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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE
BACKGROUND DOCUMENT

AMSTE-RF-702-100

*Test Operations Procedure 1-1-005

13 October 1984

~~AD No. 770034~~

ADAPTATION OF MILITARY MATERIEL FOR COLD REGIONS USE

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1. SCOPE. This document provides background information on the test and evaluation of special cold weather adaptation kits and military materiel requiring such kits. Information is presented on supplemental devices designed to adapt specific types of materiel for operation and use under arctic winter conditions. Materiel covered includes tank/automotive, aviation, CBR equipment, generators, communications equipment, and weapons materiel. Construction, support, and service equipment (except generators) are not discussed herein in order to limit the scope of the TOP.

2. BASIC INFORMATION.

2.1 Most military materiel is designed to operate without modification at air temperatures down to -32°C (-25°F) in accordance with the requirements of AR 70-38¹. At lower temperatures, kits are furnished to accomplish one or more of the following:

2.1.1 Provide protection for sensitive components from the environmental elements.

2.1.2 Provide capability of prompt and reliable starting and warmup of equipment.

2.1.3 Maintain internal temperatures in the equipment high enough for efficient operation and reasonable reliability and durability with minimum increase in maintenance required.

¹Footnote numbers match reference numbers in appendix A.

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2.1.4 Provide protection, reasonable comfort, and visibility for the crew.

2.1.5 Minimize heat loss from sensitive components such as engines and batteries when not operating.

2.2 In addition, lubricants, antifreeze, fuels, and hydraulic fluids developed for cold regions use are required for proper operation. For additional information on these materials see reference number 2, appendix A and the appropriate equipment technical manuals.

2.3 In the case of electronic communication equipment, the functions of the hardware which constitutes the arctic adaptation kit are supplemented extensively by specialized techniques of operation of the basic equipment. Both serve to adapt the gear to the cold regions environment. For this reason, the electronic equipment portion of this TOP includes descriptions of both hardware and techniques which are used to get the most out of the equipment in cold regions.

3. TANK/AUTOMOTIVE MATERIEL

3.1 Engine

3.1.1 Engine Starting: A reciprocating internal combustion engine is started by motoring it from some external source of power until the favorable combustion conditions discussed below have been established so that the engine will run under its own power.

3.1.2 Adequate Cranking Speed: Obtaining adequate cranking speed is necessary for both the spark ignition (SI) (i.e., gasoline) and compression ignition (CI) (i.e., diesel) engines. The cranking power requirements are higher for the CI engine due to the higher compression pressures and generally higher speeds (SI engines usually require speeds from 50 to 150 rpm, CI engines require speeds from 100 to 200 rpm). Cranking speeds are critical due to their influence on ignition, as insufficient cranking speeds result in inadequate compression pressures and temperatures.

3.1.3 Correct Air/Fuel Mixtures to Form a Combustible Mixture:

a. One of the principal differences between SI and CI engines is the air/fuel ratio at which they operate. SI engines require a nearly stoichiometric mixture for operation; whereas in CI engines, combustion can be obtained with an excess of air varying over a relatively large range. As a consequence, the mixture control for cold starting a CI engine is a simpler problem.

b. Most CI engines are started with the throttle at or near the full open position to insure an adequate supply of fuel. The fuel is generally well atomized by the injector nozzle but when introduced into a cold

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cylinder wall, condensation occurs. The prevention of this condensation or re-evaporation of the fuel is primarily an ignition problem. In some CI engines, this condensing action is employed to control burning rates. A point to bear in mind is that the air/fuel mixture for CI engines is formed inside the cylinder or precombustion chamber.

c. The main problem in cold starting SI engines lies in vaporizing enough fuel (gasoline) to form a combustible mixture. At a temperature of -54°C (-65°F), less than 5 percent of the fuel will be vaporized when it enters the cylinder. Since only that portion of the fuel which is in vapor form is effective in forming the air/fuel ratio for a combustible mixture, an excess of fuel must be supplied to compensate for the loss in volatility of the fuel at low temperatures.

d. The fuel is atomized in the carburetor or at the injection nozzle in the form of fine droplets, which presents a large total surface area for vapor formation. However, as these droplets pass through the manifold and over the cylinder and piston surfaces, the fuel may condense into a liquid film with a relatively small evaporation surface.

e. The two general methods of obtaining the desired air/fuel ratios in SI engines are increasing the fuel quantity by use of chokes and primers and heating the air, fuel, air/fuel mixture, and manifold or cylinder walls.

f. In both SI and CI engines, excess fuel will dilute the lubricating oil in the engine cylinders and thus cause a lack of lubrication.

3.1.4 Ignition of the Charge

a. The ignition of the charge in the SI engine is not a serious problem provided a combustible mixture is available and the spark plug is not fouled. The most frequent difficulty encountered in these engines is fouling of the plugs from condensed moisture or liquid fuel (as a result of the excess fuel supplied).

b. Ignition of the charge is the major problem encountered with CI engines in low temperature starting. Ignition in the CI engine depends upon raising the temperature of the fuel vapor to its self-ignition point during the compression stroke. A temperature on the order of 400°C (750°F) is required.

c. At low temperatures the compression temperature in both CI and SI engines is reduced because of the lower inlet temperatures, loss of heat to the cylinder walls and piston, and lower compression pressures resulting from increased blowby (due to larger clearance and reduced cranking speed).

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3.1.5 Heating Criteria

a. A generally accepted requirement for military vehicles is that they should be capable of being started after a maximum of 1 hour of pre-heating after the vehicle has been cold-soaked to -32°C (-25°F) or lower.

b. Cranking time must be limited as much as possible because of certain undesirable results, especially in the CI engine. If no firing occurs, the excess fuel will wash the lubricating oil out of the cylinders, thus increasing wear of the cylinder walls. Dilution of the lubricant also has an adverse effect on the other moving components of the engine. The battery cannot recuperate as well. The starter can become overheated causing damage to the windings.

c. The heating system is commonly required to maintain the engine and battery component temperatures at a standby level sufficient to permit the vehicle to be started on short notice after a maximum of 24-hour standby operation in ambient air temperatures of -32°C (-25°F) and below. The maximum total cranking time varies with the type of vehicle. As an example, the maximum cranking time was 1 minute on the M792 Ambulance³.

3.1.6 Power Plant Heaters

a. General. Forced-draft, electrically ignited, diesel-fuel, or gasoline-burning heater(s) of the capacity required are applied to the equipment for 24-volt operation from storage batteries.

b. Engine heaters. Engine heaters are of either the coolant-circulation (thermosyphon or pump) or the hot air type. They are provided with an automatic shutoff feature in the event of lack of fuel or flame extinguishment during operation and equipped with a metering device to insure that rate of fuel flow to the burner is constant within acceptable tolerances. Combustion air is furnished by a dc, low amperage, electric motor driven blower.

c. Coolant heaters. Coolant heaters generally have a high heat output (to the coolant) rating of 1.3 to 1.7×10^7 joules/hr (12,000 to 16,000 BTU/HR) and are available in 3.2 to 6.3×10^7 joules/hr (30,000 to 60,000 BTU/HR) sizes. For instance, the M792³ three cylinder diesel utilized a 1.6×10^7 joules/hr (15,000 BTU/HR) (heat output to the coolant) unit with satisfactory results.

d. Pulsating heaters. Another type of heater requires electrical power only for starting the unit. It is a pulsating heater which operates on the intermittent detonation principle. The heater is used to provide heated air to heat the engine coolant through appropriate heat exchangers in which the heater is mounted. The heated air is either ducted toward the engine and blown directly on it, or circulated through a coolant jacket which in turn heats the coolant of the engine⁴.

³, ⁴Footnote numbers match reference numbers in appendix A.

e. Air-cooled engines. Air-cooled engines utilize hot air heaters of the types discussed above to provide heated air to the engine.

3.1.7 Engine Shrouds: Engine shrouds consisting of canvas and metal grill covers, radiator covers, and engine compartment blankets are designed to reduce the heat losses during preheat, warmup, standby, or shutdown; and to prevent entry of ice and snow. They also provide a means of regulating engine temperatures during operation. Prevention of the entry of snow during standby storage is often the primary objective of grill covers.

3.1.8 Intake Air Heating:

a. In some diesel and multifuel engines a means is provided to heat the intake air and provide burning particles of fuel to the cylinders during cold weather starting. The system commonly known as the "airbox heater" or "manifold heater" consists of an air aspirated nozzle type unit with a spark plug for igniting the fuel/air mixture. An air pump delivers compressed air through the nozzle, aspirating and spraying fuel into the airbox. The fuel vapor is ignited by the spark plug and burns in the airbox, heating the air in the airbox before entering the combustion chamber. The spark plug is energized by an ignition coil. Fuel flow is generally controlled by a solenoid valve.

b. The heater can also be of the type which meters only the fuel and uses combustion air from the manifold. Heaters of this type are sometimes less effective due to oxygen "starvation" in the heated mixture inducted into the cylinders.

c. The intake air heater is not necessarily part of the kit for operation below -32°C (-25°F). In many cases in fact, the heater is designed for use below 0°C (32°F) and is provided as part of the standard vehicle.

3.2 Fuel Heating: Heating is often provided to the fuel at the fuel filters to facilitate fuel flow. For example, on the M578 Recovery Vehicle⁴, wrap-around fuel filter heaters of chloroprene-coated nylon blankets with electric heating coils in them were used on the primary and secondary filters. The heat not only prevents icing in the filter, but helps alleviate any waxing which might occur with diesel fuels. However, with arctic grade diesel fuel (DFA), waxing problems are reduced until temperatures of -48°C (-55°F) and below are reached. The amount of heat supplied to the fuel is relatively low so that little actual temperature rise occurs across the filters when fuel is flowing.

3.3 ELECTRICAL SYSTEM

3.3.1 General: An adequate and properly functioning electrical system is essential to successful operation of the vehicle at low temperatures. As this is the most severe service condition for the electrical system, special

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attention must be given to the adequacy of the components to perform their function and to insure that the system is in good condition at all times. The most critical component is the battery due to its adverse temperature performance characteristics; however, the characteristics of the starter must also be considered.

3.3.2 Battery Characteristics:

a. Low Temperature Effects. The battery is an electrochemical device and its performance is reduced at low temperature because of two factors. First, the chemical reaction rate is slower. Second, increased resistance in the battery reduces voltage. The effect is to reduce the available energy and decrease the voltage. The discharge time of the high rate current is also severely reduced with low temperatures.

b. Recuperation. If the battery is not completely run down after one high rate discharge it will recuperate after a rest. The recuperative power is present, to a degree, in all batteries. In wet-cell batteries this recuperation results from diffusion of fresh electrolyte into pores of the plates. It is most pronounced under high discharge conditions such as during cranking.

c. Battery Types. Two types of batteries have been standardized for Army use. They are the lead-acid and nickel-cadmium cells. The low temperature power output and ability to accept charge of the nickel-cadmium are superior to the lead-acid. Due to the high cost of the nickel-cadmium batteries, their use is generally restricted to aircraft. The two standard sizes of 12-volt lead-acid batteries are the 2HN and 6TN. For 24-volt systems, the batteries are used in multiples of two.

d. Battery Capacities. Because of the variations in conditions of use with respect to load, storage batteries are given two ratings. The nominal amp-hour capacity is determined by a 20-hour discharge at a light load at 27°C (80°F). This rating gives the number of ampere hours the battery will deliver if discharged at a uniform rate of 20 hours at a temperature of 27°C (80°F) with a terminal voltage at the end of the period of 1.75 volts per cell. The initial charged battery condition is 2.0 volts per cell. As the discharge current is increased, the voltage and the discharge time are decreased. A second rating is given for cold starting at a temperature of -40°C (-40°F) (table 1). The 6TNC (nickel-cadmium equivalent of the 6TN lead-acid battery) will maintain 7 volts or more at a 300-amp discharge rate at -40°C (-40°F) for more than 8 minutes as compared to 1.25 minutes for the 6TN⁵.

⁵Footnote number matches reference number in appendix A.

TABLE 1. Electrical Performance Characteristic - Cranking Ability (Lead-Acid Batteries)

Type	Nominal Voltage	Average Capacity at 20-Hour Rate	Cranking Ability			
			Minimum Cranking Time (300 amp at -40°F)	Minimum Cranking Time (300 amp at 80°F to 1-Volt/Cell)	Minimum Life Cycle Capacity	
	volts	amp-hr	min	5-sec voltage	minute	cycles
2HN	12	45	1.25*	7.00*	5.0*	250
6TN	12	100	1.25**	7.00**	5.0	275

*Rate of discharge shall be 150 amperes at -40°F. **Rate of discharge shall be 300 amperes at -40°C (-40°F).

e. Rated voltage. The rated electrical system voltage is 24 volts. The actual nominal no-load voltage of the system is 28V DC when the batteries are fully charged. The voltage is normally maintained by a regulator setting of 27.5 to 28.5 volts⁶.

f. Battery condition. The state-of-charge of the battery is normally determined by measuring the specific gravity with a hydrometer or the optical battery antifreeze tester. Since the specific gravity is affected by temperature, a correction must be applied. That is, for each 6 degrees C (10 degrees F) below 27°C (80°F), 0.004 must be subtracted from the specific gravity reading and for each 6 degrees C (10 degrees F) above 27°C (80°F), 0.004 must be added to the reading. This procedure is not required when using the optical tester. The precision of the specific gravity measurement is affected by a number of factors which reduce the accuracy of the state-of-charge determination; therefore, attention should also be paid to the no-load voltage and to the initial cranking voltage as additional indicators of battery condition.

g. Freezing of electrolyte. Another problem which must be guarded against at low temperatures is freezing of the battery electrolyte (which can damage the plates and battery case by expansion of the frozen electrolyte). The freezing temperature of the electrolyte is a function of the state-of-charge of the battery and will occur at higher temperatures as the battery is discharged. For specific information, see page 2-8, table 3, reference number 2, appendix A.

⁶Footnote number matches reference number in appendix A.

h. Charging. The rate of charge acceptance and the efficiency of charging are also affected by temperature. Charge acceptance (current) decreases with decreasing temperature. Efficiency of charge also decreases with decrease in temperature. For effective recharging, the battery must be warmed to a temperature of approximately 2°C to 4°C (35°F to 40°F).

3.3.3 Battery Heating

a. A battery heater is commonly used as part of an arctic adaptation kit to warm the battery to a temperature at which it will accept a charge (4°C (40°F)). For best operation, it should maintain the temperature at 27°C (80°F), but also avoid overheating (maximum case temperature of 66°C (150°F)). The design of the heater also reduces heat loss during cold soaks. The heaters used are either the coolant type or hot air. The coolant type generally use the engine coolant and circulate it through a plate on which the battery rests with the heat being transferred from the coolant, through the plate to the battery during preheat and standby operations. During vehicle operation, the heater is not operated, but the heated coolant from the engine is allowed to circulate through the heating plate. In an alternate method, heated air is directed to the battery from the heater. The battery is normally enclosed in an insulated box with either method.

b. Recent tests show that an effective means of heating the battery is to conduct the heat through the battery posts by the use of heated air impinging on finned cable connectors⁷.

c. In some cases, additional batteries are added to the vehicle to overcome the loss of capacity due to the cold and the increased cranking resistance. The XM813/817, 5-ton, 6x6 trucks are examples of vehicles using extra batteries as part of the arctic adaptation kit⁸.

3.3.4 Starter Characteristics:

a. While the starter itself is not normally affected by low temperatures, its performance is directly affected by the characteristics of the battery and the engine cranking characteristic, both of which are adversely affected by temperature. As this is a severe condition of use of the starter, its adequacy deserves particular attention in arctic testing.

b. The cranking speed decreases with a decrease in temperature as a result of two factors. As temperature declines the engine cranking torque increases. This increase in torque is primarily due to increased viscosity of the lubricants. The battery voltage is reduced at lower temperatures as a function of the battery capacity, further lowering the speed (speed is directly related to voltage in direct current systems).

⁷, ⁸Footnote numbers match reference numbers in appendix A.

c. In addition, there is normally a reduction in cranking speed with cranking time resulting from the decreasing voltage as the battery is discharged. Frequent exceptions are noted which are thought to be due to the warming of the engine friction surfaces and oil film as a result of cranking and the heating of the battery plates due to rapid discharge.

d. The consequence of reduced cranking speed and voltage is an increase in cranking current. A practical limit is placed on the sustained cranking current by the available battery power. A limitation may also be met in the horsepower rating for the starter design which is a function primarily of the internal resistance of the starter (high resistance limiting current). In a vehicle installation, the current and cranking power may also be affected by the resistance of the electrical circuit.

3.4 Personnel Heating and Defrosting Systems

3.4.1 Heating Criteria

a. Personnel heaters are required to maintain an average temperature of at least 4°C (40°F) in the personnel compartment in order to prevent loss of manual dexterity⁹.

b. Vehicles used as ambulances should maintain a temperature of at least 10°C (50°F) dry bulb through the patient compartment¹⁰.

3.4.2 Personnel Heaters:

a. The heaters used for personnel heating are similar to the hot air type used for power plant heating (para 3.1.6). Hot water heaters using the engine coolant as a heat source may be used; however, this is no longer a common means of personnel heating for arctic equipped tactical vehicles.

b. A hardtop closure kit is provided for arctic equipped vehicles for protection of the driver and assistant driver. It is authorized in those areas where the average temperature during the coldest month of the year is -15°C (5°F) or colder¹¹. All around vision is provided by a glass window on each side and to the rear.

c. Defrosters: Defrosters generally use the warm air from the personnel heater to keep the windows free of moisture. Uneven distribution of the defrosting air coupled with outside ambient air temperatures below -18°C (0°F) can create a condition which will lead to cracks in the glass due to stresses created because of the temperature differentials.

d. Test conducted: Tests are conducted to determine the technical performance and safety characteristics of personnel heating and defrosting systems when installed in military vehicles¹².

⁹, ¹⁰, ¹¹, ¹²Footnote numbers match reference numbers in appendix A.

3.5 Traction Devices Traction devices are essentially accessory equipment for wheeled vehicles, and are designed to permit crossing otherwise impossible terrain. Tire chains are the simplest and best known of such accessories. Most of these devices consist of a series of grousers fastened around the wheels by a system of connectors, the designs of which vary from simple cables or chains to special arrangements. Grousers are usually constructed of welded metal section, sometimes with rubber pads. Some of these devices are secured around individual tires, like chains, while other encircle a pair of wheels on tandem axes.

3.6 Water Trailers

3.6.1 Water trailers such as the Trailer, Tank: Water, 400-Gallon, 1½-Ton, Two-Wheel, W/E, M149 currently do not utilize a means to heat the water to prevent freezing in the tank but the tank is insulated. The water tank controls are designed so that an external valve can be closed to then permit the piping to be drained by use of the water faucet levers.

3.6.2 An immersion heater unit is available and adapts the heater discussed at para 3.1.6d⁷ to heat the water in order to prevent freezing in the trailer.

4. AVIATION MATERIEL

4.1 Engine

4.1.1 Engine Starting:

a. Internal combustion and gas turbine engines are started by motoring from some external source of power until favorable combustion conditions have been established so that the engine will run under its own power.

b. Since the gas turbine engine is replacing the reciprocating internal combustion engine in many aircraft applications, the following discussions will center on the turbine engine (for a discussion of the reciprocating internal combustion engine see paragraph 3a of the Tank/Automotive Materiel Section of this document).

4.1.2 Adequate Cranking Speed

a. In the turbine engine, the starter must accelerate the compressor to a speed which will provide airflow to the combustion chamber in an amount which will give a safe turbine inlet temperature and at a pressure that will force the burning gas rearward from the combustion chamber. The pressure of the air delivered to the combustion chamber may be 12 times or more the pressure at the compressor inlet.

b. The starter must overcome the bearing oil-film resistance which will form during cold-soak. This initial resistance will be somewhat less than for a reciprocating engine of comparable size because of the fewer number of bearings. However, from this point on, the power requirement on the starter will increase due to the increasing compressor load (speed, acceleration, compressing air to higher pressures).

c. Engine runups should be long enough to bring the engine up to operating temperature. Any shorter period will cause water vapor to condense. This water could freeze and split the oil coolers, block oil lines, and increase the possibility of an engine failure. Short engine ground runups should always be avoided.

4.1.3 Air/Fuel Mixture and Ignition

a. The turbine engine operates with an excess of air (lean condition). The mixture is additionally cold and rushes past the ignitor plugs at high velocity. This causes difficulty because, in order to start a fire, the mixture must be brought to the ignition temperature in the brief instant that it is adjacent to the ignitor plugs.

b. Also, spark plug fouling is a problem, since the ignition system only operates during the starting cycle, it is not able to keep the plug or ignitor clean by continuous arcing across the gap.

c. Heating criteria. Whenever possible, heating is utilized to assist in starting. Heat is supplied from an auxiliary source for the amount of time specified by the appropriate operator's TM. Heating results in a faster starter cranking speed, which tends to reduce the hot start hazard by assisting the engine in reaching a self-sustaining speed in the least possible time. Additionally, an external power source is used when available. The temperature at which heat should be used varies with the engine. As an example, the UH-1D/H Helicopter¹³ operator's TM recommends that heat be used below -26°C (-15°F) when the aircraft batteries are used.

d. Electrical system. An adequate and properly functioning electrical system is essential to starting and operating at low temperatures as in the reciprocating engine. Again, the most critical component is the battery. However, in aircraft, utilization of the nickel-cadmium battery is made instead of the lead-acid as used in tank/automotive equipment due to its superior low temperature characteristics. The system voltage is 24 volts. A start can be made, for example, on the UH-1D/H Helicopter¹³ if the battery voltage does not drop below 14 volts with the starter energized.

4.2 Personnel Heating and Defrosting Systems

4.2.1 For cold regions environmental use, it is required to have a heater of sufficient capacity to provide adequate heat to maintain crew and cargo compartment temperatures of 4°C (40°F) at an outside ambient air temperature of -54°C (-65°F), and to defrost the windshield¹⁴. The use of

¹³, ¹⁴Footnote matches reference numbers in appendix A.

bleed air only from the turbine is not generally sufficient to provide the defrost capability, and the system is commonly supplemented with a fuel-burning heater. For further details on these heaters refer to para 3a(6).

4.3 Flight and Engine Instruments

a. Gyro-operated flight instruments such as the directional gyro, turn-and-slip indicator, and attitude indicator may be unreliable because of increased bearing friction caused by cold and congealed lubricants. Cabin heaters, however, may be used to keep flight and engine instruments at operating temperatures. If these heaters fail during flight, you must weigh these factors in deciding whether to continue the mission.

b. During start, oil pressure gages will indicate maximum pressure. Tachometers may indicate a lower than normal reading. The engine should be run at flight idle until operating limits have been reached. The warmup time required depends upon the outside air temperature and the amount of preheating used. Be aware that a rapid throttle increase while parked on snow or ice can result in yawing. Cold weather aircraft starts should be in accordance with the appropriate operator's manual and current maintenance directives.

4.4 Plastics and Protective Covers

a. Plastics may become brittle and crack when the aircraft is moved from inside a warm hangar to the outside. Check for small cracks at the edge of the mounting frames, bubbles, windcreens, windows, and doors. These cracks may lead to disintegration in flight.

b. Protective covers provide adequate protection against rain, freezing rain, sleet, and snow when installed on a dry aircraft prior to the precipitation.

c. It is not practical to completely cover an unsheltered aircraft. Therefore, those parts not protected by covers require closer attention during preflight, especially after blowing snow or freezing rain.

4.5 Batteries

a. The nickel-cadmium battery performs well even in cold weather. Since it performs better when it is warm, it should be protected from extreme cold whenever possible.

b. When available, external power should be used for starting. Also, walk the rotor blades around three to five times to make starting easier.

c. After each cold weather flight and before shutting down the engine, the battery should be checked for charge using the procedure outlined in the appropriate operator's manual.

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d. Preheating the aircraft battery will result in faster starts. This tends to reduce the hot start hazard associated with turbine engines and it increases the life of the battery.

4.6 Synthetic Rubber. This material, when used in oil and fuel lines and in coating electrical wiring, may become stiff. To prevent synthetic rubber from cracking, avoid bending the lines and wiring.

4.7 Control Cables. When adjusted inside a hangar, control cables may develop slack because the airframe contracts more than the cable when the temperature drops. To insure the proper response, check control movements.

4.8 Tires. Cold weather can cause tires to stiffen, leaving a flat spot on them. However, this flat spot will disappear when the aircraft is taxied. In extreme cold when moisture is present, tires may freeze to the surfaces; and when moved, the tread may tear off. This can be prevented by parking the aircraft on boards, planks, dunnage, or similar material. The best time to check tire pressure is when the tire is cool.

4.9 Rotor Blades and Propellers. Icing on aircraft control linkages and surfaces can disrupt the aerodynamic characteristics of rotor blades and propellers and/or restrict their movement. Therefore, during preflight, check to see that blade and propeller surfaces are free of ice, frost, and snow.

CAUTION. Do not remove icing from an aircraft by striking the aircraft with blunt objects (hand, hammer, etc.), or by using sharp-bladed objects because these methods could cause external and internal damage to certain aircraft components.

4.10 Hydraulic and Pneumatic Leaks

a. Leaks may appear more frequently due to contraction and expansion of metals which result from temperature extremes. Cold weather aircraft starts should be accomplished in accordance with appropriate operator's manual and current maintenance directives.

b. Static leaks may tend to disappear with increasing temperature. A close evaluation of the leak should be completed to determine if the aircraft is safe to fly. If the leak develops after warmup it will not disappear; and the aircraft will require maintenance.

c. Hydraulic leaks may occur due to deforming and contracting of seals. Before leaking hydraulic units are replaced, move the aircraft into a heated hangar or apply external heat to the component for approximately 1 hour. The temperature of the hydraulic fluid should be increased by operating the system. Cycling the system a number of times after a little heat may stop the leak.

4.11 Fuel and Oil

a. The aircraft should be serviced with fuel upon landing to prevent excessive sweating of fuel tanks. Fuel pumps should be drained after servicing to reduce the amount of water in the fuel because this water will freeze and cause the fuel boost pumps to malfunction. It is important to check the operation of the fuel boost pump prior to flight, since ice damage is very common.

b. Defueling an aircraft in an arctic environment may be difficult and hazardous. If no other means are available and the aircraft engine can be run safely, you may have to run the aircraft out of fuel. If you do drain the fuel, keep in mind that fuel does not freeze and is in a super-cooled state. If fuel is spilled on an individual, it will probably result in instant frostbite. Fuel handlers and mechanics must have access to insulated fuel handler gloves.

c. Oil levels should be checked after operational temperatures have been reached. Any oil that is needed should be preheated and added while the system is hot.

4.12 Specific Aircraft Considerations

a. The OH-58 battery is small and has a relatively low amperage. If it is not sufficient to provide enough power to start your aircraft, take the battery out of an AH-1. This battery is compatible with the OH-58 system but contains a higher amperage.

b. The CH-47 has an extensive hydraulic system; therefore, during the extreme cold weather, consideration must be given to preheating the aircraft prior to flight. The Herman Nelson heater, which is a portable hot-air heater using gasoline, can be used for this purpose. The CH-47 landing gear strut should always be serviced to the highest extension allowable.

c. The UH-1 muff heater system is a reliable system, but problems have occurred in adjusting the temperature control. To avoid this problem, position the flapper valve to a fixed position of two-thirds open. This can be done by adding washers to the adjustment linkages. This will prevent a full open position that can result in excessive temperatures, causing partial melting and deformation of the plastic ducting.

d. The AH-1 canopy has a fogging problem in that low temperatures can cause the canopy to shrink to the point of leaving a small gap at the closure seam. This gap allows moisture to enter and provides a source of condensation. Due to the degree of condensation accumulation, it may take a long time to clear the canopy. If this problem is encountered, consider using a Herman Nelson heater to speed up the clearing process.

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e. The effects of cold weather on the weapon system and adjustment of fire of the AH-1 should also be considered. Frozen or stiff lubricants can cause malfunction of the M134 machine gun. Ball ammunition striking snow is extremely difficult to detect. It is almost impossible under these conditions to adjust fire visually beyond tracer burnout. Greater reliance must be placed on the sighting system. Another factor is that 20mm and 40mm explosive ammunition is difficult to detonate when fired into soft snow. This causes not only adjustment problems, but, in a combat situation, a dud hazard when troops cross the impact area.

f. After flying through icing conditions, the operation of the weapon system should be checked because the accumulations of ice may render the system inoperative.

4.13 Towing

a. Aircraft should be towed at a slow rate because control is difficult while turning or stopping. If the parked area is on an incline, the aircraft will tend to push the towing vehicle. While marshaling an aircraft out of or into a parking area, use caution to avoid turning the aircraft too short. The nose gear on fixed wing aircraft will tend to slide straight ahead rather than turn. Tire chains may be used on the towing vehicle to increase traction.

b. When towing skid-type helicopters, the towing wheels may be down in the snow - hindering rather than helping. The wheels should be taken off and the aircraft towed on its skids.

c. Parking spot markings and centerlines may become covered with snow and ice. A method used successfully to replace these lines is to mix a solution of dye, either food or clothing dye, and pour lines of this dye over the ice. These lines will freeze and provide ample marking for normal operations.

5. NBC PROTECTION EQUIPMENT

5.1 Collective Protection Equipment. No particular arctic adaptation devices are normally applied to collective protection equipment with the exception of kits which may be applied to the stationary engines which drive the compressors. The discussion of internal combustion engines in the tank/automotive section (para 3a) is applicable.

5.2 Individual Protective Equipment

5.2.1 Winterization kits for individual NBC protective devices (masks), are necessitated primarily due to problems of frost buildup on eyeglasses and respiratory valves. In addition, prevention of glare during use on snow-covered surfaces, can also be a function of the winterization kit.

5.2.2 Prevention of Frost on Lenses: Prevention of frost on lenses may be accomplished by insulating the existing eyepiece by the addition of a lens outsert and/or by warming the incoming air through the use of heat from exhaled air.

5.2.3 Prevention of Frost Buildup in Valves: Prevention of frost buildup is accomplished by warming as described at para 5.2.2 above, by the use of an ice particle prefilter as in the M17 NBC Mask Winterization Kit and by using special cold weather valve discs which remain flexible in lower temperatures, thus resisting frost buildup.

5.2.4 Prevention of Glare from Snow: The M17 Mask Winterization Kit incorporates a special antiglare lens outsert for this purpose.

6. GENERATORS

6.1 General

6.1.1 Output capacities of generators in current Army inventory range from 0.4 to 15.0 kw DC for engine-driven generators. These generators are designed to operate in ambient temperature as low as -54°C (-65°F). When the ambient temperature is below -32°C (-25°F), however, the batteries and the engine driving the generator need to be preheated in order to start the engine. Winterization equipment varies in composition and function depending on the type of generator it is used with. Preheating can be accomplished with integrally mounted winterization heating equipment and/or a portable auxiliary winterization kit.

6.1.2 An additional function of winterization kits on generator sets is to provide as much protection for the equipment as is practical both during operation and shutdown. When operating in cold environments (below -18°C (0°F)) canvas covers or other protective shelters around the equipment are commonly employed. Whereas some generators are supplied with canvas covers, in other cases the generators are protected, when not in use, by expedient protective covers drawn from local supplies. This permits easier servicing and better performance of the equipment. For correct arctic winter operation and maintenance of the generator set, refer to the appropriate TM for the proper use of thermostats, shutters, and cooling shrouds.

6.2 Integrally-Mounted Winterization Equipment

6.2.1 Engine and Battery Heaters: Both fuel-burning and electrical resistance type heaters are employed to provide heat to engine oil, intake manifold, engine coolant, batteries, and fuel. Further technical information pertaining to the application of heat to cold-soaked internal combustion engines can be found at para 3.1.6. In addition to the electrically

ignited fuel-burning heaters similar to those applied on tank/automotive equipment, blowtorches and electrical resistance type heaters are also used.

a. Electrically ignited fuel-burning heaters. Detailed descriptions of these types of heaters can be found at para 3.1.6. They may be of either the coolant or hot air heating type which through the use of ducts and/or coolant hoses apply heat to critical components of the engine, batteries, and electrical system of the generator. Fuel for these heaters is usually taken from the generator fuel supply by means of a fuel pump and line installed specifically for the heater. Thermostats are frequently designed into the systems to regulate the output of the heater within acceptable limits.

b. Electrical resistance heaters. Engine heaters of this type may consist simply of a coil which is mounted directly in the oil pump (referred to as an engine base oil heater in TM 5-6115-300-15¹⁵, or contains a similar coil encased in a tank, which in turn is used to heat the coolant of the engine and circulate it by thermosyphon action. Batteries may be heated by electrical resistance "blankets" or "plates" which are mounted around or under the battery, respectively.

c. Manifold heaters. Intake manifold heaters of either the fuel-burning type (refer to paragraph 3.1.8) or electrical resistance type may come installed. As with tank/automotive engines, the manifold heaters are frequently part of the basic generator, not necessarily part of the arctic adaptation kit.

6.2.2 Ether injectors: Pressurized ether injection systems are used on some diesel engine-driven generators and are designed for temperatures below 4°C (40°F). A metered shot of ether is injected into the engine air intake system to aid combustion through the high volatility of the ether. Excess ether, or the use of ether in warm engines, can damage the engine; therefore, great care must be exercised in its use.

6.2.3 Protective Shrouds, Doors, and Covers: Generators are commonly equipped with these devices, ranging from canvas covers, tailored to small air-cooled generators, to automatically controlled radiator shutters for larger liquid-cooled generators. These devices are used to protect the equipment from chilling winds, snow, and low temperature, and to retain the unit at proper operating temperature. An exhaust manifold heat exchanger and shutter in the air cleaner is used to provide preheated air to the carburetor during low temperature operation (below -4°C (25°F)) of some units.

6.3 External Winterization Equipment: These items are used as prescribed by the appropriate TM. Any heater (e.g., Heater, Duct, Type, Portable, 400,000 BTU), slave kit (e.g., M40 Slave Kit), battery charging device, or

¹⁵Footnote number matches reference number in appendix A.

enclosure used in conjunction with the generator, constitutes an external winterization kit. Canvas or wooden enclosures are commonly locally fabricated to provide necessary protection for generators operating for long periods in the arctic.

7. RADIO EQUIPMENT

7.1 Capabilities and Limitations

7.1.1 The primary capability of radio communication is that it can provide communication between two or more stationary or mobile units without the need for physical interconnection. In addition, radios can be made small, light, and therefore portable. Also, radios are more easily installed than any other means of communication required to give the same range and service.

7.1.2 Radio communication systems have several limitations or weaknesses including:

a. Susceptibility to component failure and performance degradation induced by environmental stress.

b. Disruption of communications caused by irregularities in the transmission path induced by ionic disturbances in the atmosphere.

7.2 Effects of Cold Temperatures and Cold Shock on Radio Equipment

7.2.1 The following are some of the effects of low ambient temperatures on radio equipment.

a. Temporary or permanent change of electrical and magnetic characteristics of components.

b. Loss of calibration.

c. Binding of mechanical parts due to ice formation or congealing of lubricants.

d. Embrittlement of mechanical components.

7.2.2 In addition to the cold temperature effects listed above, there are several special effects caused by cold shock which occur when a piece of equipment undergoes a sudden change in ambient temperature. This cold shock occurs, for example, when the equipment is transported to and from heated shelters in cold regions. Cold shock induces differential cooling and condensation. Effects related to differential cooling and condensation are listed below:

a. Rupture of conductors or insulators.

- b. Cracking or delamination of finishes.
- c. Cracking of embedding or encapsulating compounds.
- d. Opening of terminal seals and case seams.
- e. Leakage of fluids.
- f. Breathing, caused by influx of cold air into the radio set which occurs when the cold-soaked set is turned off. Glass, ceramic, and plastic parts may break if cooled too rapidly.
- g. Sweating occurs when a cold-soaked set is brought into a warm enclosure. The moisture which condenses may cause short circuits, or frost buildup if the set is brought back outside without being dried.

7.3 Adaptation of Radio Communication Equipment to Low Ambient Temperatures and Temperature Shock.

7.3.1 General: The above section discusses the general effects of cold temperatures and cold shock on the mechanical and electrical components of radio equipment. This section will describe specific effects of low temperatures, and the adaptation equipment and techniques used to counteract these effects and insure that the reliability of the communication system (power units and batteries, antennas, radios) is sufficient for normal operations.

7.3.2 Power Units: As the temperature goes down, it becomes increasingly difficult to operate and maintain internal combustion engine-driven power units. For a discussion of arctic adaptation kits for internal combustion engines, see para 3.1. If vehicle mounted radio gear (e.g., radio AN/VRC-46 set) is to be operated off of the vehicle's electrical system, the electrical power unit and regulator must be compatible with the electronic equipment in terms of voltage levels and current handling capability. Often, the capacity of a vehicle's electrical system will have to be increased to power both the radio and a vehicle compartment heater used to keep the radio warm.

7.3.3 Batteries:

a. The effects of cold temperatures on storage and dry cell batteries depends upon the following factors:

- (1) Type of battery used.
- (2) The load on the battery.
- (3) The particular use of the battery.
- (4) The degree of exposure of cold conditions.

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b. Batteries such as the BA-2030 Dry Cell and BA-5598 Lithium Battery have been specifically developed and manufactured for use in cold regions operations.

c. The AN/PRC-77 may be adapted for use with the one-man field radio, standard equipment flat, canvas battery pack (BA-4386/u) which may be worn by an operator between his OG wool shirt and his parka, and thus provide warmth and insulation and increased battery life. If the unit is not available, a spare set of batteries may be kept warm if placed in the operator's pockets.

d. Storage batteries and other large batteries which can't be heated by body heat can be placed in an insulated box heated by a hand warmer or a similar device¹⁶.

e. Several techniques are available for lengthening battery life and include utilizing a low transmit-receive ratio, and maintaining proper squelch level. These techniques should be considered by test personnel in evaluating appropriate draft technical publications.

f. Transmitting requires much more power than receiving because adequate power must be radiated if long distance communication is to be effective. If the ratio of time a set is transmitting to the time it is receiving can be kept low, a battery can be kept in service much longer.

g. A squelch control mutes a receiver when a carrier of inadequate strength is being received. Muting cuts off the amplifiers and reduces the standby power dissipated by bias circuits. If the squelch is adjusted properly this standby power will be minimized and battery life lengthened.

7.3.4 Antennas:

a. Cold temperatures have minor effects upon the electrical characteristics of an antenna, but various adaptive procedures should be followed to insure the mechanical reliability of the unit.

b. Antenna sections should be handled carefully because they become brittle in low temperatures. Also, whenever possible, antenna feeder cables should be elevated to prevent damage from heavy snowfalls and frost. Nylon rope guys, if available, should be used in preference to cotton or hemp, since nylon does not readily absorb moisture and is less likely to freeze and break. Antennas should be strong enough to withstand high ice and wind loading as well as great temperature variations. Antennas should be kept free of ice whenever possible.

¹⁶Footnote matches reference number in appendix A.

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7.3.5 Radio Sets:

a. The radio set itself and its associated equipment (cables, microphones, etc.) are greatly affected by cold and cold shock, and must be protected to insure reliability.

b. Cold and cold shock have various effects on the electrical components of the radio. For example, composition type resistors have positive temperature coefficients of resistance i.e., the resistance goes down as the temperature goes down. Semiconductor components such as diodes, thermistors, and transistors have negative temperature coefficients of resistance i.e., resistance goes up as temperature goes down. The frequency of vibration of crystals used in filters and oscillators is a function of temperature. If a crystal oscillator is not kept at a stable temperature it may undergo frequency drift and disrupt communication. Also, condensation which forms on parts of the radio may cause short circuits and grounds which will disrupt circuit functions.

c. Effects of cold temperatures and cold shock on mechanical components include brittleness, differential contraction, condensation, and thickening of lubricants. Brittleness caused by cold may reduce the effectiveness of shock mounts, and excessive vibration may then destroy the set. Interconnection cables and power cords become brittle and will break if sharply bent. Differential contraction, condensation, and thickened lubrication may cause binding or locking of mechanical tuning trains, plugs, jacks, keys, shafts, bearings, dials, and switches.

d. Equipment which must operate at low temperatures may require winterization to insure proper operation. For example, certain parts of the radio may have to be replaced because of their inability to function at low temperatures. Normal lubricants must be replaced with proper cold regions lubricants¹⁶. Standard microphone covers should be used to prevent moisture from the operator's breath from freezing on the buttons and perforated cover plate. If standard covers are not available, a suitable one can be improvised from rubber or cellophane membranes, or from cloth such as rayon or nylon fabric. Also, the cover will protect the operator from freeze burn if his lips should touch the microphone.

e. To prevent and reduce the effects of cold shock, equipment should be covered when transported into or out of warm shelters. This will prevent rapid temperature changes by offering some insulation, and will keep moist air off the equipment.

7.4 Adaptation of Radio Equipment to Other Peculiarities of Cold Regions Environment.

7.4.1 The cold regions environment has several other distinguishing characteristics not necessarily associated with extreme cold. Any set of adaptation equipment or techniques to be used in the cold regions must take these characteristics into account.

7.4.2 Solar Disturbances:

a. Magnetic storms of the kind which interfere with radio communication have been correlated with solar disturbances. During a solar disturbance, a cloud of high energy electrons and protons is given off by the sun. Some particles are intercepted by the earth and are deflected by the earth's magnetic field. The particles then concentrate near the polar regions. The moving particles produce a magnetic field of their own and they may collide with gas atoms in the atmosphere causing ionization of the gas (electrons knocked away from the atom) and emission of light (auroras). This ionization changes the electrical characteristics of the atmosphere and disturbs radio communication. Severe static may accompany such disturbances. Also, blackouts and fading which may last for minutes, hours, days, or even weeks, often occur and are caused by changes in the density and height of the ionosphere. These changes affect the height at which the signal is reflected thus causing the signal to return in varying locations.

b. The greatest auroral activity occurs between 60 degrees and 70 degrees north latitude and occurs at intervals of 27 to 28 days¹⁷. Weekly predictions of expected conditions are published by the National Oceanic and Atmospheric Administration (NOAA) and are available to Communication-Electronics Staff Officers. Due to the high rate of occurrence of these disturbances in the arctic (and antarctic), radio equipment to be used in these regions must be adapted to reduce these effects.

c. The degree to which ionic disturbances affect a radio signal depends on the frequency used to transmit the signal. Low frequency circuits (100-500 KHz) provide the best medium for long distance, point-to-point radio communication because the low frequency ground wave is not seriously affected by auroral disturbances. Higher frequency sets which often utilize the sky wave portion of the total radiated energy must be able to operate over a band of frequencies so that if an ionic disturbance occurs, the frequency of operation can be changed and communication reinstated. Tactical radio equipment operations in the so-called line-of-sight frequency band (30 MHz and upwards) is not affected adversely by auroral activity. The use of VHF and microwave radio relay equipment will provide the greatest degree of reliability for multichannel means of communications in northern areas. Tactical tropospheric scatter radio equipment, when available, is another means of providing multichannel communications up to 300 kilometers¹⁷. In summary, radios used in the arctic which utilize a skywave transmission path should be equipped with the capability to operate on a wide variety of frequencies. Also, the antennas used with these radios should have sufficient band width to accommodate the range of frequencies that may be used.

7.4.3 Grounding Problems:

a. General. The frozen earth and the presence of an over-layer of light, dry snow makes it difficult to obtain adequate electrical earth

¹⁷Footnote matches reference number in appendix A.

grounds. Placement of grounding rods is made difficult by the fact that the earth is so hard to penetrate. Also, since frozen earth has low conductivity, grounding rods are of little use even if installed. The ground resistance is greatest immediately surrounding the rod(s). The ground resistance can be reduced by using multiple ground rods that are interconnected and by pouring a saline solution around the ground rods (USA Corp of Engineers, CRREL, Special Report 82-13¹⁸). The preference method of emplacing grounding rods is prior to the earths freezing.

b. Effects of inadequate grounds. Inadequate grounds lead to several serious problems including:

- (1) Static electricity buildup.
- (2) Noise.
- (3) Unreliable antennas.
- (4) Safety hazards.

c. Static buildup. Wind friction and relative motion of two objects may produce a buildup of charge on the objects. For example, charged snow particles may build up large charges on antennas. If vehicles become excessively charged, arcing may occur which may be quite dangerous if the vehicle is being fueled. Buildup of charge on personnel is also possible. If the charge is discharged through sensitive galvanometers or high impedance voltmeters, the instrument will give erratic and inaccurate readings. Static effects can be reduced by attempting to ground vehicles and personnel as well as possible by using a large conductive grid as an artificial ground or by connection to a ground rod placed in frozen ground by explosive techniques. Personnel should keep hands covered by a thin insulating layer when using sensitive equipment to reduce sparking and discharge.

d. Noise interference. Noise interference among a set of equipment located on a surface of snow and ice can be traced to ungrounded noise producers such as dc generators, unsuppressed vehicles, and unfiltered electrical equipment. All noise producers which are intended for use near a receiving station should be isolated as much as possible and bonded to a common point, but they should not, in any instance, be connected to the receiver ground system. Adaptation equipment may include filters on output circuits to reduce noise, and suppressors to limit interference caused by vehicles.

e. Antennas. Antennas are usually grounded to improve the far-zone field pattern and strength. As previously discussed, adequate grounds are often difficult to obtain, and adaptive equipment must be utilized. Adaptive equipment includes counterpoises and ground plane antennas. A counterpoise

¹⁸Footnote matches reference number in appendix A.

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is a horizontal array of conductors placed below an antenna to simulate a ground plane. Ground plane antennas are antennas which use a set of reflector elements which function similarly to a counterpoise. Counterpoises should be installed high enough above ground to insure that it will not become snow-covered. Deep snow on the system will change antenna tuning.

f. Generators. Ungrounded power generators and equipment are a safety hazard. If possible, metal chassis should be bonded to a common point to prevent dangerous voltages from building up between equipment.

8. WIRE COMMUNICATIONS

8.1 Capabilities and Limitations

8.1.1 Capabilities: Wire communication systems, if properly installed, can be quite reliable even in the cold regions. It is a mode of communication immune to the atmospheric disturbances common on polar regions. Multiplex gear, loading coils, and repeater networks increase the range and usefulness of wire communication systems. Wire systems can be adapted for use with many types of communication equipment including: telegraph, teletype, voice, data, facsimile, and video. Wire systems are considered more secure than radio systems.

8.1.2 Limitations: The time required to install a wire channel is much greater than the time needed to set up a radio channel with the same capabilities. Cold regions conditions greatly increase this discrepancy, due to the fact that carefully implemented installation procedures are necessary if high functional reliability is to be maintained in spite of cold and snow. Wire systems, whether permanent or temporary, allow little or no mobility of the users.

8.2 Effect of Cold Regions Environment on Wire Communication Systems.

8.2.1 A basic wire communication system consists of a phone set, interconnecting wire with supports, and a battery or other type of power source. Some phone sets, however, are voice powered and do not require an electrical power source for operation. The effects of cold and cold shock on the electrical and mechanical components of a phone set and on the batteries are the same as referred to in para 7 with regard to radio equipment. The interconnecting wire which is the distinguishing characteristic of the wire system requires specialized installation and maintenance techniques to adapt it to the arctic environment. Characteristics of the cold regions environment which affect the integrity of the wire includes snow, moisture, temperature variations, and local wildlife.

8.2.2 The above factors affect the wire in the following ways:

a. If wire is laid over the ground and becomes covered by snow it may become difficult to find when maintenance must be performed. Also, a heavy

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overburden or dense snow may cause excessive loading of the wire which may lead to breakage.

b. Wet ground and rain which occur in the cold regions during seasonal transitions will affect the performance of the wire. For example, WD-1/TT (field wire) when used with Phone Set TA-312/PT (3-volt operating voltage) will allow communication up to 35 km (22 miles) when dry, but to only 23 km (14 miles) when wet¹⁹.

c. Temperature variations cause contraction and expansion cycles which may cause fatiguing of the wire and weaken splices. Cold temperatures cause embrittlement which will make the wire more susceptible to wind damage.

d. Local wildlife both large and small may damage wire laid on the ground.

8.3 Adaptation of Wire Equipment to Cold Regions Environment.

8.3.1 Adaptation of wire equipment to the cold regions environment can be implemented by utilizing the following techniques and equipment.

a. Wire lines in the arctic areas should be elevated to protect them from deep snow and vehicle and foot traffic. Because of a lack of trees in tundra areas, lance poles (PO-2) must be used for aerial construction. Other techniques which apply to wire installation procedures include the following:

(1) A heated shelter should be provided for the wire laying crews. The arctic personnel shelter mounted on a 2½-ton truck or tracked vehicle provides a good facility for wire laying. The field wire can be kept warm and pliable as it is spliced and payed out the rear of the shelter.

(2) To place the aerial wires, tie three lance poles together at the top to form a tripod which provides a stable support without the need of penetrating the frozen ground. Use a basket hitch or weave tie to secure the wire lines to the top of this tripod. Never tie wire in the normal manner in arctic areas. Bending the lines will crack and break insulation, causing a short circuit.

(3) When wire lines must be taped for any reason, Electrical Insulation Tape TL-600/U (Polyethylene) should be used. This tape retains its adhesiveness in cold areas.

(4) Adequate sag must be maintained between poles to allow for thermal contraction of the wire as it undergoes a cold-soak cycle. Certain

¹⁹Footnote matches reference number in appendix A.

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types of stranded wire will elongate at cold temperatures, and this must be considered when planning aerial clearance over roads.

(5) Wire should be installed so as to protect it from the many animals found in cold regions areas. In winter months rabbits will ravage the insulation of unprotected wires causing shorts. Migrating caribou and moose can easily break wire laid on the ground. WD-1/TT wire is especially susceptible to the above problems, and is therefore used mainly for temporary communication hookups. Permanent hookups should be installed aerially whenever possible to give protection against animals. When wire must be laid on the ground, steel clad heavy-duty cable should be used. Spiral/4 cable, for example, is such a cable and is impervious to small animals. Even though it has a high tensile strength, moose have been known to run into the cable and break it.

9. WEAPONS MATERIEL

9.1 Small Arms

9.1.1 The primary piece of adaptation equipment found on small arms weapons is an enlarged trigger to permit firing with the arctic mitten set. See the appropriate equipment TM's.

9.1.2 Areas of concern in the operation of weapons include: sluggishness, higher breakage and malfunction rates, condensation, visibility, and emplacement. These problem areas and appropriate action to take are covered in chapter 5, TM-9-207².

9.1 Heavy Weapons

Heavy weapons (artillery, mortars, etc.) are not normally equipped with specialized arctic adaptation kits. Canvas covers, normally supplied by the unit, are commonly employed to protect these items from the effects of weather. Specialized techniques of maintenance and employment of these weapons, such as lubrication, emplacement of trails, etc., are covered in chapter 4, TM 9-207².

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APPENDIX B GLOSSARY OF TERMS

Airbox: Pressurized area around the engine cylinder walls through which the intake air from the blower passes to enter the ports on two-cycle engines.

Cold-Soak: A period of time during which the vehicle components are allowed to reach the ambient air temperature.

Cool-Down Rate: The rate at which a vehicle's components cool to the ambient temperature.

Dry Bulb Temperature: The temperature of the atmosphere as indicated by an ordinary thermometer.

Preheat: The heat applied to the engine or engine accessories before the starter is engaged. The engine and accessories are in the cold-soak condition prior to the application of heat. The preheat period normally varies up to 1 hour in length.

Standby: The period of operation of the engine heater(s) after the vehicle has reached stabilized operating conditions and then shutdown. The period of time varies up to 24 hours. Operation of the heater is done to insure instant startup of the vehicle.

Stoichiometric: Amount of individual chemicals necessary for a complete chemical reaction to occur (quantitative relationships).

Thermosyphon: Natural circulation of the coolant in the engine. Heated coolant rises in the system and as it flows through the system cools and completes the loop. No pump is required for movement of the fluid.

Unassisted Start: Starting of a cold-soaked engine without the aid of heat or other external aid.

APPENDIX C - CHECKLIST FOR ENGINE COLD-STARTING TESTS

<u>ITEM</u>	<u>YES</u>	<u>NO</u>	<u>NA</u>
1. Preoperational inspection and services performed on vehicle.			
2. Vehicle prepared for cold-weather operation.			
3. Batteries fully charged.			
4. All required instrumentation calibrated, properly installed, and operational.			
5. Spare batteries on hand and fully charged.			
6. Means available to slave-start engine if necessary.			
7. Required data recorded.			
8. Safety procedures posted and followed.			
9. Appropriate cold-weather clothing available for test personnel.			