AD-763 925

ARCTIC MAINTENANCE CONSIDERATIONS

Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland

11 September 1972

UNCLASSIFIED

Security Classification

AD 763 925

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

U. S. Army Test and Evaluation Command Test Operations Procedure "Arctic Maintenance Considerations"

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5. AUTHOR(S) (First name, middle initial, last name)

6. REPORT DATE 11 September 1972	7a. TOTAL NO. OF PAGES 19	7b. NO. OF REFS 8
8a. CONTRACT OR GRANT NO. b. PROJECT NO. AMCR 310-6 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) TOP 1-1-002 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Headquarters U. S. Army Test and Evaluation Command Aberdeen Proving Ground, Maryland

13. ABSTRACT

Provides background information on the test of materials in an arctic environment. Describes arctic environmental characteristics and the effects of cold weather on solid materials, personnel, and maintenance. Discusses personnel safety, maintenance equipment, and the maintenance of materiel such as vehicles, aircraft, weapons, small arms, munitions, electrical equipment, optical equipment, personnel clothing and equipment to include design considerations.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Arctic Environmental Test						
Maintenance						
Arctic Maintenance						

U. S. ARMY TEST AND EVALUATION COMMAND
BACKGROUND DOCUMENT

AMSTE-RP-702-100
Test Operations Procedure 1-1-002 — 11 September 1972

ARCTIC MAINTENANCE CONSIDERATIONS

SECTION I
GENERAL

1. Purpose and Scope. This document provides general guidance and points out problem areas encountered in accomplishing maintenance of Army materiel under arctic winter conditions. It provides basic background information for personnel involved in planning arctic testing activities and managing test facilities. The cold weather (climatic categories 6, 7, and 8, AR 70-38) effects on materiel and personnel as applied to the proper performance of maintenance are critical factors in the determination of the suitability of equipment for Army use in subarctic and arctic regions of the world.

2. Basic Information. The effects of cold weather on material and personnel result in major differences in maintenance philosophy under arctic winter conditions as compared to maintenance under temperate zone conditions. In many cases, maintenance is not practical outside under arctic winter conditions and organizational maintenance must revert to higher levels.

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SECTION II
TECHNICAL PRESENTATION

3. Cold Weather Effects on Solid Materials.

a. Materials exhibit changes in physical parameters with temperature changes which must be considered during material operation and maintenance. Most materials will contract at different rates when cooled. For example, the contraction of steel, brass, and aluminum varies approximately in the order of one for steel, one and one-half for brass, and two for aluminum. This must be considered when a close tolerance must be maintained between two different materials. Adjustments made indoors may require compensation to allow for material contraction in subzero temperature operation. Conversely, adjustments made outdoors must be checked under indoor conditions when possible.

b. Brittleness is another property of many materials in subzero temperatures, making equipment components susceptible to failures at levels of shock and vibration that could normally be tolerated in moderate temperatures.

c. Materials such as ferrous and nonferrous metals and nonmetallic substances used in the construction of equipment are affected by subzero temperatures as follows:

(1) Most common ferrous metals become brittle and contract as the temperature is reduced to below zero levels.

(2) Most of the commonly used nonferrous metals or their alloys in general do not become brittle at low temperatures; however, tin solders may expand and disintegrate with prolonged exposure to subzero temperatures. This consideration is extremely important in selecting solders for mechanical and electrical connections.

(3) Nonmetallic materials react differently from exposure to cold weather. Some of the common examples are:

(a) Synthetic rubber becomes very brittle at temperatures below -20°F., and may easily shatter if subjected to shock or vibration.

(b) Natural rubber retains a large part of its resiliency below -20°F., and when cooled gradually will remain flexible to approximately -60°F. However, it tends to lose tensile strength at the extreme temperature limits.

(c) Commonly used plastics become brittle, thus impractical for use in subzero temperatures. One exception is polyethylene which remains pliable down to -70°F.

(d) Most fabrics will remain flexible in subzero temperatures if kept dry. Once fabrics become wet and freeze, they must be thawed out and dried to regain their flexibility. Tears and rips are common at such temperatures, especially with clothing.

(e) Leather does not perform satisfactorily in subzero temperatures. It cracks, becomes stiff, and is usually ruined if frozen while wet.

(f) Cold temperature has little effect on dry lumber; however, the low absolute humidity associated with subzero temperatures may result in in drying effects which could be destructive to the wood.

(4) Refer to TECOM Background Document TOP 1-1-001 (reference 1, appendix A) for more detailed information on cold weather effects on materials.

4. Personnel Safety Considerations.

a. Efficiency of operators, mechanics, and repairmen under arctic winter conditions is lowered by reduced dexterity. The lower limit of dexterity has been found to be at an extremity skin temperature of approximately 60°F. Tests have shown that while wearing the complete cold-dry uniform the skin temperature will remain above this level for prolonged periods of time if the air temperature at hand and head level is kept above 40°F. and above 44°F. at foot level (reference 2, appendix A).

b. Three types of handwear may be worn while performing arctic maintenance in subzero temperatures. They are, in order of degree of warmth provided: Arctic mittens (with or without liners), leather work gloves (with or without liners), and the anticontact gloves. The arctic mittens are the most bulky and cannot be worn where small parts must be handled and close clearances are a critical factor. Leather work gloves are used where arctic mittens are too bulky. Anticontact gloves are used where tactility is required, such as when working with small screws, nuts, and bolts. Maintenance working times tend to be greater when wearing arctic mittens as compared to the other types of handwear; however, the use of leather work gloves and especially anticontact gloves require longer and more frequent warmup periods. Recent investigations at the Arctic Test Center (ATC) indicated that the total maintenance time, which includes maintenance working time plus warmup time, is less for mechanics wearing the arctic mittens than for mechanics wearing work or anticontact gloves for those tasks that can be performed with all types of handwear.

c. Care must be taken to protect personnel from cold injury during all types of cold weather maintenance operations. All maintenance,

if possible, should be performed indoors at room temperature after items requiring maintenance have thawed. However, when performing maintenance in subzero temperatures on fuel, cooling, and lubrication systems, or when cleaning weapons or optical equipment, fluids may soak into the mechanics handwear. This decreases the insulating value of the handwear and will cause discomfort or possible cold injury due to rapid skin cooling. For this reason, maintenance personnel should carry extra handwear. Cold injury may also result if metal/skin contact is made, as the moisture on a person's skin may freeze to the cold-soaked metal causing frostbite. Personnel should also avoid leaning against cold metal parts as rapid body cooling may result causing discomfort. The same is true for handling other cold-soaked Army materiel. Some insulation (e.g., rags) should be used if it is necessary to lean on cold-soaked material while performing maintenance. Personnel who perform maintenance outside should erect a shelter around the item requiring maintenance, take frequent warmup breaks, and be familiar with signs of and treatment for cold injury. Personnel should be protected from the cold and wind while riding in a vehicle, which may be accomplished by using a personnel heater and a vehicle cab enclosure or protective cold weather face mask when enclosures are not available.

d. The sensation of coldness followed by numbness or a tingling, stinging, or aching feeling are indications of cold injury. Red skin, later turning a pale gray or waxy white are also indications of cold injury. The buddy system should be used to detect these signs of cold injury and administer proper treatment. Areas of the body where skin is exposed to the elements should be expecially watched. At windchill temperatures below -75°F,, exposed skin may freeze in 30 seconds without the victim realizing it. See TOP 1-1-003 (reference 3, appendix A) for further information on Arctic Personnel Effects.

e. Ice and slush may be formed when liquids drain onto the ground, making footing hazardous.

f. Static electricity may be generated while fueling engine-powered equipment, especially in the cold-dry weather common during arctic winters. Proper electrical grounding of the equipment will eliminate static discharges which might ignite the fuel. Static electricity may also result in unexpected detonation of explosive material resulting in injury to personnel.

g. When performing maintenance in an enclosed area, carbon monoxide may be present in sufficient amounts to be harmful to personnel. Provisions must be made to rid maintenance areas of exhaust fumes.

h. A fire extinguisher must be located in or near all maintenance areas. Fire extinguishers for subzero use should be the CO_2 type, winterized by the addition of 10 percent nitrogen.

5. Maintenance Equipment.

a. When equipment is to be operated in arctic winter climates, considerations must be given to the availability of special equipment for emergency maintenance. The on-vehicle materiel (OVM) must be sufficient to allow accomplishment of operator/crew maintenance. Special items that should be included in the OVM are:

(1) Two tarpaulins; one to provide protection of maintenance personnel from wind and snow, and the other to be placed under the vehicle while performing maintenance to catch parts that may fall to the ground. The latter tarpaulin would also provide added protection to the mechanic by preventing contact with the cold ground or snow.

(2) Lighting equipment, portable heaters, and snow removal equipment which facilitate maintenance.

(3) Items which may become lost or damaged such as nuts or bolts and small parts. Previous maintenance experience should be considered in determining the size and quantity of the items most likely to be needed.

b. Maintenance on electrical and electronic gear, weapons, aircraft, clothing gear, and optical equipment is performed in a maintenance shop whenever possible. Therefore, only tools and necessary material to make minor, necessary, or common adjustments should be included with the above equipment.

6. Vehicle Maintenance Considerations.

a. Cooling Systems

(1) Antifreeze must be used to prevent the coolant from freezing at the lowest ambient temperature expected in the locale in which the vehicle will be operated. Ethylene glycol (O-A-548 Type I) is used for temperatures from 32°F. down to -54°F. The amount of antifreeze used depends upon the capacity of the cooling system as well as the lowest expected ambient temperature, as prescribed at table 2, TM 9-207 (reference 4, appendix A). For ambient temperatures lower than -54°F., arctic grade permanent antifreeze must be used. Water or any other type of antifreeze must not be added.

(2) The cooling system must be kept clean to insure maximum heat transfer. Rust and other contaminants must be flushed from the system before adding antifreeze. Antifreeze compounds should also be kept clean and free of contaminants.

(3) Cooling system components such as hoses, valves, and clamps must be regularly inspected. Large temperature differentials between the cooling system components and the atmosphere may result in broken, cracked, or loosened components.

b. Lubrication Systems

(1) Special arctic lubricants are necessary for equipment operating in subzero temperatures. Proper weight lubrication oil (OES) is used in internal combustion engine crankcases in subzero temperatures because standard oil congeals and will not provide adequate lubrication. Where high operating temperatures are not a factor, such as in gearboxes, lubrication oil (GOS) should be used in subzero ambient temperatures to insure adequate lubrication. Grease need not be changed seasonally because Grease, Automotive and Artillery (GAA) provides adequate lubrication in ambient temperatures ranging from -65°F. to 125°F. Table 1, TM 9-207, (reference 4, appendix A) lists other lubricants for use in cold weather (0° to -65°F.).

(2) When adding oil to equipment, use oil that is warm enough to pour easily; and when draining oil, the oil temperature must be near engine operating temperature to aid in removal of sediment and sludge from the sump.

c. Electrical Systems

(1) The wet cell storage battery must be maintained in good condition in subzero temperatures because engine starting requirements are more severe and the battery's efficiency is decreased. Equipment batteries should be kept at or above 75 percent charge (specific gravity of 1.250 corrected to 80°F.). The battery should be maintained at 35°F. or higher to allow receipt of a charge from the vehicle generator and to increase its available energy for starting the vehicle. Battery electrolyte must be checked daily because of high evaporation rates in the low humidity environment common during arctic winters. Water should be added only when the battery is warm (35°F. or above) and capable of receiving a charge. The cells should not be overfilled in order to allow room for expansion of the electrolyte as it warms.

(2) Other electrical components must be properly maintained to insure reliable vehicle starts and operation.

(a) Grease or dirt on the armature shaft, bendix drive, or other types of mechanical drive will prevent the gears from meshing properly or cause them to remain in mesh after the engine is started.

(b) Oil, grease, or dirt on brushed, commutators, distributor breaker points, and switch contacts may prevent a good electrical contact which is necessary to carry the large amount of current necessary for cranking.

(c) Ice caused by condensation may coat the exterior or spark plugs causing the plugs to become short circuited to the chassis thru the ice.

(d) Contraction of the generator's helical spring in subzero temperatures will affect voltage regulator adjustments and may result in high voltages. These adjustments will be considered normal action and should be emphasized in training of mechanics.

d. Fuel Requirements

(1) Standard grades of fuel for spark ignition engines are generally inadequate for use in subzero temperatures because they will not produce a sufficiently combustible mixture. Gas, automotive, regular, low lead/no lead, class E (winter), FSN: 9130-167-9775 should be used in arctic winter climates to alleviate this problem.

(2) Standard diesel fuels contain waxes that congeal at low temperatures and may clog the fuel system. Therefore, arctic grade diesel fuel VVF-800 (DF-A) must be used in temperatures below -25°F. to alleviate that probelm.

(3) Moisture created by condensation may freeze and clog fuel lines. This moisture can be kept to a minimum by keeping fuel tanks as full as possible at all times, and by using moisture reduction additives. For spark ignition engine fuel, the additive methenol, technical, FSN: 6810-275-6010 (5 gallon) must be used. For diesel fuels, use inhibitor, icing, fuel system (ethylene glycol monomethyl ether), FSN: 6850-753-5061 (5 gallon). Both additives will be admixed with the fuel in the ratio of 1 pint of additive to 40 gallons of fuel during periods where ambient temperatures range below 32°F. (reference 5, appendix A).

e. Hydraulic Components. Hydraulic components, such as shock absorbers, require use of hydraulic fluid as indicated in pertinent lubrication orders. Hoses and seals in hydraulic systems become brittle and shrink in subzero temperatures, and crack or rupture under high fluid pressure.

f. Brake Systems

(1) Air brake components may freeze if moisture is present in the air lines. Therefore, an alcohol evaporation kit should be utilized

for maximum moisture reduction. Water which does accumulate should be drained daily after operation from the compressed air reservoir to prevent freezing.

(2) Hydraulic brakes require no seasonal charge of brake fluid. Hydraulic brake fluid type (H5A) should be maintained in the system for all-season use.

(3) Emergency brakes should never be utilized for prolonged parking during subfreezing temperatures because the brake shoe will freeze to the drum. The vehicle should be blocked to prevent accidental motion.

g. Vehicle Heaters

(1) The vehicle engine, battery, and associated components must be kept at a temperature that will insure reliable starting if indoor storage is not possible. Current practice is to design the vehicle to be capable of being started down to a cold-soaked temperature of -25°F. without heat being added by external heaters. Below this temperature, heaters must be utilized as explained in detail in TOP 1-1-005 (reference 6, appendix A), Arctic Adaptation Kits.

(2) A carbon buildup forms on the fuel inlet to the heater after several hours use. To assure reliable heater operation, this carbon must periodically be blown clear of the inlet.

h. Vehicle Starting

(1) Towing a vehicle to aid in starting is not a recommended practice because internal mechanical parts associated with the drive train may be frozen or sluggish so they will not move freely. Thus damage to the stalled vehicle may result from towing. It also may prove to be a safety hazard because many times vehicles will not have adequate traction on ice and/or snow.

(2) Low rpm engine idling to eliminate starting difficulties is not a recommended practice. Such practice may cause battery discharge, oil dilution, spark plug fouling, or engine overheating. If engine idling proves necessary, the vehicle TM should be consulted.

7. Aircraft Maintenance Considerations.

a. The majority of difficulties encountered during operation in extreme cold weather results from not understanding the proper steps to be taken prior to and immediately after flight. Areas to consider are ice and snow buildup on the aircraft, condensation in fuel cells, brittleness of aircraft material, lubrication problems, use of heaters and deicing devices, and other cold weather effects on aircraft and aircraft personnel.

b. Aircraft should be stored in a heated shelter. However, when this is not possible, several preflight steps must be taken in addition to standard procedures. Ice, snow, and frost may accumulate on aircraft surfaces and clog orifices and freeze mechanical linkages. Protective covers should be used to minimize this problem. All ice and snow should be removed and the aircraft preheated to free frozen parts and also warm the engine. Heat must also be applied to landing gear should it become frozen to the ground. To start the aircraft, an external power source may be needed to compensate for low battery efficiency in subzero temperatures. Control surfaces, heaters, instruments, and other devices should then be checked for proper functioning. These above tasks must be performed while the aircraft is tied down (with excepcion of helicopters), expecially on an icy area. Deep snow must be avoided when taxing airplanes to prevent snow and ice from forming on the body of the aircraft.

c. Aircraft fuel, lubrication, and hydraulic systems require maintenance similar to vehicles (paragraphs 6b, d, and e). Fuel cells must be filled after landing to keep condensation to a minimum. Checks must be made regularly for water in the fuel lines, which could result in the fuel metering system freezing. Lubricants may require heating to become viscous enough to permit an engine to turn over. At extremely low temperatures, instruments must be monitored to check for excessive oil pressure resulting from thickened oil. Constant checks should also be made on hydraulic systems as leaks may develop in couplings on valves. Refer to pertinent technical manuals for proper types of cold weather fuels, lubricants, and hydraulic fluids.

d. The aircraft electrical system involves maintenance consideration similar to vehicles (paragraph 6c). Electrical instruments may require heat to operate accurately. Antennas which are mounted on the exterior of the craft may become brittle and break resulting in communication or navigational difficulties.

e. Aircraft heaters and deicing mechanisms must be maintained in working order to provide personnel comfort as well as proper aircraft operation. The cabin should be heated to a temperature such that wearing bulky clothing (arctic mittens), which may hamper instrument operation, is not necessary. Deicing and anti-icing devices, and defrosters must be used to prevent ice buildup which will effect the operation of control surfaces as well as alter the aerodynamic characteristics of the aircraft.

f. Survival clothing and equipment for each passenger is required onboard aircraft in areas where subzero temperatures are common. This will provide personnel with some means to survive the cold weather in the event the aircraft must make an energency landing away from a populated area.

8. Weapons, Small Arms, and Munitions Maintenance Considerations.

a. When weapons are to be operated in freezing temperatures, winterization measures must be accomplished as soon as these temperatures are anticipated. Failures can be kept to a minimum if the user will perform proper preventive maintenance on the weapon; thereby avoiding the conditions that cause difficulty, rather than waiting until they occur and require correction. The following are areas that require attention:

(1) Idle materiel should be adequately covered to prevent snow or ice from accumulating on the weapon, and possible rendering it inoperative. The material used to cover the weapon should be kept off the ground to prevent the cover from freezing down.

(2) Condensation will occur when a cold-soaked weapon is brought into a warm area. Corrosion may occur if resulting moisture is not soon removed by drying. It is especially important that the unit be free of moisture before it is returned to cold weather use as parts will freeze and become inoperable. Ideally all weapons should be stored in a snow-tight locker (at ambient temperatures), but when a weapon must be brought indoors, it should first be enclosed in an anticondensation container, size permitting, or blanket material to impede moisture condensation.

(3) Proper use of lubricants is essential for safe and reliable weapon operation. The lack of lubricant may permit the formation of rust on the uncoated surfaces and also result in friction between rubbing surfaces, which will impede the functioning of the weapon. Minimum friction must be maintained because the operating power of the weapon cannot be increased to compensate for this extra drag. On the other hand, too much lubricant may impede the motion of the components or result in a buildup of solidified oil or grease. It is equally essential that the proper type and grade of lubricant be used (table 1, TM 9-207). To provide satisfactory lubrication and protection against rust, all bare metal parts should be cleaned and dried before applying a lubricant or preservative. Lubricants must be applied sparingly at subzero temperatures because of the tendancy to many lubricants to thicken or solidify at low temperatures.

b. The following are specific weapon components which require special winterization consideration.

(1) Breech and firing mechanisms:

(a) Breech and firing mechanisms must be completely disassembled for cleaning and lubrication after use. A light film of general purpose lubrication oil (PL-S) should then be applied.

(b) If ice prevents opening or closing of the breech, use a portable heater for thawing, then remove the breech and dry it thoroughly. Ice buildup may also result in inoperable mechanical linkages or solenoids, rendering the firing mechanism useless.

(c) After firing, all parts must be cleaned as indicated in the weapon's TM. At temperatures below -25°F., rifle bore cleaning solvent must be warmed sufficiently to permit effective use.

(d) Gas check pads should be cleaned by wiping with a dry cloth - do not apply a solvent or a lubricant. The asbestos covering of Gerdom-type gas check pads becomes extremely brittle when cold and should be regularly inspected for cracks.

(2) Bores:

(a) Before firing, the bore and chamber should be wiped dry and clean. The bore evacuator, muzzle brake, blast deflector, and/or counterweights must receive a light coat of oil as prescribed in the appropriate TM's.

(b) During firing, inspect the muzzle end of the tube, bore evacuator, muzzle brake, blast deflector, counterweight (as applicable), and the breech ring at every opportunity for the development of cracks.

(c) After firing, clean the bore evacuator, muzzle brake, bore and chamber with rifle bore cleaner solvent while the cannon is still warm. Do not apply solvent cleaning compound if the weapon is too hot to be touched with the bare hand. All compound remaining after cleaning must be wiped off or it will freeze making firing dangerous.

(3) Recoil mechanisms:

(a) Recoil mechanisms parts such as recoil and counter-recoil rods and variable recoil cams must be wiped dry daily, and all metal surfaces should receive a light film of PL-S general purpose lubricating oil to protect these parts against corrosion and prevent moisture from freezing to the surface.

(b) All hydropneumatic and hydrospring recoil mechansims will be filled with hydraulic fluid (OHT). Hydropneumatic mechanisms are affected by reduction of gas pressure at low temperatures, as well as thickening of recoil oil. These pressure changes must be watched and adjusted by competent personnel to keep within the required pressure range. The cycle of recoil may take longer than usual when the weapon is cold; this is normal and should be expected.

(c) A sticking recoil mechanism may occur at low temperatures and can best be prevented by frequently exercising the mechanism (refer to pertinent TM regarding exercising mechanism).

(4) Recoil slides and guides absorb an appreciable amount of energy and must be properly cared for to operate effectively. Thickened lubricant, or lubricant contaminated with snow and condensation will increase friction, shorten recoil, and retard counter-recoil. For this reason, the slides must be cleaned daily with dry cleaning solvent or mineral spirits paint thinner and lightly relubricated.

(5) Equilibrators:

(a) Piston rods or tubes of equilibrators should be cleaned, dried, and lightly lubricated with PL-S daily to prevent icing.

(b) Nitrogen pressure of pneumatic equalizers require adjustment to provide proper equalizing action in subzero temperatures.

(6) Elevating and traversing mechanism may collect snow and ice which will cake under the pressure of the grease. This build-up must be removed and the mechanism lightly lubricated with PL-S to assure ease of operation and rust prevention.

c. Small Arms Materiel

(1) Most malfunctions of small arms occur during the first several rounds. Short bursts will gradually warm the weapon to a normal firing temperature.

(2) All small arms, to include pistols, rifles, and machineguns must be stripped completely and cleaned with a dry cleaning solvent to remove all lubricants and rust prevention compounds after firing or subjection to ice or snow. The prescribed application of lubricating oil (LAW) should then be made.

d. Munition. Cold weather does not materially affect the maintenance of ammunition; however, muzzle velocities are reduced. Ammunition, clips, and magazines must be cleaned of all oil, preservative ice, snow, and condensation before use, and stored at the same temperature as the weapon.

e. Fuzes and Charges. There are no unique maintenance problems associated with fuzes and charges in a natural cold environment other than handling difficulties.

9. Electrical and Electronic Maintenance Considerations.

a. Items such as radios and wire communication devices, test instruments, and control devices must receive special attention before use in the field under arctic winter conditions. Some units are capable of being operated in extremely adverse conditions while precision instruments like volt meters and frequency meters must be kept warm (approximately 70°F.) to perform properly. Further information on instrumentation can be found in TOP 1-1-004 (reference 7, appendix A). Some factors which must be considered when operating the above equipment in subzero temperatures are:

(1) Equipment kept outside must be protected as well as possible from ice, snow, wind, and cold. Snow accumulating on a piece of equipment which has been in use for some time, and thus warm, may melt and freeze. This could cause switches and knobs to freeze solid. If antennas are permitted to ice up, the efficiency of the transmitter and receiver may be reduced.

(2) Condensation will occur when a cold-soaked piece of equipment is brought into a warm area. This moisture must be dried before the equipment is put into service in subzero temperatures as freezing may result. Condensation can be eliminated when bringing cold-soaked equipment indoors by using an anticondensation container, or, as a substitute, any insulating material which can be used to cover the equipment. In general, heating and cooling cycles should be avoided as much as possible.

(3) Cold temperatures have a definite effect on the reliability and accuracy of electrical and electronic materiel. Shock mounts become brittle and hard and offer very little cushioning. This could result in breakage of vacuum tubes, metal support brackets, meters, and other fragile components. A suitable cover such as nylon or rayon should be used to prevent moisture from reaching the microphone diaphragm. Electrical characteristics of resistors, capacitors, inductors, tubes, crystals, and solid state devices are altered when subjected to cold temperatures. Without the use of a heater, the performance of equipment utilizing these components will be impaired. Batteries for battery powered equipment must be kept warm and charged because of loss of battery efficiency at low temperatures. This may be accomplished by keeping the equipment under one's parka, size permitting. Another problem associated with cold temperatures is the cracking of vacuum tubes and plastic or ceramic components when subjected to a rapid temperature change, such as when transported from room temperature to subzero temperatures.

(4) Wire, used in wire communications equipment, will become brittle at low temperatures and can be easily broken when stepped on or driven over. Small animals, especially rabbits, will chew through the insulation on wires which could cause an open or short circuit. For this reason, wire should be strung from trees and poles where possible. Steel clad wire (spiral 4) has been found to stand up well under the above conditions.

(5) A communication problem common in arctic regions is the inability to communicate on certain radio frequencies, and should not be confused as an equipment failure. This is caused by "magnetic storms," aurora borealis, or ionisphonic disturbances. For this reason, all radio gear to be used in arctic regions must be capable of covering a wide band of frequencies.

10. Optical Equipment Maintenance Considerations.

a. Equipment such as compasses, telescopes, binoculars, and scopes for weapons must receive special maintenance consideration when used in arctic climates. This equipment should be covered when not in use. If snow gathers on the device during use, it should be brushed off and wiped dry as soon as practical. Failure to do this may result in frozen components. Snow should never be blown clear of a lens or wiped off with a finger as moisture from the fingers or breath, or melted snow, may freeze there.

b. Condensation can be prevented when transporting an optical instrument from a cold to a warm area by use of an anticondensation container. The instrument must be free of moisture when returned to cold weather use.

c. Lensatic compasses must be kept warm (placed close to body) to prevent the fluid from becoming thickened.

d. Care must be exercised not to breathe directly on or near lenses as condensation (fogging) may occur. If lenses should fog up, wads of cotton should be used to remove the frost.

e. There is no accepted method used to prevent condensation from forming on corrective lenses when going from a cold to a warm area. One expedient method is to use a cloth to clean glasses when fogging occurs.

f. Difficulty is also experienced while operating camera equipment in subzero temperatures. Shutter mechanism may freeze or become sluggish resulting in improper exposures. Film may become brittle and should be advanced or rewound very slowly at a constant speed. A slow and constant film rewind speed is also necessary to prevent static electricity discharges from damaging film.

11. Personnel Clothing and Equipment Maintenance Considerations.

a. Proper care and maintenance of clothing and personal equipment are essential for maximum protection against the hazards of cold weather environments. The following areas require special consideration.

(1) Body clothing, to include sleeping bags, must be kept clean, dry, and in good condition. Soiled items lose much of their insulation value and also retain perspiration which could freeze, thus causing discomfort in subzero temperatures. Items which become covered with water, snow, or mud should be brushed clean as soon as practical. Tears, rips, or holes in clothing should also be repaired as soon as possible. When washing clothing, reference should be made to the pertinent cleaning instructions. Whether washing by machine or by hand, care must be taken to assure the proper type of detergent or soap is used as well as making sure the clothing items are dried thoroughly before use. In the field clothing must never be washed in below freezing temperatures.

(2) Boots must be kept clean, dry, and moisture proof to provide the user maximum warmth. Inspect regularly for holes, tears, or cracks which could permit moisture to collect in the boot, thus reducing its insulating value. When cleaning boots, pertinent washing and drying instructions must be followed. In the case of the vapor barrier (VB) boots, extreme care must be taken to prevent moisture from entering the vapor pocket. This will reduce substantially the insulating value of the boot and possibly result in cold injury.

(3) Canvas, web, and netting equipment, as well as coated items (poncho) must be cared for as stated in individual cleaning and care instructions. Care must be taken when cleaning not to use any materials which may be destructive or cause discoloring to the items.

(4) Mess gear must be kept clean for the well being of the individual as stated in FM 21-15 (reference 8, appendix A). The mess gear, including the canteen and cup, must be thoroughly dried after use and never wiped with a damp cloth.

(5) Sunglasses must be kept in the protective case when not in use and stored where they are not likely to be damaged.

12. Design Considerations.

a. Equipment should be designed to facilitate maintenance while wearing the cold/dry/wet uniform in subzero temperatures. Tolerances and clearances between various componets should be adequate to allow

a mechanic wearing arctic mittens to make emergency repairs. Coolant, fuel, and lubricating systems should be capable of being easily drained without handwear become saturated with these fluids during servicing and maintenance under arctic winter conditions. Handles, knobs, switches, and controls should be constructed or modified to permit easy handling while wearing arctic mittens with liners. Steps, pedals, and walkways should accomodate the additional width of vapor barrier (VB) boots.

Recommended changes to this publication should be forwarded to Commander, U. S. Army Test and Evaluation Command, ATTN: AMSTE-ME, Aberdeen Proving Ground, Maryland 21005. Technical information related to this publication may be obtained from the preparing activity (Commander, U. S. Army Arctic Test Center, ATTN: STEAC-MT-END, APG Seattle 98733). Additional copies of this document are available from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX
REFERENCES

1. TM 9-207, Operation and Maintenance of Ordnance Materiel in Cold Weather (0° to - 65°).

2. FM 21-15, Care and Use of Individual Clothing and Equipment.

3. Letter, ARAGL-M, 4 August 1972, subject: Anti-icing Agents for Military Fuels.

4. TECOM Background Document, Test Operations Procedure 1-1-001, Arctic Environmental Considerations.

5. TECOM Background Document, Test Operations Procedure 1-1-003. Arctic Personnel Effects.

6. TECOM Background Document, Test Operations Procedure 1-1-004, Arctic Instrumentation Considerations.

7. TECOM Background Document, Test Operations Procedure 1-1-005. Arctic Adaptation Kits.

8. Human Factors Reference Data by R. F. Goldman, U. S. Army Institute of Environmental Medicine, 1966.