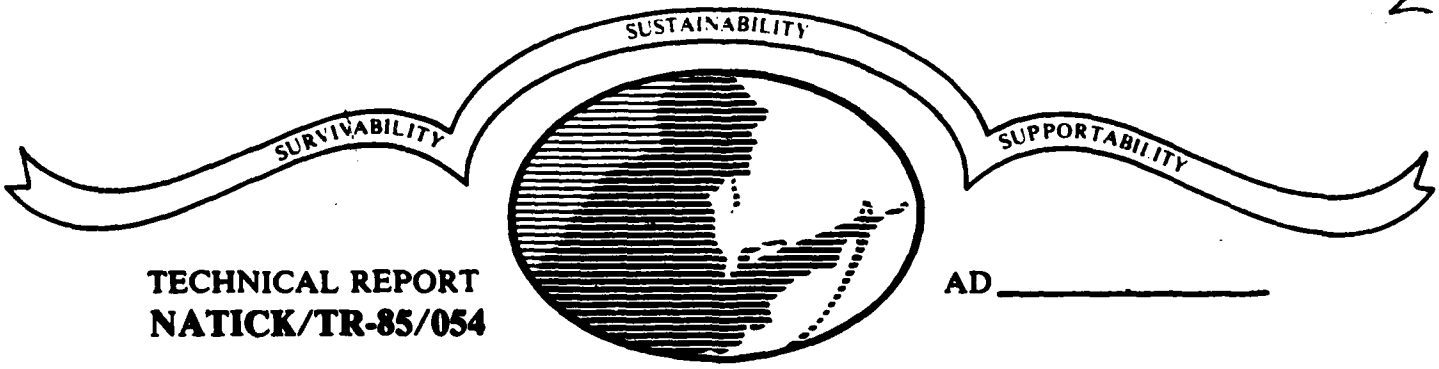


TECHNICAL REPORT
NATICK/TR-85/054

AD_____

TECHNOLOGY DEMONSTRATIONS OF THE PROPOSED USMC FIELD FEEDING SYSTEM FOR THE 1990s

BY
HARRY J. KIREJCZYK

JUNE 1985

FINAL REPORT 1983 - 1985

UNITED STATES ARMY NATICK
RESEARCH AND DEVELOPMENT CENTER
NATICK, MASSACHUSETTS 01760-5000

DIRECTORATE FOR SYSTEMS ANALYSIS AND CONCEPT DEVELOPMENT

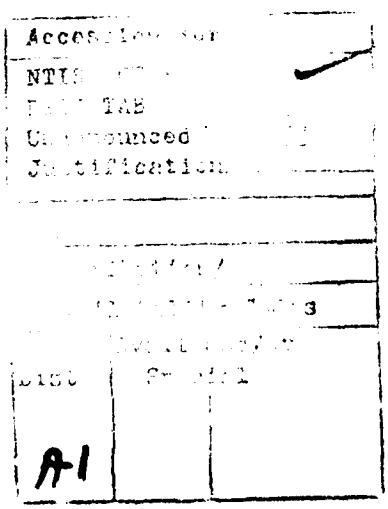
Disclaimers

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For classified documents, follow the procedures in DoD 5200.1-R, Chapter IX or DoD 5220.22-M, "Industrial Security Manual," paragraph 19. For unclassified documents, destroy by any method which precludes reconstruction of the document.



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: Natick /TR-85/054	2. GOVT ACCESSION NO: AD-A157967
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Technology Demonstrations of the Proposed USMC Field Feeding System for the 1990s	5. TYPE OF REPORT & PERIOD COVERED: Final 1983 - 1985
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Harry J. Kirejczyk	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Natick R&D Center, STRNC-OF, Kansas St., Natick, MA 01760-5015	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 6.2, Project 1L62724AH99, Task AA, Work Unit 109
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Natick R&D Center, STRNC-OF, Kansas St., Natick, MA 01760-5015	12. REPORT DATE: June 1985
	13. NUMBER OF PAGES: 50
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

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

COMBAT FOOD SERVICE
FIELD FEEDING
MOBILE FOOD SERVICE UNIT
MODULAR FIELD KITCHENS
FIELD EVALUATIONS
T RATIONS
TRAY PACKS

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

This report documents three field evaluations (technology demonstrations) of the proposed new field feeding system concept to support U.S. Marine Corps combat forces in the 1990s. Field evaluation objectives were to validate required system performance characteristics and projected system benefits. Evaluation results clearly demonstrate that the proposed system has the responsiveness, mobility, and flexibility characteristics required to maxi-

(continued)

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

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract (cont'd)

mize both the frequency and the acceptability of the hot meals provided, given the tactical situation. In addition, results confirm that the new system offers significant reductions (over 60%) in foodservice system personnel and fuel requirements. Keywords include:

SUMMARY

This report documents the field evaluations (technology demonstrations) of the proposed new field feeding system to support U.S. Marine Corps forces in the 1990s. The new system was designed with the responsiveness, mobility, and flexibility characteristics necessary to support the assigned USMC combat role of the future and to ensure that combat troops are provided the most frequent and most acceptable hot meals possible given the tactical situation. Field evaluation objectives were to validate required system performance characteristics and projected system benefits. These evaluations clearly demonstrated the following:

° The Mobile Food Service Unit (MFSU) and the Modular Field Kitchen (MFK) will perform effectively, and T Rations are highly acceptable in environments from very cold to very hot;

° the MFSU and T Rations provide the responsiveness, mobility, and flexibility necessary to ensure combat troops are provided both frequent and highly acceptable hot meals; the MFSU's heat-on-the-move capability is essential for these performance characteristics;

° new system T Ration staffing levels, which result in a 66% reduction in total foodservice worker requirements, are more than adequate; and

° compared to B or A Rations, T Rations reduce the foodservice system fuel requirements by a projected 74%; this savings assumes the use of disposable messgear with each type ration.

PREFACE

These field evaluations were conducted by the U.S. Army Natick Research and Development Center (NRDC) as part of the Department of Defense Food and Nutrition Research, and Engineering Program under Military Research Requirement, M84-6 "Combat Food Service Concept for USMC Ground Forces in the 1990's."

The successful completion of these field evaluations can be attributed in part to the diligent efforts of Maj Thomas W. Parker, former Natick R&D Center Marine Corps Liaison Officer, and MGySgt Jacob D. Sattler, Marine Corps Development and Education Command.

Special recognition is accorded to Bruce Thomas and Robert Mortenson of the Food Engineering Laboratory at Natick R&D Center. These two individuals provided the engineering support required to conduct the field evaluations. Also at Natick R&D Center, Herbert Meiselman, Edward Hirsch, and Barbara Edelman of the Science and Advanced Technology Laboratory, and Stephen Rei, Directorate for Systems Analysis and Concept Development, are acknowledged for their data collection and analysis efforts relative to the test objectives.

A special appreciation is extended to Ms. Maura Severance who provided excellent and timely secretarial support in the preparation of this final technical report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TECHNOLOGY DEMONSTRATIONS OF THE PROPOSED USMC FIELD FEEDING SYSTEM FOR THE 1990s

INTRODUCTION

This report documents the field evaluations of prototypes (technology demonstrators) of the proposed new field feeding system to support USMC combat forces in the 1990s.[1] The objective of these evaluations was to validate the performance characteristics and projected benefits of the new system. This system was designed with the responsiveness, mobility, and flexibility characteristics required to "best" support the USMC's assigned varied combat roles of the future and provide the most frequent and most acceptable hot meals possible given the tactical situation. In addition to the above performance characteristics, projected new system benefits include the following: a minimum 9% savings in total system cost; a 66% reduction in foodservice staffing requirements; and a 73% and 94% reduction in foodservice system water and fuel requirements, respectively.

SYSTEM DESCRIPTION

The proposed new system consists of three major components: the Mobile Food Service Unit (MFSU), a heat-on-the-move, trailer-mounted Tray Pack heating system for highly mobile combat units; Modular Field Kitchens (MFKs), tent-based kitchens for nonground combat elements, which can be configured to support from 100 to 2,200 troops with A, B, or T Ration meals; and the T Ration, which incorporates Tray Packs, precooked, thermostabilized heat and serve food items for the entree, starch, vegetable, and dessert meal components. Each of these, along with the proposed concept of operation, is described below in detail.

T RATION

With the T Ration, Tray Pack items are provided for the entree, starch, vegetable, and dessert meal components. Other meal components, for example beverages, condiments, bread, soups, and cereals, are the same as with the B or A Rations. Tray Pack items are precooked, thermostabilized bulk food items in half-size steamtable trays (Figure 1). Each tray holds about 6½ pounds of food. The items are fully prepared and require only heating prior to serving. Following heating, in hot water for about 30 minutes, the trays are opened only as required and placed on the serving line. The food items are served directly from the opened trays, which are discarded when empty. With the T Ration, the labor-intensive B Ration items, which are prepared from scratch using shelf stable ingredients, are replaced with low labor, high response, heat and serve Tray Pack items. Without this ration, the new system would lack the responsiveness and flexibility required to provide frequent, highly acceptable hot meals to forward-deployed combat troops.

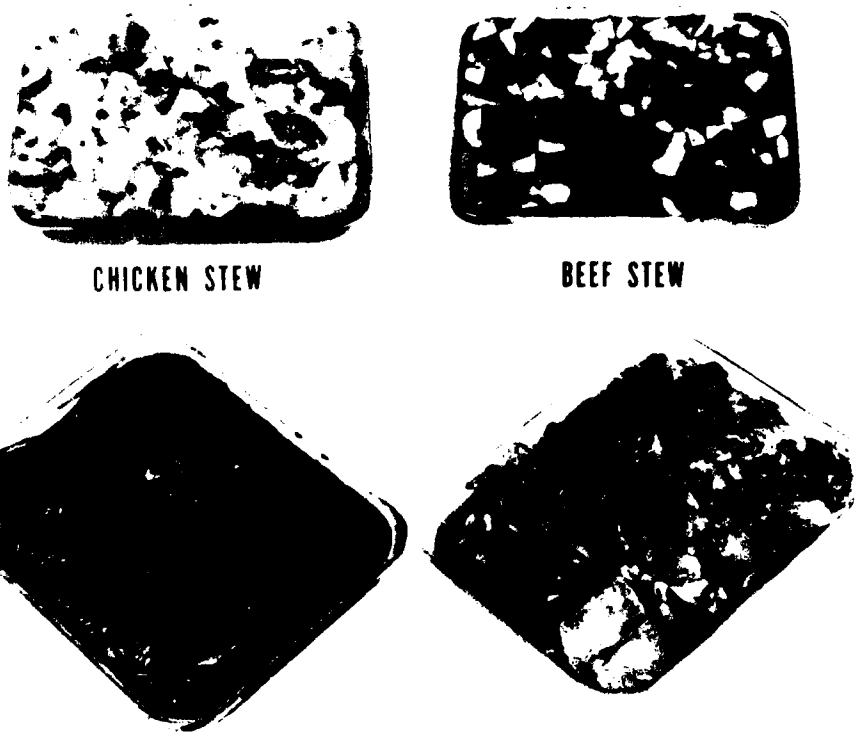


Figure 1. Tray Pack items.

Several Tray Pack items are being developed at Natick R&D Center under the Tray Pack Product and Menu Development Program. This program is being conducted in accordance with a plan approved by the military services, including the USMC and the Armed Forces Product Evaluation Committee (AFPEC). The program includes 39 basic Tray Pack items and 29 alternate Tray Pack items as listed in Table 1. Additional egg and non-egg breakfast entree items will be formulated and incorporated into the Tray Pack development program. Following successful production and acceptance testing, and final approval by AFPEC, the 39 basic Tray Pack items will be introduced into the supply system. These items are expected to be available for recurring procurements during 2Q FY85. Similarly, the alternate Tray Pack items are expected to become available by the same process in FY86.

TABLE 1. Tray Pack Development Program Items.

Component	Basic Menu Items	Alternate Menu Items
Entrees	Beef Stew	Pork Slices/Gravy
	Beef/BBQ Sauce	Lasagna
	Beef Pepper Steak	Swedish Meatballs
	Ham Slices	Beef Pot Roast
	Franks/Brine	Chili Con Carne
	Roast Beef/Gravy	Spaghetti/Meatballs
	Canadian Bacon/Brine*	Stuffed Peppers
	Roast Chicken/Gravy	BBQ Pork
	Creamed Ground Beef*	Swiss Steak
	Pork Sausage Links*	Chicken Breasts/Gravy
	Eggloaf/Ham*	Chicken/Noodles
	Sliced Turkey/Gravy	Beef Tips/Gravy
	Breakfast Bake*	Chicken Cacciatore
	Chicken a la King	Chicken Stew
	Meatloaf/Gravy	Meatballs/Cabbage Style
Vegetables	Sliced Carrots	Creamed Style Corn
	Whole Kernel Corn	Glazed Carrots
	Green Beans	Lima Beans
	Mixed Vegetables	Peas/Carrots
	Peas/Mushrooms	Stewed Tomatoes
Starches	Escalloped Potatoes	Spanish Rice
	Beans/Bacon	Potatoes/Chicken Sauce
	Macaroni & Cheese	Macaroni Salad
	Glazed Sweet Potatoes	
	Buttered Noodles	
	Rice	
	Potatoes/Butter Sauce	
	Potato Salad	
Desserts	Spice Cake	Marble Cake
	Peaches/Syrup	Pound Cake
	Apple Dessert	Fruit Cake
	Pears/Syrup	Blueberry Dessert
	Applesauce	Cherry Dessert
	Fruit Cocktail	
	Apple Coffee Cake	
	Chocolate Pudding	
	Chocolate Cake	
	Blueberry Cake	
	Pineapple/Syrup	

* Breakfast menu item.

MOBILE FOOD SERVICE UNIT (MFSU)

The Mobile Food Service Unit (MFSU) is a trailer-mounted Tray Pack heating system intended for highly mobile ground combat units. This unit has the high response, heat-on-the-move capability required to provide forward-deployed combat troops with frequent hot T Ration meals. In the proposed new system, the components of the MFSU are mounted on a 1¼-ton trailer. However, if desired, they could be mounted on a 2½-ton truck, a 5-ton truck, or operated from the ground. For example, some units (air wing, force service support group) do not require the heat-on-the-move capability. For these units, the major components of the MFSU are skid-mounted and operated at the Modular Field Kitchen.

Major equipment components of the MFSU, as depicted in Figure 2, include the Tray Pack (T Pack) heater, a 3-kW diesel generator, two 40-gallon potable water tanks, a hot and cold water dispensing system, and an emergency (backup) Tray Pack heater. The T Pack heater, which is fired by a diesel hot water heater, is designed to hold a maximum of 24 Tray Packs, which is a sufficient quantity of the hot meal components (entree, starch, vegetable, and sometimes dessert) for 120 to 130 troops. In the T Pack heater, the Tray Packs are submersed in and heated by a water bath what is itself heated by the hot water heater. The thermostatically controlled hot water heater shuts off automatically when the water reaches about 190°F and restarts again automatically when the water drops to about 170°F. For cold weather operation (below 32°F), the T Pack heater is filled with a food-grade antifreeze (propylene glycol, USP) and water solution to prevent equipment damage due to freezing. In addition, for other than cold weather operation, the MFSU is equipped with an 80-gallon (two 40-gallon tanks) hot and/or ambient temperature potable water supply and distribution system. For cold weather operations this feature can be removed.

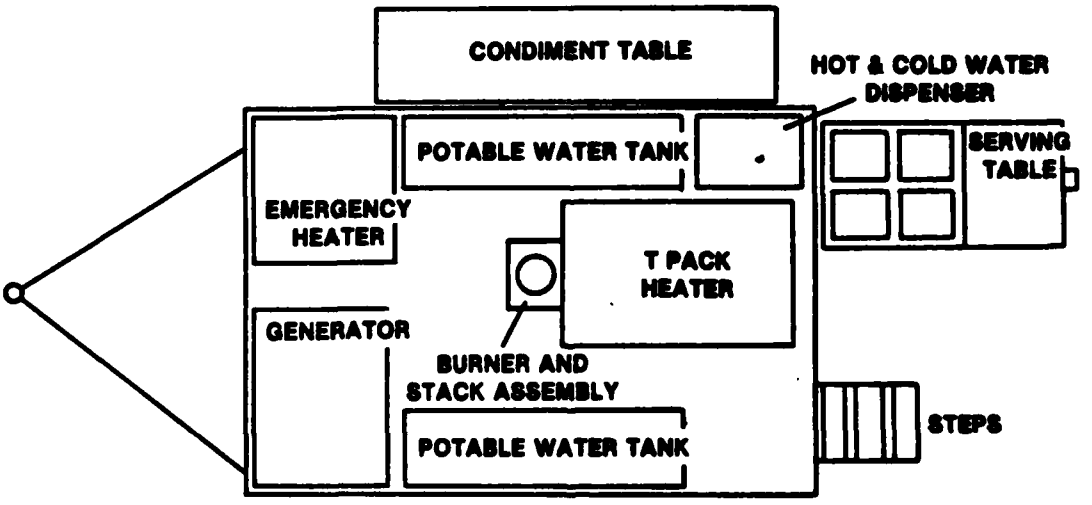


Figure 2. Mobile Food Service Unit equipment layout.
(second generation technology demonstrator)

The MFSU provides both the mobility and the responsiveness required to deliver frequent, hot T Ration meals to deployed combat troops. At a moment's notice, the T Pack heater can be loaded and the MFSU's Tray Pack heating system becomes operational with the flipping of one switch. The prime mover vehicle can then depart and the MFSU will heat the Tray Packs while enroute to the remote feeding site. The total time requirement to heat trays from ambient (not frozen) to serving temperature is 30 minutes or less. Further, due to the low (170° to 190°F) water temperature, the trays may be maintained in the T Pack heater for extended periods of time (2-3 hours) without any noticeable degradation in food quality.

The T Pack heating capacity was set at 24 to provide a nonstop hot Tray Pack meal serving capability. From extensive field observations, the maximum serving rate that can be maintained for extended periods of time is not more than four troops per minute. Therefore, provided cold Tray Packs are inserted as hot ones are removed, the MFSU is capable of supporting and maintaining a nonstop serving rate of four troops per minute indefinitely.

MODULAR FIELD KITCHEN (MFK)

Modular Field Kitchens (MFKs) are designed and intended for those units or situations for which a highly mobile, heat-on-the-move capability is not required. With the proposed system, Marine Air Wing and Force Service Support Group units are authorized MFKs only. For these units, the MFK is equipped with a complete T, B, or A Ration (less refrigeration) capability. However, divisional combat units which are authorized MFSUs are also authorized or issued MFKs for those situations (typically the later stages of a conflict) for which the heat-on-the-move capability is not always required. For these units, the MFK should be equipped with a B or A Ration capability only, because any required T Ration capability would be provided by the authorized MFSUs.

MFKs are housed in the Army's TEMPER (Tent, Extendable, Modular, Personnel) tent, which represents an extendable, frame-supported shelter system. However, MFKs could be housed in other suitable modular or extendable shelter systems. The TEMPER tent (frame and fabric) comes in sections 20 ft. wide and 8 ft. long, which can be joined lengthwise together. The joined units can be interconnected by passageways to provide a variety of tent configurations. Each 8 ft. length (side) section is provided with either a zippered doorway or a window. In addition, screened roof vents, which can be opened or shut as desired to let out fumes and to regulate kitchen temperatures, are provided on each side of the ridge pole. The entire tent is covered by a fabric fly to reduce the solar load and to permit the roof vents to be open even during inclement weather.

These MFKs in TEMPER tents (or other shelter systems) can be configured to support from 100 to 2,200 troops. Each kitchen contains exactly the same equipment items with the only difference being the quantity of each item and the amount of tentage. An MFK designed to support from 451 to 1,100 troops is shown in Figure 3.

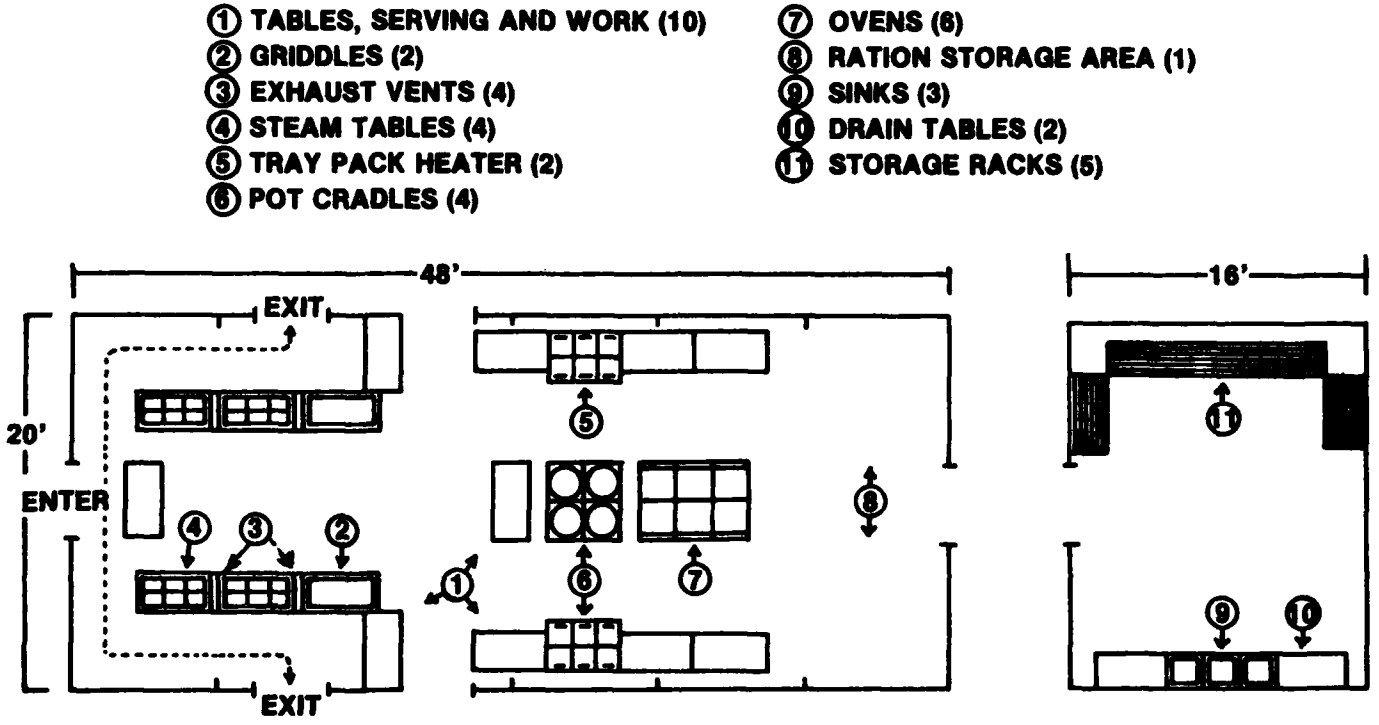


Figure 3. Large Modular Field Kitchen (451-1,100 troops) for A, B, or T Rations.

The MFKs include several new field equipment items which eliminate the numerous equipment deficiencies associated with current field kitchens. In essence, current authorized field feeding equipment consists of only four items: the range outfit for heating or cooking food items and beverages; the immersion heater with garbage cans for sanitation of pots, pans, and other kitchen items; and insulated food containers and beverage jugs for maintaining food and beverages hot or cold. Based on extensive field observations, the immersion heater and garbage can combination is considered inadequate for proper field sanitation due to the inability to submerse totally the larger pots and pans. In addition, current TO&E authorizations do not provide for serving or worktables, griddles, steamtables, or storage and drying racks. As a result, many units deploy to the field with additional nonauthorized items of equipment in order to perform better their field feeding function. These items typically represent either salvage from the garrison dining halls or unit-made equipment. By their nature, these items are not standard, vary between units, are not designed for field use, and do not include efficient packing. In addition, they are often difficult or impossible to sanitize properly. The new equipment items incorporated in the MFK include: serving and worktables, steamtables, griddles, ovens, pot cradles, Tray Pack heater, sinks, draintables, storage/drying racks, and a hot water heater for pot and pan sanitation (large MFKs only).

All new MFK items are designed to facilitate both easy and proper sanitation. The items are made predominantly of stainless steel. In addition, the items are made to facilitate easy and quick assembly and disassembly and to provide efficient (minimum volume) packing for mount-out purposes.

CONCEPT OF OPERATION

From an equipment standpoint, the proposed system provides a complete T, B, and A Ration preparation capability. However, due to supply and resupply constraints, only the T and B Rations are feasible for the initial periods of a conflict. Compared to the B Ration, the benefits of the T Ration include: increased responsiveness and thus more frequent hot meals; elimination of the need to assemble and mix several ingredients to make a single menu item; consistently uniform and highly acceptable quality products; and a significantly reduced field sanitation requirement. In addition, the T Ration requires significantly less equipment and labor than the B Ration.

For the above reasons, the proposed system is to deploy with a T Ration capability only for the initial phases of a conflict. With this concept of operation, highly mobile ground combat units would deploy with MFSUs only. To maximize the frequency of hot T Ration meals, these units should be attached to and operated from the headquarters unit of each combat battalion whenever the combat situation permits. Other units not requiring heat-on-the-move capability would deploy with reduced MFKs configured to provide T Rations only. For example, such a unit supporting up to 1,100 troops would deploy with the reduced (T Ration only) large MFK depicted in Figure 4, rather than the large MFK shown in Figure 3. This concept of operation permits units to deploy with a minimal amount of foodservice equipment. The remaining MFK equipment would then be deployed to the theater at a later time when the supply system permitted transitioning to an A Ration.

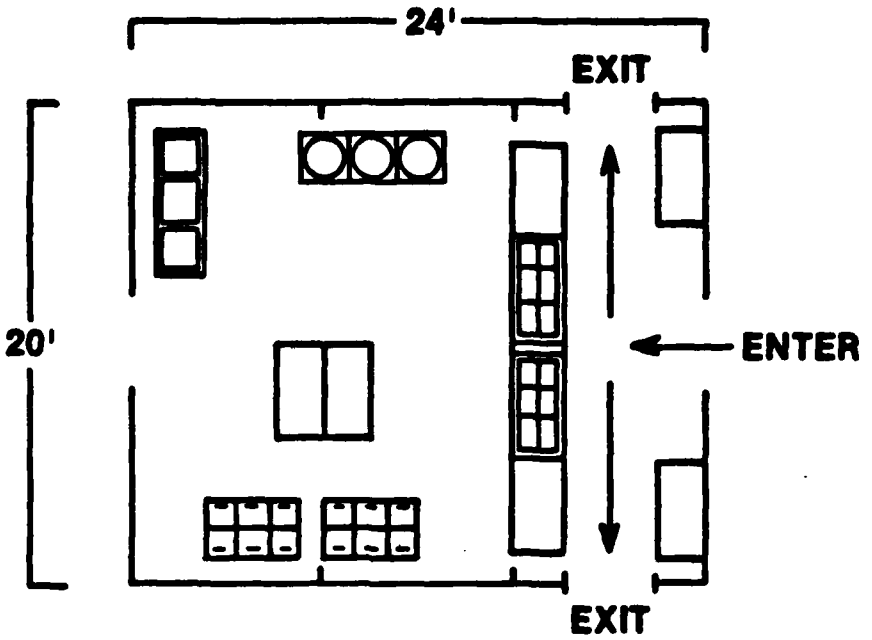


Figure 4. Large Modular Field Kitchen (451-1,100 troops) for T Rations.

DESCRIPTION OF FIELD EVALUATIONS

This report documents the results of four separate field evaluations of prototypes (technology demonstrators) of the proposed new field feeding system to support USMC combat forces in the 1990s. Together, the four evaluations were selected and conducted to ascertain equipment performance and system mobility, responsiveness, and flexibility characteristics. System benefits were to include the provision of highly acceptable hot meals and reduced manpower and fuel requirements in a variety of feeding situations and climatic environments from very cold (-20°F) to very hot (+124°F).

The extreme environments are the most demanding or difficult for proper equipment and effective human performance. Of the four evaluations, three involved the MFSU, of which two were conducted in very cold environments and one in a very hot environment. These environments were selected on the premise that if the equipment and workers performed effectively in these evaluations, then they would for all environments in between. Versions of MFKs have been in development and have undergone extensive field testing over an extended period of time. These include the earlier XM-75 system for the Marine Corps,[2] the current Tactical Field Kitchen for the Army,[3] and the New Harvest Eagle for the Air Force.[4] These prior tests were conducted in temperate to hot environments and demonstrated the effectiveness of an MFK-type kitchen in these environments. No prior testing occurred in cold to very cold environments. Therefore, as part of this project, only one MFK evaluation was conducted and that was in a very cold environment.

A general description of each evaluation, to include test location, weather conditions, specific test objectives, and overall concept of operation, follows.

NORWAY-83

This evaluation was conducted during the NATO exercise Cold Weather-83 in northern Norway. Actual test dates were from 11 to 15 March 1983. Ambient temperatures during the evaluation ranged between about -20°F to +35°F. Specific major objectives of this evaluation were to:

- evaluate the effectiveness (mobility, responsiveness, flexibility) of the Mobile Food Service Unit concept in very cold environments;
- evaluate MFSU equipment performance in very cold environments;
- validate the projected MFSU requirement of two per combat battalion to provide a two-hot-meals-per-day-capability;
- validate the adequacy of the proposed new system staffing levels for MFSUs and T Rations; and

- evaluate acceptance of both regular (separate entree, starch, and vegetable items) and single hot item (double portion of a stew/casserole only) T Ration meals, when provided to deployed combat troops in very cold environments.

The MFSU utilized during this evaluation, depicted in Figure 5, was a first generation technology demonstrator. For this evaluation, the hot and cold (ambient) water distribution system was removed to avoid possible freezing and subsequent equipment damage. In addition, a food grade antifreeze (propylene glycol, USP) was added to the circulating hot water Tray Pack heating system (Tray Pack heater, hoses, pump, and hot water heater) to prevent freezing, especially when shut off and not in use. During this evaluation, the Tray Pack heating system was filled and operated with a solution of about 50% propylene glycol and 50% water. This solution provided protection from freezing down to -28°F. With the second generation MFSU technology demonstrator utilized for the Twentynine Palms evaluation (depicted in Figure 2), the Tray Pack heater and hot water heater are combined into a single equipment item, which eliminates the need for pumps and hoses. This design change significantly reduces the potential for freezing and subsequent equipment damage, even in extremely cold environments.

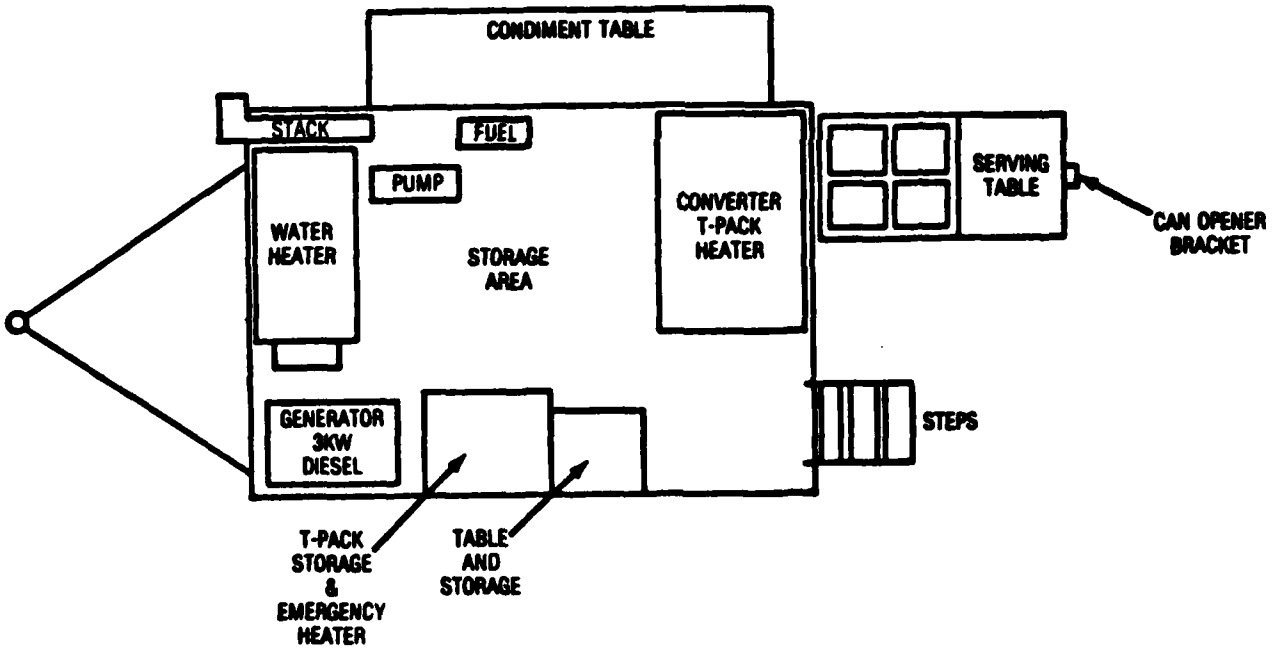


Figure 5. Mobile Food Service Unit equipment layout. (first generation technology demonstrator)

With the proposed new system, two MFSUs would be assigned to the headquarters company or battery of each combat battalion. From this location, the MFSUs would deploy on an as-required basis to support subordinate line companies of the same battalion. During this evaluation, however, the single MFSU was used to support elements of both an infantry and an artillery battalion in addition to various headquarter units. For this reason, the MFSU was assigned to and operated from the Beach Support Area (BSA). Depending on the feeding plan, the MFSU departed the BSA to support units at one to six different locations before returning to the BSA.

NORWAY-84

This evaluation was conducted during the NATO exercise Teamwork-84 in northern Norway. Test dates were from 9 to 22 March 1984. Ambient temperatures during the evaluation, which were warmer than normal, were in the 5°F to 35°F range. Major objectives of this evaluation were to:

- evaluate Modular Field Kitchen (MFK) performance in cold weather environments when utilized to provide T and B Rations;
- evaluate MFK workloads and resultant staffing requirements to provide T and B Rations;
- evaluate the fuel requirement to provide T and B Rations; and
- evaluate troop acceptance of regular and single hot item Tray Pack meals when provided to air wing type troops.

The MFK utilized for this evaluation, to include a layout of all major equipment items, is depicted in Figure 6. With two exceptions, this kitchen is the same as the large MFK in the proposed system (depicted in Figure 3), which is designed to support from 451 to 1,100 troops per meal. The major difference is that the MFK was equipped with only one rather than two Tray Pack heating systems (due to limited availability). As a result, to maintain two serving lines flowing, it was necessary to heat and hold two to three batches of Tray Packs prior to the start of the actual serving period. If two Tray Pack heating systems (one per serving line) were available, this advanced preparation would not have been necessary. The second difference is that no M-80 hot water heating and distribution system was provided for pot and pan sanitation purposes. As with the MFSU's hot and cold water distribution system, this item is deleted for cold weather operations due to the potential for freezing and subsequent equipment damage.

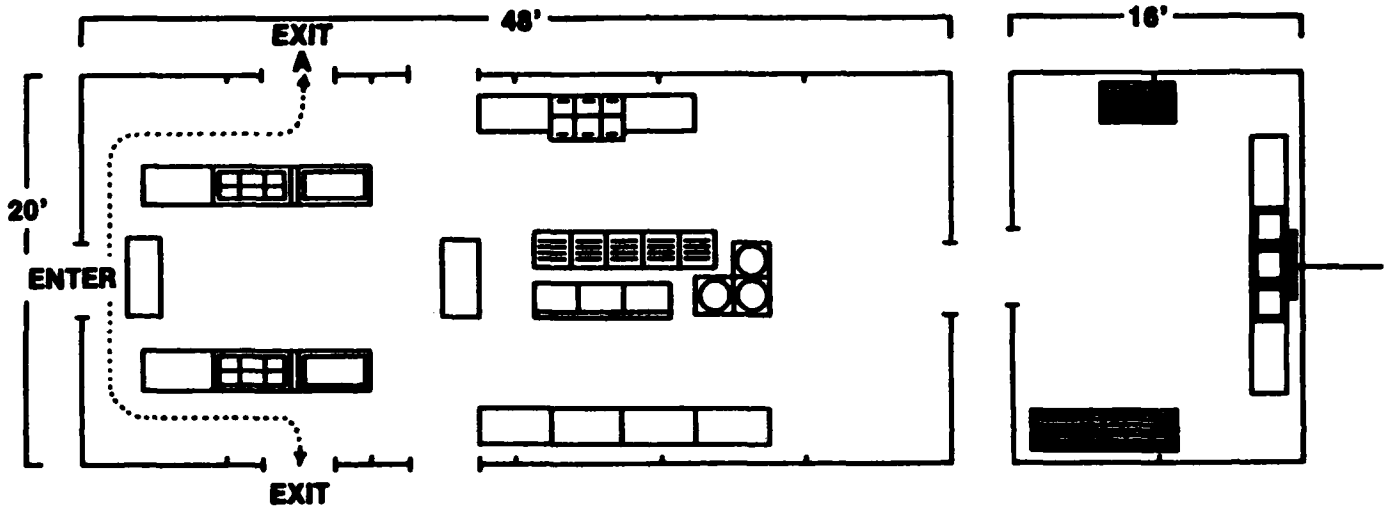


Figure 6. Modular Field Kitchen for Norway-84 field evaluation.

The MFK was utilized to provide hot B and T Ration meals to the 28th Marine Air Group (MAG), which remained in the same location throughout the exercise. Initially, the hot meal discipline was two and then three B Ration meals per day. During the middle part of the evaluation, three hot T or B Ration meals were provided on alternating days. For the last three days, only hot T Ration meals were provided so that the foodservice personnel could clean and then repack all the B Ration cooking equipment (ranges, ovens, griddles). In addition, on three of the days the 28th MAG troops were provided with T Ration meals, the MFK was also used to prepare from 300 to 1,000 T Ration meals for forward-deployed ground combat troops. These meals were transported from the MFK by helicopter to a 5-ton truck from which they were served to the supported units.

ETHAN ALLEN

This evaluation was conducted during the Extended Cold Weather Clothing System (ECWCS) Test at Camp Ethan Allen (Jericho, VT). The evaluation covered the period from 23 January to 17 February 1984. With the exception of the final week, ambient temperatures were often below 0°F and reached as low as -25°F. The MFSU utilized during this evaluation was also a first generation technology demonstrator. Objectives of this evaluation were to:

- obtain additional MFSU equipment operational experience in very cold environments; and

- evaluate the acceptability of comparable regular and single hot item Tray Pack meals, as a function of the type of bread product (fresh bread, canned bread, British Biscuit) included.

During the Norway-83 cold weather evaluation, the MFSU operated without equipment problems or failures. However, this evaluation was of a limited, five-day duration. Of all environments from very hot to very cold, MFSU design engineers consider the very cold environment to be the most difficult or demanding on equipment performance with the greatest potential for start-up and operational problems. Therefore, the major objective of this evaluation was to gain additional operational experience with the MFSU so as to pre-identify potential equipment problems, if any, in very cold environments. The data relative to Tray Pack (T Ration) meal acceptability as a function of type bread product was collected primarily for another project, A85-4, "Systems Analysis of Army Field Bread/Bakery Requirements."[5]

The MFSU was utilized to provide one hot T Ration meal per day to about 80 to 100 test troops and test evaluators. Depending on the actual ECWCS test schedule, the troops were provided with a lunch or dinner T Ration meal. No T Ration breakfast meals were provided.

TWENTYNINE PALMS

This evaluation was conducted in two parts during tactical exercises at the Marine Corps Air Ground Combat Center (MCAGCC) in Twentynine Palms, California. The initial part of the evaluation was conducted with the 27th Marines from 6 to 13 August 1984 while the later part of the evaluation was conducted with the 11th Marines (from Camp Pendleton) from 7 to 12 October 1984. During the August part of the evaluation, daytime high ambient temperatures were typically in the 110°F to 115°F range and as high as 124°F, while during the October part of the evaluation they were in the 80°F to 100°F range. Major objectives of this evaluation were to:

- evaluate the effectiveness (mobility, responsiveness, flexibility) of the MFSU concept in very hot, rough terrain, desert environments;
- evaluate MFSU equipment performance in very hot environments; and
- evaluate the acceptance of hot T Ration meals when provided to deployed combat troops in very hot environments.

Two MFSUs were utilized for both parts of this evaluation. Both units were second generation technology demonstrators (Figure 2). During the August portion of the evaluation, the two MFSUs were assigned to and operated from the field logistics train. For feeding purposes, usually only one MFSU departed the logistics train to support various combat line companies in their positions. The other MFSU normally remained at the logistic train where it was utilized to heat Tray Packs. Other line units came back to this location, picked up heated Tray Packs, and transported them to their unit for serving purposes. However, during the October evaluation with the 11th Marines, the two units were attached to the headquarters battery of an artillery battalion. From this location, the MFSUs deployed on demand and supported the artillery batteries in this position. This corresponds to the proposed new system concept of operation.

EVALUATION RESULTS, FINDINGS, AND DISCUSSIONS

MOBILE FOOD SERVICE UNIT PERFORMANCE CHARACTERISTICS

To evaluate the Mobile Food Service Unit's mobility and responsiveness characteristics, to include the number of units required to provide two-hot-meals-per-day, elapsed clock time data were collected relative to MFSU remote feeding operations. The data collected during the Norway-83 cold weather and the Twentynine Palms hot weather evaluations covered a total of 41 different feeding locations. The total remote clock time was separated into 10 distinct time elements as defined in Table 2. The number of feeding locations per MFSU remote trip varied between one and six. All clock times were collected to the nearest minute. The resulting clock times are summarized in Table 3 by time element for each evaluation.

TABLE 2. Time Element Definitions.

Time Element	Definition	
	Time 1	Time 2
Travel - To Site 1	Arrive Site 1	- Depart Starting Location
Travel - Between Sites	Arrive Site (Next)	- Depart Site (Prior)
Delay (before setup)	Start Setup	- Arrive Site
Setup	Finish Setup	- Start Setup
Delay (before serving)	Start Serving	- Finish Setup
Serve	Finish Serving	- Start Serving
Delay (before packup)	Start Packup	- Finish Serving
Packup	Finish Packup	- Start Packup
Delay (before departure)	Depart Site	- Finish Packup
Return Travel	Arrive Starting Location	- Depart Site (Final)

Travel to Site 1. During the Norway-83 and initial Twentynine Palms evaluations, the MFSU operated from the Beach Support Area and logistics train areas, respectively. For the Norway-83 evaluation, the travel times to the first feeding site varied considerably (17 to 87 minutes) and averaged 48 minutes. For the initial Twentynine Palms evaluation this time element averaged 20 minutes. The travel time to the first feeding location varied primarily as a function of the distance to travel. In addition, it is noted that this data excludes those occasions for which the unit to be supported was never located; if included, the average travel times would have been longer. For the second Twentynine Palms evaluation, the MFSU was attached to and operated from the battalion's headquarters battery. As shown by the data for this evaluation, the travel time to the first feeding site averaged a short 6.2 minutes. Additional benefits of operating from the headquarters battery, not reflected in the data, include: units were supported on demand, rather than some preset schedule; units to be supported were always located; and as a result, units were supported with more frequent hot meals.

TABLE 3. Mobile Food Service Unit Remote Clock Times (minutes).

Time Element	Norway March-83			Twentynine Palms August 84			Twentynine Palms October 84			All Evaluations		
	N	X	Med	N	X	Med	N	X	Med	N	X	Med
Travel - To Site	7	48.0	31.0	3	20.0	20.0	6	6.2	6.0	16	27.1	18.5
Travel - Between Sites	11	16.5	16.0	10	16.4	15.5	4	4.8	4.5	25	14.6	11.0
Delay (before setup)	18	5.0	3.0	13	2.0	1.0	10	0.6	1.0	41	3.0	1.0
Setup	18	7.3	7.5	13	4.0	4.0	10	4.3	4.5	41	5.5	5.0
Delay (before serving)	18	1.6	1.0	13	2.6	2.0	10	0.7	1.0	41	1.7	1.0
Serve	18	24.7	21.0	13	19.2	15.0	10	24.5	24.0	41	22.9	22.0
Delay (before packup)	18	5.0	2.5	13	2.5	1.0	10	0.7	1.0	41	3.1	1.0
Packup	18	5.9	4.0	13	3.6	4.0	10	3.8	4.0	41	4.7	4.0
Delay (before departure)	18	3.7	3.0	13	2.5	1.0	10	1.4	1.0	41	2.8	2.0
Return Travel	7	35.6	40.0	3	27.7	25.0	6	6.2	6.0	16	23.1	19.5

Travel Between Sites. During the Norway-83 and first Twentynine Palms evaluations, the MFSU traveled both between units of the same battalion and units of different battalions while during the second Twentynine Palms evaluation the MFSU traveled only between units of the same battalion. As a result, average travel times between sites was about 16 minutes for the Norway-83 and first Twentynine Palms evaluation, but only about 5 minutes for the second Twentynine Palms evaluation.

Delay (before setup). The time between arrival at the remote site and the start of setup was normally short, three minutes or less. During this period, the unit commander/first sergeant was contacted, a serving site selected, and the unit maneuvered to the selected site.

Setup. This element corresponds to the total time from start to completion of MFSU setup and the foodservice personnel being ready to start serving. Setup times averaged 7.3 minutes for the Norway-83 evaluation and about 4.1 minutes for the two Twentynine Palms evaluations. This difference in average setup times is attributable to both the more difficult work conditions presented by a cold weather environment and the MFSU being staffed with three foodservice personnel during the Norway-83 evaluation and four foodservice personnel during the two Twentynine Palms evaluations.

Delay (before serving). Normally, the foodservice personnel began serving immediately or within a minute or two following completion of setup at each location. However, on two occasions the foodservice personnel waited about 13 minutes before the troops were ready to eat. On average this delay was less than two minutes.

Serving. Serving times varied considerably from site to site and depended primarily on the total number of troops supported.

Delay (before packup). The delay between the end of serving and the start of packup was typically short, one or two minutes. However, on occasion the delay was over 10 minutes. The average delay for the three evaluations was about three minutes.

Packup. The average packup times experienced during the Norway-83 and the two Twentynine Palms evaluations were 5.9 and 3.7 minutes, respectively. As with setup times, the difference in average packup times is attributable to the more difficult conditions presented by a cold weather environment and the unit being staffed with four workers during both Twentynine Palms evaluations and three workers during the Norway-83 evaluation.

Delay (before departure). Following packup, the delay before departure ranged from 0 to 10 minutes and averaged about three minutes.

Return Travel. Return travel time from the last feeding site varied considerably, primarily as a function of distance, and ranged from 5 to 65 minutes. For the second Twentynine Palms evaluation, the MFSU operated from the battalion headquarters and supported only subordinate line companies of the battalion. As a result, travel distances were quite short and the return travel time averaged only about six minutes. For the other two evaluations where the

MFSU operated from more distant BSA and logistics train areas, the average return travel times were much longer, in the 25 to 35 minute range.

The MFSU elapsed clock time data demonstrate that the unit has the mobility and responsiveness characteristics required to provide frequent hot meals to forward-deployed combat units in all environments from extreme hot to extreme cold. During the initial Twentynine Palms evaluation, day time temperatures were in the 105°F to 125°F range, while during the Norway-83 evaluation temperatures were as low as -20°F. On each remote trip the MFSU provided hot T Ration meals to troops at one to six different locations. Based on the Twentynine Palms data, on the average at each site, a crew of four set up the MFSU and was ready to start serving in about four minutes. In addition, on the average, the crew performed all clean up functions, repacked the MFSU, and was ready to depart the area also in four minutes. For the Norway-83 evaluation, the setup and packup times which were somewhat higher, averaged only 7.3 and 5.9 minutes, respectively. These somewhat longer times are attributable to the smaller crew size - three persons - and the more difficult work conditions due to the low ambient temperatures.

The remote site serving rates for the Norway-83 and first Twentynine Palms evaluations are summarized in Table 4. No serving rate data were collected during the second Twentynine Palms evaluation. The actual serving rate experienced per site varied considerably and ranged from 2.0 to 6.3 troops per minute. However, the average or typical serving rate experienced per site was about the same for both evaluations - 3.0 to 3.4 troops per minute. These results indicate that a crew of four does not result in a higher average serving rate. In addition, a review of the actual serving rates indicates they varied primarily as a function of factors other than the number of troops supported at the site. High and low serving rates were experienced at both small and large feeding sites. The low serving rates are mostly attributable to slower troop arrival rate at the MFSU for service.

Based on the Norway-83 data, two MFSUs per combat battalion are sufficient to provide an on-demand, two-hot-T Ration-meals-per-day capability.[6] This allocation is confirmed by the Twentynine Palms remote clock time data.

TABLE 4. Mobile Food Service Unit Serving Rates.

Field Evaluation	No. Sites	Serving Rate (Troops/Minute)			
		Min	Max	Ave	Median
Norway-83	18	2.0	5.5	3.4	3.2
Twentynine Palms-Aug	13	2.2	6.3	3.0	3.3

T AND B RATION WORKLOADS

During the Norway-84 field evaluation, the Modular Field Kitchen was utilized to prepare both B and T Rations. On each day of the operation, only one type ration was prepared. To assess the workloads, and thus staffing requirements generated by each type ration, work sampling data were collected.

Relative to the B Ration operation, the work sampling data cover six entire workdays, excluding the night shift, which consisted of two foodservice personnel and one K.P. With the B Ration, the night shift prepared the baked items (desserts) on the following day's menu and initiated the preparation of the breakfast menu items (bacon, dehydrated potatoes, etc.) The night crew's shift, which averaged about eight hours, started after the day shift secured for the day, about 2000 hours, and ended when the day shift reported to duty, about 0400 hours.

For the T Ration, the work sampling data cover four entire workdays. With the T Ration there was no night shift due to the heat-and-serve nature of the Tray Pack items. For both B and T Rations, work sampling observations were taken at 15 minute intervals throughout the day shifts. At each observation, each on-duty foodservice worker (foodservice personnel or K.P.) was classified as performing one of a defined set of activities.

The actual meal headcounts for the days on which work sampling data were collected are presented in Table 5. The B Rations were prepared for on-site feeding purposes only while the T Rations were prepared for both on-site and remote feeding. However, for each type ration, the work sampling data cover about the same number of total meals; 5,404 B Ration meals, and 5,345 T Ration meals. For remote site feeding, the Tray Packs were heated at the MFK and packed still sealed in insulated containers. These preheated Tray Packs, along with fresh made hot coffee in insulated beverage jugs, were then normally transported by helicopter to a forward staging area. At the staging area, they were transferred to a 5-ton truck for distribution and serving to forward-deployed ground combat elements.

For each type ration, the actual work sampling data are summarized in Table 6, in terms of number of observations per activity (N), total worker hours per activity, percent of total observations per activity, and work hours per 100 meals for each activity. Because observations were recorded every 15 minutes (four times per hour), the work hours expended per activity are estimated by dividing the number of observations per activity by four. With only one exception, the work hours expended on each activity per 100 meals was established by dividing the total work hours expended on the activity by the total number of meals (in hundreds) prepared. Relative to B Rations, all of these figures are based on 5,404 meals. For example, work hours expended per 100 B Ration meals on the activity M-2 burners were (62 work hours/54.04 meals) 1.15 hours. The T Ration work sampling data covered 5,345 meals which were prepared at the MFK of which 3,545 were served at the MFK and 1,800 were sent out for remote site feeding. Therefore, for the T Ration, the work hours expended per 100 meals were based on 3,545 meals for the activity serving and 5,345 meals for all other activities.

TABLE 5. Meal Headcounts for Work Sampling Data (Norway-84).

Type Rations	Date	Breakfast		Lunch		Dinner		Total	
		On Site	Remote	On Site	Remote	On Site	Remote	On Site	Remote
B	10 March	302	-	-	-	499	-	801	-
	11 March	353	-	-	-	443	-	796	-
	13 March	269	-	218	-	468	-	955	-
	14 March	354	-	265	-	422	-	1,041	-
	15 March	244	-	213	-	385	-	842	-
	17 March	225	-	313	-	431	-	969	-
	All	1,747	-	1,009	-	2,648	-	5,404	-
T	16 March	277	-	262	-	422	-	961	-
	18 March	230	-	255	300	477	-	962	300
	20 March	244	-	360	500	427	500	1,031	1,000
	21 March	291	-	300	500	-	-	591	500
	All	1,042	-	1,177	1,300	1,326	500	3,545	1,800

TABLE 6. Work Sampling Data Summary.

Activity	B Rations				T Rations			
	N	Worker Hours	% Total	Work Hrs/ 100 Meals	N	Worker Hours	% Total	Work Hrs/ 100 Meals
Supervision	77	19	2	0.36	3	1	0	0.01
M-2 Burners	248	62	6	1.15	43	11	4	0.20
B Rations	688	172	15	3.18	-	-	-	-
Non T Rations	-	-	-	-	44	11	4	0.21
T Rations	-	-	-	-	116	29	10	0.54
Beverages	81	20	2	0.37	38	10	3	0.18
Serving	708	177	16	3.28	357	89	30	2.52
General Cleanup	93	23	2	0.43	45	11	4	0.21
Equip. Sanit.	117	29	3	0.54	29	7	2	0.14
Pots & Pans	395	99	9	1.82	56	14	5	0.26
Resupply	44	11	1	0.20	13	3	1	0.06
Other	22	6	0	0.10	2	1	0	0.01
Night Shift[a]	432	108	10	2.00	-	-	-	-
Nonproductive[b]	1,576	394	35	7.28	459	115	38	2.15
Total	4,481	1,120	100%	20.71	1,205	301	100%	6.49

a No work sampling data collected during night shift, which consisted of 2 foodservice personnel and 1 KP. Figures represent projected night shift productive effort based on eight hour work shift and 75% productive time factor.

b For the B Ration only, includes projected 144 observations, or 36 worker hours, based on assumed 25% nonproductive time for the night shift.

Table 7 presents a direct comparison of both the actual and adjusted work hour expenditure per activity for each type ration. The actual work hour expenditures are based on the B and T Ration work sampling data summarized in Table 6. To facilitate a direct, unbiased comparison of the B and T Ration, adjustments were made to the actual work hour expenditures for three activities.

TABLE 7. Actual and Adjusted B and T Ration Labor Requirements (Worker Hours per 100 Meals).

Activity	Actual			Adjusted		
	B	T	Red	B	T	Red
B Rations	3.18	-		3.18	-	
Night Shift	2.00	-		2.00	-	
Non T Rations	-	0.21	86%	-	0.21	86%
T Rations	-	0.54		-	0.54	
Beverages	0.37	0.18	51%	0.37	0.37	0%
M-2 Burners	1.15	0.20	83%	1.15	0.20	83%
Serving	3.28	2.52	23%	2.98	2.98	0%
General Cleanup	0.43	0.21	51%	0.43	0.21	51%
Equip. Sanit.	0.54	0.14	74%	0.54	0.14	74%
Pots & Pans	1.82	0.26	86%	1.82	0.26	86%
Misc[a]	0.66	0.08	88%	0.66	0.08	88%
Productive Total	13.43	4.34	68%	13.13	4.99	62%
Nonproductive	7.28	2.15	70%	4.38	1.66	62%
Total	20.71	6.49	69%	17.51	6.65	62%

[a] Consolidation of supervision, resupply, and other activities from Table 6.

A brief explanation of each activity, to include rationale of any adjustments and discussion of the work hours expended by type ration, follows.

B Rations and Night Shift. These two categories together represent all productive efforts expended to prepare the B Ration menu items (excluding beverages). The "prepare B Ration" activity represents the worker hours expended by the day shift (0400 - 2000 hours), while the category "night shift" represents the estimated number of productive work hours expended by the night shift personnel. No work sampling observations were taken during the night shift. However, the night shift expended no productive efforts relative to pot and pan sanitation, serving, or beverage preparation, and only minimal productive efforts relative to equipment sanitation and equipment cleanup. Based on current manpower planning factors, 75% of the night shift's total work hours were assumed to be expended on B Ration preparation and 25% on nonproductive efforts. Together, the day and night shift expended an estimated 5.18 productive work hours per 100 meals on B Ration preparation.

Non T Rations and T Rations. All productive efforts observed on actual T Ration preparation (excluding beverages) were categorized into one of these two activities. The activity "T Rations" included all efforts expended to prepare hot Tray Packs for on-site or remote-site feeding to include: opening cases of Tray Packs; loading trays into the Tray Pack heater (also #10 cans of fruit dessert into squareheads); removing heated trays; and loading heated trays into insulated containers to hold until the start of the MFK's serving period or for remote-site feeding. The activity "non T Rations" included all productive efforts expended on the non-Tray Pack portion of the T Ration, for example: assembling relish trays, slicing bread, and preparing butter, jams, jellies, and peanut butter for self-service. Together only 0.75 work hours were expended on these two activities combined per 100 T Ration meals. Compared to the B Ration, this represents an 86% reduction in the work hours expended on actual ration preparation.

Beverages. The type and variety of beverages offered is independent of the type ration provided. Therefore, all productive effort expended on beverage preparation with each ration was recorded under this separate activity. For the initial period of the MFK evaluation, when B Rations were being prepared, a wider variety of hot and cold beverages were prepared and offered at each meal period. During the later period of the evaluation, when T Rations were provided, the variety offered was more limited due to nonavailability. In addition, only hot coffee was provided with the hot T Ration meals for remote feeding. Because of the above, the actual work sampling data reflected a significant drop in work hours expended on beverage preparation for the T Ration. Therefore, to facilitate a direct, unbiased comparison of B and T Rations total work impact, the work hours expended on beverage preparation with the T Ration were adjusted upward to be the same as the B Rations; 0.37 work hours per 100 meals.

M-2 Burners. This activity includes all efforts expended fueling, maintaining, repairing, starting, adjusting, and carrying the M-2 burners. In addition, with T Rations, this activity includes the very minimal efforts expended to start the Tray Pack heating system (push two buttons) and to refuel the system once a day. The Tray Pack heating system required no adjustments, maintainance, or repair during the evaluation. Based on the work sampling data results (0.20 versus 1.15 work hours per 100 T and B Ration meals, respectively), the T Ration provides an 83% reduction in the work hours expended on this activity. This large reduction is attributable to the significantly reduced M-2 burner requirement with the T Ration due to the high response heat-and-serve nature of the Tray Pack, and the significantly reduced field sanitation requirement with the T Ration. The reduced M-2 burner requirement with T Rations was confirmed by the equipment utilization data, which are presented and discussed in the section "Modular Field Kitchen Equipment Utilization."

Serving. This activity includes all efforts expended setting up, replenishing, and tearing down the serving line, opening Tray Packs, and manning the serving line during the serving period whether actively serving or not. A

very significant portion of the observations recorded under this activity represents workers assigned to the serving lines during the serving period. The actual work sampling results indicate the T Ration offers an unexpected 23% reduction in the work hours expended for this activity. However, the number of workers required on a serving line with a B or T Ration is the same. The larger work effort recorded on this activity for the B Ration is attributable to the following two factors: on the average, the serving line with B Rations was staffed with more workers than the serving line with T Rations; and during the serving periods, workers assigned to the serving line were classified as performing the activity whether actively serving or not. To facilitate a direct, unbiased comparison of the total workload for each ration, the work efforts expended on serving for B and T Rations were adjusted to be the same, based on a weighted average of the actual data for each ration. Based on the adjusted figure, about 2.98 work hours are expended on the activity "serving" per 100 B or T Ration meals.

General Cleanup. This activity includes general cleanup of the MFK and sanitation center to include: pickup/removal of rubbish; removal of pots, pans, and utensils requiring sanitation from the kitchen to the sanitation center; and rearrangement of kitchen supplies and small equipment items. An estimated 0.43 and 0.21 work hours were expended on this activity per 100 B and T Ration meals, respectively. The estimated 51% reduced work effort with the T Ration is attributable to the Tray Pack, which eliminates the need to assemble and then cleanup several ingredients to make a single menu item and reduces considerably the number of pots, pans, and other small items requiring removal from the kitchen to the sanitation center for sanitation purposes.

Equipment Sanitation. This activity includes all productive efforts expended to sanitize or clean the MFK's equipment, to include: griddles, steamtables, worktables, ranges, ovens, pot cradles, and Tray Pack heaters. With the Tray Pack, significantly less equipment is utilized and therefore the equipment sanitation requirement is reduced. This reduction is reflected in the work sampling results, which indicate an expenditure of 0.54 and 0.14 work hours per 100 B and T Ration meals, respectively. Following the evaluation, an extensive effort was expended (not included in work sampling observations) to completely clean the ranges and ovens before packing them up. If included, the expenditure of 0.54 work hours per 100 B Ration meals would have been higher making the proposed concept appear even more effective.

Pots and Pans. This activity includes all efforts expended to properly sanitize pots, pans, utensils, and insulated containers and jugs. Also included were all efforts to fill and empty the field sinks and to clean the sanitation equipment itself. The Tray Pack eliminates the need for pots or pans for food preparation, cooking, and serving purposes. Therefore, with the T Ration, a significant reduction in the work effort expended on this activity was expected. With an expenditure of 1.82 and 0.26 work hours per 100 B and T Ration meals, respectively, the T Ration offers an 86% reduction on the required work effort expended on this activity.

Miscellaneous Productive. This activity includes the productive efforts categorized as supervision, resupply, or "other" on the data collection form. Work categorized as "other" represents those infrequent productive efforts observed which did not properly fall into the set of predefined productive activities. For all productive efforts covered by this activity, only 0.66 and 0.08 work hours were expended per 100 B and T Ration meals, respectively.

Productive Total. Referring to the adjusted figures in Table 7, the T and B Rations generate productive workloads of 4.99 and 13.13 work hours per 100 meals. In other words, the productive effort expended to provide T Rations is 62% less than the B Rations. Previous Natick R&D Center evaluations have confirmed that the total productive workloads generated by B and A Rations to be the same. Therefore, based on the Norway-84 and these previous evaluations together, the productive effort required to prepare T Rations is 62% less than that required to provide A or B Rations.

Nonproductive. Referring back to Table 6, 35% and 38% of all work sampling observations with the B and T Rations, respectively, were classified as nonproductive. This translates into 7.28 and 2.15 nonproductive work hours per 100 B and T Ration meals. Current military foodservice staffing levels are based on a 75% productivity factor, that is one on-duty worker hour yields 45 minutes of productive effort and 15 minutes of nonproductive effort. In addition, the total productive effort expended to prepare rations (assuming no make work) is independent of the actual staffing level. Thus, overstaffing results in a higher nonproductivity rate and understaffing in a lower nonproductivity rate. Based on the current military foodservice planning factors, the MFK was overstaffed while providing both B and T Rations. For both rations, the adjusted nonproductive work hours equal one third of the rations' total productive hours. This adjustment results in 75% and 25% of each ration's total work hours being classified as productive and nonproductive, respectively.

Total Work Hours. These figures reflect the total number of on-duty work hours, to include productive and nonproductive time, which need be provided per 100 B or T Ration meals. Based on the adjusted work hours in Table 7, the T Ration requires 62% fewer on-duty work hours than the B Ration - 6.65 versus 17.51 work hours per 100 meals. This reduction translates into a potential 62% reduction in actual foodservice system staffing requirements with the T Ration.

ADEQUACY OF PROPOSED NEW SYSTEM STAFFING LEVELS

Two different staffing levels are proposed for the new system; one for a T Ration capability; and the other for an A or B Ration capability. The proposed T Ration staffing level is intended to provide a two-hot-meals-per-day capability when supporting battalion troops at multiple feeding locations, and a three-hot-meals-per-day capability when supporting battalion troops at one consolidated feeding location. The proposed A/B Ration staffing level is intended to provide a three-hot-meals-per-day capability when supporting troops at one consolidated location only.

During the Norway-83 evaluation, the MFSU was utilized to provide hot T Ration meals to troops at multiple remote sites. To assess the workload for this type operation, both work sampling data and remote clock time were collected. These data were collected in a format to facilitate the projection of workloads, and thus staffing requirements, for all MFSU and T Ration feeding situations to include: different size units; feeding disciplines of one, two, or three T Ration meals per day; and for consolidated as well as multiple remote-site feeding.

During the Norway-84 evaluation, the MFK was utilized to provide T and B Rations. Work sampling data were collected to assess the workload to prepare and serve T and B Rations at a MFK. Based on previous evaluations, the workload to prepare A Rations is the same as that to prepare B Rations.

The projected workloads and resulting staffing requirements for an infantry and an artillery battalion are presented in Table 8 for a variety of T and A/B Ration feeding situations. Workloads projected from the Norway-83 data are for the MFSU with T Rations, while those projected from the Norway-84 data are for the MFK with T or A/B Rations. The feeding situation, two meals per day and five sites per meal, corresponds to each company of the battalion being setup in a different location with the MFSU traveling to, and providing, two hot T Ration meals to each company in location. The feeding situation, one site per meal, corresponds to the entire battalion being consolidated and thus fed at one location. The workloads, in terms of work hours per day, include both productive and nonproductive time. These workloads are based on 75% of work hours being productive and the remaining 25% being nonproductive. Worker days, which are equivalent to staffing requirements, are based on a 12 hour workday. Each 12 hour worker day provides 9 productive hours (75%) of effort and 3 hours (25%) of nonproductive time.

TABLE 8. Adequacy of Proposed New System Staffing Levels.

Unit	Norway Test Data	Type Ration	Projected Workload				Proposed Staffing Levels		
			Meals /Day	Sites /Meal	Hrs/ Day	Worker Days	FSP	KP	Total
Infantry	83	T	2	5	165.6	13.8	16	6	22
Battalion	83	T	3	1	175.2	14.6	16	6	22
(940	84	T	3	1	187.5	15.6	16	6	22
Troops)	84	B/A	3	1	493.8	41.2	26	13	39
Artillery	83	T	2	5	111.8	9.3	11	5	16
Battalion	83	T	3	1	128.7	10.7	11	5	16
(682	84	T	3	1	136.1	11.3	11	5	16
Troops)	84	B/A	3	1	358.3	29.9	16	9	25

Referring to Table 8, the proposed T Ration staffing levels are more than adequate to provide a two-hot-meals-per-day capability when supporting troops at multiple remote sites, or a three-hot-meals-per-day capability when supporting battalion troops at a single consolidated site. The workload for consolidated field feeding with MFSUs and T Ration is based on extrapolation of the Norway-83 data. However, the projected workloads for consolidated T Ration field feeding are similar for both MFSU- and MFK-type operations, with the MFK operation being about 7% higher. The projected maximum T Ration workloads are 15.6 and 11.3 workers for the infantry and artillery battalions. These maximum workloads are considerably less than the proposed new system staffing levels of 22 workers (foodservice personnel and K.P.) for the infantry battalion and 16 workers for the artillery battalion.

From the Norway-83 data, the projected new system workloads to provide a three hot A or B Ration capability per day are somewhat higher than the originally proposed staffing levels. Referring to Table 8 for an infantry battalion, the projected workload is 41.2 work days while the proposed staffing level was 39 total workers. Similarly, for an artillery battalion the projected workload is 29.9 work days while the proposed staffing level was 25 total workers.

In summary, the originally proposed new system T Ration staffing levels, which provided a 66% reduction in total foodservice worker requirements, are more than adequate. However, for an A/B Ration capability, the required new staffing levels are somewhat higher than those originally proposed. Based on the data for an A/B Ration capability, the new system can provide a reduction in total foodservice worker requirements in the 30% to 35% range rather than the 43% originally projected.

MODULAR FIELD KITCHEN EQUIPMENT UTILIZATION

Equipment utilization data were collected during the Norway-84 test of the MFK to assess the amount of time various equipment items were utilized to provide T and B Rations, and the amount of fuel consumed to provide both type rations. Observations were taken at half hour intervals throughout the day shift's workday (from about 0400 hours to about 2000 hours). At each observation an equipment item, except for the Tray Pack heater, was categorized as being utilized if it had a lit M-2 burner. In addition, the number of lit M-2 burners under each griddle and the number of lit M-2 burners not being used with any equipment item were noted. For the Tray Pack heater, the item was categorized as being utilized if the 3-kW generator was running. The data for the B Ration excludes equipment utilization by the night shift (from about 2000 hours to 0400 hours). Due to their primary work duty, to prepare the dessert-type items on the following day's menu, the night shift utilized the ovens predominately. Observations were taken at 30-minute intervals (two times per hour) and therefore equipment utilization (hours) is estimated by dividing the number of times an item was observed being used by two. The equipment utilization data are presented in Table 9 and Table 10 for the B and T Ration, respectively.

TABLE 9. Modular Field Kitchen Equipment Item Utilization for B Rations.

Item	Total Eqpmt Hrs/Day			No. Items	Ave Daily Hrs/Item
	Min.	Max.	Ave.		
Ranges	22.0	33.0	26.4	5	5.3
Ovens	0.0	26.5	11.4	3	3.8
Pot Cradles	23.5	29.5	25.3	3	8.4
Griddles	2.0	12.0	7.6	2	3.8
Steamtables	12.0	17.0	14.3	2	7.1
Sinks	22.0	27.5	25.0	3	8.3
Tray Pack Heater	0.0	0.0	0.0	1	0.0

TABLE 10. Modular Field Kitchen Equipment Item Utilization for T Rations.

Item	Total Eqpmt Hrs/Day			No. Items	Ave Daily Hrs/Item
	Min.	Max.	Ave.		
Ranges	0.0	6.0	3.0	5	0.6
Ovens	0.0	0.0	0.0	3	0.0
Pot Cradles	17.5	25.5	21.6	3	7.2
Griddles	0.0	0.0	0.0	2	0.0
Steamtables	4.5	14.0	10.6	2	5.3
Sinks	4.0	11.0	8.0	3	2.7
Tray Pack Heater	8.5	13.5	10.3	1	10.3

Relative to the B Ration operation, the standard field ranges were used much more frequently than the ovens. In addition, the ovens varied considerably in use from day to day and ranged from no use on one day to over 26 hours of total use on another day. The foodservice personnel utilized the ovens almost exclusively for baking purposes and occasionally to maintain cooked food items hot. On the one day the ovens were operated for 26.5 total hours, they were used predominately to bake B Ration biscuits. For other than baking, the foodservice personnel tended to use the field ranges. The pot cradles were used extensively for B Ration preparation. On the average, each pot cradle was utilized over eight hours per day. These items were used mostly for making hot coffee, hot soup, or heating vegetables. The foodservice personnel liked the pot cradle item because of the fast rate at which the contents of a 15 or 10 gallon pot heated, and the minimal equipment sanitation requirements.

Each serving line had one griddle and one steamtable. The steamtables were utilized for each meal period to maintain hot items on the line. Griddle utilization varied considerably from day to day depending on the number of menu items requiring this type of cooking. As shown by the data, with B Rations the field sinks were utilized extensively to wash and sanitize all of the pots, pans, and other utensils requiring such. On the average, the sinks were utilized over eight hours each day.

Relative to the T Ration operation, the ovens and griddles were not used at all. The field ranges were utilized a small amount of time to heat hot fruit dessert items, which were packed in #10 cans. These items were not available in Tray Packs at the time of the evaluation. With the T Ration, the pot cradles were used for hot beverage preparation only. With the T Ration, the average daily pot cradle utilization of 21.6 hours for beverage preparation may appear high, but it corresponds to an average of 1,338 meals per day while the B Ration data correspond to an average of 900 meals per day. With the T Ration, the steamtables were used for a shorter time than with the B Ration. This is because with T Rations, the foodservice personnel set the hot portion (Tray Packs) of the line up just before the start of the actual serving period. The reduced sanitation workload generated by the T Ration is reflected in the average number of hours the sinks were utilized. Again, it is important to note that the average utilization data for the B and T Rations are based on 900 B Ration and 1,338 T Ration meals per day. The single Tray Pack heater was operated between 8.5 and 13.5 hours per day and on the average 10.3 hours per day.

FUEL REQUIREMENTS FOR B AND T RATIONS

The fuel requirements for B and T Rations, based on the Norway-84 equipment utilization data, are projected in Table 11. Disposable messgear was utilized with both type rations and therefore this requirement excludes any fuel for messgear sanitation purposes. Equipment utilization data were not collected during the B Ration night shift. However, based on discussions with the night shift, on the average four M-2 burners were operated throughout the eight hour shift. Typically, one M-2 burner was utilized with each of the three ovens, and the fourth was used with a pot cradle to provide warm water for baking purposes. Therefore, the B Ration fuel requirement includes an estimated 32 hours of M-2 burner operation per night shift.

The fuel requirements for B and T Ration meals are projected based on an estimated fuel consumption rate of 0.5 gallons per M-2 burner and Tray Pack heater operating hour. Based on the data, the fuel consumption per 100 B Ration meals varied between 7.13 and 9.99 and averaged 8.28 gallons per 100 meals. For the T Ration, the fuel consumption varied between 1.67 and 2.50 and averaged only 2.09 gallons per 100 meals. Based on the Norway-84 data, T Rations reduce the field feeding fuel requirements by 74%.

TABLE 11. Fuel Requirement for B and T Rations (Gals/100 Meals).

Type Ration	Date	No. Meals	Equipment Item (Hours)			Meals/ Total Hr	Total Hrs/ 100 Meals	Fuel Req't/ 100 Meals
			M-2 Burners[a]	Tray Heater	Total			
B	10 March	801	133.5	-	133.5	6.00	16.67	8.33
	11 March	796	159.0	-	159.0	5.01	19.97	9.99
	13 March	955	155.5	-	155.5	6.14	16.28	8.14
	14 March	1,041	148.5	-	148.5	7.01	14.27	7.13
	15 March	842	144.5	-	144.5	5.83	17.16	8.58
	17 March	969	154.0	-	154.0	6.29	15.89	7.95
	Total	5,404	895.0	-	895.0	6.04	16.56	8.28
T	16 March	961	39.5	8.5	48.0	20.02	4.99	2.50
	18 March	1,262	56.5	10.5	57.0	22.14	4.52	2.26
	20 March	2,031	54.5	13.5	68.0	29.87	3.35	1.67
	21 March	1,091	31.5	8.5	40.0	27.28	3.67	1.83
	Total	5,345	182.0	41.0	223.0	23.97	4.17	2.09

[a] For the B Ration only, includes estimated 32 hours of M-2 burner operation for the night shift.

CONSUMER ACCEPTANCE OF TRAY PACK ITEMS

To assess troop opinions of the various Tray Pack items, consumer acceptance data were collected during each field evaluation. Following completion of the T Ration meal, troops were verbally asked to give their impression of each Tray Pack meal component just consumed. Their responses were based on the nine point acceptance (hedonic) scale shown in Figure 7. The average rating for each item for each evaluation is presented in Table 12. All items, except those footnoted in the table, represent specification items being developed for the armed services as part of the Tray Pack product development program.

9 Like Extremely

8 Like Very Much

7 Like Moderately

6 Like Slightly

5 Neither Like nor Dislike

4 Dislike Slightly

3 Dislike Moderatly

2 Dislike Very Much

1 Dislike Extremely

Figure 7. Customer acceptance (hedonic) rating scale.

TABLE 12. Tray Pack Item Average Consumer Acceptance Ratings.

Item[a]	Evaluation			
	Norway 84	Ethan Allen	Twentynine Palms	All
Beef/BBQ Sauce	7.06	7.61	-	7.34
Beef Pepper Steak	7.16	7.40	-	7.28
Beef Stew	8.14	7.64	7.43	7.74
Ham Slices	6.87	-	-	6.87
Lasagna	7.79	7.65	-	7.72
Meatloaf/Mushroom Gravy	-	-	6.95	6.95
Pork Slices/Gravy	6.93	7.06	-	7.00
Roast Beef/Gravy	7.06	5.88	6.42	6.45
Breakfast Bake	7.71	7.32	-	7.52
Creamed Ground Beef	-	-	5.85	5.85
Scrambled Eggs/Ham	5.86	6.50	5.63	6.00
Beans/Bacon	6.32	-	-	6.32
Escalloped Potatoes	6.41	6.74	7.20	6.78
Macaroni/Cheese	6.62	7.10	6.22	6.65
Potatoes/Butter Sauce	6.62	7.41	6.44	6.82
Rice White[b]	-	7.41	-	7.41
Corn[c]	7.52	7.87	7.64	7.68
Green Beans	7.50	7.25	-	7.38
Mixed Vegetables	6.96	7.02	-	6.99
Peas[c]	7.18	7.06	-	7.12
Apple Dessert	8.48	7.69	6.93	7.70
Blueberry Dessert[d]	7.80	-	7.81	7.81
Cherry Dessert[d]	7.45	-	-	7.45
Peach Dessert[d]	7.01	-	-	7.01
Apple Spice Cake	-	-	6.94	6.94
Cinnamon Rolls[b]	7.83	7.56	-	7.70
Pound Cake	-	7.29	-	7.29
Spice Cake	7.77	7.85	-	7.81
Cherry Nut Cake	-	6.51	5.88	6.20
Orange Nut Cake	5.66	-	-	5.66

[a] Specification items, except as noted
[b] Specification item not available at time of evaluation, therefore produced at Natick R&D Center
[c] Commercial Tray Pack item
[d] Regular pie filling, #10 cans

In general, the acceptance data demonstrate that most Tray Pack products are highly acceptable in climatic environments from very cold (-20°F) to very hot (124°F). Acceptance data were collected on 10 items in both cold and hot environments. For 8 out of 10 of these items, the average acceptance rating in a hot environment was lower than that in a cold environment. Overall, the average rating for an item in a hot environment was 0.36 points lower than that in a cold environment. These data indicate that troops tend to rate the same item higher in a cold environment than a hot environment.

Relative to entree items, with two exceptions, all Tray Pack products averaged 6.45 or higher. The two exceptions, both breakfast items, were scrambled eggs with ham and creamed ground beef. The average ratings for Tray Pack starch items were similar and in the 6.32 to 6.82 range, with the exception of white rice which had an average rating of 7.41. Average ratings for vegetable items were all high and in the 6.99 to 7.68 range. Relative to dessert items, with the exception of cherry and orange nut cake, all items averaged 6.94 or higher. It should be noted that the Tray Pack cherry and orange nut cake products are identical to those provided with the Meal, Ready-to-Eat Ration. In addition, a large proportion of troops did not take this product when offered. The blueberry, cherry, and peach dessert items represent regular #10 cans of pie filling. During the Norway-84 evaluation, the sealed #10 cans of pie filling were heated in squareheads with water by M-2 burners. They were then opened and emptied into steamtable inserts on an as-required basis. Average ratings for the pie fillings, 7.45 to 7.81, indicate high troop acceptance for these types of items. Similar cherry and blueberry Tray Pack items are planned but were not available at the time of the evaluation.

The acceptance data collected during these evaluations confirm the high troop acceptability for the single hot item meal concept. With this concept, originally evaluated during the Norway-82 and Norway-83 evaluations, troops are provided with a double portion of a stew or casserole type item (yielding 6 to 7 portions per tray). These items are augmented with a hot or cold Tray Pack dessert item. No separate starch or vegetable items are provided. During the Norway-82 and Norway-83 evaluations, lasagna and chicken stew (both commercial items) were provided to combat troops as single hot item meals. For the Norway-82 and Norway-83 evaluations the lasagna averaged 8.6 and 8.4, respectively, while the chicken stew averaged 7.7 and 8.3, respectively. During the Norway-84, Ethan Allen, and Twentynine Palms evaluations, beef stew was provided as a single hot item meal while the lasagna was augmented with a vegetable but no separate starch. On the average, the beef stew was the highest rated meal during these exercises while the lasagna was a close second.

For entree items, Table 13 presents a comparison of troop preference ratings and actual Tray Pack acceptance ratings. With one exception, roast beef, the item acceptance ratings were higher than the troop preference ratings for the item. These high ratings demonstrate the high quality and thus acceptability of Tray Pack items. In addition, the largest increase in item acceptance, compared to item preference, was with the beef stew and lasagna Tray Pack items. These higher ratings indicate that stew, casserole, and pasta type items "Tray Pack" well and, therefore, are more acceptable.

TABLE 13. Comparison of Armed Forces Food Preferences and Actual Tray Pack Item Acceptance Ratings.

Item[a]	Item Preference[b]	Tray Pack Acceptance
Baked Ham	6.82	6.87
BBQ Beef Cubes	6.13	7.34
Pepper Steak	6.59	7.28
Roast Beef	7.04	6.74
Roast Pork	6.49	7.00
Beef Stew	6.68	7.74
Lasagna	6.67	7.72
Meatloaf	6.69	6.95

[a] Item description as listed in preference survey. Actual Tray Pack item and description may vary slightly (see Table 1).

[b] Ratings from "Armed Forces Food Preferences", Natick R&D Center TR75-63-FSL, by Herbert L. Meiselman, Dave Waterman, Lawrence E. Symington (AD A110 512)

EQUIPMENT PERFORMANCE

Mobile Food Service Unit. Two (Norway-83 and Ethan Allen) of the three evaluations with the MFSU were conducted in very cold environments. Both of these evaluations were with a first generation technology demonstrator. To prevent freezing and potential equipment damage, the Tray Pack heating system was filled with an approximate 50% water and 50% propylene glycol solution. This solution provided protection from freezing down to about -28°F. During the initial cold weather test, Norway-83, the MFSU operated without equipment problems or failures. Total equipment operating time during the test is estimated at about 50 hours. The MFSU's diesel-fired 3-kW generator and hot water heater started and operated properly in ambient temperatures as low as -20°F. Of all environments, from very hot to very cold, the cold environment is the most difficult or demanding on proper equipment performance. Therefore, due to the limited five-day duration of the Norway-83 evaluation, the Ethan Allen evaluation with the MFSU was also conducted. This evaluation covered an extended four-week period and included 20 days of operation. Again, the MFSU operated without equipment problems or failures in ambient temperatures as low as -25°F. As during the Norway-83 evaluation, at the lower temperatures the generator's small battery was not strong enough to start it. However, with a jump from the MFSU's prime mover, the generator started with no major problems. Together, these two evaluations demonstrated that the MFSU equipment will start and operate properly in temperatures at least as low as -25°F.

Two MFSUs were utilized during the Twentynine Palms hot weather evaluations. Both units were "second generation" technology demonstrators. Ambient temperatures during the initial evaluation were normally above 100°F and as high as 124°F. With one exception, both MFSUs operated throughout the evaluation without equipment problems or failures. The one exception was the hot water heater on one MFSU, which malfunctioned. Following its replacement, this MFSU operated without any other problems thoughout the remainder of the evaluation.

During the Twentynine Palms evaluations, each MFSU was towed over 500 miles across extremely rugged, desert terrain. Due to the rugged terrain, the king pin broke on one of the prime movers during the initial evaluations, However, the MFSU experienced no structural failures in its equipment on the trailer itself. In addition, the MFSU's hot water heater and generator operated without problems while being towed over this rugged terrain.

The Norway-83, Ethan Allen, and Twentynine Palms evaluations together demonstrated that the MFSU equipment will start and operate properly in temperatures at least as low as -25°F and at least as high as 124°F.

Modular Field Kitchens. Versions of the MFK have been under development and have undergone extensive field evaluations. The evaluations have been conducted with the Marine Corps, Army, Air Force, and National Guard. These evaluations have demonstrated the benefits or advantages of a MFK-type kitchen and its effectiveness in hot to temperate environments. The advantages include the ability to vary the shelter size and effectively design and house different size kitchens within a single shelter, and the ability to ventilate fumes from the M-2 burners and heat from the kitchen, even during inclement weather. For example, in hot environments internal kitchen temperatures during food preparation and cooking are typically only 3°F to 8°F above ambient. In addition, these earlier evaluations demonstrated the effectiveness of the MFK's new equipment items to include griddles, steamtables, pot cradles, ovens, worktables, sinks, and the M-80 hot water system. With the exception of the M-80 hot water system, all of these items are passive in nature and therefore no operational problems as a function of ambient temperature are expected. The M-80 hot water system consists of the standard hot water heater of the shower and bath unit, a pump, and some hoses. This system would not be utilized in below freezing environments due to the potential for freezing. At the current time, the Army and Air Force are proceeding with plans to field the Tactical Field Kitchen (TFK) and New Harvest Eagle, respectively -- both versions of the MFK.

During the Norway-84 evaluation of the MFK, temperatures were in the 5°F to 35°F range. As expected, all MFK new equipment items performed satisfactorily. Since ambient temperatures were below freezing, the M-80 hot water system was not provided with the MFK.

For the Norway-84 evaluation, the MFK's TEMPER shelter had a temperate climate fabric cover and no liner. When the MFK was utilized to provide B Rations, the numerous M-2 burners generated sufficient heat to maintain the MFK comfortably warm, even with the roof vents somewhat open to let out fumes generated by the M-2 burners. On occasion the fumes tended to build up to a

noticeable level. When this occurred, foodservice personnel opened the roof vents somewhat wider to let the fumes out which resulted in the MFK cooling off. With T Rations, the reduced number of M-2 burners was not sufficient even to maintain the MFK warm with the roof vents closed. For these situations, a Herman Nelson heater was utilized. Therefore, for cold weather operations, to provide for both improved ventilation and better temperature control, the MFK's shelter must be provided with a liner. Current planning is to provide a liner and vestibule doorway sytem with all TEMPER shelters for cold weather operations. The vestibule doorway system will significantly reduce the heat loss and cold drafts caused by open doorways during the serving period.

CONCEPT OF OPERATION

The proposed MFSU concept of operation would have two units assigned to the headquarters company or battery of each combat battalion. From this location, the MFSUs would deploy and support subordinate line companies of the same battalion in their positions. The second Twentynine Palms evaluation demonstrated the benefits and advantages of the proposed concept of operations.

During the Norway-83 evaluation, the single MFSU supported two combat battalions and various headquarters elements. Therefore the MFSU was assigned to and operated from the Beach Support Area (BSA). Due to the lack of communications between the BSA and the supported units, it was necessary to set the planned feeding schedule one day in advance based on anticipated unit locations and activities. As a result, the MFSU's on-demand feeding capability was not exercised. In addition, the average travel time was long (48 minutes from the BSA to the first unit supported). These conditions reduced both the responsiveness of the MFSU and, as a result, the number of troops supported with hot meals. During the initial Twentynine Palms evaluations, the MFSUs operated from the logistics trains area. From this location it was often difficult to establish unit locations and when units were ready or available to eat. As a result, as with the Norway-83 evaluation, the number of units supported was lower than it could have been. To obtain maximum benefits from the new system, the MFSUs must operate from the headquarters element of combat battalions if the combat situation permits. These benefits were clearly demonstrated during the second Twentynine Palms evaluation. During this evaluation, the MFSUs operated from the headquarters battery of an artillery battalion. From this location, because of communication links, the MFSUs were able to respond and support each battery on demand rather than according to some predetermined feeding schedule. This capability, coupled with the shorter travel distances and times, significantly increased the responsiveness of the MFSU and the resulting frequency of hot meals.

During the Norway-83, all units, with three exceptions, were supported in location by the MFSU. On three occasions it was necessary to support two units at about the same time at two different distance locations. When this occurred, one unit was supported with hot trays from insulated containers while the other unit was supported with hot Tray Packs from the MFSU. For a three-day period during the initial Twentynine Palms evaluation, one MFSU remained stationary at the logistics train. During this period, one MFSU supported some of the units in their positions. Other units desiring hot T Ration meals sent a driver and a

vehicle back to the logistics train to pick up the hot T Ration meals required to support the unit. At sites supported by the MFSU, all troops were provided a complete hot T Ration meal. Foodservice personnel made sure that portion sizes were both adequate and uniform. In addition, any leftover unopened heated Tray Packs remained with the MFSU rather than at the site. These trays were taken to the next site where they were opened and served. When units were supported with hot Tray Packs from insulated containers there were normally several Tray Packs left over at the site. This occurred because the number of troops actually fed was less than the number projected to be fed. Two possible explanations for this difference in numbers exist, namely, some troops anticipated to eat were not available to eat; or the projected number of troops to be fed was artificially inflated to ensure sufficient quantities of food were provided. These observations demonstrate the benefits of the MFSU supporting units in their positions rather than sending heated Tray Packs to units in insulated containers. These benefits include: the ability to readily respond to increases or decreases in the number of troops to support; reduced waste; and improved control over the entire foodservice operation.

The proposed new system ration policy is to provide T Rations, to the extent possible, during the initial stages of a deployment and later to transition to an A ration as the supply and combat situations permit. However, for extremely cold environments, it may be desirable to stay with T Rations and not transition to A Rations. Both A and B Rations generate a large pot and pan sanitation requirement and thus a large water requirement. During the Norway-84 evaluation of the MFK and B Rations, ambient temperatures were warmer than normal and in the +5°F to +35°F range. Even at these temperatures the sanitation function started to result in three problems: waste water from the sinks froze and blocked the drain hoses; the ground froze resulting in the necessity for a back hoe to dig the soakage pit; and waste water froze in the soakage pit. At much lower temperatures, the problems associated with obtaining and eliminating sanitation water are both accentuated and more numerous. Therefore, to eliminate this potentially serious problem area, for very cold environments it may be advantageous to stay with T Rations and not transition to A (or B) Rations.

For the Norway-83 and Twentynine Palms evaluations, at about 25% of the sites supported by the MFSU, there were small groups or teams of combat troops who were unable to leave their positions and come to the MFSU for a hot T Ration meal. The sizes of these small groups were in the 5 to 15 troop range. For these troops, hot sealed Tray Packs were taken to their position by unit personnel where they were opened and served. For this feeding situation, the single hot item meal concept is ideal. With this concept, only a single tray of a stew- or casserole-type item need be sent for every five to six troops rather than separate trays of entree, starch, and vegetable items.

CONCLUSIONS AND RECOMMENDATIONS

Based on the field evaluations, the following recommendations and conclusions are made:

° the MFSU and MFK perform effectively and T Rations are highly acceptable in environments from very cold to very hot;

° the MFSU with T Rations provide the responsiveness, mobility, and flexibility characteristics required to maximize both the frequency and acceptability of hot meals provided, given the tactical situation. The MFSU's heat-on-the-move capability is essential for these performance characteristics.

° For an on-demand, two-hot-T Ration-meals-per-day capability, the MFSU requirement is two per battalion.

° For maximum system performance, the MFSUs should be assigned to and operate from the headquarters element of combat battalions, and support subordinate line companies of the battalion in their positions.

° A core group of single item Tray Pack meals (stew/casserole-type items) should be included in any T Ration menu developed. These items are both highly acceptable and ideal for supporting small groups of troops who are unable to leave their positions and go to the MFSU for meal service.

° Based on actual data, the new system T Ration staffing levels, which resulted in a 66% reduction in total foodservice worker requirements, are more than sufficient.

° Based on actual data, the new system A or B Ration staffing levels, which resulted in a 43% reduction in total foodservice requirements, are slightly understated. With proper staffing the actual manpower reduction is about 30-35%.

° Compared to B or A Rations, based on actual data, T Rations reduce the foodservice system fuel requirement by a projected 74%. This savings does not include additional reductions in fuel requirements provided by the use of disposables.

REFERENCES

1. Kirejczyk, H.J., Field Feeding System to Support USMC Forces in the 1990s, NATICK/TR-85/011, Natick Research and Development Center, July 1984. (AD A148 953)

2. Baritz, S.G., et al., The Camp Pendleton Experiment in Battalion Level Field Feeding, NATICK/TR-7T-4-OR/SA, Natick Research and Development Center, July 1976. (AD A028 346)

3. Kirejczyk, H.J., Bonczyk, T.S., Hertweck, G., Evaluation of Alternative Field Feeding Systems for Army Field Medical Units, NATICK/TR-79/040, Natick Research and Development Center, July 1978. (AD A078 620)

4. Nuss, E.M., et al., Field Evaluations and Definition of the Proposed Air Force Forward Base Foodservice System - The New Harvest Eagle, NATICK/TR-82/033, Natick Research and Development Center, July 1982. (AD A120 688)

5. Kirejczyk, H.J., Chevalier, W., Edelman, B., Decareau, R.V., A Systems Analysis of Army Field Bread and Bakery Requirements, NATICK/TR-85/012, Natick Research and Development Center, February 1985.

6. Kirejczyk, H.J., The Cold Weather 83 Evaluation of the Modified Mobile Food Service Unit and Tray Packs, NATICK/TR-85/009, Natick Research and Development Center, August 1984. (AD A148 850)

BIBLIOGRAPHY

Byrne, R.J., et al., A Proposed Combat Food Service System for the Army in 1990, NATICK/TR-80/027, Natick Research and Development Center, January 1980. (AD A113 311)

Kirejczyk, H.J., Tray Pack Related Evaluations at Alloy Express 82, NATICK/TN-83/005, Natick Research and Development Center, 1983.