 3-1 Appendix II) was detailed to the US Army Natick Research and Development Laboratories (USA NLABS) by the Commandant of the Marine Corps in November 1976. The performance characteristics embodied by the NLABS concept were developed by the Operations Research and Systems Analysis Office (ORSA) to include the following:

- o capability to operate both afloat and ashore,
- o service of three hot meals per day,
- o design for compatibility with hard shelters that meet ISO standards, and
- o utilization of fuel expected to be available in the 1980's or electricity.

A design was formulated that incorporated all of the characteristics specified. The efforts of many individuals should be recognized for their invaluable assistance during the course of the project.

MARINE CORPS DEVELOPMENT AND EDUCATION COMMAND, MOBILITY AND LOGISTICS DIVISION.

Review of project plans as well as helpful insights into various critical areas allowed the project to progress at an extremely rapid rate. Special acknowledgement is given to Col. Taylor, LTC Barents, and GySgt Jackson.

US ARMY NATICK RESEARCH AND DEVELOPMENT LABORATORIES

o Food Sciences Laboratory. Drs. Meiselman and Symington both provided contributions to the development of the proposed menu for the MCESS galley.

o Food Engineering Laboratory. Mr. J. Prifti provided valuable assistance in coordinating the building and assembly effort of the shelters and foodservice equipment. Mr. Bumbacca furnished technical guidance concerning set-up and operation of foodservice equipment.

o Experimental Kitchen. Ms. Virginia White developed menus to be used in the MCESS galley and assisted in the selection of food products to be used in latter tests.

o Operations Research and Systems Analysis Office. Dr. Robert J. Byrne, Chief ORSA Office, supported the project from its inception and helped direct the concept formulation. Mr. R. P. Richardson, Program Manager, and Dr. G. Hertweck provided specialized knowledge of military foodservice systems during the early planning and design stages. Mr. Richard Laferriere was a participant in defining system parameters. Mr. Michael Ostrowsky assisted in editing. Acknowledgement is also given to Mrs. Maryellen Jennings and Mrs. Patricia A. Yow for their efforts in secretarial support of the project.

TABLE OF CONTENTS

A-1

LIST OF FIGURES

LIST OF TABLES

MARINE CORPS SHELTERIZED EXPEDITIONARY FOOD SERVICE SYSTEM

SECTION 1

DE..GN CONCEPT

INTRODUCTION

The Marine Corps is investigating a new shelter system for housing tactical equipment and supporting military operations on board containerized ships and in base camps in the field. Unlike the present system, composed primarily of tents, the new system, called the Marine Corps Expeditionary Shelter System (MCESS)[1], consists of several types of hard shelters. The larger shelters, each assembled in the field from prefabricated panels and a steel framework, are intended for warehouses and maintenance shops for aircraft or heavy equipment. Some of the smaller shelters are rigid room-sized boxes that are electromagnetically shielded to house and protect electronic equipment. The keystone of the system, however, is a small, multipurpose shelter.

As seen from the outside, this shelter resembles a cargo container 8 feet high, 8 feet wide and 20 feet long. At one end it has double doors for personnel access, and at the other end it has removable, square panels which cover openings provided for utilities access. The shelter appears to be an integral unit, but its side walls, which are not load-bearing members, can be removed, leaving the shelter wide open from side to side. From the inside, with the side walls in place, the shelter is bare except for fluorescent lights and electric outlets built into the ceiling. There are two versions of this shelter: One is rigid and, except for its side walls, must remain erect. The other, a knock-down, can be disassembled into its component floor, wall and roof panels, which can then be reassembled into a package 8 feet wide, 2 feet high, and 20 feet long for either storage or transportation.

The shelter's resemblance to a cargo container is more than superficial. The shelter is designed to meet the cargo container specifications established by the International Organization for Standardization (ISO). These standards specify the shelter's overall dimensions, corner fittings and stacking and racking strengths. As a result, this shelter, the ISO Shelter, is readily transportable. For short distances the shelter can be moved by forklift, since its gross weight is limited to 10,000 pounds; for long hauls the shelter, like a cargo container, can be transported by air, rail, truck, and ship using existing military and commercial cargo carriers and cargo handling equipment.

---

[1]D. A. Bond, System Analysis and Design Study for a Family of Standard Shelters and a Logistics Trailer, NORT 71-124 - Final Report, NASC Contract N00019-71-C-0499, December 1971.

Once in the field, the ISO shelter is very versatile; it can be used as a stand alone shelter or it can be attached to other shelters to form large and varied shelter complexes. Specifically, two knock-down shelters can be attached end-to-end, and two or more shelters, either knock-down or rigid, can be attached side by side. The joint between attached shelters can be sealed with weather strips, and the adjacent walls between the shelters can be removed to produce a relatively large, open, weather tight room. These rooms, or shelter complexes, can be used to house facilities like command posts, communication centers, dispensaries and, in particular, the life support facilities required by Marines in the field. These life support facilities, such as shower, laundry and food service units, are to be built into shelters so that they can be transported to their destination as complete units where they will require only minimum assembly time.

The ISO Shelter and the shelterized life support units are being developed primarily for shipboard use; they will give the Marine Corps the option of rapidly converting a commercial container ship into a troop transport ship.[2] Because ISO Shelters can be treated as cargo containers, they can be stowed aboard ship with the same ease and speed as cargo containers. Once aboard, shelters and life support units, provided they are capable of operating aboard ship, can be used to support troops in transit in the same way they would be used to support troops in the field. Other systems required for ship conversion heat and ventilation systems, power generation and distribution systems, and systems of passageways and stairways -- are being developed as parts of the Expeditionary Shelter System.

Several Commands are involved in this development effort; some are designing the systems and procedures for ship conversion, and others are designing the life support units of the Expeditionary Shelter System. The US Army Natick Research and Development Laboratories (NLABS) has been tasked to develop the food service unit.

This report outlines the design of this food service unit and contains an analysis in which the unit's operating parameters, such as water and power consumption and food storage requirements, are estimated. These are documented here to provide a convenient reference for the developers of other aspects of the shelter system.

The food service unit discussed in this report has not yet been built and tested. It is expected that prototype construction and testing, which is underway, will result in some design changes. In anticipation of these changes, the food service unit discussed will be referred to as the proposed food service unit.

The design for this unit is contained in Section II. The remainder of this section describes the design concept of the proposed food service unit and relates this concept to the operating requirements of the unit.

---

[2] Marine Corps Expeditionary Shelter System (MCESS) Study. Summary Report, Navy Contract N00 600-75-0-0814, HW19, February 1977.

FOOD SERVICE UNIT DESIGN REQUIREMENTS

The characteristics and operating requirements that the food service unit must satisfy are listed below:

1. The food service unit must be housed in, and operated from, the ISO Shelter.

2. The food service unit must be capable of operating at sea, aboard a container ship, as well as ashore.

3. The food service unit must be adequately equipped to prepare an A Ration menu. Custom foods that reduce on-site food preparation are acceptable, provided first, that an adequate production base for these custom foods can be insured before 1985, and second, that the use of custom foods does not result in reducing the overall skill level of Marine Corps food service workers.

4. The food service unit must be equipped with items, either military or commercial, which are off-the-shelf, thereby decreasing the equipment development time so that a Technical Data Package can be prepared for procurement in 1982.

5. The food service unit must be a functionally modular design to accommodate customer populations ranging nominally from the 200-man, Company/Squadron, level to the 1000-man, Battalion/Air Group, level.

6. The food service unit may use either electric or fuel burning equipment. Fuel burning equipment must use fuel expected to be available during the next decade; electric equipment must be limited to a maximum power consumption of 100 kW.

7. The food service unit must include the means for washing and sanitizing reusable serving ware. Reusable serving ware is required because the exclusive use of disposable serving ware is unacceptable to the Marine Corps, and because individual messgear -- the other alternative -- will no longer be issued to Marines.

DESIGN CONCEPT

The design concept of the food service unit is partially defined by the kind of cooking equipment employed. Cooking equipment can be classified as either electric or fuel burning; either kind is suitable for use in field kitchens, and both kinds are available for near term procurement. However, because of the questionable availability of some fuels -- solid fuels, bottled gas -- during the next decade, only fuel burning equipment that uses liquid fuel will be acceptable for military applications.

The equipment developed and used by the military in its field kitchens during the past several decades has been predominantly liquid fuel fired.

Some of the most recent field kitchens, like the M-75 and the Mobile Kitchen Trailer use the field range cabinet for cooking.[3] The field range cabinet is heated by the M-2 burner in which pressurized gasoline is burned to produce an open flame. Filling the M-2 burner with fuel, pumping it up, igniting it, and adjusting its flame level are all manual operations. In contrast, the Bare Base Kitchen uses fuel fired equipment which is more automatic.[4] Fuel is piped to the equipment, and pumped through atomizing nozzles, where it is electrically ignited to produce a contained flame. Both the manual and automatic equipment work well, are well suited to military applications in the field, and are available for use in the Marine Corps food service unit. However, fuel fired equipment, with either the open or contained flame, is not acceptable for use aboard converted container ships.

In a converted container ship, the food service unit will be located in the hold, either within, or proximate to, the berthing area. Several food service units, distributed throughout the berthing area, may be used on large ships to reduce necessary personnel movement. In these locations, food service units using fuel fired cooking equipment would require that the fuel be brought into, and used within, the densely occupied berthing area. This would create a serious safety hazard. First, the combustion process produces toxic gases, which could cause carbon monoxide poisoning if the venting system should leak or malfunction. Secondly, any fuel leak or spill, would present a fire hazard that could be especially dangerous in the berthing area. The use of electric equipment eliminates these hazards.

Primarily for reasons of safety aboard ship, electric cooking equipment is specified for use in the proposed Marine Corps food service unit. This will not, however, eliminate the need for using liquid fuel aboard ship.

In converting a ship, the Marines will not, in general, be able to rely on ship systems for heat, ventilation, or electric power. For example, shipboard electric generators are designed to support the vessel and crew, and are not adequate to supply the power needed for the hundreds of Marines that would be aboard as passengers. The Marines will have to provide their own generators needed to power their own life support systems. These generators will have to be installed aboard ship, supplied with fuel, and operated throughout the voyage; all of this will have to be done safely. In this case, in contrast to that of the fuel fired cooking equipment, the risks can be reduced by isolating the fuel and generators in an unoccupied area of the ship, where emergency procedures could be initiated without first evacuating the area.

---

[3]S. G. Baritz, et. al., The Camp Pendleton Equipment in Battalion Level Field Feeding, TR 7T-4-ORSA, US Army Natick R&D Laboratories, Natick, MA 01760, July 1976, (AD A028 346)

[4]Erection, Operation, Storage, Inspection and Maintenance Instruction, Kitchen Facility, Bare Base, T.O. 35 E4-129-1, (Part Number 7335545-10). 17 September 1973.

Relative safety is not the only advantage of electric equipment. This kind of equipment is commonly used in cafeterias and restaurants, and the equipment manufacturers that supply this civilian market constitute a large and well established procurement base. In civilian applications, electric equipment has also established a long record of reliability and maintainability. Finally, electric equipment is very easy to use and maintain -- one merely dials the desired temperature and cooks -- no fuel tanks have to be filled, no fuel lines connected, no pressure gauges monitored, and no valves and nozzles have to be removed, cleaned and reinstalled.

Electric cooking equipment does have disadvantages. First, it requires a large amount of energy. An all-electric food service unit sized for a battalion would consume approximately 170 kW of power, and the generator sets needed to supply this much power are large, heavy pieces of equipment. Generator sets in 60 to 200 kW sizes are 3 to 4 feet wide, 5 to 6 feet high, 7 to 10 feet long, and weigh 5,000 to 10,000 pounds.* The difficulty of maneuvering such heavy pieces of support equipment in the field is the primary operational disadvantage of electric food service units. This disadvantage is only apparent, however, because with the necessary materials handling equipment, generator sets can be maneuvered just as easily as ISO Shelters, and because the Expeditionary Shelter System requires it for support, the necessary materials handling equipment will be available in the field.

A second disadvantage of electric cooking equipment is that it is not fuel efficient. That is, converting the heat energy of fuel into electricity first, and then converting the electricity back into heat for cooking is practically less efficient than using the heat energy of fuel directly for cooking. For lack of data, only a rough comparison can be made between the fuel consumption rates of otherwise equivalent electric and fuel fired field kitchens. The Camp Pendleton experiment involved a conventional Marine Corps field kitchen which used M-2 burners for cooking, immersion heaters for the mess kit laundry line, and a diesel generator to power refrigerators and lights.[5] Based on the data gathered during this experiment, 190 gallons per day can be projected for the overall fuel consumption rate of a battalion sized, fuel fired, field kitchen. The estimated consumption rate of an electric kitchen of the same size is 310 gallons per day. Although the percent difference between these figures is large, the figures themselves are not; a battalion of 1000 men, depending on its degree of mechanization and the extent of its daily movement, can consume as much as 7000 gallons of fuel per day. Relative to the total requirement, the fuel demand of a food service unit, even an inefficient one, is not significant.

---

*Generator sets are also expensive, $15,000 to $40,000 each. The cost of an electric food service unit, including the cost of the necessary generators, can be justified as a result of the unit's unique capability of operating aboard ship, but to do so is beyond the scope of this report.

[5]Baritz, Op. cit.

In summary, the proposed food service unit, using available electric equipment, can be procured by 1982, will be safe for shipboard operation, and, will be reliable and convenient to use in the base camp operations. The generator sets and fuel required to support the unit should not create an excessive logistics burden.

The proposed food service unit is sized to support a battalion of 1000 men, since this is the largest customer group that the Marine Corps plans to support from a single unit. The food service goal is to provide these men with three A Ration meals per day and to serve these meals on reusable trays, cups, and flatware, that is, on the plastic and metal serving ware typically used in mess halls. With a group this large, the troops served first will have finished the meal and returned their serving ware before the last of them will have been served. This means that the operations of serving meals and sanitizing serving ware may have to be performed simultaneously, at least toward the end of a meal period. To provide for both operations, the proposed food service unit consists of two sections, a galley section for preparing and serving food and a sanitation section for washing pots, pans, and serving ware. The sections are separate so that these operations will not interfere with each other.

The galley section consists of five ISO Shelters complexed side by side (Figure 1). The center shelter contains general purpose cooking equipment, a sink and work tables. The cooking/serving shelters on either side of the center shelter contain a serving line, consisting of cooking and food warming equipment and beverage dispensers. The two shelters at either end of the complex are access shelters, used for storing and dispensing serving ware and as passageways to the serving lines.

The galley section is designed and equipped to be symmetrical in form and function about the center shelter. The cooking/serving shelters are identically equipped, and the access shelters are identical. This duplication allows the battalion sized galley section to be separated into two, smaller, independently operating galley modules. This is done by moving some equipment from the center shelter into one of the two cooking/serving shelters, and then separating this cooking/serving shelter, together with its attached access shelter, from the battalion sized complex. This two-shelter complex is the intermediate sized galley module.

It is estimated that the small and intermediate modules will be capable of supporting 200 and 500 men, respectively.

Throughput is the limiting factor of the intermediate galley. It has one serving line, and at a typical rate of 8 men per minute, one and one-half hours would be needed to serve 500 meals. The cooking equipment of this module is adequate to prepare more meals, but to do so would require longer meal periods. The small unit galley contains a large enough variety of cooking equipment to prepare an A Ration meal, but it is limited by equipment capacity to serving an estimated 200 meals per day in comparable periods of time.

In addition to the galley section, the food service unit requires a sanitation section.

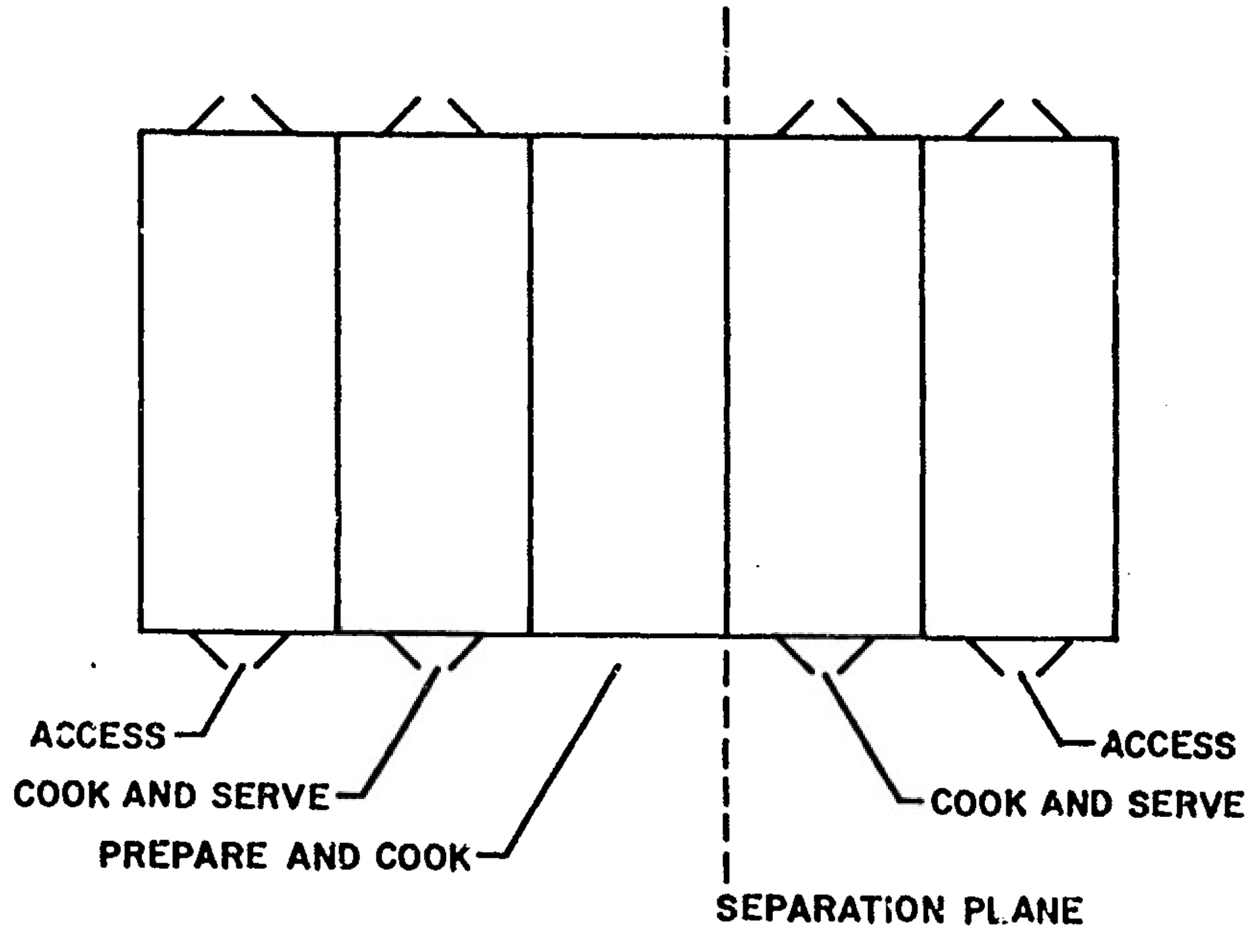


FIGURE I GALLEY SECTION

The battalion sized sanitation module consists of two ISO Shelters which are annexed side by side. One shelter contains a pot and pan washline, and the other contains a serving ware washline which includes an automatic traywasher.

This sanitation section can be separated into its component shelters to provide separate sanitation modules for use with the small and intermediate galley modules. The shelter containing the manual washline is intended to be used with the small galley module, and in this application it would be used for both pot and pan washing, and serving ware washing. Manual washing is relatively slow, and therefore imposes another limitation on the customer capacity of the small food service unit. The sanitation shelter which contains the traywasher, is intended for use with the intermediate galley module. In the resulting intermediate-sized food service unit, serving ware will be washed automatically in the sanitation module, and pots and pans will be washed in the sink in the center shelter of the galley module.

The design concept of the proposed food service unit employs water heaters which are external to both the galley and sanitation sections. Unlike the equipment within the modules, the water heaters are fuel fired, not electric. Electric water heaters were not proposed because of the large amount of power they require---about half that required by the rest of the food service unit---and because of their long recovery time. A long recovery time means that physically large heaters would be required to keep up with the demand for hot water, and commercially available heaters would have to be located within either the galley or sanitation section where space is limited.

The M-77 Water Heaters are proposed for use with the food service unit[6]. The M-77 is a complete, stand-alone water heater designed for use in the field. It is a demand type heater that is capable of supplying about 400 gallons of hot water per hour. A pump is included, which draws water from the water source, and delivers it under pressure to the point of use, either directly as cold water, or by a separate hose through the heater, as hot water. Two heaters are used with the battalion-sized unit to meet peak hot water demand, and so that one of the two heaters can accompany each of the small and intermediate food service units when the battalion unit is separated.

For shipboard use, the M-77 heaters should be located with the generator sets since, being fuel burning, they create the same safety hazards. From this location, hot and cold water can be piped to the galley module through the same utility chase used for power distribution.

Although reusable serving ware is generally required by the Marine Corps, disposable serving ware will be used for feeding Marines aboard ship to reduce the total requirement for fresh water. The Marine Corps plans to produce fresh water aboard ship by desalinating sea water. Disposable serving

---

[6]C. McKeown, Heater, Water and Circulating System for Field Kitchen M-1975 (Water Heater - M-77). Technical Manual (Draft), US Army Natick R&D Command, Natick, MA 01760. September 1977.

ware will reduce the fresh water demand on the desalinating equipment by about 1800 gallons per day per battalion-sized food service unit. Also, without serving ware to wash, the sanitation module will not need to be operated with either the battalion or the intermediate sized food service units. The sink in the center shelter of the galley section will suffice for pot and pan washing. Consequently, the redundant sanitation module can be stowed as cargo in the cargo area of the ship; only the galley section will need to be located and operated near the berthing area. Because it consists of fewer shelters, the galley section alone should be more adaptable to shipboard installation than the entire food service unit. The sanitation module will be needed, however, with the small food service unit, since this would be the only source of water for this unit.

A complete food service system also requires storage containers for both dry (ambient temperature) and refrigerated food storage. These storage containers are assumed will be standard Marine Corps items. The ISO Reefer has been assumed for chilled and frozen storage. This Reefer is 8 feet wide, 8 feet high, and 10 feet long. It complies with the ISO container specifications for strength and corner fittings, and it can be transported in the same way as the ISO Shelter. For dry storage the Quadcon has been assumed. It also is part of the Expeditionary Shelter System, complies with ISO specifications, and can be similarly transported.

Finally, it has been assumed that power will be supplied from three 60kW generator sets, and that potable water will be supplied from the Sixcon, or water module that is also a part of the Expeditionary Shelter System. The resulting food service system is schematically represented in its battalion configuration in Figure 2, and in the small and intermediate configurations in Figures 3 and 4, respectively.

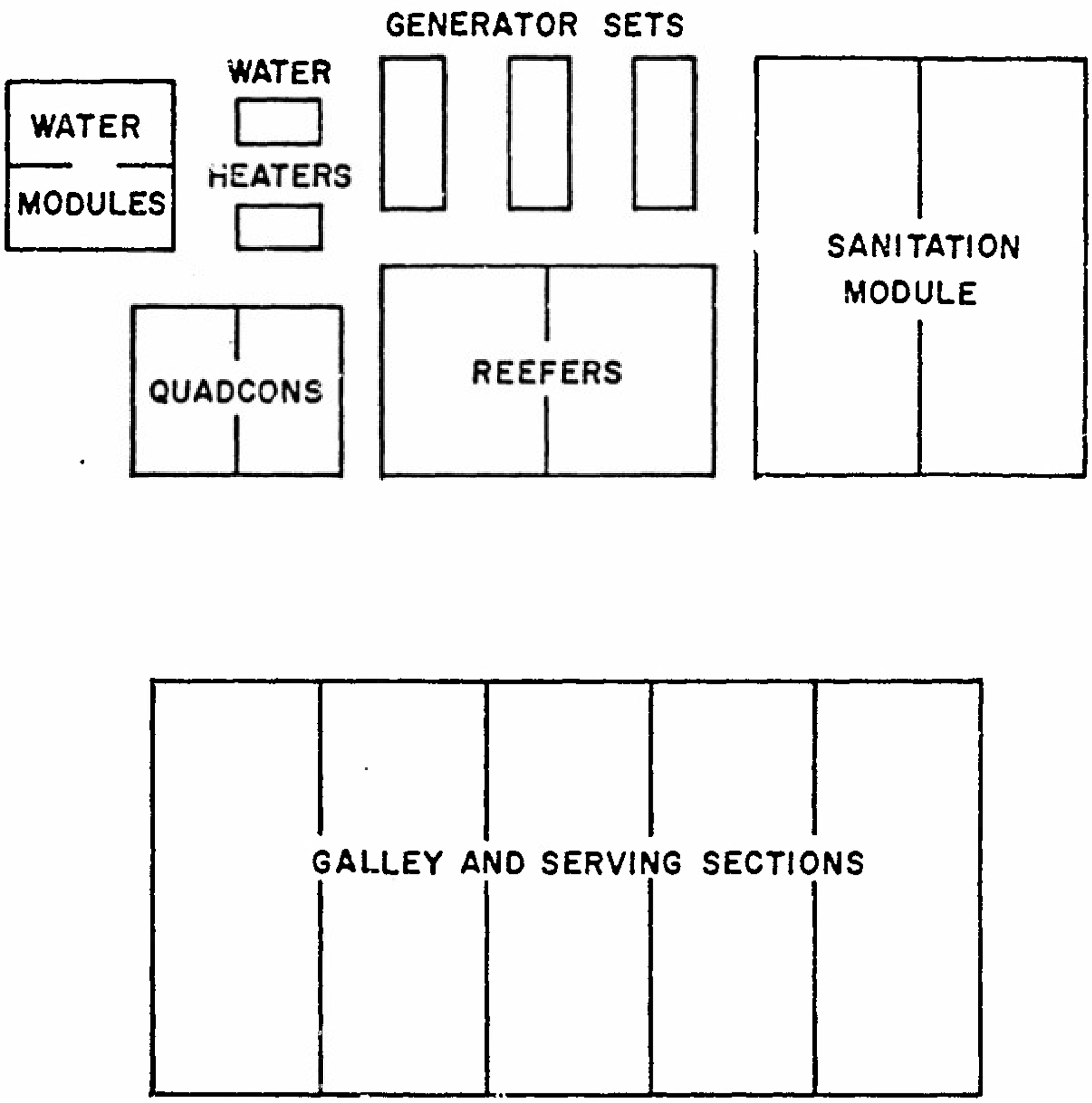


FIGURE 2 SHELTERIZED EXPEDITIONARY FOOD SERVICE SYSTEM BATTALION CONFIGURATION

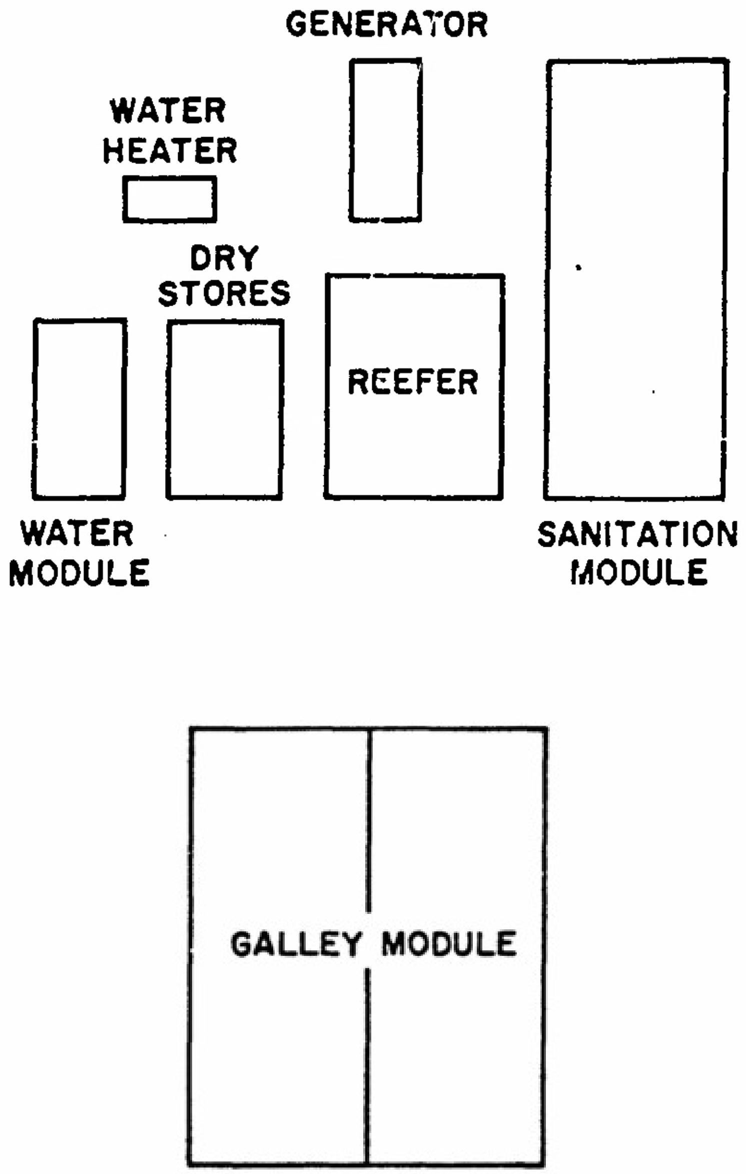


FIGURE 3 SHELTERIZED EXPEDITIONARY FOOD SERVICE SYSTEM SMALL UNIT CONFIGURATION

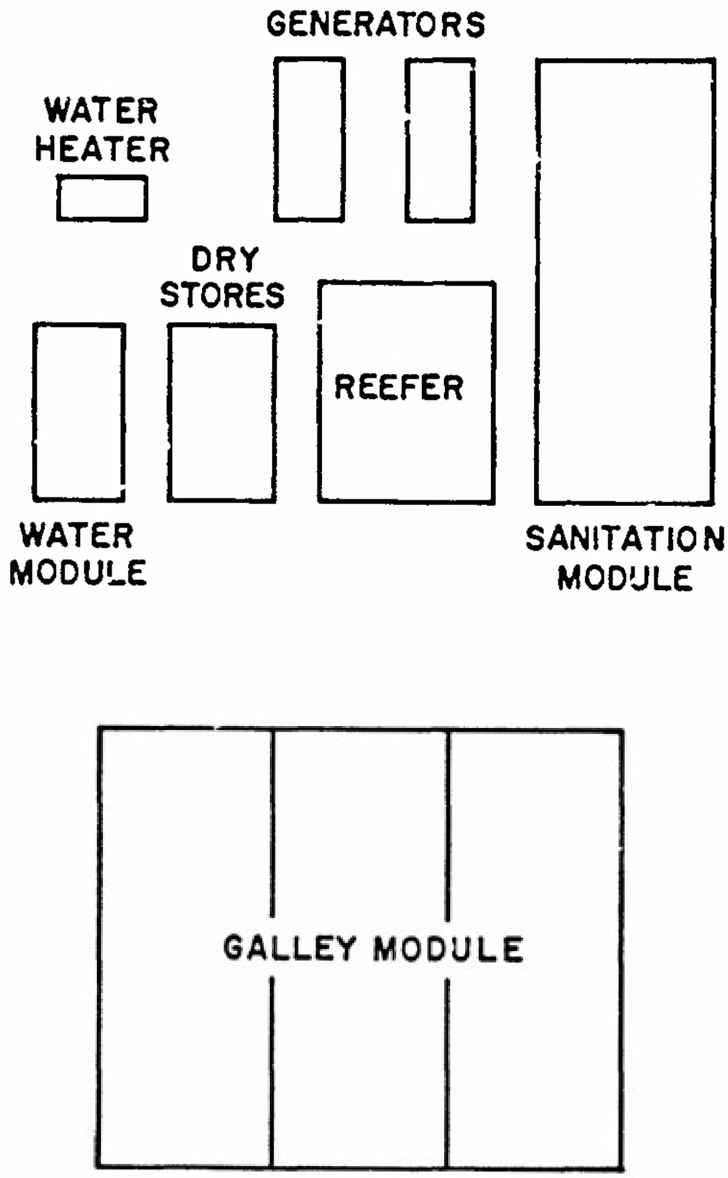


FIGURE 4 SHELTERIZED EXPEDITIONARY FOOD SERVICE SYSTEM INTERMEDIATE CONFIGURATION

SECTION II

UNIT DESIGN AND OPERATING PARAMETERS

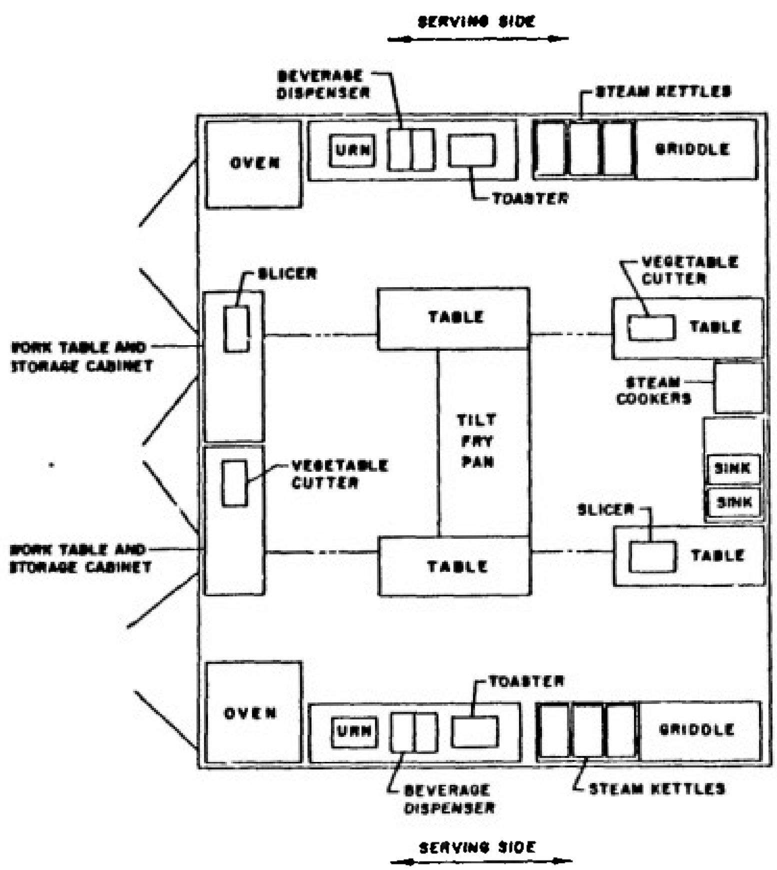
The following discussion briefly describes the equipment contained in the galley and sanitation sections, provides cost estimate of the complete food service unit and estimates the operating parameters for both shipboard and field applications.

EQUIPMENT DESIGN

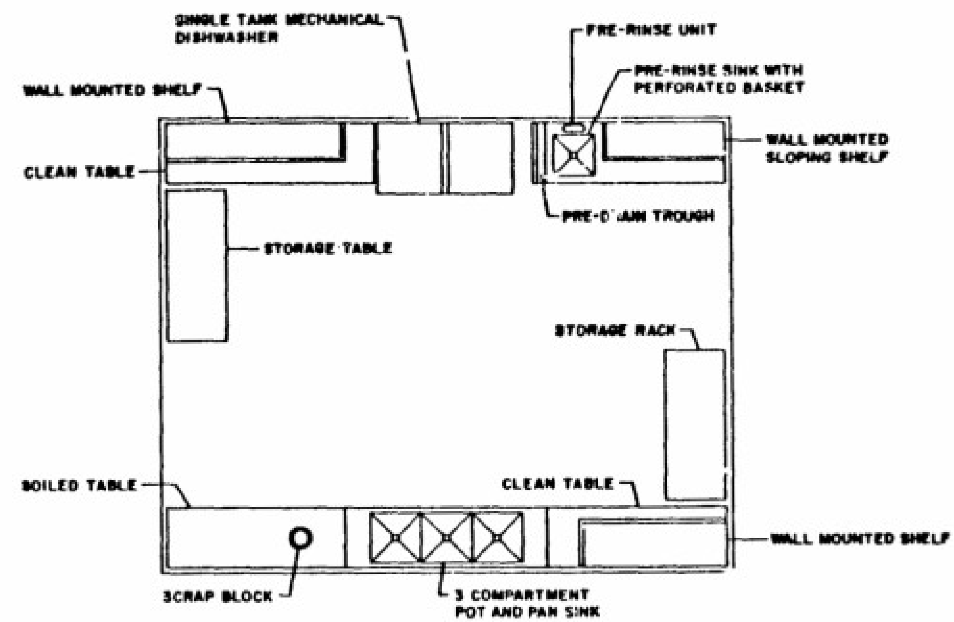
A layout of the battalion-size food service unit, Figure 5, shows the equipment arrangement in both the sanitation and the galley sections. The major pieces of equipment in the center shelter of the galley section are a tilt frypan and two steam cookers. The tilt frypan is especially useful for preparing large quantities of food; it is 24 inches wide and 40 inches long, and can be used for frying foods, such as eggs and potatoes or simmering liquids, such as soups and gravies. The frypan tilts so that liquid products, after being cooked, can be quickly poured out instead of ladled out. The steam cookers, which hold two half-size steam table pans, rapidly cook food, such as vegetables and seafood, with pressurized steam.

The center shelter also contains a sink to provide hot and cold water for food preparation and general clean-up, and tables to provide the necessary work surfaces. A sump pump, under the sink, pumps waste water out of the shelter.

The two cooking/serving shelters are identically equipped. Each contains a serving line which is adjacent to a side wall, so that when the wall is removed, the serving line is accessible to customers. Each serving line consists of a griddle, a three-well steam table, a storage cabinet, and a table which supports a toaster, coffee maker and two beverage dispensers. The griddle, with a cooking surface two feet wide and four feet long, can be used for grilling or frying prepared-to-order items, such as breakfast eggs, hamburgers, and steaks. The three-well steam table has a dual purpose: It can be used as a steam table to keep food warm on the serving line, or it can be used as a steam kettle for cooking. Each of the three wells in the steam table has a 15-gallon capacity, and foods, such as potatoes and pasta products, can be boiled in these wells. These kettles can also be used to reheat thermostabilized, convenience foods, such as the Tray Pack. A conveyor type toaster is sized to produce 960 slices of toast per hour, and the coffee maker is sized to produce 27 gallons of coffee per hour. For cold drinks, such as milk and fruit juices, insulated, 5-gallon container/dispensers are used. These would be filled before a meal and stored in a reefer to be kept chilled. At mealtime, they would be placed on the serving line as needed. Ten container/dispensers are specified for use with the unit, though no more than two would be needed on a serving line at any one time. Apart from the serving line, each cooking/serving shelter also contains a work table with a vegetable cutter and a cabinet/table with a meat slicer.



GALLEY SECTION



SANITATION SECTION

FIGURE 5 FLOOR PLAN, BATTALION CONFIGURATION

The access shelters, which are not shown in figure 5, would be annexed alongside the cooking/serving shelters. The access shelters do not contain any equipment, but they would be used to store and dispense serving ware, and to provide passageways to the serving lines.

The sanitation module, shown in figure 5, consists of two shelters, one containing a pot and pan washline, and one containing a serving ware washline. The pot and pan washline consists of a three-well sink flanked by a clean table and a dirty table. The dirty table has a built-in scrap block for removing garbage. The clean table is used to drain the pots, pans and kitchen utensils after they have been washed in the sink. The shelter also has a storage rack for the cleaned utensils and a sump pump under the sink to strain the dishwater and pump it out of the shelter.

The serving ware washline consists of a combination table/pre-rinse sink, an automatic serving ware washer and a clean table. A rack type washer, is capable of washing and sanitizing more than 1000 trays per hour. The shelter also has a table for storing cleaned serving ware.

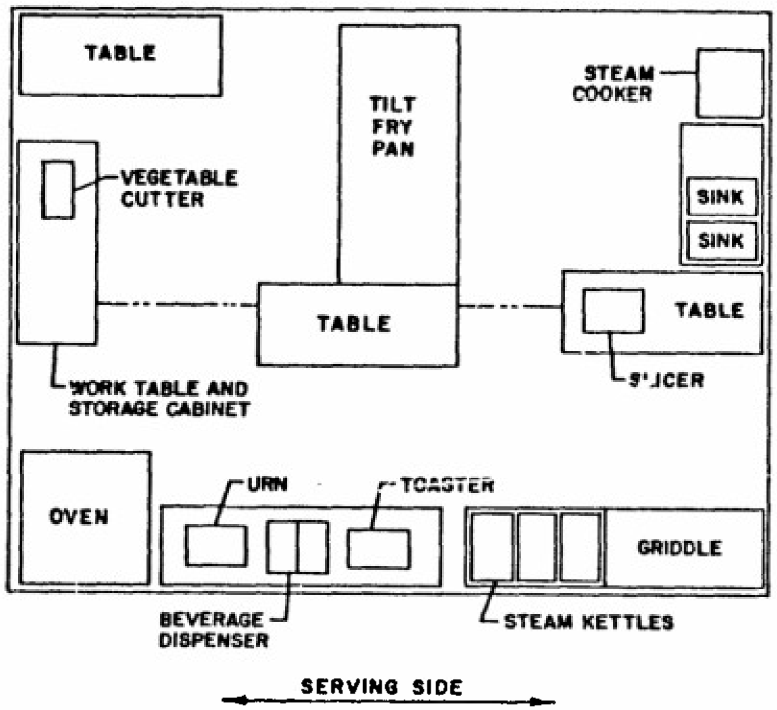
Figures 6 and 7 show the shelter and equipment configurations for the small and intermediate food service units.

SYSTEM COST

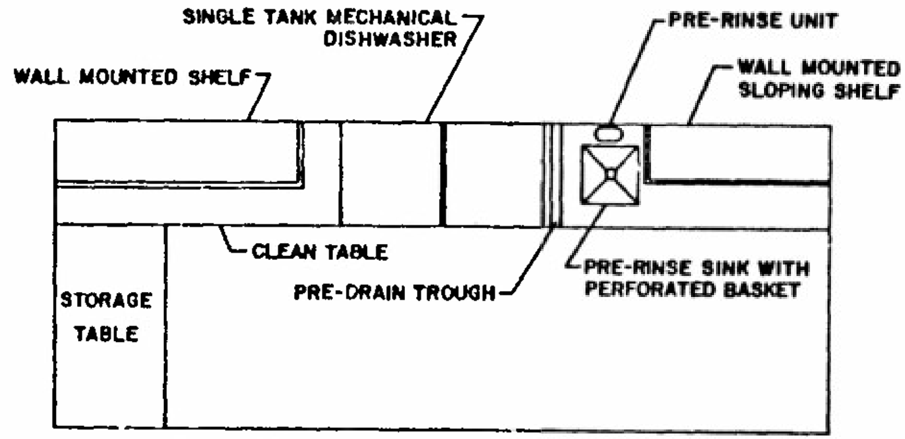
The equipment costs for the battalion sized galley and sanitation modules are tabulated below. These costs were supplied by the equipment manufacturers and are given in 1978 dollars.

Galley Equipment Costs:

Item	Number Required	Unit Cost	Total Cost
Griddles	2	$ 700	$ 1,400
Steam Kettle/Table	2	8,000	16,000
Oven	2	1,700	3,400
Steam Cookers	2	3,500	7,000
Tilt Frypan	1	2,840	2,840
Coffee Maker	2	1,750	3,500
Toaster	2	550	1,100
Vegetable Cutter	2	850	1,700
Food Slicer	2	700	1,400
Can Opener	2	95	190
Sink (3-Well)	1	590	590
Tables 6 ft	4	150	600
Tables	4	550	2,200
Sump Pump	1	100	100
Hoods, Duct Work, Exhaust Fans			1,385
Plumbing, Water Box			1,400
Electrical Cables, Connectors, Panel			2,260
Total			$ 47,065

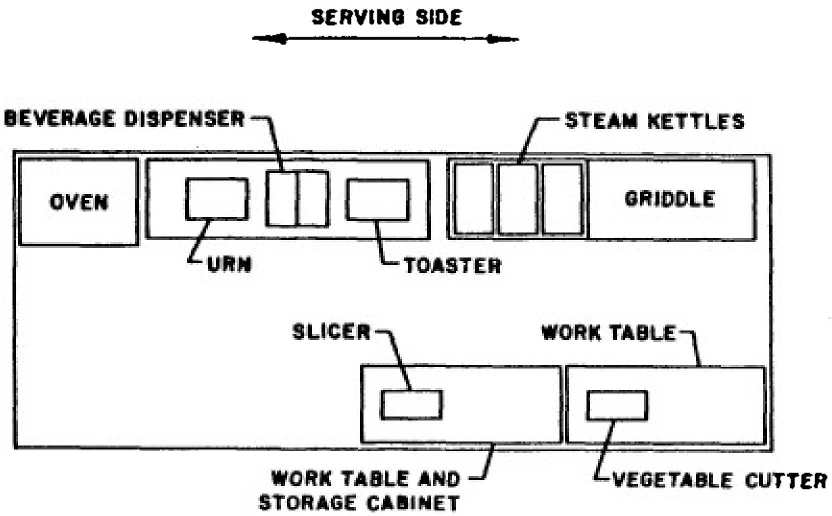


GALLEY SECTION

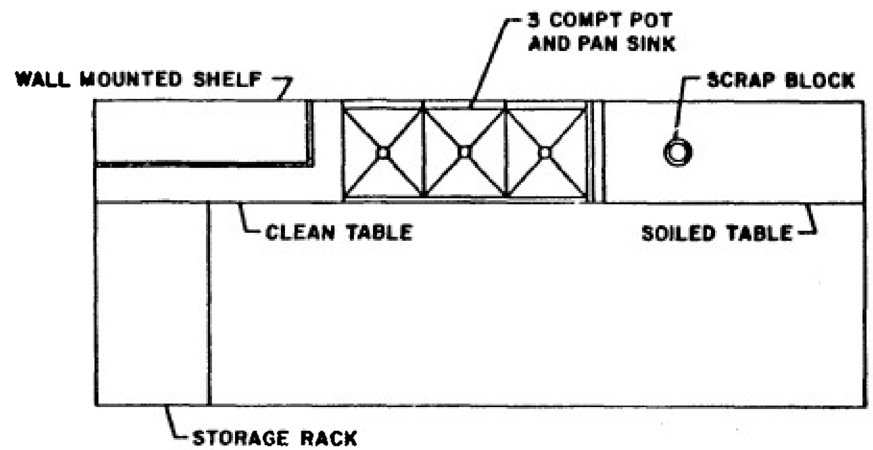


SANITATION SECTION

FIGURE 6 FLOOR PLAN, INTERMEDIATE CONFIGURATION



GALLEY SECTION



SANITATION SECTION

FIGURE 7 FLOOR PLAN, SMALL UNIT CONFIGURATION

Sanitation Equipment Costs:

Item	Number Required	Unit Cost	Total Cost
Tray Washer	1	$ 7,500	$ 7,500
Sink (3-Well)	1	590	590
Clean Table	2	330	660
Pre-Drain Trough	2	50	100
Pre-Rinse Unit/Sink	1	625	625
Dirty Table	1	330	330
Scrap Block	1	25	25
Sump Pump	2	100	200
Plumbing, Water Box			1,400
Electrical Cables, Connectors, Panel			2,260
Total			$13,690

Seven shelters are needed to house the food service unit, five shelters for the galley section and two for the sanitation section. The passive storage requirements of the food service unit can be met by two Quadcon containers, which will hold about a five-day supply of dry food stores, and by two water modules, which will hold about two-thirds of a day's supply of potable water. The shelter/container costs are also given in 1978 dollars.

Shelter/Container Costs:

Item	Number Required	Unit Cost	Total Cost
ISO Rigid Shelters	7	$13,000	$ 91,000
Quadcons	2	2,400	4,800
Water Modules	2	4,500	9,000
Total			$104,800

Support equipment consist of ISO Reefers for refrigerated food storage, generator sets to supply power, and M-77 Water Heaters.

Support Equipment Cost:

Item	Number Required	Unit Cost	Total Cost
ISO Reefer	2	$15,000	$ 30,000
Generator Set (MEP 006)	3	14,500	43,500
M-77 Water Heater	2	3,800	7,600
Total			$ 81,100

The particular storage containers and generator sets listed above are for analysis and cost estimating purposes only. In operation, the equipment used for storage and power generation would not necessarily be those listed. Nevertheless, the items listed are realistic choices and could be employed in practice. The storage containers and reefers are all part of the Expeditionary Shelter System and will be available to support the food service unit. The containers and the water heaters are specified in pairs to support the battalion size unit, so that each pair can be separated to provide individual support for each of the small and intermediate food service units if the battalion unit is separated.

The choice of sets to supply power for the food service system was based on three factors: compatibility, portability, and redundancy. Compatibility means that the generators selected must be capable of meeting the feeding system's power requirements. Portability is a function of the weight of a generator set. The materials handling equipment associated with the Exepditionary Shelter System has a load limitation of 10,000 pounds, and items weighing more than 10,000 pounds can only be moved with special equipment. Redundance means two or more generator sets used in parallel, rather than one, to supply power. Redundancy is desirable in the event of a generator failure. The choice of generators also depends on how the food service system is to be used.

The selection of three 60kW generator sets is the most practical for all applications. The three generators together satisfy the feeding system's power requirement when complexed; two of the generators will power the intermediate-size food service system, and the third will power the small unit system. The generator sets are also relatively light and, therefore, portable, and with three sets in parallel supplying power, a generator failure would not completely shut down the food service system. The cost of a complete food service system is summarized in Table 1.

TABLE 1

FOOD SERVICE SYSTEM COST

Item	Cost
Galley Equipment	$ 47,065
Sanitation Equipment	13,690
ISO Reefers	30,000
M-77 Water Heaters	7,600
Generator Sets	43,500
ISO Rigid Shelters	91,000
Quadcons/Water Modules	13,800
Total	$246,655

OPERATIONAL ANALYSIS (ASHORE)

An operational analysis was performed on the proposed food service unit to estimate its major operating parameters. The analyses are contained in the Appendix, and the results are summarized below in Table 2.

TABLE 2

OPERATING PARAMETERS (ASHORE)

Parameter	Complexed	Intermediate/Small
Feeding Level (men)	1000	500/200
Water Consumption (gal/day)	3019	1654/752
Power Consumption (kW)	185	125/60
Fuel Consumption (gal/day)	334	221/106
Personnel, Food Service	12	6/3
Personnel Messmen	18	9/4
Waste (lbs)	2152	1077/431

The food service unit is designed to be most efficient when operating at the battalion level. When it is separated into the smaller food service units, the resulting loss in efficiency reduces the total number of customers that can be fed from 1000 to 700. The small food service unit (200-man) is inefficient. It lacks the equipment necessary to prepare more than 200 rations per day, and lacks the sanitation facilities necessary for warewashing at higher serving levels. The intermediate food service unit (500-man) is limited by the number of customers that can pass through the serving line during the serving period of approximately one and one-half hours.

The per man consumption rate for the battalion unit, 3 gallons per man per day, is lower than the consumption rate for the two separate configurations, 3.4 gallons per man per day. This difference in water consumption is the result of the manual method of warewashing used in the small food service unit.

The water consumption rates are derived in Appendix A.

The power consumption rate calculated in Appendix B and the fuel consumption rate calculated in Appendix C are based on the use of three 60kW generators to supply power.

The personnel estimates in Table 2 are not based on published staffing guides. The proposed food service unit contains labor saving devices and operates exclusively on electric equipment which is especially convenient to use. Consequently, staffing guides, developed for conventional food service operations, would overestimate the personnel requirements of the proposed unit. Instead, they are derived from the work sampling data gathered during the Camp Pendleton[7] experiment which did include some labor saving devices. These estimates will be verified by testing a prototype of the proposed food service unit in a field feeding environment.

The proposed food service unit does not include any office space for supervisory and administrative functions. It is assumed that the battalion will have shelters designated for administrative functions, and that the food service

[7]Baritz, Op. cit.

supervisor will be located in one such shelter.

The waste estimates, derived in Appendix E, treat dry trash and wet garbage separately, and include estimates of both weight and volume. These waste estimates are approximate, and, as in the case of staffing requirements, better estimates will result from field testing a prototype of the proposed food service unit.

OPERATIONAL ANALYSIS (SHIPBOARD)

Because of different operating conditions, the operating requirements of the food service unit aboard ship are different from those of the unit in the field. To estimate the shipboard requirements, three assumptions have been made about these operating conditions.

Disposable serving ware will be used aboard ship. As a consequence, the sanitation module will be used only with the small food service unit and not with either the battalion or intermediate size units.

The first assumption is that the ship will not be resupplied during a 15 day transit period. This assumption is needed because, without resupply, all consumables for the trip must be stowed aboard prior to embarkation, and those consumables that require refrigerated storage affect food service system parameters, such as power demand, fuel consumption and space requirements. The period of 15 days is not related to a particular requirement, but represents a reasonable maximum transit time, since a container ship can travel almost half way around the earth in that time. The data, methods and results contained in the Appendix can be simply adjusted to compute food service system parameters and requirements for any other desired transit time.

The second assumption is that fresh milk will be included in the shipboard menu. Fresh milk, however, has a limited refrigerated storage life which, in the analysis, is taken to be seven days. From the eighth day on, a powdered milk substitute will be used. This assumption minimizes the refrigerated storage requirement and increases the amount of water needed to rehydrate the powdered milk.

The third assumption is that the same 60 kW generator sets used in the field will also be used aboard ship to power the food service system. This assumption was made to keep the shipboard analysis consistent with the ashore analysis, and because the assumption of a particular generator set is required in order to calculate the fuel consumption rate. The consumption rates, based on 60 kW generators, listed in Table 4 are conservatively high, since larger and more efficient generators will probably be used aboard ship.

TABLE 3

FOOD AND SERVING WARE STORAGE REQUIREMENTS

Item	Daily Requirement Weight (lb)	Daily Requirement Volume (ft^3)	Type Container	Number Required 1000/500/200
Dry Food	2530	68.1	Quadcon	6/ 3/ 1
Serving Ware	525	48.3	Quadcon	4/ 2/ 1
Chilled/Frozen Foods	2450	89.4	ISO Reefer	6/ 3/ 1
Milk	1680	26.6	ISO Reefer	2/ 1/ 1

Table 3 contains the ambient and refrigerated storage requirements for food and serving ware. The daily requirement is the weight and volume of each item per 1000 men per day. The last two columns list the type and number of containers needed to store a 15 day supply of each of the first three items and a 7-day supply of milk. The number of containers required column is determined for the number of customers served by each of the battalion, intermediate, and small food service units. For example, the battalion size unit, supporting 1000 men, will need four Quadcons to store a 15-day supply of serving ware, and the small unit, supporting 200 men, will need one Quadcon to store a 15-day supply of serving ware. The required number of containers cited in the table are estimated in Appendix D.

Table 4 contains the power, water and fuel requirements for each size food service unit.

TABLE 4

POWER, WATER AND FUEL REQUIREMENTS

Item	Battalion Unit	Intermediate Unit	Small Unit
Power (kW)	162	94	63
Fuel (gal/day)	275	167	109
Water (gal/day)			
First 7 Days	1776	1032	586
Last 8 Days	2038	1163	638

The power and fuel figures reflect the assumption that the generators which power the food service unit will also power the M-77 Water Heaters and the ISO Reefers needed for refrigerated storage. If fuel is stored in the 1000-gallon fuel modules, a 15-day supply of fuel will require 4-, 3-, and 2-fuel modules, respectively, for the battalion, intermediate, and small food service units. The water requirement for the first seven days at sea is the estimated daily water requirement, assuming fresh milk will be served at meals. The daily water requirement increases during the last eight days at sea by the amount of water that will be required to rehydrate the powdered substitute for fresh milk.

The amount of waste generated per day and for the entire 15 day, for each size food service unit are contained in Tables 5 and 6.

TABLE 5

WASTE GENERATED PER DAY

Type Waste	Battalion Unit	Intermediate Unit	Small Unit
Dry Trash			
Weight (lbs)	1427	714	285
Volume (ft^3)	295	148	59
Wet Garbage			
Weight (lbs)	1229	615	246
Volume (ft^3)	23	12	5
Waste Water			
Volume (gal)	788	538	388

TABLE 6

WASTE GENERATED PER 15 DAYS

Type Waste	Battalion Unit	Intermediate Unit	Small Unit
Dry Trash			
Weight (lbs)	21,405	10,710	4,275
Volume (ft^3)	4,425	2,220	885
Wet Garbage			
Weight (lbs)	18,435	9,225	3,690
Volume (ft^3)	345	180	75
Waste Water			
Volume (gal)	11,820	8,070	5,820

Dry trash is packaging waste consisting of paper, metal, glass, and plastic, plus the discarded paper and plastic serving ware; wet garbage is primarily food waste. The waste generated by a food service unit is a highly variable quantity, and the estimates given above are only approximate. The data and methods used in deriving these estimates are contained in Appendix E. Waste water is the water drained from the sink in either the galley or the sanitation module, and includes water from dishwater, water discarded after being used to prepare and cook food.

The proposed food service unit has exhaust hoods above the cooking equipment in the galley section. Heated air and food vapors produced by cooking are collected by these hoods and blown out of the galley section by exhaust fans. The galley section exhaust - 6000 CFM - is released to the atmosphere when the unit is operated in the field, but, for shipboard operation, this exhaust will be input into the ventilation system for the ships hold, and therefore, must be considered as one of the shipboard operating parameters.

SECTION III

ALTERNATIVES TO THE PROPOSED FOOD SERVICE UNIT

The proposed food service unit was developed by identifying and evaluating various alternatives for satisfying the operational requirements listed in Section I. A summary of the evaluations of two alternatives --- manual warewashing instead of automatic warewashing and the use of electric water heaters instead of the M-77 heaters is presented in this section to supply the rationale for the choices that were made for the proposed unit.

MANUAL WAREWASHING

The automatic warewashing machine is the single most expensive piece of kitchen/sanitation equipment (about $7,500) proposed for use with the food service unit. Manual warewashing would eliminate this equipment cost and is, therefore, considered as an alternative.

A sanitation section designed for manual warewashing would consist of three wash lines built into three rigid, ISO shelters. The major items in each wash line would be a dirty table with a scrap block, a three-well sink, and a clean table. The equipment costs for this manual sanitation section are shown below and are given in 1973 dollars:

Item	Number Required	Unit Cost	Total Cost
Sink	3	$ 590	$ 1,770
Clean Table	3	330	990
Pre-Drain Table	3	50	150
Dirty Table	3	330	990
Scrap Block	3	25	75
Sump Pump	2	100	200
Hoods, Duct Work, Exhaust Fans			1,385
Plumbing, Water Box			1,400
Electrical Cables, Panel, Connectors			1,000
Total			$ 7,960

This is about $5,500 less than the equipment cost, $13,690 for the proposed sanitation section with the automatic warewasher. However, this cost savings is more than offset by the $13,000 increased cost for the additional shelter required by the manual warewashing alternative.

The cost of this alternative is also affected by the reduced power requirement. Without the automatic warewasher, the manual sanitation module requires less power. From Appendix B, the power demand of a food service unit using manual warewashing is 146 kW. This power demand could be met by a 100-kW generator set (MEP 007) together with a 60-kW generator set (MEP 006A).

The costs of these generator sets are:

100 kW (MEP 007)	$34,872
60 kW (MEP 006A)	14,500
Total	$49,372

Three 60-kW generator sets, at a lower cost of $43,500 could also be used to supply the unit's power, but the 100-kW/60-kW combination was chosen in this evaluation because the 100-kW generator is more fuel efficient (8.5 gallons per 100 kW hr) than the 60-kW generator (10 gallons per 100 kW hr).

All other costs for this alternative would be the same as for the proposed unit. The cost summary for the manual warewashing alternative is:

Item	Cost
Galley Equipment	$ 47,065
Sanitation Equipment	7,960
ISO Reefers	30,000
M-77 Water Heaters	7,600
Generator Sets	49,372
ISO Rigid Shelters	104,000
Quadcons/Water Modules	13,800
Total	$259,797

Table 7 is a comparison between the cost and operating parameters of the proposed unit and the alternative manual warewashing unit. In this table, the figures for water and fuel consumption are taken from Appendices A and C.

TABLE 7

AUTOMATIC SYSTEM VS. MANUAL WAREWASH SYSTEM

Parameters	Automatic	Manual
Shelters	7	8
Water Consumption	3019 gal/day	2606 gal/day
Power Consumption	170 kW	146 kW
Fuel Consumption	310 gal/day	245 dal/day
Messmen	18	20
Costs		
Sanitation Equipment	$ 13,690	$ 7,690
Sanitation Shelters	26,000	39,000
Generator Sets	43,500 (60/60/60 kW)	49,372 (100/60 kW)
Total System Cost	$246,655	$259,797

As seen from Table 7, a manual warewashing system would require less water, power, and fuel, than the proposed unit with an automatic warewasher. It would, however, require an additional shelter for the sanitation function and two additional messmen. As a result, the total system cost for the manual alternative is greater than the cost of the proposed system. If the manual alternative were powered by the 60 kW generators, the alternative would still be more expensive, ($253,925), than the proposed unit.

ELECTRIC WATER HEATING

Electric water heaters would be less expensive and require less maintenance than the proposed M-77 water heaters. A food service unit designed to take advantage of the low cost and maintenance of electric heaters would require two tank-type water heaters, two water pumps, and three booster heaters would be needed in the sinks and warewasher to maintain water temperature during sanitizing, because appropriately sized electric water heaters would not have the recovery capacity to supply replacement hot water at the rate needed to maintain correct water temperature during the sanitizing operation.

The galley section would require one booster heater at a cost of $270. The total galley section equipment cost for this alternative would be, therefore, $270 more than the galley equipment cost for the proposed system or, $46,065 + $270 = $47,335.

The sanitation section would also require one booster heater, and the resulting equipment cost would be:

Item	Number Required	Unit Cost	Total Cost
Water Heaters	2	$ 905	$ 1,810
Booster Heater	1	270	270
Pumps	2	400	800
Proposed Sanitation Unit Equipment Costs			13,960
Total			$16,840

As shown in Part II of the appendix, the power demand of this alternative would be 285 kW. This power demand could be met by a 200-kW generator set (MEP 009) in parallel with a 100-kW generator set (MEP 007) at a cost of:

200 kW MEP 009	$40,684
100 kW MEP 007	34,872
Total	$75,556

Excluding the M-77 Water Heater costs, the remaining costs for this alternative are the same as those of the proposed food service system.

The cost summary for the all electric alternative to the proposed food service system follows:

Item	Cost
Galley Equipment	$ 47,335
Sanitation Equipment	16,840
ISO Reefers	30,000
Generator Sets	75,556
ISO Rigid Shelters	91,000
Quadcons/Water Modules	13,800
Total	$274,531

There would be no difference in the number of shelters required, the water consumption rate, or the required number of messmen between the all-electric alternative and the proposed system. The only significant difference between the two systems is between their investment costs, about $275,000 for the all-electric alternative and about $247,000 for the proposed system. This difference of $28,000 is due to the larger generator sets required for the all-electric food service system, which more than offsets the cost savings achieved by replacing the M-77 heaters, with electric water heaters.

LIST OF REFERENCES

Baritz, S. G., et. al, The Camp Pendleton Experiment in Battalion Level Field Feeding. TR 7T-4-OR/SA, US Army Natick R&D Laboratories, Natick, MA 01760. July 1976 (AD A028 346).

Baritz, S. G. et. al, The Camp Edwards Experiment in Battalion Level Consolidated Field Feeding. TR 76-45-OR/SA, US Army Natick R&D Laboratories, Natick, MA 01760. December 1975 (AD A024 070).

Bond, D. A., System Analysis and Design Study for a Family of Standard Shelters and a Logistics Trailer. NORT 71-124, (Final Report), NASC Contract N00019-71-C-0499, December 1971.

Erection, Operation, Storage, Inspection and Maintenance Instruction, Kitchen Facility, Bare Base, T. O. 35E4-129-1, (Part Number 7333545-10). 17 September 1973.

Marine Corps Expeditionary Shelter System (MCESS) Study, (Summary Report). Navy Contract N00600-75-D-9814, HW19, February 1977.

McKeown, C., Heater, Water and Circulating System for Field Kitchen M-175 (Water Heater - M-77). Technical Manual (Draft), US Army Natick R&D Laboratories, Natick, MA 01760. September 1977.

Mobile Electric Power Engine Generator Standard Family Characteristics Data Sheets, MIL-STD-633D, 30 September 1974.

Southwest Asia: Environment and Its Relationship To Military Activities, TR EP-118, Quartermaster Research & Engineering Center, Environmental Protection Research Division, Natick, MA 01760. July 1959 (AD 227 067).

APPENDIX A

WATER CONSUMPTION

APPENDIX A

WATER CONSUMPTION

This part of the appendix contains the derivation of the water consumption rates for the proposed food service unit, and for the manual warewashing alternative to the proposed unit. These consumption rates are calculated separately for unit operation in the field, aboard ship, and in each of the small, intermediate and battalion sizes.

The first section of this part of the appendix defines five categories of water use, and derives the water use rate in gallons of water used, per customer served, per day for each water use category, assuming that three meals per day are served. The total consumption rates of the food service units are derived in subsequent sections by summing the water use rates of those categories that are appropriate for each of the different food service units under their different operating conditions.

Water Use Rates By Category

The galley water category consists of water used for food and beverage preparation and general cleanup within the galley section. The amount of water needed for food and beverage preparation was computed from the Viet Nam 28-day menu and is 0.858 gallons per man per day. The amount of water needed for cleanup is estimated to be 0.02 gallons per man per day, and the total galley water use rate is the sum of these, which is 0.878 gallons per man per day.

Of this total galley use rate, only 0.378 gallons per man per day becomes part of the food and prepared beverages that are served to and consumed by the customers. The water retained by the cooked food is contained in the .378 gallons/man/day figure while the remainder of the food preparation water, such as water used for boiling spaghetti or potatoes, is subsequently drained from the prepared food and discarded. In addition to the prepared beverages, fresh milk is also served and consumed at the rate of 0.262 gallons per man per day, and this brings to 0.64 gallons per man per day the total volume of liquids received by the individual Marine from the food service unit. This is less than an individual's daily requirement for liquids. An individual needs to consume between 0.5 and 5 gallons of water per day from all sources, depending on his environment and level of activity. It is assumed that when ashore, the individual will have sources of water other than the food service unit available to him, such as his canteen which may be filled at a water trailer, and that these other sources of water do not contribute to the water consumption rate of the food service unit. However, for shipboard operation, it is assumed that the food service unit will be the only source of liquids for its customer population, and that any necessary beverages supplementary to the ordinary mealtime beverages will contribute to the food service unit's water consumption rate.

In this evaluation, an individual's daily water requirement is taken to be 1.25 gallons per day.[8] This is the water requirement of a man doing moderately hard work, outside in the sun, for eight hours per day, with an ambient temperature of 85°F. The difference between this daily requirement and what is ordinarily supplied through the food service unit -- 0.61 gallons per man per day -- is termed the supplementary water use rate.

Because of its limited storage life, it is assumed that fresh milk will be served aboard ship only for the first seven days at sea, and that thereafter, powdered milk will be served as a substitute. Assuming the milk substutute is consumed at the same rate as milk, 0.262 gallons per man per oay, the amount of water needed to rehydrate the milk substitute, termed rehydration water, will also be 0.262 gallons per man per day.

In addition to the galley use water, supplementary water and rehydration water, all of which are food related, water is also needed for the sanitation operations. The calculation of the water required for the traywasher is based on the manufacturer's equipment specifications and on the volume of serving ware that will need to be washed each day. This water requirement, termed traywasher water, is 1.853 gallons per man per day. For washing pots, pans and galley utensils, the sinks in either the galley or sanitation module will be used. The amount of water needed to fill the sinks' wells, termed "sink water", is 96 gallons.

It will be convenient in the following sections to refer to the water use rates of these five categories with abbreviations. The following table lists these use rates and assigns an appropriate abbreviation to each:

Category	Abbreviation	Use Rate
Galley Use Water	Gly	0.878 gal per man per day
Supplementary Water	Sup	0.61 gal per man per day
Rehydration Water	Reh	0.262 gal per man per day
Traywasher Water	Try	1.853 gal per man per day
Sink Water	Sin	96 gal per fill

PROPOSED FOOD SERVICE UNIT (ASHORE)

In the case where the food service unit is operating at the battalion (1000-man) level, where fresh milk is available and being served, and where the food service unit is not the sole source of liquids for its customers, the unit will need water to prepare food (galley water), to sanitize serving ware (traywasher water), and to wash pots and pans (sink water). The water consumption rate is calculated, in this case by adjusting the individual water use rates for 1000 men, and adjusting the sink water for three fills per day, one per meal, to give:

---

[8] Southwest Asia: Environment and Its Relationship to Military Activities. TR EP-118, Quartermaster Research and Engineering Center, Environmental Protection Research Division, Natick, MA 01760. July 1959 (AD 227067).

$$1000 \times (Gly + Try) + 3 \times Sin = 3019 \text{ gal/day.}$$

In the case where fresh milk is not available, and powdered milk is substituted, rehydration water will have to be included in the above equation to give:

$$1000 \times (Gly + Try + Reh) + 3 \times Sin = 3281 \text{ gal/day.}$$

In the case where the food service unit is the sole source of liquids for its customer population, supplementary water will have to be included in the above equations to give, when fresh milk is available:

$$1000 \times (Gly + Try + Sup) + 3 \times Sin = 3629 \text{ gal/day,}$$

and when powdered milk is used:

$$1000 \times (Gly + Try + Reh + Sup) + 3 \times Sin = 3891 \text{ gal/day.}$$

Following is a summary of the results for the water consumption rates, in gallons per day, for the proposed food service unit operating ashore at the battalion level:

	Fresh Milk	Powdered Milk
Menu Liquids	3019	3281
All Liquids	3629	3891

In the case where the proposed food service unit is operated at the intermediate level, the water consumption rates are calculated the same way, except that the use rates are adjusted for 500 men instead of 1000 men. Following are the results of these calculations in gallons per day:

	Fresh Milk	Powdered Milk
Menu Liquids	1654	1785
All Liquids	1959	2090

In the case where the food service unit is operated at the small (200-man) level, the traywasher is not used and all washing is done in the sanitation module sink, which will have to be filled twice per meal, or six times per day, in order to wash both serving ware and pots and pans. The total water consumption rate for the small food service unit, when fresh milk is served, and the unit is not the sole source of liquids for its customers, is:

$$200 \times Gly + 6 \times Sin = 752 \text{ gal/day.}$$

Similar calculations for the other operating conditions give the following results in gallons per day:

	Fresh Milk	Powdered Milk
Menu Liquids	752	804
All Liquids	874	926

PROPOSED FOOD SERVICE UNIT (SHIPBOARD)

Aboard ship, disposable serving ware will used, thereby eliminating the need for serving ware washing. Pot and pan washing will be performed in the galley module sink of the battalion and intermediate size units, and in the sanitation module sink of the small food service unit. In each case, the sink will have to be filled once per meal. It is assumed that aboard ship the food service unit will be the sole source of liquids for its customers. The battalion size food service unit's water consumption rate is, therefore, when fresh milk is served:

1000 x (Gly + Sup) + 3 x Sin = 1776 gal/day,

and, when powdered milk is served,

1000 x (Gly + Sup + Reh) + 3 x Sin = 2038 gal/day.

Similar calculations give the water consumption rates for the intermediate and small food service units. The results of these calculations in gallons per day follow:

	Battalion Unit	Intermediate Unit	Small Unit
Fresh Milk	1776	1032	586
Powdered Milk	2038	1163	638

MANUAL WAREWASHING ALTERNATIVE

The sanitation section of a food service unit designed for manual warewashing would consist of three wash lines, each composed of a three-well sink, and clean and dirty tables. To wash both serving ware and pots and pans, each sink will have to be filled twice per meal. The water consumption rate of the manual warewashing alternative to the proposed food service unit when it is operating at the battalion level, serving fresh milk, and when it is not the sole source of liquids is:

1000 x Gly + 18 x Sin = 2606 gal/day.

The sanitation module of the intermediate size unit (500-man) consists of two wash lines, and the sanitation module of the small (200-man) unit consists of only one wash line. The water consumption rates of these units, operating under the same conditions as for the battalion unit above, are, for the intermediate size unit,

500 x Gly + 12 x Sin = 1591 gal/day,

and for the small unit,

200 x Gly + 6 x Sin = 752 gal/day.

Similar calculations give the water consumption rates for the other operating conditions. The results of these calculations, in gallons per day, are:

	1000 Man Unit	500 Man Unit	200 Man Unit
Fresh Milk, menu liquid	2606	1591	752
Fresh Milk, all liquids	3216	1896	874
Powdered Milk, menu liquids	2868	1722	804
Powdered Milk, all liquids	3478	2027	926

APPENDIX B

POWER REQUIREMENTS

APPENDIX B

POWER REQUIREMENTS

This appendix contains the derivations of the power requirements of the proposed food service unit, and of the manual warewashing and all-electric alternatives to the proposed unit. In the first section of this appendix the power demands of the galley and sanitation sections are derived. The section also lists the power requirements of the ISO Reefer, the M-77 Water Heater, and the electrical equipment used in the alternative units. The power requirements of the complete food service systems are derived in subsequent sections from these subsystem power requirements.

POWER DEMAND BY SUBSYSTEM

The galley section's power demand is the sum of the power demands of its electrical equipment. The following power demand figures, in kilowatts, were supplied by the equipment manufacturers:

GALLEY MODULE EQUIPMENT

Item	Number Required	Unit Power	Battalion Unit	Intermediate Unit	Small Unit
Griddle	2	16	32	16	16
Steam Kettle/Table	2	32.4	64.8	32.4	32.4
Oven	2	11	22	11	11
Steam Cookers	2	10.8	21.6	21.6	
Tilt Fry Pan	1	15	15	15	
Coffee Maker	2	12	24	12	12
Toaster	2	5	10	5	5
Vegetable Cutter	2	0.3	0.6	0.3	0.3
Food Slicer	2	0.3	0.6	0.3	0.3
Can Opener	2	0.1	0.2	0.1	0.1
Sump Pump	1	0.3	0.3	0.3	
Exhaust Fan	3	0.4	1.2	0.8	0.4
Lights	5	0.3	1.5	0.9	0.6
Maximum power demand			193.8 kW	115.7 kW	78.1 kW

The totals above are the maximum amounts of power that would be drawn if every piece of equipment were turned on simultaneously. In actual operation, not all pieces of equipment will be in use simultaneously, and those equipment items which are temperature controlled will cycle on and off during operation in order to maintain the set temperature. For this reason, engineering practice is to use, as an estimate of system peak power demand 70% of the above maximum power demand figures. Therefore, galley module power demand is estimated to be:

Battalion System	193.8 kW x 0.7 = 135.7 kW
Intermediate System	115.7 kW x 0.7 = 81.0 kW
Small System	78.1 kW x 0.7 = 54.7 kW

For the sanitation module, the equipment and power demands in kilowatts are:

SANITATION MODULE EQUIPMENT

Item	Number Required	Unit Power	Battalion Unit	Intermediate Unit	Small System
Tray Washer[a*]	1	23.7	23.7	23.7	
Sump Pump	2	0.3	0.6	0.3	0.3
Exhaust Fan	2	0.4	0.8	0.4	0.4
Lights	2	0.4	0.6	0.3	0.3
Maximum sanitation module power demand			25.7 kW	24.7 kW	1 kW

[a*]As supplied by the manufacturer, the tray washer requires 56.7 kW. Of this total, 45 kW is used to power an internal booster heater which is used to raise the standard temperature (140°F) of the input water to the 180°F needed for proper sanitation. However, the M-77 Water Heater proposed for use with the food service unit is capable of supplying water at 180°F. With this 180°F input water, it is estimated that a modified tray washer containing a 12 kW booster heater will maintain the proper water temperature for sanitation. The tray washer unit power figure listed above reflects this modification.

No utilization factor is used in estimating the power demand of the sanitation section, since in operation, all of the equipment will be used simultaneously.

The power required by support and alternative system equipment is:

SUPPORT EQUIPMENT

Item	Number Required	Unit Power	Battalion System	Intermediate System	Small System
ISO Reefer	2	3	6	3	3
M-77 Heater	2	1.2	2.4	1.2	1.2

ALTERNATIVE SYSTEM EQUIPMENT

Electric Water Heater	36 kW each
Electric Booster Heater	6 kW each
Water Pump	2.5 kW each

PROPOSED FOOD SERVICE SYSTEM (ASHORE)

The proposed food service system consists of the galley and sanitation sections, ISO Reefers, and M-77 Water Heaters. The total system power demand is the sum of the demands of each of these subsystems:

	Battalion System	Intermediate System	Small System
Galley Module	135.7	81.0	54.7
Sanitation Module	25.7	24.7	1
ISO Reefer	6	3	3
M-77 Water Heater	2.4	1.2	1.2
Total Demand	169.8 kW	109.9 kW	59.9 kW

PROPOSED FOOD SERVICE SYSTEM (SHIPBOARD)

For shipboard operation, the proposed battalion size, food service system consists of the galley section, M-77 Water Heaters, and, as shows in Part IV, eight ISO Reefers for chilled and frozen storage. The intermediate and small system configurations required respectively four and two reefers for chilled and frozen storage. The small sanitation module is used with the small galley module to provide the means for pot and pan washing, and the power demand of the small sanitation module must be added to the other power demands for the small system. The total system power demands for shipboard operation are:

	Battalion System	Intermediate System	Small System
Galley Module	135.7	81.0	54.7
ISO Reefer	24	12	6
M-77 Water Heater	2.4	1.2	1.2
Sanitation Module			1
Total Demand	142.1 kW	94.2 kW	62.9 kW

MANUAL WAREWASHING ALTERNATIVE

The galley module, reefer and M-77 power demand for a food service system using manual ware washing is the same as for the proposed system. The sanitation module power demand results from the sump pumps, exhaust fans and lights in the three ISO Shelters of the manual sanitation section. The resulting power demand for the manual warewashing alternative is:

	Battalion System	Intermediate System	Small System
Galley Module	135.7 kW	81.0 kW	54.7 kW
Reefers	6	3	3
M-77 Water Heaters	2.4	1.2	1.2
Sanitation Module			
Sump Pump	0.6	0.3	0.3
Exhaust Fan	0.8	0.4	0.4
Lights	0.9	0.6	0.3
Total Demand	146.4 kW	85.5 kW	59.9 kW

ALL-ELECTRIC ALTERNATIVE

In the all-electric alternative to the proposed system, the power demand will be that of the proposed system, plus that required by two water pumps, two electric water heaters and two booster heaters (one in the galley module sink and one in the sanitation module sink). The booster heaters are needed to compensate for the low recovery rate of the electric water heaters. In addition, the tray washer power demand will be that specified by the manufacturer, since, in this case, the temperature of the input water to the tray washer would be about 140°F. The total system power demands for the all electric alternative are, therefore:

	Battalion System	Intermediate System	Small System
Galley Module	135.7 kW	81.0 kW	54.7 kW
Booster Heater	6	6	
Reefer	6	3	3
Sanitation Module			
Water Heater	72	36	36
Tray Washer	56.7	56.7	
Booster Heater	6		6
Water Pump	1	0.5	0.5
Sump Pump	0.6	0.3	0.3
Exhaust Fan	0.8	0.4	0.4
Lights	0.6	0.3	0.3
Total Demand	285.4 kW	184.2 kW	101.2 kW

APPENDIX C

FUEL CONSUMPTION

APPENDIX C

FUEL CONSUMPTION

This appendix contains the derivation of the fuel consumption rates of the proposed food service unit, and the manual warewashing and all-electric alternatives to the proposed unit. The first section of this appendix lists the fuel consumption rates for the generator sets and the M-77 Water Heater, and goes on to describe the method for calculating the fuel consumption rate of an entire food service unit. This method is used in subsequent sections to derive the fuel consumption rates of the various food service units.

DATA AND METHOD OF CALCULATION

The fuel consumption rates of the various generator sets used to power the proposed and alternative food service units are listed in the table below. The fuel consumption rates are restated from MIL-STD-633D[9] to be expressed in terms of gallons of fuel burned per 100 kW hr of energy produced.

Generator Set	Fuel Consumption
MEP 006, 60 kW	10 gal/100 kW-hr
MEP 007, 100 kW	8.5 gal/100 kW-hr
MEP 009, 200 kW	5 gal/100 kW-hr

The operating specifications of the M-77 Water Heater are:[10]

Output	- 420 gallons of water per hour at a temperature increase of 100°F
Fuel Consumption	- 5 gallons of diesel fuel per hour.
Power Demand	- 1.2 kW

The method of calculating the fuel consumption rates of the food service units is based on three assumptions: first, that the galley and sanitation sections operate for 16 hours per day at the power demand levels estimated in Appendix B; second, that the reefers operate continuously, 24 hours per day, at their rated power demand of 3 kW; third, that the amount of hot water used by each food service unit is equal to the total amount of water used by that unit, when it is serving fresh milk, and when it is not the sole source of liquids for its customer population. This water requirement for each unit is computed in Appendix A.

The fuel consumption of a food service system is the sum of the daily fuel requirements of the water heaters and the generator sets. The fuel requirement of the M-77 heater is calculated in two parts: first, the water consumption rate of the given food service unit is divided by the M-77's water heating rate

---

[9] Mobile Electric Power Engine Generator Standard Family Characteristics Data Sheets, MIL-STD-633D, 30 September 1974.

[10] C. McKeown, Op. cit.

of 420 gallons per hour to give the length of time that the M-77 must operate each day to heat the required amount of water. Second, this length of time is multiplied by the 5-gallon-per-hour fuel consumption rate of the M-77, to give the M-77's daily fuel requirement.

The fuel requirement of the generator sets is also calculated in two parts: First, the total daily energy requirement of the given food service unit is calculated by multiplying the power demand of each subsystem - galley section, sanitation section, M-77 heaters and ISO Reefers - by the length of time each of these subsystems must operate each day, and then summing the products to give the food service unit's total energy requirement in kW-hrs. Second, the food service unit's energy requirement is multiplied by the fuel consumption rate of the generator sets to give their daily fuel requirement. This fuel requirement is then added to the M-77 fuel requirement to give the food rvice unit's fuel requirement in gallons per day.

PROPOSED FOOD SERVICE UNIT (ASHORE)

The water requirement of the proposed, battalion size, food service unit is, from Appendix A 3019 gallons per day. The M-77's fuel requirement for heating this amount of water is:

Hot Water Required	M-77 Operating Time	M-77 Fuel Requirement
3019 gal/day	7.2 hrs/day	36 gal/day

Taking the power demands from Appendix B, the proposed unit's energy requirement is:

	Power Demand (kW)	Operating Time (hr)	Energy Requirement (kW-hr)
Galley Section	135.7	16	2171.2
Sanitation Section	25.7	16	411.2
Reefers (2 ea.)	6	24	144
M-77	1.2	7.2	8.6
Total Energy			2735.0 kW-hr

With 60 kW generator sets powering the proposed unit, the generator set fuel consumption rate is 10 gal/100 kW-hr, and the tal fuel consumption rate of the proposed unit is:

Generator Fuel = 2735.0 x 10/100 =	273.5	gal/day
M-77 Fuel	36	gal/day
Total Fuel	309.5	gal/day

For the intermediate size food service unit, similar calculations give the following results:

M-77 Fuel

Hot Water Required	M-77 Operating Time	M-77 Fuel Requirement
1654 gal/day	3.9 hrs/day	19.7 gal/day

Unit Energy

	Power Demand (kW)	Operating Time (hr)	Energy Requirement (kW-hr)
Galley Module	81.0	16	1296.0
Sanitation Module	24.7	16	395.2
Reefers (1 ea.)	3	24	72
M-77	1.2	3.9	4.7
Total Energy			1767.9

Total Fuel

Generator Fuel	176.8
M-77 Fuel	19.7
Total Fuel	196.5 gal/day

The result for the small food service unit is:

M-77 Fuel

Hot Water Required	M-77 Operating Time	M-77 Fuel Requirement
752 gal/day	1.8 hrs/day	9 gal/day

Unit Energy

	Power Demand (kW)	Operating Time (hr)	Energy Requirement (kW-hr)
Galley Module	54.7	16	875.2
Sanitation Module	1	16	16
Reefers (1 ea.)	3	24	72
M-77	1.2	1.8	2.2
Total Energy			965.4 kW-hr

Total Fuel

Generator Fuel	96.5
M-77 Fuel	9
Total Fuel	105.5 gal/day

In summary, the fuel consumption rates of the proposed food service unit operating ashore are:

Operating Level	Fuel Consumption Rate
Battalion	309.5 gal/day
Intermediate	196.5 gal/day
Small	105.5 gal/day

PROPOSED FOOD SERVICE UNIT (SHIPBOARD)

The water requirement of the proposed food service unit aboard ship includes supplementary water which will be used cold to rehydrate beverages and will not require heating. To exclude this supplementary water from the M-77 fuel calculation, the hot water requirement of the proposed food service unit aboard ship is here taken to be that of the disposable serving ware alternative to the proposed unit from Appendix A, since the only difference in the water requirements of the two units is due to the supplementary water. That is, the hot water requirements of the battalion, intermediate, and small units are taken to be, respectively, 1166 gal/day, 727 gal/day and 464 gal/day.

As calculated in Appendix D, the shipboard refrigerated storage requirement is greater than the ashore requirement. For the assumed 15-day transit, the battalion, intermediate, and small units require, respectively, 6,4, and 2 ISO reefers.

Using the above figures for the water requirement and for the reefer power demand, the fuel requirement of the proposed unit operating aboard ship can be calculated as in the previous section for use ashore. The results of this calculation are:

Operating Level	Fuel Consumption Rate
Battalion	274.7 gal/day
Intermediate	167.3 gal/day
Small	107.6 gal/day

MANUAL WAREWASHING ALTERNATIVE

The battalion size, manual warewashing alternative to the proposed unit is powered by a 100 kW generator set in combination with a 60 kW generator set. To get a composite fuel consumption rate for these two generator sets, their respective fuel consumption rates are proportioned according to their sizes. Hence, $\frac{100}{160} \times 8.5 + \frac{60}{160} \times 10 = 9.06$ gal/100 kW-hr is used as the generator set fuel consumption rate in the calculation for the fuel consumption of the battalion size unit. The 100 kW generator set is used alone to power the intermediate size unit, so the 8.5 gal/100 kW-hr rate is used in the intermediate unit fuel consumption calculation, and the 60 kW generator set is used alone to power the small unit, so the 10 gal/100 kW-hr rate is used in the small unit calculation.

Using the above fuel consumption rates and the appropriate water consumption rates from Appendix A the total fuel consumption rates of the manual warewashing food service units are calculated according to the previous method and give:

Operating Level	Fuel Consumption Rate
Battalion	244.8 gal/day
Intermediate	137.4 gal/day
Small	105.5 gal/day

ALL ELECTRIC ALTERNATIVE

The all-electric battalion size, food service unit requires 285 kW, and is powered by a 200 kW generator set and a 100 kW generator set operating together. A composite fuel consumption rate for these two generators is obtained by proportioning their respective consumption rates according to their sizes, as in the previous section, to get 7.33 gal/100 kW-hr. The generator sets are used separately to power the intermediate and small units, and their individual fuel consumption rates are used in the fuel calculations for these units.

Using the indicated generator set fuel consumption rates and the appropriate water consumption rates from Appendix A, the total fuel consumption rates for the all-electric alternative to the proposed food service unit are:

Operating Level	Fuel Consumption Rate
Battalion	338.2 gal/day
Intermediate	148.6 gal/day
Small	139.7 gal/day

APPENDIX D

STORAGE REQUIREMENTS

APPENDIX D

STORAGE REQUIREMENTS

This appendix contains the derivation of the number of containers needed with a food service unit for storing food, water and serving ware. It also contains the derivation of the number of days of food service operation that can be achieved without resupply, by the proposed and alternative food service units, with the number of storage containers specified in Sections I and II.

The derivations are based on the number of man-days of product that can be stored in an appropriate container. The first section of this appendix contains the derivation of the man-day capacities of each product/container combination. Subsequent sections contain the calculations for the number of containers required, and the number of days of operation achievable by the proposed and alternative food service units.

CONTAINER CAPACITIES

The products which require storage are dry food, disposable serving ware, refrigerated food, milk, and water. The term "dry food" means any food product, such as canned goods, that may be stored at ambient temperatures. Refrigerated food here means those food products, with the exception of milk, which must be stored chilled or frozen. It is assumed that dry food and disposable serving ware will be stored in the Quadcon container, that refrigerated food and milk will be stored in the ISO Reefer, and that water will be stored in the 1000 gallon capacity water module. The calculation of the required number of water modules for a food service unit depends on the unit's water consumption rate and is left for subsequent sections.

The Quadcon has a capacity of 216 ft^3, but, in this analysis, an 80% volume utilization factor is assumed. That is, no more than 80% of the Quadcon's volume, or 173 ft^3, will be filled with product, in order to provide room for accessing and retrieving the stored product. The Quadcon also has a net weight limitation of 8800 lbs, but neither dry food nor disposable serving ware is dense enough to reach this weight limit within the 173 ft^3 volume limit. The ISO Reefer's net weight limit is 6500 lbs, and both refrigerated food and milk are more than dense enough to reach this weight limit before reaching 80% of the reefer's volume limitation of about 250 ft^3.

To calculate the storage capacities of Quadcons and ISO Reefers, the volume and weight of the stored products per man-day are required. These have been calculated from the Viet Nam 28-day menu for the food products, and from GSA data for the disposable serving ware, and are:

Product	Volume (Weight) per Man-Day
Dry Food	0.0681 ft^3/man-day
Disposable Serving Ware	0.0483 ft^3/man-day
Refrigerated Food	2.45 lb/man-day
Fresh Milk	1.68 lb/man-day

The storage capacity, in man-days, for Quadcons is found by dividing the Quadcon's available volume of 173 ft^3 by the ft^3/man-day requirement for dry food, for disposable serving ware, and by the ft^3/man-day requirement of the sum of both. The storage capacity of the ISO Reefer is similarly found by dividing its 6500 lb net weight limitation by the lb/man-day requirement for refrigerated food, for milk, and for refrigerated food and milk combined. The results are:

Product	Container	Capacity (man-days)
Dry Food	Quadcon	2537 man-days
Serving Ware	Quadcon	3578 man-days
Dry Food and Serving Ware Together	Quadcon	1485 man-days
Refrigerated Food	ISO Reefer	2653 man-days
Fresh Milk	ISO Reefer	3869 man-days
Refrigerated Food and Milk Together	ISO Reefer	1574 man-days

PROPOSED FOOD SERVICE UNIT (ASHORE)

The proposed food service unit uses 2 Quadcons, 2 Reefers and 2 water modules for storage. For operation ashore, disposable serving ware is not used, and it is assumed that refrigerated food and milk are stored together in the reefers. The number of days that the food service unit can operate without resupply is calculated by multiplying the storage capacity of the container in man-days by the number of containers used, and dividing by the number of men served at the unit's operating level. The number of days of water storage is calculated by multiplying the water module's capacity (1000 gallons) by the number of modules used and dividing the product by the unit's water requirement (taken from Appendix A), when fresh milk is served and the unit is not the sole source of liquids for its customers. The results of these calculations are summarized in the following tables:

Battalion Level (1000-Man)

Product	Container	Number of Containers	Number of Operating Days
Dry Food	Quadcon	2	5.07 days
Refrigerated Food and Milk	ISO Reefer	2	3.15 days
Water	Water Module	2	0.[illegible]6 days

Intermediate Level (500-Man)

Product	Container	Number of Containers	Number of Operating Days
Dry Food	Quadcon	1	5.07 days
Refrigerated Food and Milk	ISO Reefer	1	3.15 days
Water	Water Module	1	0.60 days

Small Level (200-Man)

Product	Container	Number of Containers	Number of Operating Days
Dry Food Refrigerated	Quadcon	1	12.69 days
Food and Milk	ISO Reefer	1	7.87 days
Water	Water Module	1	1.33 days

PROPOSED FOOD SERVICE UNIT (SHIPBOARD)

The storage requirements for shipboard operation are based on a 15-day transit without resupply. It is assumed that the food service unit will be the sole source of liquids for the Marines while in transit, that fresh milk will be served during the first seven days, that powdered milk will be rehydrated and served during the last eight days, and that disposable serving ware will be used.

The number of containers required for the 15-day supply of product is calculated by multiplying 15 days by the number of men served at the unit's operating level, and dividing the result by the storage capacity of the container. The number of reefers needed for the 7-day supply of milk is calculated by multiplying 7 days by the number of men served at the unit's operating level, and dividing the product by the reefer's capacity for milk. The water storage requirement for the 15 days is calculated by multiplying the water requirement for the food service unit, for its operating level aboard ship, when fresh milk is served (taken from Appendix A) by 7 days, and adding to this product 8 times the unit's water requirement when fresh milk is not served, and then dividing the sum by the water module's capacity. The results of these calculations are summarized in the following tables.

Product	Container	Number of Containers at Level 1000-Man	500-Man	200-Man
Dry Food	Quadcon	5.91	2.96	1.18
Serving Ware	Quadcon	4.19	2.10	0.84
Refrigerated Food	Reefer	5.65	2.83	1.13
Fresh Milk	Reefer	1.81	0.91	0.36
Water	Water Module	28.74	16.53	9.21

MANUAL WAREWASHING ALTERNATIVE

For this alternative the Quadcon and reefer storage capacities would be the same as those of the proposed unit operating ashore. With water consumption rates taken from Appendix A the water storage capacity is:

Battalion Level (1000-Man)

(2 modules) x (1000 gal/module) ÷ (2606 gal/day) = 0.77 days

Intermediate Level (500-Man)

(1 module) x (1000 gal/module) ÷ (1591 gal/day) = 0.63 days

Small Level (200-Man)

(1 module) x (1000 gal/module) ÷ (752 gal/day) = 1.33 days

APPENDIX E

WASTE ESTIMATES

APPENDIX E

WASTE ESTIMATES

The estimates of the amount of water generated by the proposed and alternative food service units are based on data gathered during field feeding exercises at Camp Pendleton[10] and Camp Edwards,[11] during which the generated amounts of dry trash, disposables trash, and wet garbage were measured. The dry trash is packaging waste which consists of fiberboard, glass, tin, and plastic; disposables trash consists of paper and plastic serving ware; and wet garbage consists of plate waste and leftover food resulting from overproduction. The data from these experiments is expressed below in the form of pounds and cubic feet of waste generated, per customer served, per day, for each type of waste:

Type of Waste	Generated Amounts (lb /man/day	(ft^3/man/day)
Dry Trash	0.923	0.191
Disposables Trash	0.504	0.104
Wet Garbage	1.229	0.023

In addition to trash and garbage, a food service unit will also generate waste water, which consists of water used for washing and sanitizing, plus food preparation water that is subsequently drained from the food product and discarded. The rate at which waste water is generated is based on the water use rates which are divided in Appendix A and which are restated here:

Use Category	Use Rate
Galley Use Water (discarded)	0.500 gal per man per day
Traywasher Water	1.853 gal per man per day
Sink Water	96 gal per fill

The amount of trash, garbage, and waste water generated by a food service unit is estimated by multiplying the above rates by the number of customers served by the food service unit.

PROPOSED FOOD SERVICE UNIT (ASHORE)

For operation ashore, the proposed food service unit uses reusable serving ware, so no disposable trash is involved in the unit's waste estimates. The unit's dry trash and wet garbage estimates are calculated by miltiplying the rate at which these types of waste are generated, by the number of customers

---

10 S. G. Baritz, Op. cit.,

11 S. G. Baritz, et. al., The Camp Edwards Experiment in Battalion Level Consolidated Field Feeding. TR 76-45-ORSA, US Army Natick Research and Development Laboratories, Natick, MA 01760. December 1975 (AD A024 07J).

served at each of the unit's three operating levels. The unit's waste water is estimated by multiplying the sum of the galley and traywasher water, by the number of customers served, and adding to this sum the sink water, multiplied by the required number of fills per day. Three fills per day are required for the battalion and intermediate size units and six fills per day are needed for the small unit. The results of these calculations are:

Type Waste and Units		Battalion Level	Intermediate Level	Small Level
Dry Trash:	Weight (lb/day)	923	462	185
	Volume (ft^3/day)	191	96	38
Wet Garbage:	Weight (lb/day)	1229	615	246
	Volume (ft^3/day)	23	12	5
Waste Water:	(gal/day)	2641	1465	676

PROPOSED FOOD SERVICE UNIT (SHIPBOARD)

For operation aboard ship disposable serving ware is used, and, since "disposables trash" is dry and can be treated in the same way as "dry trash", these two types of trash are added in the following calculation to produce a single trash estimate. With this definition of "trash", the trash and wet garbage estimates are calculated by the same procedure used in Appendix D. With disposable serving ware, the waste water for shipboard operations does not involve any traywasher water, and only three sink fills per day are needed at each operating level, since only pots, pans, and kitchen utensils need to be washed. Using the galley water rate and three sink fills per day, the waste water generated by the proposed unit aboard ship is calculated by the same procedure used in the previous section. The results of these calculations are:

Type Waste and Units		Battalion Level	Intermediate Level	Small Level
Trash:	Weight (lb/day)	1427	714	285
	Volume (ft^3/day)	295	148	59
Wet Garbage:	Weight (lb/day)	1229	615	246
	Volume (ft^3/day)	23	12	5
Waste Water:	(gal/day)	788	538	388

ALTERNATIVE UNITS

For the manual warewashing alternative, the dry trash and wet garbage that would be generated would be the same as that generated by the proposed food service unit. The waste water generated by this alternative would not involve any traywasher water, but would require 18 sink fills per day for the battalion size unit, 12 sink fills per day for the intermediate size unit and 6 sink fills per day for the small size unit. Using these numbers of sink fills and galley use water rate, the manual alternative waste water is calculated by the procedure of the previous appendicies, and gives:

	Battalion Level	Intermediate Level	Small Level
Waste Water (gal/day)	2228	1402	676

The trash, wet garbage, and waste water generated by the all-electric alternative to the proposed food service unit is the same as that of the proposed food service unit operating ashore.