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CB COLLECTIVE PROTECTION OF MOBILE VEHICLES, VANS AND SHELTERS

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CB COLLECTIVE PROTECTION OF MOBILE VEHICLES, VANS AND SHELTERS

1. This handbook has been prepared under the CB Collective Protection Engineering Guide Task of Contract F08635-68-C-0015 for the Air Force Armament Laboratory, Eglin Air Force Base, Florida under the sponsorship of the Joint Technical Coordinating Group for Tactical Air Control Systems, working party on general support equipment.

2. This document presents a summary of engineering guidance relative to mobile field CB collection protection shelters. The document identifies and describes significant factors affecting the performance of shelter systems and summarizes the qualitative design requirements of CB collective protection equipment. The current state of the art is also presented in the form of an itemized list of current standardized equipment and items which are currently undergoing research and development.

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I. INTRODUCTION

1. PURPOSE

This handbook was originally prepared under the sponsorship of the working party on Ground Support Equipment, Joint Technical Coordinating Group, Tactical Air Control Systems (TACS). The original objective of the handbook was to provide basic guidance to development agencies having responsibility for providing a collective protection capability in TACS mobile field shelter systems. Nevertheless, the material presented has direct applicability in the provision of collective protection for field vehicles, vans and shelters of the military services. Though many of the general principles and listed equipments are applicable to fixed installations, this was by coincidence, full coverage of this specific technical area was not the objective, nor was the intent to supersede or update existing approved technical documentation and guidance relative to collective protection for fixed installations. For added information on collective protection for fixed installations, a bibliography of references for this technical area are included in the last section of the bibliography.

The objective of this handbook which is specifically addressed to field collection protection systems will be accomplished by:

Providing basic information on the qualitative design requirements of CB collective protection equipment for use by government agencies and their contractors in the planning and implementation of protective requirements for new development items.

Presenting pertinent design and performance data for current standardized equipment and items which are in the research and development stage.

Since this handbook provides only basic engineering guidance in this technical area, engineering assistance in the resolution of questions or problems which may arise in the provision of collective protection for mobile or fixed installations can be obtained from Defense Development and Engineering Laboratories, Edgewood Arsenal.

2. SCOPE

This handbook summarizes the state of the art for positive pressure CB collective protection shelters and contains information useful for the planning, design, testing, and evaluation of collective protection equipment.

The systems described in this handbook provide protection against chemical and biological agents and radioactive particulate matter; however, protection is not afforded against gamma radiation and neutrons.

Collective protection for aircraft and naval ships is not addressed in this handbook because of the peculiar nature of their operating environments and protection requirements.

II. SYSTEMS DEFINITION OF COLLECTIVE PROTECTION

1. REQUIREMENT FOR COLLECTIVE PROTECTION SYSTEM

The purpose of collective protection is to provide a protected environment in which individuals can carry out tactical functions without the encumbrance of individual CB protective equipment. Typical situations requiring collective protection are found in command posts, communications centers, fire control complexes, tactical and strategic air control centers, hospitals, and rest and relief stations.

It may also be necessary to provide protection for certain unoccupied equipment centers where contamination would prevent operation or maintenance of the equipment. The letter from Headquarters, USACDC to CG, USAMC, Subject: Ad Hoc Group on Environmental and Test Criteria for Collective Protection for Missile Control Complexes and Vans, 3 June 1964, states "The necessity for filtration of the air used to vent the electronic racks is not necessarily determined by the collective protection presumably applied for the protection of operating personnel. The complexity and sensitiveness of electronic equipment may make the equipment itself the prime target of an attack. The corrosiveness of several available candidate agents and the employment of potential anti-material agents can render the equipment inoperable or inaccurate. Consequently, future development of vans and shelters housing electronic gear should consider requirement for filtration of air used for ventilation of this equipment as well as the requirement of filtration of air for operation personnel."

2. CATEGORIES OF PROTECTION

To assist in the definition of protection requirements, the establishment of certain categories of protection was recommended by a subcommittee of the Working Party for General Support Equipment (JTCG/TACS) in 1968. Under this system, the degree of protection which is assigned to any facility depends upon the function of the facility and the need for its utilization in a toxic environment. In the code devised, the first character represents level of protection for operating personnel. The second character represents level of protection of personnel for entering or exit of the system enclosure. The third character represents level of protection for the system equipments mounted within the enclosure.

A is the highest level of protection and designates positive pressurization with purified air of an enclosure (i.e., shelter, van, vehicle body) for personnel, equipment (i.e., electronics, etc.) or material (i.e., food supplies).

B designates individual protection of personnel or equipment within an enclosure. Example: the air within the enclosure is contaminated, but purified air is mechanically supplied to ventilated face pieces (masks) of the individual occupants via hoses and protective clothing is utilized.

C designates that the enclosure is not protected and the occupants wear individual field protective masks and clothing when operating in a CB environment.

D designates an enclosure used for storage which is not normally occupied by personnel and which is sealed (built in or field expedient) to minimize the infiltration of contaminants during a CB attack.

O indicates no protection.

For the purposes of further definition, the code will be modified by the use of the following:

$\overline{}_1$ indicates the air purification equipment built into the system.

$\overline{}_2$ indicates the air purification equipment is an accessory item supplied by logistic support based on predetermined mission.

Where the level of protection must change under extreme environmental conditions, the following additional designations will be used with an explanation to define the specific environmental extreme involved:

/‾‾‾‾ indicates change in level of protection such as a result of a change from the normal ambient temperature (outside environments).

Example: AAA/AAC ₂

The AAA specifies that the system has maximum protection under normal ambient temperature. The /AAO specifies that the collective protection system protects the personnel under all conditions including entry and exit, but not the equipment. The ___ (2) specifies that the CB air purifying equipment is external and obtained from supply support when required. The space over the / divider is reserved for the explanation of the condition where the change occurs and will be filled in after the system is tested.

By standardization and use of these designators, all the services, the designers, and the users will establish a common language and better understanding of the CB protection required and provided by the particular system under development.

3. PRINCIPLE OF POSITIVE PRESSURE COLLECTIVE PROTECTION

Collective protection of this type is provided by a continuous input of filtered air into a shelter which maintains a slight positive pressure with reference to the outside atmosphere. Since the pressure inside the shelter is higher than that of the surrounding atmosphere, there is a continuous leakage of air outward from the shelter which precludes the entrance of outside atmospheric contaminants. The pressure differential does not have to be very large to achieve the desired effect - usually a difference of at least 0.5 in. wg between the protected area and the adjoining contaminated area is sufficient in all applications. This technique of providing protection is applicable to both permanent and portable type shelters and to mobile vehicles and vans. A motor blower is used to provide the necessary air flow through gas and particulate filters to provide both the overpressure and the ventilation requirements for the shelter. The blower can be driven by a gasoline engine or by electrical power from a generator or vehicle power supply depending on the specific application. Protective entry systems (airlocks) are provided where personnel must enter and exit from the shelter in a toxic environment. The airlock is usually maintained at a pressure slightly less than that of the shelter itself (but still above atmospheric pressure) and serves to prevent a significant loss of pressure in the shelter during entry and exit. Due to its relatively small volume, the airlock can be rapidly scavenged by filtered air to remove any contaminants which may have infiltrated during the entry-exit process. Partial or complete decontamination of entering peronnel may also be performed in the protective entrance chamber.

4. LEVEL OF PROTECTION PROVIDED

In general, the protection afforded by collective protection equipment is designed to be equivalent to that provided by the M17A1 Field Protective Gas Mask. The performance data for this mask is set forth in Chemical Warfare Laboratory Report 2203, "Final Design Report on Field Protective Mask," by B. L. Karpel, December 1957. Both aerosol and gas protection levels are described together with the projected number of gas attacks through which this mask could continue to provide protection. Present collective protection filter units have both an aerosol filter for the removal of particulate matter and a charcoal filter for the removal of toxic gases. The aerosol filter component is a mechanical filter which does not deteriorate in performance with extended use. It is, however, subject to "loading-up" and must be replaced when its resistance to airflow becomes excessive. Most units also employ a mechanical pre-filter and in some instances an inertial dust separator to remove larger aerosol particles and reduce the load on the particulate filter.

The gas filters used in gas-particulate filter units for providing collective protection are designed, so that at the rated air flow capacity, both the useful gas life and adsorption capacity for all types of chemical warfare agents equals or exceeds that of the field protective mask. The uniformity of charcoal performance in gas sorption is assured through the use of charcoal conforming to the requirements of MIL-C-13724, Charcoal, Activated, Impregnated ASC, dated 4 May 1960. This specification requires gas life testing with a variety of gases to insure the protective capability of the charcoal sorbent against typical classes of chemical warfare gases. When the approved charcoal is used in collective protection filters, the lots produced are randomly sampled and tested after rough handling at rated flow capacity with phosgene to insure proper utilization and performance of the sorbent in its use configuration.

The particulate filter which removes aerosols (liquid and solid particles) is tested on a 100 percent basis; using a 0.3 micron Dioctyl Phthalate (DOP) test smoke. The specification limit for penetration varies somewhat with the specific particulate filter, but is less than 0.03 percent with a removal efficiency of 99.97 percent or higher. It should be noted that the size of the test particulate is smaller than that normally achieved in field dissemination of tactical aerosols. In the range of 1-5 micron particles, these particulate filters have demonstrated removal efficiencies approaching a reduction factor of one million to one.

5. ELEMENTS OF POSITIVE PRESSURE COLLECTIVE PROTECTION SYSTEMS

The major elements of a complete positive pressure collective protection system can be identified as:

- Protective shelter
- Decontamination area
- Protective entrance (airlock)
- Gas Particulate filter unit
- Environmental control system (heating and cooling)
- Miscellaneous equipment (queing shelters, interconnects).

All of these elements may not be necessary in any particular system because of the various functions and requirements specific to each facility, structure, or vehicle. The following paragraphs discuss in general terms the characteristics of these elements.

(1) Protective Shelter

This element of the system provides the protected space in which necessary functions are carried out. The shelter size and filtered air requirements for ventilation depend upon its use. It can range in size from large rooms in fixed structures to the more confined space found in a tactical armored vehicle or missile control van. The important factor is that the personnel utilizing this space have complete freedom from the restrictions imposed by masks or protective clothing. The function assigned to this element can vary from a simple rest and relief area for forward operations to a hospital operating room or housing for personnel and electronics equipment in control or communications centers.

(2) Decontamination Area

This element may be combined with the protective entrance (airlock) or may be a seperate element. Partial or complete decontamination of entering peronnel is accomplished at this point. The complexity of this element depends entirely on the shelter's function and its tactical situation. In some cases, it is merely a small area where personnel can decontaminate using the M13 decontamination kit or remove their protective overgarments. In other applications where the tactical situation permits, showering facilities or changes of clothing may be supplied.

(3) Protective Entrance (Airlock)

The function of this element is to provide a means of entry and exit into the shelter without destroying the protective integrity of the shelter. The protective entrance is maintained at a pressure slightly lower than that of the shelter proper. Upon opening of the outer door there is an outward flow of air and the pressure in the protective entrance falls to approximately atmospheric pressure, or near that level, depending upon the type of door. The inner door should be kept closed while the outer door is open to prevent loss of pressure in the shelter. The outer door should remain open only long enough to permit entry. The scavenging air is usually provided by filtered makeup air provided by the gas-particulate filter unit (i.e., the M14 CPE). The scavenging rate can be further increased to provide more frequent air changes through the use of supplemental recirculating filters (as used on the XM51 shelter system). For other systems, the scavenging flow is automatically initiated whenever an entry is made and remains on for a specified period of time. In this system, the scavenging air is supplied either by the GPFU (as for M14 CPE and XM51 CPE Shelter System). Using scavenging air only when required extends the useful life of the filters. It should be noted that the air used for pressurizing the protective entrance and for scavenging operation does not usually pass through the shelter (except for fixed installations) since this would add an extra load to the heater/air conditioner unit.

During the scavenging period, the personnel perform whatever decontamination procedures are prescribed and then enter the shelter at the completion of the scavenging cycle. It is important to note that the protective integrity of the shelter itself is not affected by utilization of the protective entrance if proper procedures are followed and the equipment is operating correctly. Exit from the shelter through the protective entrance follows the same principle except that the decontamination is not necessary and a mask and protective clothing must be donned either in the shelter or the protective entrance prior to exit into the outside atmosphere. Protective entrances can range in size from small, one-man systems to larger structures capable of handling several men and/or stretchers. They can be rigid, as normally used for fixed installations, or the flexible, collapsible type used for vans, vehicles, and portable shelters. Doors may be the hinged rigid, or zippered, or spring-loaded, self-closing, slit type.

(4) Filter Systems

Filtered air is normally obtained from a gas particulate filter unit (GPFU) which consists essentially of gas and a particulate filter with a blower assembly for moving air through the filters. The system may or may not be equipped with a prefilter or air cleaner depending on its application. The blower is usually powered by an electric motor; however, it could be run by a gasoline engine. The blower provides the power necessary to move the air through the filter for purposes of removing contaminants and also providing enough air under pressure to establish and maintain the overpressure required. The flow capacities of the filter-blower units range from 12 cfm to units rated at 5,000 cfm capacity. The filtration function and hardware assembly may be integrated into the existing environmental control equipment (heating and cooling) or may be a separate unit. A separate unit is, of course, required in shelters which do not have environmental control systems.

(5) Environmental Control Systems

This is the system which controls the heating and cooling of shelters. It consists of heaters, air conditioners and fan units. These systems are designed to maintain tolerable working conditions within a shelter during operation in climatic extremes or when the function of the shelter itself produces high temperatures (e.g. electronic equipment vans). As such, the environmental control system possesses no capability for removing agents from the incoming air except for the very limited protection offered by particulate pre-filters in the unit. Filtration equipment may be integrated into environmental control equipment during the design of the system or, in some cases, may be added to existing environmental control units. The added filtration equipment must be compatible with the environmental control equipment in terms of airflow requirements and heating and cooling capacities. During periods of protective operation, the filter unit provides the only source of make-up air for pressurizing the entire recirculating environmental control system as well as the shelter proper.

(6) Miscellaneous Equipment

Included in this category are many accessory items of equipment which contribute to the usefulness of proper operation of collective protection shelters. The items include the following.

1. Queing Shelters

Unpressurized structures similar to, and usually preceeding an airlock, where troops may gather prior to entering the airlock. Some protection is offered by presenting a mechanical barrier to agents, but the degree of protection will depend on the nature of the material used and the natural and personnel induced transport of contamination into the interior.

2. Protective Passageways (Interconnects)

Enclosure constructed of agent impermeable material to provide a protected passageway between protective shelters, e.g., the M14 CPE which provides a protected passageway between collective protected M820A3 expansible van trucks.

3. Pressure Regulators and Automatic Pressure Control Systems

Pressure Regulator. A variable orifice which can be adjusted manually to provide a fixed flow at a given pressure drop in establishing the desired level of pressure between shelter sections, i.e., shelter to protective entrance

Automatic Pressure Control System. A control system that automatically maintains proper pressures in a shelter system. Pressure sensors actuate servo-motor operated airflow valves to increase or decrease the input of filtered air until the desired pressure level is reached. Pressure control systems of this type have been used in the M14 and XM15 CPE.

4. Anti-Backdraft Valves

Mechanical devices that regulate the pressure within a protective entrance or shelter and at the same time serve as check valves to prevent reverse flow of contaminated air into the protected areas.

III. SYSTEM DESIGN APPROACH

1. ENGINEERING APPROACH

When doctrinal guidance requires the provision of CB protection for a specific development item, early action should be taken to control the leakage of the shelter at a specified level of positive pressure by specification. The leakage rate of the shelter defines the filtered air input required for pressurization and determines the amount of make-up to be handled by the heating and air conditioning equipment. With early design planning of this type, an optimum compatibility of equipment can be achieved with improved assurance of satisfying environmental and protective performance requirements for the developmental item.

The use of standard or the new modular collective protection equipment being developed by the Army should be closely analyzed for applicability in the new system to preclude the need for the more expensive development of new equipment when available items would satisfactorily service the new application.

The shelter design ideally should integrate the required supported equipment including power, air conditioning, and heating, collective protection and tactical equipment with complete interface capability so that externally mounted equipment is eliminated. Where this objective is not entirely feasible, the amount of externally mounted equipment should be minimized insofar as possible to optimize operational use and logistic considerations.

2. BASIC SHELTER PACKAGE CONCEPT

In consonance with the engineering approach described above and in view of the fact that a number of current development items have not been designed to accept collective protection, it is felt that a uniform policy should be adopted which would insure that the basic shelter package be designed to accept collective protection. By this approach, each shelter type used would be designed for compatibility with collective protection and evaluated to insure an adequate protective performance. Thus, for each shelter there would be specified and proven collective protection equipment for servicing this item in maintaining optimum tactical efficiency when operating in a CB environment. Accordingly, there would be an inherent capability for keeping the logistical burden on each system consistent with the need. For example, a reasonable decision from the standpoint of logistics would be to provide collective protection equipment only in areas where a CB tactical threat existed, but in areas where the threat did not exist, the system would not be so burdened.

(1) Unpressurized Basic Shelter

Implementation of this concept would provide a basic shelter package in which the overall leakage rate of the shelter at a fixed level of positive pressure within the shelter as well as the leakage between personnel and equipment sections would be controlled by specification. The personnel and equipment sections would be physically separated and have separate ventilation systems. The electronic equipment would be designed to operate satisfactorily under all encounterable extremes of environment with ambient air cooling. A capability for recirculating air between personnel and equipment sections would be provided to supplement the basic heating capability in the personnel section. The personnel section would be provided with heating and cooling equipment capable of handling the pressurization flow requirements and provide tolerable conditions within the shelter for personnel throughout the environmental temperature operating range. This basic shelter package would be designed to be compatible with collective protection. If no collective protection filter equipment were provided with the basic shelter package, the wearing of individual protective equipment would be mandatory and both personnel and equipment sections would become contaminated during operation in a CB environment. The chart which follows provides tabulated capabilities of the basic shelter package (Item 1) and the increased protective capability achieved through the use of add-on equipment to the basic package.

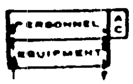
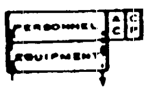
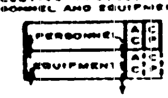
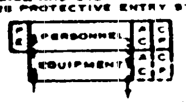
(2) Protective Pressurization - Personnel Section Only

Item 2 on the chart indicates the CB protective capability achieved by the addition of a CB Gas Particulate Filter Unit whose primary use is to provide a positive protective pressurization of the personnel section only, but which can also provide positive pressurization for the equipment section when operating in the recirculating mode (where cooling air for the equipment is drawn from and returned to the personnel section). It is recognized that this operating mode can only be used through a limited external environmental temperature range. When outside ambient air is used for cooling of the equipment, contamination of this section would be inevitable when operating in a CB environment. Maintenance of the contaminated equipment would be made more difficult due to the need for the use of individual protective equipment and the risk of introducing contamination into the personnel section.

(3) Protective Pressurization of Personnel and Equipment Sections

Item 3 on the chart provides positive pressure collective protection for both personnel and equipment section by either adding additional air conditioning capacity for the electronic equipment or by adding additional filtered air capacity so that the equipment cooling can be effected with the use of filtered ambient air. There is a trade-off here as to the optimum approach. The large amount of air that must be filtered (assuming a filtration efficiency and useful filter life equal to the personnel section filter unit) to provide a given cooling capacity is within state-of-the-art equipment, but is larger and heavier than an air conditioner with equivalent cooling capacity. However, the power required by the air conditioning unit is substantially higher than that of the filter unit so the choice of approach would depend on whether weight and volume or power were more critical in the system under consideration.

Table III-1
CB Protection Using Basic Shelter
Package Concept

ITEM	CB PROTECTION		CAPABILITY FOR OPERATION IN A CB ENVIRONMENT		ENVIRONMENTAL CAPABILITY		LOGISTICAL PENALTY	REMARKS
	PERSONNEL	EQUIPMENT	PERSONNEL	EQUIPMENT	PERSONNEL	EQUIPMENT	(WEIGHT, POWER, CUBAGE)	
1. BASIC SHELTER PACKAGE-OVERALL LEAKAGE OF SHELTER AND BETWEEN SECTIONS CONTROLLED BY SPECIFICATION. AC FOR PERSONNEL SECTION AMBIENT AIR VENTILATION OF EQUIPMENT SECTIONS PLUS RECIRCULATION CAPABILITY FOR COLD WEATHER OPERATION 	COMPLETE INDIVIDUAL PROTECTIVE EQUIPMENT MUST BE USED CB DETECTION CAPABILITY PROVIDED	NONE NO CAPABILITY FOR PREVENTING OR CONTAMINATION	LIMITED, DUE TO ENCUMBRANCE OF INDIVIDUAL PROTECTIVE EQUIPMENT IN TACTICAL OPERATIONS AND IN EQUIPMENT MAINTENANCE	RISK OF ADVERSE EFFECTS OF CB AND ANTI MATERIEL AGENTS AND DECONTAMINATION OF ELECTRONIC EQUIPMENT	ADEQUATE AT ALL ENVIRONMENTAL EXTREMES, PLUS SUPPLEMENTARY HEAT FROM EQUIPMENT SECTION FOR LOW TEMPERATURE OPERATION	AMBIENT AIR VENTILATION SATISFACTORY FOR HIGH AMBIENT TEMPERATURE COOLING OF ELECTRONIC EQUIPMENT	MINIMUM	C CATEGORY OF CB PROTECTION PROVIDED. MINIMUM TACTICAL LOGISTICAL PACKAGE. INDIVIDUAL PROTECTIVE EQUIPMENT REQUIRED. POTENTIAL CB CONTAMINATION OF BOTH PERSONNEL AND EQUIPMENT SECTIONS
2. BASIC SHELTER PACKAGE PLUS COLLECTIVE PROTECTION FOR PERSONNEL SECTION (POSITIVE PRESSURE COLLECTIVE PROTECTION FOR PERSONNEL SECTION ONLY) 	COMPLETE-POSITIVE PRESSURIZATION WITH FILTERED AIR. NO REQUIREMENT FOR WEARING INDIVIDUAL PROTECTIVE EQUIPMENT. CB DETECTION CAPABILITY PROVIDED NO PROTECTIVE ENTRY CAPABILITY	PARTIAL NO CAPABILITY WHEN COOLING WITH AMBIENT AIR. PROTECTIVE CAPABILITY WHEN EQUIPMENT COOLING AIR IS RECIRCULATED TO PERSONNEL SECTION AND BOTH SECTIONS ARE PRESSURIZED WITH FILTERED AIR	LIMITED NO PROTECTIVE ENTRY CAPABILITY. CONTAMINATED EQUIPMENT SECTION WOULD POSE PROBLEM IN MAINTENANCE AND PRECLUDE USE OF RECIRCULATION MODE ONCE CONTAMINATED	SAME RISK AS IN 1 ABOVE, EXCEPT PROTECTION COULD BE PROVIDED FOR EQUIPMENT AS LONG AS RECIRCULATION MODE AND PROTECTIVE PRESSURIZATION OF BOTH SECTIONS CAN BE MAINTAINED	SAME AS 1 ABOVE	SAME AS 1 ABOVE	INCREASED AS COMPARED TO 1 ABOVE	AAO CATEGORY OF CB PROTECTION PROVIDED. MINIMUM COLLECTIVE PROTECTION CAPABILITY. PROTECTION OF PERSONNEL AND EQUIPMENT SECTIONS ONLY IN RECIRCULATING MODE. EQUIPMENT MAINTENANCE AND TACTICAL OPERATION POTENTIALLY DIFFICULT WHEN NONFILTERED AMBIENT AIR VENTILATION OF EQUIPMENT IS NECESSARY NO ENTRY CAPABILITY
3. BASIC SHELTER PACKAGE PLUS COLLECTIVE PROTECTION FOR PERSONNEL AND EQUIPMENT SECTIONS 	COMPLETE SAME AS 2 ABOVE CB DETECTION CAPABILITY PROVIDED NO PROTECTIVE ENTRY CAPABILITY	COMPLETE-POSITIVE PRESSURIZATION WITH FILTERED AIR	COMPLETE-EXCEPT FOR PROTECTIVE ENTRY CAPABILITY	COMPLETE NO HAZARD OF EQUIPMENT CONTAMINATION OR IN EQUIPMENT MAINTENANCE	SAME AS 1 ABOVE	CAPABILITY FOR FULL TACTICAL OPERATION AND MAINTENANCE IN A CB ENVIRONMENT	INCREASED AS COMPARED TO 1 ABOVE	AAO CATEGORY OF CB PROTECTION. FULL PROTECTION OF BOTH PERSONNEL AND EQUIPMENT SECTIONS IN ALL OPERATING ENVIRONMENTS. NO PROTECTIVE ENTRY CAPABILITY. PROTECTION OF EQUIPMENT SECTION BY ADDING FILTERED AIR CAPACITY FOR EQUIPMENT VENTILATION OR BY COOLING WITH ADDITIONAL AIR CONDITIONING EQUIPMENT
4. BASIC SHELTER PACKAGE PLUS COLLECTIVE PROTECTION FOR PERSONNEL AND EQUIPMENT SECTIONS PLUS PROTECTIVE ENTRY SYSTEM 	COMPLETE SAME AS ABOVE CB DETECTION CAPABILITY REQUIRED PROTECTIVE ENTRY CAPABILITY PROVIDED	COMPLETE-SAME AS 3 ABOVE	COMPLETE SAME AS 3 ABOVE PLUS PROTECTIVE ENTRY CAPABILITY	COMPLETE SAME AS 3 ABOVE	SAME AS 1 ABOVE	SAME AS 3 ABOVE	INCREASED AS COMPARED TO 3 ABOVE	'AAA' CATEGORY OF CB PROTECTION SAME AS 3 ABOVE PLUS PROTECTIVE ENTRY CAPABILITY IN A CB ENVIRONMENT

LEGEND:

AC AIR CONDITIONER
CP - COLLECTIVE PROTECTION FILTER UNIT, ALSO CALLED GAS PARTICULATE FILTER UNIT
PE - PROTECTIVE ENTRY SYSTEM

NOTE:

DOTTED LINES INDICATE OPTIONAL FLOWS OR EQUIPMENT ADDITIONS

It is recognized that certain shelters may be included in "quick tactical response" type systems where movement between geographical areas and variable CB risk conditions must be accomplished in a minimal time and for which the add on of equipment to match the risk is unacceptable. In these cases, the additional logistic burden of providing an integral, and environment operational capability would be accepted. In these cases, the integration of all filtered air capacity in a single filter unit and the inclusion of all cooling capability in a single unit servicing both personnel and equipment sections should be evaluated in minimizing the overall logistical burden on the systems.

With the CB protection provided for both personnel and equipment, the only capability lacking is that of enabling protective entry while operating in a CB environment.

(4) Positive Pressurization, Personnel and Equipment Sections, Plus Entry System

This level of protection includes protection of both personnel and equipment sections and a protective entry capability when operating in a CB environment. This level of protection is indicated as Item 4 on the chart and provides the best overall protection for the shelter where a tactical requirement for personnel entry under all operating conditions exists.

3. CONTROL OF LEAKAGE

The rate of air leakage from a vehicle or shelter under pressurization is an important factor when CB protection is required. Experience has shown that it is usually the leakage rate of the shelter rather than the ventilation requirements of the personnel that defines the amount of filtered air required for CB protection. Specifying the amount for leakage, or the requirement for ventilation, whichever is greater, establishes the quantity of make-up air to be handled by the heating and air conditioning equipment and determines the required capacity of this equipment as well as the GPFU. Reduction of the make-up air, which in most cases results from reduction of the leakage rate, leads to a reduced size of the filter unit and environmental control unit required thereby effecting savings in cubage, weight, and power requirements and ultimate cost.

If collective protection is required for an existing vehicle or shelter, it may be necessary to institute modifications to reduce the leakage of filtered air. Doors, windows, cracks and holes can be sealed with a variety of sealants and materials. A program entitled "Study on Sealing and Leakage Reduction Measures for CB Protective Shelters" is currently being conducted for the Army by Donaldson Co., Inc. under contract DAAA15-70-C-0129 to develop newer methods and materials for sealing. In cases of extreme leakage, a rubberized liner can be installed in the shelter as, for example, in the Air Force Flight Line Taxi and the Army M820A3 Expansible Van Truck.

Some portable shelters require no leakage reduction measures, however, most vans and vehicles for which collective protection has been developed leaked excessively. Leakage should be reduced as much as feasible to approach the airflow rate needed for ventilation. A point can be reached, depending upon the type of leakage, where it is more practical to supply additional filtered air than to apply further leakage reduction measures.

4. FILTERED AIR REQUIREMENTS

In addition to the filtered air required for the shelter proper and the protective entrance, some systems may require filtered unconditioned air to cool the electronic equipment. Part or all of the electronic equipment may be in a separate section from the personnel section and cooled by ambient air. If this equipment section has an access door in the personnel section that may be opened for any reason during operation, or if the equipment is subject to deterioration by exposure to airborne agents, then the cooling air should be filtered. If filtered air is not required, it should be noted that this equipment section should not operate at a positive pressure level which would result in contamination entering the personnel section through possible leakages. The GPFU at rated flow must provide sufficient air:

- For ventilation requirements of personnel
- To maintain a specified positive pressure within the shelter and protective entrance
- To adequately cool equipment as required
- To effectively purge the protective entrance and shelter of any contaminants within a specified time.

In the design approach, every effort must be made to reduce the total quantity of filtered air required and yet satisfy the demands shown above. The larger the amount of filtered air required, the greater the penalty in weight, cubage and power. A more detailed explanation of the filtered air requirements is presented in Section IV.

5. HIGH TEMPERATURE ENVIRONMENTAL CONDITIONS

The employment of a GPFU in a system may raise the temperature of the air being filtered on the order of 5° - 15°F. In temperate climates, 10 cfm of make-up air per person will be sufficient. Under certain hot humid conditions, without air conditioner, it may be advisable to increase the flow rate, capacity of filter unit permitting, by introducing artificial leakage.

It is recommended that the personnel section be provided with an air conditioning unit capable of providing a maximum inside effective temperature (ET) of 85°F under maximum design external operating conditions. This is normally where the combined parameters of temperature and humidity are at a maximum. An effective temperature (ET) of 85°F is the maximum allowable without affecting performance as prescribed by the U.S. Army Human Engineering Laboratory. An accurate method for determining ventilation rates necessary to maintain an effective temperature of 85°F for various climatic conditions is described in TM-5-311, Military Protective Construction.

6. SIZING OF EQUIPMENT

In the design of new equipment, particular emphasis should be placed on the control of leakage since this factor determines the capacity, size, and power requirements for both the collective protection and the environmental control equipment. The use of standardized collective protection equipment should be evaluated for application in the new system to eliminate the need for the more costly and time consuming development of special equipment for a single new item. If environmental control equipment is to be used, selection should be made from standard military types of air conditioners of proven performance and reliability. All equipment should be selected to meet the collective protection and heating/cooling requirements while imposing minimum power, weight, and cubage burdens on the shelter system being supported. A detailed example of the equipment selection process is given in Appendix B. This particular example is for an electronic equipment van, but similar procedures can be used for other applications.

If collective protection equipment is being chosen for an existing vehicle or shelter, the first step is to reduce leakage by the means described above. To provide collective protection, an existing GPFU should be chosen if possible. The GPFU must be capable of supplying the required amount of filtered air and maintaining the desired pressurization. At the same time, it must satisfy fairly well defined cubage, weight, power and configuration restraints imposed by the fact that it is being incorporated into an existing system. The collective protection equipment must also be compatible with any existing environment control equipment in terms of fit and air volume needs. In some cases, the installation of collective protection equipment may make it necessary to install environmental control equipment because of the closed nature of the protected system. In other cases, it may be necessary to increase the capacity of the environmental control units. Descriptions of standardized and development items in Section V and VI illustrate methods for the solutions of these problems.

IV. DESIGN CONSIDERATIONS

1. INTEGRATED COLLECTIVE PROTECTION EQUIPMENT

In the past, controversies over the basic requirement for collective protection, the level of protection, and the methods for meeting this requirement have resulted in no collective protection capability in many systems now in the field or in many systems currently under development or considered for development in the future by all the services. If protection for a vehicle or shelter is deemed necessary, an analysis of the shelter and its function should lead to the selection of the category of protection (AAA, AOA, etc.) as explained in Section II. The shelter or vehicle could then be designed for compatibility with collective protection equipment and evaluated to insure adequate performance of the protective equipment. In this manner there would exist standard collective protection equipment for this item when operating in a CB environment. In addition, there would be an inherent capability for keeping the logistical burden on each system consistent with the need. This would enable planners to provide collective protection equipment only in areas where a CB tactical threat existed but not include the equipment in areas where no CB threat existed. If threat conditions changed or vehicles were redeployed to other areas, the protective equipment could be either installed or removed. In short, CB protection equipment should be considered during the early design phase and in systems where it is needed; provision should be made for its installation on an optional basis. This approach will also obviate modification of vehicles or shelters for compatibility with collective protection equipment. In most cases, this modification has been complicated and costly.

2. INSIDE/OUTSIDE INSTALLATION OF COLLECTIVE PROTECTION EQUIPMENT

Usually space considerations or the need for interfacing with environmental control equipment dictate whether the GPFU be installed outside or inside the shelter. If the GPFU is located outside the shelter, the motor-blower must be mounted upstream of the gas and particulate filters to prevent contamination of the air after it has passed through the filters. In this push-through arrangement, any leakage is out of the GPFU into the contaminated atmosphere. If the GPFU is located inside the shelter, the motor-blower must be mounted downstream of the gas and particulate filters. In this pull-through arrangement, any leakage is clean air into the GPFU.

3. INTERFACE WITH ENVIRONMENTAL CONTROL SYSTEMS

As pointed out in Section III, it is extremely important that the collective protection equipment be compatible with the environmental control unit (ECU). The only recommended manner of interface should be to use the filter unit to provide make-up air for the ECU. In a pressurized system, the lowest level of pressure is at the intake to the air conditioner evaporator blower. If this area is adjacent to the contaminated atmosphere, it should be maintained at a safe pressure of at least 0.5 in. wg. To accomplish this will require maintaining the pressure in the shelter proper at a higher level due to pressure drop in the recirculating air path. The difference is pressures of the shelter proper and the intake to the ECU blower is less if the blower is located upstream of the evaporator coil. It is desirable that the cooling air for the condenser be drawn (down-stream) through the coils, otherwise the condenser section is under positive pressure and, if adjacent to a clean area, requires that this clean area be at a higher pressure. Figure 1 illustrates the disadvantages of a draw through evaporator blower and a push through condenser fan. Figure 2 shows the desired arrangement. Note that the pressure level in the shelter is lower in the second case requiring less air for pressurization.

4. FILTERED AIR REQUIREMENTS

As shown in Section III, sufficient air must be supplied to the shelter to:

- Provide ventilation for personnel
- Maintain a system overpressure
- Provide for equipment cooling if required
- Effectively purge the airlock and shelter of contaminants.

Each of these requirements will be discussed briefly in the succeeding paragraphs.

(1) Ventilation

The build-up of carbon dioxide concentration must be prevented by a continuous flow input of fresh air. The rate of build-up varies, of course, with the number of personnel occupying the shelter

FIGURE 1
Air Conditioner Not Compatible with Collective Protection

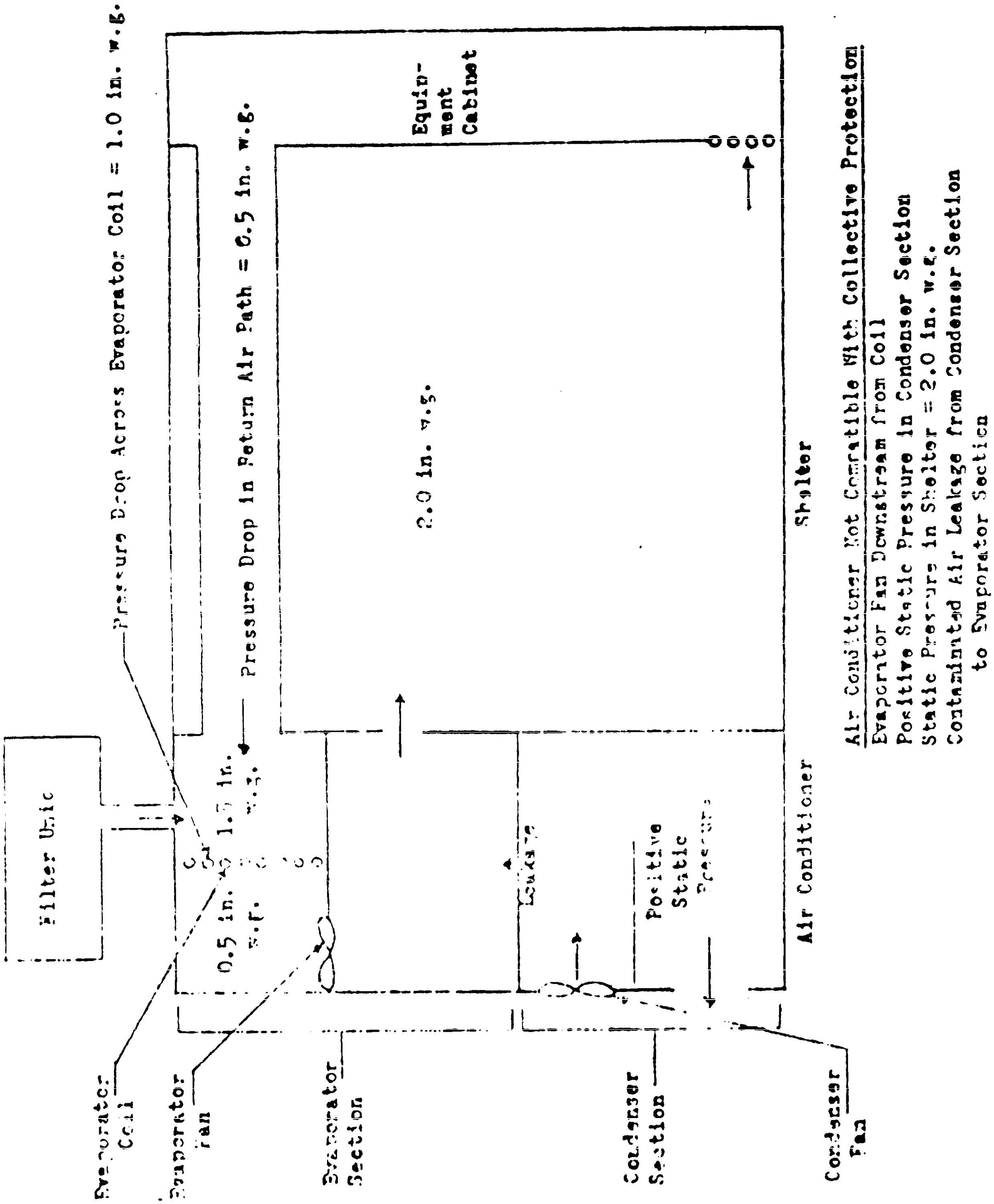
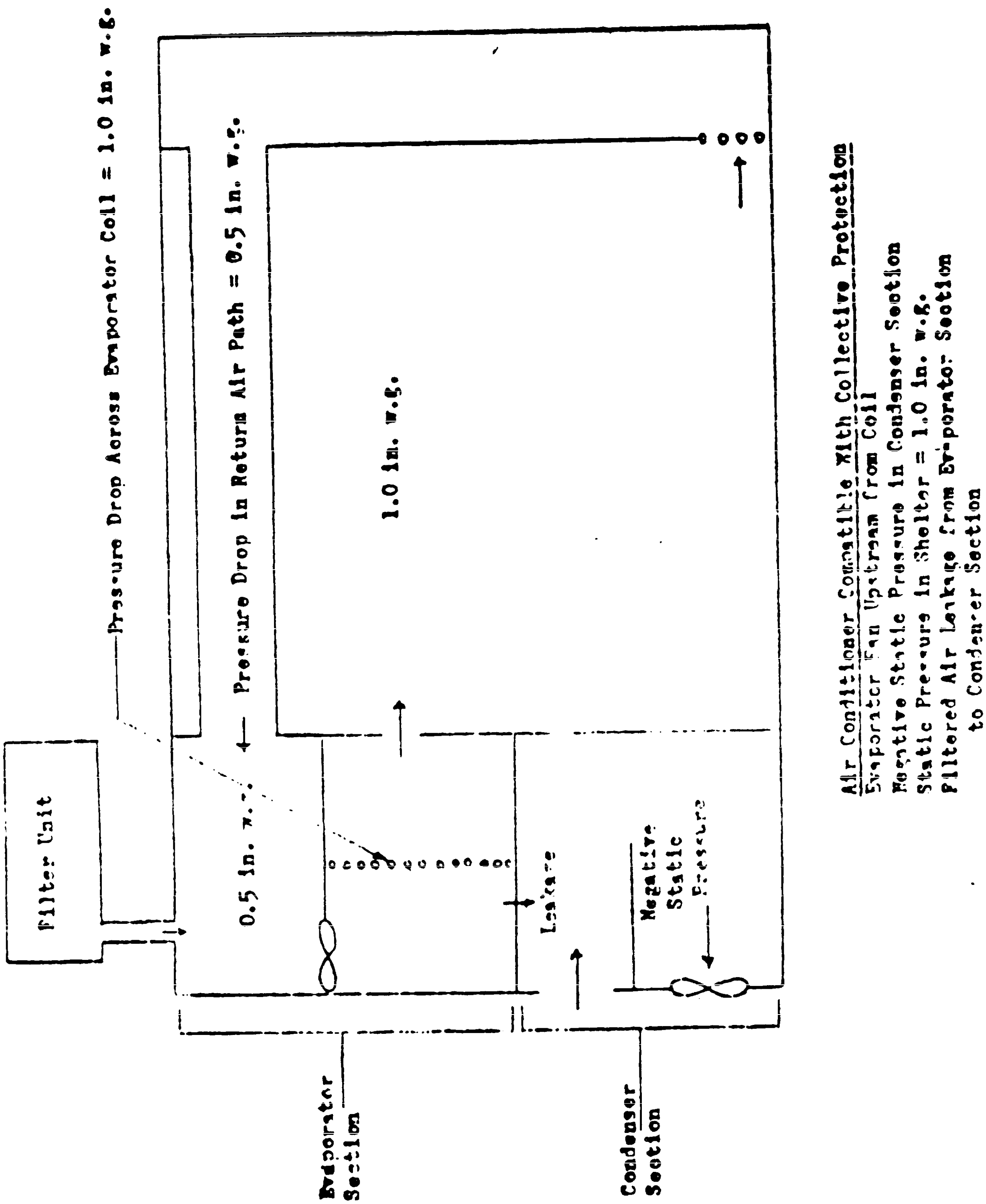


FIGURE 2
Air Conditioner Compatible with Collective Protection



and their physical activity. Other factors such as elimination of body odors and removal of cigarette smoke also enter into a determination of the ventilation requirements. Approximately 10 cfm per occupant is generally satisfactory for adequate ventilation. Figures 3 and 4 which are reproduced from ENCR No. 30, "Protection of Structures from CBR Contamination" dated June 1959, show the physiological effects of carbon dioxide and indicate the quantity of air required from the standpoint of ideal conditions of occupancy.

(2) Overpressure

Sufficient filtered air must be supplied to satisfy leakage and maintain the overpressure in the shelter system and the protective entrance. Every practical effort should be made to reduce excessive leakage in order to reduce filtered air requirements. Some systems are designed so that the GPFU always operates at a relatively constant flow. This flow must be capable of keeping the overpressure within specified limits during entry and exit of personnel. Other units are capable of supplying filtered air at increased flow rates when personnel enter or exit.

(3) Equipment Cooling

This requirement has been adequately covered in Section III.2.

FIGURE 3
Effect of Percent of CO_2
in Atmosphere on Lung Action

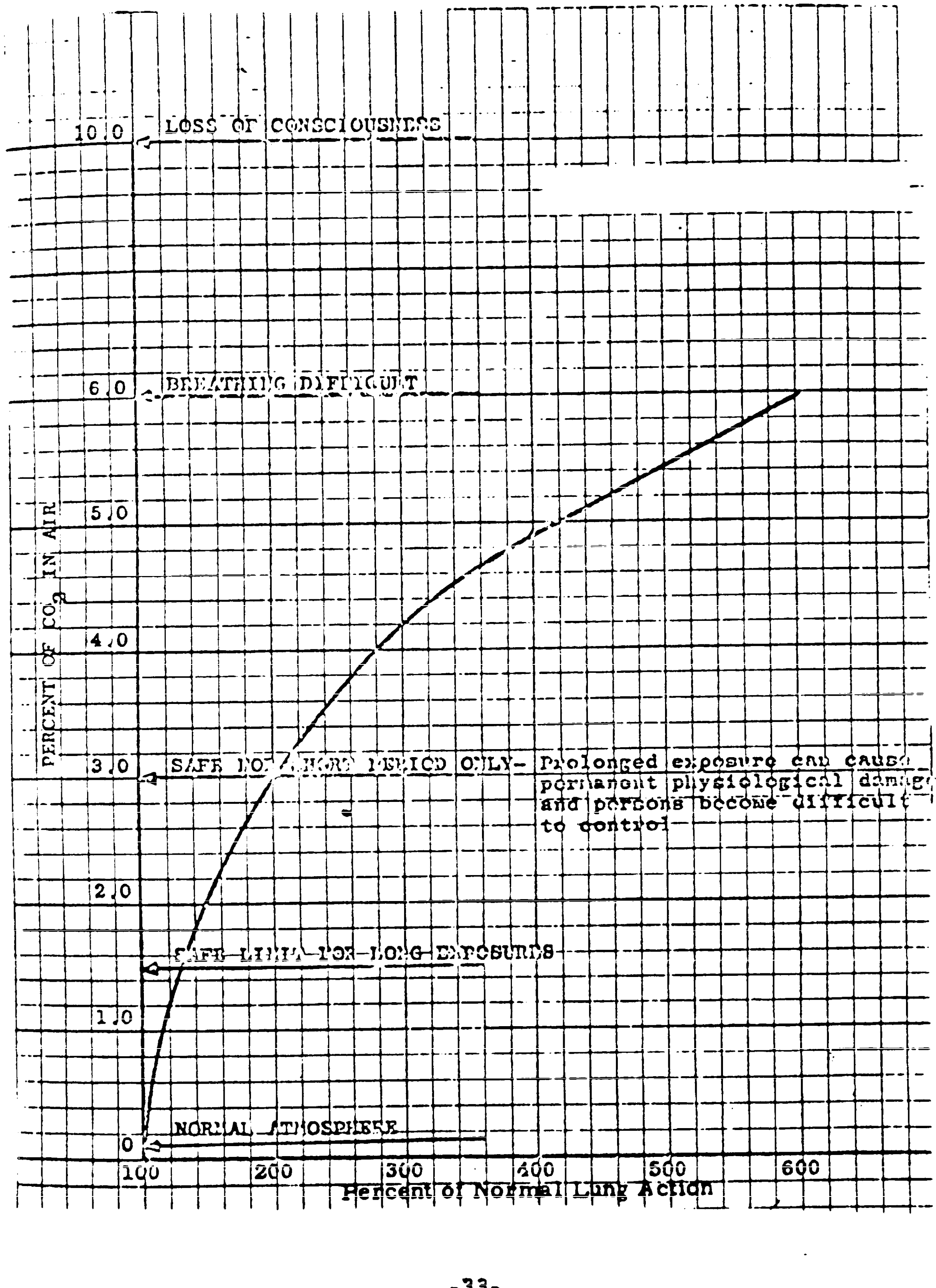
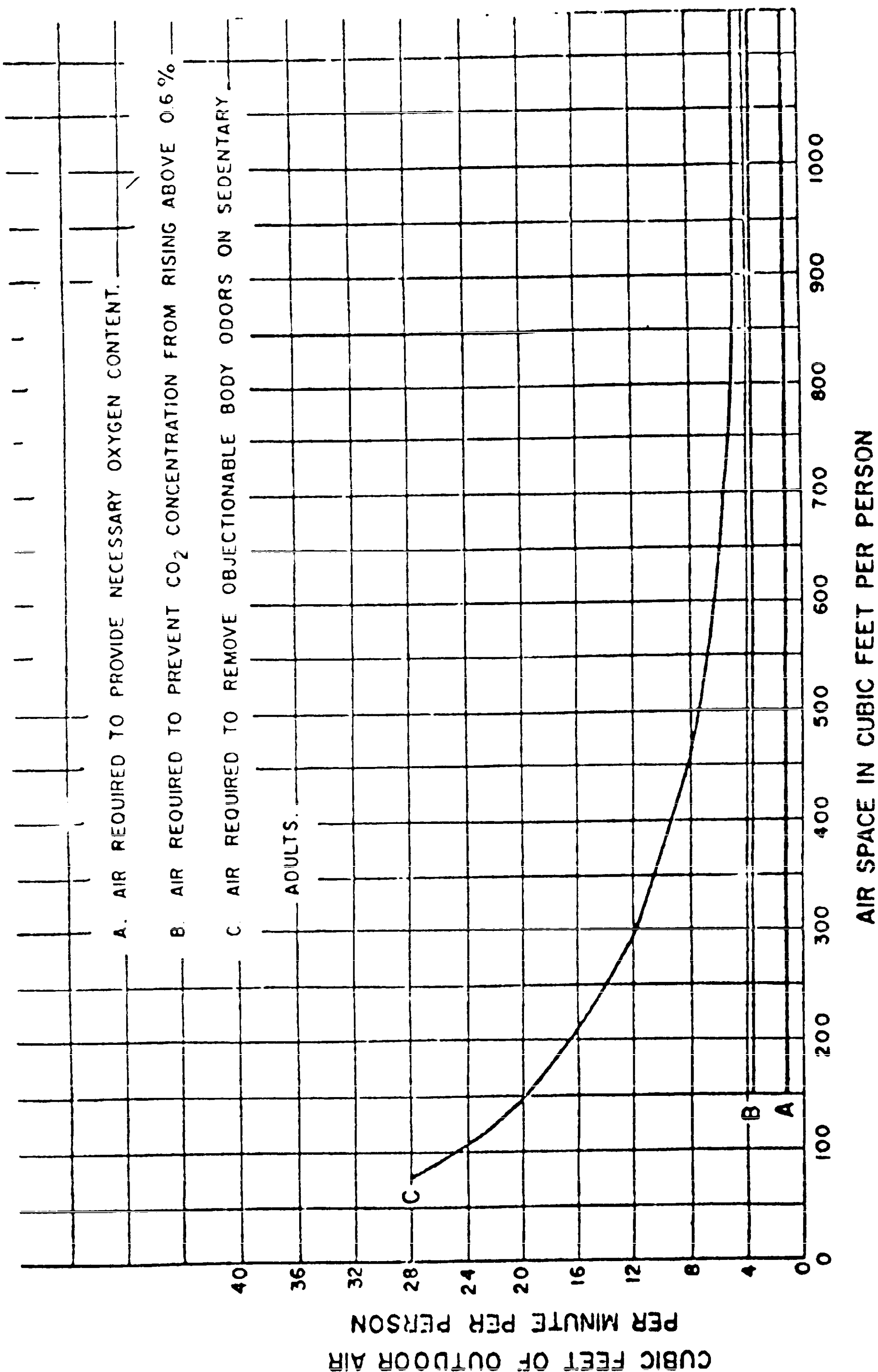


FIGURE 4
Ventilation Requirements



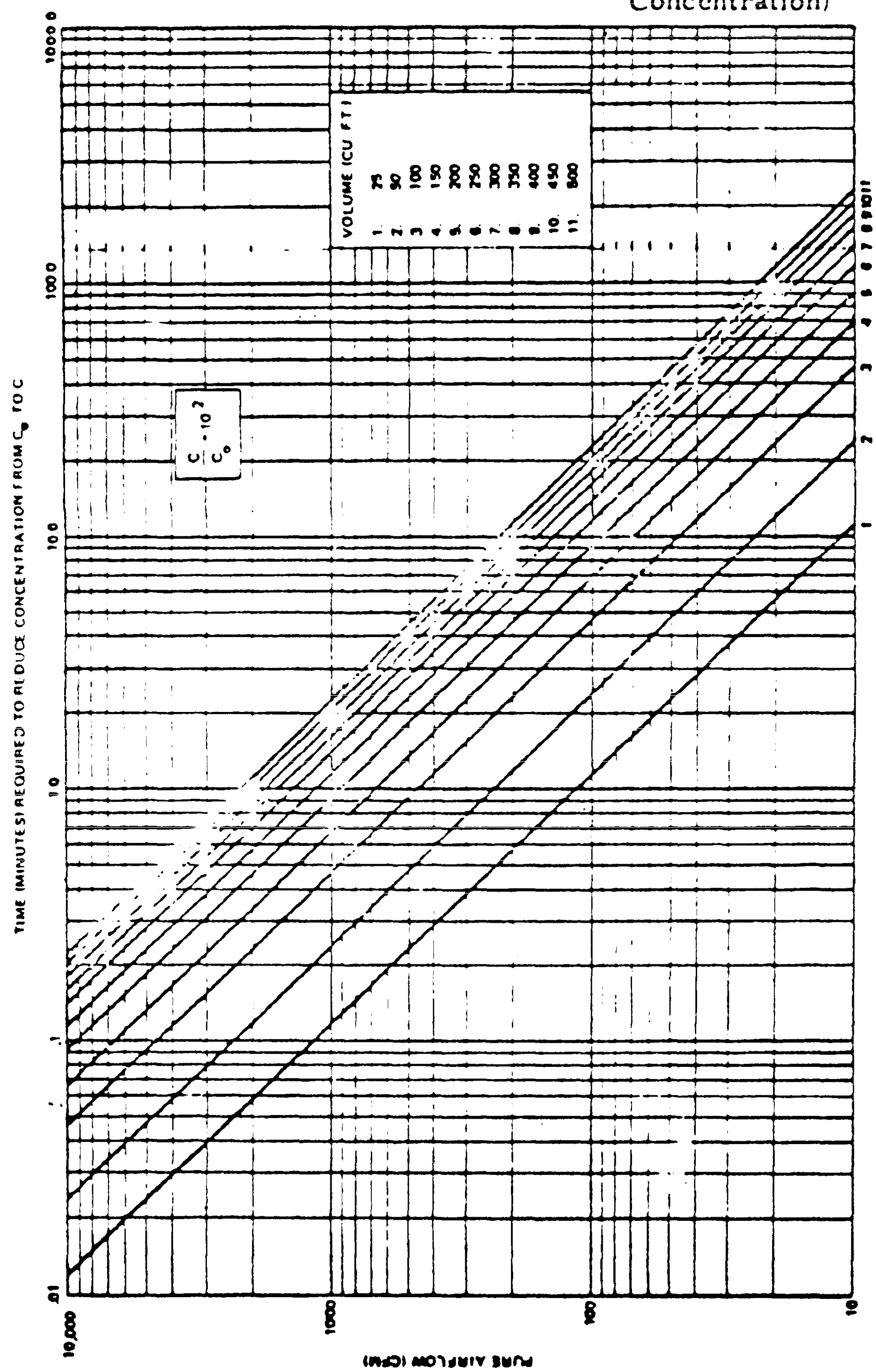
(4) Purging

When a person enters the protective entrance, the pressure falls to approximately atmospheric pressure permitting airborne contaminants to enter. Before entry into the main shelter can be accomplished, the airlock must be supplied with sufficient quantities of air to restore the overpressure and purge the airlock of the contaminant by dilution. The general criterion is that this scavenging action must reduce the concentration of the agent by three logs within five minutes. The shelter, as well as the protective entrance requires scavenging if it has been exposed to contaminated atmosphere while collective protection was not in operation. There may be times when shelter scavenging is required during operation, as when a person enters directly into the shelter in case of an emergency, or, possibly after a normal entry when the shelter pressurization air flow is relatively small. The optimum purging operation is based on minimum volume of shelter or airlock and a high volume of filtered air. Figures 5, 6, and 7 define the relationship between scavenging action and volume of filtered air and shelter volume. Inspection of these curves illustrates the importance of these parameters to adequate design and efficient operation.

5. PRESSURIZATION REQUIREMENTS

The only way to prevent penetration of contaminants is to insure that pressures within the shelter are high enough to cause an outward flow of air from the shelter to the atmosphere at all times. This

FIGURE 5
Scavenging Airflow Requirements
(10^2 Reduction of Initial
Concentration)



Scavenging Airflow Requirements
(10^3 Reduction of Initial
Concentration)

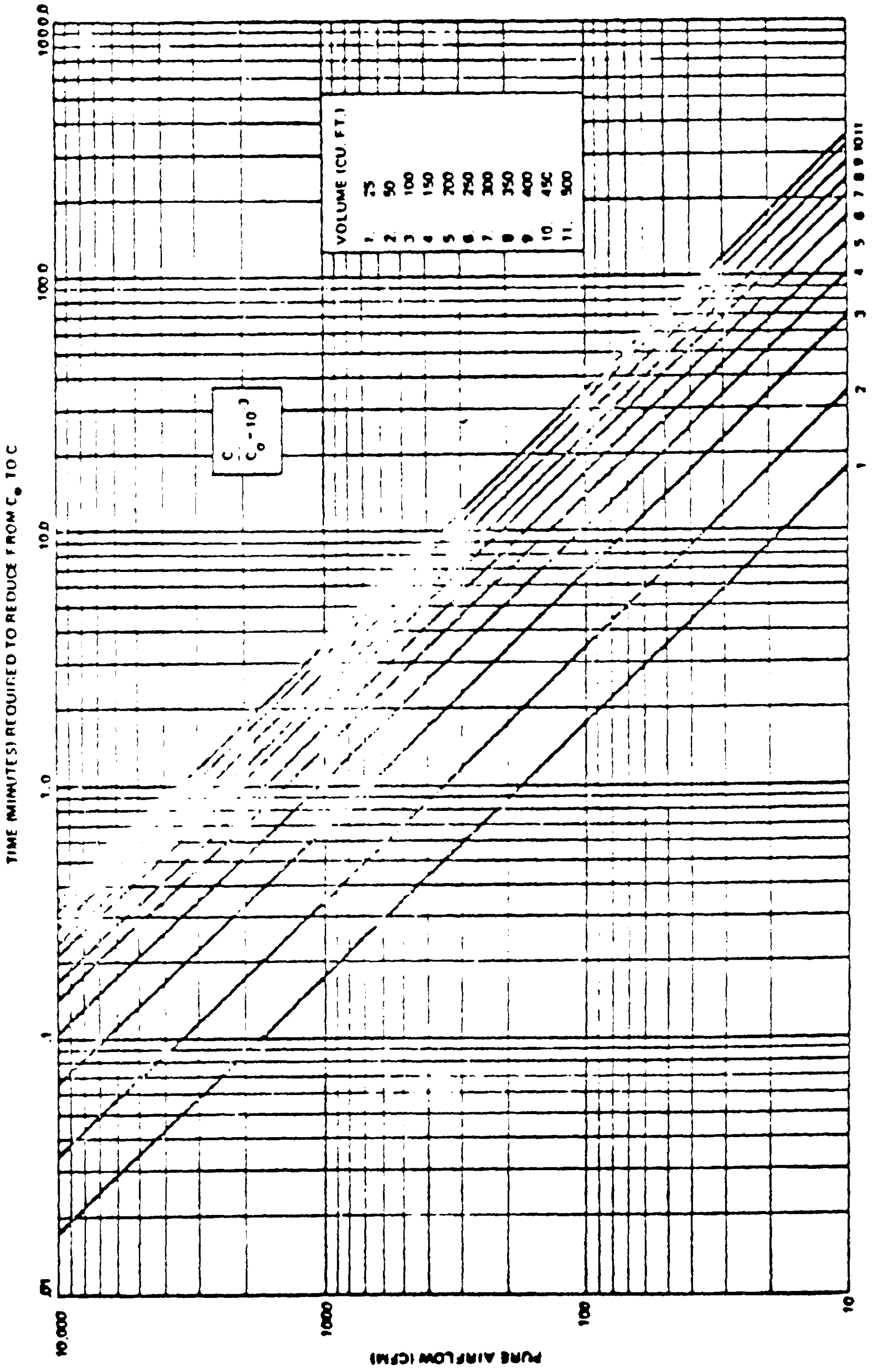
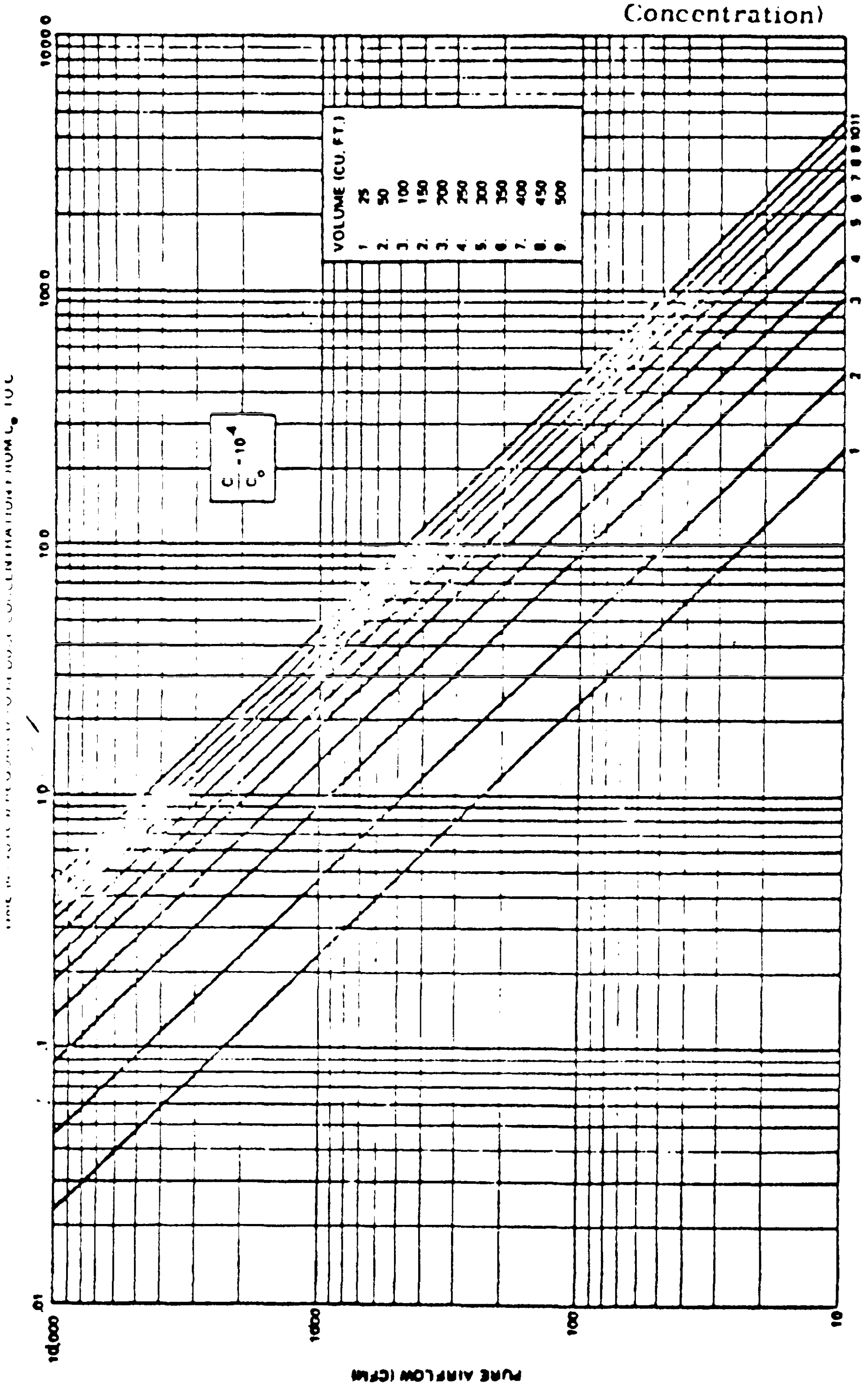


FIGURE 7
Scavenging Airflow Requirements
(10^4 Reduction of Initial
Concentration)

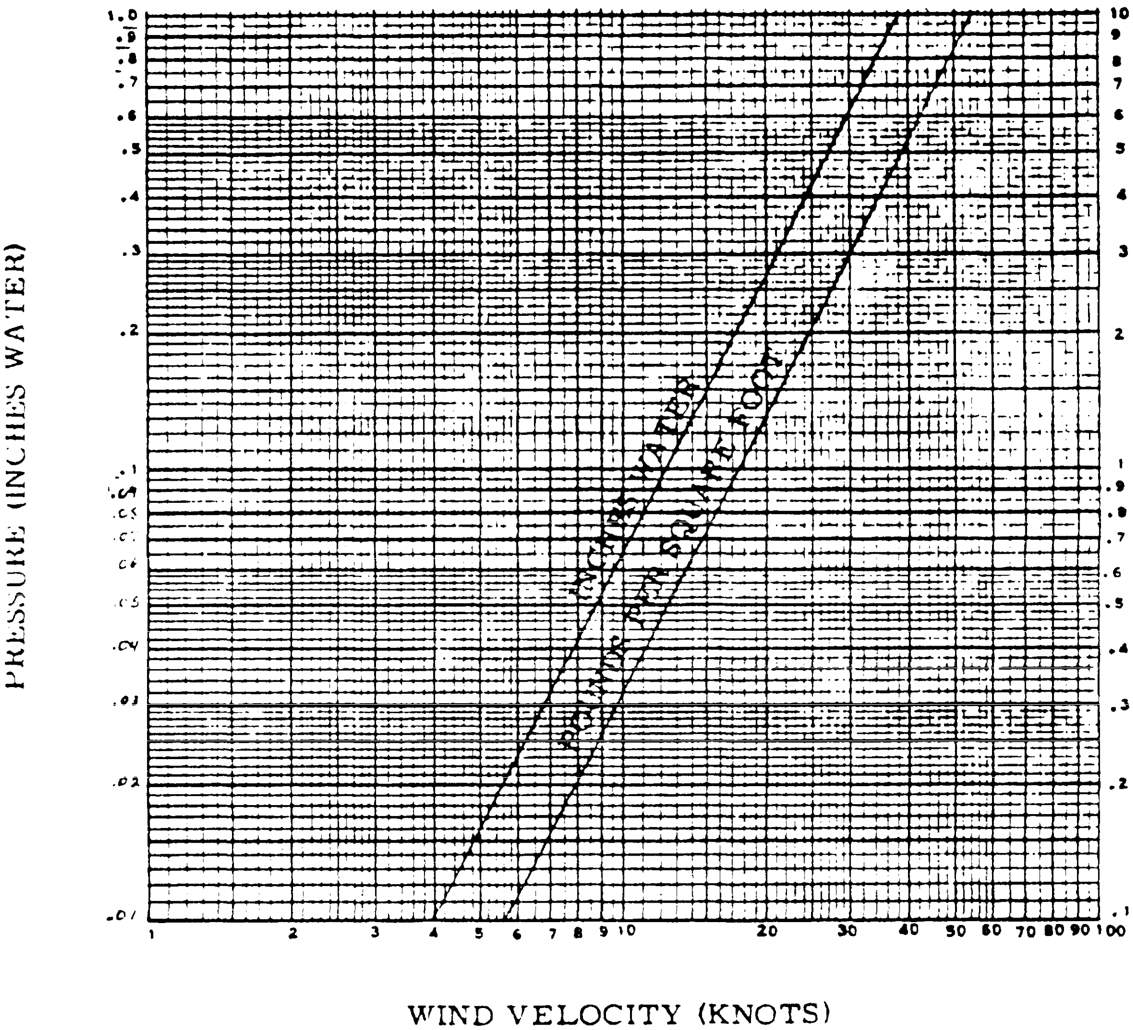


requirement could be met with very slight overpressure if wind effects on the walls of the shelter could be ignored. Winds of even low velocities blowing against the outside walls can force contamination into the shelter. Figure 8 shows the static overpressure required to overcome the effects of outside wind.

It has been established that the lowest overpressure which should be considered for field shelters is 0.3 water. This pressure will prevent infiltration of contaminants during a steady 25 mph (21.8 knots) wind under normal conditions. In order to meet low temperature (higher air density) requirements and provide tolerance for automatic pressure control systems, the minimum pressure usually maintained in the typical protective entrance in field applications is 0.5 to 0.7 in. wg. Under normal temperature conditions and using a manual pressure regulator, a minimum of 0.3 in. wg. should be maintained as the lowest pressure level in the protected system, usually the protective entrance. The pressure in the shelter proper should be normally maintained at least 0.1 in. wg. higher than in the protective entrance to insure an outward flow of air from the shelter under all conditions of operation.

If consideration is being given to providing protection to a vehicle or van while it is in motion, the combined effects of wind velocity and vehicle speed must be considered in determining the minimum pressurization.

FIGURE 8
Wind Pressure Chart



6. AUTOMATIC PRESSURE CONTROLS

The protective system should be provided with automatic pressure controls and sensors for controlling the positive pressure in both the main chamber and protective entrance. These controls consists of pressure actuated switches (draphron type switches or pressure transducers) that operate servo-motor power airflow control valves in the filtered air supply to the shelter and the protective entrance. The difference in pressure between the main chamber and the airlock must never be lost or reversed if protection is to be maintained. The overpressure of the system should also be kept at or near prescribed performance specifications to insure that the required level of protection is provided. Automatic pressure control does not require monitoring by the operating personnel and is generally more reliable than manually controlled pressure systems. In a system where the scavenging flow through the protective entrance is increased during entry, automatic pressure control devices are used to initiate this mode.

7. RESERVE CAPACITY OF MOTOR-BLOWER

The motor-blower should be capable of delivering a sufficient amount of air to maintain the design overpressure in the protected system under the specified range of climatic conditions and loading of the particulate filter and, in addition, supply scavenging air for the protective entrance required. The motor-blower should also be capable of maintaining this delivery rate when the internal resistance of the GPFU increases. This reserve capacity is required to offset the loss in flow caused by "loading up" of the particulate filter as a function of time in use. Usually in fixed installations a reserve head capacity of 2 in. wg. is adequate. In tracked combat vehicle applications, reserve head capacity of up to 10 in. wg. have been provided due to the extremely dusty conditions that can be encountered. Since the filtering effectiveness of the particulate filter is not decreased by "loading", a reserve head in the motor-blower is a good method of increasing the filter life. The amount of reserve capacity for any particular application, therefore, depends on the design flow rate, the pressurization requirement, and the projected operating time and environmental conditions.

8. SPECIAL REQUIREMENTS FOR PRE-FILTERS AND INERTIAL DUST SEPARATORS

Shelters which are designed for operation in very dusty situations such as tracked vehicles or shelters which will be utilized in the desert, will require the incorporation of prefilters or inertial dust separators. These are required to reduce the amount of dust reaching the filters of the GPFU and causing a rapid build-up of internal resistance in the unit.

Several types of mechanical dust separators are available but most collective protection applications have utilized the vortex type in which centrifugal force is used to separate and exhaust the dust particles. A separator of this type is being designed for use with the modular collective protection equipment being developed by the Army for a variety of vehicles, vans, and shelters. These units will be capable of removing a minimum of about 90% of all dust from a dust cloud containing 0.025 gram/cu. ft. of AC Standardized Coarse Test Dust. Provision can be made for removal of the separator when it is not needed in order to reduce weight and power requirements.

9. SPECIAL CONSIDERATIONS

In the design of collective protection equipment several additional factors must be considered in relation to the intended use of the item for which protection is being provided.

(1) Fixed Installations

The structures are usually large and of a permanent nature. Many have existing heating and cooling systems which can be operated in either make-up or recirculating air only modes. When consideration is given to collective protection equipment, weight, power and cubage problems usually are not as critical as in some other applications. Adequate equipment can usually be selected from the list of standard GPFUs. Existing rooms in the structure can be converted into airlocks or separate entrances, utilizing, if necessary, recirculating GPFUs attached to the structure. In larger structures where adequate facilities and supplies exist, it is possible to provide shower facilities and clothing replacement.

The Air Force is currently developing the CB Modification Kit for existing structures which consist of a unitized entry/exit system with built in shower decontamination facilities. Standard GPFUs and motor-blowers are attached to the Modification Kit to provide filtered air to the module. In use, the module is secured to a doorway to an existing building, the building is sealed as tightly as possible, and uses its own recirculating environmental control units to maintain a habitable atmosphere.

(2) Mobile Applications

Mobile applications include portable shelters, vans, and vehicles. Protection may be required for vehicles while stationary and in motion or while stationary only. In the later case, it is not necessary that the collective protection equipment operate from the vehicle's power supply. However, in general, the CPE, the ECU, and the electronic equipment in the shelter operate from the same power source.

Severe restraints are imposed in terms of cubage, power, and weight on collective protection equipment for use in mobile applications. The collective protection equipment may be required to operate off the vehicle's power supply and in many cases the power supply must be upgraded to handle the additional load. Size and factors become important when inside installation is considered. Leakage reduction is sometimes difficult because of the way vehicles are designed.

If protection is to be provided while the vehicle is in motion, the overpressurization required can increase several fold. Since mobility is of prime importance, the protective entrances must be collapsible and rapidly deployable. Incorporation of collective protection equipment may result in intolerable environmental conditions within the shelter and make the installation of environmental equipment mandatory. Noise levels must be controlled to meet acceptable standards. Ballistic shields and deep fording valves for the air inlets may be necessary for certain tactical vehicles.

(3) Interfacing Components

Effective operations in a toxic environment will demand an integrated approach providing protection across a wide span of routine activities. For example, the development of the Flight Line Taxi has been paralleled by the development of the Cockpit Canopy and the Modification Kit for existing structures. Nothing would be accomplished if the flight crew could not complete the chain of movement from the protected ready room to the Flight Line Taxi to the protected aircraft access. All of these components are capable of interfacing with each other in the proper sequence without loss of protection by use of the Interconnect Adapter Kit. Design provision has been made in the XM51 Shelter System for interconnection of multiple units to increase the size of the protective shelter. This requirement for integration of equipment must be borne in mind in the development of new equipment so that maximum flexibility in use and application of the protective equipment is provided.

10. INDIVIDUAL EQUIPMENT FOR USE IN EVENT OF COLLECTIVE PROTECTION MALFUNCTION

Although the standard collective protection equipment has been designed for a very high degree of reliability and endurance and has completed severe testing for these factors, the possibility does exist that on rare occasions the equipment will malfunction with a resultant loss in protective capability. Due to unforseen emergencies, it is imperative that personnel within the shelter have immediate access to personal protective equipment, particularly the masks. In the design of shelters, provision must be made for storage space for an adequate supply of individual protective equipment. An alternative solution is for the entry procedures to specify that personnel retain their individual masks after removal from the head. This may be done without fear of contaminating the shelter if the mask is enclosed in an impermeable bag or in the gas mask carrier. Procedures for handling and redonning a mask which has been exposed to agents are described in the manuals for the particular mask.

The possibility of loss of protection by malfunction, enemy action, or exhaustion of filter capacity illustrates the need for agent detection equipment within the shelter. For the present, pending the availability of an automatic alarm such as the M8, the use of the Detector Kit, Chemical Agent, ABC M18A2 is recommended. The use of standard paper detector kits for indicating liquid chemical contamination is similarly recommended. Maximum use should be made of the Decontamination and Reimpregnating Kit, Individual, M13. Recommended procedures for entry/exit and decontamination are presented in Appendix C of this report and are discussed in the next section.

11. ENTRY/EXIT PROCEDURES

The tactical situation and the function of shelters requires that personnel enter and leave for rest and relief, to conduct missions, and to transmit communications. In the unusual situation where entry or exit is not required during an attack, there is no need for formal procedures to maintain the protective integrity of the shelter.

The sole purpose of the protective entrance or airlock is to permit the entrance or exit of personnel without causing contamination of the shelter for the personnel inside. The rate of reduction of contamination in the protective entrance by the purging action determines the residence time required for a person before entry into the shelter proper. Size considerations may determine the procedures for handling groups of men at the same time or for stretcher cases. Examples of approved procedures are presented in Appendix C.

The importance of proper training for personnel and strict adherence to entry/exit procedures and thorough decontamination before entering cannot be overemphasized. A well-designed and properly operating shelter can be completely defeated by a lack of regard for these considerations.

V. STANDARDIZED ARMY AND AIR FORCE COLLECTIVE PROTECTION EQUIPMENT

1. COLLECTIVE PROTECTION EQUIPMENT (SHELTER SYSTEMS)

There are currently a number of standard CB collective protection systems developed primarily as protection for missile vans.

Since this report is intended to provide information pertinent to the design, test, and evaluation of collective protection equipment, detailed information is not provided on these systems which have completed the design, test, and evaluation cycle.

A listing of the standard systems is provided in Table V-1. This list includes only Army systems since there are currently no standardized Air Force collective protection shelter systems.

Additional descriptive information on these systems is available through the various manuals and descriptive documentation associated with the systems.

2. GAS PARTICULATE FILTER EQUIPMENT

The current standard air purification systems utilize a particulate filter and a gas filter contained in a single housing with a motor blower contained either inside or external to the housing.

The aerosol or particulate filter is made from a glass fiber-based felted sheet filter material in conformance with military specification MIL-F-51079. The filter material is folded into pleats with separations and cemented into a rigid wood or metal frame. The

Table V-1
Standard Collective Protection
Shelter Systems

Unit	Use	Designation
NIKE-HERCULES Trailer Mounted, M1	Guided Missile Van	FSN 4240-715-6557
AN/MSQ-28 Skid Mounted, M2	Weapons Monitor Center/ Radar Data Processing Center	FSN 4240-766-5920
AN/MSQ-28 Skid Mounted, M3	Radar Equipment Trailer	FSN 4240-766-5918
AN/MSQ-28 Skid Mounted, M4	Radar Antenna Trailer	FSN 4240-766-5919
AN/MSM-34 Skid Mounted, M5	Maintenance Trailer	FSN 4240-766-5917
AN/MSM-55 Skid Mounted, M6	Maintenance Trailer	FSN 4240-766-5916
AN/MSQ-18 Skid Mounted, M7	Operations Central/ Coder-Decoder Group	FSN 4240-766-5915
AN/TSQ-38 Skid Mounted, M8	Operations Central	FSN 4240-766-5914
AN/TSQ-38 Skid Mounted, M9	Coder-Decoder Group	FSN 4240-766-5913
HAWK, M10	Battery Control Central	FSN 4240-736-7743

Table V-1
(Continued)

Unit	Use	Designation
NIKE-HERCULES CONUS, M11	Fixed Installation	FSN 4240-937-7030
NIKE-HERCULES CONUS, M12	Fixed Installation	FSN 4240-937-7031
NIKE-HERCULES CONUS, M13	Fixed Installation	FSN 4240-937-7032

filters occupy approximately .002 - .008 cubic feet per cfm of delivered air. In general, this parameter is lowest in the larger flow capacity filters. The filters are capable of removing solid and liquid aerosols with the same degree of effectiveness as individual protective masks. Where dust loading is excessive, cyclone-type dust separators or prefilters are normally used to prevent the filters from loading and increasing their resistance to air flow.

The gas filter is made from granular (12-30 mesh) impregnated, activated charcoal. This material is packed into a rigid metal frame or holder between perforated metal screens lined with a thin cotton batting type fine filter medium. The charcoal removes gaseous toxic agents principally by physical adsorption with the same effectiveness as individual mask filter elements or canisters.

Table V-2 provides a listing and a brief description of the standard gas particulate filter units.

3. PROTECTIVE ENTRANCES

Protective entrances (airlocks) have been developed for a number of shelter systems to permit personnel transit between toxic environments and protected interiors of shelters without introducing contamination. Established procedures have been developed for personnel using airlocks, including the removal of outer and protective garments, stowing packs, passing messages, and the amount of time spent in an airlock. In some instances, the protective entrances have been designed to provide an

Table V-2
Standard Gas Particulate Filter Units

Filter Unit	Use	Capacity (CFM)	Dimensions (inches)	Weight (lbs.)	Power Supply	Power Rating (hp)	Power Consumption
M6 (GED)	Field Collective Protector	300	24 x 34 x 39	400	Gasoline Engine	1.5	1/16 gal/hr
M6 (EMD)	Field Collective Protector	300	24 x 34 x 39	400	110v, 60 cps single phase	1	1 KW
M8 (EMD)	Tanks	12	12-5/8 x 7-1/2 x 6	27	27.5 vdc		72 watts
* M9 (EMD)	Fixed Installations	600	103 x 30-1/2 x 40	800	230v, 60 cps three phase	1	0.73 KW
* M9 (GED)	Fixed Installations	600	81 x 30-1/2 x 40	600	Gasoline Engine	1.5	0.33 gal/hr
* M10 (EMD)	Fixed Installations	1,200	163 x 35 x 40	1,200	230v, 60 cps three phase	5	3.3 KW
* M10 (GEF)	Fixed Installations	1,200	136 x 30-1/2 x 40	1,000	Gasoline Engine	5.6	0.58 gal/hr
* M11 (EMD)	Fixed Installations	2,500	163 x 52 x 40	1,700	230v, 60 cps three phase	5	3.3 KW
* M11 (GED)	Fixed Installations	2,500	138 x 52 x 40	1,500	Gasoline Engine	5.6	0.58 gal/hr
* M12 (EMD)	Fixed Installations	5,000	168 x 52 x 60	2,800	230v, 60 cps three phase	7.5	4.75 KW
* M12 (GED)	Fixed Installations	5,000	158 x 53 x 60	2,600	Gasoline Engine	10	1.33 gal/hr
M13	Tanks	20			27.5 vdc		135 watts
M15	NIKE Missile Vans	2,400	84 x 46-1/2 x 36-1/4	1,200	208v, 400 cps three phase	7.5	8.44 KW
M18	HAWK Missile Vans	300	40 x 24 x 18	160	416v, 400 cps three phase	0.7	
* M16	Missile Monitor	400	64 x 35 x 20-1/2	382	208/416v, 60 cps three phase	1.8	

*Being proposed for deletion pending AMTC Action.

area where personnel can decontaminate themselves prior to entry, and can don protective garments before exiting to the toxic environment. Table V-3 summarizes those standardized systems which utilize a protective entrance or airlock as a part of the shelter system.

Protective entrances are designed to provide for purging of an interior contamination level by means of either a controlled flow of purified air from the shelter and/or direct line from the main filter unit; or by means of a special gas particulate filter unit for recirculating and purifying the air within the entry system. By either method the system for purging the airlock is most commonly required to achieve a 3-log reduction in interior protective entrance level of contamination within a 5 minute period while retaining internal protective entrance pressure between .5 and 1 inch water gauge.

Materials of construction should be agent impermeable. For flexible type protective entrance, butyl-coated nylon and Tedlar/Dacron laminant have been successfully used. In selecting the materials, full consideration have been given to structural strength, ability to withstand use and abuse, and weight.

4. MISCELLANEOUS EQUIPMENT

There are several additional items of collective protection equipment which have been standardized for use only in fixed type collective protection shelters (with the exception of the M2 anti-backdraft valve). These standard items are:

Table V-3
Standard Airlocks

Protective Entrance	Application	Description	Comments
(1) M2 pressurized protective entrance	NIKE-HERCULES guided missile van collective protection system	Butyl-coated nylon supported on aluminum frame mounted in sockets and supported by chains. The system has a self-closing entrance slit and utilizes filtered air from the interior of the van. Air passes along the length of the protective entrance in uniform flow and is exhausted through flap valves	The system utilizes a M15 GPFU rated at 2,400 cfm which pressurizes the personnel section of the van to .8 to .9 inches WG and the protective entrance to .15 to .30 inches WG. The entrance system weighs 50 pounds and is 26 1/4 inches length x 80 1/4 inches width x 83 7/8 inches high (erected measurements)
(2) M7 protective entrance	HAWK battery control central	Butyl-coated nylon over metal frame assembly. The system uses overlapping edges of panels as a door. The panels are held together by a spring operated closing device. Air flow to the entrance is both from a filter unit direct (175 cfm) and from the control central through an anti-backdraft valve (100 cfm)	The system utilizes a M 18 GPFU rated at 300 cfm to pressurize control central to .8 to 1.2 inches WG and the protective entrance to approximately .3 inches WG. The M7 protective entrance is 3 feet wide x 4 feet long x 6 1/2 feet high (erected measurements)
(3) Long body and short body protective entrance	Radar tracking station OA-2952/GSQ	Dual cylindrical chambers of butyl-coated nylon supported by metal hoop frame. Entrance is either long-body type for vehicle-mounted shelters, or short-body type for ground-mounted shelters	The system utilizes a 400 cfm GPFU to pressurize the personnel section to 1.75 inches WG; the main protective entrance chamber to 1.40 inches WG; and the outer protective entrance chamber to .50 inches WG. The dimensions of the protective entrance are: (1) Ground mounted Erected height main body assembly 98.38" Erected height outer chamber assembly 78.50" Erected diameter main body assembly 48.00" Weight 37 lbs. (2) Vehicle mounted Erected height main body assembly 145.00" Erected height outer chamber assembly 78.50" Erected diameter main body assembly 48.00" Erected diameter outer chamber assembly 30.00" Weight 47 lbs.

Table V-3
(Continued)

(4) M3 (AN/MSQ-28) Weapons Monitor Center Radar Data Processing Center	AN/MSG-4 Anti-Aircraft Defense System	Butyl-coated nylon fabric with aluminum tubing frame. The entrances are of two shapes—circular for vehicles, and oval for shelters. The system utilizes a zipper type door	The system utilizes a 400 cfm GPFU to pressurize the personnel sections to 1.5 inches WG and the protective entrance to 1.2 in. wg. The erected height is 146 inches; erected diameter 48 inches; and weight 37 pounds
(5) M4 (AN/MSQ-28) Radar Equipment Trailer/Maintenance Trailer	AN/MSG-4 Anti-Aircraft Defense System	Butyl-coated nylon fabric with aluminum tubing frame. The entrances are of two shapes—circular for vehicles, and oval for shelters. The system utilizes a zipper type door	The system utilizes a 400 cfm GPFU to pressurize the personnel sections to 1.5 inches WG and the protective entrance to 1.2 in. wg. The erected height is 146 inches; erected diameter 48 inches; and weight 37 pounds
(6) M5 (AN/MSQ-18) Operations Central/ Coder-Decoder Group	AN/MSG-4 Anti-Aircraft Defense System	Butyl-coated nylon fabric with aluminum tubing frame. The entrances are of two shapes—circular for vehicles, and oval for shelters. The system utilizes a zipper type door	The system utilizes a 400 cfm GPFU to pressurize the personnel sections to 1.5 inches WG and the protective entrance to 1.2 in. wg. The erected height is 139 inches; erected diameter 48 inches; and weight 35 pounds
(7) M6 (AN/TSQ-38) Operations Central/ Coder-Decoder Group	AN/MSG-4 Anti-Aircraft Defense System	Butyl-coated nylon fabric with aluminum tubing frame. The entrances are of two shapes—circular for vehicles, and oval for shelters. The system utilizes a zipper type door	The system utilizes a 400 cfm GPFU to pressurize the personnel sections to 1.5 inches WG and the protective entrance to 1.2 in. wg. The erected height for the ground-mounted unit is 93 inches x 60 inches lenght x 48 inches width and the system weighs 37 pounds. The erected height for the truck-mounted unit is 142 inches x 60 inches length x 48 inches width and weight 42 pounds

The M1 Contaminated Clothing Chute - a flanged sheet metal chute designed to convey contaminated clothing from an airlock of a shelter to a 32 gallon container in an unprotected area

The ABC-M2 Protective Shelter Permeable Membrane Door - a door designed for installation in a 3 foot x 7 foot doorway or corridor to provide safe entry for personnel. This door consists of two permeable elastic panels mounted on holding rings hinged to steel angles on the side of the doorway. Air flows through the panels at approximately 400 cubic feet per minute

The M1 Air Pressure Regulator - a regulator consisting of a steel frame (23 inches high x 13 inches wide) with an opening 9 inches square at one end. A moveable steel panel is raised or lowered to vary the size of the air passage.

The AN-M2 Antibackdraft Valve - a valve for regulating the air pressure inside a protective shelter. The valve also prevents the reverse flow of air into the shelter. The unit is $17\frac{1}{2}$ inches x 14 inches and consists of a flanged sheet steel body with a hinged cover. An adjustable counterweight is screwed to a shaft inside the hinged cover. This counterweight is adjusted to determine the pressure necessary to open the valve

The M2 Antibackdraft Valve - a valve for the regulation of air pressure inside the protective shelter and the prevention of reverse flow of air into the shelter. The unit consists of a flanged sheet steel body fitted with a hinged cover. The cover is attached through a linkage to a pivoted arm and an adjustable counterweight assembly.

VI. DEVELOPMENTAL ARMY AND AIR FORCE EQUIPMENT

1. COLLECTIVE PROTECTION EQUIPMENT (COMPLETE SHELTER SYSTEM)

Military requirements exist for a variety of shelter systems to provide protection against chemical and biological agents. To meet the specific mission requirements of the services, the following shelter systems are being developed by the Army and Air Force:

(1) Shelter System, Collective Protection, CB: Inflatable 10-Man, Trailer Transported, XM51

This portable air-droppable, multipurpose field shelter is being developed by the U. S. Army, Edgewood Arsenal, and uses filtered air under slightly positive pressure to protect as many as ten persons within 210 square feet of inside floor space.

The shelter is in the shape of a half cylinder with dual wall construction consisting of inflated tube like support ribs, 16 inches in diameter on the sidewalls and the arched ceiling and 12 inches in diameter on the end walls. Similar inflatable tube construction is used for the airlock which is connected to one end of the shelter.

A Gas Particulate Filter Unit (GPFU), Environmental Control Unit (ECU), and power plant (20 hp gasoline engine driving a 7.25 kw electric generator) comprise the remainder of the shelter system. These units are shock mounted on the bed of a $1\frac{1}{2}$ ton cargo trailer.

The GPFU provides filtered air to satisfy the ventilation requirements of 150 cubic feet per minute, and maintaining an overpressure of at least .4 inches of water in the shelter and .3 inches of water in the airlock.

The ECU provides both heating and cooling modes of operation with thermostat control of shelter air temperature. A recirculating filter unit is contained within the ECU for the continuous scavenging of recirculated air from the shelter. A separate recirculating filter is used for scavenging the protective entrance. The scavenging action of each of these filters is further enhanced by the filtered pressurization air passing through these enclosed spaces.

The tentative principal characteristics of the system are as follows:

Type	mobile, portable, pressurized CB field shelter
Construction	dual wall, air inflated ribs
Material	Tedlar/Dacron laminant, coated with neoprene
Wall thickness	
Sides and arched roof	16 in
End walls	12 in
Airlock	7 in
Floor area (interior)	210 sq ft
Ground anchors	
Type	arrowhead, military standard
Size	4 in
Number	14

7.3.1 Natural ventilation. Natural ventilation can be accomplished by

External guy lines	4
Weight (shelter and airlock)	500 lb
Volume (shelter and airlock packed for trailer stowage)	87 cu ft
Pressure requirements	
Blower	1.5 psig
Shelter atmosphere	0.4 in (water)
Airlock atmosphere	0.3 in (water)
Power plant	
Type	20-bph gasoline engine
Model	4A084 (Mk III)
Fuel tank capacity	50 gal
Generator	
Make	Generac
Model	VPO-80C
Rating	12/208 v, 60 Hz, AC, 7.25 kw
Refrigerant compressor	
Type	gasoline engine driven
Make	Frigidaire
Air heater	
Type	gasoline-fired
Make	Stewart-Warner
Model	MF510A2
Trailer	
Type	1½-ton cargo
Model	M105A2
Weight	2,650 lb
Weight of trailer and stowed shelter system	4,850 lb

(2) <u>M14 CPE Collective Protection Equipment for M292 Expansible Van Truck</u>

This collective protection equipment has been developed by the U. S. Army, Edgewood Arsenal, to provide protection for personnel in the M820A3 expansible van truck who are performing command post and fire direction center functions.

An interior liner of nylon fabric coated with butyl rubber is used to partially cover the inside of the van, reducing air leakage to approximately 250 cfm. Zippered openings are provided in the liner for access to switches and operating equipment.

A protective entrance (airlock) constructed of nylon fabric coated with butyl rubber rests on an aluminum platform and is supported by means of a pulley and bar assembly. It is attached to the liner by means of a zipper.

Additional components of the system include a 400 cfm capacity GPFU and an automatic air pressure control and warning system.

The equipment, except items that can remain installed in the van, are stowed on a $1\frac{1}{2}$ ton cargo trailer along with a military-type diesel-engine-powered generator which supplies power for the operation of the equipment.

Filtered air is provided by the GPFU to maintain pressure inside the van at a level slightly greater than 1 inch of water and slightly less than 1 inch of water in the protective entrance. Sufficient airflow is provided by the GPFU primarily to maintain these pressure levels by offsetting leakage from the van and secondarily to provide for scavenging operations.

The automatic pressure control system regulates the airflow from the GPFU and provides warning of low pressure levels by means of audible and visual signals.

The tentative principal characteristics of the system are as follows:

Model	M14 CPE
Type	collective protection equipment for M292 expansible van truck
Power Plant	diesel engine
Electric generator	15 kw, 208/416 v, 60 Hz, AC
Transformer-rectifier (for operation of control components)	24 DC, 9 amp capacity
Trailer	
Model	M105A2
Capacity	1½ tons
Weight	
Empty	2,650 lb
Fully loaded with CPE components, including power plant and modification hardware	6,246 lb
Removable CPE components	996 lb
Air Pressure requirements	
Van	1 in (water gage)
Protective entrance	slightly less than 1 in (water gage)
GPFU	
Rated Air input	440 cfm
Rated air output (to van and airlock)	400 cfm
Air-supply fan rating	208 v, 60 Hz, 3-phase, AC
Operating temperature range	-65° to 125°F
Width	23 in
Length	52 in
Height	38 in
Weight	465 lb
Material (van liner and protective entrance)	nylon fabric coated with butyl rubber

(3) XM15 Collective Protection Equipment for M577-Series Command Post Carrier

This collective protection equipment has been developed by the U. S. Army, Edgewood Arsenal, to provide protection for crew members of the M577-series command post carrier in their performance of command post and fire direction center functions.

Purified air is provided under positive pressure to the crew compartment of the carrier from a 250 cfm capacity GPFU.

A protective entrance made of butyl coated nylon fabric is attached on the ramp of the carrier and supported by a collapsible metal frame.

By leakage reduction measures, the vehicle can be pressurized to a positive pressure 7 inches (water gage) with respect to the atmosphere, or 1 inch (water gage) higher than the maximum pressure level in the engine compartment at maximum engine speed.

The system also includes a control system for automatic regulation of the air pressure in the crew compartment and the protective entrance.

The tentative principal characteristics of the system are as follows:

Type	collective protection equipment for M577-series command post carrier
Power source	vehicle's electric power system - 27.5 v DC
Power requirement	50 amps

Air pressure requirements	
Crew compartment	1 in (water gage) higher than pressure in engine compartment, which varies with engine rpm
Protective entrance	slightly less than 1 in (water gage) higher than pressure outside vehicle
GPFU	
Rated airflow	250 cfm
Operating temperature range	-65° to 125°F
Dimensions	
Width	29.5 in
Depth	26.5 in
Height	13.0 in
Weight	200 lb (approximately)
Material (protective entrance)	nylon fabric coated with butyl rubber

(4) CB Modification Kit for Flight Line Taxi

The modification kit for flight line taxis was developed by the Air Force Armament Laboratory for installation in any multistop panel truck with a minimum of modification to the vehicle.

Each kit includes a butyl coated nylon protective liner with supporting structure and accessories, an airlock compartment, an air purification and pressurization system, and a control and warning system.

The filter unit consists of a 4 cycle gasoline engine which powers a centrifugal blower. A pressure gage provides the vehicle driver with a continuous indication of crew chamber pressure.

A 2 inch by 24 inch by 24 inch commercial prefilter, a MIL-F-5121A activated charcoal gas filter, and a MIL-F-51215A particulate filter are used in the system. The activated charcoal filter limits the airflow capacity of the filter system to 600 cubic feet of air per minute. The unit is factory calibrated to indicate an internal operating pressure of 1.5 inches water gage at the maximum rated capacity of the filter.

The airlock consists of a double door sealed chamber which can accommodate two occupants. There is no interlock between the doors of the airlock other than a system of warning lights. A time delay switch, sensing the reclosing of the outer airlock door, maintains current to the red warning lights visible on both sides of the inner airlock door for a period of 30 seconds, allowing sufficient time to purge the airlock. The door latches are mechanical devices similar to conventional door latches.

(5) A/E 29P-1 CB Shelter-Decontamination Unit

The A/E 29P-1 portable CB shelter was designed by the Air Force Armament Laboratory to provide protection to essential personnel to insure a restrike capability in a CB environment. The unit is air transportable and is simplified in design and construction to require minimum manpower and time to prepare and operate the shelter.

The shelter is approximately 8 feet wide, 8 feet high, 32 feet long, and weights 12,000 pounds without water. The unit has rubber tire casters and jacks to afford limited mobility (5 mph maximum speed on casters), and it can be transported by highway trailer, internal rail, ship, or C-130 aircraft. With wheels extended, the height of the shelter increases to 10 feet, 6 inches. The shelter requires 208 volts, 60 cycles, 3-phase, 4-wire power, and it operates on approximately 30 Kilowatts. The unit has a cooling capacity (maximum load) of 42,000 BTU/hour and heating capacity (maximum load) of 56,000 BTU/hour. Temperature is thermostatically controlled from -60°F minimum to 85°F (dry bulb) maximum at 50 percent relative humidity.

Once the unit has been placed at the operational site, it is prepared for operation by filling the water storage tank, connecting the main control panel to a source of electrical power, erecting the queueing shelter and unfolding the egress airlock.

With adequate level of water in the storage tank, the low-water cutout switch will be closed, and, if the water is sufficiently cold (below 100°F) the water thermostat will close the immersion heater circuit. Initial activation of the electrical subsystem takes place immediately after power is applied through a circuit protector in the main control panel. A circuit will be established through the first stage of the thermostat in the hot water tank to the relay, activating the first (3-Kw) stage of the immersion heaters. If additional heat is called for by the second stage of the hot water tank thermostat, a time delay will act 30 seconds later to energize the second (18-Kw) stage of water heating.

The second phase of system operation (lighting, unit pressurization, and environmental control) will be initiated by the closing of a switch activated by opening of the ingress airlock doors. Advanced activation in preparation for a chemical-biological attack could also be accomplished by this means.

For a typical operational cycle, personnel will enter through the airlock, remove their contaminated clothing, deposit it into a laundry chute, and proceed to a shower area to be decontaminated by the wet-scrub-rinse cycle. This cycle involves a 15-second wetting period, followed by a 2 3/4 minute scrubbing period, and terminated with a one minute rinse. Personnel wearing protective masks will deposit them in a contaminated-mask disposal chute between the scrub and rinse phases. After the rinse phase, personnel will enter a drying room to dry and don clean clothing. Personnel will then proceed to the main protection chamber where they will either remain until it is safe or don protective clothing and return to the toxic environment to continue their prescribed mission.

The shelter has a personnel capacity of 15 people for 36 hours or 24 people for 8 hours.

2. COLLECTIVE PROTECTION EQUIPMENT (FOR EXISTING STRUCTURES)

In addition to the previously described shelter systems there are a number of equipment items in development which are designed for the conversion of existing structures into CB shelters. The items being developed by the Army and Air Force include:

(1) CB Modification Kit for Existing Air Force Field Structures

The CB Modification Kit for existing structures was designed by the Air Force Armament Laboratory and consists of a service module with airlocks, decontamination facilities, and a filter-blower system which provides filtered air to maintain a 0.4 to 0.6 inch water gage (IWG) overpressure. The kit provides the necessary sealing, air purification, pressurization, ingress/egress, and decontamination capability to insure CB protection for Air Force personnel. It is a removable modification to a structure and will not inhibit the normal functions of the structure.

An operational kit contains a collapsible pre-fabricated, transition section which connects it to the building to be protected and sealing compound to reduce the building's natural leak rate. As supplied with three filter-blower units, the modification kit is designed to protect buildings with 16,000 to 20,000 cubic feet (ft^3) volume. By employing a maximum of three additional filter-blower units, buildings with 32,000 to 40,000 ft^3 volume can be protected.

The service module has an aluminum frame and stressed aluminum skin and is mounted on extruded aluminum skids. It is 12 feet long, 7 feet wide, 7 feet 4 inches high, and it weighs approximately 3,000 pounds. It has double wall construction and is insulated with

2.75 inches of rigid polyurethane foam in the walls, floor, and ceiling. The service module is divided into seven compartments: entrance airlock; undressing room; shower stall; service compartment; dressing room; plenum chamber; exit airlock.

The modification kit has a decontamination system (shower), an air heating system, an electrical system, a control system which regulates personnel entrance, and an air pressurization system.

Separate entrance and exit airlocks eliminate interference between entering and exiting personnel. The two airlocks are similar except for the lights in the entrance airlock which regulates personnel entry. Each airlock is 3 feet long, 3 feet wide, and 6 feet 6 inches high inside. The inner and outer airlock doors have a fiber glass laminate skin and a foamed-in-place polyurethane core. Each door is self closing through the use of a conventional overhead hydraulic door closer.

Personnel entry into the service module is controlled to allow purging of contamination from the airlock and to allow enough time for an entrant to clear the undressing room before another tries to enter. A time delay relay controls each function with "wait" and "enter" lights in the entrance airlock. Switches on the airlock door jambs sense the entry and passage of personnel and energize the relays.

Air flows into the airlock from the interior of the service module through a damper in the ceiling. The damper is normally open but closes automatically when the outer door opens. Air flow through each airlock is controlled by an outlet near the bottom of each outer airlock door which is adjusted to give a pressure differential of 0.4 to 0.6 inches of water gage (IWG). This is equal to an airflow of approximately 100 cubic feet per minute.

The air pressurization system consists of the filter-blower units, an influent air panel located on the side of the modification kit, and flexible ducts which connect the filter-blowers to the panel.

Each filter-blower unit is composed of a blower fan, a commercial prefilter, a particulate filter, and a gas filter. The blower fan is a direct drive, radial blade, centrifugal fan powered by a one horsepower 208-220 volt, 60 hertz, 3 phase motor. Each filter-blower unit will supply filtered air to the modification kit at the rate of 600 cubic feet per minute.

The flexible ducting used to connect the filter-blower to the influent air panel is 13 inches in diameter and supplied in 10-foot lengths. It is made of butyl coated nylon and is helical wire reinforced. It can be collapsed to a length of approximately 2.5 feet for storage and is fastened to flanges on the filter-blower and the influent air panel with screw type clamps. The influent air panel is located on the side of the modification kit at the plenum chamber. It has six flanges on it to which the flexible ducts from the filter-blower units are attached. The unused flanges are capped.

The flow of filtered air, entering the modification kit through the influent air panel is split in the plenum chamber. The bulk of the filtered air flows from the plenum chamber directly into the protected building. One hundred cubic feet per minute flows through a ceiling duct into the exit airlock. The remaining 100 cubic feet per minute flows into the other compartments of the kit through a perforated door located between the dressing room and the plenum chamber. This air eventually flows through a ceiling duct into the entrance airlock.

The kit requires 208-240 volts, 60 hertz, 3 phase, 4 wire power source with approximately 15 kilowatts capacity at peak demand. A portable gasoline-engine-driven generator, common to Air Force inventory, will fulfill this requirement. Power is supplied to the kit through a standard aircraft 400 Hz plug at an external junction box. It is routed to the main electrical control panel where it is fed to the pressurization, air heating, water, and lighting subsystems.

(2) Aircraft Chemical-Biological Protective Overlay/Entrance

The Aircraft Chemical-Biological Protective Overlay/Entrance was developed by the Air Force Armament Laboratory to permit aircrews to safely enter the aircraft in a hazardous CB environment.

The overlay is a rigid fiberglass and aluminum structure 12 feet long, 7 feet high, and 6 feet wide and is mounted on a specially designed expandable stand. The stand can be raised hydraulically to position the overlay over the cockpit. The overlay will seal to the fuselage, and can be adapted to the A-7, F-100, F105, F-4C, F-5 and F-111 aircraft by installing the proper seal designed for each fuselage configuration. Automotive type running gear is provided for towing the overlay at 20 mph. An electric filter/blower system will produce an overpressure of approximately 1 inch water gage in the overlay and .5 inches water gage in the airlock for CB protection. The unit can be powered by the ground support unit or by the aircraft itself. The overlay is operated by a crew chief wearing CB protective clothing and can be positioned on the aircraft in 30 minutes.

The overlay/entrance is stored near the flight line on its stand, which is in the collapsed position. It will be towed out to the desired aircraft and the expandable stand will be raised above the fuselage, the overlay will be tipped to clear the canopy, and the seal will be fitted around the fuselage. The pressurization system will then be activated, and the aircrew will enter the overlay through the entrance tube without exposure to the toxic environment. After the canopy is closed, the overlay is removed, decontaminated, and readied for re-use as required.

(3) Modular Collective Protection Equipment for Vehicles Vans, and Shelters

A number of promising candidate components have been developed by the U. S. Army, Edgewood Arsenal, to meet the collective protection requirements for present and future vehicles, vans, and shelters. These components include GPFUs, protective entrances, and attachments which can be integrated into modular collective protection for vehicles, vans, and shelters having airflow requirements in the range of 50-600 cfm. The Modular Collective Equipment can be powered from 27.5 vdc, 60 Hz, and 400 Hz power sources. It is planned that this equipment will enter engineering development in FY71 with type classification scheduled for FY75.

The GPFUs under development in this program have design improvements in the air inlet protector, dust collector, fan assembly, particulate filters and gas filters over the current standard GPFUs. Multiple filter designs were developed with airflow ratings (and various fan assemblies) as follows:

Single filter GPFU	50-200 cfm
Two filter GPFU	200-400 cfm
Three filter GPFU	400-600 cfm

Improved designs have also been developed for airflow valves to regulate the amount of airflow through the GPFU and into the protective shelter. Control equipment has also been developed to provide automatic regulation of the GPFU to maintain a safe level of pressure within the protected enclosure. The control equipment provides the appropriate audible and visual alarm signal for low pressure, monitors the status of the particulate filters with respect to restriction of airflow, and provides overload protection for certain major components.

A butyl-coated nylon flexible membrane entrance was developed for highly mobile applications where simple and fast erect and strike operations are desired and limited storage space is available.

The weight and electrical power consumption of the dc versions while in advanced development are as follows:

GPFU Unit	Weight (lbs)	Power Requirements (amps at 27.5 V dc)
200 cfm	174.5	55
400 cfm	252.4	89
600 cfm	272.1	130

APPENDICES

APPENDIX A
PROPOSED MILITARY CHARACTERISTICS FOR COLLECTIVE PROTECTION FOR CARRIER COMMAND POST, LIGHT TRACKED, M577

(SOURCE: LETTER TO CG, U.S. ARMY MATERIEL COMMAND FROM USACDCMR DATED 27 JANUARY 1966)

1. Performance Characteristics. The following listed operational characteristics for collective protection for the M577 Command Post are considered essential:

a. This system will provide M 577 Command Post vehicles with filtered air under positive pressure to prevent the entrance at hazard levels of chemical and biological lethal and incapacitating agents and radioactive particulants. This system will allow performance of duties (medical aid station) within the vehicle which requires a CBR hazard free area or are critical duties (command and communications) most effectively performed without the limitations imposed by the wearing of complete CB individual protection.

b. The interior of the M 577 Command Post vehicle does not provide sufficient space for full performance of either command post or medical aid functions, therefore, when stationary, a CB Pressurized Protective Shelter will be attached to provide CB protection and essential environmental control for the entire command post or aid station effort. This protection will provide a CBR toxic hazard free area within the M 577 to allow minimal use while in transit or will allow ready attachment to the CB Pressurized Protective Shelter without the delay caused by the need for decontaminating an unprotected M 577 Command Post vehicle.

c. This protective system will reduce the possibility of contamination of the interior of the vehicle, thus decreasing or eliminating the requirement for decontamination before attachment and use with the CB Pressurized Pod.

d. The system must be capable of providing the same degree of respiratory protection as the current standard field protective mask.

e. The protective system shall be capable of satisfactory continuous operation under intermediate operating ranges specified in AR 705-15. Attachment of the CB Pressurized Protective Shelter will provide heating or cooling needed for operation under extreme hot or cold conditions.

f. The components of the collective protection system shall withstand the normal wear and rough handling imposed upon the other equipment within the M 577.

g. Operation of the collective protection system shall be capable of accomplishment by the crew of the M 577.

2. Physical Characteristics. The following listed physical characteristics are regarded as essential. Variations and trade-offs determined by developing agencies to be necessary to produce a feasible item will be submitted to the user agency who will determine the tactical acceptability of the proposed item.

a. The collective protection system shall not require an additional power source and shall be designed for maximum use of existing heating and ventilating systems of the M 577.

b. The system shall be designed for installation within the interior of the vehicle.

c. The inertial dust separator component shall be capable of ejecting overboard at least 93% of AC spark plug coarse test dust to minimize buildup on the particulate filter of CB and radioactive particulants.

d. The rated air flow of the collective protector must be sufficient to develop an effective overpressure within the troop and crew compartments while the vehicle is either in motion or stationary, provide adequate ventilation to occupants and equipment, and purge the interior of the vehicle of airborne toxic gas and aerosol contaminants contained on or in the clothing of entrants.

e. The collective protector shall be designed to prevent the accumulation of combustion gases within the troop and crew compartments of the M 577 whenever the vehicle motor is in operation.

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f. Simple and effective control devices shall be used for adjustment and control of pressure level within the protected areas.

g. A simple effective warning device shall be used to indicate a drop below the required overpressurization within the vehicle caused by malfunction of components of the system.

h. The collective protection system shall be of minimum weight consistent with protective and operational requirements. Cubage shall not exceed four cubic feet; cubage of two cubic feet is desirable.

i. Storage requirements shall be the same as those requirements of the vehicles in which the collective protection is installed.

j. An adequate air lock entry and exit system will be required, which, when installed and not in use, shall have a minimum space requirement and shall not interfere with the operation of the vehicle upon which it is installed. It shall not present a hindrance to the rapid loading or unloading of the occupants when the vehicle is engaged in an attack or withdrawal phase of combat operations.

k. The air-lock entry/exit system shall incorporate the following features and shall:

(1) Be capable of rapid extension for use when the vehicle is stopped, and rapid return to mobile (non-use) position.

(2) Not interfere with the opening of the door or ramp when not extended for use.

(3) Have provision for interior lighting and blackout operations.

(4) Have an entrance-way which is easily opened and closed and shall be capable of being readily attached and detached to the CB Pod developed under the QMR for positive Pressure Collective Protection for Field Shelters, to the entry/exit system of the M292 Command Post Expansible Van, to each other or to any other collective protection system developed.

l. Provision of a means of communication to include transferral of written messages, maps, and overlays, is required. This may be tied in with the air lock system.

m. The best currently available toxic chemical agent alarm or detection system shall be included with the collective protection system to indicate presence of agent in the vehicle so that necessary protective measures may be taken by the occupants.

n. Purge time (see para 2e above) of five minutes is required. (Less than one minute is desirable).

o. The air filtration component of the system must permit a 48-hour continuing operation cycle. All critical components must function properly 90% of the time (92% desirable).

3. Maintenance Characteristics. Maintenance of the system will be within the performance capability of the using units. It will consist primarily of changing of filters and servicing of the motor unit of the filter. Not more than fifteen minutes downtime should be required for maintenance.

4. Human Engineering Characteristics. The following human engineering characteristics are regarded as essential:

a. Noise level will not interfere with the performance of communication personnel within the command post nor have any adverse effects upon operational efficiency of personnel in the battalion aid station.

b. Ventilation of the interior will prevent the buildup of heat to an intolerable level when system is used in moderate climatic conditions. When used in extremes of heat and cold, attachment of the CB Positive Pressure Field Protective Shelter will provide sufficient heating or cooling to prevent the buildup of intolerable stresses while the vehicle is stationary and will alleviate heat stresses developed while the vehicle is mobile.

5. Priority of Characteristics.

a. Protection from CBR agents afforded to user.

b. Compatibility with present configuration of M577 Command Post vehicle.

c. Compatibility with functions being performed within the M577 Command Post vehicle.

d. Provision for adequate protected enclosed area to allow performance of command post or battalion aid station functions through capability of attachment to the CB Positive Pressure Protective Field Shelter, to the M292 Command Post Van, in lieu of use of the tent extension.

e. Prevention of heat stress through ventilation or attachment of CB Positive Pressure Protective Field Shelter.

Technical Characteristics—Collective Protection for Carrier, Command Post, Light Tracked M577

1. General: The M577 Command Post Carrier is a light weight, lightly armored, self-propelled, tracked vehicle. The enclosed space to be provided with collective protection has approximately 60 square feet of floor space resembling the size and shape, and using the chassis of the M113A1 Armored Personnel Carrier. This mobile command post vehicle, which provides armor-protected mobility for field commanders, may also be used as a fire direction center. Category A collective protection will be provided for this vehicle when used in the Command Post and Fire Direction Center roles to permit the continuance of tactical operations within the vehicle without the use of individual protective equipment in a CB environment. The allocation will be one collective protective system for each M577 vehicle assigned for Command Post or Fire Direction Center usage.

2. Components: The major components of the collective protection system for the M577 Command Post Carrier shall be a gas-particulate filter unit assembly (including an inertial dust separator, air flow-pressure control system, and control panel), protective entrance (air lock), modification kit, installation kit, and tool and repair kit.

3. Design Requirements:

a. Compatibility: The collective protection system shall be designed to be compatible with the vehicle's ventilating and heating systems, as applicable and to minimize interference with the primary tactical mission of the vehicle.

b. Stowage and Installation: The collective protection system shall be designed for field installation within the designated vehicle. The installation shall be accomplished with minimum modifications to the vehicle. Modifications shall be non-complex and of the type which can be accomplished in the field.

c. Design Complexity: The collective protection system shall be non-complex in design to facilitate installation, maintenance, and repair. The collective protection system shall be compact and of minimum weight and bulk consistent with protective and operational requirements.

d. Protection: The collective protection system shall be capable of providing the same degree of respiratory protection as the current standard field protective mask.

e. Noise and Vibration: The collective protection system shall produce a minimum of noise and vibration and shall be free from acoustically objectionable frequencies. The noise of the filter unit assembly shall not exceed the levels specified in Table 3 or 4 of HEL Standard S-1-63B, dated June 1965.

f. Vibration, Shock, Humidity, Barometric Pressure:

(1) Non-Operating Conditions:

(a) Vibration—The collective protection equipment shall withstand vibration when tested in Level A packaging as specified by MIL-STD-810A (USAF), dated 23 June 1964, Method 514.1, Table 514-1, under Equipment Class 6, Shipment by Common Carrier, with the following exception: There shall be a continuous frequency sweep during vibration without resonance dwell.

(b) Shock-Transportation Shock—The collective protection equipment shall withstand shock when tested in Level A packaging as specified in MIL-STD-810A, Method 516.1, Procedure III.

(c) Humidity—Exposure of the collective protection equipment to humidity, as prescribed in MIL-STD-810A, Method 507.1, Procedure I, shall not produce a major deterioration in overall performance.

(2) Operating Conditions:

(a) Vibration—The performance of the collective protection equipment shall not be appreciably affected when vibrated in accordance with MIL-STD-810A, Method 514.1, Table 514-1, under Equipment Class 5, Ground Vehicles, Curve B, with the following exception: There shall be a continuous frequency sweep during vibration without resonance dwell.

(b) Shock—The collective protection equipment shall withstand shock as prescribed in MIL-STD-810A, Method 516.1, Procedure I, without adversely affecting performance.

(c) Humidity—The collective protection equipment shall operate satisfactorily when subjected to 100% humidity at 85°F for a period of 2 hours.

(d) Barometric Pressure—The collective protection equipment shall operate satisfactorily when tested at an equivalent altitude of 10,000 feet (20.58 in hg) as specified in MIL-STD-810A, Method 500.1, Procedure I.

g. Operating Temperatures: The collective protection equipment shall be capable of operating for a period of 4 hours in ambient temperatures as specified in MIL-STD-810A, Methods 501.1 and 502.1. It shall be capable of safe storage as specified in MIL-STD-810A, Methods 501.1 and 502.1. Temperature tolerances of ±3°F are acceptable.

h. Rain, Snow, Wind: The collective protection equipment shall withstand rain, snow, and wind conditions as specified in AR 705-15, Change 1, dated 14 October 1963, Paragraph 7c, Intermediate Climatic Conditions.

i. Pressure Control System: The collective protection system shall have an automatic pressure control system capable of maintaining a level of protective pressure which precludes the infiltration of atmospheric contaminants during operation of the protective system.

j. Filter Unit Capacity: The gas-particulate filter unit shall be capable of supplying sufficient purified air to satisfy the crew compartment leakage at a pressure level consistent with adequate protection, or to meet the ventilation requirements, whichever is greater. In addition, the air flow capacity of the filter unit shall be sufficient to provide purified air for both pressurization and scavenging of the protective entrance.

k. Maintenance: The gas-particulate filter unit design shall be such that maintenance and filter replacement can be readily accomplished without special tools in a reasonable period of time by inexperienced personnel with minimum instruction.

l. Filter Unit Reserve; Dust Build-up: The filter unit assembly shall be capable of removing a minimum of 92 percent of dust from a cloud containing 0.025 gram per cubic foot of AC Spark Plug Company Standardized Coarse Test Dust (Sonic feed method) at rated air flow. Provisions shall be made for continuous discharge of the separated dust outside the protected area (overboard).

m. Motor-blower Output: The motor-blower output must be capable of producing controlled air flows within the desired operating range without significant pressure loss due to a "saddle of stall" condition. After 44 hours of continuous operation at rated air flow in an atmosphere containing 0.1 gram per cubic foot of Silica flour, as set forth in MIL-STD-810A, Method 510.1, the motor-blower shall meet performance requirements with the exception that the rated air flow may decrease by 10 percent. Since the gas-particulate filter unit is installed inside the vehicle, the motor-blower will be downstream or the gas and particulate filters. In this case, the dust erosion requirement does not apply to the filter unit motor-blower. However, this requirement does apply to the motor-blower component of the inertial dust separator.

n. Particulate Filter: The particulate filter shall be constructed in accordance with MIL-F-51068, dated 30 October 1964, using filter media in accordance with MIL-F-51079, dated 10 September 1963. It shall be capable of removing a minimum of 99.97 percent of the standard 0.3 micron DOP test aerosol at its rated flow capacity when tested in accordance with MIL-STD-282, dates 28 May 1956.

o. Gas Filter: The gas filter media shall be ASC Whetlerite charcoal in accordance with MIL-C-13724A, dated 4 May 1960, and shall be capable of providing complete protection against all gaseous toxic warfare agents. When the gas filter, with incorporated charcoal meeting the above-mentioned military specification, is tested at rated flow and in accordance with MIL-STD-282 against a phosgene concentration of 10 milligrams per liter, the life shall not be less than 20 minutes.

p. Protective Entrance: The protective entrance (air lock) shall be collapsible, readily stowed, and capable of quick and easy attachment to, or detachment from, the vehicle. When stowed, the protective entrance shall not interfere with the normal use of either the ramp or the personnel entry door within the ramp. Provision shall be provided for interior lighting and blackout operation. Provisions shall be provided for interconnection with the CB Pressurized Pod. Butyl-coated nylon or similar toxic agent resistant material shall be used together with appropriate metal frame supports. The protective entrance shall be designed for protective operation in wind speeds up to 22 knots (essential) and shall have structural strength to withstand winds of 45 knots for a 5 minute period with gusts to 65 knots with tie-downs (desirable). Possible interference by the wearing of combat equipment and arctic winter clothing must be considered in the design of the protective entry system. A means of transferral of written messages, maps and overlays through the protective entrance into the protected area will be provided.

q. Control Panel: The control panel shall be designed for simplicity of operation and shall have a display or layout that will provide the operator with complete information as required for the operation of the collective protection system. It shall be designed in accordance with HEL Standard S-2-64, dated May 1964. The control panel shall consist of the following components:

(1) Indicator lights for motor-blower "on" and "off", particulate filter replacement, and low crew-compartment pressure. The low pressure shall also be indicated by audible alarm.

(2) Push button for testing operation of indicator lights.

(3) Push button for shutting off audible alarm.

(4) Necessary "on" and "off" switches.

(5) Necessary relays, circuit breakers, and/or fuses.

(6) Timer for recording motor-blower operation.

r. Installation Kit: This kit shall consist of equipment required to install and connect the prime collective protection system components, such as hoses, electrical cables, etc. The kit shall be compatible with the vehicle after necessary modifications have been made.

s. Modification Kit: This kit shall consist of equipment and materials (including leakage reduction materials and methods), plus instructions, for modifying the vehicle to make it compatible with the collective protection equipment. Once installed, this kit shall become an integral part of the vehicle.

t. Mobile Protection: The gas-particulate filter unit shall be designed to be capable of operation while the vehicle is in motion, so as to prevent the infiltration of gas and aerosol contaminants into the crew compartment while the vehicle is traveling through CB contaminated areas.

u. Power Supply: The collective protection equipment shall be powered by the vehicle's engine or by the auxiliary power unit (d-c energy) mounted on the vehicle. No additional power supply unit shall be required.

v. Purge Time: Purge time is defined as that period of time required to reduce the airborne contaminant level by a factor of 3 logs (i.e., initial concentration at time zero-100, concentration at specified time level—0.1%), with no additional input of contamination into the volume being purged, during the test period. On this basis, purge time for the crew compartment and entry system are:

(1) Crew Compartment—The purge time shall be such that a 3-log reduction in contamination level can be effected in a period of 25 minutes (essential), 10 minutes (desirable).

(2) Protective Entrance—The purge time shall be such that a 3-log reduction in contamination level can be effected in a period of 5 minutes (essential), 3 minutes (desirable).

w. Compatibility with CB Pressurized Pod: The collective protection system for the M577 Command Post Carrier shall be so designed so that by appropriate interconnection with the C-B Pressurized Pod, the protected areas of both the vehicle and the pod can be utilized in carrying out the command post function of the vehicle in an integrated CB protected area complete with entry system.

x. Detection System: The best currently available toxic chemical agent alarm or detection shall be included in the collective protection system.

4. Operational and Maintenance Characteristics:

a. Mission Time: The mission time is 48 hours.

b. Reliability: Based on a 48 hour mission time, the overall reliability of the collective protection system shall be at least 0.90 (essential), 0.92 (desirable).

c. Durability: The durability of the collective protection equipment shall permit 500 hours of operation (essential), 1000 hours (desirable), without requiring other than organizational maintenance.

d. Planned Deployment: See Paragraph 1.

e. Reaction Time: Once the M577 Command Post Carrier has been initially adapted for collective protection, the time required for making the collective protection system fully operational shall not exceed 5 minutes from the time the vehicle is halted in the selected area.

f. Environment: The collective protection system shall be capable of satisfactory continuous operation under intermediate operating ranges as specified in AR 705-15, Change 1, dated 14 October 1963. Attachment of the CB Pressurized Pod will provide heating or cooling needed for operation under extreme cold or hot conditions.

g. Utilization: The CB protected M577 Command Post Carrier will be utilized on a continuous basis in those areas in which CB operations are occurring or imminent.

h. Mean Down Time: Maximum interchangeability of parts, tools, and test equipment with other U.S. Army Systems is essential. Interchangeability of modules is desirable. Higher maintenance echelons will have maintenance float for immediate issue to replace defective equipment to minimize down time. Down time for changing filters will be 15 minutes or less.

i. Reliability After Storage: There must be no degradation in equipment performance after limited storage, performance of 1st and 2nd echelon maintenance, or after a period of storage or decontamination to a degree which will permit occupancy without the use of the field protective mask. Replacement of modules will eliminate fault isolation by user. Checkout procedures for maintenance personnel will be covered in appropriate maintenance documentation for the various modules and components of the collective protection system.

j. Maintenance Personnel: There are no requirements for new skills since 1st echelon maintenance will consist of pre-operational check, care and cleaning, to include decontamination when necessary, repair of rips and tears in the protective entrance with a field repair kit, and prescribed 1st echelon maintenance of the filter units. This maintenance should be performed by maintenance personnel available to the unit.

5. Human Factors Engineering Characteristics: Possible interference by the wearing of combat equipment must be considered in the design of the protective entrance system (see Paragraph 3p).

Interior temperatures and humidities must be maintained within limits to provide reasonable working conditions for human occupants.

6. Priority of Characteristics:

a. Performance

b. Reliability

c. Weight and Size (Transportability)

d. Simplicity of Operation and Training

e. Maintenance

f. Environmental Requirements

7. Quantitative and Qualitative Personnel Considerations: The installation and use of the collective protection system shall not present any undue problems in training of personnel nor shall it require additional personnel in the using unit. No new MOS or special skills will be required.

8. Training Considerations: No formalized training shall be required in installation, operation, and maintenance of the collective protection equipment. Concurrent training should be conducted in scheduling and use of the collective protection equipment and to acquaint and accustom the unit commander with the effects, if any, upon the operation of his unit. The equipment should be such that a 2 hour period of instruction will provide unit personnel with sufficient knowledge to install and operate the collective protection system under day or night conditions while wearing full individual protection gear, and/or arctic clothing.

APPENDIX B

SAMPLE CALCULATION AND TRADE-OFF PROCEDURES FOR SELECTION OF CB PROTECTION AND ENVIRONMENTAL CONTROL UNITS FOR AN ELECTRONIC EQUIPMENT VAN

(Reproduced from "CB Protection for Tactical Air Control Systems" Draft Report for JTCG/TACS, June 1969)

1. Selection of Shelter and Ground Support Equipment for Trade-off Study:

This study utilized a typical 2 1/2 ton electronic shelter with an electrical equipment load of 5.0 kw with current "state of the art" CB filter equipment, air conditioning and electric generator equipment. In the case of the CB filter equipment, the E-52 Gas-Particulate Filter Unit design capacity of 400 cfm (200 cfm for shelter—200 cfm for entry system) and performance characteristics appear to be optimum. Other filter units used in the analysis are based on this basic design with best estimates of weight, power, cubage and cost presently available. Entry system weight, cubage and cost figures are based on currently available designs. The air conditioning equipment criteria is based on the compact series of vertical air conditioners developed by the Army. Electric Generator data is based on presently available standard Army gasoline powered generators.

2. Design Conditions and Cooling Load for Typical Shelter w/5.0 kw Electronic Equipment Load:

a. Design Conditions:

(1) Outside: 360 BTU/hr/sq ft, solar heat 105°F DB with an equivalent 85°F saturated moisture content—91°FET.

(2) Inside: 85°FET required (95°F DB, 79°F WB).

b. Cooling Load Sensible Heat

Transmission and solar heat gain	3770 BTU/hr
Personnel and make-up air	2280 BTU/hr
Electric load 5.0 kw	17075 BTU/hr
Collective Protector (2.5 kw)	8538 BTU/hr
	31,663 BTU/hr

Latent Heat:

Personnel and make-up air	4630 BTU/hr
Total (Latent and Sensible) (Approximate load—3.0 tons of air conditioning)	36,293 BTU/hr

3. Ground Support Equipment Options and Trade-offs in Weight, Power and Cubage:

In meeting the CB protection and environmental requirements several possibilities exist in terms of optional approaches deserving consideration in assessing what is to be the optimum approach. Table II gives comparative values for six possible optional ground support equipment combinations. Where specific data was not available on certain CB filters not yet developed with respect to weight, power and cubage, data and criteria have been estimated. These estimates are felt to be sufficiently accurate for this comparative evaluation although a more detailed study in depth of the specific designs may produce some changes in the values indicated. CB detection equipment was not included since the added weight, cubage and power are minor as compared to the listed CB protective items. A narrative description of each of the options is provided in Table 1.

TABLE 1
EQUIPMENT OPTIONS

OPTION	APPROACH
1	Single CB Filter Unit (400 cfm) with air conditioning provided for personnel and equipment sections from a single air conditioner (3 ton)
2	Single CB Filter Unit (400 cfm) with single air conditioner (1 1/2 ton) of reduced capacity principally for personnel section. Ambient air cooling of electronic equipment with non-filtered air at higher temperature
3	Single CB Filter Unit (400 cfm) with one air conditioner (1 1/2 ton) principally for personnel section. At higher temperatures, an additional 1 1/2 ton air conditioner would be provided
4	Single CB Filter Unit (1000 cfm) to service equipment and personnel sections through all temperature ranges. 1 1/2 ton air conditioner for personnel section
5	Single CB Filter Unit (400 cfm) and 1 1/2 ton air conditioner for personnel section. A 600 cfm CB Filter Unit would be added to provide filtered air equipment cooling at high temperatures
6	Single CB Filter Unit (400 cfm) and 1 1/2 ton air conditioner for personnel section. A 600 cfm CB Filter of reduced capacity would be added for equipment protection at high temperatures

TABLE 2
GROUND SUPPORT EQUIPMENT OPTIONS FOR TYPICAL SHELTER; OPTIONS #1 AND # 2

OPTION 1

1. 3 Ton Air Conditioner (1)
   Weight - 390, 380 lbs. *
   Cubage - 17.2 cu ft
   Power - 9.5, 11 kw*

2. Gas-Particulate Filter Unit, 400 cfm
   Weight - 250 lbs
   Cubage - 11.1 cu ft
   Power - 2.5 kw (estimated for 400 Hz power)

3. Air Lock
   Weight - 70 lbs (est)
   Cubage - 13 cu ft (est)

4. Electronic Equipment
   Power Required - 5.0 kw

5. Total System-Power Required
   18.5 kw

6. Electric Power Generators Required
   2 ea Model SF-10.0/SIED
   Weight of 2 Items - 1700 lbs
   Cubage of 2 Items - 58.2 cu ft

7. Totals:
   Weight - 2400 lbs
   Cubage - 99.5 cu ft
   Power - 18.5 kw (400 Hz)

OPTION 2

1. 1 1/2 Ton Air Conditioner (1)
   Weight - 210, 200 lbs*
   Cubage - 8.5 cu ft
   Power - 5.4-6.35*

2. Same as Item 2, Option 1

3. Same as Item 3, Option 1

4. Same as Item 4, Option 1

5. Total System Power - 13.9 kw

6. Electric Power Generators Required
   1 ea Model SF-10.0/SIED
   1 ea Model SF-5.0/SIED
   Weight of 2 Items - 1338 lbs
   Cubage of 2 Items - 45.4 cu ft

7. Totals:
   Weight - 1878 lbs
   Cubage - 78.0 cu ft
   Power - 13.9 kw

TABLE 2
GROUND SUPPORT EQUIPMENT OPTIONS FOR TYPICAL SHELTER;
OPTIONS #1 and #2

OPTION 1	OPTION 2
Remarks:	Remarks:
a. Environmental Will meet intermediate, hot-dry, warm, wet requirements of AR 705-15. Utilizes equipment heat for personnel in cold environment.	a. Environmental Will meet same requirements as Option 1. Non CB filtered ambient air cooling of equipment above 74°F ET.
b. CB Protection Positive pressure protection for personnel and equipment under all conditions of operation with protective entry capability.	b. CB Protection Positive pressure protection for personnel under all conditions and for equipment up to 74°F ET above which protection for equipment can only be provided by adding filtered air or air conditioning capacity.

* 1st value for 60 Hz version; second for 400 Hz version
* Totals based on 400 Hz powered equipment
NOTE: Data for CB filters do not include flexible ducts

TABLE 2
GROUND SUPPORT EQUIPMENT OPTIONS FOR TYPICAL SHELTER; OPTIONS #3 AND #4

OPTION 3

1. 1 1/2 Ton Air Conditioner (2)*
   (Add-on air conditioner for equipment cooling at high temperature)
   Weight(2) - 400 lbs
   Cubage(2) - 17.0 cu ft
   Power(2) - 12.7 kw

2. Gas-Particulate Filter Unit (400 cfm)*
   Weight - 250 lbs
   Cubage - 11.1 cu ft
   Power - 2.5 kw (400 Hz)

3. Air Lock
   Weight - 70 lbs (est)
   Cubage - 13.0 cu ft (est)

4. Electronic Equipment
   Power Required - 5.0 kw

5. Total System Power Required
   20.2 kw

6. Electric Power Generators Required
   2 ea model SF-10.0/SIED
   Weight of 2 items - 1700 lbs
   Cubage of 2 items - 58.2 cu ft

7. Totals**
   Weight - 2460
   Cubage - 94.9 cu ft
   Power - 20.2 kw

OPTION 4

1. 1 1/2 Ton Air Conditioner (1)*
   Weight - 220 lbs*
   Cubage - 8.5 cu ft
   Power - 6.35 kw

2. Gas-Particulate Filter Unit (1000 cfm)*
   Weight - 600 lb (est)
   Cubage - 19.5 cu ft (est)
   Power - 6.3 kw (est)
   (Filtered air provided for personnel, equipment and air lock)

3. Air Lock
   Same as item 3, option #3

4. Electronic Equipment
   Power Required - 5.0 kw

5. Total System Power Required
   17.6 kw

6. Electric Power Generators Required
   Same as item 6, option #3

7. Totals**
   Weight - 2590 lbs
   Cubage - 99.2 cu ft
   Power - 17.6 kw

TABLE 2
GROUND SUPPORT EQUIPMENT OPTIONS FOR TYPICAL SHELTER; OPTIONS #3 AND #4

OPTION 3

Remarks:

a. Environmental

Will meet intermediate, hot-dry, warm-wet requirement of AR 705-15. Utilizes equipment heat for personnel in cold environment.

b. CB Protection

Positive pressure collective protection for personnel and equipment under all conditions with protective entry capability.

OPTION 4

Remarks:

a. Same as option #3

b. Same as option #3

* 400 Hz powered equipment

** Totals based on 400 Hz powered equipment

NOTE: Data for CB filters do not include flexible ducts

TABLE 2
GROUND SUPPORT EQUIPMENT OPTIONS FOR TYPICAL SHELTER; OPTIONS #5 AND #6

OPTION 5

1. 1 1/2 Ton Air Conditioner*
   Weight - 220 lbs
   Cubage - 8.5 cu ft
   Power - 6.35 kw

2. Gas-Particulate Filter Unit, 400 cfm*
   Weight - 250 lbs
   Cubage - 11.1 cu ft
   Power - 2.5 kw

   Gas-Particulate Filter Unit, 600 cfm*
   Weight - 358 lbs (est)
   Cubage - 16.6 cu ft (est)
   Power - 3.75 kw (est)

3. Air Lock
   Weight - 70 lbs (est)
   Cubage - 13.0 cu ft (est)

4. Electronic Equipment
   Power Required - 5.0 kw

5. Total System - Power Required: 16.8 kw

6. Electric Power Generators Required
   2 ea Model SF-10.0/SIED
   Weight of 2 items - 1700 lbs
   Cubage of 2 items - 58.2 cu ft

OPTION 6

1. Same as item 1, option #5

2. Gas-Particulate Filter Unit, 400 cfm*
   Weight - 250 lbs
   Cubage - 11.1 cu ft
   Power - 2.5 kw

   Gas-Particulate Filter Unit, 600 cfm* (reduced life filter)
   Weight - 180 lbs (est)
   Cubage - 8 cu ft (est)
   Power - 1 kw (est)

3. Same as item 3, option #5

4. Electronic Equipment
   Power Required - 5.0 kw

5. Total System - Power Required: 14.6 kw

6. Electric Power Generators Required
   1 ea Model SF-10.0/SIED
   1 ea Model SF-5.0/SIED
   Weight of 2 items - 1338 lbs
   Cubage of 2 items - 45.4 cu ft

TABLE 2
GROUND SUPPORT EQUIPMENT OPTIONS FOR TYPICAL SHELTER; OPTIONS #5 AND #6

c OPTION 5

7. Totals**
Weight - 2598 lbs
Cubage - 94.4 cu ft
Power - 17.6 kw

Remarks:

a. Environmental
Will meet intermediate, hot-dry, warm-wet requirements of AR 705-15. Utilizes equipment heat for personnel in cold environment.

b. CB Protection
Positive pressure collective protection for personnel and equipment under all conditions with protective entry capability.

OPTION 6

7. Totals**
Weight - 2058 lbs
Cubage - 73.0 cu ft
Power - 14.8 kw

Remarks:

a. Environmental
Same as option #5

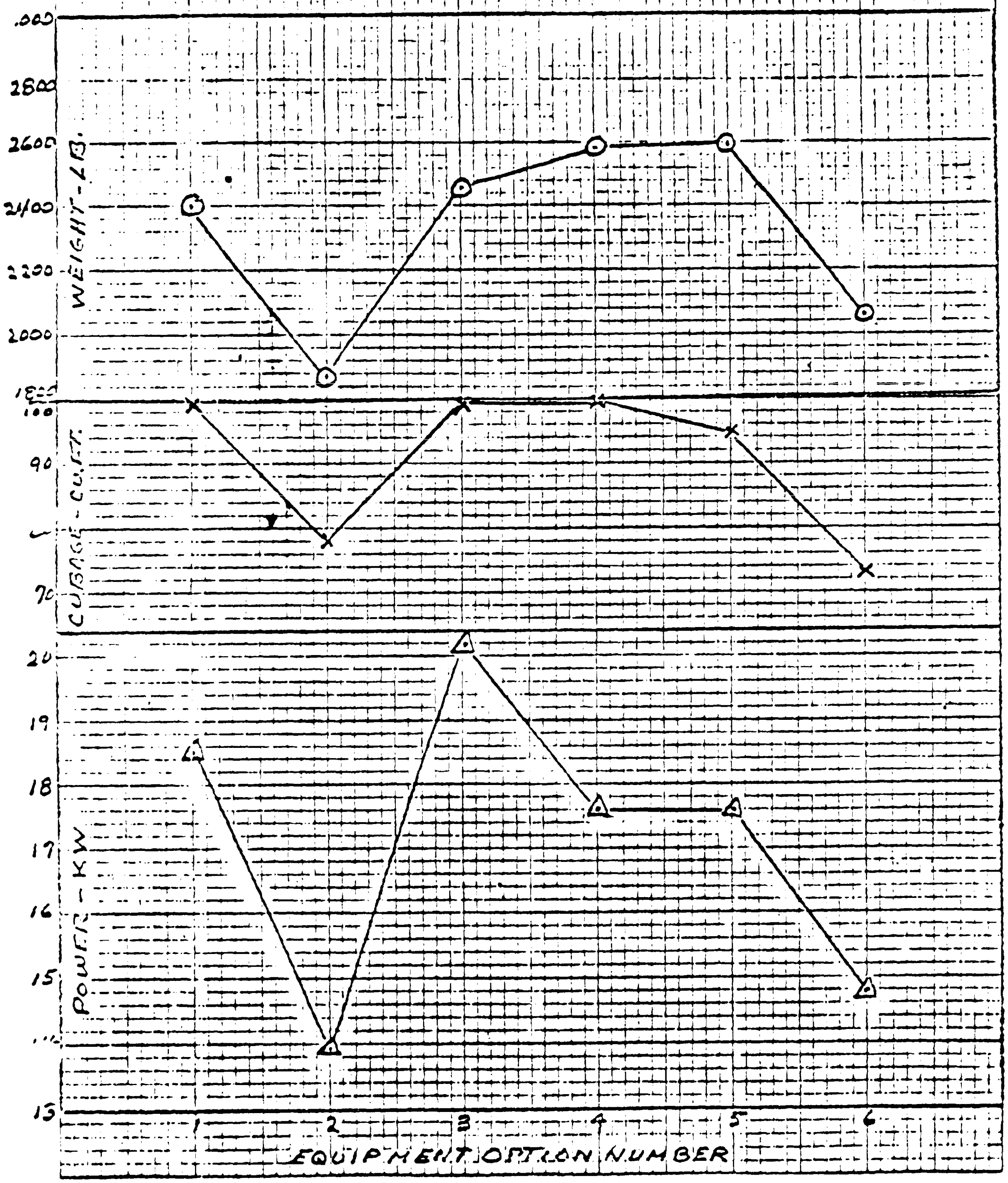
b. CB Protection
Positive pressure protection for personnel under all conditions and for equipment up to 74°F ET, above which the add-on reduced capacity filter provides protection for equipment.

* 400 Hz powered equipment
** Totals based on 400 Hz powered equipment
NOTE: Data for CB filters do not include flexible ducts

By referring to Figure 1, it can be seen that option #2 offers the ninimum weight, power and cubage values. However, there is a calculated ·isk assumed in this option of equipment malfunction when operating in he upper temperature range with non-filtered ambient cooling air.)ption #1 provides full protection and environmental control through all emperatures but does not allow flexibility in being able to delete the 1/2 ton air conditioning capacity provided for operation of the electronic ·quipment section at the upper temperature levels. Option #3 provides his capability at a slight increase in weight power and cubage. Option 4 provides an integrated CB filter unit for both personnel and equipment ections in all operating environments but has the disadvantage that there s no capability for deletion of the added filtered air capacity for the quipment section when not required. It does offer an advantage of reduced ower as compared to options #1 and #3. Option #5, provides two separate B filters. The CB filter for the equipment air can be deleted when not ·equired. Power required in this option is less than in options #1, #3, nd #4. Option #6 is similar to option #5 except that the additional CB ilter unit for the equipment in the upper temperature range is of reduced apacity. On the basis of weight, power and cubage, option #6 compares avorably with option #2.

Pending the accomplishment of a study to define the hazard of anti-nateriel agents to electronic equipment when operating on non-filtered ir, options #3 and #5 provide flexibility in adjusting the logistical load ·hile meeting the protection and environmental requirements. Option #5 ppears slightly advantageous in that the power requirements are lower nd there is a capability for sustaining the CB protection despite mechanical nalfunction in either of the two filter units. If the study indicates a ·educed level of protection in the equipment section as acceptable, then ption #6 should be considered. Should the study indicate the hazard f equipment malfunction to be negligible then option #2 would represent he best approach.

FIGURE 1
COMPARISON OF OPTIONS ON BASIS OF TOTAL WEIGHT, POWER AND CUBAGE



APPENDIX C
EXAMPLE OF ENTRY/EXIT PROCEDURES FOR CB SHELTERS

CB OPERATING PROCEDURES FOR COLLECTIVE PROTECTED M577 COMMAND POST CARRIER, M292 EXPANSIBLE VAN TRUCK AND SHELTER SYSTEM XM51 (CB PRESSURIZED POD)

(Source: Attachment to RFQ, DAAA15-69-R-0834
from Edgewood Arsenal, 11 July 1969)

APPENDIX C
CB OPERATING PROCEDURES FOR COLLECTIVE PROTECTED M577 COMMAND POST CARRIER, M292 EXPANSIBLE VAN TRUCK AND SHELTER SYSTEM XM51 (CB PRESSURIZED POD)

I. Introduction:

A. Purpose: The procedures described herein provide recommended actions for the safe use of collective protection shelters. Specifically these procedures address the type of problems and decisions faced by a unit commander in establishing specific operating procedures for shelter systems under his command. Intelligent application of those guidelines will permit the maximum utilization of these facilities with the least risk of contamination and the minimal interference with the tactical operations.

B. General:

The actions required for the safe use of collective protection shelters are basically commensurate with the degree of hazard from toxic agents which exists or is believed to exist. Thus, where the shelter is in an uncontaminated area and using personnel are also uncontaminated, entry into the shelter is essentially unrestricted. Conversely, where the shelter is in a contaminated area and personnel are heavily contaminated, entry procedures induce the greatest interference with tactical operations. In every case, it is the duty of the unit commander to assess the hazard, utilizing the means normally available to include intelligence information, alarms, detection kits, etc., and select the operating procedures which are consistent with the contamination conditions involved yet minimize the interference with the carrying out ot the tactical mission.

An integrated use of individual and collective protection equipment is prescribed to optimize the overall protection afforded to personnel entering or leaving and within the CB protective shelter. The equipment utilized is as follows:

Individual	Collective Protection Shelter
a. M17 Mask-Hood Combination or equivalent plus carrier and M1 Waterproof Bag (TM 3-4240-202-15)	a. Positive Pressure Collective Protection System. Collective Protection Equipment, CBR; M577 Command Post Carrier,

Individual	Collective Protection Shelter
b. Protective outer garment and protective gloves, as issued.	E13 (M P 3-4240-261-12); Collective Protection Equipment, CBR; Expansible Van Truck, XM 14 (M P 3-4240-260-12), Shelter System, Collective Protection, Chemical-Biological XM 51 (POM M 3-4240-264-12).
c. Paper, Chemical Agent Detector, VGH, ABC M 8 (TM 3-6665-254-12).	b. Automatic Agent Alarm (pending availability, use Detector Kit, Chemical Agent ABC - M 18 A2 (TM 3-6665-254-12).
d. Decontamination and Reimpregnating Kit, Individual, M 13 (TB 3-4230-207-10).	c. Boot covers (provided with collective protection equipment)

The M 8 Detector Paper is used for detecting liquid contamination on nonadsorbent surfaces. The alarm or detector kit is used for detecting airborne contamination inside or outside the shelter. The boot covers are used to confine vapors generated from the shoes of individuals while in the shelter. Each of these items is necessary and provides a specific contribution to the overall protection provided for the shelter occupants.

Decontamination procedures used in the Shelter Entry procedures consist of the minimum effort necessary for the safety of personnel entering the shelters and permits entry without hazard to those already in the shelter.

II. Operating Procedures:

In Table A a two letter contamination code is established based upon the following:

a. First letter - condition of atmosphere around the shelter either contaminated (C) or uncontaminated (U).

b. Second letter - suspected or determined contamination of

Table B indicates the specific operating procedures applicable for each set of conditions

Upon initiation of a collective protection shelter, a contamination code is first selected from Table A, then the applicable operating procedures listed in Table B are followed.

TABLE A

Determination of Contamination Code

Conditions outside shelter (1st letter)		Conditions of Arriving Personnel (2nd letter)	
		C	U
	C	CC	CU
	U	UC	UU

C - contaminated

U - uncontaminated

OPERATING PROCEDURES FOR EACH CONTAMINATION CODE ARE FOUND IN TABLE B.

TABLE B
Selection of Operational Procedures

Operating Procedure #	Required Activity[1]	Contamination Code[1]		
		CC or CU	UC	UU[2]
1	Area preparation	X		
2	Entry procedure	X	X	
3	Shelter activities	X	X	
4	Exit procedures	X		
5	Message transfer	X	X	
6	Emergency entry	X	X	
7	Litter entry/exit[3]	X	X	

NOTES:

1. When an operating procedure is not checked for a contamination code it is not applicable for that code.

2. No special actions are required under the UU contamination code.

3. Litter entry/exit procedure is prescribed for use only with the XM51 Shelter System.

DETAILED OPERATING PROCEDURES FOR ENTRY/EXIT OF PERSONNEL AND TRANSFER OF MESSAGES FOR CB PROTECTED SHELTER

Operating Procedure No. 1
Contamination Around Shelter

Preparation of Clean Area Adjacent to Protective Entrance

f area has been subjected to a chemical agent spray attack as determined ısually and/or by the use of ABC M8 Detector Paper (TM 6665-254-12) ›erform the following steps:

a. Clean up area around protective entrance by turning over soil (removing snow), adding layer of clean soil or sand, and/or using Decontamination Agent, STB, if available (TM 3-220). If possible, provide a protective cover with adequate ventilation underneath (poncho, held upright on stakes, tent, etc.) where protective overgarments, etc. are to be stowed.

b. Decontaminate door handles, pull tabs (if present), and area adjacent to protective entrance door opening(s). Use the large bag from the M13 Decontaminating and Reimpregnating Kit (TB 3-4230-207-10), or any rags.

Operating Procedure No. 2
Contamination on Personnel Arriving at Shelter

Entry Procedure:

a. Stow combat pack, mask carrier, and load carrying equipment (belts, straps, slings, etc.) in a clean area near, but not in path of, entrance door.

b. Remove the M13 decontaminating and reimpregnating kit from the carrier.

c. Determine presence of liquid agent on individual weapon, protective outer garments, mittens (gloves), mask-hood assembly, and boots by use of large bag from M13 kit or ABC M8 Detector Paper and/or visual check.

d. If liquid contamination is detected, decontaminate individual weapon if not previously done, and with or without an assistant, as available, decontaminate mask-hood assembly and boots using the most expedient method (M13 kit, soap and water, shuffle box, or rags). Return large powder bag to M13 kit if used, unless contaminated with liquid agent.

NOTE: When airborne contamination is present in shelter area, steps e through j should be accomplished as quickly as possible to reduce, to a minimum, the time exposed without protective outer garment.

e. Remove outer garment, fold so as not to contaminate or leave exposed the interior of the garment, (if reuse is anticipated) and stow in clean area near pack, mask carrier, etc.

NOTE: Under arctic environment: Remove parka hood, if contaminated and stow with outer garment. Handle weapon according to local standard operating procedure, (SOP). If weapon is to be carried into shelter it should be decontaminated with the M13 kit, if not previously done. If weapon is to be left outside, decontamination is not required.

f. Obtain two boot covers and rubber bands (or string) from designated storage space.

g. Place boot covers over boots and secure with rubber bands (or string).

h. Remove M1 or M1E1 Waterproofing Bag (TM 3-4240-202-15) from mask carrier and remove small pad from M13 kit and place in waterproofing bag.

i. Remove outer mittens and/or protective gloves from hands and place with pack, carrier, etc.

j. Open protective entrance door and enter protective entrance carrying weapon (or without weapon as prescribed by local SOP) and waterproofing bag. Close protective entrance door.

k. Wait in protective entrance the following periods of time before removing mask-hood assembly if airborne contamination is present around shelter:

(1) 2 1/2 minutes for one person.

(2) 4 minutes for two to eight persons (applicable only to XM51 Shelter System).

l. Remove hood straps from around arms and reattach to mating fasteners. Insert hands under back of hood and pull it forward over head leaving hood suspended from front of mask. Remove mask-hood assembly. Shake or wipe moisture or front accumulation from inside of hood. Gather the inside-out hood to one side of facepiece.

m. Place mask-hood assembly in M1 bag.

n. Decontaminate hands using small skin decontamination pad. Replace in M1 bag. Fold bag over to prevent egress of vapor.

o. Enter shelter, carrying weapon (if required by local SOP) and M1 bag.

Operating Procedure No. 3
Shelter Activities

1. Periodically, after entry, check atmosphere in shelter for possible contamination using automatic alarm if available, otherwise use M18A1 Chemical Detector Kit, or other available chemical detector kit.

2. Don mask, if contamination is found, and wear until subsequent tests indicate a clean atmosphere.

Operating Procedure No. 4
Exit Procedure

1. Don mask-hood assembly after entering protective entrance if an airborne contaminant is present or suspected around the shelter.

2. Remove and discard boot covers outside the protective entrance.

3. Replace or redon overgarment, gloves, and other individual items of issue if required, in accordance with procedures prescribed for these items.

Operating Procedure No. 5
Transfer of Messages, Maps, Overlays, etc.

1. While enroute, keep messages, maps, etc., under cover, such as pocket in uniform, protective mask carrier (M1 waterproofing bag), or other field expedient.

2. Upon arrival, open outer door of protective entrance, remove message from protective cover, reach inside the entrance without entering and place the message in a wall pocket. Close door.

NOTE: In the case of the XM51 Shelter System, the procedure is the same except that in step 2 above, the message is passed into the shelter through the "message pass through" port rather than through the protective entrance and step 4 below should be omitted.

3. Notify personnel within of the delivery of message by telephone, knocking on shelter wall, or direct voice communication.

4. Individual from shelter opens inner protective entrance door and picks up message.

NOTE: There should be no liquid contamination on any delivered message.

Operating Procedure No. 6
Emergency Entry Procedure - When Authorized by Unit SOP

In an extreme tactical emergency where entry must be made during an attack with chemical agents, the following procedure should be used:

a. Leave pack, mask carrier, etc. outside.

b. Obtain two boot covers and rubber bands (or string)

c. Enter airlock and notify occupants of shelter to don masks.

d. Proceed into shelter.

e. Set collective protection system to provide maximum filtered airflow through shelter.

f. When tactical situation permits, check for liquid agent contamination on clothing and equipment using M8 agent detecter paper and/or large bag from M13 decontaminating kit.

g. Decontaminate weapon, hood, and boots if contamination is found on them.

h. Discard contaminated protective outer garments outside of shelter and protective entrance.

i. Don boot covers.

j. Remain masked until the shelter atmosphere is indicated safe by the automatic alarm and/or tests with the M18A1 detecter kit.

k. When tactical situation permits, check and decontaminate any points in the shelter contacted or contaminated by the individual entering, when following emergency entry procedures.

Operating Procedure No. 7
Litter Entry/Exit, Shelter System XM51

1. Entering Shelter. The following entry procedures should be followed when in CB environment, contamination codes CC, CU or UC. No special procedures are required for the UU contamination code.

NOTE: Litter patients are covered with a poncho when picked-up and arrive at Battalion Aid Station in that manner.

a. Prior to entry into airlock, the CBR sentinel will notify medical attendants in shelter of arrival of litter patient. Attendants will place a clean litter in the airlock and return to the shelter. CBR sentinel will inform litter bearers to procede with entry. Litter bearers will don boot covers (secure with rubber bands) and carry litter patient into airlock.

b. While in airlock, litter bearers will:

(1) Remove poncho and overgarments from patient.

(2) Check patient for contamination and decontaminate patient as necessary using M13 kit.

(3) Transfer patient to clean litter.

c.] Litter bearers will exit airlock with contaminated litter and patient's poncho and overgarments, leave overgarments and poncho outside airlock and remove boot covers.

d. When red "DO NOT ENTER WHEN ON" light goes off medical attendants in shelter will check airlock to see if it is clear of litter bearers and contaminated clothing, and if so, enter airlock and carry clean litter with patient into shelter and remove patient's mask.

2. Exiting Shelter. The following exit procedure should be followed when in CB environment.

a. Replace patient's mask. Attendants carry patient into airlock and return to shelter.

b. Occupants of shelter signal CBR sentinel a patient in airlock is ready for removal.

c. Litter bearers don boot covers, enter airlock with poncho, cover patient with poncho, and exit carrying patient.

BIBLIOGRAPHY

Analysis and Design of CBR Protection for the AN/TSQ-47 System (Final Report), Technical Documentary Report No. ESD-TDR-64-230, AD 603 100, General Dynamics Corporation, Convair Division, San Diego, California, July 1964, Unclassified.

Chemical, Biological, Radiological and Nuclear Defense, FM 21-40, Revised Final Manuscript, U.S. Army Combat Developments Command, CBR Agency, Fort McClellan, Alabama, September 1968, Unclassified.

Collective Protection Equipment, E13 for the M577 Series Command Post Carrier, Interim Report, TIR 36.2.1.11, AD 817 581, University of Pittsburgh, June 1967, Unclassified.

Cromwell, D. E., CB Modification Kit for Existing Air Force Field Structures, Final Report AFATL-TR-69-5, General American Transportation Corporation, General American Research Division, April 1969, Unclassified.

Development of Collective Protection for Tentage and Field Shelters, TIR 21-4-1B1, AD 444 298 Army Material Research Staff, University of Pittsburgh, April 1964, Unclassified.

Development of Collective Protection for Vehicles, Vans, and Missile Complexes, Technical Information Report 36.2.1.2, AD 447 680, University of Pittsburgh, July 1964, Unclassified.

Development of the Environmental Control Unit for the Main Battle Tank, Final Report 7/1/64-12/31/65, HRD-AC-66-154, AD 484 468L, Contract DA-44-009-AMC-728(T), Harrison Radiator Division, GMC, December 1965, Unclassified.

Engineering and Design: Protection Against Chemical and Biological Agents and Radiological Fallouts, TM-5-855-2, 19 January 1961, Unclassified.

Karpel, B. L., et al, Summary of Progress, DDEL Report EATM-311-16, AD 846 352L, Physical Protection Laboratory, Edgewood Arsenal, December 1968, Unclassified.

Karpel, B. L., et al, Summary of Progress, DDEL Report EATM-311-17, AD 501 032L Physical Protection Laboratory, Edgewood Arsenal, March 1969, Confidential.

Klotz, Paul W., Test of the A/E29P-1 Portable CB Shelter and Decontamination Unit, Report ADTC-TR-68-69 Air Proving Ground Center, July 1968, Unclassified.

Klotz, Paul W., Tests of the Modified Chemical and Biological Flight Line Taxis, Report ADTC-TR-68-4, Armament Development and Test Center, August 1968, Unclassified.

Malik, Peter W., Development of the CB Pressurized Pod System, Reports No. 0415-7 and No. 0415-8, American Air Filter Company, Inc., Defense Product Group, St. Louis, Mo., July 1969, Unclassified.

McDonald, John L., Study of Requirements for Mobile Utility Module Systems (MUMS), AD 821 591L, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., August 1967, Unclassified.

Military Protective Construction (Nuclear Warfare and Chemical and Biological Operations), TM-5-311, 11 May 1965, Unclassified.

Modular Collective Protection Equipment for Vehicles, Vans and Shelters, DAAA15-67-C-0715-EA-DDEL, Donaldson Company, Inc., Minneapolis, Minn., August 1969, Unclassified.

Oldson, N. P., and Zablodil, R. J., Collective Protector Design and Development, Interim Report, Technical Note N-783, AD 625 402, U.S. Naval Civil Engineering Laboratory, Port Hueneme, California, November 1965, Unclassified.

Personnel Shelters and Protective Construction, NAVDOCKS P-81 CH-1, CH-2, Department of the Navy, Naval Facilities Engineering Command, September 1961, Unclassified.

Positive Pressure CB Collective Protection Field Shelter (CB Pressurized Pod), Interim Report, TIR 36.2.1.3, University of Pittsburgh, December 1966, Unclassified.

Protection of Structures from Chemical, Biological, and Radiological CBR Contamination, ENCR-30, June 1959, October 1959, August 1960, and March 1962, Unclassified.

Report of Field Tests on CB Shelter/Decontamination Unit A/E29P-1 (AAF Model CBS-640-1), Report MKP-152, American Air Filter Company, Inc., June 23, 1967, Unclassified.

Report of Qualification Tests on CB Shelter Decontamination Unit A/E29P-1 (AAF Model CBS-640-1), Report No. MKP-135, American Air Filter Company, St. Louis, Mo., August 10, 1966, Unclassified.

Richards, R. J., Design Evaluation Report, Interconnect Adapter Kit for CB Modified Flight Line Taxi, General American Transportation Corporation, General American Research Division, May 13, 1969, Unclassified.

Scott, John H., Collective Protection for Command Post Vehicles, Bimonthly Progress Report, Contract DA18-035-AMC-723(A), Donaldson Company, Inc., Minneapolis, Minn., Report #1, April 1966, Report #2, June 1966, AD 484 369, Unclassified.

Tactical Air Control System - Support Equipment Development, Working Party for General Support Equipment, Joint Technical Coordinating Group, Tactical Air Control Systems, Charles R. Martel, Chairman, August 1968, Unclassified.

Test Report - Low Temperature Heating Operation Test 308 On The Environmental Control Unit for the Main Battle Tank, HRD-AC-66-156, AD 487 760, Harrison Radiator Division, GMC, Lockport, N. Y., May 12, 1966, Unclassified.

Working Party for General Support Equipment, Final Report, 1st Task, Joint Technical Coordinating Group, Tactical Air Control Systems, James E. Brown, Chairman, August 31, 1966, Unclassified.

Installation, Operation and Maintenance Instructions, Vehicular Environmental Control System (MBT), HRD-AC-65-149, Contract DA-44-009-AMC-728(T), AD 481 331, Harrison Radiator Division, GMC, Lockport, N. Y., Unclassified.

Equipment and Methods for Collective Protection, DA 18-108-CML-4504, Lehigh University, Institute of Research, Bethlehem, Pa., Unclassified.

Peterson, Ray, Nominal 9,000 BTU/HR Compact Horizontal Air Conditioning Units (Stratos), Report 1903, AD 656 743, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., July 1967, Unclassified.

Smith, Gary J., Nominal 36,000 BTU/HR Compact, Vertical, 208 Volt, 3 Phase, 60 Cycle (Model CE40VAL6) and 208 Volt, 3 Phase, 400 Cycle (Model CE40VAL4) Air Conditioning Units (TRANE), Report 1861, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., June 1966, Unclassified.

Nominal 36,000 BTU/HR Compact, Horizontal Air Conditioning Units (STRATOS), Report 1918, AD 665 368, Army Mobility Equipment Research and Development Center, Fort Belvoir, Va., December 1967, Unclassified.

Nominal 18,000 BTU/HR, Compact, Horizontal Air Conditioning Units (STRATOS), Report 1902, AD 655 853, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., June 1967, Unclassified.

Good, Franklyn P., Nominal 24,000 BTU/HR Air to Air Thermaelectric Environmental Control Unit (Westinghouse), Report 1939, AD 684 928, U. S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va., February 1969, Unclassified.

Nominal 60,000 BTU/HR Compact, Vertical, 208 Volt, 3 Phase, 60 Cycle (Model CE60VAL6) and 208 Volt, 3 Phase, 400 Cycle (Model CE60VAL4) Air Conditioning Units (TRANE), Report 1881, AD 649 508, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., December 1966, Unclassified.

Nominal 9,000 BTU/HR Compact, Vertical 230 Volt, Single Phase, 60 Cycle, (Model CE11VAL6-230) and 208 Volt, 3 Phase, 400 Cycle (Model 11VAL4-208) Air Conditioning Units (TRANE), Report 1841, AD 631 325, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., December 1965, Unclassified.

Nominal 60,000 BTU/HR, Compact, Horizontal, Air Conditioning Units (STRATOS), Report 1932, AD 676 119, U. S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va., August 1968, Unclassifi...

Air Conditioning Equipment for FMF Use, AD 858 459, Marine Corps Development and Education Command, Quantico, Va., August 28, 1969, Unclassified.

Gooley, Walter and McCullough, Robert, Engineering Test of E13 Collective Protector for M577 Command Post Carrier, Final Report, AD 822 694, Dugway Proving Ground, September 1967, Unclassified.

Dunman, C. A., and Maloney, W. A., Service Test of E12 Collective Protector for M292 Command Post Van (XM14 Collective Protection Equipment), Final Report, AD 848 170, U.S. Army Infantry Board, Fort Benning, Ga., May 1968, Unclassified (Supplement to Final Report, AD 848 171, E-3844, June 1968, Unclassified.)

Gooley, W., and Jones, W. T., Engineering Test of the XM14 Collective Protection Equipment for the M292 Expansible Van Truck, Final Report, AD 849 309, Deseret Test Center, Dugway Proving Ground, January 1969, Unclassified.

Munson, H. R., and May, L. C., Check Test of Collective Protection Equipment, CBR: Command Post Carrier, XM15(E13), Final Report, AD 844 446, U. S. Army Armor and Engineer Board, Fort Knox, Kentucky, 20 September 1968, Unclassified.

Gooley, Walter, and McCullough, Robert, Report for Engineering Test of Collective Protection Unit for Combat Vehicle, Mechanized Infantry: XM701, Final Report, AD 482 623, Dugway Proving Ground, March 1966, Unclassified.

Snider, William L., Deseret Testing of Military Vehicles, Technical Memorandum AD-13-68, AD 693 268, Yuma Proving Ground, December 1968, Unclassified.

The ARCHON Weapons System Effectiveness Simulation System, Final Report, DTC-DAAD-09-68-C-0023, Booz, Allen Applied Research, Inc., Los Angeles, California, December 1968, Unclassified.

Scott, John H., Collective Protection for Vehicles, Vans and Shelters, Contract DAAA15-67-C-0715, Donaldson Company, Inc., Minneapolis, Minn., Unclassified.

Army Equipment Data Sheet, Chemical Weapons and Defense Equipment, TM-750-5-15, Department of the Army, April 1969, Unclassified.

Hagberg, C. A., Feasibility and Design Summary Report (Phase VII) Collective Protection for Combat Field Structures, Volume 1, Report No. 3000, AD 800 648, Litton Systems, Inc., Applied Science Division, Minneapolis, Minn., 15 September 1966, Unclassified.

Hagberg, C. A., Feasibility and Design Summary Report (Phase VII) Collective Protection for Combat Field Structures, Volume 5, Material Investigation Supplement, Report No. 3000, AD 811 557, Litton Systems, Inc., Applied Science Division, Minneapolis, Minn., 11 April 1967, Unclassified.

Feasibility Study, Collective Protection Equipment for Missile Integration Terminal Equipment, Shelter Mounted AN/TSQ-58; Radar Tracking Station, OA-2952/GSQ; and Electronic Shop, Shelter Mounted AN/GSM-44, Report FR-64-11-7, AD 431 306, Hughes Aircraft Company, Ground Systems, Fullerton, California, 5 February 1964, Unclassified.

Appendix A, Analysis of Cooling, Heating - Collective Protection for AN/GSM-44 System, AD 609 406, Contract DA 18-035-AMC-305 (A), Hughes Aircraft Company, Fullerton, California, December 1964, Unclassified.

Collective Protection Equipment for the AN/MSG-44 System, Feasibility Studies and Equipment Development, Bimonthly Progress Report, April - May 1965, FR-65-11-134, AD 646 721, DA 18-035-AMC-305(A), Hughes Aircraft Company, 15 June 1965, Unclassified.

Design and Development of a Collective Protection System for the Main Battle Tank, Design Study Report, Contract DA 18-035-AMC-100(A), AD 429 171, Donaldson Company, Inc., 30 January 1964, Unclassified.

Design and Development of a Collective Protection System for the Main Battle Tank, Contract DA-18-035-AMC-100(A) (2nd Monthly Progress Report, 18 December 1963, AD 425 693, E-0988; 5th Monthly Progress Report, 10 April 1964, AD 434 867,), Donaldson Company, Inc., Minneapolis, Minn., Unclassified.

Improved Entry Systems for CB Protective Shelters, First Quarterly Progress Report, March 1969, Contract DAAA15-70-C-1083, Booz, Allen Applied Research, Inc., Bethesda, Maryland.

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