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STUDIES OF THE BUREAU OF YARDS AND DOCKS PROTECTIVE SHELTER

I. WINTER TRIALS

Prepared Cooperatively by
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Bureau of Yards and Docks
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ABSTRACT

A two-day and a two-week winter trial were conducted at Bethesda, Md., during January and February 1962, in a protective shelter (blast, radioactive fallout, and biological and chemical warfare) designed by the Bureau of Yards and Docks. In each trial 100 Navy volunteers served as the shelter subjects. Two naval officers served as shelter commander and medical officer in each trial. Since the primary purpose of these trials was to study the engineering features of the shelter, it was considered desirable to conduct the trials with a carefully selected, reasonably homogeneous group of shelterees. Therefore, the shelterees, selected from a group of volunteers, were screened both medically and psychologically.

Both trials were conducted successfully, with no major difficulties encountered. Most of the shelter equipment performed satisfactorily; the notable exception was the diesel-generator unit. The ration, basically survival-ration crackers and soup, provided approximately 1800 kilogram calories per man per day. Weight-loss studies indicated that this was a marginal ration. Water was unlimited for drinking purposes but prohibited for personal hygiene; under these conditions, the average total water consumption was 1.8 quarts per man per day. Inlet air temperatures during the trials varied from 12° to 55°F. Although no artificial heating was provided in the shelter, inside temperatures were maintained between 70° and 80°F by adjusting the air-ventilation rate. Hot bunking (50 bunks for 100 men) proved to be an acceptable procedure. Psychological studies indicated that food, lack of water for washing, crowding of the shelter, dirt, and behavior of others were the five leading sources of discomfort. By similar measurements, bunks, lights while sleeping, odors and temperature and humidity were considered least bothersome.

PROBLEM STATUS

This is a final report on one phase of the problem; work is continuing on other phases.

AUTHORIZATION

NRL Problem C08-35
BuY&D Project Y-E011-05-331

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STUDIES OF THE BUREAU OF YARDS AND DOCKS PROTECTIVE SHELTER

I. WINTER TRIALS

CHAPTER 1

INTRODUCTION

In accordance with U.S. Navy Regulations, the Bureau of Yards and Docks (BuDocks) has responsibility for the design and construction of shelters for the Naval shore establishment. To meet its responsibility, BuDocks designed an experimental, 100-man protective shelter and contracted for its construction at the National Naval Medical Center (NNMC), Bethesda, Md. Construction of the shelter was completed in January 1962.

During the design phase of the experimental shelter, BuDocks requested the U.S. Naval Research Laboratory (NRL) to determine the engineering adequacy of the shelter in a series of trails using Navy volunteers (1,2). This request was accepted by NRL (3,4). BuDocks agreed to arrange for adequate medical assistance with the Bureau of Medicine and Surgery (BuMed) (1). Such assistance was arranged and furnished by the Naval Medical Research Institute (NMRI) (5,6).

Although the primary objective of the trials was to determine the adequacy of the engineering aspects of the shelter, it very early became evident that several other aspects would necessarily be encountered. Among these may be mentioned the medical, physiological, psychological, nutritional, management, and shelter-organization aspects. It was decided that these additional aspects would be studied to the greatest extent possible with available manpower and funds but not to the extent of interfering with the primary purpose.

During the planning phase of the trials, maximum advantage was taken of the experiences gained in previous shelter trials. Notable among these were the trials conducted by the Naval Radiological Defense Laboratory (NRDL) in 1959 and 1960 at Camp Parks, California (7,8). Also, the trials conducted by the American Institute for Research (AIR) from March to June 1960 were of great value (9).

It was initially planned to conduct a preliminary trial using electrical heat sources instead of men. The purpose of such a trial was to check features such as the diesel generator, the motor blower, air-flow rates, positive pressures, temperature increases, etc. However, it was soon realized that additional features, such as acceptability of the ration, organizational procedure, performance of the chemical toilets, etc., should be checked, and these required the use of men. Therefore, a 48-hour trial using 100 volunteers from Naval stations in the Washington area was conducted starting Jan. 31, 1962. The results of the two-day trial were responsible for some changes in the plans for the two-week trial. These changes were, however, minor in nature and extent.

The two-week trial was conducted starting Feb. 17, 1962 and ending Mar. 3, 1962. The primary difference between the two-day and two-week trials, other than time, was in the selection of subjects. Of course, much more extensive data were obtained in the two-week trial. The results of the two trials are described in the subsequent sections of this report.

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CHAPTER 2

CONSTRUCTION AND SUPPLIES

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INTRODUCTION

The basic design criteria for this shelter called for overall blast protection of at least 75 psi overpressure, a radiation-protection factor of 5,000, and biological, chemical, and fallout protection. It was also to have the facilities for decontaminating entering personnel. It was required to sustain the above protection over a period of at least two weeks, after which time individuals would be able to set forth, not merely alive, but physically able to fight and/or begin the tasks of recovery. These objectives were to be achieved at minimum cost.

CONSTRUCTION DETAILS

Structure

The shelter is a reinforced quonset hut 25 ft wide, 48 ft long, and 12 ft high along the center line. It is essentially the Navy's standard ammunition magazine. Reinforced structures of this type tested under atomic-blast loadings* have withstood 100 psi overpressures. The layout and relationship of components are shown in Fig. 1.

The outer covering of the shelter is 10-gauge galvanized corrugated steel, while the end walls and the circular sections used as passageways are 8-gauge galvanized steel. All exterior steel surfaces are covered with a bitumastic coating which serves as a seal against moisture.

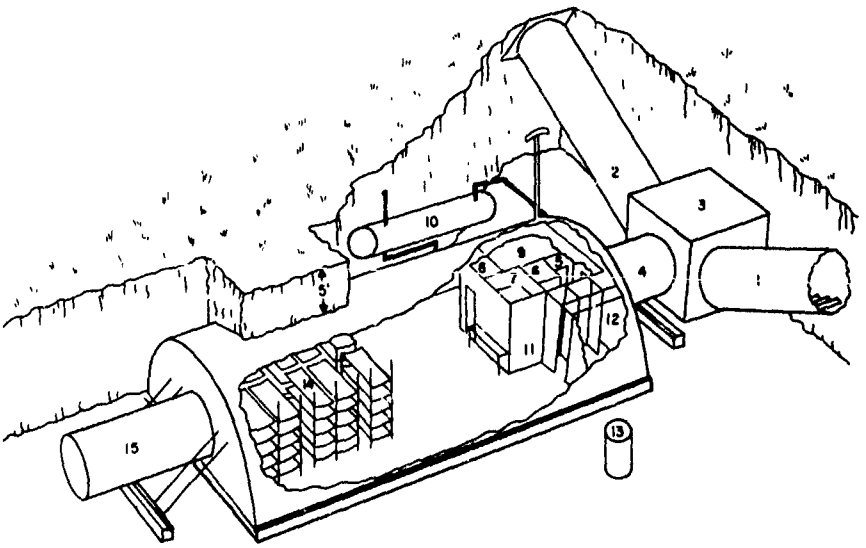
Within the shelter itself, there are 6-in.-deep "I" beams, spaced every 4 ft throughout the length of the shelter. These semicircular reinforcing ribs increase the blast resistance of this type of structure from 30 psi to 75 psi.

The vertical loading is transmitted to a 12 × 15 in. reinforced concrete footing which is continuous around the periphery of the shelter. The floor is a reinforced concrete slab placed on 4 in. of gravel. The floor slab is isolated from the footing by a 1/2-in. joint filled with mastic.

Entrance

As indicated by item 1 of Fig. 1, entrance to the shelter is afforded through a 7-ft-diameter culvert section having built-in stairs for quicker and easier access. Item 2, Fig. 1, is an identical culvert section directly opposite the entrance section. This section has been provided to keep reflected blast waves from building up in the reinforced concrete room housing a motor generator and to provide adequate ventilation for the motor generator. It has no steps, but it could be used to bring in equipment and supplies.

*G. H. Albright, et al., "Evaluation of Buried Corrugated-Steel Arch Structures and Associated Components," Project 3.3, Operation Plumbbob, WT-1422, U.S. Naval Civil Engineering Lab., Feb. 28, 1961.



LEGEND

1 ENTRANCE	8 DRYING ROOM
2 POTENTIAL ENTRANCE SECTION	9. FILTER ROOM
3. MOTOR-GENERATOR ROOM	10. 4000-GALLON WATER TANK
4 ENTRY PASSAGE; BLAST DOOR BETWEEN 3 AND 4 NOT SHOWN	11. DEEPSINK OCCUPIES THIS SPACE
5 TRASH ROOM	12 CHEMICAL TOILETS (6 UNITS)
6 UNDRESSING ROOM FOR DECONTAMINATION TEAM	13 DRY WELL
7 SHOWER ROOM	14. BUNK AREA (CAPACITY 50)
	15 EMERGENCY EXIT

Fig. 1 - Perspective cutaway drawing of shelter, showing arrangement of bunk area and separate rooms

Motor Generator Room

Item 3 of Fig. 1 is a reinforced concrete room 9 ft square and 8 ft high, inside dimensions, which contains a 10-kw diesel generator.

Blast Door

A 32 × 73 in. bank-vault-type door affords the shelter proper with blast protection and will withstand peak overpressures up to 100 psi. The blast door is located in the generator room at the entrance to the passageway (item 4 of Fig. 1) which leads to the shelter proper. This connecting passageway is a 7-ft-diameter steel culvert section, 9-1/2 ft long.

Decontamination Area and Ventilating System

Entrance to the living portion of the shelter is through the personnel decontamination area, items 5, 6, 7, and 8 of Fig. 1. Also in this 12 × 14 ft area (item 9 of Fig. 1) is located the Army's standard M9A1 Gas Particulate Filter Unit. This unit affords

biological, chemical, and fallout protection by means of particulate filters and trays of activated charcoal.

Air from the outside is drawn through an intake pipe and the filter unit by a blower having a maximum capacity of 600 cubic feet per minute. This air is conveyed by duct along the longitudinal center line of the shelter to three diffuser vents located near the ceiling over the bunking area. The air then circulates back toward the forward part of the shelter, where it escapes through small openings in the doors of the drying, shower, and undressing rooms into the trash room. There it is vented through a pipe to the outside by a 300-cfm blower. By this method, the clean atmosphere in the shelter is kept at a higher pressure than the contaminated atmosphere on the outside.

The intake and exhaust-duct connections to the outside atmosphere have heavy-duty, manually operated, quick-closing gate valves located inside the shelter. These valves must be closed during the blast phase.

An emergency hand-operated blower is located beside the drying-room entrance, just inside the shelter living area. This unit has a rated capacity of 200 cfm of fresh air.

Water System

Water for drinking and decontamination purposes is supplied by an underground 4,000-gallon steel storage tank buried outside the shelter (item 10, Fig. 1). The tank can be filled or isolated from municipally supplied water by means of a valve located within the shelter. Emergency filling could also be accomplished by using a pipe which leads up to the surface. There are two water outlets within the shelter, both located in the area indicated by item 11 in Fig. 1. The air vent for the tank is also located within the shelter.

Sanitary System

Toilet facilities consist of six chemical units located in the general area designated as item 12 in Fig. 1. Each of these units has a capacity of 9 gallons and is connected by a piping system to a dry well 6 ft in diameter and 7 ft deep, located outside the shelter (item 13, Fig. 1). The units are partitioned with cement, asbestos board, and canvas curtains.

Bunk Layout

The bunking arrangement of two longitudinal rows, five deep and five tiers high (item 14, Fig. 1), dictates an alternate sleeping schedule, commonly known as "hot-bunking." The bunks are made from no. 10 duck canvas supported between two 1-in.-diameter standard pipes. The pipes are supported at both ends by steel plates 4 in. wide and 1/4 in. thick which are in turn supported by vertical pipe stanchions of 2-in. standard diameter. The 1-in. pipes are capped at each end, to prevent them from slipping out of their supports. The bunks are 78 in. long by 27-1/2 in. wide, with a 20-in. vertical spacing between. Transverse aisleways 2 ft wide are provided between every other set of tiers. Supporting connections are made with nuts and bolts, so the bunks can be easily disassembled. In the event a blast should occur with the bunks in the assembled position, a slip connection has been provided between the top of the bunk stanchions and the shelter overhead. This would allow the arch to deflect under loading without transmitting this force to the bunk stanchions.

Lighting and Power

The shelter living area is lighted by the use of twelve 40-watt fluorescent units. Eight of these units are located in the forward area, and two units are located along either side of the bunking area. There are no lights in the bunk area itself, since the lights along either side give adequate low-level lighting for this area. The toilet area, decontamination areas, and passageways have nine 75-watt incandescent fixtures for illumination. Circuit breakers for the shelter are located in the filter room (item 9, Fig. 1).

Power is supplied either by the normal city distributing system or from the emergency 10-kw diesel generator. The generator is not a new unit. It had been operated previously and had been held in storage for a considerable length of time prior to its use here. A mechanical check-up and trial run after installation in the shelter indicated that it was in good operating condition. The generator, located outside the shelter proper, has a 275 gallon steel fuel tank buried outside the concrete generator room. The exhaust fumes from the generator engine are vented to the outside through a 2-1/2-in. steel pipe. Fresh air for combustion and cooling is drawn from the outside by way of the entrance tunnels. In order to keep the generator from overheating, the outside doors to the culvert entranceways were kept open.

Communications

The shelter has one small transistor radio, stocked for the purpose of monitoring Conelrad. There is also a capped opening provided in the top of the shelter for a walkie-talkie antenna. A telephone has been substituted for radio communication in these trials. This facility is located at the front of the shelter on the shower room partition. It is connected into the National Naval Medical Center switchboard and would not ordinarily be considered as a standard facility of an operational shelter.

Emergency Exit

The rear of the shelter is connected by means of a 42-in.-diameter steel culvert section to an existing underground passageway which joins buildings of the National Naval Medical Center. This emergency exit, item 15 on Fig. 1, is 12-1/2 feet long. A standard 24-in.-diameter Navy shipboard hatch is used to prevent the entrance of blast pressures into the emergency exit tunnel and shelter proper.

Floor-Space Organization

The organization of the shelter spaces is shown in Fig. 2. These selections were somewhat controlled by the physical layout of the shelter; e.g., the main recreation area is in the forward section, with the greatest open space and lighting; the cooking area is close to water and electrical outlets; the medical area, requiring good light, is in the forward part of the shelter; the Administration area is located where good overall observation is possible, and also where it is somewhat isolated from the main traffic streams; supplies, located in the proximity of the Administration area for control purposes, help to isolate the Administration area further from the mainstream of activity. Figures 3 through 10 show details of the shelter.

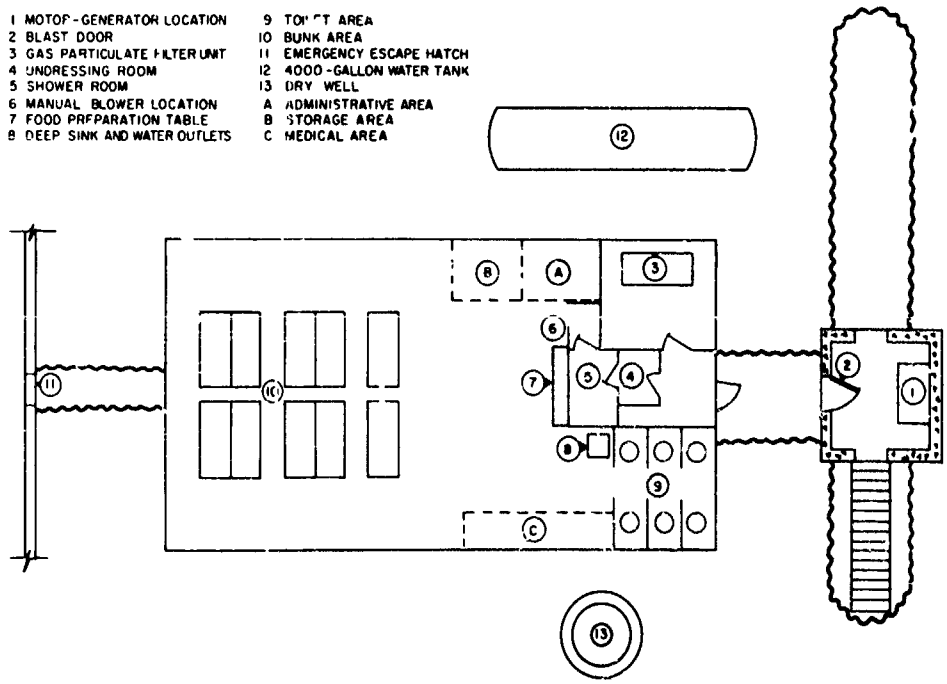


Fig. 2 - Plan view of the shelter

Fig. 3 - Entrance to the shelter. Note the vent pipes to the left of the entrance, and the motor-generator exhaust stack to the right.

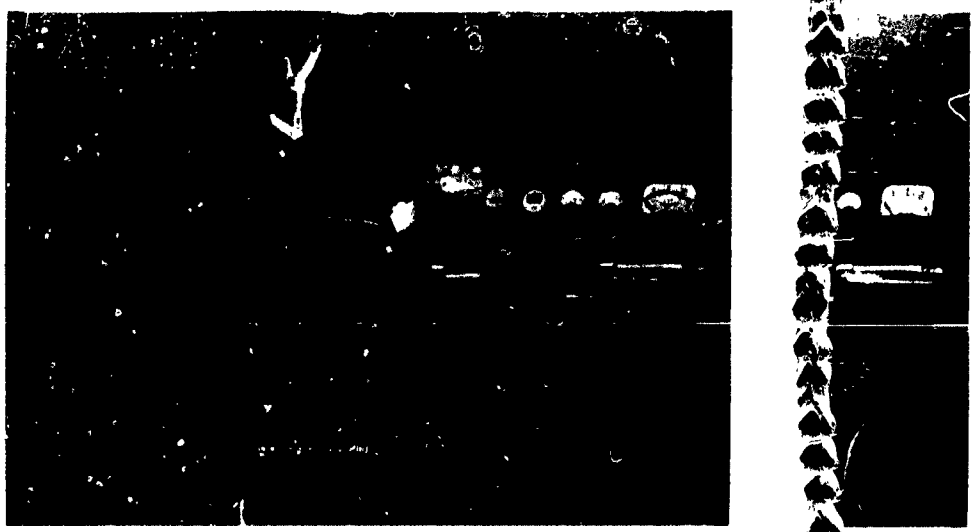


Fig. 4 - Diesel motor-generator system

Fig. 5 - View of the blast door from inside the motor-generator room

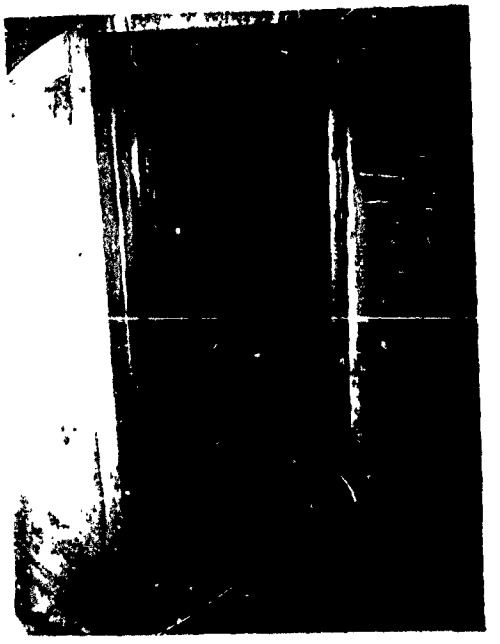


Fig. 6 - Blast door as seen from the entrance passage (item 4, Fig. 1)

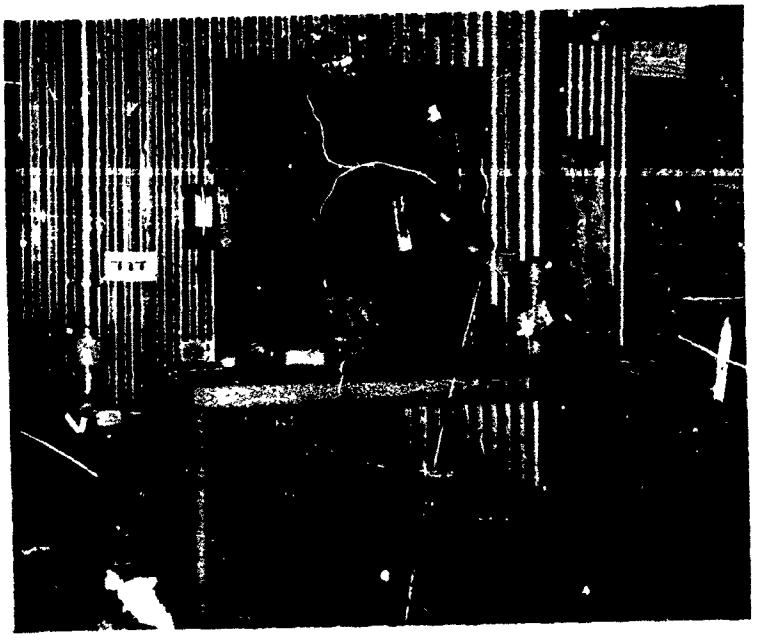


Fig. 7 - Front of living area in the shelter, showing the food-preparation table and the hand-operated blower

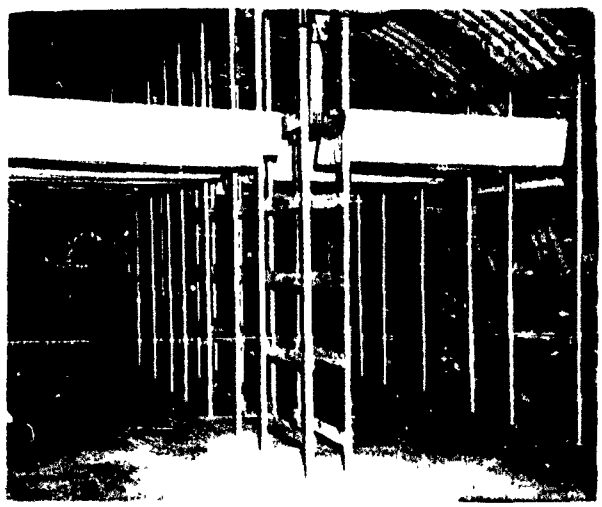


Fig. 8 - Bunk area, with bunks in stowed position. Note the emergency escape hatch to the rear of the shelter.

Fig. 9 - Chemical toilet

Fig. 10 - View of emergency escape tunnel, looking toward the shelter. The escape hatch can be seen to the right.

EQUIPMENT AND SUPPLIES

The following is a list of the equipment and supplies used during the Winter Habitability Studies:

Furniture

10 - 6-ft wooden benches
48 - Folding camp chairs (canvas with tubular steel frame)
6 - Folding card tables
1 - 8 ft built-in food-preparation table

Food Preparation and Serving

1 - 5-quart deep frier
2 - 2-1/2-gallon coffee urn*
1 - 1 gallon measure (stainless steel)
2 - Mixing spoons (stainless steel)
1 - 6-oz ladle
6 - Tablespoons (stainless steel)
105 - Plastic cups with handles
2 - 55-peg drainboards for cups
1500 - Paper bowls
3000 - Plastic knives
5000 - Plastic spoons
1 - Masonite pegboard for wall storage

Cleaning and Sanitation

2 - Mops
2 - Push brooms
2 - Toilet scrub brushes

*Only one coffee urn used during the 2-day trial

Cleaning and Sanitation (Cont'd.)

6 - Sponges
2 - Dust pans (plastic)
2 - 10 quart buckets (plastic)
1 - 10 quart bucket (galvanized steel)
25 - Ash trays
50 - 12-cubic-foot plastic trash bags
25 - Packages paper towels
1 - Paper towel dispenser
10 - Rolls toilet paper
5600 - Wet packet napkins
6 - Tubes of tooth paste
50 - Boxes of facial tissue
26 - Cans of foot powder
3 - Pints isopropyl alcohol
28 - Terry cloth bath towels
1 - Gallon antiseptic
2 - Pairs rubber gloves
13 - Gallons chemical for toilets
Active Ingredients:
Phosphoric acid - 15.95%
Nonylphenoxypolyethoxyethenol-iodine complex - 12.60%
Polyethoxypolypropoxy-iodine complex - 4.85%
12 - Bars soap

Recreation

25 - Decks playing cards
10 - Decks pinochle
4 - Dominoes sets
8 - Checker sets
4 - Chess sets
4 - Bingo sets
4 - Scrabble sets
4 - Cribbage boards
200 - Magazines
200 - Pocket books
24 - 8-1/2 x 1, plain paper pads
24 - 5 x 8 scratch pads
24 - 3 x 5 scratch pads
108 - Ball point pens
108 - Mechanical pencils
6 - 36-in. square masonite boards
6 - 30-in. square masonite boards
6 - 24-in. square masonite boards *
1 - Set coloring pencils*
300 - Pkg chewing gum
20 - Clipboards

*Not stocked during the two-day trial.
Note: Cigarettes and matches were bought by the individual users and issued as needed by the Recreation Watch.

Protective Equipment

10 - Individual permeable protective suits
10 - M9A1 field protective masks*
2 - Pairs of boots*
1 - Radiac meter

Tools and Miscellaneous

1 - Plumber's plunger*
2 - Screwdrivers
1 - Pair pliers
1 - Wrench (adjustable)
1 - Roll electrical tape
4 - Battle lanterns (with replacement bulbs and batteries)
2 - CO_2 fire extinguishers
1 - 6-ft stepladder
1 - Wall mirror
1 - Wall clock
6 - Can openers (3 roll type - 3 punch type)
1 - 4 x 4 ft blackboard
2 - Erasers
1 - Box chalk
1 - AM battery radio with replacement batteries
1 - Battery megaphone
110 - Ditty bags
110 - Memo books for use as diaries
1 - Religious services kit*
2 - Large log books
4 - Small log books
6 - Fluorescent light tubes
6 - Light starters
2 - Quarts lubricating oil (diesel generator)
100 - Blankets†
1 - Electric razor
1 - Safety razor kit*
3 - Water meters
3 - Electric power meters
1 - Small line (200 ft coil)

*Not stocked during the two-day trial.
†Only 81 blankets were available during the two-day trial.
Note: Food and medical supplies and instruments used in the environmental studies are listed in their appropriate sections.

TWO-DAY TRIAL

Preliminary Work

Several minor items of work directly associated with the construction features were completed before the trials began.

1. Ends of the bunk-support plate protruded beyond the pipe stanchions, presenting a hazardous sharp surface to anyone moving in the area. This was corrected before the two-day trial by taping foam-rubber pads around the ends. Prior to the two-week trial, the hazardous protrusions were cut off.

2. In testing the ventilation equipment, it was discovered that there were many air leaks; thus it was difficult to maintain the minimum air pressure required to prevent outside contamination from entering the shelter. This was corrected by plugging leaking areas with mastic.

3. The blast door required refitting before it could be properly secured.

Entry

During the two-day trial, twelve minutes elapsed from the time the men began to enter the shelter until all openings had been closed. The men had been lined up outside the outer entrance, and when the door was opened they filed into the shelter. The power had been cut off, and the only light was supplied by four battle lanterns. The men had never been in this shelter before. Picture-taking by photographers interfered with rapid loading to some extent. However, a twelve-minute entrance time is cause for alarm in light of anticipated warning times. Since there were unrealistic factors involved here which are hard to compensate for, it was decided to run several entering tests at a later time, which would be more representative of this shelter's entrance design.

Decontamination Area

The decontamination facilities, including the shower, were not used, since not all the protective equipment was available during this trial.

Ventilation System

The ventilation system functioned satisfactorily. See Chapter 3 for details. The manual blower was not used during the two-day trial.

Water System

The 4000-gallon water tank was flushed several times and filled two days prior to the two-day trial. For the two-day trial 74.6 gallons of water were used. This gives an average of 1.5 quarts per man per day, nearly all of which was used for drinking. See Chapter 7 for the water monitor's record of internal consumption.

Sanitation

The chemical-toilet piping arrangement was the source of some concern before the beginning of this trial. The primary question was whether the chemical used would sufficiently digest the sewage to enable it to pass through the 2-in. opening in the bottoms of the units. By utilizing all six units, only four had to be emptied during the two-day trial period. Although no firm conclusions should be reached after such a limited test period, it appeared that (a) a chemical solution of 1/2 ounce per usage controlled the production of offensive gases adequately, (b) liquefaction progressed slowly, and (c) appreciable liquefaction was not necessary, since the small drain in the bottom of the unit would handle the solid matter adequately.

Lighting and Power

Lighting during the two-day trial was considered entirely adequate. The bunk area, although illuminated only by lights located along the sides, appeared satisfactory for both sleeping conditions and recreational activities. Bunks were put up to the top supporting tiers to provide additional usable shelter space during the four-hour periods when all occupants were awake.

After approximately 12-1/2 hours of operating time, the pulley on the diesel generator's water pump worked loose, and the shelter power supply was switched from generator to station supply for the duration of the trial. The breakdown of the generator would have posed a serious threat to those inside the shelter in a real emergency situation. The shelter occupants would have been forced to repair it themselves or do without power. This was not done during the two-day trial, since the risk of seriously damaging the generator and jeopardizing the rapidly approaching two-week trial was too great.

Communications

Reception on the transistor radio supplied was tested and found to be excellent within the shelter.

The telephone was frequently used for reporting and coordinating the data-collecting aspects of the trial.

Bunks

The bunks and supporting structure were sufficiently strong to withstand hard usage without tearing or bending.

Equipment and Supplies

The furniture supplied all held up well with little or no damage during the two-day trial. Several recommendations for changes were made regarding food preparation and serving, and supplies for the two-week trial. First, there should be two hot-water urns, so that hot water would be available at all times, and second, 16-ounce paper soup bowls should be substituted in the two-week trial for the 8-ounce size used in the two-day trial. The larger bowl would permit intermingling and wetting the dry wheat wafer with the soup, thereby making them more palatable.

The individual plastic drinking cups were marked and hung on plyboard mounted with pegs to drain after each usage. This worked well,with one exception. Those individuals utilizing the optional hot chocolate consistently had a residue remaining in the bottom of their cups. Since this constituted a food-poisoning hazard, the hot chocolate was eliminated from the two-week trial diet.

The cleaning and sanitation equipment and supplies appeared adequate. The recreation equipment was well received and much used. All the tools and miscellaneous equipment appeared adequate, with a notable exception being can openers. The type supplied, roll-along-the-lip domestic hand size, would not penetrate the deep-lipped wheat biscuit containers. A resourceful shelter occupant solved this by separating the tops of the cans along their seams, with a screw driver and pliers. Although solving the immediate problem, it left open cans with sharp edges, and these were a safety hazard.

Only 81 blankets were available for the two-day trial. This meant that some individuals (in the less drafty middle tiers) were supplied with only one blanket. As a result, some of these men, and even some with two blankets, complained of being uncomfortably cold.

TWO-WEEK TRIAL

Preliminary Work

Prior to the two-week trial the lateral bunk members were disassembled and cut off flush with the vertical supporting members in order to eliminate the protruding edges. After the two-day trial it was noted that the electrical "ground" wire was carrying a charge. Several skinned wires were located and replaced prior to the two-week trial. Also, the decontamination-room doors were difficult to close tightly, since the thin-wall construction composing the decontamination rooms distorted under stress. To eliminate this, additional bracing for the door jambs was added.

Entry

In order to get better data on entry times, the men were taken to the shelter several days before the two-week trial. Two entry conditions were tested: (a) the men who were unfamiliar with the shelter entered in darkness; the only lighting used was that provided by four flashlights (battle lanterns), and (b) the men who were then familiar with the shelter entered with all the passage and shelter lights on. The first condition required 5 minutes, 10 seconds, and the second 2 minutes, 1 second.

Decontamination Area

During the two-week trial, simulated outside monitoring tasks were conducted twice a day. Two men donned the individual permeable protective suits and M9A1 protective masks and went out of the shelter as far as the generator room. They checked the generator oil pressure, water temperature, and air temperature of the generator room. During the afternoon trip each day they also took a radiac reading of a radioactive source placed in the entranceway by the NNMC. By assuming that the milliroentgen readings were roentgens, the shelterees on day 4 were able to plot the readings and thus predict the shelter stay time at approximately 14 days.

Upon return to the shelter the men passed through the decontamination area, where they removed their "contaminated" clothing, simulated discarding it, and then showered. The effectiveness of the showers taken to remove all contamination is questioned, due to the small amounts of water used (average 0.3 gallons per man per shower). The wash water, although welcomed by the men after several days in the shelter, was nonetheless very cool (50° to 60° F), and this may have contributed to the highly conservative use of water.

Ventilation System

The ventilation system again was satisfactory, but it produced a high background noise, which made shelter management difficult. In addition to the high noise level, the regulating vanes in the filter unit's blower worked loose during the trial and resulted in a pulsating air flow to the shelter. This was very irritating to the shelterees, since the sudden pressure drop was noticeable on the ear drums. This occurred only infrequently during the lower air-flow rates, and not at all when the flow rate was increased to 600 cfm.

With the possible exception of prolonged stay times in the head area, odors did not prove to be a problem.

For two hours on the last day, the ventilating system was secured and the manual blower was used. Forty men took turns cranking the handle. At the beginning of this exercise the men cranked for two minutes each. However, it was soon observed that the men could not sustain the assigned pace for the full two minutes, and the time was cut to one minute. It should be noted here that the manual blower was able to maintain a fairly constant 0.5 to 0.6 in. of water pressure within the shelter. At the end of the two-hour test, it was noted that many connections on the blower were coming loose and that it could not have continued much longer in operation.

Water System

The water remaining in the tank from the two-day trial was not flushed prior to the two-week trial. The tank was filled and tested for potability the day before the two-week trial began. By the 12th day of the trial, the chlorine was all used, but no harmful bacteria developed during the trial. The rapid disappearance of the chlorine indicates that maintenance crews will be required to use chlorine pills rather frequently.

A total of 604 gallons of water was used for all purposes. Approximately 548 gallons went for internal consumption, the remainder for showering, washing teeth, charging heads, and damp mopping the deck. The amount of water used for showering was unrepresentative, as noted above.

Sanitation

On the basis of the information obtained during the two-day trial, it was determined that under normal circumstances, three heads would meet the occupants' requirements. Only three heads were used during the two-week trial, and these proved to be sufficient. Since this meant the three units were in constant use, some of the solid matter was mechanically broken down by vigorous stirring with a short section of pipe just prior to opening the drain valve. Occasional sluggishness in draining was effectively remedied by a plumber's plunger.

There was approximately 270 gallons of sewage generated during the two-week trial. In attempting to find the lowest rate of chemical usage required, a total of only 13 gallons of chemical was used.

Lighting and Power

Again, the lighting proved to be adequate for the shelter activities without interfering with the sleep of the men in the bunk area. Due to difficulties encountered with the diesel generator, shelter power was supplied from station sources, for two-thirds of the period of the trial. Diesel problems included overheating (as a result of the outside doors having been tightly closed after entrance), air leaks developing in the fuel feed system, and oil leaks developing around one cylinder. Repairs were effected by outside mechanics.

Communications

Communications in the two trials were limited to the experimental aspects of the trials. Conelrad radio broadcasts were not simulated. The location of the telephone just above the manual blower proved to be poor, since this area seemed to have the greatest activity and noise.

Trash

Approximately 200 cubic feet of trash was generated during the two-week trial. This was composed primarily of the residues remaining from meals – paper towels, plastic knives and spoons, soup tins, etc. This was all stored in the trash room and along either side of the entrance way. Although inside storage was carried out for test purposes, internal storage of all trash is not recommended, since it creates a fire hazard and adds additional odors.

Equipment and Supplies

The two-week trial resulted in some damage being inflicted to the shelter furniture. Six of the folding camp chairs were damaged beyond use, and one of the benches was damaged. The remaining furniture held up well. The use of two coffee urns worked out well, keeping a supply of hot water available at all times. The larger 16-oz soup bowls also proved to be superior to those used in the two-day trial. The cleaning and sanitation equipment was adequate, with the exception of the two plastic dust pans; both of these were broken before the termination of the two-week trial. The flashlight-battery-powered megaphone, although helpful, could have been more powerful, since some individuals in the rear of the shelter still had difficulty hearing announcements. Again, difficulty was experienced with the can openers. The punch type supplied for the two-week trial lasted only long enough to open several cans. A large industrial type can opener was introduced into the shelter after several days but was broken a short time later. The large biscuit cans were thereafter opened on the bottom (which had a shallower lip) by the original roller type of can openers, but this was effective only as long as the opener's cutting edge was sharp. The protective clothing was not discarded after each use, as would be the case in an actual situation. This, of course, means that a greater quantity would be required in stocking the shelter for operational use. All other items appeared to be adequate in type and amounts supplied.

SUMMER TRIAL

On the basis of the observations made during the winter trials, the following are items of recommended work which should be completed prior to the summer trial.

1. Repair and test run the diesel generator.
2. Fabricate vent from head area to exhaust blower.
3. Repair manual blower.
4. Move the telephone into the Administrative Area.
5. Tighten regulating vanes on filter-unit blower.

CHAPTER 3

ENVIRONMENTAL MONITORING

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INTRODUCTION

During the winter trials in the BuDocks protective shelter, the atmosphere within the shelter was monitored extensively. The temperatures, relative humidity, ventilation rates, pressure, and concentrations of carbon dioxide, carbon monoxide, oxygen, and aerosol were followed closely and are discussed in the subsections which follow. In addition, this section has been expanded to include such items as water consumption, quantity of electricity used, sound level, photographic coverage, and closed-circuit television monitoring. In the subsections which follow, the data and discussions refer to the two-week trial, unless otherwise noted.

TEMPERATURE

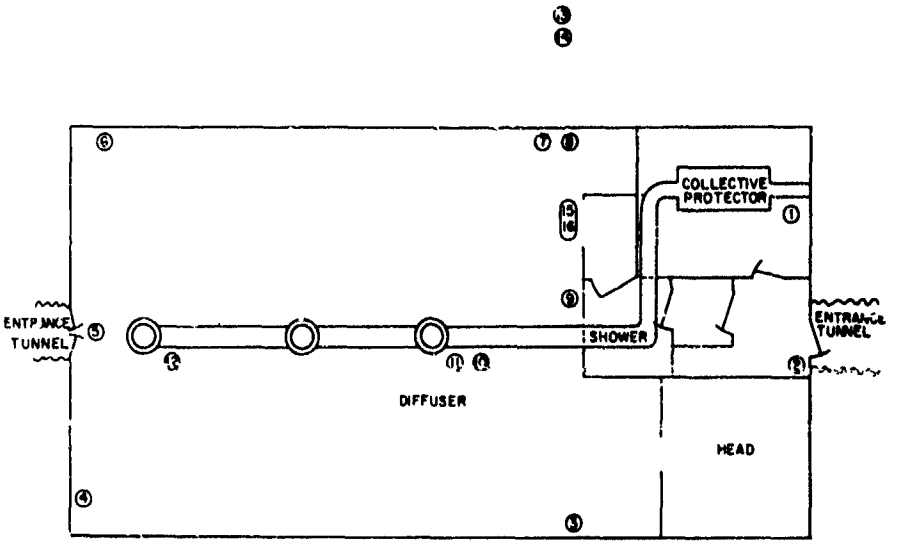
The location and type of temperature-measuring instruments used in the winter trials are shown in Fig. 11. Thermometers 1 and 2 were read at 0130 and 1330 each day by the engineering team. Thermometers 3 through 12 and 15 and 16 inclusive were read at 0000, 1200, and 2000 each day by the engineering team. Thermometers 13 and 14 were read daily by personnel outside the shelter.

The temperature data from the two-day trial are shown in Fig. 12. Curve A is plotted from hourly dry-bulb readings taken at National Airport. Curve B is the dry-bulb temperature in the shelter (thermometer 9). Curve C is the effective temperature in the shelter as determined from thermometers 15 and 16. Effective temperature is based upon physiological response. It may be defined as any combination of temperature and humidity which produces the same physiological effect as 100-percent relative humidity at that temperature. Figure 13 shows the relationship between dry-bulb temperature and relative humidity for a series of effective temperatures.

Although not shown in Fig. 12, the temperature at the rear of the shelter, thermometer 5, was approximately 6°F lower than the temperature in the front. The deck and bulkhead temperatures shown in curve D of Fig. 12 are averages of the readings from thermometers 3, 4, 6, 7, 8, and 12.

Inspection of the data of Fig. 12 indicates that the shelter did not come to equilibrium with its surroundings during the two-day trial. When the outside temperature dropped below 15°F, it was necessary to reduce the ventilation rate to maintain a reasonable degree of comfort in the shelter.

The temperature data from the two-week trial are shown in Fig. 14. Curves A and B are from hourly temperature readings at the Washington National Airport. Curve C is the dry-bulb temperature in the supply duct at the first diffuser (thermometer 10). The blower for the collective protector, through which all of the supply air passed, is a vaneaxial fan; thus essentially all of the heat generated by the motor was added to the



Sensor No.	Location	Type	Measures	Sensor No.	Location	Type	Measures
1	Inlet duct	Bimetallic, dial, immersion	Inlet air	9	Suspended 6 ft from deck	Maximum-minimum	Shelter air
2	Entrance tunnel 6 ft from deck	Maximum-minimum	Exhaust air	10	Supply duct	Bimetallic, dial, immersion	Inlet air
3	Bulkhead 3 ft from deck	Bimetallic, surface	Bulkhead	11	Suspended 6 ft from deck	Maximum-minimum	Shelter air
4	Bulkhead 3 ft from deck	Bimetallic, surface	Bulkhead	12	Deck, between last row of bunks	Bimetallic, surface	Deck
5	Suspended 6 ft from deck	Maximum-minimum	Shelter air	13	In ground 3 ft from shelter, level with deck	Thermistor probe	Soil
6	Bulkhead 3 ft from deck	Bimetallic, surface	Bulkhead				
7	Bulkhead 18 in. from deck	Bimetallic, surface	Bulkhead	14	10 ft above No. 13	Thermistor probe	Soil
8	Bulkhead 3 ft from deck	Bimetallic, surface	Bulkhead	15,16	3 ft from deck	Battery-powered psychrometer	Relative humidity

Fig. 11 - Locations of the temperature sensors

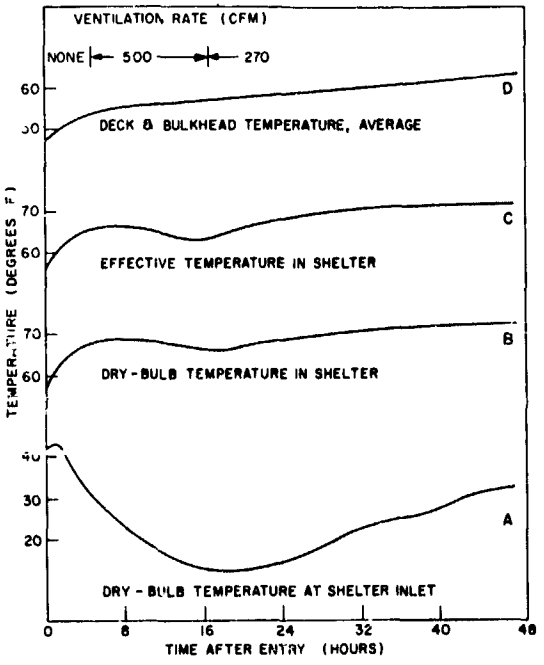


Fig. 12 - Temperature data, two-day shelter trial, Jan. 30 to Feb. 1, 1962

supply air. After leaving the supply blower and before reaching the first of three diffusers, the temperature of the air was further moderated by passing through approximately 25 ft of 8-in. duct located inside the shelter. The supply ventilator system was responsible for the absence of expected diurnal variations in the shelter air temperature.

The effective temperatures in the shelter are shown in curve D (thermometers 15 and 16), and the dry-bulb temperatures are shown in curve E (thermometer 9). The air-temperature readings near the center of the shelter, thermometer 11, were within 1°F of the readings at the front, thermometer 9. The readings at the rear of the shelter, thermometer 5, were about 5°F lower than those at the front.

The deck and bulkhead temperatures shown in curve F are averages of the deck and all of the bulkhead-thermometer readings. As the shelter came to equilibrium, the deck temperature approached the 3-ft bulkhead temperature, and after day 3 these two temperatures were essentially the same. The 6-in. bulkhead temperatures were about 5°F lower than the 3-ft bulkhead temperature.

The ground temperatures (thermometers 13 and 14) are shown on curve G of Fig. 14. The dew point of the air in the shelter (thermometers 15 and 16) is shown on curve H, and the relative humidity (thermometers 15 and 16) is shown on curve I of Fig. 14.

During the 3-1/2-hour buttoned-up period following entry, the temperature increased from 52° to 69°F. During this period, the deck and bulkhead temperatures increased

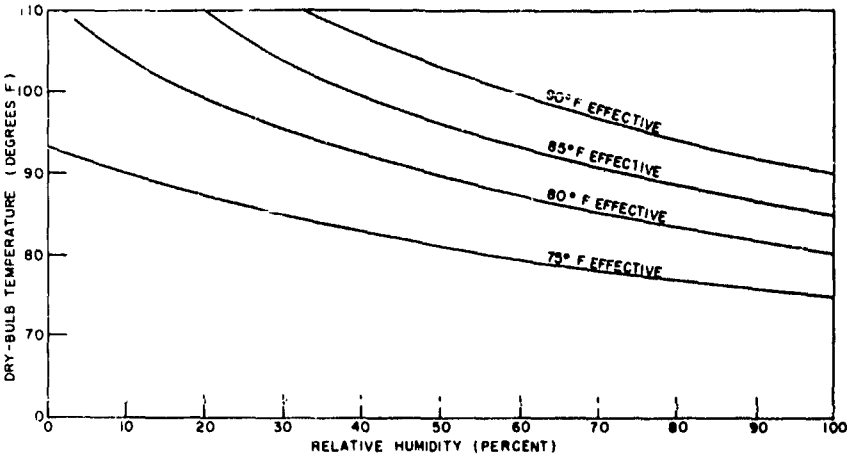


Fig. 13 - Effective temperature, related to relative humidity and dry-bulb temperature (Newburgh, L. H., "Physiology of Heat Regulation and the Science of Clothing," Philadelphia:Saunders 1949)

approximately 6°F. After the ventilation blower was activated, the temperatures continued to rise, but at a much slower rate. On Feb. 24, the ventilation rate was increased to 450 cfm. During the following 24 hours, temperature in the shelter decreased to 73°F. Part of this decrease was due to the increased ventilation rate and part of it to a decrease in outside temperatures. The deck and bulkhead temperatures decreased slightly, but the ground temperature at the probe sites continued to increase slowly. The relative humidity decreased from 67 to 36 percent. It should be noted that, after the ventilation blower was activated, the dew point of the air in the shelter remained below the deck and bulkhead temperatures; consequently the walls and deck remained dry. Some condensation occurred on the supply duct.

For the summer trial, it is planned to use thermocouples for temperature measurements and to read them every hour. Several soil probes, from 6 in. to 3 ft in length, will be used to determine more precisely the soil temperature gradient out from the shelter.

VENTILATION

Fresh air was brought into the shelter through a U.S. Army M9A1 600-cfm collective protector. A pitot tube and a sensitive pressure transducer were used to determine the flow rate through the collective protector as a function of the pressure drop across the collective protector. The data are shown in Fig. 15. The flow rate was controlled by variable louvers located in the collective protector unit. The flow rates through the collective protector as a function of the pressure drop were rechecked after the two-week trial. No appreciable changes were found; however, as dust collects on the particulate filter the flow rate-pressure drop relationship will change, and the data in Fig. 15 will no longer be useful. Also, the data in Fig. 15 are not necessarily valid for any collective protector other than the one used in these trials.

The pressure drop across the collective protector was read at 0130 and 1330 each day and also whenever the flow rate was changed. The ventilation rates for the shelter, as determined by the pressure-drop measurements, are shown in curve A, Fig. 16. The

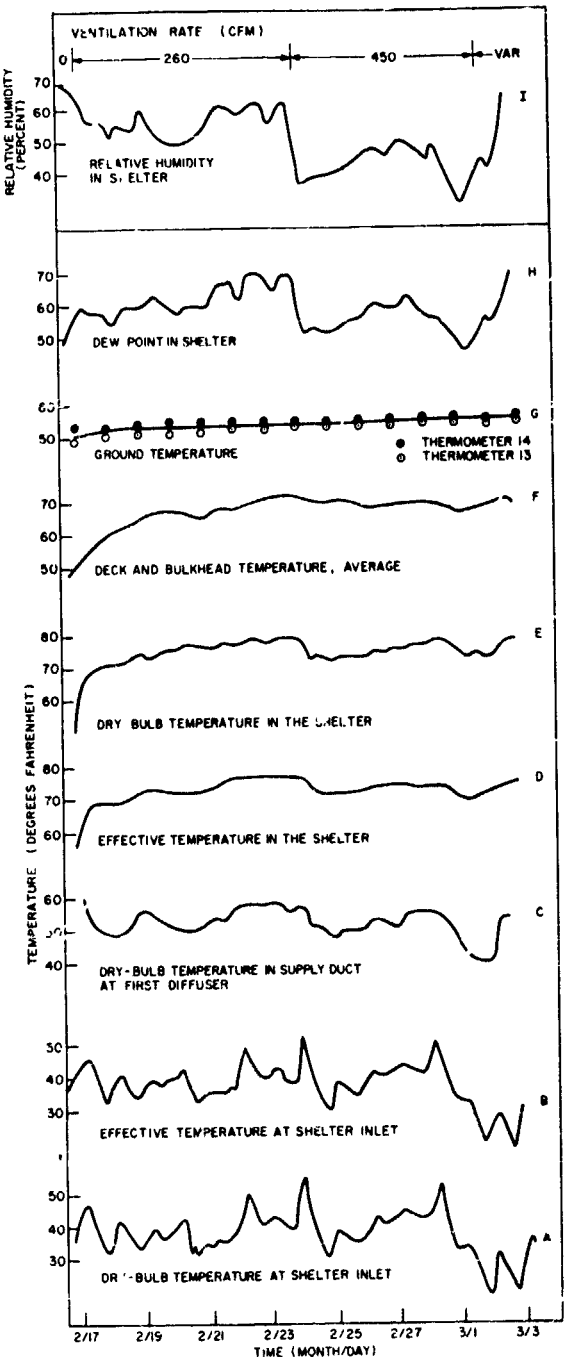


Fig. 14 - Temperature and relative humidity, two-week winter shelter trial, Feb. 17 to March 3, 1952

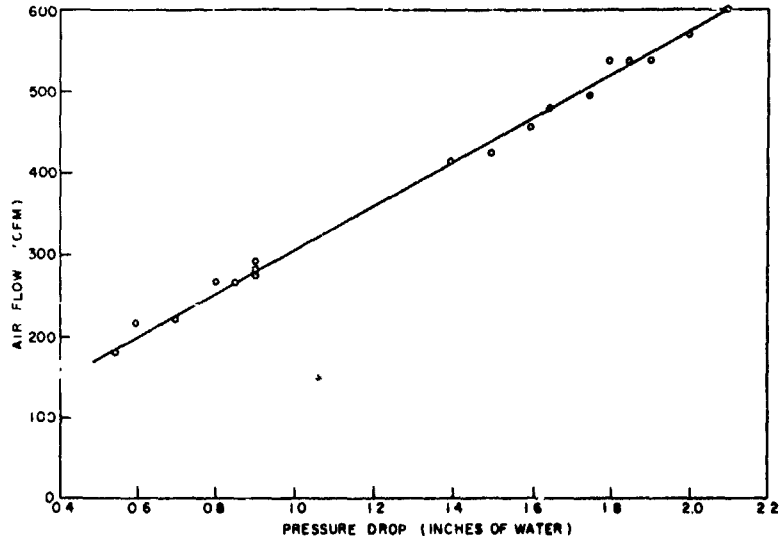


Fig. 15 - Air-flow rate through the gas particulate filter unit as a function of pressure drop

minor changes, such as those which occurred on Feb. 20, 25, and 28, were not intentional. The flow-control louvers were not as well secured as they should have been, and it is believed that these ventilating-rate changes were due to shifts in the position of the louvers. The major changes, such as on Feb. 24, were intentional and were made because the shelter was getting either too hot or too cold.

On March 2, the 200-cfm hand blower was used for a brief period (see Chapter 2). A 300-cfm exhaust blower was included in the exhaust system as standard shelter equipment. It was not used during either of the winter trials (see next section). Higher ventilation rates will be necessary for the summer trial (see section titled "Heat-Balance").

PRESSURE

In order to prevent the entry of contaminated air, the pressure inside a protective shelter must exceed atmospheric pressure. A positive pressure of 0.3 in. of water is generally accepted as adequate. During the two-day trial, the exhaust blower (see section titled Ventilation) could not be used because, when it was operating, it was not possible to maintain an adequate positive pressure within the shelter. During the period between the two-day and the two-week trials, the shelter was caulked extensively. As a result, during the two-week trial, it was possible to maintain a pressure in the shelter of 0.95 in. of water at 260 cfm and 2.5 in. of water at 450 cfm with the exhaust blower not operating. The exhaust blower would have been used during the two-week trial had ventilation rates greater than 450 cfm been desired.

HEAT BALANCE

The heat input to the shelter is composed of two items: (a) that produced by the 100 men, and (b) that produced by the electrical equipment in the shelter. The heat produced

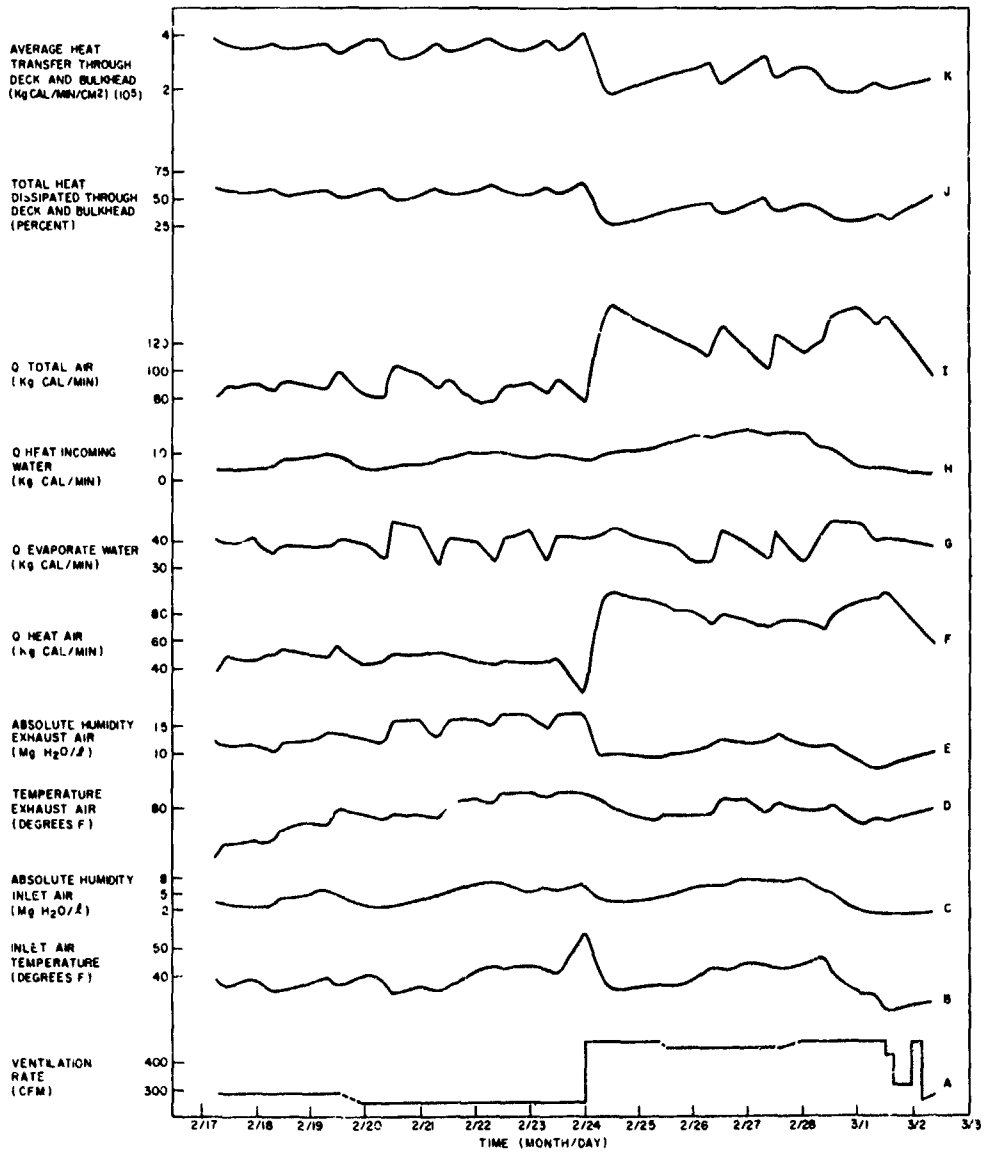


Fig. 16 - Heat balance, two-week winter shelter trial

by the 100 men was estimated from the CO_2 data to be 8500 kg cal/hr. The heat produced by the electrical equipment normal to the shelter was 2220 kg cal/hr, while 1360 kg cal/hr were produced by the experimental electrical equipment.

When temperature equilibrium is reached in the shelter, the heat dissipated from the shelter must equal the heat input to the shelter. The heat dissipated from the shelter is composed of two items: (a) that carried out by the ventilating air, and (b) that carried away by the surrounding soil. Using temperature, humidity, and ventilation-rate data (curves A through E, Fig. 16), the total quantity of heat carried out of the shelter by the ventilating air was calculated. This quantity was composed of three parts: (a) the quantity of heat absorbed in heating the ventilating air from the inlet temperature to the exhaust temperature, (b) the quantity Q of heat absorbed in heating the water vapor in the inlet air to the exhaust temperature, and (c) the quantity of heat absorbed by the water which was evaporated in the shelter (curves F through I, Fig. 16). The water which was evaporated in the shelter came from two sources: (a) the men (respiration and sweat), and (b) hot soup and hot coffee. The heat absorbed through water of evaporation (curve G) is not considered unreasonable. The data at 0000 and 1200 followed the serving of meals. The data at 2000 approached the condition in which all of the moisture in the air came from the men. On this premise, the heat represented by water of evaporation was converted to cubic centimeters of water evaporated per man per hour. These data are shown by the points in Fig. 17; the solid line represents data obtained in other studies (1). With a few exceptions, the correlation between these two sets of data is good.

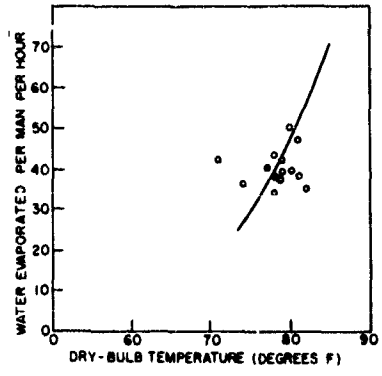


Fig. 17 - Evaporative cooling, two-week winter shelter trial. The solid line represents data obtained in other studies (1).

At a ventilation rate of 260 cfm, approximately 52 percent of the total heat was dissipated into the soil around the shelter (curve J, Fig. 16). When the ventilation rate was increased, the quantity of heat dissipated to the soil decreased sharply. This was followed by a gradual increase as the outside temperature increased, thereby decreasing the percentage of the heat removed by the ventilating air. The total inside surface area of the shelter is 31.8×10^5 cm^2. This gives an average heat transfer through the deck and bulkhead of 1.7 to 4.0×10^{-5} kg cal/min/cm^2 (curve K). The limited temperature measurements taken in the soil surrounding the shelter were not sufficient to justify calculations of the soil thermal conductivity and heat capacity.

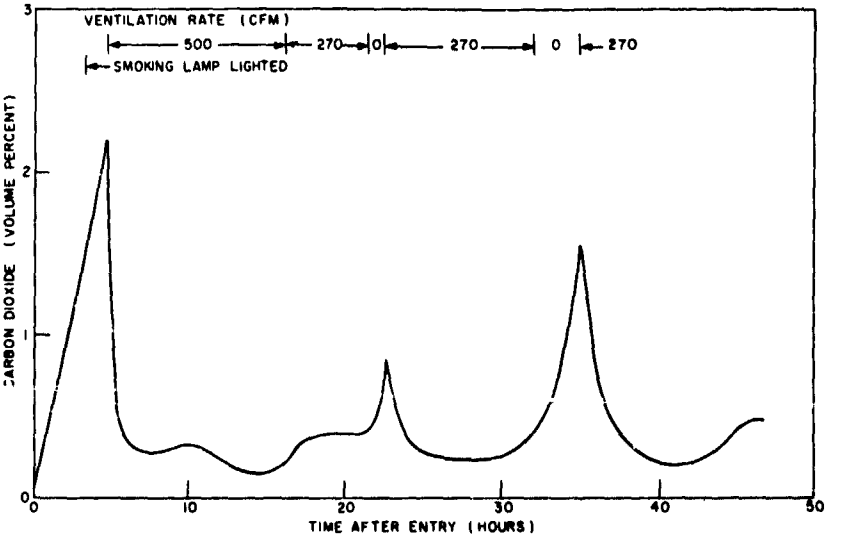


Fig. 18 - Carbon dioxide concentration, two-day shelter trial

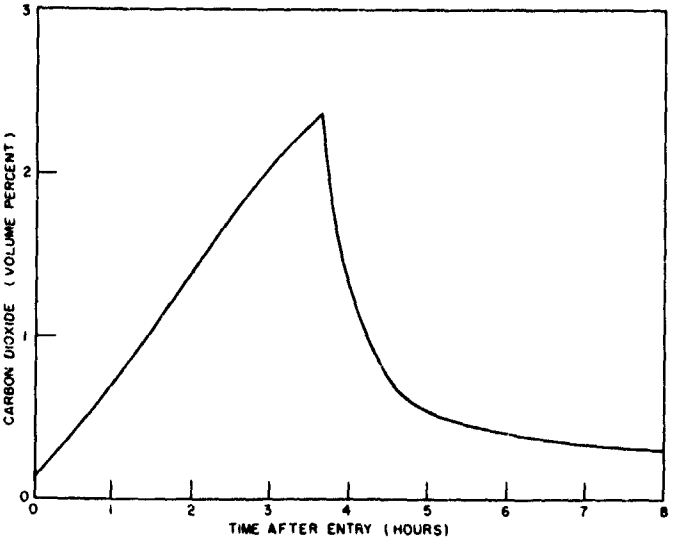


Fig. 19 - Carbon dioxide concentration, two-week winter shelter trial

In preparing for the summer trial, it has been agreed that steps should be taken to keep the effective temperature in the shelter from going above 85°F. A survey of summer conditions in the Washington area shows that the effective temperature of the atmosphere may go above 85°F. Extensive calculations have been made in an effort to predict the effective temperature in the shelter during the summer trial. These calculations have taken into account past weather conditions, the caloric output and sweat rate of sedentary men, the heat dissipated through the walls from the winter trial, and various ventilation rates. In order to guarantee a full two-week trial during the worst Washington weather and not exceed an effective temperature of 85°F in the shelter, it has been decided that standby air-conditioning and a ventilation capacity of 1000 cfm will be required.

CARBON DIOXIDE

Two types of instruments were used for the measurement of CO_2: (a) a simple, inexpensive unit which could be considered a candidate for standard shelter equipment, and (b) a sensitive research instrument for continuous monitoring of the atmosphere during these trials. The Dräger CO_2 detector tubes were used to meet the requirements for type a, and the Beckman Model LB-1 infrared CO_2 analyzer to meet the requirements of type b. The signal from the Beckman instrument was continuously recorded with a 10-millivolt strip-chart recorder.

The data from the two-day trial are shown in Fig. 18. The buttoned-up period lasted 4 hours and 40 minutes. The CO_2 reached a peak concentration of 2.2 percent. Figures shown in the section on carbon monoxide (next section) indicate that 125 cigarettes were smoked during this period. If we assume (a) the average cigarette produces 0.36 liter of CO_2 at 20°C (2), (b) a shelter volume of 10,000 cubic feet, and (c) a respiratory quotient of 0.82, this CO_2 level indicates a caloric output of 82 kg cal/man/hour. This figure is lower than expected, but not unreasonable in view of the degree of activity.

The CO_2 data for the first eight hours of the two-week trial are shown in Fig. 19. During the buttoned-up period at the beginning of this trial, the men were more active than at the beginning of the two-day trial, and the calculations indicate a caloric output of 95 kg cal/man/hour.

After the ventilation was started, the CO_2 level decreased rapidly. The decay curve is logarithmic and, using the equation (Ref. 3):

$$t_{0.5} = 0.69 \frac{V}{R}$$

where

$t_{0.5}$ = time required for the concentration to decrease 50% of the difference between the initial and final concentrations (20 minutes in the two-week trial)

V = ventilated volume

R = rate of ventilation (285 cfm in the time-period during which these measurements were being made)

we find a ventilated volume of 8200 cubic feet for the shelter. The total volume of the shelter is approximately 10,000 cubic feet. The collective protector room and the decontamination tunnel occupy approximately 1300 cubic feet, leaving a potential ventilated volume of 8700 cubic feet. To obtain the true ventilated volume, this potential volume

must be reduced by the volume of the men and supplies. In addition, the space above the decontamination tunnel and the space occupied by the head were "dead-end" spaces, and one would not expect these spaces to be well ventilated. The ventilated volume estimated from the dimensions of the shelter and the volume of men and supplies agrees very well with the volume calculated from the CO_2 decay curve.

The carbon dioxide data from the two-day trial (Fig. 18) typify the fluctuations resulting from variations in ventilation rate and activity level within the shelter. After the first eight hours of occupancy of the two-week trial, the CO_2 level fluctuated in a manner similar to that shown in Fig. 18. The CO_2 data for the two-week trial indicate an average caloric output of 85 kg cal per man per hour.

The CO_2 data agree very well with the expected levels for men essentially at rest. If the number of occupants and the volume of a shelter, or the ventilation rate when the shelter is being ventilated, are known, the CO_2 level can be calculated as accurately as it can be measured with any simple, inexpensive instrument suitable for consideration as standard shelter equipment.

During the summer trial, the CO_2 will again be monitored with the Beckman infrared analyzer and with the Dräger tubes.

CARBON MONOXIDE

Two instruments were used for the measurement of carbon monoxide concentrations: the Bacharach detector tube and a Mine Safety Appliances Company infrared analyzer. The signal from the infrared analyzer was continuously recorded on a ten-millivolt strip chart recorder. The data obtained during the two-day trial are shown in Fig. 20; data obtained during the first eight hours of the two-week trial are shown in Fig. 21. The curves of Figs. 20 and 21 show a marked similarity during the first eight hours after entry. The period between entry and the time the smoking lamp was lighted is of particular interest. During this period, the main source of carbon monoxide was the carboxyhemoglobin in the blood of the smokers. It is logical to assume that each smoker had smoked at least one cigarette shortly before entering the shelter. During the no-smoking period in the shelter, carbon monoxide was desorbed from the blood of each smoker and was exhaled into the shelter atmosphere. Using the data presented in Figs. 20 and 21, calculations of the average volume of carbon monoxide desorbed per man per hour have been made. Table 1 shows the average rate of exhalation of carbon monoxide per man per hour during the no-smoking period.

After smoking began, the CO level increased rapidly until the ventilation was turned on. The average cigarette produces 48 cc (STP) of carbon monoxide (2). From this, we calculate that 125 cigarettes were smoked during the buttoned-up period at the beginning of the two-day trial. In each trial, smoking tapered off towards the end of the no-ventilation period and then increased again after the ventilation had been on for an hour or more. The carbon monoxide data from the two-day trial (Fig. 20) typify those resulting from variations in the number of men smoking as well as variations in ventilation rate.

Table 1
Average Exhalation of Carbon Monoxide During the No-Smoking Periods (cc(STP)/man/hour)

Hour	Two-Day Trial	Two-Week Trial
1st	18	20
2nd	11	13
3rd	7	-

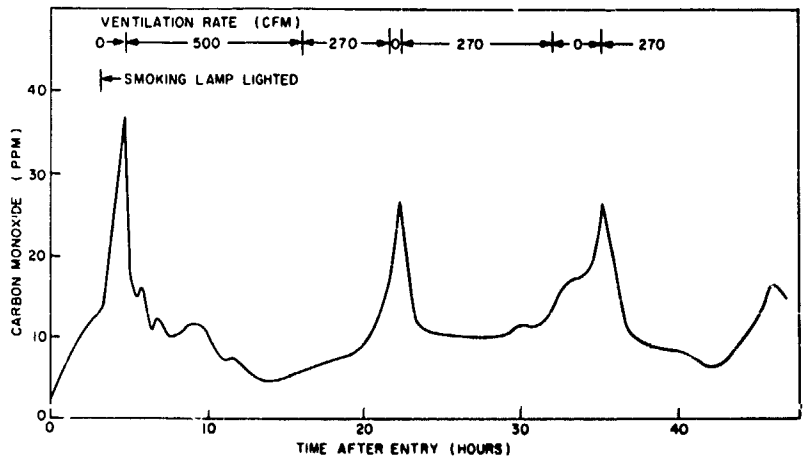


Fig. 20 - Carbon monoxide concentration, two-day shelter trial

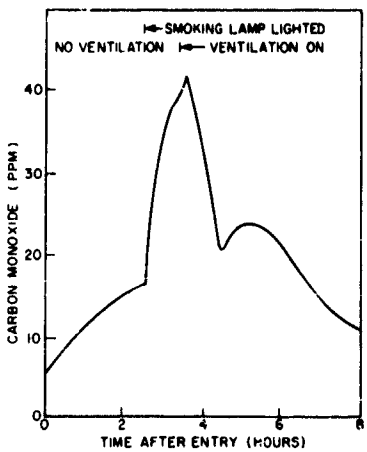


Fig. 21 - Carbon monoxide concentration, two-week winter shelter trial

The maximum acceptable concentration of carbon monoxide is 100 ppm for a 40-hour week (4). On nuclear submarines the maximum acceptable concentration is 25 ppm (5). During the periods when the ventilation was off, the carbon monoxide did not go above 42 ppm and remained below 20 ppm at other times. Thus, even with unlimited smoking, carbon monoxide was not considered a problem. Nevertheless, under actual conditions, smoking should not be permitted until the ventilation blower has been started. Under such conditions it is not likely that the carbon monoxide concentration would even exceed 20 ppm.

The Bacharach tubes were used principally by the shelter engineering team to sample the outside air and the air in the motor-generator room. For this purpose, 1/4-in. O.D. copper tubing was run through the shelter wall to the outside and to the motor-generator room. Thus, the team could determine the CO concentration in these spaces without

leaving the protected area of the shelter. In an actual emergency situation, this procedure is considered to be of utmost importance. If there is or has been a fire of any nature topside, it will not be safe to ventilate the shelter until the air outside is proved free of carbon monoxide. Likewise, if the exhaust system of the motor generator is not tight, carbon monoxide may be released into the motor-generator room. The space should be proved free of carbon monoxide before the engineering team exits to check the motor generator.

No changes are contemplated in the carbon monoxide assessment during the summer trial.

OXYGEN

The oxygen concentration in the shelter was monitored with a Pauling oxygen meter; this meter uses the paramagnetic property of oxygen to measure concentration. During the buttoned-up period, the oxygen concentration decreased to about 19 percent. After the ventilation blower was started the oxygen concentration increased rapidly and remained above 20 percent during the remainder of the trial. In a nonventilated shelter, the increase in carbon dioxide may be expected to produce more serious physiological results than will the corresponding decrease in oxygen. Hence, it is considered that the oxygen-concentration measurement is not critical, provided the carbon dioxide content of the shelter is known.

During the summer trial, the Pauling meter will again be used to monitor the oxygen content of the shelter air.

AEROSOL CONCENTRATION

The concentration of dust and smoke in the shelter atmosphere was monitored continuously with a Sinclair-Phoenix light-scattering dust and smoke photometer. In addition, samples were collected on Tared filter papers and weighed to determine the average mass concentration of aerosol in micrograms per liter over a specified period.

The light-scattering meter was calibrated to read 100 percent when subjected to a 0.3-micron-diameter dioctylphthalate aerosol having a mass concentration of 80 micrograms per liter. Aerosol-contamination data during the early part of the trial, as determined by the light-scattering meter, are shown in Fig. 22. During the period before smoking began, there was a relatively small quantity of dust in the atmosphere. After smoking was allowed, the aerosol concentration increased very rapidly. Within a short time the air became so dense with smoke that nearly everyone stopped smoking, and the aerosol concentration began to level off. After the ventilation was started the concentration decreased rapidly, until men began to smoke again; then it began to fluctuate as a function of ventilation rate and the number of men smoking. The carbon monoxide concentration shown in Fig. 21 follows the same general pattern as the aerosol concentration.

The aerosol-mass-concentration data are shown in Figs. 23 and 24. The data from the two-week period are the more useful, because the sampling periods were coordinated with shelter activity. During the period between entry time and the beginning of smoking, the average mass concentration of dust in the air was 0.29 microgram per liter. During the period when there was smoking without ventilation, the average mass concentration was 8.7 micrograms per liter. During the latter part of this period, watering of the eyes was noted among smokers and nonsmokers alike. During the remainder of the trial, the mass concentration fluctuated with activity level and ventilation rate. The highest concentrations were obtained when all the men were up and the ventilation rate was low. After smoking began, the average aerosol concentration never went below 0.8 microgram

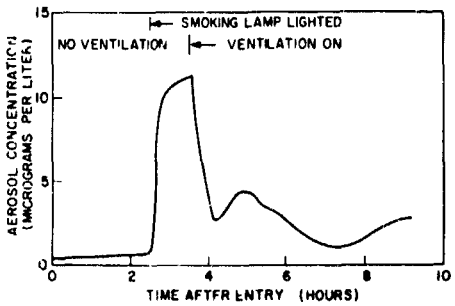


Fig. 22 - Aerosol concentration, two-week winter shelter trial

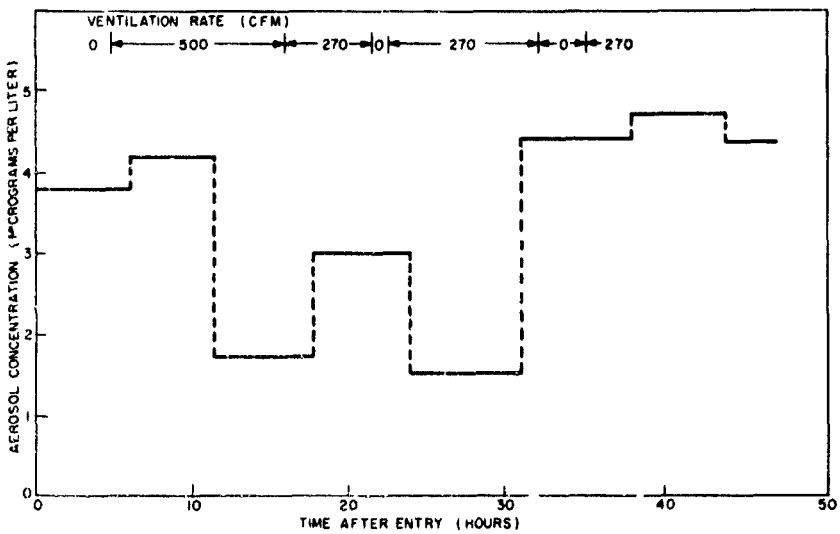


Fig. 23 - Mass concentration of aerosols, two-day shelter trial

per liter and went as high as 5.2, with a mean of approximately 2.5 micrograms per liter. This is of the order of ten times the aerosol concentration of "normal" air, and it may have contributed to the severity of the upper respiratory infections described in Chapter 9 of this report.

No changes are contemplated in the aerosol-monitoring techniques for the summer trial.

TRACE GASES

In order to determine whether or not the unlimited smoking, preparation of food, body odors, odors from the chemical toilets, etc., would produce physiologically significant quantities of gases, generally organic, the atmosphere within the shelter was continuously sampled using standard ND-C-2 gas mask canisters. This procedure is similar to that used aboard nuclear submarines to monitor the atmosphere for trace gases (6).

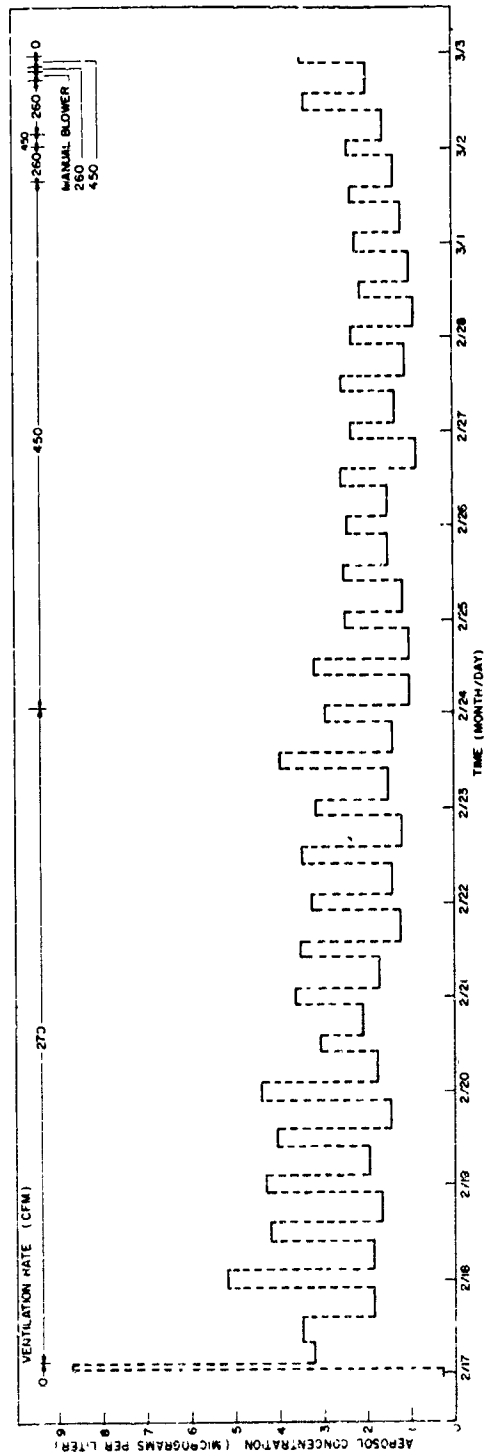


Fig. 24 - Mass concentration of aerosols, two-week winter shelter trial

The report from the analysis of the exposed canisters is shown in Appendix A. Only water, carbon dioxide, nitrous oxide and an unidentified amine were detected. The study indicated that, for the ventilation rates used, the concentration of trace gases from the sources mentioned above was not significant; therefore, the study will not be repeated during the summer trial.

SOUND LEVEL

The sound level was measured with a General Electric Portable Sound Level Meter, Model 1551A. Prior to entry, with the ventilation blower off, the sound level was 54 db; with the ventilation blower on at 270 cfm, the sound level was 78 db. After entry, with the ventilation blower on at 270 cfm, the sound level was 74 to 86 db. When the ventilation rate was increased to 450 cfm, the sound level dropped to 70 to 79 db. This sound-level reduction was attributed to a decrease in the noise created by the air passing through the flow-rate control louvers in the blower housing.

The lowest sound-level reading after entry was 67 decibels, obtained when both the ventilation blower and the motor generator were secured and quiet hour was in effect. A reading of 73 was obtained when the ventilation blower was secured during a psychological test.

The high noise level made lecturing to the entire group impossible unless the ventilation blower was turned off. A public address system will be installed for the summer trial. The sound level will again be measured with a sound-level meter.

ELECTRICITY

Kilowatt-hour meters were installed so that the electrical power consumption could be monitored. During the two-week trial, 181 kwh were used for food preparation, 467 kwh for lights, and 208 kwh for ventilation. The kwh meters will be used again during the summer trial.

WATER

Water meters were installed so that the total quantity of water used could be monitored. The water consumption during the two-week trial was 1.8 quarts per man per day for all purposes. The water-intake data in Chapter 7 of this report indicates a water consumption of 1.5 quarts per man per day. The difference leaves a total of 30 quarts per day for all other purposes, such as (a) oral hygiene, (b) showering by engineering team, (c) washing hands by those who were going to prepare food, (d) cleaning of cooking utensils, and (e) charging of heads. The water meters will again be used during the summer trial.

PHOTOGRAPHY

A 16-mm Auricon Super 1200 Camera with a 5.7-mm focal length lens was mounted above the decontamination tunnel and focused on the area between the bunks and the food-preparation bench. Tri-x film was used so that pictures could be obtained with available light. The camera was operated at 24 frames per second. The camera was remotely controlled from the administration area, and it was possible to obtain good candid shots of shelter life. In addition, one of the shelterees was equipped with (a) a 16-mm Bell and Howell 50-ft magazine-loaded camera equipped with a 13-mm lens, (b) an Eastman Kodak camera with flash attachment for black and white still pictures, and (c) an Eastman Kodak fixed-focus camera with flash attachment for color transparencies.

Although the pictures obtained during the winter trial are very good and very useful, an effort will be made to recruit a rated photographer for the summer trial.

CLOSED-CIRCUIT TELEVISION

A closed-circuit television system was installed so that activities inside the shelter could be observed from a monitoring station located near the shelter. This station, manned 24 hours a day, served as a security watch to assure that prompt action would be taken in case of an emergency within the shelter. This monitoring system will again be used during the summer trial.

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CHAPTER 4

SELECTION OF SUBJECTS

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INTRODUCTION

The selection of subjects for this series of studies has been carried out with three broad criteria in mind. First, every effort was made to insure that each subject participating in the study actually would complete the test in which he was involved. Thus, much more stringent selection standards were established for the two-week trial than for the two-day trial. Second, inasmuch as certain physiological studies were conducted as an integral part of the engineering habitability experiment, it was considered necessary that the men serving as subjects present no evidence of medical defect or disease. Third, in order to reduce management problems to a minimum, relatively stringent psychiatric standards were established.

TWO-DAY TRIAL

Inasmuch as the two-day trial was conducted solely to determine the feasibility of the various experimental and management procedures selected for the subsequent two-week trial, and because of the minimal stress involved during a two-day period of confinement, the criteria for selection of subjects were fairly broad.

Through the office of the Commandant, 100 volunteers were solicited from all activities within the Potomac River Naval Command. The majority of the subjects came from the U.S. Naval Air Station, Patuxent River, Maryland. Commanding Officers were requested to have each volunteer examined by a naval medical officer prior to the trial. Any man considered fit under the provisions of the "Manual of the Medical Department" to perform the duties of his rate both ashore and afloat was considered to be physically qualified, although men undergoing out-patient treatment of any nature were disqualified. Commanding Officers also were requested to eliminate any man with a history of disciplinary difficulty, excessive alcoholic indulgence, or acute family problems.

No further physical or psychiatric examination was undertaken on men selected by their local command for the two-day trial. The selection procedure utilized for this trial is considered to be satisfactory.

TWO-WEEK TRIAL

The selection of subjects for the two-week trial was a relatively complex procedure. After obtaining appropriate Bureau and Command clearances, volunteers were requested from among recruits graduating at the U.S. Naval Training Center, Great Lakes, Illinois, on Feb. 10, 1962. Of the 400 solicited for the study, 283 recruits actually volunteered. Of this number, the Training Center Personnel Officer arbitrarily selected a pool of 150 men for physical and psychiatric examinations. It should be noted that this group of 150 men was a definitely biased sample of the recruit population. As a result of certain administrative restrictions imposed upon the selection of subjects for this test, all of the volunteers were selected from men scheduled for general sea duty rather than attendance at service school. The precise influence of this sampling artifact was not

explored. However, it is reasonable to assume that, for the most part, the better educated, more intelligent, and culturally privileged recruits were excluded from the sample of men available for selection.

The authors of this chapter visited the Training Center to assist in and supervise the actual examination procedure. Just prior to examination, the pool of 150 volunteers was briefed in detail as to the purpose of the study and the general nature of conditions under which they would live. Parenthetically, it should be noted that little, if any, information of this nature was given to the men at the time they originally volunteered as subjects. An effort was made during this indoctrination lecture to point out clearly the negative aspects of the study as a means of crystallizing weak or nonspecific motivation. Prior to the lecture, the recruits had been told unofficially that the test would be of two weeks duration. During the course of the indoctrination, great emphasis was placed on the fact that no assurance whatsoever could be given as to the duration of the test. In this connection, the volunteers were urged to drop out of the test unless they were willing to enter into the trial without knowledge as to the length of time that they would be confined. In addition to emphasizing the uncertainty regarding the duration of the trial, the subjects were offered no incentive or reward whatsoever for participation in the study. Approximately five of the 150 recruits devolunteered following the indoctrination lecture.

PSYCHIATRIC ASSESSMENT

The NP assessment was conducted at the Recruit Evaluation Unit of the Administrative Command Medical Department. In addition to the junior author, the entire staff of the unit, three psychiatrists and two clinical psychologists, participated in the actual examination procedure.

In addition to the records which included complete documentation of any contact the recruit may have had with the Psychiatric Evaluation Unit during the course of his training, a current Company Commander's report was available on each man. This report, completed by the staff officer directly responsible for the individual recruit's training, is designed to evaluate a number of aspects in the recruit's present adjustment to Naval Service.

Each man was interviewed for approximately 30 minutes. The psychiatrist or psychologist conducting the interview had the material listed above available before he saw each of the subjects. Inasmuch as the recruits had completed approximately seven weeks of training, a considerable amount of information was available as to their adjustment in service. In addition, the information on preservice adjustment, routinely obtained on all recruits, also was available to the examiner. It was possible, therefore, to conduct a relatively intensive evaluation during the somewhat limited time available.

Each examiner was requested to use the interview technique with which he felt most comfortable. The factors receiving particular attention during the psychiatric assessment are listed below. Items were included in this list either because of their known importance in adjustment of small groups in Antarctic isolation or on the basis of recommendations made by Dr. J. W. Altman of the American Institute of Research.

Ego Strength and Adequacy of Defense Mechanisms

The emphasis in this area was directed toward detection of possible incipient psychosis and the adequacy of defense mechanisms to prevent personality disintegration under stress. Providing the defense mechanisms were considered effective, no specific effort was made to rule out neurotic mechanisms. Even minimal evidence of defect in this assessment factor was considered justification for an unequivocal disqualification.

Psychosexual Conflict

Any evidence of disturbances in psychosexual activities, either overt or latent, was clearly disqualifying.

Stability of Interpersonal Relationships

Individuals presenting a history of schizoid adjustment or discomfort in gross interpersonal relationships were disqualified. Particular emphasis was placed on the stability and duration of close interpersonal relationships rather than on the number of relationships per se.

Attitude Toward Authority

Men presenting a history of parental conflict and/or conflict with teachers or authority figures of the Naval Service were disqualified.

Antisocial and Acting-Out Behavior

Heavy emphasis was placed on the elimination of any volunteers who exhibited a propensity for acting-out or antisocial behavior in the nature of fighting, conflict with police, hot-rodding, drinking, etc.

Motivation and Attitude

Effort was made to assess maturity indirectly by an evaluation of the qualitative aspects of motivation and the degree to which the individual realistically perceived the situation for which he had volunteered.

Family Status

All men were questioned as to possible family problems, such as wife with complicated pregnancy, financial problems, or parents with serious medical or economic difficulties. Evidence of any such difficulty was considered adequate justification for disqualification.

MEDICAL ASSESSMENT

Subsequent to his acceptance by the Psychiatric Evaluation Unit, physical examination of each volunteer was performed by medical and dental officers at NTC who clinically evaluated each candidate for the history or presence of disease or other defect which would be regarded as disqualifying for recruit training. Records on the clinical findings in the case of each candidate were entered on Report of Medical Examination (Standard Form 88) together with the examiner's opinion regarding each man's qualifications as a test subject. The Report of Medical History (Standard Form 89) was completed by the volunteer himself. The health record of each volunteer was reviewed by the medical officer of the test team to evaluate entries of illness recorded during the period of recruit training. The following laboratory tests completed the screening procedure: examination of blood, including hematocrit, white-cell count, and differential; urinalysis including routine tests for pH, specific gravity, albumin, sugar and microscopic examination of the sediment; and finally, chest x-ray on 70-mm film by photofluoroscopy. In eight cases among those ultimately accepted as test subjects, the health records revealed hospital

admissions during the recruit training period for bronchopneumonia. In each case a 14 x 17 in. chest x-ray was requested. With a subsequent report of negative findings, these men were regarded as qualified for the test.

RESULTS OF ASSESSMENT PROCEDURES

Of the 150 men initially examined, 62 either devolunteered or were disqualified on the basis of medical-assessment procedures. The overwhelming majority of the disqualifications occurred during the psychiatric assessment. Additional recruits were obtained from among the men who originally volunteered, so that at the conclusion of the selection procedure a total of 110 qualified recruits were available for the study. Although only 100 recruits were needed for the study, at the recommendation of the Commanding Officer at the Retraining Command, an additional ten qualified recruits were placed in a standby pool so that provision could be made for replacing any subjects who might drop out because of hospitalization, etc., prior to their detachment from the Retraining Command.

As might be expected, the rejection rate on the basis of clinical and laboratory examination was low, in view of the fact that these men had already undergone and passed identical examinations a few months previously in qualifying for recruit training. One man was rejected because of an acute febrile illness diagnosed as mild influenza. Another failed to qualify because of extensive acne. Two volunteers with positive findings in urinalysis were rejected, one with hematuria, the other with glycosuria. Two cases in which the examiner reported presence of a Ghon complex in the photofluoroscopic examination were considered unqualified for the test.

On advice of the Head of the Preventive Medicine Division of the Bureau of Medicine and Surgery, a decision was made to regard a positive tuberculin reaction as a cause for rejection. Of the first 100 men otherwise qualified, six were reported to have positive tuberculin reactions varying from +2 to +20. These men were disqualified, and additional volunteers were screened to fill the quota.

One-hundred volunteer recruit graduates reported to the Naval Station, Anacostia on Feb. 12, 1962, for duty as test subjects. It was necessary to conduct a final selection of 96 subjects who would actually reside within the shelter for the trial period, the remaining four to stand watch at the monitoring station on the outside. The four who were rejected as shelter subjects were the following:

(1) Subject J.J.B. reported on Feb. 15 to sick call with a fever of 103.8°F. Aside from mild pharyngitis, the physical findings were negative. In an effort to avoid spread of what appeared to be an influenzal type disease, this man was transferred on Feb. 16 to the dispensary for isolation and treatment. He recovered uneventfully and returned to duty on Feb. 19 as a monitor.

(2) Subject E.M., Jr. presented a history of persistent hoarseness of several weeks duration. Clinical examination was negative except for anterior cervical lymphadenopathy. It was decided that this man should not be exposed to the shelter environment. During the period of the trial, he received treatment as an outpatient at the Naval Hospital, with marked improvement of the laryngitis.

(3) Subject L.G.B. was reported to have the finding of a healed Ghon complex at the right base. This report had been overlooked in the screening procedure. He was thus considered unqualified as a shelter subject but served as a monitor outside.

(4) Subject L.L.B., Jr. was found to have a report of positive tuberculin reaction in his record. This had been inadvertently overlooked in the screening procedure. He, too, was thus assigned duties outside the shelter.

All subjects were interviewed each morning from Feb. 12 through 16. Any complaint suggesting acute illness was noted, and the subject was directed to report to sick call. However, aside from those attending sick call, the majority of subjects were not examined clinically during the pretest period except for the routine recording each morning of body weight, pulse rate, and oral temperature. On Feb. 16, eighteen subjects attended sick call. Except for two cases of chronic nonproductive cough, the remaining 16 exhibited symptoms of coryza. None of these disorders was considered to be serious enough to be disqualifying. No cases of febrile illness were noted on either the day before entry or on the morning of Feb. 17, 1962, three hours before the test began.

The ages of the 100 recruits selected for the two-week trial ranged from 17 to 24, with a median of 19 years. Their educations ranged from grade 7 to 16, with a median of 11. A number of negroes were included in the group, but no racial breakdown was obtained. Protestant, Jewish, and Catholic religious faiths were represented, but no tabulation was made of religion.

SUMMER TRIAL

The administrative procedures for selection of subjects during the two-week winter trial were considered satisfactory, and no change is recommended for the summer trial. The psychiatric assessment criteria utilized were adequate within the administrative limitations imposed. As will be recalled, the population selected was limited in that it did not include men scheduled for service school. As a result, it would appear that the subjects selected for the two-week winter trial were at the lower end of the recruit continuum in the terms of maturity. It would be desirable to utilize service-school personnel for the summer trial, if possible, as a means of securing more mature subjects. However, this factor is not considered critical if it creates undue administrative complications.

The procedure for medical assessment of subjects for the summer trial (August 1962) will be essentially the same as that already described. However, greater attention will be directed to the existence of acute or chronic diseases of the skin. Excessive sweating and the limitations on personal hygiene will tend to aggravate existing skin disease and may lead to secondary infection. Therefore, the rejection rate for dermatological disorders is expected to be higher than in the selection of subjects for the winter tests. Evidence of susceptibility to heat stress, as indicated by a history of heat illness, such as heat stroke, heat cramps, or heat exhaustion will require evaluation by the medical officer of the test team through personal interview with the volunteer in question.

CHAPTER 5

ORGANIZATION AND MANAGEMENT

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PRELIMINARY PLANS

The organization and management aspects of the BuDocks shelter studies were not designed for an exact simulation of actual fallout conditions. In the initial planning stages of the study, it became quite apparent that not all shelter problems could be solved in one series of investigations. Moreover, an attempt to study a multitude of problems in a single experiment could well result in a confounding of variables which would defeat the primary purpose of the study. Inasmuch as the present investigation was undertaken primarily to study the facility from an engineering standpoint, no attempt was made to study behavioral problems which would require systematic manipulation of management and scheduling variables. Rather, every effort was made to keep management problems to an absolute minimum.

Three artifacts in fallout-shelter organization intentionally were introduced in this study as a means of minimizing management problems. First, the subjects were very carefully selected and definitely did not constitute a true random sample of the general population, either military or civilian. Second, there was active telephone communication from the monitoring center in connection with administration problems related to research data collection. Third, the shelter-management schedules were, to a great extent, constructed so as to facilitate the collection of research data. This requirement introduced a significant amount of activity which would not be found under actual fallout-shelter conditions. Because of the artifacts built into this study, it is considered inappropriate to generalize conclusions related to problems of management or schedule effectiveness to the general Civil Defense situation.

Although certain biases were intentionally built into the studies as a means of reducing management problems, there were two unique conditions introduced in the two-week trial which enhanced the realism of the experience and undoubtedly permitted a somewhat more accurate test of shelter habitability. These conditions, which have not been present in any study reported in the literature to date, are as follows: First, absolutely no rewards or incentives were offered to the subjects who volunteered for the trials. Moreover, the subjects were not informed of the rewards which they did receive until approximately one hour prior to the end of the trial. Thus, the recruits who served as subjects had no ulterior motives or secondary gain in completing the full period of confinement. The second unique condition in the two-week trial related to information as to the length of confinement. In order to simulate more realistically actual fallout-shelter conditions, the volunteers were not officially informed as to the duration of the trial. Thus, they knew only that their assignment in the Washington area was not to exceed a period of 30 days.

The shelter management and schedule for these trials were structured primarily after the programs developed by the AIR in their Pittsburgh studies*; however, the planning also was influenced heavily by reports of the NRDL studies.† As neither of these studies had employed hot bunking, various modifications of the AIR and NRDL programs were necessary for the present study.

GENERAL MANAGEMENT CONSIDERATIONS

Leadership Approach

The shelter program was built around a combination of democratic and authoritarian leadership techniques. Thus, the leadership was structured so as to utilize a direct authoritarian approach on all matters pertaining to health and safety. It was planned that all matters not in this category be solved by the subjects themselves through democratic processes, with the leader executing group decisions. The organization of the subjects and command hierarchy of the shelter was structured in such a way as to encourage positive decisions, as well as the resolution of conflict pertaining to every-day routine, at a level in the hierarchy below the Shelter Commander.

This leadership approach was adopted not only because of its superior effectiveness, as documented in the social psychology literature, but also as a means of preserving the status of the Shelter Commander during the actual period of isolation. Inasmuch as the Commander would not be able to utilize the usual military disciplinary measures, such as extra duty, restriction from liberty, loss of pay, etc., it was considered desirable to maximize the use of peer-group social pressure to enforce individual conformity to group norms. Moreover, it was considered desirable that techniques be built into the management procedure to insure the leader remaining at the top of the status hierarchy in spite of his enforced close social proximity with all of the subjects. This was accomplished by developing a chain-of-command procedure for dealing with shelter problems. Thus, insofar as possible, it was planned that the Shelter Commander assume the position of discussing and resolving problems with section leaders representative of large groups of shelterees rather than with individuals. However, group "gripe periods" also were planned so each man could express his opinion.

Previous fallout-shelter studies have pointed up problems arising from inadequate or weak leadership below the level of Shelter Commander. Accordingly, it was planned to build in a technique whereby team or division leaders could be rotated as necessary without losing face. In fact, it was considered that provision be made to permit a systematic rotation of duties among shelterees, if such action appeared desirable as a means of alleviating boredom and maintaining morale. In a further effort to cope with any problems of morale which might arise, it was considered desirable to provide the Shelter Commander with a "bag of tricks," such as ideas for parties, contests, etc., which he might introduce during periods of low morale.

Recreation

Following the lead of previous studies, it was planned that a three-man recreation committee would be appointed in each section of shelterees. This committee would be

*"Psychological and Social Adjustment in a Simulated Shelter," Am. Inst. for Research, Sponsored by the Office of Civil and Defense Mobilization, Nov. 1960.

†W.E. Strope, H.S. Etter, R.A. Goldbeck, R.H. Heiskell, and J.H. Sheard, "Preliminary Report on the Shelter Occupancy Test of 3-17 December 1959," USNRDL Report TR-418, May 4, 1960.

W.E. Strope, D.P. Schultze, and J.I. Pond, "Preliminary Report on the Shelter Occupancy Test of 25-29 July 1960," USNRDL Report TR-502, Mar. 21, 1961.

charged with the responsibility for planning games, contests, variety shows, and other entertainment. No attempt was made to plan any formal recreational activities before the trials. Rather, it was considered more realistic to permit this function to develop spontaneously. The list of recreational supplies for stocking the shelter was based largely on the AIR and NRDL studies. The supplies planned for the two-week trial were as follows:

1. 200 pocket book novels and 200 magazines
2. 50 decks of playing cards
3. 4 sets of each of the following games:
   a. Bingo
   b. Dominoes
   c. Chess
   d. Scrabble
   e. Cribbage
4. 8 sets of checkers
5. 25 tablets and 100 ballpoint pens

Religious Activities

Although no plans were made to schedule religious activity in the shelter, it was considered desirable to make services possible at the discretion of the subjects participating in the study. On the advice of staff Chaplains at the National Naval Medical Center, 25 Army-Navy Religious Field Manuals were stocked in the shelter along with 25 rosaries. This material was considered sufficient to conduct Protestant, Jewish, and Catholic services such as might be held aboard small ships where a Chaplain was not available.

ORGANIZATION

The preliminary plans provided for organization of the 100 shelterees into: (a) a staff group of six men, and (b) two sections, each consisting of 47 men. The staff group included the Shelter Commander, the two section leaders, the Medical Officer, and two Hospital Corpsmen. The sections were planned to consist of four divisions, each containing 11 or 12 men. Elected leaders were to represent their respective divisions in dealings with the section leaders.

Organization of the shelterees into two major sections was necessitated by the hot-bunking arrangement. The further subdivision of sections into divisions of equal size was undertaken primarily as a means of providing a clear channel whereby individual and/or group problems could be mediated through the chain of command.

However, the divisions served another equally important function in supplying men to carry out shelter duties. Each section was expected to furnish the following teams, which would be responsible for carrying out the daily routine of shelter operation:

1. Food - 11 men

2. Engineers - 12 men

3. Communications and Records - 12 men

4. Health and Sanitation - 4 men

5. Recreation - 4 men

6. Bunking - 4 men

On the basis of the team structure set forth above, each division would contribute team members as follows:

1. Food - 3-4 men

2. Engineers - 3 men

3. Communication and Records - 3 men

4. Health and Sanitation - 1 man

5. Recreation - 1 man

6. Bunking - 1 man

During the initial planning stages, it was considered desirable to make provisions for rotation of men on the teams in order to avoid monotony, etc. On the other hand, it was recognized that the rotation must be handled in such a manner as to avoid impairment of team efficiency because of a disruption in continuity. A schedule was devised whereby each division in the two sections would be permitted to rotate its team members once during the two-week trial, if the men so desired. Thus, it was planned to vote on the desirability of rotation of team assignments within the division concerned according to the following schedule.

Division Voting	Rotation Day
I	3
II	6
III	9
IV	12

In addition to the built-in provision for rotation, it was planned that the men within a given section would be free to shift team assignments by mutual agreement among themselves at any time they might desire, with the concurrence of the section leader. The routine and more monotonous duties of sweeping the deck, cleaning the heads, bunk assembly, etc., were to be rotated daily by divisions; i.e., each division would be responsible for cleaning the heads every fourth day in addition to their routine team duties. The division not assigned a routine duty for the day was scheduled to serve as the Shelter Commander's work party.

The preliminary planning called for responsibility to be designated to individual teams as follows:

1. Food: Food inventory and records. Food storage and disposal. Menu selection. Food preparation, serving, and distribution. Meal cleanup, and "rules" for usage of food.

2. Engineers: Operation and maintenance of shelter equipment. Monitor shelter instruments. Develop plans for emergency procedures. Log water consumption. Storage, issue, and inventory of sanitary supplies.

3. Records and Communication: Establish and maintain communications watches. Keep running log of shelter activity. Insure receipt and storage of appropriate section and team reports.

4. Health and Sanitation: Assist Medical Officer in data collection as requested. Storage, issue and inventory of sanitary supplies. With advice of Medical Officer develop and enforce rules for sanitation.

5. Recreation: Plan and organize group or subgroup recreational activity and contests. Maintain and issue recreational materials. Resolve conflicts on use of gear.

6. Bunking: Responsible for bunk reassignment. Establishing and enforcing sleep and quiet hours.

It was planned to draw up detailed instruction cards outlining the duties of each team. However, only the gross outline of these instruction cards was prepared before the two-day trial, as it was desired to base the detailed instructions on actual experience in the shelter.

Coordination of team, division, and section activities was to be accomplished through daily meetings. Thus, team leaders were scheduled to meet daily with their section leaders as well as with their counterparts in the opposite section. Division leaders were scheduled to meet daily with the section leaders to resolve any problems which could not be handled at the division level.

The original plan called for each man being assigned a bunk number on entry into the shelter. However, it was planned that changes in bunk assignments could be made any time during the trial through the bunking team. Because of the complications which were anticipated in hot bunking, it was considered advisable to develop more specific rules and regulations with regard to sleeping during the course of the two-day trial.

The preliminary plans called for the sections to eat separately; however, again, it was planned to defer development of specific rules, regulations, and schedules until the two-day study had been completed.

Preliminary planning called for maintaining the following records:

1. Telephone log
2. Shelter-activity log of all communications
3. Team logs recording expenditure of supplies
4. Shelter Commander log recording significant problems and incidents.
5. Appropriate medical records
6. Personal diaries

No simulated Civil Defense radio messages were planned for this trial. Telephone communication was to be provided only for use in carrying out the actual communication of research data and for emergency communication.

SCHEDULE

The preliminary schedule developed for the two-day and two-week trial is contained in Appendix B. The schedule was divided into two major periods or phases. The first phase (E time) covered the sequence of experimental activities for the five d[illegible]rior to the trial as well as the organizational activities during the first eight hours within the shelter. The second phase (R time) of the schedule covered the regular shelter routine and experimental activity for a 24-hour period. The daily schedule was intended to be repeated throughout the trial.

As will be noted in Appendix B, the daily activity of the shelter was scheduled under two headings: normal shelter routine and experimental routine. This procedure was considered desirable to minimize confusion between normal shelter operations and the extensive activity involved in collection of research data. It should be noted that a separate time sequence was used for the two major schedule phases. All time before the regular schedule was designate[illegible] entry, E, plus or minus the appropriate day and hour. Time on the routine schedule was prefixed by R plus the appropriate day and hour. Prior to the two-week trial the E and R designations were deleted. The revised schedule is shown in Appendix C.

TWO-DAY TRIAL

The organization, management, and schedule set forth above was utilized essentially without change during the two-day trial.

Management

The leadership approach, developed during the preliminary planning phases of the study, was utilized during the two-day trial and found to be quite effective. However, due to the short duration of the trial, management functions other than implementation of the normal routine were not tested. For example, it was not possible to rotate leaders, as was called for in the master schedule. Because of the time required to organize shelter activities, the effectiveness of meetings between various leaders below the Shelter Commander level, for coordination of shelter activities, could not be tested.

With the two-day limit, no untoward psychological responses were noted. Some mild anxiety was experienced by most subjects; however, this was considered in keeping with the general atmosphere and excitement of the trial. There were no disciplinary problems, and morale (except for a marked disappointment in the diet) was no problem. There was considerable interest generated on all levels toward contributing helpful suggestions to improve the two-week trial. Several of these suggestions were actually adopted.

One general discussion period was included during the two-day trial. However, it was necessary to secure the ventilating system to reduce the high background noise level. It was found impossible to carry on these discussions or effectively present any lecture material with the blower in operation.

The proposed telephone and official logs were combined during the two-day trial because of the close proximity of the official recorder to the physical location of the telephone. The physical arrangement of the shelter was such that both functions could be carried out easily by one individual. Further, it was considered that for these studies separate logs were not necessary. It should be noted that this procedure would not be recommended under actual emergency conditions in view of the critical importance of communication.

A problem with regard to recreation material developed, since much of the reading material delivered to the shelter was considered inappropriate. Through an error in procurement, much of the reading material consisted of magazines such as "Ladies Home Journal," "American Home," and "Better Homes and Gardens." Because of the possible negative response to this material by the older and "saltier" petty officers participating in the trial, it was considered advisable not to include these magazines in the shelter supplies.

It must also be pointed out, however, that the pocket books and magazines actually stocked were pointed toward supplying reading material which would actually appeal to the interests of the men and therefore effectively fill their idle time. With no actual threat of nuclear attack, the men could not be expected to sustain a continuing interest in literature treating of the recovery operations. Therefore, little such material was stocked. However, in the event of an actual attack, there would be a definite requirement for this type of information.

Organization

The shelter organization outlined previously was utilized during the two-day trial. This organization was found to be unnecessarily complex and unwieldy. Specifically, the procedure for assigning men to duties was considered unnecessarily cumbersome. The organizational phase of the schedule took much longer than was considered appropriate. This was due not only to the complexity of organization, but also to the fact that the instruction cards containing team duties were only partially completed.

Schedule

Except for the problems noted below, the schedule as originally planned proved to be satisfactory during the two-day trial. For the two-day trial, the volunteers reported to the National Naval Medical Center two hours before entry. The reason for this was that the preliminary physiological measurements were not required, since this aspect of the schedule was not being tested as a part of the two-day trial.

The times allotted in the schedule turned out to be rather optimistic. Where the schedule allows eight hours for the initial organizational phase, this in fact took eleven and one half hours.

The change of time between the entry and routine phases of the schedule proved to be confusing and unwieldy. On the basis of this trial, it was considered desirable not to have any change in time designation between shelter time and outside time.

TWO-WEEK TRIAL

Management

During the two-week trial no change was planned in the leadership techniques used in the two-day trial. With the single exception which follows, these techniques proved to be highly satisfactory.

Ninety-six of the subjects in the two-week trial were Seaman Apprentices. All of the section and division leaders had gone through recruit training with the men under them and were of the same military rate. Particular difficulty was found with the section leaders achieving and maintaining leadership status. While this was due partly to the fact that the selected leaders were not always the emergent leaders, there were additional

reasons for the problems which were encountered. First, one of the section leaders demonstrated a tendency towards authoritarianism which was irritating to the men under him to the point of engendering resentment and passive-aggressive behavior. Second, it soon became apparent that a number of grudges and personality conflicts between the subjects had been carried over from their association in recruit training. These conflicts became quite apparent on occasion; however, there was no evidence that any interpersonal conflicts of a serious magnitude actually originated during the two-week trial.

Because of the problems outlined above, the section leaders during the two-week trial were much less effective than those who served during the two-day trial. This necessitated the Shelter Commander taking a much more active role in directing team activity. Moreover, the physician, a senior Navy medical officer, obviously served as a stabilizing and guiding influence to the recruit leaders, although at no time was he directly involved in the shelter management. Few discipline problems were encountered, although this may be a reflection of the emphasis placed on this area in selection of subjects.

Minor infractions, i.e., in medical area when unauthorized, nonobservance of reveille, miscellaneous horseplay, etc., were handled by forming a "10-percent club" around the fourth day of the trial, after everyone was familiar with the routine. The "10-percent club" met once each day, usually around 1200, to perform 30 push-ups in front of the group, in payment to the group for their delays, etc. This mild form of ridicule, while not being physically punishing, was nonetheless tiring and served to enforce conformity through group pressure. This technique is considered to have aided in achieving the goal of upholding the status and authority of the Shelter Commander by placing him above the level of dealing with minor problems of social nonconformity.

More serious infractions, such as the one incident of a brief fist fight, were handled directly by the Shelter Commander with an authoritarian approach. Verbal reprimand was utilized along with a discussion of the absolute inability of the shelterees to tolerate such behavior. This approach to the problem was successful; however, other courses of action had been formulated in the event that they were needed. For example, if verbal reprimand by the Shelter Commander had not proved adequate, it was planned to assign offenders to such undesirable duties as permanent head detail.

Morale was surprisingly good overall, but it did take a dip downward, beginning about the fourth day, when the men learned from radiation readings that they were likely to be in the shelter for an additional ten days. The low point was reached in the seventh day, when high humidity, coupled with a high temperature produced by the reduced ventilation rate, made the interior of the shelter quite uncomfortable. Morale was noticeably improved when the ventilation was increased to make the shelter more comfortable and when gum was passed out the sixth, ninth, and twelfth days.

The group entertainment, in the form of skits, dances, etc., which took place on the eighth, tenth, twelfth, and thirteenth days (Fig. 26), had a very positive role in maintaining morale. In addition, a formal competition in checkers, card games (Fig. 25), etc., was initiated between the two sections to determine which men would do the final cleanup of the shelter before departure. Artistic talent was encouraged, and pictures and cartoons were publicly displayed and favorably commented upon. A significant problem in general shelter management which was encountered related to the lack of adequate passageways or aisles for moving from one place to another. This problem was particularly acute during the periods when all 100 men were up and about. While instructions were given to maintain clear passageways in the shelter, the organization of the space was such that this was extremely difficult, if not impossible. Not only did men tend to stand and carry on group discussions in the aisles, but occasional card games developed in areas designated as passageways. The most serious difficulty occurred at meal time, when men sat in the passageways and balanced food on their laps. Although this was basically a problem in shelter management, the poor utilization of space constituted a leading source of psychological discomfort, as is noted elsewhere.

Fig. 25 - One form of recreation in the shelter

It will be noted that the noise level in the shelter was quite high at all times. This ranged from 73 decibels during the so-called "quiet period" to 86 decibels during the common, or high-activity, period. This high level was primarily attributable to the ventilating system. It was necessary to shout in order to be heard, and oftentimes groups in the rear of the shelter were still unable to hear. After several days, a portable, battery-powered megaphone was introduced into the shelter and used for the duration of the trial. This helped considerably in communicating, but it still did not guarantee everyone hearing the instructions when first announced. For this reason then, instructions and group discussions, although attempted, were ruled out in favor of the personal-contact or small-group approach. Although these are obvious drawbacks to a high background noise level, it is suspected that some benefits may have been derived from its presence. The constant-pitch background noise was fairly acceptable to the subjects, and may have helped drown out disturbing noises, especially during the sleeping periods. Further, the noise effectively isolated small conversation groups and led to a sense of privacy.

Organization

As described above, it was concluded that the two-day trial organization was workable, although it was more sophisticated than necessary in light of the relatively simple tasks required in operating the shelter. Half of the men were designated "Port Section," and the other half "Starboard Section." Then the men were assigned to a division, such as the Engineering Division, which determined the type of work they did. The organization during the two week trial is presented below:

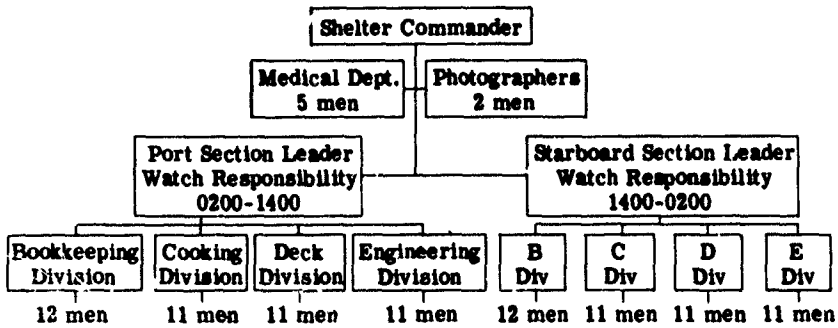


Fig. 26 - Group entertainment

The specific responsibilities for each division were as follows:

1. Bookkeeping Division: It was the responsibility of the B Division to maintain continuous official recorder and water-monitor watches, to keep a running log of shelter activities, and insure receipt and storage of appropriate division reports.

2. Cooking Division: It was the responsibility of the C Division to keep records on food inventory and meals served, to prepare and serve all meals, and to clean up the food-preparation area at the termination of each meal. In addition, it established a "recreation and supply" watch, whose duty it was to see that individuals signed for and were responsible for the return of recreation gear and other items checked out of the stock area.

3. Deck Division: It was the responsibility of the D Division to enforce smoking regulations, sleeping and quiet periods, to take down bunks for use or to stow out of the way, to supervise the cleaning of the shelter, and to establish a watch which would insure the keeping of adequate records of the D Division activities

4. Engineering Division: It was the responsibility of the E Division to operate and maintain the shelter equipment, including the diesel generator and collective protector, to service the heads and record the amount of chemical used, to monitor the shelter instruments and outside radiation level (Fig. 27), and to record E Division activities as well as the experimental data collected.

Fig 27 - A shelter occupant dressed for radiation monitoring

The Shelter Commander, medical staff, photographers, and section leaders were grouped for identification purposes into a fifth division, the A or Administration Division. These ten men were also split into groups of five so that half of the administration division was on duty while any section was sleeping. This organization, which is a marked simplification of that originally planned, was considered desirable despite the fact that the actual administration of shelter activities was considerably "easier" during the two-day trial because of the greater range of military rates, age, and experience of the subjects. It was considered that the organization during the two-week trial was as simple as possible for good control and, despite chain-of-command difficulties experienced due to the homogeneous group of volunteers, was nonetheless effective in carrying out the assigned responsibilities.

As noted in the section on preliminary organization plans, provision was made to rotate team members in accordance with a predetermined schedule. This plan was not followed, although it was considered during the first week of the trial. Initial assignment to team duties was on a quasi-voluntary basis, following a limited number of shifts during the organization period, and no further dissatisfaction was expressed by the subjects until shortly before the end of the trial. At that time, rotation was considered ill-advised because it would result in pronounced interference with scheduling subjects for various medical studies. The lack of rotation did not result in management difficulties, and no morale problems became apparent in this area.

Schedule

On the basis of the two-day-trial recommendation, shelter time and actual outside time were the same. The schedule for the two-week trial is reproduced in Appendix C and was adhered to quite closely, except for the following additions or deletions:

A limited form of exercise was introduced after two days, and sick call was moved to the "common" period. The 1045 and 2245 shelter-wide sweepdowns were eliminated during the first week as unnecessary. Church services were held at 2400 Feb. 18 and 1300 Feb. 25 for approximately 45 minutes each. Intra-group entertainment was held at 0100 Feb. 25, 0100 Feb. 27, 0100 Mar. 1, and 0100 Mar. 2 for approximately one hour each. The inter-section competition in chess, checkers, scrabble, and cards was run off from 1200 to 1430 on Mar. 2.

The "hot-bunking" scheme proposed by this schedule, and indeed dictated by the construction of the shelter itself, was a source of some concern before the trials because of possible sleep disturbance resulting from the noise and light. However, these factors did not appear to have much adverse effect, since very few individuals complained of difficulty in sleeping. This finding may have been introduced by the youthful population, of whom it may be said "can sleep anywhere." These results should not be interpreted as indicating that hot-bunking would not constitute a problem in the summer trial or with a more representative Navy or civilian population.

The schedule, with one section sleeping eight hours, four hours common activity, eight hours with the second section sleeping, and four hours common activity, is quite adequate for wintertime hot-bunking. Moreover, this schedule may have contributed significantly to the generally expressed feeling by the subjects of time passing rapidly during the two-week period. It is considered advisable, however, that this schedule be closely re-examined upon the completion of heat-conductivity calculations for this shelter with a view toward eliminating unnecessary heat-generating activities during the "common" period.

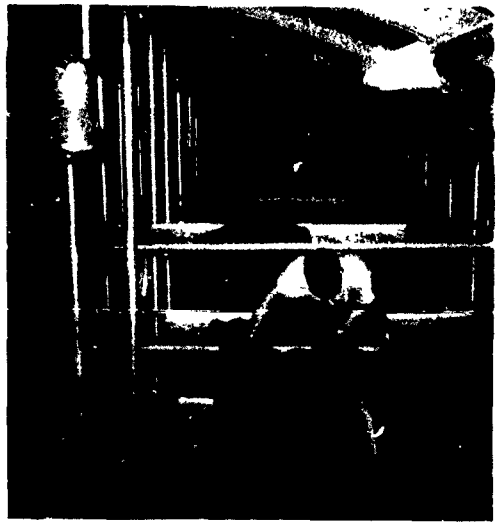
During the two-week trial, the Engineering Team left the shelter daily at 0130 and 1330 to check the motor generator. The team also was scheduled to monitor, by radiac gear, a radioactive source placed in the entrance way daily at 1330 by the NNMC staff in order to simulate the decay one would experience under actual fallout conditions. With these readings, and by using the known laws of radioactive decay, it was possible to plot and compute the trial duration after several days' readings had been taken. Although the men knew of the artificiality of this situation, they nonetheless took a keen interest in the daily readings obtained by the Engineering Teams.

The daily meetings between division leaders and their team and section leaders proposed in the original schedule outline were not needed during the two-week trial, since the team functions were integrated with the divisions. Other than the scheduled meetings of section and division leaders with the Shelter Commander, there were no formal meetings.

Also, the group meetings or "gripe" periods planned in the preliminary schedule were not utilized during the two-week trial. Primarily, this was because of the impossibility of having effective large group communication with the high background noise level. While one such meeting was held during the two-day trial, the blower had been secured at that time in order to give a psychological discomfort rating test. It was considered inappropriate to secure the blower for purposes other than the actual collection of the experimental data. Under genuine fallout-shelter conditions, securing the blower would introduce the possibility of contaminated particles entering the shelter when the positive interior air pressure is lost. Other means of expression were available through which men could make known their "gripes," e.g., passing word up the chain of comman on minor problems and direct personal access to the Shelter Doctor and Shelter Commander on highly disturbing personal problems.

SUMMER TRIAL

Because of the problems experienced in attempting to develop a command hierarchy among subjects who had completed recruit training together, it is strongly recommended that two experienced petty officers participate in the next trial as section leaders.



(a) Bunks being set up prior to use

(b) Bunks in use. Note the head-to-foot arrangement.

Fig. 28 - Bunking procedure

In order to simulate emergency conditions more realistically, it is recommended that less reliance be placed upon outside assistance; e.g., if difficulty develops with the diesel-generator the shelter occupants should attempt to make the repairs, rather than outside mechanics, as was done in the winter trial. To this end one of the petty officers should have a background familiarity with motor generators.

To simulate realistic conditions, fewer phone calls to the shelter are recommended. These may be rationalized to the shelter occupants by having them represent walkie-talkie contact with a central control.

In order to cope more effectively with the high background noise level, it is strongly recommended that a more powerful speaker system be installed. To help alleviate the problem of crowding and congestion, especially as it relates to ease of movement, two items are recommended. First, folding shelves should be built along the greater portion of both bulkheads, to provide a natural reading, writing, or eating area for occupants seated on benches. Second, passageways or aisles and other designated activity areas should be identified by use of a sharply contrasting paint for the deck.

It is believed that the elimination of the Recreation Team after the two-day trial left a void which was not filled by just urging individuals to contribute spontaneously ideas and suggestions. Therefore, it is recommended that representatives be elected or appointed from each division to form a committee to develop and carry out a recreation program.

It is recommended that the winter schedule be re-evaluated after an analysis is made on the heat-load characteristics expected during the summer trial. It is believed that, if necessary, the schedule could be modified to cope more effectively with heat-generating activities.

CHAPTER 6

NUTRITIONAL STUDIES

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PRELIMINARY PLANS

The primary purpose of the studies made in the Bureau of Yards and Docks protective shelter was to determine the effectiveness of the shelter from an engineering standpoint. However, it was also considered that the studies would present an unusual opportunity to determine the acceptability and nutritive value of a relatively austere, storable type of diet.

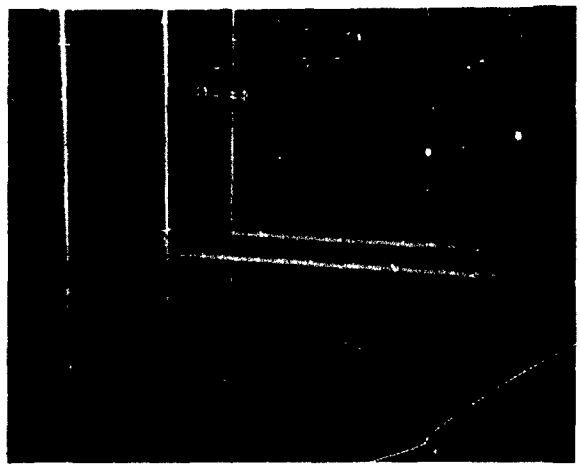
A number of factors were considered in selecting the ration to be used in the habitability trials, with the hope that the results obtained in the study would be of considerable use in the planning of rations for shelters. The first consideration concerned water, which is of prime importance in a survival situation. The ration would have to be of a type to conserve water as much as possible. With this in mind, the ration was to be relatively low in protein, salts, and spices. Other considerations were: (a) the ration should provide 1500 to 2000 kilogram calories per man per day, (b) it should be relatively simple, bland, easy to prepare and distribute, and should not require cooking, (c) it should have a long shelf-life, and (d) it should be relatively inexpensive. A number of publications were consulted in considering possible rations (1-5). The ration shown in Table 2 was decided upon, with the major source of nutrition from a commercial cracker (Fig. 29).

Table 2
Protective Shelter Ration

Food	Cold Meal (grams)	Hot Meal (grams)	
	Days 1-14	Days 1-8	Days 9-14
Crackers	172	66	172
Jam	20	0	0
Soup, condensed	0	90	90
Peanut butter	0	16	16
Sugar	13	6	6
Pream	8	4	4
Total Daily Calorie Intake (Approximate)	898	585	963

NOTE: The survival-ration crackers are 2-1/2 by 2-1/2 in. in size and provide approximately 30 calories per cracker. Twenty-six crackers are wrapped in waxed packets. One such packet, which weighs 172g, was the issue, except for the hot meal on days 1 through 8, when 1/2 packet was issued.

(a) A tin of crackers



(b) The survival-ration storage area, at the back of the shelter

Fig. 29 - The survival-ration crackers

THE TWO-DAY TRIAL

Only limited observations concerning nutritional status were made during the two-day study, since this had been arranged primarily to establish routines and to observe problems not previously considered. It was found that the overall acceptability of the ration was not as good as had been anticipated. This was particularly noticeable in regard to the "hot meal" with soup. Cracker consumption at this meal was only about 50 percent of that issued. The crackers were well received, however, at the "cold meal," which was served shortly after arising from sleeping.

THE TWO-WEEK TRIAL

The Ration

The ration which was planned for the study is shown in Table 2. Two meals were to be provided each man in a 24-hour period. The cold meal was to provide approximately

898 calories and the hot meal 963 Calories In the actual trial during the first eight days, the hot meal provided only 585 Calories; thus, the total values of the issued foods were 1483 Calories/man/day for days 1 through 8 and 1861 Calories/man/day for days 9 through 14. The smaller issue of crackers for the first eight days was based on the observation, made during the two-day trial, that there was a high rate of rejection of the crackers, particularly with the meal which included soup. The issue was increased later in the study, since an average weight loss of 5.0 lb per man occurred during the first 8 days.

The ingredients found in the survival-ration crackers are as follows: wheat flour, cane sugar, corn flour, corn sugar, cottonseed oil, soya flour, salt, and leavening. The crackers are also fortified with vitamin B_1 and contain butylated hydroxyanisole, propyl gallate, and citric acid in propylene glycol. The proportions of the major constituents of foods found in the crackers are shown in Table 3. Some of the minerals, vitamins, and amino acids found in the crackers are shown in Table 4.

Table 3
Composition of the Survival-Ration Cracker*

Compound	Amount (Percent)
Protein	8.6
Fat	8.8
Ash	1.5
Crude Fiber	0.4
Sucrose	14.8
Reducing Sugar	5.8
Other Carbohydrate	57.1
Moisture	3.0
Total	100.0

*Data provided by the manufacturer.

Table 4
Minerals, Vitamins, and Amino Acids in the Survival-Ration Cracker*

Compound	Amount	Compound	Amount
Sodium Chloride	1.0 g/100 g	Thiamine	0.22 mg/100 g (0.60 mg/100 g)†
Calcium	33.2 mg/100 g	Riboflavin	0.11 mg/100 g (0.04 mg/100 g)†
Phosphorus	99.2 mg/100 g	Niacin	0.88 mg/100 g (0.99 mg/100 g)†
Arginine	0.54 g/100 g	Methionine	0.17 g/100 g
Cystine-Cysteine	0.26 g/100 g	Phenylalanine	0.61 g/100 g
Histidine	0.25 g/100 g	Threonine	0.38 g/100 g
Isoleucine	0.55 g/100 g	Tryptophane	0.14 g/100 g
Leucine	0.82 g/100 g	Tyrosine	0.30 g/100 g
Lysine	0.39 g/100 g	Valine	0.52 g/100 g

* These values were taken from data provided by the manufacturer. The values were obtained by calculation from the composition of the ingredients.
†These values were found by independent assays.

A variety of jams were used, including cherry, strawberry, currant, and grape. Several different soups were also used, including chicken rice, tomato, vegetable beef, and beef noodle. The soups were diluted with water, heated, and served over a portion of the survival crackers. The caloric values of the jams and soups are somewhat different: therefore, the mean values were used to determine the mean caloric intakes given in Table 5.

Table 5
Mean Daily Caloric Issue and Intake per Man

Division	Daily Issue and Intake (Calories)			
	Days 1-8		Days 9-14	
	Issue	Intake	Issue	Intake
Starboard	1483	1429	1870	1820
Port	1530	1436	1861	1785
Both	1506	1432	1866	1802

The caloric value of the survival cracker is about 4.39 Calories/g; thus, the 258 g of crackers per day issued during the first eight days of the test provided 1133 Calories, or 76 percent, of the total Calories during this period. During the period from the 9th through the 14th day, 344 g of crackers were issued each day, providing 1510 Calories, or 81 percent of the total Calories of the ration. It is quite obvious that the major portion of the ration was provided in the form of the survival cracker, and thus to a large degree the nutritional adequacy of the ration is related to the adequacy of the crackers.

Acceptability of the Crackers

As indicated previously, crackers were issued to each man with each meal. Any crackers remaining from a meal were turned in before a new issue was made. The rejects were either counted or weighed, and this quantity was subtracted from that issued to determine the quantity of crackers consumed. Data concerning the acceptability of the crackers are presented in Table 6. Since different quantities of crackers were issued during days 1 through 8 and 9 through 14, the consumption during these periods was calculated separately. It can be seen that on the average the survival crackers were eaten without much wastage, with well over 90 percent of the issued crackers apparently consumed. It is of interest that the acceptability of the survival cracker was not decreased when the issue was increased after the first eight days of the test. The findings suggest that the high rejection rate of the crackers during the two-day trial may have been due to factors such as knowledge that the test was only for two days, a desire to lose some weight, fatigue associated with the varied activities necessary to habitate the shelter, and lack of time to accommodate to the new ration.

The figures presented in Table 6 are mean values. Some of the men who were ill during the study consumed very few crackers during their illness; others failed to consume their full quota for unknown reasons. It is of interest, however, that 44 of the 96 men did not return any crackers during the entire 14-day trial.

Caloric Intake

It is indicated in Table 5 that during the first eight days of the study the men were issued food with an approximate average caloric value of 1506 Calories per day, and for

the last six days they were issued an average of 1866 Calories per day. Some small variations in these caloric values occurred, since the various soups used had different caloric values; also, at the start of the trial the Port Division was served two successive cold meals, and some variation occurs in the quantity of soup served. The actual caloric intakes have been calculated on the basis of food issued minus food returned. For all 96 men, the average caloric value of the consumed ration was 1432 Calories per man per day during days 1 through 8 and 1802 Calories per man per day during days 9 through 14 (Fig. 30).

(a) Ration being weighed

(b) Preparation of hot soup

(c) Food being served

(d) Shelter occupants eating a meal of hot soup and crackers

Fig. 30 - Food preparation and serving in the shelter

Weight Responses

The changes in total body weights during the course of the protective-shelter study are presented in Chapter 7. In brief, however, an average of 5.0 lb per man was lost during the first eight days of the test, using average body weights for four days previous to entering the shelter as the control values. During the last six days of the study, when the issue of survival crackers was increased to 172 grams per man per day, an additional 0.4 lb per man was lost. Thus, a total of 5.4 lb of body weight was lost per man, with the far greater proportion lost early in the study.

Biochemical Studies

The habitability study was considered an unusual opportunity to evaluate the usefulness of the survival ration in maintaining the nutritional status of a group of young men. A rather complete nutritional study was considered appropriate, since the information gained might suggest modifications of the ration should use of the survival ration be prolonged for more than two weeks.

The procedures used in the evaluation of nutrition were mainly those established by the Interdepartmental Committee on Nutrition for National Defense (ICNND) as published in their Manual for Nutrition Surveys (6). Unless otherwise noted, the various assays were performed as indicated in the Manual. The evaluation of the biochemical findings was made on the basis of the suggested guides to the interpretation of blood and urine data which have been presented in the Manual for Nutrition Surveys. In some cases, interpretive guidelines other than those of the ICNND have been used, since the ICNND has not used these assays in nutrition surveys. In these latter cases, the source of the classification of blood or urine values as low, acceptable, etc., are indicated.

Two days before entering the shelter, blood and urine samples were obtained from 24 of the 96 recruits. The following procedure was followed in sampling. At about 2300 hours, the test subjects were told to empty their bladders, were given 1/2 pint of water, and then allowed to go to bed. Six hours later the men were aroused, and fasting six-hour urine samples were obtained in plastic bottles containing meta-Phosphoric acid. The volumes of the fasting urine samples were measured and recorded. A 100-ml aliquot was removed from each bottle, and the remainder of the urine was retained in the large collection bottle for the 24-hour sample. The pH of each aliquot was adjusted to about 3.0. The samples were then placed in an ice chest. Collection of all urine was continued throughout the day, until 2300 hours, when each man provided the last specimen. The volumes of the 24-hour samples were taken, and then an aliquot of each sample was placed in a small bottle, the pH adjusted, if necessary, to about 3.0, and the samples were placed in an ice chest. Venous blood samples were obtained from each man by the vacutainer technique. The samples were collected in tubes containing sodium heparin and were iced immediately after collection. The blood and urine samples were refrigerated and dispatched by air express to the U.S. Army Medical Research and Nutrition Laboratory at Fitzsimons General Hospital, Denver, Colorado, where they arrived within 12 hours of the final urine collection. A similar procedure was used to obtain blood and urine samples at the termination of the shelter trial, using the same 24 subjects. Urine samples were obtained during the final day in the shelter, and blood samples within two hours of emerging from the shelter and before any normal foods or drinks were consumed. Again the samples were dispatched to Denver, where all analyses except for hematocrit were performed.

Table 6
Acceptability of the Crackers

Division	Days	Crackers Issued Per Man Per Day (grams)	Crackers Consumed Per Man Per Day (grams)	Acceptability (percent)
Starboard	1-8	258	250	97
	9-14	344	333	97
Port	1-8	269	251	93
	9-14	344	329	96
Both	1-14	298	285	96

Vitamins in the Ration

Some of the B vitamins contained in the survival cracker are shown in Table 4. In estimating the approximate intake of some of the B vitamins, the values obtained at the U.S. Army Medical Research and Nutrition Laboratory were used, not only for that contained in the crackers but also for the vitamins contributed by some of the minor dietary constituents as well. The estimated intakes of vitamins B_1, B_2, B_6, and niacin are presented in Table 7. A comparison of the above figures with the ICNND's suggested guide to interpretation on nutrient intake data indicates that the vitamin B_1 intakes were high. An intake of vitamin B_2 of less than 1.2 mg/day is considered low; however, in the present study the intake was only 0.23 mg/day when the full issue of crackers was made. The intake of niacin can also be considered to be low, or deficient, according to the ICNND's guide (6). No guideline is available for vitamin B_6 intakes.

Table 7
Estimation of Vitamin Intakes on Survival Ration

Vitamin	Vitamin Intake (mg per day)		
	Days 1-8	Days 9-14	ICNND* Acceptable Intake
B_1	1.62	2.14	0.6-1.0
B_2	0.19	0.23	1.2-1.5
B_6	0.12	0.15	-
Niacin	4.75	5.60	10-15

*Interdepartmental Committee on Nutrition for National Defense.

Blood Studies

Mean plasma vitamin A levels at the start and end of the shelter study are shown in Table 8. Little difference was observed in the values, as might be expected, since vitamin A is a fat-soluble vitamin and can be stored to a considerable degree in the liver and elsewhere. The mean plasma carotene values are also shown in Table 8. It is quite interesting that there was a considerable change in the mean values. At the start of the study an average of 91.2 micrograms of carotene per 100 ml was found, whereas at the termination of the study only 38.3 micrograms per 100 ml was detected. The distribution of values suggests that a number of the individuals were in the low range. The distribution of vitamin A and carotene in the plasma at the beginning and the end of the two-week trial are shown in Tables 9 and 10.

Table 8
Selected Vitamins in Plasma at Beginning and End of Two-Week Trial

Vitamin	Concentration (micrograms/100 ml)	
	Beginning	End
A	45.2 ± 1.6	42.1 ± 3.0
Carotene	91.2 ± 6.4	38.3 ± 1.9
C	450 ± 50	360 ± 20

Table 9
Plasma Vitamin A Distribution in 24 Subjects at Beginning and End of Two-Week Trial

Rating	Micrograms per 100 ml	Number of Subjects	
		Beginning	End
Deficient	<10	0	0
Low	10 - 19	0	3
Acceptable	20 - 50	17	15
High	>50	7	6

Table 10
Plasma Carotene Distribution in 24 Subjects at Beginning and End of Two-Week Trial

Rating	Micrograms per 100 ml	Number of Subjects	
		Beginning	End
Deficient	<20	0	1
Low	20 - 39	1	12
Acceptable	40 - 100	16	11
High	>100	7	0

The mean plasma vitamin C value in the 24 subjects dropped from 450 to 360 mmg/100 ml, as shown in Table 8. The mean value at the end of the trial falls within an acceptable range, and the distribution of values shown in Table 11 indicated only one individual in the low range.

The mean hemoglobin value (Table 12) was higher at the end of the shelter trial than at the start, probably as a result of some water loss. The value at the start was 14.3 g/100 ml and at the end 16.8 g/100 ml. All of the individuals were in the high range of hemoglobin values. Hematocrit values (Table 12) also rose during the course of the study, again suggesting a water loss. These results do not agree with the weight responses reported in Chapter 7, which suggested that the weight losses were not due to water imbalance. The reasons for this discrepancy are not clear. Mean corpuscular hemoglobin values (Table 12) rose slightly during the trial.

The erythrocyte is able to convert ribose-5-phosphate to glucose-6-phosphate. One of the enzymes in this conversion, transketolase, requires thiamine pyrophosphate (TPP)

Table 11
Plasma Vitamin C Distribution in 24 Subjects at Beginning and End of Two-Week Trial

Rating	Micrograms per 100 ml	Number of Subjects	
		Beginning	End
Deficient	< 100	0	0
Low	100 - 199	1	1
Acceptable	200 - 400	11	16
High	> 400	12	7

Table 12
Hemoglobin, Hematocrit, and Mean Corpuscular Hemoglobin (MCHB)*

Measured Blood Fraction	Average Values	
	Beginning	End
Hemoglobin (g/100 ml)	14.3 ± 0.2	16.8 ± 0.2
Hematocrit (percent)	45.8 ± 0.4	49.3 ± 0.5
MCHB (percent)	31.4 ± 0.5	34.1 ± 0.3

*Twenty-four subjects were used throughout this experiment.

as a cofactor. Brin, et al. (7), have suggested that the utilization of ribose-5-phosphate by erythrocytes can be a measure of thiamine nutrition. In the absence of adequate thiamine in the diet, there is not an adequate supply of the cofactor, and the utilization of ribose-5-phosphate is impaired; however, the reaction can be stimulated by the addition of TPP to the assay system. Thus the amount of stimulation obtained by exogenous TPP when erythrocytes are incubated with ribose-5-phosphate is a measure of thiamine status. A stimulation of 16 to 20 percent is considered an indication of inadequate thiamine nutrition. The assay system for erythrocyte transketolase and the evaluation of results are based on the data of Brin, et al. (7). The mean values for the increase in erythrocyte transketolase activity with the addition of TPP are shown in Table 13. Very small stimulations were found at the start and at the end of the trial, indicating adequate thiamine nutrition in the subjects. These results were expected in view of the total thiamine content (about 1 mg/2000 Calories) provided in the crackers.

Data concerning the plasma proteins are presented in Table 14. There was a small increase in total serum proteins, from 7.34 to 7.77 g/100 ml, during the course of the study. As in the case of hemoglobin and hematocrit, this increase could have been caused by dehydration. An increase in serum albumins and a decrease in serum globulins, which resulted in a change in the A/G ratio, was also observed. The significance of these alterations is not understood at the present time, but they are of considerable interest.

The level of riboflavin (vitamin B_2) in the erythrocyte has been used as a measure of nutritional status in regard to this vitamin. Although this method is not included in the "Manual for Nutrition Surveys" (1957), it has been used on several nutrition surveys of the ICNND in foreign countries. The evaluation of levels is based on the work of Burch, et al. (8), and Bessey, et al. (9). It can be seen in Table 15 that adequate levels of

Table 13
Increase in Erythrocyte Transketolase Activity With the Addition of TPP

Rating	Increase (percent)	Number of Subjects	
		Beginning	End
Deficient	> 20	0	0
Low	16 - 20	0	0
Acceptable	10 - 15	1	1
High	< 10	22	23

Average Increase for 24 Subjects (percent)

Beginning 2.6 ± 0.8

End 2.4 ± 0.6

Table 14
Plasma Proteins*

Measured Blood Fraction	Average Values	
	Beginning	End
Total Protein (g/100 ml)	7.34 ± 0.08	7.77 ± 0.14
Albumin (g/100 ml)	3.98 ± 0.07	4.95 ± 0.11
Globulin (g/100 ml)	3.36 ± 0.09	2.82 ± 0.14
Albumin/Globulin	1.18	1.75

*Twenty-four subjects were used throughout this experiment.

Table 15
Red Blood Cell* Riboflavin

Rating	Micrograms per 100 ml RBC	Number of Subjects	
		Beginning	End
Deficient	< 10	0	0
Low	10.0 - 14.9	1	0
Acceptable	15.0 - 19.9	16	4
High	⩾20.0	7	20

Vitamin B_2, Average for 24 Subjects (micrograms per 100 ml RBC)

Beginning 18.0 ± 0.4

End 26.5 ± 1.1

*Erythrocyte

erythrocyte riboflavin were found at both the beginning and the end of the study, with even somewhat higher values at the end. Only one subject had what is considered a low level of erythrocyte riboflavin at the start of the trial, and none of the values were in the low range at the end of the study.

Urine Studies

Urinary riboflavin (vitamin B_2) was estimated by the microbiological assay utilizing lactobacillus casei #7469, as outlined in the publication of the "Official Methods of Analysis" of the AOAC (10a). It can be seen from the data in Table 16 that the test subjects were excreting high levels of riboflavin during the period previous to entering the shelter and that this level of excretion dropped markedly during the trial (Tables 16 and 17). Nevertheless, the terminal values were in the acceptable or high range, except for one individual who had a low excretion value. It would appear that for the two-week period on the survival ration, riboflavin nutrition is not severely influenced.

Table 16
Selected Vitamins in Urine from 24 * Subjects at Beginning and End of the Two-Week Trial

Vitamin	Vitamins Excreted in 6 Hours (micrograms)		Vitamins Excreted in 24 Hours (micrograms)	
	Beginning	End	Beginning	End
B_2	386 ± 40	107 ± 16	1568 ± 206	363 ± 39
N'-Methyl Nicotinamide	3490 ± 290	2390 ± 260	9240 ± 520	9700 ± 950
Niacin	330 ± 30	220 ± 10	860 ± 40	650 ± 30
B_1	83.5 ± 7.9	115.8 ± 15.8	287.5 ± 17.7	491.0 ± 54.0
B_6	21.22 ± 2.20	3.42 ± 0.27	61.87 ± 5.09	15.38 ± 1.12

*Twenty-three subjects used for N'-Methyl Nicotinamide studies.

Table 17
Distribution of Vitamin B_2 in Six-Hour Urine Samples from 24 Subjects at Beginning and End of Two-Week Trial

Rating	Micrograms per six hours	Number of Subjects	
		Beginning	End
Deficient	< 10	0	0
Low	10 - 29	0	1
Acceptable	30 - 100	0	12
High	> 100	24	11

The excretion of N'-Methyl Nicotinamide (N'MN) has been taken as a reflection of niacin nutrition in studies of the ICNND and was investigated in the present shelter trial (Tables 16 and 18). The data presented indicate no problem in regard to niacin, since at the start of the trial all excretion values for N'MN were in the high range, and at the end 18 values were still in the high range and five in the acceptable range. These values are based on the fasting six-hour excretion samples.

The excretion of niacin was also investigated, although this is a relatively minor excretion product. Niacin was determined microbiologically by a procedure outlined in the "Official Methods of Analysis" of the AOAC (10b), utilizing lactobacillus arabinosus as the test organism. The data in Table 16 indicate a reduction in niacin excretion at the end of the study. It is of interest that at the end of the shelter trial the excretion of N'MN was about 68 percent of pretrial values and the excretion of niacin about 67 percent of pretrial values. The similar trends in excretion of N'MN and niacin are interesting but do not indicate a problem in regard to niacin nutrition in the two-week test. Normal values for niacin excretion of from 0.14 to 1.40 mg/day have been quoted (11). Our values fall within this wide range.

Table 18
Distribution of N' -Methyl Nicotinamide in Six-Hour Urine Samples from 23 Subjects at Beginning and End of Two-Week Trial

Rating	Weight (micrograms)	Number of Subjects	
		Beginning	End
Deficient	< 200	0	0
Low	200 - 599	0	0
Acceptable	600 - 1600	0	5
High	> 1600	23	18

Although the activity of erythrocyte transketolase was used to determine the thiamine status of the test subjects, the excretion of thiamine was also studied as well. Urinary thiamine appeared to be adequate in all subjects at the start of the study and in all but three subjects at the end of the trial (Tables 16 and 19). As indicated previously, the crackers used in the study were fortified with thiamine, and therefore no shortage of this vitamin was expected. One of the three low thiamine values was in an individual who did not consume his full quota of crackers for the last five days of the trial, and this may have been a factor. The reason for the two other low values is not known. The values indicate that, in general, there was no problem of thiamine nutrition, with mean excretions for the 6- and 24-hour periods being higher at the end of the test than at the start.

Total vitamin B_6 in the urine was estimated by the microbiological method of Atkin, et al. (12), using the yeast, saccharomyces carlsbergensis, as the assay organism. This method detects total vitamin B_6 activity including pyridoxine, pyridoxamine, and pyridoxal. The data presented in Tables 16 and 20 are quite interesting, in that they show a marked decrease in vitamin B_6 excretion at the end of the trial. The ICNND has not established a guide for the interpretation of normal and abnormal excretion of vitamin B_6, and those used in the table are those considered reasonable by the U.S. Army Medical Research and Nutrition Laboratory. Using these guidelines, it can be seen that all of the subjects were excreting acceptable levels of vitamin B_6 at the start of the study and that all fell to the low excretion values by the end of the trial. There is no clear-cut deficiency disease analogous to beriberi or pellagra, attributable to the absence of vitamin B_6 from the diet; however, recent evidence by Andrus, et al. (13), has shown that the excretion

Table 19
Distribution of Vitamin B_1 in Six-Hour Urine Samples from 24 Subjects at Beginning and End of Two-Week Trial

Rating	Micrograms per six hours	Number of Subjects	
		Beginning	End
Deficient	< 10	0	3
Low	10 - 24	0	0
Acceptable	25 - 50	3	1
High	> 750	21	20

Table 20
Distribution of Vitamin B_6 in Six-Hour Urine Samples from 24 Subjects at Beginning and End of Two-Week Trial

Rating	Micrograms per six hours	Number of Subjects	
		Beginning	End
Low	< 7.5	0	24
Acceptable	> 7.5	24	0

of oxalate increased in experimental animals subjected to low dietary levels of vitamin B_6 and may lead to oxalcalcinuria. The excretion of oxalate was not investigated in the present study; thus, we cannot say whether the reduced vitamin B_6 excretion had any effect on this parameter.

GENERAL CONSIDERATIONS

The Food and Nutrition Board of the National Research Council, National Academy of Sciences, via a Committee on Environmental Nutrition, has under consideration the minimal allowances of water and food for fallout-shelter survival. It is recognized by all that after air, water is the immediate essential for temporary survival. During a two-week period, many factors can influence the rate of loss of water by the body, such as increased environmental temperature and work. Dietary factors may also stimulate the loss of water via the kidneys; thus, high salt or high protein intake will require a high output of urine. Ketosis due to starvation or to high fat intakes will also increase the production of urine and thus water loss. It is quite possible that a poor combination of foods may be worse than no food at all under conditions where water is limited. A draft of possible recommendations concerning foods for fallout-shelter survival has been prepared by the Committee on Environmental Nutrition. While it must be emphasized that this is only a draft, it is of interest to compare the ration used in the present shelter study with the major concepts being considered by the Food and Nutrition Board. This has been done in Table 21. It can be seen that the Bullocks Shelter Ration compares very closely to the recommendations as to total calories, protein, fat, and mineral levels and the water allowance. This study might thus be considered as an experimental confirmation of the recommendations being considered by the Food and Nutrition Board.

Table 21
Comparison of BuDocks Shelter Ration and Draft of Recommendation by Food and Nutrition Board (NRC) for Minimal Allowances of Food and Water for Fallout Shelter Survival

Factor	Recommended Values of Intake	BuDocks Shelter Ration
Calories	1500 per day	1480-1850 per day
Protein	5-10% of calories from common cereal grains	6.5-7.0% of calories (mostly from cereal grains)
Fat	Less than 50% of calories	About 25% of calories
Vitamins	Addition not recommended	Crackers provided 0.57-0.76 mg vitamin B_1/day
Minerals	No fortification except to provide 2/g NaCl/ 1000 Calories	Crackers provided 2.6-3.4 g NaCl/day
Water	1.9 liters/day	Mean intake 1.4 liters/day

CONCLUSIONS

The ration utilized in this study appeared to fulfill the requirements for which it was designed. On the whole, the ration was acceptable to the men, although many complaints were made concerning the monotony of the food. Some weight losses occurred in the course of the two weeks; however, this was expected to a certain degree, and the losses did not appear to affect adversely the performance of the subjects either in the shelter or in tests after emerging from the shelter. No overt nutritional deficiencies were observed, and no serious gastrointestinal disturbances related to the diet were reported. The diet contained relatively low levels of riboflavin, niacin, and pyridoxine, and the six hour, fasting excretion of these vitamins was lower at the end of the trial than pretrial values; however, this does not appear to pose a serious problem in a two-week shelter trial. At the end of the trial, lower blood levels of vitamin A, carotene, and vitamin C were observed, but these decreases do not seem to be of any importance. Hemoglobin and hematocrit levels were elevated during the stay in the shelter and may partially be due to a degree of dehydration. Total serum protein levels were increased at the expense of the globulin fraction; however, the significance of this is not yet known. It is concluded that the austere ration utilized in the present study can be employed with safety in a two-week shelter life under the conditions encountered. It should be emphasized, however, that in this study the subjects were all young (median age of nineteen years), healthy, well adjusted men, and the results can only be discussed in regard to such a group.

THE SUMMER TRIAL

It is recommended that the same ration be employed in the summer trial as in the winter trial reported here. It is suggested, however, that the full ration of crackers be issued at each meal from the first day of shelter life. This will raise the caloric value of the issued foods to over 1800 kilogram calories/man/day and might reduce the weight losses encountered in the winter trial.

Condensed soups should be employed again rather than dried soups. This will reduce the need for cooking and thus will not add to the heat problem likely to be encountered during the summer.

Some improved method of disposal of the empty soup cans should be devised to avoid the odors associated with spoilage.

The can used for packing the survival crackers should be improved so that an easier method of opening the cans is possible.

Further nutritional studies should be performed during the summer trial to evaluate the ration, and these studies should include water and nitrogen balance studies.

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CHAPTER 7

PHYSIOLOGICAL STUDIES

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PRELIMINARY CONSIDERATIONS

Factors in shelter living which may lead to excessive strain on physiological mechanisms of homeostasis can be related to the physical and chemical environment, on the one hand, and to the capacity of the individual to adapt to these stresses, on the other. In the past two decades, man's ability to adapt to extreme changes in ambient temperature, pressure, and gaseous composition of the atmosphere has been intensively studied in healthy young men. In general, these studies have been concerned with acute rather than prolonged exposures and have dealt with single rather than multiple factors in the environment. Extrapolation from such data to prolonged exposure to multiple stresses is thus impossible. Moreover, little is known of age, sex, physical fitness, and disease as factors limiting man's tolerance to environmental stresses.

The aims of the shelter trial and the rationale for selecting young, healthy Navy recruit graduates have been outlined earlier. It is worth repeating, however, that the group thus selected represents a relatively homogeneous segment of the population with less spread in physiological tolerance to stress than would be found in a group selected at random either within the Navy or from the population at large. This procedure serves to place features of engineering design in principal focus, as is the intention of the study, rather than the capacity of individuals to adapt to stress. Once having established conditions of habitability required for the group selected, one can then proceed to determine the extent to which factors of age, sex, physical fitness, and disease may demand modifications in the design.

PHYSIOLOGICAL MEASUREMENTS

Because thermal factors were regarded as potential stressors of primary importance in the shelter environment, at least during the planned summer trial, physiological measurements were selected which would detect strain on thermoregulatory mechanisms. Indices of heat strain include rising body temperature, elevated pulse rate, and increased sweat production, with its resulting drain on body reserves of water and salt. Twenty-four-hour urine specimens provide important information on renal excretion of water and electrolytes and their balance in the body economy. Qualitative analysis of the same specimens for glucose, protein, and ketone bodies, together with microscopic examination of urinary sediment for blood cells and other abnormal particles, serve as screening procedures to detect less common disorders of metabolism as well as disease processes.

Finally, exercise tolerance is a useful index of physical fitness. Ability to perform brief but exhausting work can be measured by a modification of the Harvard step test. Deterioration in physical fitness during the shelter trial would indicate failure to some degree in the adaptation to stress.

Body weight, pulse rate, and oral temperature, together with intake of food and water, were the only physiological measurements made during the two-day trial. In the two-week trial, body weight, pulse rate, and oral temperature were measured daily in all 96 test subjects, beginning four days before entry, each day of the trial, during the first 48 hours after leaving, and finally on the ninth day after the subjects had left the shelter (Fig. 31). During the pretrial period these measurements were made approximately two hours after reveille and one hour after breakfast. During and after the two-week trial, the three measurements were made within one hour after reveille, after the subjects had voided urine but before they had ingested food or water.

(a) Shelter occupants taking their own pulses

(b) Chief Corpsman weighing a shelter occupant

(c) Medical interview

Fig. 31 - Daily medical check

Body weight was measured in pounds on a high-quality bathroom-type scale graduated in 1/2-pound divisions. The scale gave reproducible readings with an accuracy of ±1/4 pound. Subjects were dressed in dungaree uniform, including regulation shoes. Accessory gear, such as the ditty bag, cap, and jacket were not weighed.

Oral temperature was measured by a standard clinical thermometer retained in the mouth at least five minutes. Men of each division were given thermometers after voiding but prior to weighing. The subjects were cautioned not to drink water before the measurement was taken and not to talk or breathe through the mouth.

Pulse rate was measured for one minute while the oral temperature was being taken. All subjects had been instructed in the technique for palpation of the radial pulse. The observer instructed the men of each division when to start and when to stop counting. Upon completion of the count, and while the subject was standing on the scale, one recorder removed and read the oral thermometer. The other recorder took the weight reading and then asked the man to report his pulse rate. All three measurements were then entered on the data sheet.

Water intake and food intake were the other measurements recorded daily on all 96 subjects during the 14-day trial. Methods for estimating food consumption are described in Chapter 6. Water intake was recorded by a water monitor on a tally sheet. This record showed the number of cups of water and/or coffee drawn by the subject for each 24-hour period, beginning at 1100. Each cup, when filled to within 3/8 in. of the brim, contained 170 ml. The six-ounce daily ration of soup contributed an additional 160 ml of water to the daily intake.

Urinary output was measured in 24 men designated as "water-balance" subjects. These had been selected from volunteers for this assignment on Feb. 13. After entering the shelter, the 24 water-balance subjects were equally divided between the two sections. A preliminary 24-hour collection for control studies had been obtained beginning at 2300 on Feb. 14. Aliquots of the initial six-hour sample and of the entire 24-hour specimens were acidified with meta-Phosphoric acid and chilled on ice in preparation for air shipment to the Army Medical Research and Nutrition Laboratory (AMRNL). After entering the shelter, the 12 water-balance subjects in each section were instructed to void and discard the urine immediately before starting their initial eight-hour sleep period. Routine collection of the total urine output for each 24-hour period thus began at 1400 on Feb. 17 and continued daily to Feb. 28 for the port section and at 0200 on Feb. 18 and continued daily to Mar. 1 for the starboard section. Specimens designated for air shipment to AMRNL were obtained during a collection period beginning at 1400 on Feb. 28 for the port section and at 0200 on Mar. 1 for the starboard section. These specimens were handled in the same manner as the control specimens collected on Feb. 14.

Urine-analysis specimens were collected in wide-mouth one-gallon plastic bottles clearly labeled by name and shelter number of the subject. Separate racks for 12 bottles were provided for each section. For routine analysis, the specimens were preserved with crystals of thymol. Because the specimens for vitamin assay at AMRNL were acidified with meta-Phosphoric acid containing sodium phosphate, it was not possible to use these for routine analysis of sodium and pH.

Routine analysis included the following determinations: 24-hour urine volume, specific gravity, pH, albumin, glucose, and microscopic examination of the sediment. Special analyses of the daily specimens included quantitative measurement of sodium and potassium concentration by flame photometry and measurement of chloride concentration using an automatic titrator.

Evaporative water loss was measured as weight loss in subjects clothed only in shorts, the period being carefully timed for two hours. A precision balance was used which was

accurate to ±10 grams. The subjects were instructed not to eat, drink, void urine, or defecate between weighings.

The change in weight thus represents insensible water loss through the skin and respiratory tract, plus sweat loss either by evaporation or by dripping off the body.

Respiratory quotient and resting metabolic rate were measured in eight subjects by collecting a five- or ten-minute sample of expired air in a Douglas bag. Each subject was fasting and recumbent, having been wakened after spending six to seven hours sleeping in his bunk. A sample of the gas was transferred to a tonometer. The total volume was measured by a dry-gas meter. The concentration of O_2 and CO_2 in the samples were analyzed by the Haldane method. For estimating metabolic rate, gas volumes were corrected to conditions of standard temperature and pressure.

Physical fitness was measured in the 24 water-balance subjects using a modification of the Harvard step test. In this test, the man steps onto a bench 20 in. high and back to the deck at a rate of 30 times per minute for three minutes or until exhausted. Post-exercise pulse rates are recorded for the periods from 1 to 1.5, 2 to 2.5, 3 to 3.5, and 4 to 4.5 minutes after exercise. The sum of the pulse counts is an index of fitness for hard work. High counts indicate poor fitness. A correction is necessary if the period of stepping is less than 3 minutes. A formula is available for deriving the correction factor. Instructions and commands for timing the exercise were recorded on magnetic tape. Each test of physical fitness was conducted by play-back of the same tape record. Two practice sessions were given all subjects on Feb. 13 and 14. Control scores were then obtained on Feb. 15 and 16 by successive tests on six groups of four subjects each. The same routine was followed in conducting the tests at 1 hour, 24 hours, 48 hours, and nine days after the subjects had left the shelter.

RESULTS

Two-Day Trial

Results of physiological studies conducted in the two-day shelter trial are summarized in Table 22. Because nearly ten hours elapsed after entry before the routine schedule was started, it was not possible to collect two complete sets of data on both sections. Hence, Table 22 includes body weight, temperature, and pulse-rate data for the port section only. Caloric intake as well as water intake is given for both sections on each of the two days. The composition and caloric content of the diet was identical with that described for the last six days of the two-week trial (Chapter 6). With the exception of the lower food acceptance, data in the two-day trial show essential agreement with that obtained in the two-week trial.

Two-Week Trial

Results of measurements involving all 96 subjects who participated in the two-week trial are summarized in Table 23 and in Figs. 32 and 33.

Body Weight - Decrement in body weight was analyzed statistically for the port section. That the successive 24-hour decrements observed during the first eight days could have occurred by chance alone is improbable ($p < 0.05$). When decrements are considered for 48-hour intervals, the findings become highly significant ($p << 0.01$). On the other hand, the increase in body weight on the ninth day is not statistically significant. It is of interest to note that the decline continued for 24 hours after the subjects had left the shelter (Fig. 32), despite their return to a completely unrestricted diet both at the noon meal shortly after they left the shelter as well as at a banquet the same evening. As seen in Table 23, there

Table 22
Physiological Measurements in Subjects of the Two-Day Shelter Trial, Jan. 30 - Feb. 1, 1962

Test Group	Measurement	Day 1		Day 2	
		Mean	S.D.*	Mean	S.D.*
Port section only (47 men)	Body weight (lb)	162.8	20.3	161.4	20.3
	Pulse rate (beats/min)	80.8	4.8	89.2	13.6
	Oral temp (°F)	96.8	1.0	97.1	1.0
Both sections (92 men)	Caloric intake	1412	327	1347	476
	Acceptance of calories offerred (percent)	75		72	
	Water intake (ml)	1559	564	1009	461

*Standard deviation.

Table 23
Physiological Measurements in 96 Subjects Before, During, and After the Two-Week Shelter Trial, Feb. 13 - Mar. 5, 1962

Measurement	Pretest (4-day mean)		Day 1		Day 7		Day 14		Recovery (48 hr after exit)	
	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*
Body weight (lb)	160.1	18.4	159.6	18.9	155.3	17.7	154.2	17.3	154.2	17.5
Oral temp (°F)	98.3	0.7	97.3	1.2	97.1	1.2	96.8	1.0	97.7	1.3
Pulse rate (beats/min)	80.2	10.0	80.4	14.8	85.9	8.8	81.6	7.7	82.7	8.4
Water intake (ml)	-	-	1106	437	1537	513	1480	636	-	-

*Standard deviation.

was no significant recovery in weight by the end of 48 hours. Less than 50 percent of the total weight loss was recovered after nine days (Fig. 32). These findings suggest that this weight loss was chiefly from catabolic breakdown of tissue and that dehydration was not a significant factor.

Oral Temperature – Mean values for oral temperature are shown in Table 23 and Fig. 33. A significant decline occurs in this measurement between Feb. 23 and 24. This coincides with the increase in ventilation rate on Feb. 24, which resulted in an abrupt lowering in ambient temperature.

Pulse Rate – Mean values for pulse rate are shown for both sections in Table 23 and for each section in Fig. 33. A peak in pulse rate is observed on the seventh day, coinciding in time with the period of maximum environmental heat just before ventilation was increased. The drop in pulse rate which follows is statistically significant ($p<0.01$).

Water Intake – Water intake increases to a peak on the seventh day (Fig. 34, Table 23). Again, this coincides with the period of maximum environmental heat. Statistically, the difference between water intake on day 1 and day 7 is highly significant ($p<<0.01$).

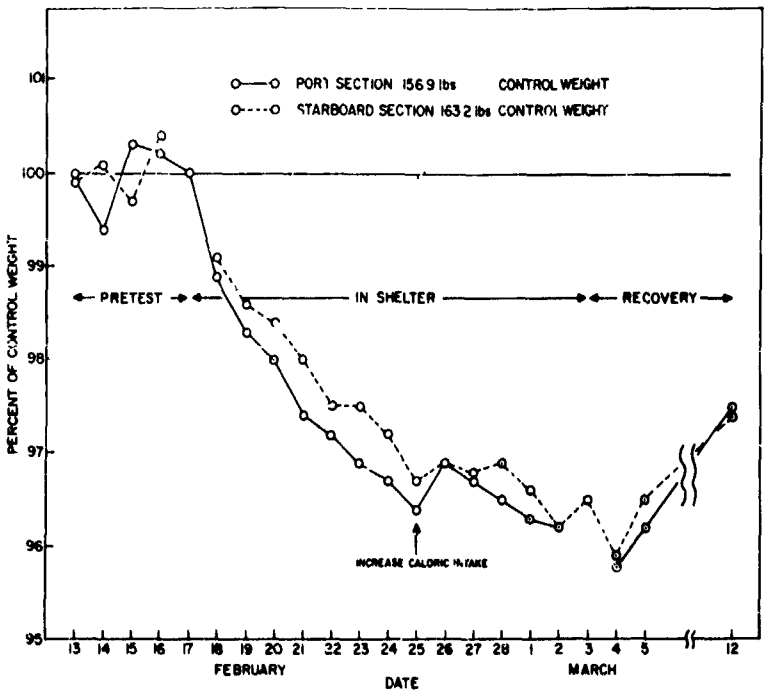

Fig. 32 - Weight changes in 96 subjects before, during, and after the two-week winter trial, Feb. 13-Mar. 12, 1962

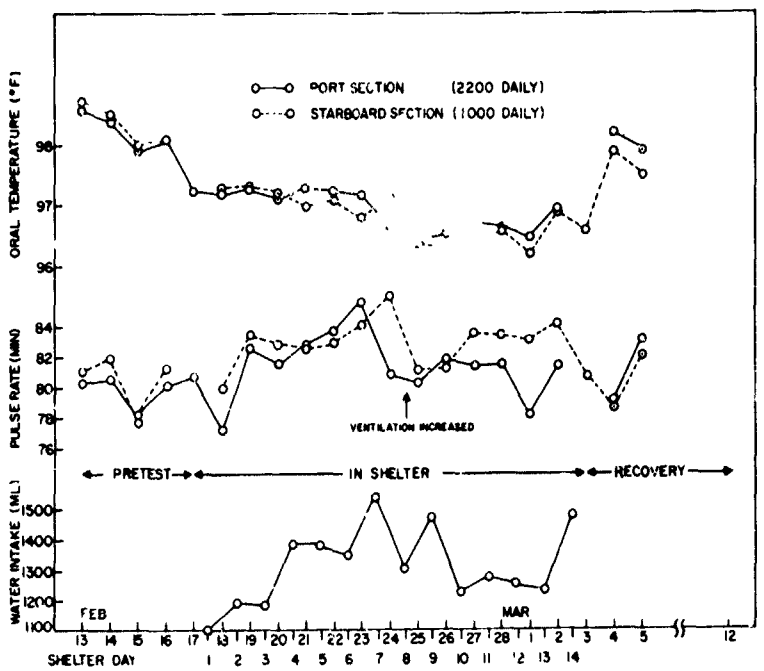

Fig. 33 - Oral temperature, pulse rate, and daily water intake in 96 subjects during the shelter trial, Feb. 13-Mar. 12, 1962

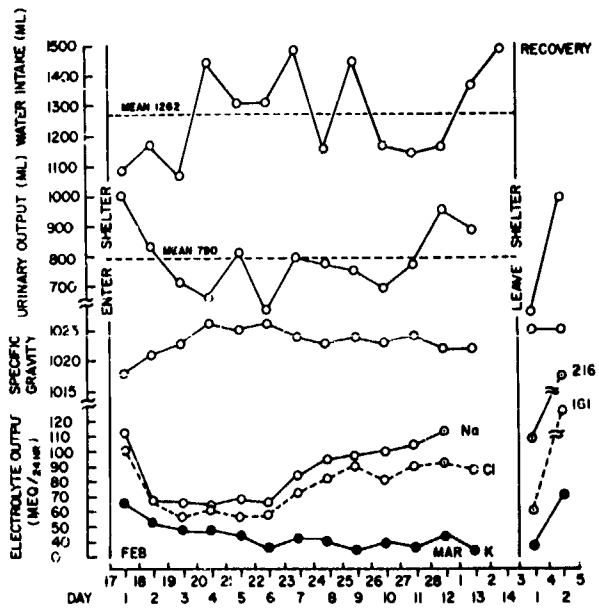

Fig. 34 - Water intake and urinary output (per 24 hours) of water and electrolytes in 24 subjects during the two-week winter trial, Feb. 17 to Mar. 5, 1962.

Urinary Excretion - Results in the 24 water-balance subjects appear in Table 24 and Fig. 34. Figure 34 includes data for the 24- and 48-hour recovery specimens. Daily water intake and weight loss in the water-balance subjects did not differ significantly from the values shown for the entire group in Table 23.

Features of principal interest in Fig. 34 are evident during the first six days. A progressive rise in water intake is seen, with a corresponding rise in urinary specific gravity coupled with a reciprocal fall in urinary volume and in urinary excretion of sodium and chloride. These findings can best be interpreted on the basis that there is a greater loss of salt and water by extrarenal channels during the first half of the two-week trial than during the latter half. Only about 50 percent of the increase in urinary output after the eighth day can be accounted for by the increased salt intake, which was contributed by the increased cracker ration.

Again, the increased extrarenal loss of water and salt during the first week corresponds in time with the period during which heat was increasing to a maximum, and suggests that sweating was the principal channel for these losses. By the same token the reduced heat strain during the latter half of the trial is accompanied by increased urinary output of salt and water, with a fall in urinary specific gravity. As is to be expected, chloride output closely parallels sodium. During the period when demands are made on body salt for sweating, the sodium-potassium ratio is low and rises as these demands subside. Both urinary volume and electrolyte excretion increase strikingly during the 48-hour recovery period, the subjects having returned to a diet unrestricted in salt.

Evaporative Water Loss - Fifty-five measurements of weight loss measured in the 24 water-balance subjects over a two-hour period on four separate days gave values for

Table 24
Water Intake and Urinary Output of Water and Electrolytes in 24 Water-Balance Subjects During the Two-Week Shelter Trial, Feb. 17 - Mar. 3, 1962

Measurement	Day 1		Day 7		Day 13	
	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*
Water Intake (ml)	1080	493	1477	539	1358	600
Urinary Output Volume (ml)	998	274	782	417	884	416
Specif Gravity	1.018	0.005	1.024	0.009	1.022	0.006
Na (meq.†	113	45.6	85.8	44.8	(meta-Phosphoric acid added)	
K (meq)	66.0	24.3	42.1	16.9	34.2	7.6
Cl (meq)	101.9	38.6	71.8	30.7	87.7	34.3

*Standard deviation.
†Milliequivalents.

a mean water loss by evaporation of one gram per minute, or 60 grams per hour, during waking activity (mean 1.02 g/min S.D. 0.58 g). This is 50 percent more than the figure which is generally accepted for insensible weight loss in the waking adult male at complete rest (40 g/hr). The relatively low figure is consistent with the comfortable thermal conditions which usually prevailed during the two-week trial. It is assumed that evaporative water loss during sleep is one-half of that during the waking state.

Water Balance – Table 25 lists factors of gain and loss to the water economy of the body for 24 hours, based on mean daily values obtained in the two-week trial. It is noted that factors of greatest weight on each side of the balance sheet are those which can be measured directly. Gains from breakdown of body tissue are based on an observed mean weight loss of 189 grams per day. For this analysis it is assumed that 75 percent of this was anhydrous fat and 25 percent lean tissue containing 25 percent protein and 70 percent water. Factors of minor consequence, such as the difference between the weight of oxygen consumed and CO_2 produced, were not taken into consideration.

Considering the limitations of the methods used, the balance between gains and losses is satisfactory. These figures will form a valid basis for comparison with the summer trial.

Respiratory Quotient and Metabolic Rate – These data appear in Table 26. Although the metabolic rate is consistent with that expected of subjects of this age and weight, the respiratory quotient showed greater variation than expected in consideration of the uniform diet.

Physical Fitness – Table 27 is a summary of measurements on physical fitness using the AMRNL modification of the Harvard step test. The average age of the 24 subjects was 19 years (S.D. 1.6), their mean weight, 153.7 pounds (S.D. 27.2), and their mean height 68.1 in. (S.D. 2.3).

Physical-fitness scores obtained on Feb. 15 and 16 do not differ significantly from those obtained immediately after the subjects left the shelter on Mar. 3. It is of interest to note, however, that the one-minute postexercise pulse rate recorded on Feb. 15 is significantly lower ($p < 0.01$) than on Mar. 5. The basis for the lower rate on Feb. 15 as compared with the rate on Mar. 3 and Mar. 5 is not apparent. Observers state that

Table 25
Water Balance in 24 Subjects During Two-Week Shelter Trial
Feb. 17 - Mar. 3, 1962

Gains	Measured Values (ml)
Mean daily water intake	1290*
Water content of food	170*
Oxidative water, food	235*
Oxidative water, tissue (142 g fat; 12 g prot.)	157
Tissue water (47 g lean tissue)	33
Total Gain	1885
Losses	**Measured Values (ml)**
Mean daily urine vol.	790*
Evaporative, waking	960*
Evaporative, sleeping	240
Fecal	100
Total Losses	2090
Gains/Losses X100	90 percent

*By direct measurement or from known composition and quantity of food.

Table 26
Respiratory Quotient and Resting Metabolic Rate in Eight Subjects
During Two-Week Shelter Trial, Feb. 17 - Mar. 3, 1962

Measurement	Mean	Standard Deviation
Respiratory quotient	0.86	0.07
Metabolic rate (kg cal/hour)	66.2	10.9

motivation seemed appreciably higher immediately after the shelter stay than two days later. On the other hand, motivation is a factor more likely to be reflected in the duration of stepping rather than in the pulse rate.

DISCUSSION

Physiological tests in this study were designed primarily to measure strain on thermoregulatory mechanisms, including water and electrolyte balance, resulting from stresses imposed on shelterees by the thermal environment. It was expected, however, that significant levels of thermal stress would not be encountered in the winter trial. Rather, data from this trial were considered as being useful mainly in providing baselines for measurements to be obtained in the summer trial, when heat stress could be expected to be a severe, and possibly limiting, factor in shelter habitability.

Table 27
Physical Fitness in 24 Subjects Measured by a Modified Harvard Step Test
Feb. 15 - Mar. 5, 1962

Measurement	Before Entry				After Exit					
	Feb. 15		Feb. 16		Mar. 3		Mar. 4		Mar. 5	
	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*
Resting pulse	71.8	9.4	77.6	10.7	82.2	7.4	73.4	9.3	78.6	7.6
Pulse 1 min postexercise	130.1	12.1	135.9	13.1	137.9	14.2	131.0	11.2	141.6	13.9
Cumulative pulse count	235.3	16.3	245.7	22.0	244.4	23.5	239.1	23.8	248.5	24.3
Duration of stepping (min)	2.91	0.20	2.94	0.17	2.91	0.25	2.85	0.40	2.95	0.14

*Standard deviation.

Analyses of results in the winter trial, however, indicate that increases in heart rate, oral temperature, water intake, and urinary specific gravity with decreases in urinary output of water and electrolytes did occur during the first week of the trial and were associated with the gradual increase in ambient temperature and humidity, which reached a peak early in the eighth day. It is true that a change in caloric intake occurred at this time. However, the evidence points to the physiological measurements referred to above as being attributable to changes in the thermal environment. On the other hand, decrease in rate of body-weight loss and part of the increase in urinary output of salt can be explained by the change in cracker ration on the eighth day, when it was increased from 266 g to 355 g per day.

Considering the fact that the effective temperature reached but did not exceed 78° F in the winter trial, one can anticipate far greater changes in the physiological indices of heat strain in the summer trial. In fact, salt deficiency with resulting dehydration may constitute a serious hazard to health, carrying with it the risk of heat illness. Prevention will require that salt be available to supplement the limited quantity in the diet and may be given either as cellulose-impregnated tablets to be taken with meals, or perhaps as salt added to drinking water in a concentration of 0.1 percent, as recommended for units of the Armed Forces operating in hot climates.

The significance of the weight loss observed in this trial has been discussed earlier. It is apparent that 1800 calories per day is a marginal ration and that at least this quantity should be provided from the onset of the summer trial.

Ability to perform brief but exhausting work and to recover from this type of exercise was not significantly impaired during the two-week trial. Tests of other types, however, would be required to measure endurance for prolonged exercise at lower work rates.

CONCLUSIONS

Physiological indices of heat strain selected for the shelter trials are sufficiently sensitive to detect effects of even the mildest degrees of heat stress. Despite limitations of methodology, there is good agreement between estimated body water gains and body water losses during the two-week trial. Physiological strains of severe degree were not observed in the winter trial, and no deterioration in physical fitness for exhausting exercise was noted.

SUMMER TRIAL

Provision must be made to ensure adequate allowances of both water and salt. Plans for conducting physical exercises must be carefully considered in light of the added heat load which increased activity would impose on the thermoregulatory mechanisms of the man. Increased metabolic heat output would also adversely affect the shelter environment.

Compared with the winter trial, water consumption in the summer trial will be greatly increased, perhaps by a factor of four. This may require modification in procedures for dispensing water. Methods for estimating rate of water turnover in the body should be investigated for possible application to the summer study.

CHAPTER 8

PSYCHOLOGICAL STUDIES

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INTRODUCTION

Inasmuch as the BuDocks studies were conducted primarily to investigate engineering habitability, no formal, large-scale behavioral studies were undertaken. However, it is obvious that there is a relationship between environmental variables and psychological response to these factors in determining man's tolerance to shelter living. Because of the heavy influence of emotional and motivational factors, as well as human values, it is not possible to judge engineering adequacy solely on the basis of such factors as air flow and water balance. In fact, it was recognized that psychological discomfort conceivably could be sufficiently important to abort the shelter trial.

The psychological investigation was focused primarily on identifying and measuring subjective discomfort factors during the shelter experience and secondarily upon generalized psychological or emotional response to the shelter test. It was anticipated that shelter habitability might be improved through correcting or modifying relatively minor engineering aspects of the shelter which are of importance in the emotional well-being of the occupants. Further, it is obvious that any adequate military shelter must be constructed and managed in such a way as to insure men maintaining sufficiently sound psychological status, motivation, and morale to function effectively as a team during the postattack period.

In the United States to date, two major groups of studies have been undertaken on behavioral problems associated with fallout-shelter living. These studies, conducted by NRDL (1960) and AIR (1960), were generally concerned with shelter organization and management problems, indices of psychological discomfort, and emotional response to the shelter experience.

The present study was broadly focused on these same problem areas and sought to extend certain technical aspects of the NRDL and AIR studies. Primarily, these technical problems were concerned with accurately separating and evaluating "acuteness" and "generality" of discomfort and meaningfully relating these to dimensions of psychological response. Moreover, it was desired to eliminate two artifacts which existed in the previous studies. First, the subjects in all previous studies knew the exact duration of the shelter trial; and secondly, the vast majority of subjects in previous studies received a meaningful reward for their participation. Either or both of these factors might be expected to have a significant influence on the subjects' psychological response to the shelter experience.

OBJECTIVES OF PRESENT STUDY

The objectives of the present study were as follows:

1. To determine the extent of agreement among shelterees on the relative subjective or psychological importance of environmental and interpersonal discomfort sources in the prototype shelter.

2. To determine the relative importance of various sources of psychological discomfort in terms of both "acuteness" and "generality" of discomfort. "Acuteness" refers to discomfort which approaches the limits of individual tolerance, regardless of frequency with which experienced during the test period. "Generality" refers to discomfort which is present and noticeable over prolonged periods of time, but does not necessarily approach limits of human tolerance.

3. To determine the relationship between relative subjective importance of discomfort factors over time:

a. As anticipated prior to shelter entry and as experienced after several days' shelter occupancy.

b. As experienced during the earlier and later phases of actual shelter occupancy.

4. To determine the significance of interaction between and among a limited number of factors which appear of major importance in fallout shelter habitability.

5. Through interviewing and diaries:

a. Provide information of a more qualitative or comprehensive nature with regard to the discomfort sources found to be most important to the subjects.

b. Provide general information on emotional or psychological factors, not assessed by psychometric scales, which might be significant in shelter habitability.

METHOD

No formal research data were collected during the two-day trial. Rather, the pilot trial was used to evaluate the psychological scales of discomfort in terms of clarity of instructions, appropriateness of test-scale items, and efficiency of administrative procedures. No major changes were made in the scales or the administrative procedures as the result of this trial. All of the data reported in this chapter were obtained during the two-week trial. Copies of the scales utilized and details of their development are presented in Appendix D.

SCALES

In order to accomplish the first four objectives, structured scales intended to tap responses to discomfort factors were used. One scale was a rank-order scale utilizing 21 sources of discomfort (ranking scale) identified by Altman, et al. (1). This scale served a threefold purpose. First, it provided data on all 21 factors used by Altman for purposes of comparison between the BuDocks and AIR studies. Second, this scale provided data which allowed comparison between rank orders based on acute discomfort and those based on generalized discomfort. Third, data from this scale provided a determination of intersubject agreement on the relative ranks of the 21 discomfort sources.

The second scale, composed of Likert-type items, was designed to assess the significance of differences in intensity of discomfort factors. That is, although the discomfort factors assume a rank ordering in terms of importance, it is necessary to determine whether some factors constitute significantly greater sources of discomfort, or whether, essentially, they are grouped in a cluster with little actual difference among factors. In addition, this scale yielded data bearing upon significance of differences between acuteness and generality of discomfort between subjects in their response to the discomfort indices, and in shifts in the relative importance of the discomfort sources with time in the shelter. The scale also permitted determination of interaction among the above variables.

PROCEDURE

The two-week study provided an opportunity for assessing changes in responsiveness to discomfort indices over time, as well as assessment at a given time. Thus, a schedule of administration of measures was as follows:

1. Two days prior to entering the shelter, the subjects were administered the scale involving ranking of all 21 discomfort sources.

2. On day 2 in the shelter, the Likert-type scale, which tapped 13 discomfort factors, was administered.

3. On day 7 in the shelter, the ranking scale was administered for the second time.

4. On day 12 in the shelter, the Likert-type scale was administered for the second time.

5. The debriefing interviews, which were of one hour's duration, were conducted approximately 30 minutes after the men left the shelter at the conclusion of the study. The interviews were conducted with groups of 10 to 12 men by psychiatrists and psychologists from the U.S. Naval Hospital, Bethesda, and NMRI.

Within a given administration of each type of scale, a counterbalanced presentation of acuteness and of generality sections of the scale was utilized, in order to offset possible effects of order of presentation. Therefore, at a given administration, half of the subjects received the acuteness section followed by the generality section, and half of the subjects received the generality section followed by the acuteness section.

RESULTS

The data obtained from the two-week trial made it possible to accomplish all of the objectives set forth in the above section. Also, a number of broad conclusions may be made regarding the relative importance of the various psychological discomfort sources, the meaningfulness of the acuteness-generality distinction, and the relative effectiveness of psychological techniques for measuring discomfort indices.

While measures of the discomfort indices were obtained on four different occasions with two techniques, the data are such that it is considered legitimate to arrive at a single summary statement regarding psychological discomfort during the winter trial. Certain minor points of inconsistency with this generalized summary do appear when the individual sources of data are considered separately. Such inconsistencies will be developed in subsequent discussion of the data.

The five leading sources of psychological discomfort in the winter trial were food, lack of water for washing, crowding of the shelter, dirt, and behavior of others. As will be shown, the Likert-type scale was found to be a more effective technique for assessing psychological discomfort indices. Accordingly, the generalized findings being discussed here are based on the 13 discomfort factors used in the Likert-type scale rather than the 21 factors used in the ranking scale.

Figure 35, derived from Table E4*, presents a list of the 13 discomfort factors used in the Likert-type scale, along with their summary value obtained by combining the measures of acuteness and generality obtained on the second and twelfth days of the test. As will be noted, food and lack of water for washing were not only the leading psychological

*See Appendix E

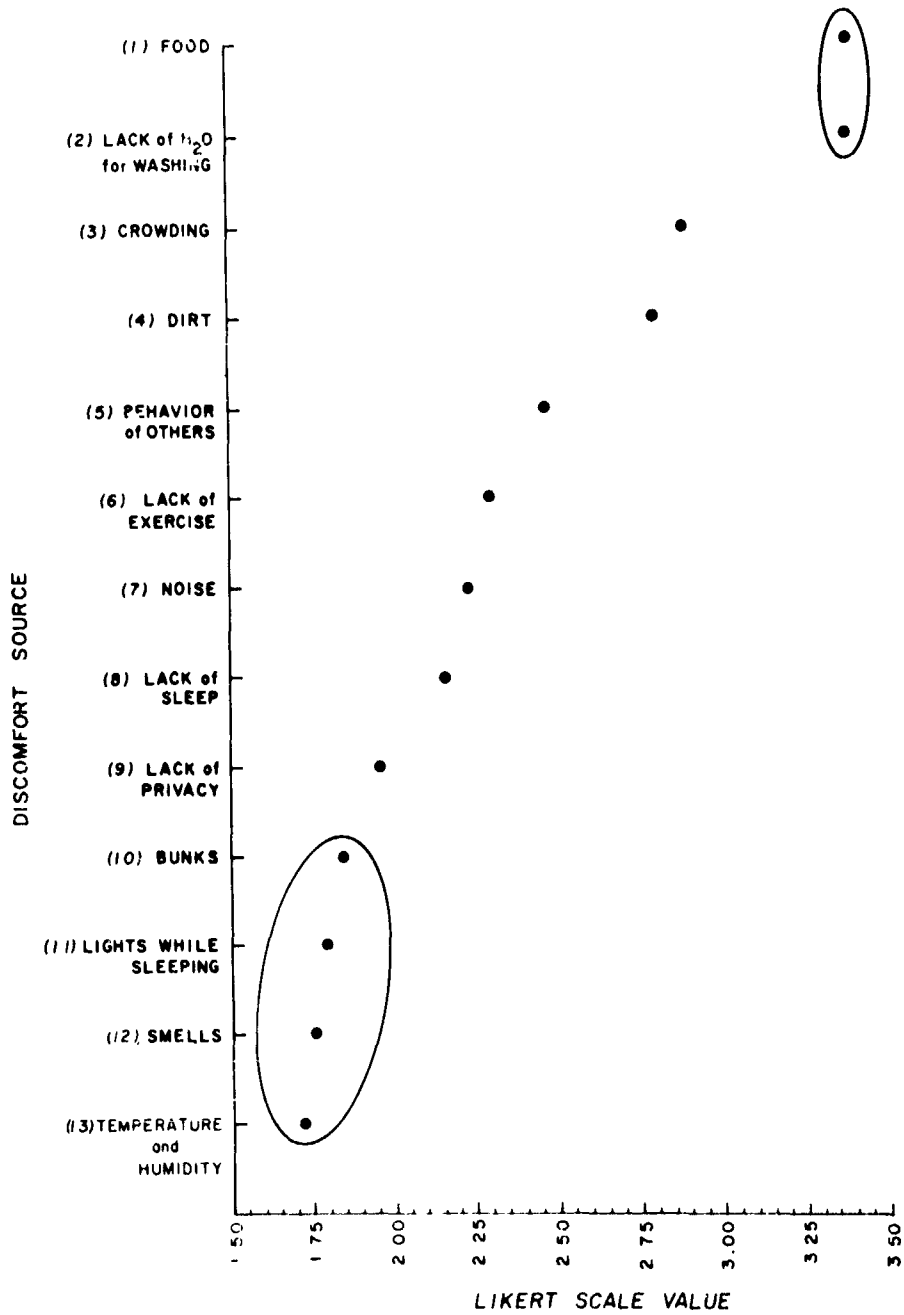

Fig. 35 - Mean scores of discomfort factors, based on acuteness and generality, with measures from day 2 and day 12 combined

discomfort factors, but they were several scale points removed from the next most significant factors. The circle around the scale values for the first two factors for Fig. 35 indicates that they are clustered so that, from the statistical standpoint, they obviously are significantly greater sources of discomfort than the other eleven factors; but they do not significantly differ from each other.

As will be noted, factors 3 through 9 may be ordered in terms of descending importance as sources of discomfort. Moreover, none of these items cluster, so that each may be considered to occupy an independent position in the hierarchy of discomfort factors. On the other hand, items 10 through 13 (bunks, lights while sleeping, odors, and temperature and humidity), are clustered even though they do occupy separate scale values and may be arranged in a hierarchial basis.

In discussing sources of psychological discomfort, it is essential to consider the significance in clustering of the discomfort factors. For example, even though food ranked as a leading source of discomfort in terms of actual scale value, from a statistical standpoint, this superiority of ranking over lack of water for washing well may be due to chance. Thus, food and lack of water for washing should be considered to have been of equal importance as discomfort sources during the winter trial. Likewise, although the four bottom factors assume a hierarchy in ranking, from a statistical standpoint, their numerical positions on the scale do not necessarily reflect genuine differences as sources of psychological discomfort. On the other hand, the factors towards the middle of the scale may be assumed to reflect genuine differences in relative importance of the discomfort sources.

Regardless of time of measurement or technique, i.e., Likert-type scale or ranking scale, the five leading sources of discomfort uniformly fell as in Fig. 35. Thus, it is considered that the validity of the findings with regard to these factors as measured in this study may be accepted with confidence. Any differences in relative rank or importance of the discomfort factors which are found with the two measurement techniques show up on factors which are lower on the discomfort hierarchy.

While rank orders of discomfort factors based on acuteness and on generality were shown to be highly correlated, more precise statistical techniques indicated that acuteness and generality are, in fact, different dimensions of discomfort. Although the five leading discomfort sources occupy parallel positions on these two dimensions, the distinctions between generality and acuteness become significant as the discomfort factors decrease in psychological importance. The psychometric techniques permitted a precise determination of hierarchial rank and significance of the sources of discomfort. However, qualitative information as to the nature of the subjective discomfort was obtained through the debriefing interviews. This qualitative information is presented in the section on interviews.

RESULTS APPLIED TO SPECIFIC TEST OBJECTIVES

The Extent of Agreement Among Shelterees on the Subjective Importance of Discomfort Sources in the Prototype Shelter

This objective was considered basic to the whole psychological test procedure. If the test instructions were understood by the subjects, and if the discomfort indices constituted generally meaningful entities which could be distinguished by the subjects, one would anticipate a fairly high degree of agreement among the shelterees. Lack of agreement would indicate such a heterogeneous response to the psychological measurements that no meaningful interpretation could be made of the data. On the other hand, agreement must not be so high as to mask individual differences.

The detailed statistical treatment of the data to meet this objective is summarized in Tables E1 and E2. As will be noted in Table E1, based upon ranking scale data, an agreement by the subjects was obtained which is significant beyond the 0.001 level of confidence. This indicates that the agreement between subjects on the relative ranks of discomfort factors was well beyond that expected on the basis of chance. However, it is important to note that in the context of this high intersubject agreement, there remains sufficient variation among the subjects to indicate that individual differences were present in response to the test instruments. Thus, significance of the difference among subjects, Table E2 (based upon Likert-type scale data), exceeds the 0.01 level of confidence.

The Relative Importance of Various Sources of Psychological Discomfort in Terms Both of "Acuteness" and "Generality" of Discomfort

Both of the scaling techniques were used in approaching this objective. Here the difference in appropriateness of the two techniques for studies of this nature becomes glaringly apparent. Rank order correlations between acuteness and generality of discomfort, as measured by the ranking scale, were positive and extremely high. As indicated in Table E3, the probability of such correlations occurring by chance was less than 0.001. On this basis alone, it might be inferred that acuteness and generality of discomfort are, psychologically, highly similar dimensions of response to discomfort. However, the fallacy of such an inference becomes immediately evident when differences in response to the same factor in terms of acuteness and generality are observed.

Table E2 indicated that significant differences existed between the means for acuteness and generality of discomfort stemming from the same factor. Figures 36 and 37, derived respectively from Tables E5 and E6, show the specific locations of these differences on day 2 and day 12 of the shelter study. Whenever these significant differences existed, acuteness of discomfort exceeded generality. On day 2, lack of water for washing, dirt, and behavior of others were rated as providing significantly more acute than general discomfort, while on day 12 temperature-humidity and behavior of others yielded the same kind of difference.

On the basis of such evidence, it is apparent that while a given discomfort factor may occupy highly similar hierarchial ranks on the acuteness and generality dimensions, position in terms of measurable magnitude of discomfort may differ significantly between the two dimensions. Only the Likert-type scale provides data allowing determination of both the rank and the measured magnitude of discomfort stemming from a given factor on the acuteness and generality dimensions.

The Relationship Between Relative Subjective Importance of Discomfort Factors as Anticipated Prior to Shelter Entry and as Experienced After Several Days' Shelter Occupancy

It is reasonable that differences would exist between anticipated discomfort and that actually experienced in the shelter. This contrast between anticipation and realization of discomfort could provide an additional source of stress in shelter occupancy. However, such stress also might be reduced by preshelter indoctrination based on findings from actual shelter living. The present objective was pursued in order to determine the need for indoctrination of this kind, both in future studies with the present shelter as well as in actual shelter occupancy.

To accomplish this objective, correlations were computed between results of the preshelter and the day 7 administrations of the ranking scale, and comparisons were

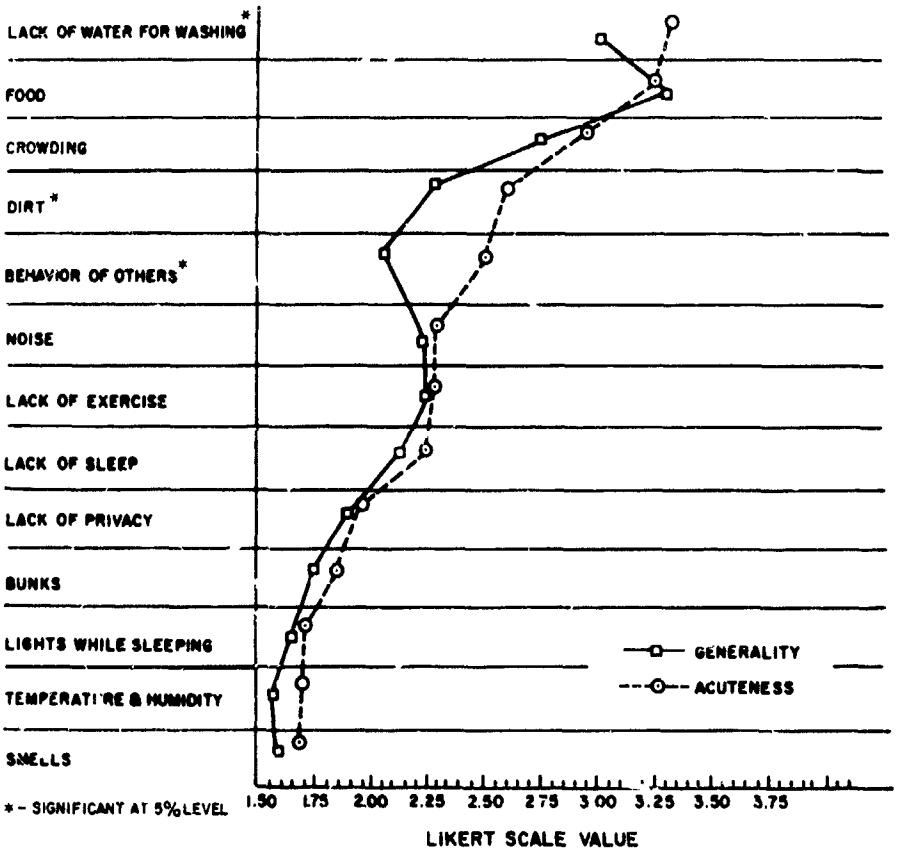

Fig. 36 - Differences between acuteness and generality of discomfort on day 2.

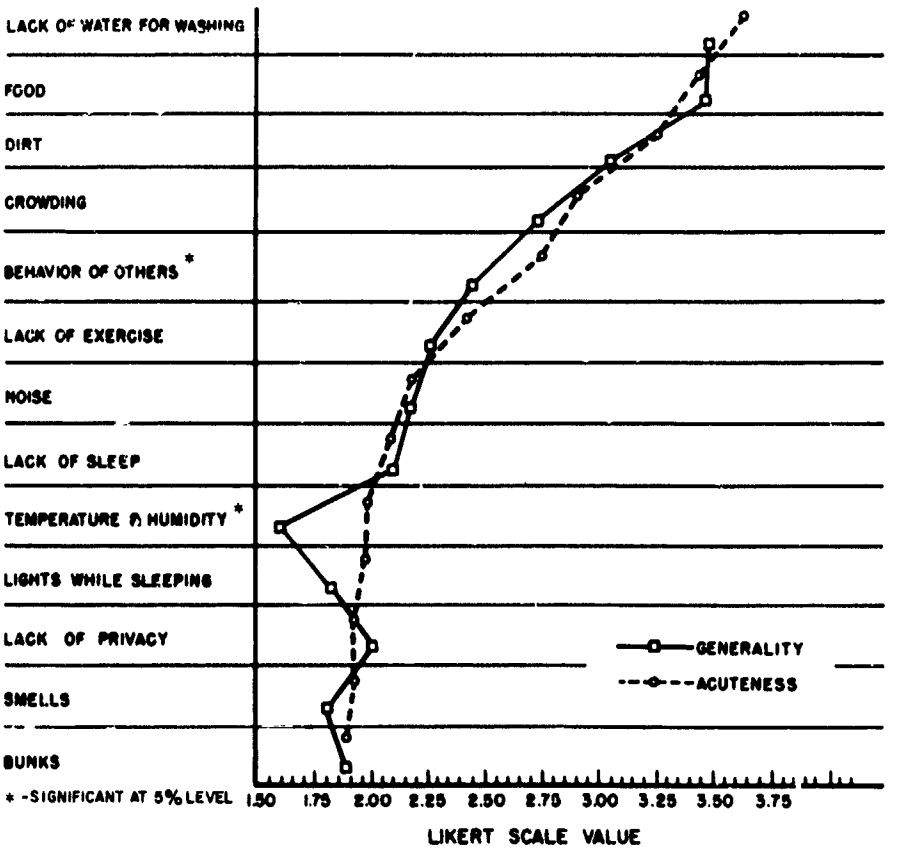

Fig. 37 - Differences between acuteness and generality of discomfort on day 12.

Table 28
Shifts in Subjective Importance of
Psychological Discomfort Factors

Preshelter-Day 7

Factor	Generality		Acuteness	
	Preshelter	Day 7	Preshelter	Day 7
Lack of water for washing	1	1	1	1
Chow	2	2	7	2
Crowding	3	3	2	3
Dirt	4	4	3	4
Odors	5	8	4	11
Behavior of others	6	5	5	5
Boredom	7	6	6	6
Temperature and humidity	8	9	8	8
Head facilities	9	12	11	9
Lack of exercise	10	11	9	10
Physical symptoms	11	14	13	14
Lack of organization	12	18	10	16
Poor leadership	13	19	12	20
Noise	14	7	14	7
Bunks	15	10	15	12
Worries about outside	16	17	17	18
Lights while sleeping	17	15	18	15
Lack of privacy	18	13	19	13
Difficulty concentrating	19	16	16	17
Trouble sleeping	20	20	20	19
Lights while awake	21	21	21	21

made for each factor, on the acuteness and generality dimensions, between preshelter and day 7 rank positions. These comparisons are presented in Table 28.

Generally speaking, as indicated in Table 28, the subjects tended to overestimate both the acuteness and generality of discomfort they would experience from odors, lack of shelter organization, and poor leadership. Likewise, on both dimensions of discomfort they tended to underestimate the importance of noise, the bunks, and lack of privacy. It is rather interesting to note that food was accurately anticipated to be the second leading source of generalized discomfort during the shelter trial. However, it was grossly underestimated as a source of acute discomfort, and during the first week it rose from seventh rank on the acuteness scale to second, which was the same rank it occupied on the generality scale. As indicated in Table E3, the rank-order correlation between preshelter and day 7 acuteness of discomfort was 0.81, and the correlation for generality of discomfort over this period was 0.86. Both correlations were significant beyond the 0.001 level, thus indicating an agreement vastly better than chance between rankings based on

anticipation and on realization of discomfort. This finding suggests that, in general, the subjects in this study predicted the discomforts of shelter living with considerable accuracy. However, two important qualifications of this inference are in order. First, while the correlations were statistically significant, their absolute size indicates that the preshelter-day 7 agreement is less than perfect and, as seen in Table 28, appreciable changes in the ranks of individual discomfort factors did occur. Second, since the ranking scale taps only relative magnitude of discomfort, a given discomfort factor could maintain the same rank over the preshelter-day 7 period, but still provide a stress-producing difference between anticipation and realization of absolute magnitude of discomfort.

The Relative Subjective Importance of Discomfort Factors as Experienced During the Earlier and Later Phases of Shelter Occupancy

It is reasonable to assume that individuals will show some change in their subjective response to sources of discomfort during the course of shelter occupancy. Thus, factors which initially may be a great source of discomfort may become relatively unimportant as the length of confinement increases. Likewise, other factors, which initially are somewhat innocuous, may become quite disturbing with the passage of time.

These possibilities were explored through analysis of variance of the data provided by the Likert-type scale. Table E2 indicates that statistically significant changes in response to discomfort factors did occur over time. The specific locations of these differences for each factor on the acuteness and on the generality dimensions are represented in Figs. 38 and 39, derived respectively from Tables E7 and E8. As these figures indicate, both dirt and lack of water for washing showed statistically significant increases on the acuteness as well as the generality dimensions of discomfort between day 2 and day 12. Since there is obviously some relationship between these factors in reality, i.e., between dirt on the person and lack of water for washing, it is not surprising that they should show concomitant increases in attributed discomfort. However, it is interesting that the increase is of sufficient magnitude to be statistically significant. One other factor, behavior of others, increased significantly between day 2 and day 12 on the generality dimension only. This change was such that while behavior of others was initially rated lower on the generality dimension than on acuteness, by day 12 the difference between its measurements on the two dimensions was almost nil. This suggests that behavior of others not only provides acute transient discomfort, but also that, over time, the accumulated stress of interpersonal conflicts may become subjectively equivalent to more severe stress experienced at a given time.

In the interpretation of these findings, it should be noted that the data are derived from only two periods during the time of shelter occupancy. Thus, a conclusion that they represent minimum and maximum limits of discomfort would not be justified. That is, a linear relationship between time and magnitude of discomfort is certainly possible, but so is a curvilinear relationship in which either a maximum or minimum degree of discomfort could occur at some intermediate point in time. Ideally, at least three, and perhaps more, points in time should be determined to establish the form of the time-discomfort relationship, but such a determination was beyond the scope of the present study.

The Significance of Interaction Between and Among a Limited Number of Factors Which Appear of Major Importance in Protective-Shelter Habitability

In the presentation of results up to this point, attention has been focused on similarities and differences of subjective discomfort in terms of the four variables involved in the present study (subjects, discomfort factors, acuteness-generality of discomfort, and time). However, this separation was made solely for purposes of discussion and is, in fact, an

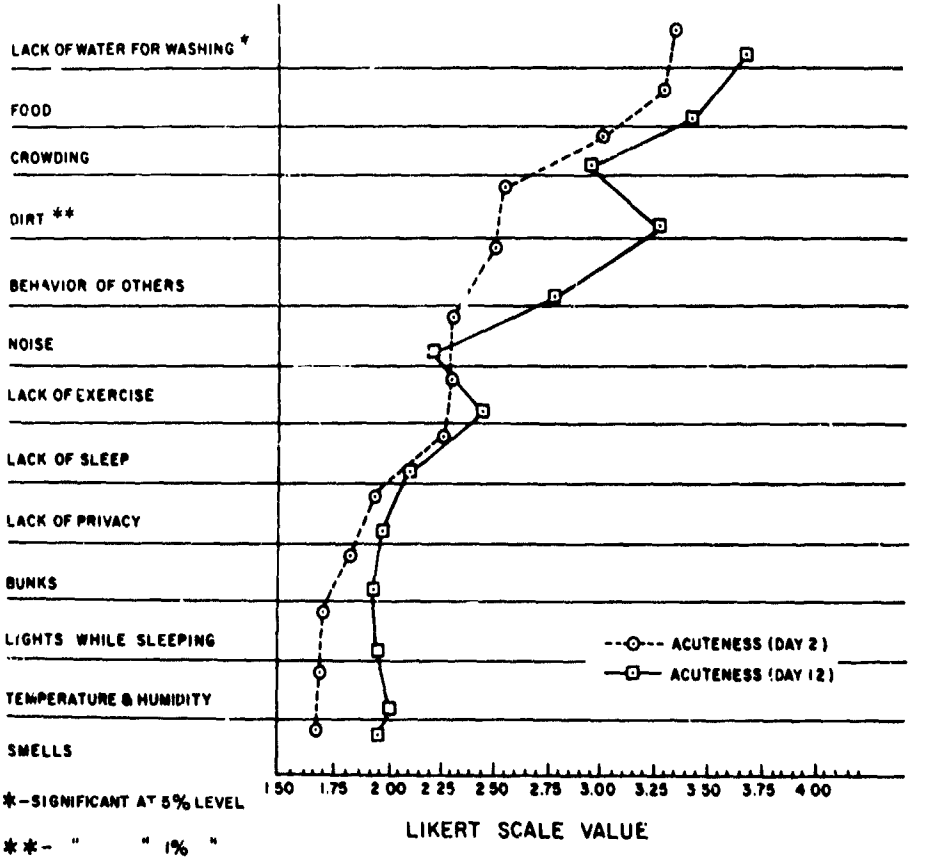

Fig. 38 - Differences in acuteness of discomfort between day 2 and day 12.

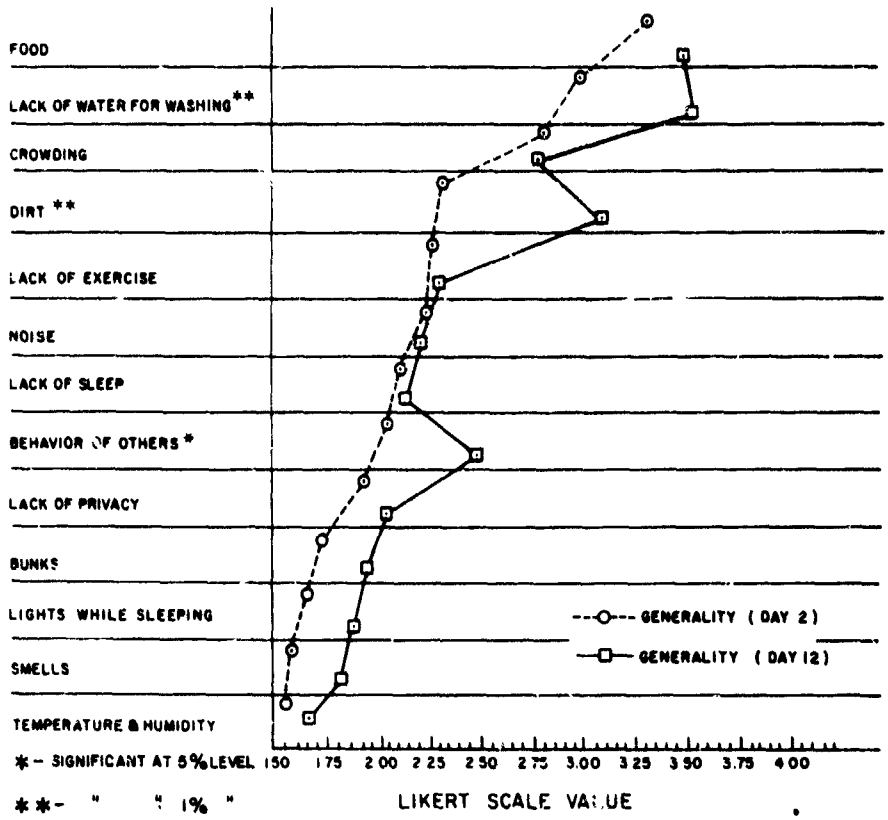

Fig. 39 - Differences in generality of discomfort between day 2 and day 12.

oversimplification of subjective discomfort. One also must consider the influence on the measurement of discomfort which results from a combination of the major variables.

Knowledge of this influence, or "interaction," of combined variables becomes important in determining the degree to which the relationship among measurements on one variable will be observed uniformly over all values of another variable with which it is combined. For example, measurements were obtained early and late in the trial to determine the rank and absolute magnitude of the discomfort factors. With the passing of time, shifts and even reversals were obtained in the hierarchy of discomfort factors. Dirt and crowding of the shelter showed a statistically significant reversal in their importance as sources of acute discomfort. Thus, it becomes obvious that the initial relationship between these two discomfort factors was not maintained uniformly with the increasing duration of shelter occupancy. In other words, the occurrence of a given relationship among discomfort factors early in the study would not have allowed the prediction that the same relationship would be maintained over time. Consequently, this relationship could not be generalized.

The possibility that similar limitations on generalizability would appear in other combinations of variables was the basis for establishment of the present objective. This objective was pursued by determination of the significance of "interaction effects" derived from the Likert-type scale data. When a significant interaction effect occurs in a combination of variables, one must conclude that relationships among measurements on one variable are not uniform over all values of the other variables. Nonsignificance of interaction indicates that although the absolute magnitudes of given measurements on a dimension may change, the relationship among these measurements does not significantly change and is therefore generalizable, over the other dimensions involved. Table E2, in which all possible interaction effects and their respective levels of significance are presented, yields the following interpretations. When combinations of two variables are considered, it is evident that the relationships among shelterees in their responses to discomfort depended upon (a) the time at which discomfort was measured, (b) the particular discomfort factor tapped, and (c) whether discomfort was measured on the acuteness or on the generality dimension. Similarly, the magnitude of discomfort attributed to a given source depended upon (a) the time at which discomfort was measured, (b) the subjects responding, and (c) whether the discomfort was rated on the acuteness or generality dimension.

The only instance of nonsignificance among the two-way interactions indicated that the differences between responses to the acuteness and generality scales were uniform over time, i.e., were not dependent upon the time at which the scale was administered. This finding gives even further support to the validity of distinguishing between "acuteness" and "generality" of psychological discomfort in protective-shelter studies.

Of the interactions among three variables, the one instance of significance indicated that the extent to which subjects changed in their responses over time depended upon the particular discomfort factor being tapped. While the remaining three-way interactions were not significant, it is to be noted that each contains a two-way interaction which was significant. This limits the generalizability involved to the statement that the shifts of subjects' responses over time, of discomfort factors over time, and of subjects over discomfort factors, do not depend upon whether the acuteness or generality dimensions of discomfort are utilized.

Finally, the nonsignificance of the four-way interaction indicates that the extent to which subjects changed in their responses over time depended upon the particular discomfort factor tapped, but not upon whether discomfort was measured on the acuteness or generality dimension. Over-all, then, it is evident that in the present study, the extent to which relationships among values of any of the four major variables may be generalized over the other variables is highly limited. This limitation indicates that the problem of measuring response to discomfort in fallout shelters may be remarkably

complex. One must be quite specific in discussing subjective discomfort and avoid attempts to generalize without consideration of all variables involved. However, these data also suggest that the measures utilized in the present study are capable of dealing with this complexity.

Debriefing Interviews

The interviews were semistructured in nature. Each interviewer was expected to cover specific material during the hour spent with a given group; however, no requirements were imposed as to interview technique or the order in which the information was obtained. Written reports on the findings were prepared for each group of subjects.

The interviews were conducted immediately after the men left the shelter. With the exception of one group, cooperation was excellent, and the subjects were quite responsive and eager to discuss their shelter experience. It would appear that one group contained several people who were not well accepted by the subjects as a whole. The presence of these individuals tended to decrease the spontaneity of the group, particularly with regard to discussions concerning morale, behavior, disturbances, disciplinary problems, etc.

The following interview material has been summarized from the individual reports and is presented under the major headings around which the interviews were structured. The first five headings reflect qualitative considerations related to the leading sources of discomfort as set forth on the ranking scale.

Food – Complaints about food were lengthy and accompanied by more indication of real emotion than was evident in any other factor. Further, the discomfort stemming from food was mentioned not only when shelterees were directly questioned about it, but also at almost any other opportunity – such as when they were questioned about morale and suggestions for improvement of shelter living. The survival crackers were the primary target of criticism. In terms of quality, there was unanimous agreement that both for any given meal and over the two-week period of time, the taste and texture of the crackers were highly unpleasant. The crackers were considered too hard (one man reportedly lost a filling while chewing crackers), and the rough texture scratched the roof of the mouth and irritated sore throats. As a result of this experience, several men reported a definite loss of interest in food upon recovering from upper respiratory ill nesses.

The flavor of the crackers also was criticized severely. The criticisms ranged from "nauseating," through "tasteless," to "too sweet." Repeated comment was made about the sweetness being particularly annoying when the crackers were served with chicken and rice soup as a topping.

The soup toppings were almost unanimously considered to constitute one of the single most important morale and positive emotional factors during the trial. As will be noted later, the soup meal was anticipated with great relish, and constituted the high point of the day. A number of men expressed a belief that there was not enough topping served to make the crackers palatable. The peanut butter and jelly toppings generally were well accepted, but not nearly to the degree of the soup toppings. There also was uniform agreement that insufficient jelly and peanut butter were served.

In addition to comments on the food per se, there were numerous complaints about the unpleasant taste of the drinking water, which apparently resulted from its storage in a tank outside the shelter. Since several men did not drink coffee, there also was a feeling that provision should have been made for water-soluble substances such as "Tang" to provide more variety in liquids.

The importance of food in maintaining morale in fallout shelters became clearly apparent in this study. It should be emphasized that the questions of dietary adequacy

raised here pertain to failure of the diet to provide emotional or psychological gratification rather than adequate nutrition. In this connection, the implications of the findings in the present study are consistent with those reported for men isolated in the Antarctic (2,3).

Lack of Water for Washing - There was a relatively high degree of agreement among the subjects regarding their response to the lack of water for washing. In general, the complaints focused on a feeling of constantly being dirty. This feeling was particularly disturbing before going to bed and before eating. Although there were individual variations among the subjects with regard to the personal discomfort experienced in this regard, it should be noted that the inability to wash was in marked contrast to the routine of recruit training, where cleanliness was greatly emphasized. There was a unanimous feeling that the wash-and-dry pads did not result in a feeling of cleanliness, regardless of whether they, in fact, did clean the face and hands. Although odor in the shelter generally was regarded as a factor causing minimal discomfort, a surprising number of individuals commented on the disagreeable body odor of other subjects which resulted from an inability to bathe.

Crowding - In general, the problem of crowding might be summarized as being not so much a shortage of space as a question of how this space was utilized. The major problem in this connection concerned moving from one place to another in the shelter (Fig. 40). Such movement necessitated interrupting group activities and conversations as well as bumping, excessive physical contact, awkwardness, and organizational confusion. Thus, changing position involved elbowing someone else out of the way. As the trial progressed, movement through the shelter was accompanied by a progressive deterioration in social amenities. As a result, moving about provided a source of considerable irritation, particularly in cases where individuals were jostled while attempting to balance food on their laps.

Fig. 40 - Shelter occupants seated during a lecture. Note the crowded conditions when all the occupants are awake at the same time.

Aside from the problem of the lack of common passageways, the crowding was made even more difficult by the insufficient number of chairs and tables during the common period when everyone was up. The subjects also reported difficulty in sitting along the sides of the shelter because of the sloping shell of the structure.

Surprisingly, there was no particular verbalized need for privacy expressed by the subjects. It is interesting to note, however, that the bunks were clearly considered to be "private space" at the time a man actually was in bed. There were two types of extremely irritating intrusion on this private space. One was found in the case of an individual who allowed a foot or arm to hang out of his bunk onto the bunk below him. The second was found in one individual putting his ditty bag on another man's bunk. The mores of the shelter indicated that an individual was perfectly within his rights to respond to such an

intrusion into his private space by kicking the ditty bag onto the floor or actively lashing out at a person putting his foot on the wrong bunk.

Dirt – There was a wide difference of opinion with regard to the importance of dirt in the shelter. There were complaints that the dust irritated sore throats and that occasionally the air was clouded with dust. However, some shelterees appeared bothered little, if at all, by dirt not immediately in contact with their bodies. It would appear that the primary concern with dirt was related to personal cleanliness and the lack of water for washing, rather than an actual accumulation of dirt in the shelter.

Behavior of Others – The primary problem with regard to behavior of others focused on the discourtesies involved in the bumping and jostling of moving from one part of the shelter to another. There was a rather remarkable agreement on the consciously felt need to surpress hostility and aggression and "forgive" the irritating behavior of others in order to maintain group integrity. For the most part, aggressive responses were well controlled. This was a matter of conscious control on the part of each member of the group.

In addition to the lack of consideration "in small things" which was an irritating source of behavior, the interview information disclosed the existence of a small clique of individuals who apparently gained stature as "outcasts" through negative or passive-aggressive behavior. It would appear that this nucleus of men attracted attention and gained identity by flouting the shelter regulations, violating group norms, and refusing to do their share of the work. However, for the most part, this was accomplished without the behavior coming to the attention of the Shelter Commander.

The one fist-fight episode was quickly terminated by other men. During the interview, this episode was cast off as unworthy of discussion, almost as if it was a source of embarrassment to the subjects.

Perceptual Changes: Compared to the way things looked before you went into the shelter, have you noticed any distortions in the size or distances of things now? If so, what? – A relatively small number of subjects expressed any gross perceptual disturbances. However, several individual subjects reported objects appearing larger after leaving the shelter. A few felt that the shelter appeared to grow smaller the longer they were in it. However, it is difficult to determine if this was due to perceptual distortion or to a more generalized emotional response. The same holds true for the few subjects who reported that the shelter was perceived as less confining with the passing of time.

There was unanimous concern, to the point of discomfort, with the silence in the interviewing rooms after exposure to the blower system in the shelter. Moreover, the majority of the subjects reported that colors appeared more vivid or saturated after leaving the shelter. Although possibly not related to perceptual distortion, a large number of men reported difficulty in maintaining a straight line in their movement from the shelter to the main building of the Institute. In addition, steps seemed higher than before, and a number of men reported actually lifting their feet higher off the ground than necessary when walking on a flat surface.

Leadership: What were some of the problems that you think could have been avoided or better handled by more effective leadership? How? – To the man, it was agreed that leadership on the part of the Shelter Commander and the Medical Officer was excellent, and there were no suggestions for improvement. One of the hospital corpsmen also was considered to be an unusually strong leader. On the other hand, there was considerable comment on the relative inadequacy of the enlisted section leaders. It was considered that one section leader, in particular, was extremely poor in his job because of his overbearing, hostile, and inconsistent manner.

Outstanding Individual Participants: Were there certain people in the shelter who made your stay easier? If so, why? – It was repeatedly mentioned that the Shelter Commander and the Medical Officer as well as one of the hospital corpsmen played a highly significant role in making shelter life more acceptable. However, there were more generalized responses to this question by a number of individuals. For example, it was considered that persons to whom one could talk aided in making the stay easier. It would appear that such conversation served as an important mechanism for tension reduction. Also, the entertainers were singled out by a number of subjects as major contributors to making the shelter experience more acceptable.

Morale: Could group cooperation and morale have been higher? If so, how could they have been raised? – The subjects were unanimously of the opinion that morale was high. Although there were certain periods when time seemed to drag, they did not interpret this as indicating poor morale. It was considered only natural that there be some letdown in spirit as the trial progressed. However, this "normal" drop in spirit was markedly offset by the first entertainment program, one week after entering the shelter, as well as by the distribution of chewing gum. Recommendations for improving morale included better food, forced participation in group activities, and more stringent group pressure on the "goof offs."

Anticipation of Shelter Experience: How did shelter life differ from what you expected it to be? – For the most part, the subjects found the shelter experience less stressful than they had anticipated. In spite of a certain degree of boredom, the time passed faster than they had expected. However, they had anticipated the food to be more adequate. Quite a few of the men expected the shelter to be larger and that they would have more time to sleep. Also, several men reported that they had anticipated less activity to occupy their time, more structured discipline, and less freedom to smoke.

Tolerance for Shelter Living: How would you feel about spending a month in this shelter? – A few expressed the opinion that they absolutely could not spend a month in the shelter under any condition. However, the overwhelming majority expressed the opinion that this would be possible providing they had adequate motivation. Most of the subjects expressed a belief that they had passed "over the hump" of adjustment problems during the first 72 hours of confinement and that any length of stay could be tolerated beyond that if necessary. Deterrents to continued occupation were unpleasantness of the food, and inability to exercise freely.

What do you remember as your most unpleasant shelter experience? – No single experience in the two-week test was considered to be uniquely unpleasant. The quantity and quality of the food was again raised in discussing this area. Individuals who had suffered from upper respiratory diseases reported their illnesses to constitute the most unpleasant experience. The most unpleasant time in any given day was unanimously agreed to be the four-hour periods when everyone was out of the bunks.

What do you remember as your most pleasant shelter experience? – Again, no single shelter experience with the possible exception of the entertainment was considered to be uniquely pleasant. The hot meal in the evening was recalled as the most anticipated and pleasant event of the day. A number of subjects generalized sleeping and the ability to "stretch out" as being their most pleasant experience.

Aside from making the shelter bigger, what changes in it would make things easier or more pleasant for the shelterees? – When asked about suggestions for changes to make shelter life easier or more pleasant, a wide variety of comment was obtained. For the most part, the suggestions were focused on alleviating the discomfort sources discussed above. However, the following additional discomfort sources were commented on by a sufficiently large number of subjects to warrant consideration here.

Noise in the shelter was considered to be a problem of some importance. This was primarily because of difficulty in communication, rather than noise level per se. Modification of the blower system also was suggested to avoid unpleasant pressure changes. It was recommended that the blower be run at a higher speed, since high-pitched blower sounds were considered more tolerable by the subjects than the lower pitches.

The head odors were considered nauseating and disagreeable, primarily to those individuals whose activity required close physical proximity to the water taps located just adjacent to the heads. A number of men serving as water monitors reported a response to head odor which reached a point of near nausea.

A number of suggestions were made with regard to deflecting the air flow from the ventilators so as to avoid directing air onto individuals occupying the upper bunks.

Miscellaneous comments included a recommendation for the use of inexpensive sleeping bags in lieu of blankets, sturdier bunk construction, better trash disposal, and the installation of hand railings at the outside entrance of the shelter. This latter point was raised by a number of subjects who found difficulty in rapidly entering the shelter after being exposed to the bright sunlight. A number of subjects commented on the desirability of having more table and chair space, as well as established aisles or passageways for moving about in the shelter.

What suggestions could you give to future shelterees which would make their shelter stay easier and more pleasant? – The responses to this question were more valuable in terms of the insight into psychological mechanisms used in shelter living than in information which could be used for indoctrination of subjects in future studies. It should be noted that all men reported their preshelter indoctrination to be adequate.

A number of mechanisms for shelter adjustment became apparent from the interviews. Some of these techniques had been planned before the subjects began the trial, and others developed during the course of the confinement. Great stress was laid on keeping one's mind occupied, be this in conversation, reading, games, etc. On the other hand, a number of subjects pointed out the need to vary activity so that an individual did not spend all of his time reading or playing cards. Talking to others was particularly important as a means for alleviating tension during the course of the trial. However, griping in one's diary seemingly was more socially acceptable in the beginning of the two-week period. In spite of the youth and lack of sophistication characterizing the majority of the subjects, there was a remarkable conscious control of aggressive response and awareness of the significance of one's behavior to others. Frustration tolerance was consciously extended. In spite of the degree to which social amenities deteriorated during the course of the test, the lack of basic courtesy was obviously quite disturbing to the majority of the subjects. A major factor in the Medical Officer maintaining his position of respect and status quite clearly could be attributed to his never failing to say "excuse me," or "thank you," throughout the two-week period.

Generalized Emotional Response to Shelter Experience

In addition to collecting information on the trial per se, the interviews were designed as a means of releasing tension and spotting any subjects who had been emotionally upset by the experience. It was the consensus of the examiners that the shelter experience had been rather unstressful to this particular group of subjects. No obvious emotional disturbance was apparent in any single member of the group. There clearly were indications that some men had experienced moderate to marked anxiety during the first few days of the study, and other men had overcome moderate periods of depression.

There appeared to be no particular pattern to depression in the shelter. Mood swings appeared to vary individually rather than as a result of group contagion. No evidence of impaired reality-testing was evident at the debriefing, although some men reported difficulty concentrating on occasion during their confinement.

No psychosexual problems arose during the test. Although there was considerable talk and planning with regard to anticipated sexual activity during the first few days of the study, this was replaced by a preoccupation with food as the trial continued. Elaborate plans were made for the first meal outside of the shelter, and gambling in card games involved the wagering of steak dinners.

Few difficulties were encountered in the subjects regulating themselves to the diurnal cycle. For the most part, those sleep difficulties reported by the subjects were related to noise problems. While some men commented on the need for eye shades and ear plugs, sleeping did not constitute a major problem.

Daily Diaries

The daily diaries which the shelterees were encouraged to keep were seen as potentially providing qualitative data of value for two reasons. First, the expression of thoughts and feelings through this medium was somewhat less structured than in the debriefing interviews, thereby allowing for the identification of factors not considered in the debriefing outline. Second, the keeping of a diary may be seen as a "concurrent debriefing" in which responses could be recorded as they occurred, rather than as they were seen in retrospect during the post-shelter debriefing.

In terms of the quality of material recorded in the diaries, 45 shelterees either left the diaries blank, outlined schedules only, or failed to turn their diaries in at the end of the trial. Minimal content was evident in the diaries of 27 shelterees, while 24 men expressed a recognizable degree of thought or feeling. In all, 35 sources of discomfort were identifiable when the content of the diaries was analyzed.

Of these 35 discomfort sources, the following were mentioned by ten or more of the shelterees: food, crowding, attitude of others, inactivity, lack of personal cleanliness, concern over weight loss, noise, confusion, cold symptoms, and feelings of fatigue or weakness. A comparison between these factors and those tapped in the psychometric instruments suggests that several possibly important additional factors came to light through the diaries. That is, at least five of the above ten factors were tapped either indirectly or not at all by the scales utilized in the study, i.e., inactivity, concern over wieght loss, confusion, cold symptoms, and feelings of fatigue or weakness. It appears possible that future shelter studies might profitably explore such factors as sources of significant discomfort.

To provide a further qualitative view of the material recorded in the diaries, the following verbatim comments are presented. These are not all from the same subject, but they indicate the vast range of individual response and feeling tone which was recorded.

"It was a funny feeling knowing that we would be in there for over a week."

"Everything is confused, I hope it's not going to be like this all the way through."

"The water tastes funny; I hope it won't bother me."

"Time is starting to crawl. I have nothing to do but write letters."

"I don't know if I can last long on th t kind of food."

"Some of the boys are starting to get on my nerves."

"I don't think, really, that I could stand another two weeks, not even a week; I feel so dirty that my skin is starting to give me trouble."

"Port lost in games. Felt a change in my men. they will do anything to upset these tests."

"You lose track of time down here pretty easily."

"I am a little shaky, from what I don't know--chow isn't too bad."

"My nervousness is gone--the crowding got me a little mad this morning, but it's alright now."

"The entry was carried out smoothly and orderly. The Shelter Commander's knowledge of organizational procedures was a large factor in the efficient manner of getting all necessary functions started. The food appears to be substantial and satisfying. Morale today was very good. The quantity of food may be difficult to adjust to. Eating only twice daily is different but not difficult to adjust to. There is a good selection of books here. The addition of a few different games would be welcome but the cards are able to provide variety."

"The days seem to be getting longer as they go by. The chow seems to be getting a little harder to eat each time. The hot meal which includes soup is fairly good, except for the crackers being put in it. By far, you do not have the interest that you first had, whenever you first entered the shelter. The crowding seems to be the worst problem. My strength seems to be holding up fine as of now."

SUMMARY AND CONCLUSIONS

Inasmuch as this research program was concerned primarily with engineering habitability, no formal, large-scale, behavioral studies were undertaken. However, there is an obvious relationship between environmental variables and psychological response to these factors in determining man's tolerance to shelter living. With this fact in mind, the psychological investigations were focused on identifying and measuring subjective discomfort sources during the shelter experience. Rank order scales and a Likert-type scale were used to obtain quantitative measures of psychological discomfort. Qualitative information was obtained through semistructured debriefing interviews conducted at the conclusion of the test and through diaries kept by the subjects.

The data obtained from the winter trial made it possible to accomplish all of the objectives which had been established, and a number of broad conclusions may be made regarding the relevant importance of the various psychological discomfort sources in the BuDocks shelter. The five leading discomfort sources in the winter trial (as measured on the Likert-type scale) were food, lack of water for washing, crowding of the shelter, dirt, and behavior of others. Food and lack of water for washing did not differ significantly from each other on a statistical basis and should be considered of equal importance as discomfort sources. Likewise, although the bottom four factors on the Likert-type scale (bunks, lights while sleeping, odors, and temperature and humidity) assume a hierarchy in ranking, from a statistical standpoint their numerical positions on the scale do not necessarily reflect genuine differences as psychological discomfort. Regardless of time of measurement, or technique utilized, the five leading sources of discomfort uniformly fell as listed above.

Prior to entering the shelter, the subjects anticipated that leadership and lack of organization would be major problems. However, the test data indicate that in actuality

these factors constituted some of the least important discomfort variables. It would appear that the discomfort stemming from dirt was related to lack of water for personal hygiene, rather than dirt in the shelter per se. Crowding constituted a problem primarily during those periods when all the shelterees were up. It is quite likely that this could be corrected by shifts in scheduling as well as by providing bunks or benches along the sides of the shelter. In addition it is recommended that aisles be painted in the shelter so that clear passageways would be possible.

The complaints with regard to the behavior of others stem primarily from the bumping or shoving which resulted from crowded conditions. The increased significance of this discomfort factor with the passing of time appeared to be directly related to a decrease in social amenities and common courtesies, such as individuals saying "excuse me" upon inadvertently bumping into someone else.

Rank orders of discomfort factors based on "acuteness" and on "generality" were shown to be highly correlated. However, through use of an analysis of variance technique, it becomes clear that "acuteness" and "generality" are meaningful distinctions in considering the psychological discomfort one encounters in protective shelter habitability. Shifts in the rank order of discomfort factors, as well as their significance in terms of acuteness and generality, occurred with the passing of time in the shelter.

The emergence of lack of water for washing as one of the two major sources of psychological discomfort in the present study is consistent with findings of the American Institute for Research (1) as well as with one of the two major studies conducted by the U.S. Naval Radiological Defense Laboratory (4,5). Because of the vastly different experimental conditions, measurement techniques, and subject populations used in these various studies, it would be inappropriate to make more precise or direct comparisons of the findings with regard to discomfort factors. However, it is interesting to note that in all of the trials, shelter equipment and/or factors in the physical environment ranked ahead of "people" per se as sources of psychological discomfort.

Certain discomfort factors, such as noise, inadequate physical space, and lack of water for washing, well may constitute engineering and cost problems which cannot be overcome in the construction of protective shelters. However, there are other sources of psychological discomfort which can be minimized with effective planning. One of the most important of these is food. The diet in the winter trial, while nutritionally adequate, was a major source of psychological discomfort. This finding is consistent with the results of other research in indicating the importance of food as a source of emotional gratification for persons under stress. The present studies clearly indicate the necessity of considering the psychological or emotional as well as nutritional, storage, and cost aspects in the selection of food for stocking protective shelters. In the event of a nuclear attack, it may be anticipated that food would play an extremely important role in maintaining the psychological integrity, values, and motivation of individuals who must undertake the work of reconstruction after a period of shelter living. At the very least, methods should be devised to vary the flavor of survival crackers as well as to change the present coarse texture. Consideration should also be given to increasing the variety of diet through the development of additional low-cost food items which have a long shelf life.

While the problems discussed above were sources of discomfort, the data indicate that no single factor or combination of factors was considered absolutely introlerable by the subjects. Moreover, there was no evidence either in the test data or the debriefing interviews that the shelter experience had been psychologically traumatic or otherwise detrimental to the subjects.

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CHAPTER 9

MEDICAL ASPECTS

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PRELIMINARY PLANS

The medical staff for both trials consisted of a medical officer, who also served as the physiological observer, and two hospitalmen as assistants. A medical kit was provided containing a generous assortment of symptomatic remedies and antibiotics. Surgical supplies consisted of sterile packs of instruments and dressings for performing minor surgical operations and also a resuscitator. A dental kit was available for emergency care of acute dental problems. Definitive treatment of major medical or surgical problems would not be attempted. Such cases would be transferred to the Naval Hospital.

Sick call for each section was held immediately after the quiet period. Interviews by the medical officer with each subject followed the morning measurement of body weight, pulse rate, and temperature. Lectures on hygiene and sanitation were given to the group as a whole, in addition to special instructions to the food handlers.

TWO-DAY TRIAL

A total of 26 patients was seen at sick call during the 46 hours of the trial. Fifteen of these complained of headache, the majority of which appeared to be caused by the accumulation of CO_2 and tobacco smoke during the initial three hours with no ventilation.

Seven patients presented symptoms of mild upper respiratory infection (URI) without fever. Treatment both of headache and URI was symptomatic only. The remaining four cases consisted of one with laceration of the finger incurred while opening a cracker tin, two cases complaining of sleeplessness, and one case complaining of sinus pain. The only complaints unearthed by medical interview were chilliness while sleeping and lack of enthusiasm for the ration. During the two-day trial there were not enough blankets to provide two per bunk, as planned.

TWO-WEEK TRIAL

Clinical Studies

Table 29 and Fig. 41 summarize the nature and incidence of the clinical problems encountered in the two-week trial. Aside from two dental cases requiring temporary fillings to relieve toothache, the remaining 75 new cases were medical. No surgical problems were encountered.

During the two weeks in the shelter, 59 of the shelter inhabitants were seen one or more times at sick call (Fig. 42). On the average, each of these 59 subjects attended sick call at least once on 2.8 different days during the trial.

Forty-nine of the total of 77 new cases complained of upper-respiratory symptoms, chiefly those of the common cold. Fifteen, however, presented a picture of moderate to

Table 29
Case Rate of Clinical Disorders in 100 Subjects During the Two-Week Shelter Trial, Feb. 17 - Mar. 3, 1962

Illness	Number of cases
Upper respiratory infections	
Afebrile	29
Febrile	21
Headache	13
Gastritis	2
Diarrhea	1
Insomnia	4
Acute anxiety state	1
Conjunctivitis	1
Skin diseases	3
Dental	2
Total cases	77

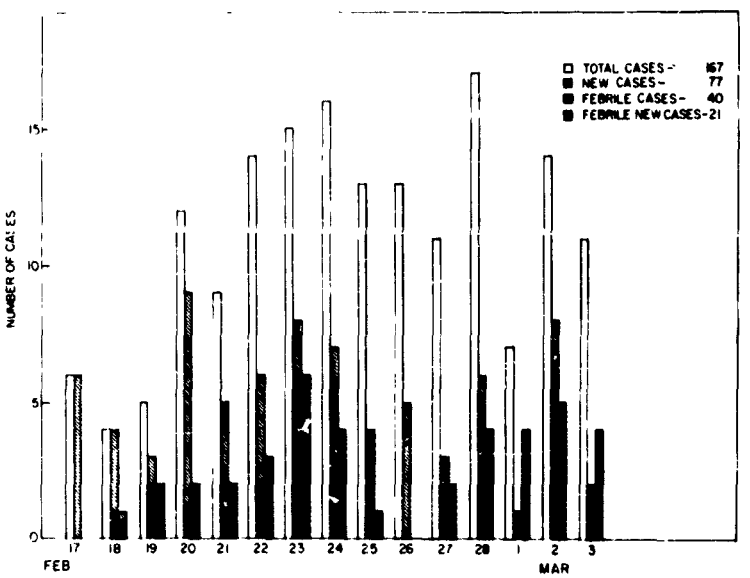

Fig. 41 - Daily incidence of febrile and afebrile illness in 100 subjects during the two-week winter shelter trial

Fig. 42 - Sick Call

severe tonsillitis or pharyngitis, with patchy areas of exudate and ulceration in the more severe cases, fever up to 104°F, local lymphadenopathy, pain on swallowing, mild headache, and malaise. Throat cultures were negative for pathogenic bacteria, leading to the conclusion that a virus was the probable causative agent. This was supported by the finding that oral tetracycline and/or intramuscular penicillin used in the early cases before reports of throat cultures were available was ineffective, and this form of treatment was abandoned in treating the later cases. Routine treatment thus became dependent only upon administration of APC's, throat lozenges, saline gargles, forced fluids, and bed rest. The duration of the illness varied from two days in mild cases to five days in the more severe ones. Recovery was invariably complete and uneventful.

Whether a common agent caused this illness is uncertain. The daily incidence pattern of febrile URI (Fig. 41) suggests this possibility. It is postulated that in the initial outbreak, which occurred between Feb. 18 and 25, were cases who entered the shelter in the incubation period, and the later outbreak, beginning on Feb. 27, involved secondary cases from contacts made within the shelter itself. The source of infection may have been the man described in the section on selection who was sent to the dispensary on Feb. 15 with pharyngitis and fever.

Diarrheal diseases did not present a problem. Control of communicable diseases of this type consisted in the routine disinfection of hands of food handlers, enforced by daily inspection and the use of alcohol-impregnated tissues "Wet 'n Dri") by each man before eating.

Psychiatric and emotional disorders of a clinical nature were extremely uncommon. One man exhibited evidence of an emotional disturbance on the third day after entry characterized by anxiety, depression, and withdrawal. Librium®10 mg/day, was administered for four days. Improvement was gradual but complete. At the end of the two-week trial, he appeared well adjusted and happy, entering into group activities with enthusiasm. Of four cases complaining of insomnia, in only one did there appear to be an underlying anxiety reaction as a basis for his difficulty. Treatment consisted of mild sedation and reassurance.

Dermatological problems were also rare, despite lack of facilities for personal hygiene. One case of dyshidrosis occurred, which appeared functional in origin, being precipitated by a heated argument the patient had with a member of the division of which the patient was leader. One case of fungus infection of the skin of the trunk and one case of folliculitis of the scalp were the only other skin diseases encountered.

The medical interview was time consuming and of questionable value, except in revealing the onset of acute diseases at an early stage of development. During the interview, however, the subject was encouraged to air any complaints, medical or otherwise, and this procedure may have alleviated emotional tensions to some extent.

Bacteriological Studies

Materials and Methods

Of the 100 volunteers taking part in the shelter study, 50 were selected (those not chosen for the fluid-balance study) for bacteriological surveillance throughout the period of the study. All of the subjects for this phase of the project were cultured once, three days prior to entering the shelter. After entering the shelter the group was randomly divided into a port section and a starboard section, each of which was cultured every four days, except at the conclusion of the period in the shelter, when the starboard section was cultured twice in three days, so that each section would be cultured an equal number of times. No cultures were taken after the subjects emerged from the shelter. The schedule for culturing was as follows:

Entry day	-3	Wednesday 2-14-62	Port and starboard sections
Entry day	+1	Sunday 2-18-62	Port section
	+3	Tuesday 2-20-62	Starboard section
	+5	Thursday 2-22-62	Port section
	+7	Saturday 2-24-62	Starboard section
	+9	Monday 2-26-62	Port section
	+11	Wednesday 2-28-62	Starboard section
	+13	Friday 3-2-62	Port and starboard sections

Both rectal and throat cultures were taken on each subject by swab each time a section was cultured. The initial pre-entry cultures were taken by the personnel of the Bacteriology Division, NMRI, and all subsequent cultures were taken by the Medical Department personnel in the shelter. During the period of confinement, sterile rectal swab and throat swab set-ups were delivered to the shelter one day in advance of their anticipated use and were taken into the shelter by the monitoring team that emerged twice daily to check radiation levels. The culturing was accomplished just prior to the monitoring of the next day, and the cultures were then carried to the outside by this team.

The swabs were immediately picked up and delivered to the Bacteriology Division, NMRI.

The subsequent culturing and identifications were then carried out as follows. The rectal swabs were immediately streaked out on MacConkey's agar (Difco), desoxycholate citrate agar (Difco), SS agar (Difco), and EMB agar (Difco); the swabs were finally placed into tetrathionate broth for subsequent restreaking on SS agar. This diversity of medium allowed for the recovery and identification of Shigella, Salmonella, and Enteropathogenic

coliform organisms if present. All suspicious colonies from these media were carried through standard bacteriological identification procedures and final identification ascertained serologically.

The throat swabs were immediately streaked to Blood agar plates (Difco) and Brain Heart Infusion agar. The character of nonselectivity of these media allowed for the free growth of all normal throat flora, as well as most pathogenic organisms that might be present. After incubation, the predominating organisms on these plates were isolated and identified, utilizing standard bacteriological identification techniques.

Throughout the two weeks the subjects were in the shelter, all-glass impingers containing 40 ml of Brain Heart Infusion broth were used to take bacteriological air samples for 15 minutes each day. These samples were removed to the laboratory each day and allowed to incubate overnight. Plate counts were then accomplished on each sample to determine the total number of organisms in the air, and the predominating organism was identified.

Results

Rectal Cultures - The results here shown are a compilation of the positive cultures found before and throughout the confinement period, using the previously described methods. It should be noted that the small number of positive findings are a reflection of the highly select nature of the subject group as well as the trouble-free dietary and food preparation regime.

	Pre-entry	During confinement
Shigella	None found	None found
Salmonella	None found	None found

Enteropathogenic coliform 0126:B16 was found in four subjects prior to entering the shelter. This organism was recovered periodically throughout the study from the same four subjects, but no spread to other subjects was discovered.

Subject	0126:B16 noted
1B-8	Pre-entry, 2-20-62, 2-22-62, 3-2-62
1D-5	Pre-entry, 2-22-62
1E-2	Pre-entry, 2-20-62, 2-22-62, 2-26-62
2C-9	Pre-entry

Throat Cultures - Using the previously described techniques and procedures for the recovery and identification of throat flora, the predominating organisms found were, in descending order of predominance:

1. Nonhemolytic streptococcus
2. Staphylococcus
3. Neisseria
4. Diptheroids
5. Beta hemolytic streptococcus

All of the above can be considered normal throat flora, with the possible exception of Beta hemolytic streptococcus.

Beta hemolytic streptococcus was recovered twelve times throughout the study, as follows:

Culture Date		Number Found	Percent
2-14-62	Pre-entry	5	10.4
2-18-62, 2-20-62	First set	1	2.1
2-22-62, 2-24-62	Second set	0	0.0
2-26-62, 2-28-62	Third set	2	4.1
3-2-62	Fourth set	4	8.0

These data, along with the consideration that no clinical symptoms accompanied the finding of the organism and that the organism was not recovered twice in succession from any subject, would preclude this organism from being pathogenic in these instances.

Air Sampling – The following is a compilation of the results obtained by the air sampling technique previously described:

Date	Time Taken	Before Sweepdown	Organisms/ml	Predominating Organism
2-20-62	1247-1302	No	2.3×10^8	Staphylococcus
2-21-62	1302-1317	No	9.5×10^6	B. subtilis
2-22-62	1329-1344	Yes	5.4×10^7	Staphylococcus
2-23-62	1337-1352	Yes	5.7×10^7	Staphylococcus
2-24-62	1259-1314	Yes	2.7×10^7	B. subtilis
2-25-62	1251-1306	Yes	1.4×10^8	Staphylococcus
2-26-62	1245-1300	Yes	4.3×10^8	B. subtilis
2-27-62	1310-1325	No	8.7×10^7	B. subtilis
2-28-62	1245-1300	No	4.6×10^6	Staphylococcus
3-1-62	1245-1300	No	2.0×10^8	Staphylococcus

As can be seen from these data, the predominating organisms are those most commonly found as air contaminants and were unchanging. The numbers of organisms varied somewhat from day to day, but the counts indicated a normal range of organisms in the air throughout the study.

Conclusions

1. Enteric pathogens would seem to be no problem in this study. The dietary regime would most certainly preclude the spread of enteric disease, even if present in some of the subjects, unless a full-blown outbreak should occur shortly after entry. In this case the proximity brought about by the limited space might be contributory to spread.

2. In this study the throat flora were essentially normal nonpathogens throughout. There was noted a tendency toward a common throat flora among the subjects as the

study progressed. These data would indicate the possibility of spread if an upper-respiratory infection should get started during the period of confinement.

3. There was noted in this first shelter study a need for virological or serological backup for the bacteriological studies. Several upper-respiratory infections were encountered in the shelter that could not be explained bacteriologically.

DISCUSSION

The factor of crowding is of primary importance in the shelter environment and contributed most to the medical problems encountered in this trial. Close contact between shelter inhabitants was unavoidable even while sleeping, despite the regulation head-to-foot orientation. Fortunately, the organism(s) which caused the more severe forms of URI were either not highly contagious or were spreading through a population which was already largely immune to it. In any event the attack rate was low, being appreciably less than for the milder forms of afebrile URI. One-half of the shelter population were victims of mild or severe URI (Table 29).

It is not pleasant to contemplate the conditions that would prevail in a shelter if the agent of a highly contagious disease were introduced into a susceptible shelter population by an immune carrier or by an infected case who was in the incubation period of the disease at time of entry. No doubt the problem of communicable diseases was minimized in this trial because these men had lived in fairly close contact with each other for several months of recruit training immediately before the trial began, and had thus acquired immunity from agents which by then were more or less uniformly distributed through the group. The bacteriological studies reported here indicate the ease with which the spread of throat organisms can occur under conditions of close contact.

From a habitability standpoint alone, hot-bunking was not a problem. Nevertheless, this feature of shelter design imposes a handicap in the treatment of disease by requiring the person who is acutely ill to yield his bunk for at least eight hours in 24 hours to a healthy man with whom he shares it. In the present trial an attempt was made to cope with the problem of providing continuous bed rest to acutely ill patients by placing two folding cots along the starboard bulkhead aft of the medical area. Blankets were hung as curtains to provide a modicum of isolation from the heavy traffic alongside. An improvised sick bay of this type is practicable only if the number of seriously ill patients is small. A better procedure would be to designate a block of bunks for continuous use by sick patients requiring bed rest and/or isolation. The number of bunks thus designated would increase or decrease to meet existing need. Each of an equal number of the remaining bunks would be shared by three, rather than two shelter occupants who were not on the sick list.

CONCLUSIONS

Crowding and lack of facilities for personal hygiene are major factors which promote the spread of disease in a shelter environment. Preventive measures are better suited to control diarrheal diseases transmitted by feces, fingers, and food than upper respiratory and other contagious diseases spread by direct contact. Psychiatric and dermatological disorders were of minor consequence in the winter trial.

PLANS FOR SUMMER TRIAL

Heat rash and its complications will probably constitute a major problem. Medical provisions will be needed for prevention and treatment of these disorders. Deficiencies

in body water and salt may lead to heat illness. Unless serious, such cases will be treated within the shelter. Psychiatric and emotional problems are likely to be more prevalent in the summer test.

The only change desirable from a medical standpoint would be in introducing modifications in organization and scheduling to permit acutely ill patients to remain at bed rest continuously if necessary.

CHAPTER 10

SUMMARY, CONCLUSIONS, AND PLANS FOR SUMMER TRIAL

INTRODUCTION

This chapter contains a summary of the results obtained in the winter trials of the BuDocks protective shelter. Conclusions reached are of two general kinds: (a) those pertaining to the use of protective shelters under Washington, D.C., winter conditions, and (b) those related to the preparation of the BuDocks shelter for the experimental summer trial scheduled for August 1962. Only those items considered most significant will be included here; the reader is referred to the appropriate chapters for detailed information.

SUMMARY

A two-day and a two-week trial were conducted at Bethesda, Md., in January and February 1962, in a protective shelter designed by BuDocks. The shelter is designed to provide overall blast protection of at least 75 psi overpressure, a radiation-protection factor of 5000, and biological, chemical, and fallout protection. The shelter is a reenforced Quonset hut 25 ft wide, 48 ft long, and 12 ft high along the center line. Electric power is supplied by a 10-kw diesel generator. Ventilating air is provided by an Army standard M9A1 Gas Particulate Filter Unit. Water is supplied from a 4000-gallon steel storage tank buried outside of the shelter. Toilet facilities consist of six chemical units which are connected to a dry well. The bunks are canvas supported between 1-in.-diameter standard pipes. Fifty bunks are provided for 100 men. An emergency tunnel connects the rear of the shelter to an underground passageway which joins buildings of the National Naval Medical Center.

In each trial 100 Navy volunteers served as the shelter subjects. Two naval officers served as shelter commander and medical officer. Inlet air temperatures during the trials varied from 12° to 55° F. Although no artificial heating was provided in the shelter, inside temperatures were maintained between 70° and 80° F by adjusting the air-ventilation rate. After the ventilation blower was activated, the dew point of the air in the shelter remained below the deck and bulkhead temperatures; consequently the walls and deck remained dry. Positive pressures of 0.95 to 2.5 in. of water were maintained in the shelter. The data show that a ventilation rate of 2.6 cfm per man is adequate to maintain a habitable atmosphere with respect to oxygen, carbon dioxide, carbon monoxide, aerosols, and odors, even when unlimited smoking is permitted. Nevertheless, the aerosol content of the atmosphere was sufficiently high that some people would find it objectionable. During the two-week trial, 856 kilowatt hours of electricity and 604 gallons of water were used. Approximately 270 gallons of sewage and 200 cubic feet of trash were generated.

Since the primary purpose of these trials was to study the engineering features of the shelter, the trials were conducted with a selected group of shelterees. Since conditions during the two-week trial were considered likely to be much more severe than during the two-day trial, selection of volunteers was done much more carefully for the second trial than for the first. Every effort was made to keep management problems to a minimum. Group entertainment played a positive role in maintaining morale. The

principal item of the diet was a survival-ration cracker. This was supplemented with jams, peanut butter, soups, and coffee. The ration provided approximately 1800 kilogram calories per day. Weight-loss studies indicated that this was a marginal ration. On the whole, the ration was acceptable to the men, although many complaints were made concerning the monotony of the diet. Physiological studies, designed primarily to measure strain on thermoregulatory mechanisms, were conducted during both trials. Significant levels of thermal stress were not encountered during the winter trials. However, the data from these trials are considered useful in providing baselines for measurements to be obtained in the summer trial.

Limited psychological studies were conducted in an effort to characterize major sources of discomfort arising from shelter living. These studies indicated that food, lack of water for washing, crowding of the shelter, dirt, and the behavior of others were at the top of the discomfort scale. By similar measurements, bunks, lights while sleeping, odors, and temperature and humidity were considered least bothersome.

Medical problems were minimal during these trials; the principal illnesses were common colds, although 15 cases of moderate to severe pharyngitis occurred during the two-week trial. Enteric pathogens were no problem during this study, and the throat flora were essentially normal nonpathogens.

CONCLUSIONS

For protective shelters operated under the conditions existing during these trials:

1. It is possible to maintain a comfortable temperature within the shelter without the use of heat sources other than the shelterees.

2. A ventilation rate of 2.6 cfm per man is adequate to maintain a habitable atmosphere.

3. Hot-bunking is acceptable.

4. An 1800-kilogram-calorie diet is marginal.

5. A water ration of 1.8 quarts per man per day is adequate. This includes water for all purposes.

PREPARATION FOR THE SUMMER TRIAL

Based on the results of the winter trial, as discussed in the foregoing chapters, the following major actions are recommended prior to the conduct of the summer trial:

1. Repair and test run the diesel generator unit.

2. Repair the manual blower.

3. Provide standby airconditioning.

4. Provide a ventilation capacity of at least 1000 cfm.

5. Provide for more extensive temperature measurements.

APPENDIX A

Analysis of Desorbate from Carbon Exposed During Winter Shelter Trials

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The atmosphere within the shelter was sampled continuously for the presence of trace quantities of gases from smoking, preparation of food, etc. The samples were collected on charcoal by drawing air at ten liters per minute through a standard ND-C-2 gas mask canister. This procedure is similar to that used aboard nuclear submarines to monitor the atmosphere for trace gases.

One carbon sample, which was exposed for nine hours during a period when the aerosol concentration was at a maximum (8.7 to 3.2 μg/l), was vacuum desorbed at 300°C for four hours. The desorbate comprised 6.3 grams of water and water-soluble material and 1.8 grams of gaseous material. Chromatograms and infrared and mass spectra of the gas indicated the presence of carbon dioxide and nitrous oxide in the approximate ratio of 25:1. No other components were detected.

The lack of hydrocarbons in the desorbate is somewhat surprising in view of the heavy concentration of cigarette smoke in the atmosphere during the carbon exposure. A large portion of cigarette smoke exists as particulate matter and would have been removed from the air stream by the particulate filter before reaching the carbon bed. A smaller portion of the smoke, however, consists of low-molecular-weight hydrocarbon gases which would have been adsorbed on the carbon. These gases are easily recovered from the carbon and would have been detected if present in sufficient concentration. Concentrations of such compounds as low as ten parts per billion in air have been previously detected (1) in other atmospheres with essentially the same sampling and analytical procedures by sampling a 10 to 15 times larger volume of air then was sampled in this case.

A hypothetical Quonset shelter with a free volume of 10,000 cubic feet, ventilated at 300 cfm, would receive a complete change of air every 30 minutes. According to Osborne, et al. (2) approximately 0.2 ml of ethylene is generated during the smoking of one cigarette. If the average man smoked one cigarette every 30 minutes, approximately 30 ml of ethylene would be produced during this period and would result in a concentration of about 100 ppb. Allowing for a reduced flow rate through the sampling canister (1/10 to 1/15 normal), this concentration is seen to be approaching the minimum limit of detection.

The water recovered from the carbon had a high pH (dark green to test paper) and an ammoniacal odor. No ammonia was detected in the gas phase by infrared or mass spectra, however. Dale Williams says his tube-test procedures indicate the presence of amines. Heating the solution yields carbon dioxide, identified chromatographically and spectrally, and evaporating the solution to dryness in the absence of heat yields a white solid, indicating the amine to be in solution in the form of a carbonate. The amine has not been otherwise identified.

Since very little material was detected on the most heavily contaminated carbon, it was not considered worthwhile to desorb the remaining samples.

REFERENCES

1. Kagarise, R.E., and Saunders, R.A. "The Analysis of Contaminants in Aviators' Breathing Oxygen," NRL Report 5554, Oct. 1960

2. Osborne, J.S., et al., "Some Components of Gas Phase of Cigarette Smoke," Anal. Chem. 28:211 (1956)

APPENDIX B

Preliminary Schedule for the Two-Day and Two-Week Winter Trials in BuDocks Protective Shelter

This preliminary schedule was developed for the two-day and two-week trial. The schedule is divided into two major periods or phases. The first phase (E time) covers the sequence of experimental activities for the five days prior to the trial as well as the organizational activities during the first eight hours within the shelter. The second phase (R time) of the schedule covers the regular shelter routine and the experimental activity for a 24-hour period. The daily schedule was intended to be repeated throughout the trial.

The daily activity of the shelter was scheduled under two heads: normal routine and experimental routine. This procedure was considered desirable to minimize confusion between normal shelter routine and the collection of research data.

BuDocks Shelter Trials

Preliminary Schedule

Time	Tasks	
	Normal	Experimental
E - 7days through E - 2 days		1. First full day after reporting, hold indoctrination on all subjects and review health records. The qualifying physical examination plus R and M (urinalysis) and CBC (blood) test should have been accomplished at Great Lakes. Form Y should be up to date. 2. Daily morning nude weight after urination. 3. Daily sick call. 4. Daily morning temperatures after rising. 5. Daily evening temperatures before chow. 6. Daily standing pulse rates .norning and evening. 7. Continued psychiatric observation and possible further screening of subjects. 8. Physical fitness test (Harvard Step Test) E - 2.
E - 1 day		1. Temperature-pulse-weight (TPW) morning and evening. 2. Sick call with EENT examination. 3. Rectal swabs and throat cultures on all subjects.
E - 0100 hour		1. Activate CO_2 recorder. 2. Activate CO recorder. 3. Activate aerosol recorder. 4. Activate R.H. recorder. 5. Read and record temperatures.

Time (hours)	Tasks	
	Normal	Experimental
E + 0000	1. Enter Shelter. 2. Shelter commander identifies himself and assumes command. 3. Smoking lamp out. 4. Secure blast door. 5. Secure blast valves. 6. Close off city water supply. 7. Break out battle lanterns. 8. Everyone sit in center of shelter, awaiting blast.	
E + 0005	1. Shelter commander discusses effects of blast, etc.	
E + 0015	1. Shelter commander appoints Activity Recorder, who immediately begins Activity Log. 2. Shelter commander appoints a temporary engineer detail. 3. Activate heads. 4. Shelter commander discusses purpose of test and organization pattern to be followed.	1. Activate mass concentration aerosol sampler. 2. Activate trace gas sampler. 3. Read and record: a. Sound level b. Water meters c. Temperatures d. Light level e. R.H. f. Electric meter
E + 0045	1. Two men, appointed by shelter commander, dress in protective clothing, go out and start motor generator. 2. Men who have started motor generator reseal blast door, discard contaminated clothing in decontamination tunnel and shower before entering shelter. 3. Lights on.	
E + 0100	1. Shelter commander appoints temporary cook detail. 2. Activate coffee urn. 3. Shelter commander appoints leaders, Division I and Division II	

Time (hours)	Tasks	
	Normal	Experimental
	4. All hands sign log book (Name (print)), (Name (sign)) As shelterees sign log book they: a. Receive identification badges b. Surrender valuables for safekeeping c. Are assigned bunks d. Are divided into two divisions of 48 men each. Each division is subdivided into teams, as follows: (1) Food - 10 (2) Health and Sanitation - 5 (3) Engineers - 9 (4) Communication - 12 (5) Bunking, recreation and stores - 9 (6) Staff - 3	
E + 0150	1. Shelter commander give instructions to temporary cook detail concerning serving of first meal.	
E + 0155	1. Temporary shelter engineer detail determines and records: a. Pressure b. Percent O_2 in atm c. Percent CO in atm d. Percent CO_2 in atm	
E + 0200	1. Smoking lamp lighted (for experimental purposes). 2. Cold meal served. 3. Shelter commander appoints second temporary activity recorder.	
E + 0240		1. Activate BW sampler.
E + 0255		1. Secure BW sampler.
E + 0300	1. Temporary shelter engineer detail determines and records: a. Pressure b. Percent O_2 in atm c. Percent CO in atm d. Percent CO_2 in atm	1. Change mass concentration aerosol sampler. 2. Change trace gas sampler. 3. Read and record: a. Sound level

Time (hours)	Tasks	
	Normal	Experimental
	2. Two men from the temporary engineer detail dress in protective clothing and go out to determine whether or not it is safe to turn on collective protector. Monitor for CO. On returning, leave blast door open (unless it is not yet safe to start collective protectors), discard contaminated clothing in decontamination tunnel, and shower before entering shelter.	b. Water meters c. Temperatures d. Light level e. R. H. f. Electric meters 4. Pass BW samples to outside.
E + 0315	1. Open blast valves. 2. Activate collective protector. 3. Teams meet. Shelter commander appoints temporary team leaders and gives each leader the instruction booklet for his team. Teams study and discuss instructions.	
E + 0400	1. Activity recorder relieved. (Division I)	1. Read and record: a. Sound level b. Light level c. Temperatures d. R. H. e. Water meters f. Electric meters
E + 0430	1. Question and answer session for everyone.	
E + 0530	1 Shelter commander meets with temporary team leaders. 2. Break out games.	
E + 0600	1. Activity recorder relieved. (Division I)	
E + 0700	1. Hot meal served.(Division I Food Team)	
E + 0800	1. Switch to regular schedule. 2. Teams elect team leaders.	1. Medical officer instructs WB subjects.

Time (hours)	Tasks	
	Normal	Experimental
R + 0000	1. Commence "Regular" time schedule. 2. Activity log recorder relieved. (Division II)	1. Read and record: a. Sound level b. Light level c. Temperatures d. R. H. e. Water meters f. Electric meters
R + 0100	1. Clean shelter. (Division I) 2. Assemble bunks.	
R + 0200	1. Division I in sack. 2. Smoking restricted to areas near ventilator outlets. 3. Activity log recorder relieved. (Division II) 4. Quiet period begins.	
R + 0300	1. Quiet period ended.	
R + 0400	1. Activity log recorder relieved. (Division II)	
R + 0600	1. Activity log recorder relieved. (Division II) 2. Inspect diesel generator and monitor entrance tunnel. (Division II)	1. Calibrate: a. CO_2 recorder b. CO recorder c. Aerosol recorder d. R. H. recorder
R + 0800	1. Activity log recorder relieved. (Division II) 2. Determine and record: (Division II) a. Pressure b. Percent O_2 in atm c. Percent CO in atm d. Percent CO_2 in atm	1. Read and record: a. Sound level b. Water meters c. Temperatures d. Light level e. R. H. f. Electric meters 2. Change mass concentration aerosol sampler. 3. Change trace gas sampler.
R + 0900	1. Hot meal for Division II.	
R + 1000	1. Activity log recorder relieved. (Division II) 2. Smoking restrictions removed.	1. Entire Division I has temperature-pulse-weight taken after urinating and prior to eating.

Time (hours)	Tasks	
	Normal	Experimental
	3. Division I out of sack. Fold blankets.	
	4. Fold bunks.	
	5. Cold meal for Division I, served by Division II food team.	
R + 1200	1. Activity log recorder relieved. (Division I)	1. Read and record: a. Sound level b. Water meters c. Temperatures d. Light level e. R.H. f. Electric meters
		2. Sick call.
R + 1300	1. Clean shelter. (Division II)	
R + 1400	1. Bunks unfolded.	
	2. Smoking restricted to areas near ventilator outlets.	
	3. Division II in sack.	
	4. Activity log recorder relieved. (Division I)	
	5. Quiet period begins.	
R + 1500	1. Quiet period ends.	1. Initial weight of Division I WB subjects (in shorts).
R + 1600	1. Activity log recorder relieved. (Division I)	
R + 1700		1. Second weight of Division I WB subjects (in shorts) for sweat rate estimation.
R + 1740		1. Activate BW sampler.
R + 1755		1 Secure BW sampler.
R + 1800	1. Activity log recorder relieved. (Division I)	1. Pass BW samples outside.
	2. Inspect diesel generator and monitor entrance tunnel. (Division I)	2. Calibrate: a. CO_2 recorder b. CO recorder c. Aerosol recorder d. R. H. recorder

Time (hours)	Tasks	
	Normal	Experimental
R + 2000	1. Activity log recorder relieved. (Division I) 2. Determine and record: (Division I) a. Pressure b. Percent O_2 in atm c. Percent CO in atm d. Percent CO_2 in atm	1. Read and record: a. Sound level b. Water meters c. Temperatures d. Light level e. R. H. f. Electric meters 2. Change mass concentration aerosol samplers. 3. Change trace gas samplers.
R + 2100	1. Hot meal for Division I.	
R + 2200	1. Activity log recorder relieved. (Division I) 2. Smoking restrictions removed. 3. Division II out of sack. Fold blankets. 4. Fold bunks. 5. Cold meal for Division II, served by Division I cooks.	1. Entire Division I has T-P-W taken after urinating and prior to eating.
R + 2400	1. End of first "Regular" time cycle.	
1R + 0000	Repeat with following additions.	
1R + 0300		1. Initial weight of Division II WB subjects (in shorts). Repeat, every 24 hours.
1R + 0500		1. Second weight of Division II WB subjects for sweat rate estimate.

NOTES:

1. On shelter occupancy days 5, 8, 11, and 14, bacteriological personnel (selected during pretrial indoctrination) will have throat cultures and rectal swabs taken during a period when all subjects are awake.
2. At R + 0600 and R + 1800 samples may be passed out of the shelter. Urine and biological samples will be passed out on a regular schedule.
3. After leaving the shelter the liquid intake and urine output will continue to be monitored on all WB subjects for 48 hours.
4. For 48 hours after leaving shelter, all subjects will report for morning sick call.
5. During each of the first two 24-hour periods after leaving the shelter, each WB subject will have his sweat rate estimated during a period of activity.

APPENDIX C

Schedule for Two-Week Winter Trial in
BuDocks Protective Shelter

On the basis of the two-day trial, the preliminary schedule shown in Appendix B was revised. The E and R designations were deleted. This new schedule was used throughout the two-week trial.

SCHEDULE (PRE-ENTRY)

Time	Normal	Experimental
Feb. 13		1. Hold indoctrination on all subjects and review health records.
Feb. 13 thru 15 (Inclusive)		1. Daily morning nude weight after urination. 2. Daily sick call. 3. Daily morning temperatures after arising. 4. Daily evening temperatures before chow. 5. Daily standing pulse rates morning and evening. 6. Continued psychiatric observation and possible further screening of subjects.
Feb. 15		1. Physical Fitness Test. (Harvard Step test)
Feb. 16		1. T-P-W morning and evening. 2. Sick call with EENT examination. 3. Rectal swabs and throat cultures on all subjects.
Feb. 17		1. T-P-W Morning. 2. Morning sick call.

SCHEDULE (ORGANIZATION PHASE)

Time	Normal	Experimental
Feb. 17 1000		1. Activate CO_2, CO, and aerosol recorders. 2. Read and record (a) temperatures, (b) sound level, (c) R.H., (d) water meters, and (e) electric meters.
1100	1. Enter Shelter; Shelter Commander (SC) identifies himself and assumes command. 2. Smoking lamp out. 3. Secure blast door and blast valves. 4. Secure city water supply. 5. Shelterees stand in center, awaiting blast, while SC discusses effects of blast. (Radio on to CONELRAD simulated)	1. Activate mass concentration aerosol sampler and trace gas sampler. 2. Read and record (a) sound level, (b) temperatures, and (c) R.H.
1120	1. "Blast." SC appoints temporary Activity Recorder, who activates clock and begins Activity Log. 2. SC calls for temporary engineer team to start generator and activate heads. 3. SC discusses purpose of test and organization pattern to be followed.	
1145	1. SC checks with engineering team to be sure instructions are understood on generator and head activiation.	
1200	1. SC gives general demonstration on use of radiac gear and dressing in protective clothing.	1. Read and record (a) temperatures, and (b) R.H.
1220	1. Engineering team departs to activate generator. 2. Heads are activated on inboard side only and opened to emergency use. 3. SC describes what team must do to start generator and how they go through air lock.	
1240	1. Generator starts up.	

Time	Normal	Experimental
1245	1. Lights on. Engineering team returns, discarding clothing and showering. 2. SC selects remainder of A group, primarily medical, and assigns temporary cooking team to begin first meal preparation. 3. Meantime, remainder of group aligns themselves into four divisions: "Bookkeeper," "Cooking," "Deck," "Engineering."	
1300	1. SC balances above divisions and appoints a "Port" and "Starboard" section leader.	1. Read and record (a) temperatures, and (b) R.H.
1320	1. Port section eats cold meal. Starboard section logs in, receives ID bibs, logs, instruction books, and ditty bags. 2. Starboard Eng. team determines and records: (a) pressure, (b) percent O_2, (c) percent CO, and (d) percent CO_2 in atm.	1. Change mass concentration aerosol sampler and trace gas sampler.
1325	1. Smoking lamp lighted (for experimental purposes).	
1340		1. Activate BW sampler.
1355	1. Starboard section eats cold meal. Port section logs in, etc.	1. Secure BW sampler.
1420	1. Port section Eng. team determines and records: (a) pressure, (b) percent O_2, (c) percent CO, and (d) percent CO_2 in atm. 2. Port section Eng. team dress in protective clothing (taking BW samples) and check air intake for CO level. If less than 100 ppm, they will open blast valves and activate air blower in filter room. Discard contaminated clothing and shower before entering shelter.	1. Change mass concentration aerosol sampler. 2. Change trace gas sampler. 3. Read and record: (a) sound level, (b) temperatures, (c) R.H. 4. Pass BW samples to outside.
1435	1. SC indicates original organizational phase completed and calls for Port Sec. D Division to set up bunks. Lecture on foot powder.	

Time	Normal	Experimental
1445	1. Pass out two blankets per man and port section in bunks. 2. SC calls for meeting with Division leaders. 3. Smoking restricted to front section. Exhort them to ration cigarettes.	
1520	1. Continue on Regular Schedule.	1. Read and record: (a) sound level, (b) temperatures, and (c) R.H.

REGULAR SCHEDULE

Time	Normal	Experimental
0000		1. Read and record: (a) sound level, (b) temperatures, (c) R.H., and (d) water meters.
0130	1. Clean shelter.(Starboard Sec. D Div.) 2. Assemble bunks.(Starboard Sec D Div.) 3. Eng. Team. Check generator.	
0200	1. Starboard Sec. in bunks. 2. Quiet period begins, with smoking restricted to forward area.	1. Change mass concentration aerosol sampler and trace gas sampler.
0230	1. Quiet period ends. However, noise level to be kept at a minimum.	1. Read and record: sound level. 2. Sick call for Port Section. Initial weight of Port Sec. WB subjects (in shorts).
0430		1. Second weight of WB subjects.
0800	1. Port Sec. Eng. team determine and record: (a) pressure, (b) percent O_2, (c) percent CO and (d) percent CO_2 in atm.	
0900	1. Hot meal for Port Section.	
1000	1. Starboard Sec. out of bunks (leave blankets in bunks). 2. Set up bunks, out of the way. (Port Sec. D Div.) 3. Smoking restrictions removed.	1. Entire Stb'd Sec. has T-P-W taken after urinating and prior to eating. 2. Change mass concentration aerosol sampler and trace gas sampler.

Time	Normal	Experimental
1015	1. Cold meal for Stb'd Sec. served by Port Sec. Cooking Div.	
1045	1. Clean shelter (Port Sec., D Div.).	
1100	1. Set up shelter for further activity (will generally be along instructional line during this "common" period).	
1200		1. Read and record: (a) sound level, (b) temperatures, (c) R.H., and (d) electric meters.
1300	1. Clean Shelter.(Port Sec., D Div.)	1. Activate BW sampler.
1315		1. Secure BW sampler.
1330	1. Assemble Bunks.(Port Sec., D Div.) 2. Eng. team check generator.	
1400	1. Port Section in bunks. 2. Quiet period begins, smoking restricted to forward area.	1. Change mass concentration aerosol sampler and trace gas sampler.
1430	1. Quiet period ends, however, noise level to be kept to a minimum.	1. Read and record sound level.
1500		1. Sick call for Stb'd Sec. 2. Initial weight of Stb'd Sec. WB subjects (in shorts).
1700		1. Second weight of Stb'd Sec. WB subjects (in shorts).
2000	1. Stb'd Sec. Eng. team determine and record: (a) pressure (b) percent O_2, (c) percent CO and (d) percent CO_2 in atm.	1. Read and record: (a) sound level, (b) temperatures, and (c) R.H.
2100	1. Hot meal for Stb'd Section.	
2200	1. Port Sec. out of bunks (leave blankets in bunk). 2. Set up bunks, out of the way. (Port Sec., D Div.) 3. Smoking restrictions removed.	1. Entire Port Sec. has T-P-W taken after urinating and prior to eating. 2. Change mass concentration aerosol and trace gas samplers.

Time	Normal	Experimental
2215	1. Cold meal for Port Sec. served by Stb'd Sec. Cooking Div.	
2245	1. Clean shelter. (Stb'd sec. D Div.)	
2300	1. Set up shelter for further activity (will generally be along group recreational lines during this "common" period).	
2400	1. End of "regular" daily schedule.	

APPENDIX D

Test Scales for Psychological Studies in BuDocks Protective Shelter

INTRODUCTION

Two structured scales were used to tap responses to discomfort factors. One scale was a ranking scale utilizing 21 sources of discomfort. The second scale was a Likert-type scale composed of multiple-choice items.

RANKING SCALE

This scale was based on the 21 factors utilized by Altman, et al. (1960), in the fallout-shelter studies conducted by the American Institute for Research. A copy of the scale is contained later in this appendix. The scale was constructed by randomly ordering the factors in a single list. The subjects were required to rank the factors in terms of relative importance as discomfort sources, designating the most important factor as number one and the least important as number 21. The instructions required that the subject rank order the discomfort factors twice, once in terms of acuteness and the second time in terms of generality of discomfort. The dual ranking was carried out at each administration of the scale.

It was anticipated that the subjects might experience difficulty in shifting their frame of reference as required to rank the discomfort indices both in terms of acuteness and generality. In order to facilitate this shift, the items were presented separately with specific instructions at the top of each page. These instructions were in addition to the longer and more detailed instructions presented at the beginning of the testing session.

The scale was pretested during the two-day trial. This gave an indication of operational validity of the scale in terms of consistency of response between subjects to the ranking of discomfort indices. Further, it was possible to assess the adequacy and clarity of instructions. This latter point is considered particularly critical in view of the shift in frame of reference which was required on the part of the subjects.

A Kendall Coefficient of Concordance was run to determine general agreement of the subjects on acuteness as well as on generality. A coefficient of 0.29 was obtained for acuteness and of 0.27 for generality. Both of these statistics were significant beyond the 0.001 level of confidence, thus indicating an extremely high degree of agreement between subjects. However, the amount of total variance accounted for by this agreement was actually quite small. Thus, it may be concluded that the scale, as designed, tapped discomfort sources with sufficient uniformity among subjects to permit generalization to the sample of shelterees as a whole. However, this agreement among subjects did not mask individual differences in responsiveness to discomfort sources.

A Spearman Rho Coefficient of Correlation of 0.90 was obtained between rankings based on acuteness and rankings based on generality; this statistic was significant beyond the 0.01 level of confidence. Thus, there was a high degree of agreement between acuteness rankings and generality rankings, although sufficient variance was left unaccounted for to justify retention of separate rankings in terms of acuteness and generality.

LIKERT-TYPE SCALE

This scale was based on 13 of the 21 factors utilized in the ranking scale. The use of a smaller number of factors was based on the desirability both of limiting the period of scale administration to approximately one hour, and of reducing data-processing requirements. The 13 factors selected were those which had been found by Altman, et al. (1960) to be ranked highest, and/or which appeared likely to be most salient under the conditions of the present study. A copy of the scale is contained later in this appendix.

The scale was constructed by developing, for each discomfort factor four multiple-choice items, two items pertaining to acuteness of discomfort and two items relating to generality of discomfort. Acuteness items and generality items were presented, with appropriate instructions, in separate sections of the scale, and the order of items was random within a section. The entire scale was presented at each administration. The Likert-type scale, like the ranking scale, was pretested during the two-day trial, for purposes of determining its operational validity and clarity of instructions. A Spearman rho between rankings based on acuteness and ratings based on generality was equal to 0.94, which was significant beyond the 0.001 level. As before, this correlation coefficient indicated a high degree of agreement, but there was sufficient variability unaccounted for to justify retention of separate acuteness and generality ratings. Since it was considered possible that differences between the ranking scale and the Likert-type scale, in item form and instructions, would tap responses to discomfort factors in different ways, it was considered desirable to measure the relationship between the two types of scales. A Spearman rho was therefore calculated between acuteness on the two types of scales and between generality on the two types of scales. The rho based on acuteness was equal to 0.90, and the rho based on generality equalled 0.95, both significant beyond the 0.01 level. The magnitude of these correlation coefficients allowed the conclusion that the two types of scales were tapping responsiveness to discomfort factors in similar ways, and that meaningful comparisons could be made between sets of data obtained from the two types of scales.

(1)

Ranking Scale, Administration #1

NAME: _____ AGE: ____ HIGHEST SCHOOL

SERVICE NUMBER: _____ GRADE COMPLETED: _____

SHELTER NUMBER: _____

As you might well expect, life in a fallout shelter isn't exactly like life at home. Almost everybody finds at least some things about shelter living to be uncomfortable. However, the things that bother one man might not really be important to others. In order to learn more about living in shelters, the Navy must find out the things that bother people. In the next few minutes, you are going to be asked to answer some questions about things which you think will bother you. Remember in answering all of these questions, we are concerned only about the things that you think will bother you; do not worry about whether you answer the questions in the same way as your buddies.

The next few pages contain a number of different things which may bother you in shelter living. On those pages, you will find 21 things that may bother you. You can tell us how you think they will bother you by "ranking" them. That is, you give rank #1 to the thing that you think will bother you most, rank #2 to the second most bothersome thing, and so forth, until the least bothersome thing gets rank #21.

Past studies in fallout shelters have shown that there are two ways in which people are made uncomfortable by shelter living. First, some things about the shelter may be uncomfortable almost all of the time; however, you could probably stand to live with them for a long time. On the other hand, there are certain factors in shelter living which do not make you uncomfortable very often; but, at the same time they are things you find very hard to take at those times when they do occur. Because we know that things can be uncomfortable and bother people in these two different ways, the things in this questionnaire are divided into two sections. In one section, you rank the things according to how often you think they will bother you even though they may not make you too uncomfortable at any one time. In the other section, you rank the things according to how much you think they will make you uncomfortable at any one time even though they may not bother you too frequently. Please be sure that you understand the difference between the way you are to rank the things in the two sections before you start working on the questionnaire.

If you are certain you understand what you are expected to do, turn to the next page and follow the instructions.

On this page, you will rank the 21 things according to how much you think they will bother you at any one time, even though they may not necessarily bother you too often. You give a thing its rank by putting a number in the space alongside the thing. The easiest way to do this is to find the thing that you think will bother you worst of all and put the number "1" alongside it. Then find the thing that you think will both you least of all and put number "21" alongside it. Next, put number "2" beside the thing that you think will bother you second worst, number "20" beside the thing that you think will bother you second least, and so forth. Keep this up until you have a number alongside all of the 21 things. Be sure to rank all things, and don't use the same number more than once.

Remember, you are ranking these things according to how much you think they will bother you at any one time, even though they may not necessarily bother you too often. Be sure to rank all things, and don't use the same number twice.

_____ Lights while sleeping

_____ Crowding of shelter

_____ Lack of water for washing

_____ Bunks

_____ Physical symptoms

_____ Lack of exercise

_____ Behavior of others

_____ Chow

_____ Lack of privacy

_____ Lack of organization

_____ Smells

_____ Not able to concentrate

_____ Worries about the outside

_____ Head facilities

_____ Temperature and humidity

_____ Lights while awake

_____ Dirt

_____ Noise

_____ Poor leadership

_____ Boredom

_____ Trouble sleeping

DO NOT GO ON TO THE NEXT PAGE UNTIL YOU HAVE FINISHED THIS ONE; ONCE YOU HAVE GONE ON TO THE NEXT PAGE, DO NOT TURN BACK TO THIS ONE.

On this page, you will rank the 21 things according to how <u>often</u> you think they will bother you, even though they may not bother you too much at any one time. You give a thing its rank by putting a number in the space alongside the thing. The easiest way to do this is to find the thing that you think will bother you <u>most often</u> and put the number "1" alongside it. Then find the thing that you think will bother you <u>least often</u> and put the number "21" alongside it. Next, put number "2" beside the thing that you think will bother you <u>second most often</u>, number "20" beside the thing that you think will bother you <u>second least often</u>, and so forth. Keep this up until you have a number alongside all of the 21 things. Be sure to rank <u>all</u> things, and don't use the same number more than once.

Remember, you are rating these things according to how <u>often</u> you think they will bother you, even though they may not bother you too much at any one time. Be sure to rank all things, and don't use the same number twice.

_____ Lights while sleeping

_____ Crowding of shelter

_____ Lack of water for washing

_____ Bunks

_____ Physical symptoms

_____ Lack of exercise

_____ Behavior of others

_____ Chow

_____ Lack of privacy

_____ Lack of organization

_____ Smells

_____ Not able to concentrate

_____ Worries about the outside

_____ Head facilities

_____ Temperature and humidity

_____ Lights while awake

_____ Dirt

_____ Noise

_____ Poor leadership

_____ Boredom

_____ Trouble sleeping

(2)

Ranking Scale, Administration #2

NAME: _____ AGE: ____ HIGHEST SCHOOL

SERVICE NUMBER: _____ GRADE COMPLETED: _____

SHELTER NUMBER: _____

Not too long before the test started you were given a questionnaire to learn what things about shelter living you expected would make you feel uncomfortable. From other tests which have been made at fallout shelters, we know that the things which people expect will make them uncomfortable are sometimes not the same as the things which bother them after they have been in the shelter for a while. Thus, today we would like you to go through the same questionnaire that you took before and answer it according to how you feel after being here for a period of time. Because things which you thought would make you uncomfortable before entering the shelter may not be important to you now, or because other things now seem to bother you more, do not try to remember how you answered the first questionnaire. At this time we are interested only in how you feel about the things now. The instructions for answering the questionnaire, which are the same as before, are given below.

The next few pages contain a number of different things which may bother you in shelter living. On those pages, you will find 21 things that may bother you. You can tell us how they bother you by "ranking" them. That is, you give rank #1 to the thing that bothers you most, rank #2 to the second most bothersome thing, and so forth, until the least bothersome thing gets rank #21.

Past studies in fallout shelters have shown that there are two ways in which people are made uncomfortable by shelter living. First, some things about the shelter may be uncomfortable almost all of the time; however, you could probably stand to live with them for a long time. On the other hand, there are certain factors in shelter living which do not make you uncomfortable very often, but at the same time, they are things you find very hard to take at those times when they do occur. Because we know that things can be uncomfortable and bother people in these two different ways, the things in this questionnaire are divided into two sections. In one section, you rank the things according to how often they bother you even though they may not make you too uncomfortable at any one time. In the other section, you rank the things according to how much they make you uncomfortable at any one time even though they may not bother you too frequently. Please be sure that you understand the difference between the way you are to rank the things in the two sections before you start working on the questionnaire.

If you are certain you understand what you are expected to do, turn to the next page and follow the instructions.

NOTE: The instructions and questions in this questionnaire are the same as those appearing in the first questionnaire.

(3)

Likert-Type Scale, Administration #1

NAME: _____ AGE: _____ HIGHEST SCHOOL

SERVICE NUMBER: _____ GRADE COMPLETED: _____

SHELTER NUMBER: _____

As you have found out by this time, life in a fallout shelter isn't exactly like life at home. Almost everybody finds at least some things about shelter living to be uncomfortable. However, the things that bother one man might not really be important to others. In order to learn more about living in shelters, the Navy must find out the things that bother people. In the next few minutes, you are going to be asked to answer some questions about things which bother you. Remember in answering all of these questions, we are concerned only about the things that bother you; do not worry about whether you answer the questions in the same way as your buddies.

The next few pages contain a number of different statements about things which may bother you in shelter living. In each question a statement will be made at the beginning of a sentence, and after this will be five endings for the sentence. You are to make a check mark alongside the sentence ending which best describes how the thing bothers you.

Past studies in fallout shelters have shown that there are two ways in which people are made uncomfortable by shelter living. First, some things about the shelter may be uncomfortable almost all of the time; however, you could probably stand to live with them for a long time. On the other hand, there are certain factors in shelter living which don't make you uncomfortable very often; but, at the same time they are things you find very hard to take at those times they do occur. Because we know that things can be uncomfortable and bother people in these two different ways, the statements in this questionnaire are divided into two sections. In one section, the statements have to do with how often things bother you even though they may not make you too uncomfortable at any one time. In the other section, the questions deal with how much these things make you uncomfortable at any one time, even though they may not bother you too frequently. Please be sure that you understand the difference between the way you are to answer the statements in the two sections before you start working on the questionnaire.

If you are certain you understand what you are expected to do, turn to the next page and follow the instructions.

This section has to do with how much things bother you at any one time, even though they may not bother you too often. You tell us how much they bother you by making a check mark alongside the sentence ending that best describes how much you are bothered.

If none of the sentence endings describes exactly how much you are bothered, check the ending that comes nearest. Be sure to answer all of the things.

1. Compared to other things that disturb me in the shelter the problem of dirt is

   a. ( ) almost the toughest to take
   b. ( ) worse than many others
   c. ( ) about average
   d. ( ) better than many others
   e. ( ) almost the easiest to take

2. Compared to other problems in the shelter, lack of privacy upsets me

   a. ( ) nearly the least of all
   b. ( ) less than many others
   c. ( ) about average
   d. ( ) more than many others
   e. ( ) nearly the worst of all

3. Lack of sleep in the shelter causes me

   a. ( ) no discomfort
   b. ( ) not much discomfort
   c. ( ) medium discomfort
   d. ( ) quite a bit of discomfort
   e. ( ) extreme discomfort

4. Compared to other problems in the shelter, noise upsets me

   a. ( ) nearly the worst of all
   b. ( ) more than many others
   c. ( ) about average
   d. ( ) less than many others
   e. ( ) nearly the least of all

5. Lack of water for washing in the shelter disturbs me

   a. ( ) not at all
   b. ( ) fairly little
   c. ( ) about medium
   d. ( ) quite a bit
   e. ( ) very badly

6. Lack of privacy in the shelter causes me

   a. ( ) extreme discomfort
   b. ( ) quite a bit of discomfort
   c. ( ) medium discomfort
   d. ( ) not much discomfort
   e. ( ) no discomfort

7. Compared to other problems in the shelter, lack of exercise upsets me

a. ( ) nearly the least of all
b. ( ) less than many others
c. ( ) about average
d. ( ) more than many others
e. ( ) nearly the worst of all

8. The behavior of other people in the shelter disturbs me

a. ( ) very badly
b. ( ) quite a bit
c. ( ) about medium
d. ( ) fairly little
e. ( ) not at all

9. Compared to other things that disturb me in the shelter, the problem of crowding is

a. ( ) almost the easiest to take
b. ( ) better than many others
c. ( ) about average
d. ( ) worse than many others
e. ( ) almost the toughest to take

10. The chow in the shelter causes me

a. ( ) no discomfort
b. ( ) not much discomfort
c. ( ) medium discomfort
d. ( ) quite a bit of discomfort
e. ( ) extreme discomfort

11. Compared to other problems in the shelter, lack of sleep upsets me

a. ( ) nearly the worst of all
b. ( ) more than many others
c. ( ) about average
d. ( ) less than many others
e. ( ) nearly the least of all

12. The temperature and humidity in the shelter disturb me

a. ( ) very badly
b. ( ) quite a bit
c. ( ) about medium
d. ( ) fairly little
e. ( ) not at all

13. Compared to other things that disturb me in the shelter, the problem of lack of water for washing is

a. ( ) almost the toughest to take
b. ( ) worse than many others
c. ( ) about average
d. ( ) better than many others
e. ( ) almost the easiest to take

14. Dirt in the shelter disturbs me

a. ( ) not at all
b. ( ) fairly little
c. ( ) about medium
d. ( ) quite a bit
e. ( ) very badly

15. Compared to other problems in the shelter, temperature and humidity upset me

a. ( ) nearly the worst of all
b. ( ) more than many others
c. ( ) about average
d. ( ) less than many others
e. ( ) nearly the least of all

16. Compared to other things that disturb me in the shelter, the problem of food is

a. ( ) almost the easiest to take
b. ( ) better than many others
c. ( ) about average
d. ( ) worse than many others
e. ( ) almost the toughest to take

17. Smells in the shelter cause me

a. ( ) no discomfort
b. ( ) not much discomfort
c. ( ) medium discomfort
d. ( ) quite a bit of discomfort
e. ( ) extreme discomfort

18. Compared to other things that disturb me in the shelter, the problem of lights while sleeping is

a. ( ) almost the easiest to take
b. ( ) better than many others
c. ( ) about average
d. ( ) worse than many others
e. ( ) almost the toughest to take

19. Compared to other problems in the shelter, the bunks upset me

a. ( ) nearly the worst of all
b. ( ) more than many others
c. ( ) about average
d. ( ) less than many others
e. ( ) nearly the least of all

20. Noise in the shelter causes me

a. ( ) extreme discomfort
b. ( ) quite a bit of discomfort
c. ( ) medium discomfort
d. ( ) not much discomfort
e. ( ) no discomfort

21. Lack of exercise in the shelter disturbs me

a. ( ) not at all
b. ( ) fairly little
c. ( ) about medium
d. ( ) quite a bit
e. ( ) very badly

22. Compared to other problems in the shelter, the behavior of others upsets me

a. ( ) nearly the least of all
b. ( ) less than many others
c. ( ) about average
d. ( ) more than many others
e. ( ) nearly the worst of all

23. The bunks in the shelter cause me

a. ( ) no discomfort
b. ( ) not much discomfort
c. ( ) medium discomfort
d. ( ) quite a bit of discomfort
e. ( ) extreme discomfort

24. Crowding in the shelter disturbs me

a. ( ) very badly
b. ( ) quite a bit
c. ( ) about medium
d. ( ) fairly little
e. ( ) not at all

25. Lights while sleeping in the shelter cause me

a. ( ) extreme discomfort
b. ( ) quite a bit of discomfort
c. ( ) medium discomfort
d. ( ) not much discomfort
e. ( ) no discomfort

26. Compared to other things that disturb me in the shelter, the problem of smells is

a. ( ) almost the toughest to take
b. ( ) worse than many others
c. ( ) about average
d. ( ) better than many others
e. ( ) almost the easiest to take

DO NOT GO ON TO THE NEXT SECTION UNTIL YOU HAVE FINISHED THIS ONE. ONCE YOU HAVE GONE ON TO THE NEXT SECTION DO NOT TURN BACK TO THIS ONE.

This section has to do with how often things bother you, even though they may not bother you too much at any one time. You tell us how often they bother you by making a check mark alongside the sentence ending that best describes how often you are bothered.

If none of the sentence endings describes exactly how often you are bothered, check the ending that comes nearest. Be sure to answer all the things.

27. Compared to other things that make me uncomfortable, dirt in the shelter bothers me

a. ( ) much more often
b. ( ) somewhat more often
c. ( ) just about as often
d. ( ) somewhat less often
e. ( ) much less often

28. Compared to other things that make me uncomfortable, lack of privacy in the shelter bothers me

a. ( ) much less frequently
b. ( ) somewhat less frequently
c. ( ) just about as frequently
d. ( ) somewhat more frequently
e. ( ) much more frequently

29. Lack of sleep in the shelter bothers me

a. ( ) almost none of the time
b. ( ) little of the time
c. ( ) about half of the time
d. ( ) much of the time
e. ( ) almost all of the time

30. Compared to other things that make me uncomfortable, noise in the shelter bothers me

a. ( ) much more frequently
b. ( ) somewhat more frequently
c. ( ) just about as frequently
d. ( ) somewhat less frequently
e. ( ) much less frequently

31. Lack of water for washing in the shelter bothers me

a. ( ) less than 1/4 of the time
b. ( ) about 1/4 of the time
c. ( ) about 1/2 of the time
d. ( ) about 3/4 of the time
e. ( ) more than 3/4 of the time

32. Lack of privacy in the shelter bothers me

a. ( ) almost all of the time
b. ( ) much of the time
c. ( ) about half of the time
d. ( ) little of the time
e. ( ) almost none of the time

33. Compared with other things that make me uncomfortable, lack of exercise in the shelter bothers me

a. ( ) much less frequently
b. ( ) somewhat less frequently
c. ( ) just about as frequently
d. ( ) somewhat more frequently
e. ( ) much more frequently

34. The behavior of other people in the shelter bothers me

a. ( ) more thab 3/4 of the time
b. ( ) about 3/4 of the time
c. ( ) about 1/2 of the time
d. ( ) about 1/4 of the time
e. ( ) less than 1/4 of the time

35. Compared to other things that make me uncomfortable, crowding in the shelter bothers me

a. ( ) much less often
b. ( ) somewhat less often
c. ( ) just about as often
d. ( ) somewhat more often
e. ( ) much more often

36. The chow in the shelter bothers me

a. ( ) almost none of the time
b. ( ) little of the time
c. ( ) about half of the time
d. ( ) much of the time
e. ( ) almost all of the time

37. Compared to other things that make me uncomfortable, lack of sleep in the shelter bothers me

a. ( ) much more frequently
b. ( ) somewhat more frequently
c. ( ) just about as frequently
d. ( ) somewhat less frequently
e. ( ) much less frequently

38. The temperature and humidity in the shelter bother me

a. ( ) more than 3/4 of the time
b. ( ) about 3/4 of the time
c. ( ) about 1/2 of the time
d. ( ) about 1/4 of the time
e. ( ) less than 1/4 of the time

39. Compared to other things that make me uncomfortable, lack of water for washing in the shelter bothers me

a. ( ) much more often
b. ( ) somewhat more often
c. ( ) just about as often
d. ( ) somewhat less often
e. ( ) much less often

40. Dirt in the shelter bothers me

a. ( ) less than 1/4 of the time
b. ( ) about 1/4 of the time
c. ( ) about 1/2 of the time
d. ( ) about 3/4 of the time
e. ( ) more than 3/4 of the time

41. Compared to other things that make me uncomfortable, temperature and humidity in the shelter bother me

a. ( ) much more frequently
b. ( ) somewhat more frequently
c. ( ) just about as frequently
d. ( ) somewhat less frequently
e. ( ) much less frequently

42. Compared to other things that make me uncomfortable, food in the shelter bothers me

a. ( ) much less often
b. ( ) somewhat less often
c. ( ) just about as often
d. ( ) somewhat more often
e. ( ) much more often

43. Smells in the shelter bother me

a. ( ) almost none of the time
b. ( ) little of the time
c. ( ) about half of the time
d. ( ) much of the time
e. ( ) almost all of the time

44. Compared to other things that make me uncomfortable, lights while sleeping in the shelter bother me

a. ( ) much less often
b. ( ) somewhat less often
c. ( ) just about as often
d. ( ) somewhat more often
e. ( ) much more often

45. Compared to other things that make me uncomfortable, the bunks in the shelter bother me

a. ( ) much more frequently
b. ( ) somewhat more frequently
c. ( ) just about as frequently
d. ( ) somewhat less frequently
e. ( ) much less frequently

46. Noise in the shelter bothers me

a. ( ) almost all of the time
b. ( ) much of the time
c. ( ) about half of the time
d. ( ) little of the time
e. ( ) almost none of the time

47. Lack of exercise in the shelter bothers me

a. ( ) less than 1/4 of the time
b. ( ) about 1/4 of the time
c. ( ) about 1/2 of the time
d. ( ) about 3/4 of the time
e. ( ) more than 3/4 of the time

48. Compared to other things that make me uncomfortable, the behavior of others in the shelter bothers me

a. ( ) much less frequently
b. ( ) somewhat less frequently
c. ( ) just about as frequently
d. ( ) somewhat more frequently
e. ( ) much more frequently

49. The bunks in the shelter bother me

a. ( ) almost none of the time
b. ( ) little of the time
c. ( ) about half of the time
d. ( ) much of the time
e. ( ) almost all of the time

50. Crowding in the shelter bothers me

a. ( ) more than 3/4 of the time
b. ( ) about 3/4 of the time
c. ( ) about 1/2 of the time
d. ( ) about 1/4 of the time
e. ( ) less than 1/4 of the time

51. Lights while sleeping in the shelter bother me

a. ( ) almost all of the time
b. ( ) much of the time
c. ( ) about half of the time
d. ( ) little of the time
e. ( ) almost none of the time

52. Compared to other things that make me uncomfortable, smells in the shelter bother me

a. ( ) much more often
b. ( ) somewhat more often
c. ( ) just about as often
d. ( ) somewhat less often
e. ( ) much less often

(4)
Likert-Type Scale, Administration #2

NAME: _____ AGE: _____ HIGHEST SCHOOL

SERVICE NUMBER: _____ GRADE COMPLETED: _____

SHELTER NUMBER: _____

Not too long after the test started, you were given a questionnaire to learn what things about shelter living made you feel uncomfortable. From other tests which have been made in fallout shelters, we know that the things which bother people at first sometimes are not the same as the things which bother them after they have been in the shelter longer. Thus, today we would like you to go through the same questionnaire that you took before and answer them according to how you feel after being here for a longer period of time. Because things which made you uncomfortable early in the study might not be important to you now; or, other things now seem to bother you more, do not try to remember how you answered the first questionnaire. At this time, we are interested in learning only how you feel about these things now. The instructions for answering the questionnaire, which are the same as before, are given below.

The next few pages contain a number of different statements about things which may bother you in shelter living. In each question a statement will be made at the beginning of a sentence, and after this will be five endings for the sentence. You are to make a check mark alongside the sentence ending which best describes how the thing bothers you.

Past studies in fallout shelters have shown that there are two ways in which people are made uncomfortable by shelter living. First, some things about the shelter may be uncomfortable almost all of the time; however, you could probably stand to live with them for a long time. On the other hand, there are certain factors in shelter living which do not make you uncomfortable very often; but, at the same time, they are things you find very hard to take at those times when they do occur. Because we know that things can be uncomfortable and bother people in these two different ways, the statements in this questionnaire are divided into two sections. In one section, the statements have to do with how often things bother you even though they may not make you too uncomfortable at any one time. In the other section, the questions deal with how much these things make you uncomfortable at any one time even though they may not bother you too frequently. Please be sure that you understand the difference between the way you are to answer the statements in the two sections before you start working on the questionnaire.

If you are certain you understand what you are expected to do, turn to the next page and follow the instructions.

NOTE: The questions appearing in this questionnaire are the same as those in the first questionnaire in all details.

(5)

Debriefing Outline

1. In what particular ways did the following things bother you, and how could things be improved so they would bother you least?

   a. Lack of water for washing
   b. Chow
   c. Crowding
   d. Dirt
   e. Behavior of others

2. Compared to the way things looked before you went into the shelter, do you notice any differences in the sizes or distances of things now? If so, what?

3. What were some of the problems you think could have been avoided or better handled by more effective leadership? How?

4. Were there certain people in the shelter who made your stay easier? Who and why?

5. Could group cooperation and morale have been higher? If so, how could they have been raised?

6. How did shelter life differ from what you expected it would be?

7. How would you feel about spending a month in this shelter?

8. What do you remember as your most unpleasant shelter experience?

9. What do you remember as your most pleasant shelter experience?

10. Aside from making the shelter bigger, what changes in it would make things easier or pleasanter for the shelterees?

11. What suggestions could you give to future shelterees that would make their shelter stay easier or more pleasant?

12. Do you have any other comments which you think might be helpful to us in our future studies, or anything else you would like to get off your chest?

APPENDIX E

Statistical Treatment of Psychological Test Data Appropriate to Each Objective

The psychological investigations for the shelter trials were focused primarily on identifying and measuring subjective discomfort factors during the shelter experience, and secondly upon generalized psychological or emotional response to shelter living. In the following paragraphs, we have divided this primary purpose into five objectives and have discussed each objective with respect to the psychological data obtained during the trials.

Objective 1: To determine the extent of agreement among shelterees on the subjective importance of discomfort sources in the prototype shelter.

To achieve this objective, two statistical approaches were in order. First, four measurements of intersubject agreement were utilized, i.e., for preshelter acuteness preshelter generality, seventh-day acuteness, and seventh-day generality. The measure of agreement utilized was the Kendall Coefficient of Concordance (W), computed from data yielded by the ranking scale. These Kendall W's are presented in Table E1, from which it is evident that all W's are significant beyond the 0.001 level.

Second, in order to pursue several objectives of the present study, the Likert-type scale data were subjected to analysis of variance in a four-variable design. This design permitted determination of the significance of variance of subjects, of scale sections (i.e., acuteness and generality), of time (i.e., early versus late administration), and of discomfort factors, and of interaction between and among these four variables. The sources of variance and their statistical significance are indicated in Table E2.

The particular focus under the present objective was upon the variance attributable to subjects, which as Table E2 indicates was significant beyond the 0.01 level. Thus, while the degree of agreement indicated by the Kendall W's was indeed significant, a large portion of the variance was left unaccounted for by this nonparametric measure, and intersubject differences were revealed by the analysis of variance.

Objective 2: To determine the relative importance of various sources of psychological discomfort in terms of both "acuteness" and "generality" of discomfort.

Both the ranking and the Likert-type scales were utilized in approaching this objective. The data yielded by these scales were utilized in three ways. First, as indicated by the upper two entries of Table E3, measures of correspondence between rankings based on acuteness and those based on generality were calculated for a given administration of the scale. The measure of correlation utilized was the Spearman rho, and the appropriate coefficient of correlations are presented in Table E3. All correlations are significant beyond the 0.001 level.

Second, while the magnitude of these rhos left some variance unaccounted for, it was considered sufficiently high that a combination of data from the acuteness and generality sections of the Likert-type scale was possible in order to reveal an over-all picture of the

magnitude of discomfort attributed to each discomfort factor. In addition, variance attributable to discomfort being of a statistically significant magnitude, as indicated in Tabl E2, the significance of differences among means of measured discomfort for each factor were computed. For this purpose, Duncan's New Multiple Range Test was utilized, and the results are presented in Table E4.

Third, the rhos of Table E3 indicated that a less-than-perfect relationship existed between the acuteness and generality dimensions of discomfort. Table E2 showed that a significant degree of variance was attributable to acuteness-generality; therefore, differences between the means of acuteness and of generality for each discomfort factor were computed for both Day 2 and Day 12. Student's t test was utilized to determine the significance of these differences, and the results are presented in Tables E5 and E6.

Objective 3: To determine the relationship between relative subjective importance of discomfort factors as anticipated prior to shelter entry and as experienced after several days' shelter occupancy.

The data on which pursuit of this objective was based were obtained from the ranking scale. Comparisons were made between results of the preshelter and of the Day 7 scale administrations for the acuteness and generality dimensions considered separately. Spearman rho's were utilized and are presented in the lower two entries of Table E3, both of which were significant beyond the 0.001 level.

Objective 4: To determine the relative subjective importance of discomfort factors as experienced during the earlier and later phases of shelter occupancy.

Table E2 indicated that the variance attributable to changes in response to discomfort over time was statistically significant. Therefore, the Likert-type scale data were analyzed by use of Student's t's to determine the significance of changes over time in response to each discomfort source, on the acuteness and generality dimensions. The results of these analyses are presented in Tables E7 and E8.

Objective 5: To determine the significance of interaction between and among a limited number of factors which appear of major importance in protective-shelter habitability.

The analysis of variance of Likert-type scale data allowed the achievement of this objective. The significance of the various interaction efforts is indicated in Table E2.

Table E1
Intersubject Agreement for Acuteness and Generality Sections of the Ranking Scale upon Preshelter and Seventh-Day Administrations

Administration	Scale Section	
	Acuteness	Generality
Preshelter	W = 0.24 *	W = 0.26*
7th Day	W = 0.30 *	W = 0.29*

*p less than 0.001

Table E2
Sources of Variance of Discomfort Factor Scores Obtained from the Likert-Type Scale

Source	Significance
Time (T)	p less than 0.01
Subjects (S)	p less than 0.01
Discomfort Factors (DF)	p less than 0.01
Scale Sections (AG)	p less than 0.01
T x S	p less than 0.01
T x DF	p less than 0.01
T x AG	N.S.*
S x DF	p less than 0.01
S x AG	p less than 0.05
DF x AG	p less than 0.05
T x S x DF	p less than 0.01
T x S x AG	N.S.*
T x DF x AG	N.S.*
S x DF x AG	N.S.*
T x S x DF x AG	N.S.*

*Not significant.

Table E3
Spearman Rhos for Acuteness-Generality, Acuteness-Acuteness, and Generality-Generality Comparisons Within the Ranking Scale Upon Pre-Shelter and Seventh-Day Administrations

Scale Sections Compared	Time of Comparison	Rho
Acuteness x Generality	Preshelter	0.96*
Acuteness x Generality	7th Day	0.98*
Acuteness x Acuteness	Preshelter-7th Day	0.81*
Generality x Generality	Preshelter-7th Day	0.86*

*$p < 0.001$

Table E4
Differences Between Ranked Means of Discomfort Factors Based on Acuteness and Generality With Measures From Day 2 and Day 12 Combined

Discomfort Factors	Means	Difference Between Means
Food	3.39	0.00
Lack of water for washing	3.39	0.51*
Crowding	2.88	0.07*
Dirt	2.81	0.34*
Behavior of others	2.47	0.16*
Lack of exercise	2.31	0.07*
Noise	2.24	0.08*
Lack of sleep	2.16	0.20*
Lack of privacy	1.96	0.11*
Bunks	1.85	0.05
Lights while sleeping	1.80	0.04
Odors	1.76	0.03
Temperature and humidity	1.73	

* $p < 0.05$

Table E5
Differences Between Means of Acuteness and Generality of Discomfort Based Upon Likert-Type Scale Data on Day 2

Discomfort Factor	Mean Acuteness	Mean Generality	Difference Between Means
Dirt	2.58	2.28	0.30*
Lack of privacy	1.94	1.91	0.03
Lack of sleep	2.26	2.13	0.13
Noise	2.32	2.23	0.09
Lack of water for washing	3.35	2.98	0.37*
Lack of exercise	2.31	2.24	0.07
Behavior of others	2.52	2.07	0.45*
Crowding	3.02	2.80	0.22
Food	3.30	3.32	0.02
Temperature and humidity	1.70	1.57	0.13
Odors	1.69	1.58	0.11
Lights while sleeping	1.71	1.66	0.05
Bunks	1.84	1.74	0.10*

* $p < 0.05$

Table E6
Differences Between Means of Acuteness and Generality of Discomfort Based Upon Likert-Type Scale Data on Day 12

Discomfort Factor	Mean Acuteness	Mean Generality	Difference Between Means
Dirt	3.28	3.09	0.19
Lack of privacy	1.96	2.03	0.07
Lack of sleep	2.12	2.14	0.02
Noise	2.22	2.21	0.01
Lack of water for washing	3.69	3.53	0.16
Lack of exercise	2.45	2.29	0.16
Behavior of others	2.78	2.48	0.30*
Crowding	2.95	2.77	0.18
Food	3.44	3.47	0.03
Temperature and humidity	2.01	1.66	0.35†
Odors	1.95	1.82	0.13
Lights while sleeping	1.99	1.86	0.14
Bunks	1.93	1.92	0.01

*$p < 0.05$
†$p < 0.01$

Table E7
Differences Between Means of Acuteness of Discomfort on Day 2 and Day 12 as Derived From Likert-Type Scale Data

Discomfort Factor	Acuteness Mean Day 2	Acuteness Mean Day 12	Difference Between Means
Dirt	2.58	3.28	0.70†
Lack of privacy	1.94	1.96	0.02
Lack of sleep	2.26	2.12	0.14
Noise	2.32	2.22	0.10
Lack of water for washing	3.35	3.69	0.34*
Lack of exercise	2.31	2.45	0.14
Behavior of others	2.52	2.78	0.26
Crowding	3.02	2.95	0.07
Food	3.30	3.44	0.14
Temperature and humidity	1.70	2.01	0.31
Odors	1.69	1.95	0.26
Lights while sleeping	1.71	1.99	0.28
Bunks	1.84	1.93	0.09

*$p < 0.05$
†$p < 0.01$

Table E8
Differences Between Means of Generality of Discomfort on Day 12 and Day 2 as Derived from Likert-Type Scale Data

Discomfort Source	Generality Mean Day 2	Generality Mean Day 12	Difference Between Means
Dirt	2.28	3.09	0.81†
Lack of privacy	1.91	2.03	0.12
Lack of sleep	2.13	2.14	0.01
Noise	2.23	2.21	0.02
Lack of water for washing	2.98	3.53	0.55†
Lack of exercise	2.24	2.29	0.05
Behavior of others	2.07	2.48	0.41*
Crowding	2.80	2.77	0.03
Food	3.32	3.47	0.15
Temperature and humidity	1.57	1.66	0.09
Odors	1.58	1.82	0.24
Lights while sleeping	1.66	1.86	0.20
Bunks	1.74	1.92	0.18

*$p < 0.05$
†$p < 0.01$

APPENDIX F

Glossary

afebrile – without fever

AMRNL – Army Medical Research and Nutrition Laboratory

anterior cervical lymphadenopathy – inflammation of the lymph glands in the front part of the neck

artifact – an artificial factor; a situation which probably will not exist under normal conditions

catabolic – that aspect of metabolism which pertains to the breakdown of body tissue

coryza – nasal catarrh, a cold in the head

dyshidrosis – a disorder of the sweat glands

enteric – pertaining to the intestines

erythrocyte – a red blood corpuscle

exogenous – developed or originating outside of the body

febrile – with fever

Ghon complex – a calcified area generally representing a healed tuberculin lesion

glycosuria – the presence of an abnormal amount of glucose in the urine

hematocrit – a centrifuge for separating the corpuscles from whole blood

hematuria – the discharge of blood in the urine

hemostasis – the controlling of bleeding

homeostasis – a tendency to uniformity for stability in the normal body status of the organism.

ICNND – Interdepartmental Committee on Nutrition for National Defense

insensible weight loss – weight loss which occurs without active sweating

Kendall coefficient of concordance (W) – a measure of the relation among several rankings of n objects or individuals

ketosis – a condition marked by the buildup of ketones in the body

Likert-type scale – a scale composed of multiple-choice items. Ordinarily the range of responses corresponds to five points on a continuum of evaluation ranging from one extreme through a neutral point to the opposite extreme

lymphadenopathy – disease of the lymph glands

NP assessment – neuropsychiatric assessment

pyridoxal – the 4-aldehyde of pyridoxine

pyridoxamine – the amine derivative of pyridoxine

pyridoxine – Vitamin B_6

reality-testing – the ability to perceive objective reality, to form meaningful judgments and to make appropriate responses

riboflavin – Vitamin B_2

S.D. – Standard deviation

Spearman rho – a coefficient of correlation based on a technique used with data which is in terms of rank order rather than in terms of actual measurement

Student's t – a number used to determine the significance of differences between samples which are too small in size to justify the use of standard deviations

thiamine – Vitamin B_1

tonometer – an apparatus used to collect gas and to keep it at atmospheric pressure

transketolase – one of the enzymes in the conversion of ribose-5-phosphate to glucose-6-phosphate

URI – upper respiratory infection

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