FM 9-207
TO 36-1-40

OPERATIONS AND MAINTENANCE OF ORDNANCE MATERIEL IN COLD WEATHER

HEADQUARTERS
DEPARTMENT OF THE ARMY
DEPARTMENT OF THE AIR FORCE

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DEPARTMENT OF THE ARMY
DEPARTMENT OF THE AIR FORCE
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PREFACE

As stated in Field Manual (FM) 100-1, *The Army*, it is the Army's fundamental purpose to win wars through land force dominance regardless of location or climate. This FM provides general doctrinal and technical guidance for operating equipment and ordnance materiel under extremely harsh cold weather conditions (0° to -65° F). Its primary purpose is to familiarize operators and crews with the special procedures and techniques for working in sub-zero temperatures. Also, this manual will assist unit commanders, supervisors (motor sergeants, battalion motor officers [BMOs]), and maintenance personnel in anticipating and planning for the onset of cold weather or an arctic deployment. Failure to follow this guidance can cause injury to personnel and damage to equipment, besides limiting mission accomplishment.

This FM does not replace applicable technical manuals (TMs) for specific equipment operations, servicing, or repair. It is intended to provide an overview of the special and unique difficulties encountered in cold weather operations. Refer to the appropriate operator or higher-level manual for specific instructions.

The proponent of this publication is Headquarters, United States Army Training and Doctrine Command (TRADOC). Much of the information in this manual was provided by the USA Cold Regions Test Activity, which is responsible for testing equipment designed for use by the soldier on the winter battlefield and the USA Cold Regions Research and Engineering Laboratory, which exists largely to solve technical problems that develop in cold regions, especially problems related to construction, transportation, and military operations.. Access to more information can be obtained though points of contact on their World Wide Web pages. Submit changes for improving this publication on DA Form 2028 (Recommended Changes to Publications and Blank Forms), directly to:

Commander
US Army Combined Arms Support Command
ATTN: ATCL-A
Fort Lee, Virginia 23801-1713

Note: Unless otherwise stated, whenever the masculine gender is used, both men and women are included.

Chapter 1
Cold Weather Considerations

"Every mile is two in winter."

George Herbert

Section 1
The Cold Weather Challenge

IMPACT ON MILITARY FORCES

The cold has been identified as an enemy of military forces and equipment since the beginning of recorded history. When employed in a cold region, a force actually faces two enemies--the tactical enemy and the environment that also aggressively attacks and can destroy equipment and men. The impact of cold weather on combat forces can readily be seen during decisive campaigns in history. Napoleon's disasterous march into Russia, Germany's failed conquest of Russia during World War II, and the operations of United Nations forces in Korea are modern examples. With United States (US) reliance on global force projection, Army forces must prepare to operate in a variety of climates, including extreme cold.

OPERATIONAL EFFECTS

Army forces may be required to conduct sustained operations in temperatures as low as -65 ° Fahrenheit (F). Under such conditions, personnel are subject to decreased efficiency and cold casualties, equipment is prone to breakdowns, supply problems are increased, and operations are restricted and complicated by the environment.

It is the responsibility of unit leaders to ensure that personnel and equipment can withstand the challenges of cold weather. US Army equipment is among the best in the world for use in cold climates. However, soldiers and their leaders must understand the effects of cold weather and adapt operations and maintenance to overcome environmental conditions.

Section II
Operational Considerations

PERSONNEL

Since most US units are stationed in temperate or tropical climates, soldiers generally lack adequate training or experience in cold weather operations and maintenance. If troops stationed in temperate climates are to be expected to move to cold climates and perform their missions, they must be prepared for it.

A large part of a soldier's time and energy in cold weather is spent in self-preservation. This naturally reduces the efficiency of personnel when operating and maintaining materiel. Besides operating equipment, soldiers must learn to protect themselves against climatic factors by dressing properly and improvising protective measures and shelters.

LEVELS OF OPERATION

Operating equipment in temperatures no lower than 10 ° F presents few problems. Conditions are similar to those experienced during winter in the northern part of the continental United States (CONUS).

From 10 ° F to -25° F, operations become more difficult (Figure 1-1). At the warmer end of this range, lack of winterization results in only a slight loss of operating efficiency. Proper training prevents many failures of materiel and injuries to operators. Nevertheless, nonacclimated troops have difficulty at even the warmer temperatures above -10 ° F.

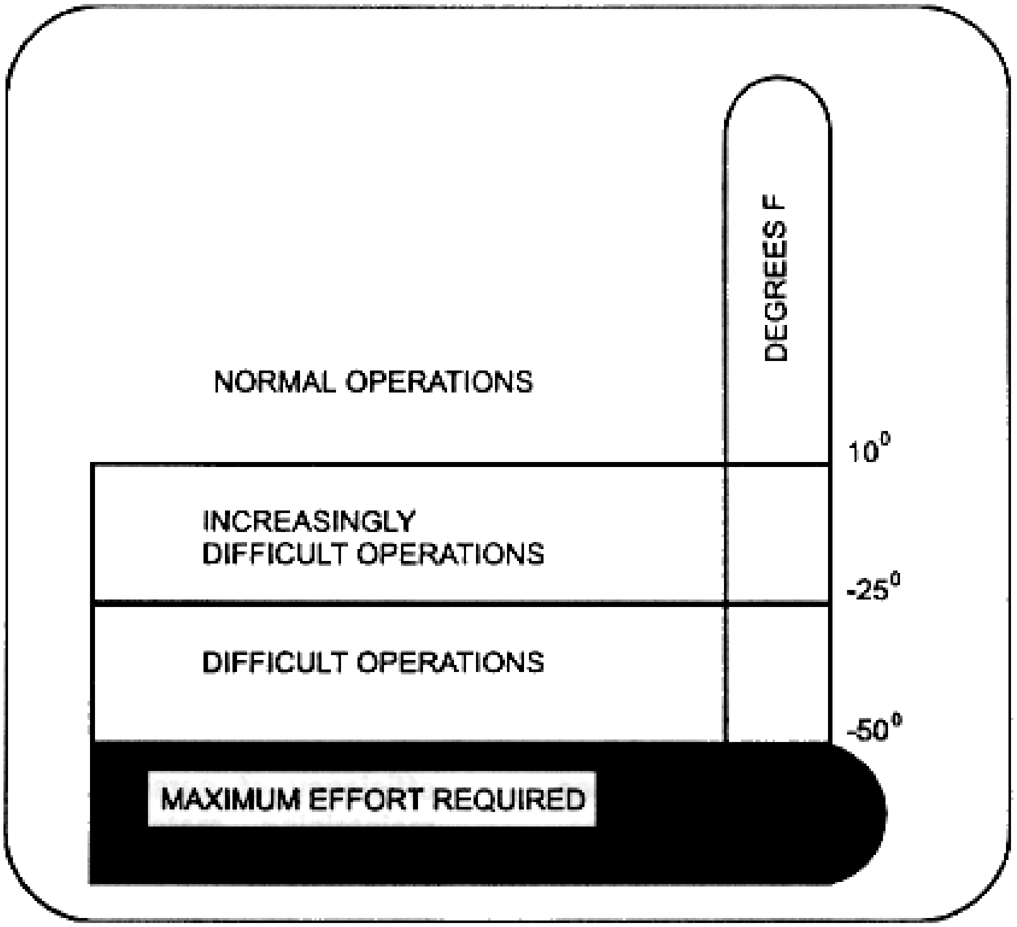


Figure 1-1. Operational difficulty vs temperature range

When temperatures drop below -25° F, operations become increasingly difficult. At temperatures nearing -50° F and lower, the maximum efforts of well-trained personnel are required to perform even the simplest tasks with completely winterized materiel.

EFFECTS ON MATERIEL

Since metals contract at lower temperatures and expand at higher temperatures, improper clearances may result in either binding or excessive looseness.

Cleaning and Preparing Equipment

Before operating vehicles, crews should review appropriate operator manuals for cold weather operations. These manuals all include a section subtitled *Operations Under Unusual Conditions*. Also, operators must know other basic skills, such as working with tire chains and slave-starting.

Soldiers must maintain equipment in the best mechanical condition to withstand the added difficulties and prevent failures during sub-zero operations. Commanders must place special emphasis on maintenance inspections.

Placing equipment in proper mechanical condition before the onset of cold weather requires time for necessary and careful disassembly, repair, cleaning, and reassembly. Low temperatures must be anticipated far enough in advance to permit completion of winterization. Refer to pertinent operator and unit maintenance technical manuals (TMs) for operation, lubrication, preventive maintenance checks and services (PMCS), and maintenance under unusual conditions. Operators must be very cautious when using equipment that has been inactive for a long time. For example, if lubricants congeal in various components, parts can fail.

Metals

Metals become brittle in severe cold temperatures; thus, parts cannot withstand the shock loads that they sustain at higher temperatures. Illustrations of such stress are at Figure 1-2. For example, at -20° F certain steels can withstand only 50 percent of the shock load that they can sustain at room temperature. For a given change in temperature, various metals will expand or contract by different amounts. These characteristics especially affect bearings in which the bearings and shaft are of different metals, are of different metals bolted together, or meshing gears are of different metals. In cold weather, special care should be taken in adjusting parts of this type, especially when adjusting bearing clearances.

Figure 1-2. Effect of cold on metal

Rubber

Besides natural rubber, there are hundreds of rubber substitutes. Synthetic rubbers look and usually react the same as natural rubber, although most do not attain a greater flexibility at high temperatures. As it cools, natural rubber gradually stiffens, but retains a large part of its elasticity until reaching temperatures below -20° F.

Below -20° F, certain peculiarities occur. When cooled gradually but continuously over a short time, rubber remains flexible until it reaches approximately -60° F. It then quickly loses its elasticity and becomes brittle. Also, if rubber is consistently kept at the relatively higher temperature of -20° F for a long time, an effect similar to crystallization occurs, causing it to become brittle. For example, hoses for fueling may crack, increasing the potential for spills.

Rubber-Covered Cables

Extreme care must be taken in handling cables at low temperatures. If the rubber jackets become hard, the cables must be protected from shock loads and bending to prevent short circuits caused by breaks in the covering. If cables are to be bent, they must first be warmed. Neoprene jackets on cables become brittle and break readily at low temperatures.

Tires

Tires become rigid in cold, causing flat spots on parts that come in contact with the ground during shutdown. At severe cold temperatures, sidewalls become brittle and crack.

Tires must be inflated to the appropriate pressure at cold temperatures. A tire inflated to 40 pounds per square inch

(PSI) indoors will change to 25 PSI when moved outside at -50° F. Failure to properly inflate tires can result in tires slipping off rims. Generally, tires should be inflated 10 PSI over the normal pressure for winter operations.

Plastics

Plastics expand and contract much more than metal or glass, causing them to be brittle in cold weather. Vehicular canvas covers with plastic windows may break due to a combination of cold and vibration.

Glass

Glass, porcelain, and other ceramics perform normally at low temperatures if handled carefully. However, cracking may result if heat is applied directly to cold windshields or other vehicle glass.

Fabrics

If kept dry, fabrics generally retain their flexibility, even at extremely low temperatures. However, tarpaulins may shrink, and wrinkles are extremely difficult to smooth out at sub-zero temperatures. Whenever possible, tarpaulins should be unfolded in heated enclosures or kept installed on equipment.

EFFECTS ON MISSION FUNCTIONS

Severe cold adversely affects the capability of a unit to accomplish its mission. Understanding the specific impacts can assist a unit in planning measures to counter these effects.

Movement/Maneuver

Units are less maneuverable in icy conditions or deep snow. Deep snow reduces vehicle traction on hills and increases the chances of breakdown/damage caused by hidden obstacles. Motorized units are restricted almost exclusively to roads. Also, personnel have a tendency to operate close to vehicles, which is tactically unwise. Trailers and towed artillery pieces further reduce mobility. Emplacement of artillery pieces for fire missions is very difficult.

When planning for battle, leaders must realistically evaluate the impact that physical factors have on operations.

Ammunition

There is an increased need for ammunition in cold weather. This is because cold temperatures adversely affect firing, responsiveness, effectiveness, and accuracy. Also, it is often necessary to fire several light-to medium-zone rounds prior to maximum propellant charges to avoid stressing the hydraulic recoil mechanisms of howitzers. Support units must be prepared to handle and transport the added volume of ammunition. Because of the harsh conditions, it is also more difficult to prepare ammunition storage areas.

Fuel/Lubrication

Units operating in a cold environment can expect a dramatic increase in petroleum, oils, and lubricants (POL) and fuel requirements due to movement difficulty, extended idling, and heating requirements. Special fuel and lubricants must also be used to prevent freezing and jelling.

Always consult the appropriate TM or lubrication order (LO). Remember to use antifreeze in coolant systems. Different grades of hydraulic fluids are also necessary. If vehicles come into theater with temperate grade automatic transmission fluids and become cold-soaked (when vehicle temperatures drop as low as the existing ambient temperatures), seals are likely to blow when transmissions are engaged.

Units may also consult the Defense Logistics Agency (DLA) publication, *Environmental Products, Chemical Alternatives, Recyclers, Aircraft Cleaners and More*, to choose environmentally preferred substitutes.

Operators and maintenance personnel must be proficient in the use of all winterization and arctic kit items, which include heating devices, insulated grill covers, and sometimes engine exhaust restrictors. When authorized, stationary engagement of hydromechanical transmissions can be used to facilitate engine warming.

Section III
Logistical Considerations

FACTORS IMPACTING LOGISTICS

Vast distances, major climatic or terrain obstacles to air or ground movement, or a combination of these factors often separate combat service support (CSS) elements from supported forces. As a result, logistical planning must be continuous and aggressive, making use of all modes of transportation. Unit standard operating procedures (SOPs) and training plans should address the following:

- Unit distribution is the rule and not the exception.
- Many munitions have known firing and/or function limitations as a result of cold temperatures, snow, and soft ground conditions. Multioption fuzes should be selected whenever available to provide for seasonal changes.
- Economic order quantities (EOQ) and ammunition required supply rates (RSR) should be computed on a seasonal basis rather than on the standard 180-day demand criterion.
- Special training and emphasis is required for using heat sources and keeping water and other liquids (especially medical items) in a liquid state when temperatures drop below 32 ° F.

At temperatures below 32 ° F, heated storage must be provided for power sources, command and control centers, dining facilities, aid stations, maintenance shelters, and critical supplies (i.e., medicines, batteries, and POL).

When preparing for sustained operations in remote, cold regions, logistical planners must understand the following environmental characteristics:

- Unrelenting hostile climate.
- Formidable and virgin terrain.
- Great distances.
- Extensive water obstacles.
- Acute movement problems.
- Poor lines of communication.
- Low population densities.
- Lack of shelter and developed resources.

PLANNING

Planning is critical to the success and survival of units operating in cold weather. Planners should consider the following:

- Plans must be both detailed and flexible.
- Personnel must be properly trained and prepared.
- A potential increase in medical problems (i.e., injuries from frostbite and hypothermia) must be anticipated.
- Prolonged exposure to cold and extended hours of darkness will lead to increased psychological stress.
- All units, especially mechanized and motorized, will require more time to accomplish tasks; cold will increase fuel consumption and the demand for lead acid and dry cell batteries.
- Although equipment is designed to function in the cold, it will be less reliable, thereby increasing maintenance, time, and supply problems. Maintenance, supply, and engineer units may require augmentation.
- Cold conditions tend to increase security problems because soldiers want to keep warm and sleep indoors.

Cold will also make command and control more difficult. Flank units must work harder to keep up with the main body and require frequent rotation.

HOST NATION SUPPORT

Logistics support can be decisive to mission accomplishment during cold weather operations. Host nation (HN) personnel are critical to identifying sources of food, shelter, warmth, supplies, and services. Leaders must incorporate all available HN support into their planning to reduce the impact of cold weather on logistics operations. HN personnel should identify specific environmental restrictions pertinent to cold weather operations (i.e., specific chemical substitutions, spill response, and corrective actions).

MAINTENANCE

The importance of maintenance, especially PMCS, must be impressed on all cold region soldiers. Maintenance of mechanical equipment is exceptionally difficult in the field during cold weather. Added time is needed to complete tasks. Even shop maintenance cannot be completed at normal speed. Mechanics must allow equipment to thaw out and warm up before making repairs. This time lag cannot be overemphasized and must be included in all planning. Personnel efficiency also is reduced by the bulky and clumsy clothing worn in extremely cold areas. Because it is dangerous to handle cold metal with bare hands, operators/mechanics must wear mittens or gloves at all times. Losing the sense of touch further reduces the soldier's efficiency. Even the most routine operations, such as handling latches or opening engine compartments, become frustrating and time-consuming when performed with protected hands.

At temperatures below -20 ° F, maintenance may take five times as long. Complete winterization, diligent maintenance, and well-trained crews are the keys to reducing the adverse effects of cold weather.

Listed below are several requirements that affect maintenance directly and require planning and preparation before a cold weather operation:

- Heated shelter for equipment maintenance.
- Proper clothing and tools for mechanics.
- Adequate portable heaters.
- Capability to store and issue antifreeze materials, fuels, hydraulic fluids, and lubricants.
- Adequate lighting.
- Supply of repair parts.
- Sufficient equipment for snow and ice removal.

WARNING

PROVIDE PROPER VENTILATION IN HEATED SHELTERS TO AVOID THE DANGER OF CARBON MONOXIDE POISONING CAUSED BY EXHAUST GASES FROM RUNNING ENGINES AND CONTAMINATED HOT AIR FROM DEFECTIVE

MAINTENANCE FACILITIES

The availability of maintenance facilities can be critical to the maintenance mission. Without some type of permanent or temporary shelter, even routine maintenance can become extremely difficult.

Buildings and Shelters

Heated buildings or shelters are necessary for cold weather maintenance. Proper and satisfactory servicing is difficult unless personnel are working in reasonably comfortable temperatures. Maintenance of many components requires careful and precise servicing. Without the use of heaters, the increase in maintenance man-hours is from 25 percent to 200 percent above normal.

When buildings are not available, maintenance tents are a temporary expedient. If possible, tents should have wood flooring and be heated by portable duct heaters or tent stoves.

WARNING

WHEN VEHICLES, GENERATORS, AND POL CONTAINERS ARE BROUGHT INTO WARM STORAGE FROM THE COLD, THE FUEL TANKS/CONTAINERS SHOULD ONLY BE FILLED THREE QUARTERS FULL. IF THIS PROCEDURE IS NOT FOLLOWED, THE EXPANSION OF THE COLD POL PRODUCTS IN THE FUEL CONTAINERS COULD CAUSE SPILLAGE AND CREATE A SERIOUS FIRE HAZARD.

In the absence of buildings or maintenance tents, tarpaulins may be used to create overhead shelter and windbreaks. A framework of poles erected around a vehicle can support the tarpaulin.

Parachutes can also make temporary shelters. The parachute should be deployed over the vehicle, securely staked down at the bottom, and then inflated by the air from a portable duct heater. If parachute shelters are used, extreme care should be taken to avoid the danger of carbon monoxide poisoning by ensuring proper ventilation.

WARNING

PERSONNEL MUST BE CONSTANTLY ON THE ALERT TO DETECT VEHICLE DEFICIENCIES THAT EXPOSE PERSONNEL TO CARBON MONOXIDE POISONING. PASSENGER AND CREW COMPARTMENTS OF WHEELED AND TRACKED CARRIERS MUST BE INSPECTED AND TESTED IN ACCORDANCE WITH (IAW) TECHNICAL BULLETIN (TB) MED 269 AT REGULAR INTERVALS. THE PURPOSE OF THE INSPECTION AND TEST IS TO DETECT ANY SIGN OF AIR CONTAMINATION FROM EXHAUST GASES CAUSED BY LEAKING GASKETS, IMPROPER EXHAUST INSTALLATIONS, CRACKED EXHAUST PIPES, DEFECTIVE PERSONNEL HEATERS, AND AUXILIARY GENERATORS. WHEN VEHICLES ARE IDLING, ALLOW FOR FRESH AIR ACCESS TO PREVENT CARBON MONOXIDE HAZARD.

Lighting Equipment

Daylight can be scarce in cold climates. Lighting equipment must be available to furnish adequate illumination for maintenance services. Lights with ample cable extensions, attachment plugs, connectors, and spare bulbs are essential.

Maintenance Personnel, Tools, and Equipment

More mechanics are needed to maintain equipment in cold weather operations (Figure 1-3). At a minimum, a highly organized, more intensive effort is required of mechanics. Providing heated buildings or shelters for maintenance of materiel increases work efficiency and morale.

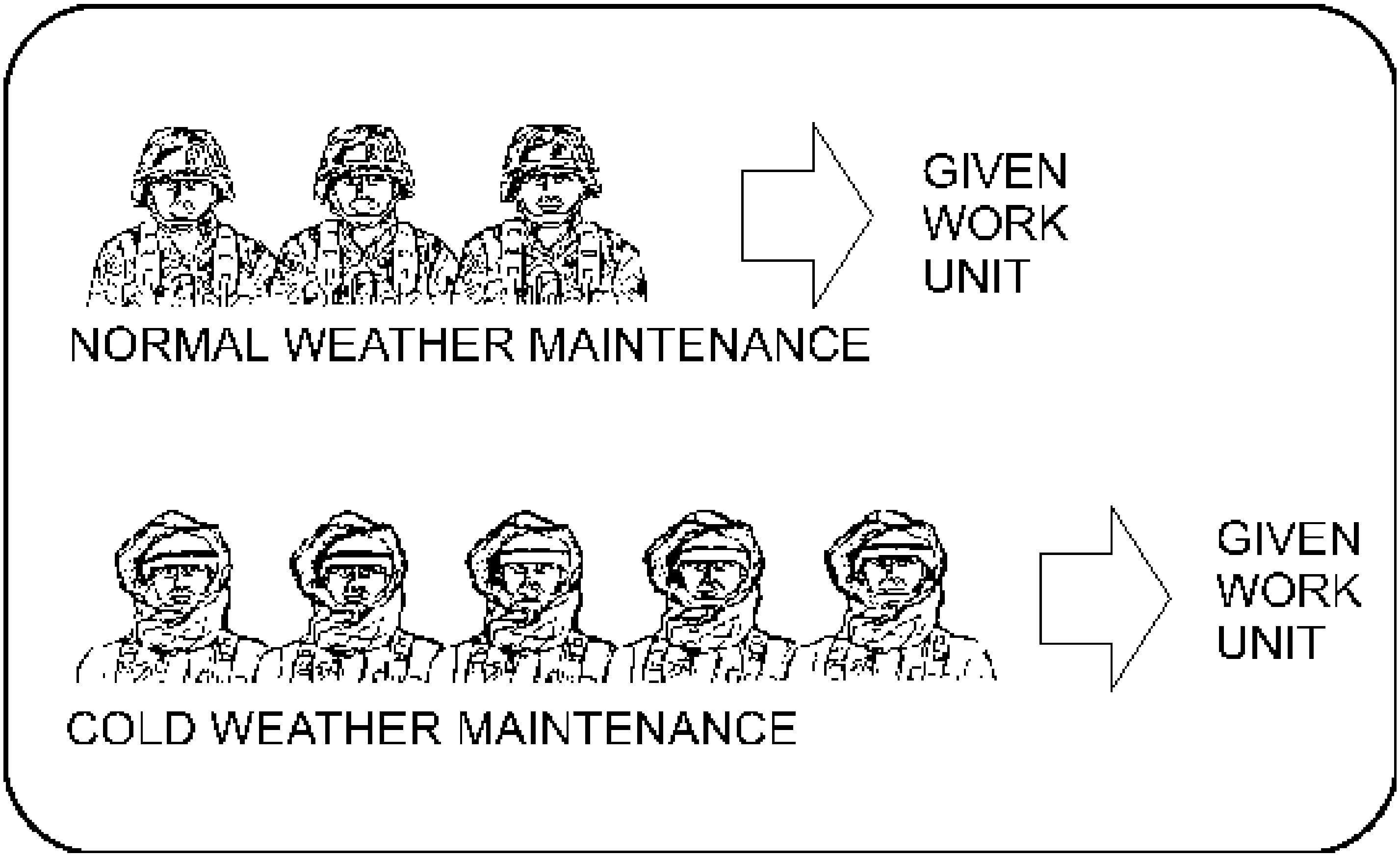


Figure 1-3. Normal vs cold weather maintenance

An added supply of battery chargers must be available to meet the heavy requirements for battery maintenance in sub-zero temperatures. Soldiers must check battery charges using hydrometers and testers.

Handwear may become saturated with fluids when soldiers perform maintenance on fuel and cooling systems. Saturation reduces the insulating value of the handwear, causing cold injuries. Soldiers should carry extra handwear when performing maintenance under arctic winter conditions.

Personnel should avoid leaning on cold-soaked equipment (equipment that has been standing in sub-zero temperatures for an extended period) or kneeling and lying on the ground. Rapid body cooling caused by heat transfer to the equipment or ground may result in cold injury.

Mechanics should place insulating material--such as fiber packing material, corrugated cardboard, rags, or tarpaulins--between themselves and cold-soaked equipment.

When performing maintenance under arctic winter conditions, a box or pan should be used to hold small parts. A tarpaulin should be placed under each vehicle to catch parts that may be dropped. This prevents the parts from becoming lost in the snow (Figure 1-4).

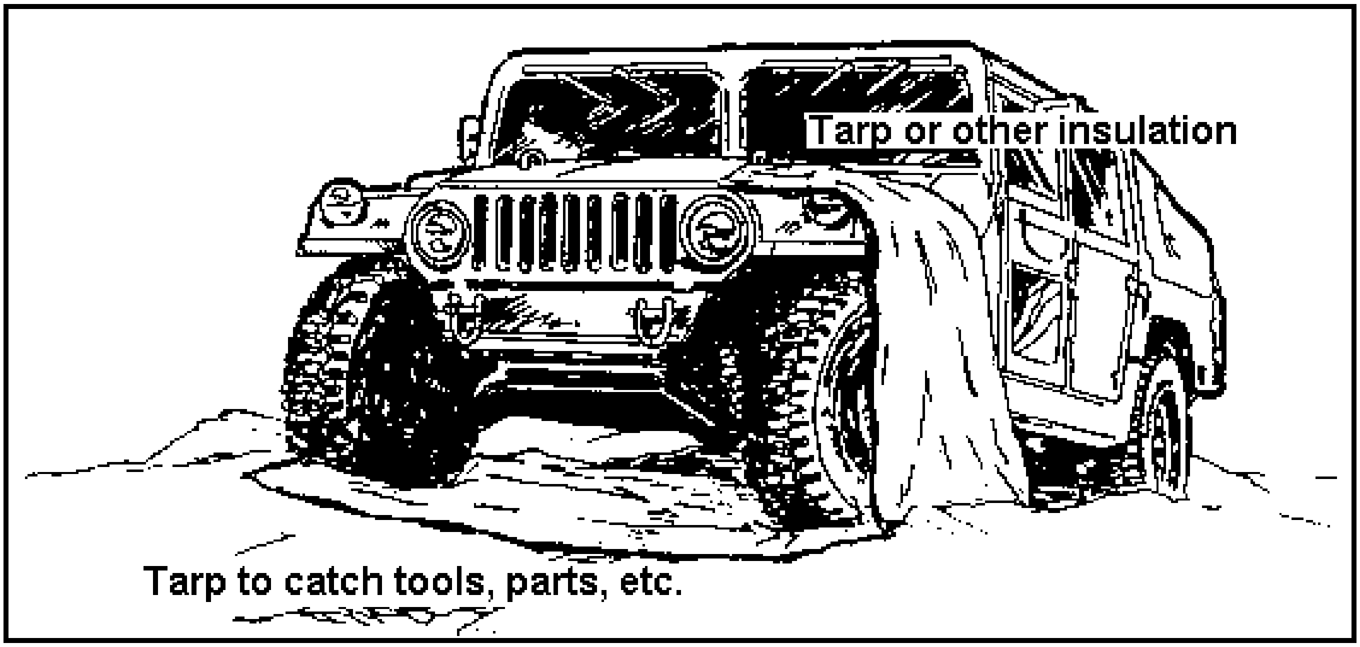


Figure 1-4. Tarps used to protect from cold and to catch dropped parts

EQUIPMENT RECOVERY

Vehicle recovery in cold, snowy conditions can be extremely dangerous. Every precaution must be taken to maintain soldier safety and ensure equipment is functioning properly.

Winches

When using the winch, operate the vehicle engine at a reasonable speed IAW the operator’s manual. High engine speeds are likely to damage the winch mechanism. Use a snatch block whenever possible to reduce the load on the winch.

Operation

Read all caution plates and estimate a 25-percent reduction in capacity when determining load. EXAMPLE: If capacity of the winch is specified as 5,000 pounds on “Winch Caution Plate,” lower the rated capacity for cold weather operations by 25 percent, making capacity 3,750 pounds. This safety factor is essential to prevent damage to the winch.

Preparation for Operation

In preparing a winch for operation, the following steps should be taken:

- Remove mud, dirt, and rust from exterior of winch.
- Inspect cable for rust and apply lubricating oil (PL-S).
- Flush and clean gear housing, and fill to level with recommended seasonal gear oil (GO75W).
- Inspect safety brake for satisfactory operation.
- Check drum brake and adjust if necessary.
- Check for iced bleeder and selector valves, controls and linkage, and winch cable sheaves.

Recovery in Cold Weather

A cold-soaked/inoperable vehicle can present a maintenance challenge. Vehicle recovery is often extremely difficult due to reduced mechanical capacity, ice, snow, and limited approach routes. Exercise care when towing cold-soaked vehicles. Drive trains may have to be disconnected to prevent further damage.

Section IV
Antifreeze, Fuels, Hydraulic Fluids, and Lubricants

ANTIFREEZE

The proper antifreeze materials are critical for cold operations. Antifreeze materials specified for protection of liquid-cooling systems are listed in Appendix A. Units can also consult DLA's publication (see DLA publication in references) for environmentally preferred antifreeze substitutes.

FUELS

Arctic fuels for gasoline or diesel engines are selected to obtain the proper atomization necessary for a combustible fuel-air mixture. These fuels are listed in Appendix A.

HYDRAULIC FLUIDS

Hydraulic fluids must be able to work in cold conditions. Hydraulic fluids specified for hydraulic systems, recoil mechanisms, and equilibrates are listed in Appendix A.

LUBRICANTS

Lubrication required for Army equipment is specified in the LO or TM pertinent to the equipment. LOs are based on three anticipated ranges: above 32° F, from +40 to -10 ° F, and from 0 to -65 ° F.

NOTE: Oil, engine, arctic (OEA), is a synthetic SAE OW-20 lubricant intended for temperature range 40 ° F to -65 ° F for engine systems and 120 ° F to -65° F for transmission and hydraulic systems. This lubricant is approved for use in engines, power steering systems, and both automatic and standard transmissions. Although OEA can be used in most automatic transmissions, it is necessary to consult the LO prior to use. The use of OEA may void the warranty in some transmission applications.

MATERIALS

The materials normally required to prepare equipment for operation in cold weather are listed in Appendix B. These items are listed in Department of Defense (DOD) Federal Supply Catalogs (FSC), FSC Groups 68 and 92. Consult these catalogs when requisitioning. Other items--with specification numbers, unit of issue, stock numbers, and issuing services--are listed herein for requisition through supply channels.

LUBRICATION ORDERS

The provisions of Department of the Army (DA) LOs are mandatory and will be adhered to at all times, unless DA authorizes deviation.

Increased service scheduling from that specified on LOs is necessary to compensate for cold conditions that destroy the protective qualities of the lubricant. The incomplete combustion of fuels in a cold engine, and the piston rings not sealing tightly until the engine reaches operating temperatures, causes rapid fuel dilution of the oil. The commander may extend intervals during inactive periods, provided adequate preservation continues. During prolonged periods of extreme cold weather, it may be necessary to take oil samples more frequently for equipment registered in the Army Oil Analysis Program (AOAP). This precaution ensures the protection provided by the lubricating oils is adequate.

Military symbols for petroleum and related products indicated in the "KEY" on LOs are standardized in Military Standard (MIL-STD) 290. To identify the contents, container markings for these items include the North Atlantic

Treaty Organization (NATO) and military symbols, the national stock number (NSN), and specification nomenclature.

Contaminated petroleum products and coolants must be disposed of in an environmentally safe manner IAW US and HN laws and regulations and unit SOPs. Units must identify US and HN requirements in advance.

Section V
Batteries

One of the greatest hindrances to successful military operations in a winter environment is the effect of cold on batteries.

VEHICLE BATTERIES

The storage battery's available energy decreases sharply when temperatures fall. Power requirements for starting an engine increase when the battery is least capable of delivering power. Current delivered at 15 ° F is only 50 percent of that produced at normal temperatures. The amount delivered at -30 ° F is only a little over 10 percent of that produced at room temperature (Figure 1-5).

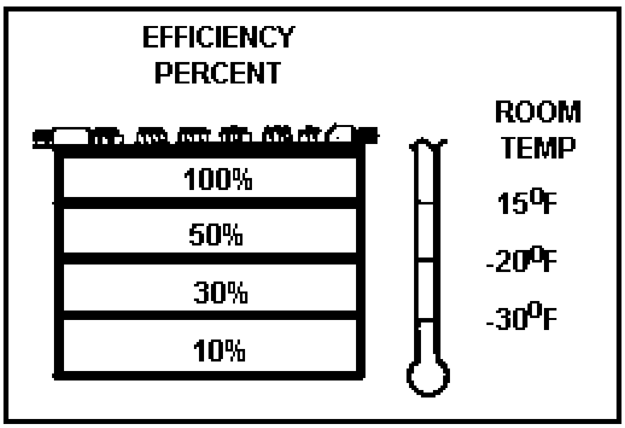


Figure 1-5. Battery efficiency at varying temperatures

At -40 ° F and below, the available current is practically zero. A fully charged battery does not freeze in extreme cold climates, but a battery with specific gravity 1.100 freezes at 10° F. It is essential to keep batteries fully charged.

Frozen batteries rupture and break internally and externally. Table 1-1 shows freezing points of batteries at various specific gravities. Unless a storage battery is warmed to about 35° F, it does not receive an adequate charge from the generator. In constant cold weather, storage batteries should be tested for state of charge every three days. Recharge batteries if the specific gravity is less that 1.1250.

Specific Gravity of Electrolyte (Corrected to 80 ° F)	Freezing Points of Electrolyte (° F)
1.280	-90
1.250	-62
1.200	-16
1.150	5
1.100	19

1.000	32

Table 1-1. Freezing points of batteries at various specific gravities

If the vehicle is equipped with a battery preheater, it should be used IAW the operator's TM. If the vehicle does not have a preheater, an insulated battery box can help maintain specific gravity at higher levels for longer periods. Batteries should be filled with 1.280 specific gravity electrolyte, not the tropical electrolyte of 1.250. Deployment of tactical vehicles from a hot to a cold region requires a change in electrolyte for maximum battery effectiveness.

For more information on operations and maintenance of lead-acid storage batteries, refer to TM 9-6140-200-14.

CAUTION

BATTERIES PRODUCE HYDROGEN GAS. HYDROGEN GAS CAN CAUSE A BATTERY CASING TO EXPLODE DUE TO BLOCKAGE OF THE BATTERY VENT BY ICE. SEE FIGURE 1-6 FOR PROPER JUMP-STARTING PROCEDURE.

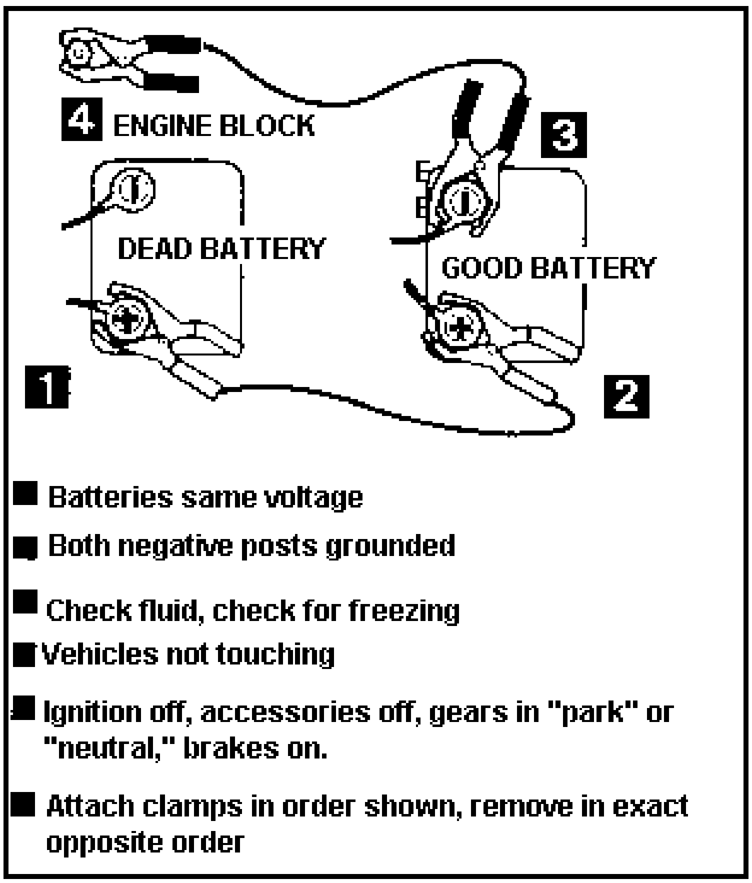


Figure 1-6. Proper jump-start procedure

SMALL EQUIPMENT BATTERIES

For small equipment, alkaline batteries are far superior to carbon batteries. For example, flashlights (essential items in regions with long periods of darkness) using size D batteries should use the BA-3030/U rather than the BA-30. These same batteries should be used in artillery, mortar, and tank night-aiming post lights along with tactical telephones such as the TA-312/PT (see TB 43-PS-491. The Preventive Maintenance Monthly, October 1993, for more information).

NICKEL-CADMIUM BATTERIES

When properly maintained, the nickel-cadmium (NICAD) batteries used in some Army equipment (such as range finders, some night vision sights, and ground surveillance radars) are very effective low-temperature power sources.

To get maximum effectiveness when charging NICAD batteries, one must destroy the charging memory characteristic of the battery. For example, if a NICAD battery is continually called upon to deliver an average of only 25 percent of its capacity before it is recharged, it will eventually "memorize" this fact and become incapable of supplying the remaining 70 percent capacity. Operators must discharge NICAD batteries down to their lowest operating levels, then recharge them fully, then discharge them again to their lowest operating levels, then once again recharge them fully to destroy the "memory".

The preferred cold weather batteries are lithium-based, but precautions must be taken in their storage and disposal. Mercury batteries should not be used below 0 ° F.

LITHIUM SULFUR DIOXIDE BATTERIES

The lithium sulfur dioxide battery is recommended for use in the AN/PRC-77 and single-channel ground and airborne radio subsystem (SINCGARS) radio sets when used in extreme cold weather areas. The lithium battery has unique characteristics that provide improved operational capabilities and extended battery life. Lithium sulfur dioxide batteries require special handling. Turn-in instructions must be followed carefully IAW host nation, federal, state, and local environmental laws and regulations.

Section VI
Winterization Equipment

Special equipment is provided for a vehicle when protection against cold weather is required. This equipment is issued in specific kits. Geographic location and ambient temperatures dictate the use of winterization equipment as per Supply Bulletin (SB) 9-16.

Where the temperature falls only a few degrees below freezing for a short period, only ordinary preparations are needed; for example, changing engine oil to a lighter grade and adding antifreeze to the cooling system.

For anticipated temperatures of -25 ° F or lower, personnel heater kits and hardtop closures are installed. Operations will not be attempted without winterization kits in areas where temperatures from -25 ° F to -65 ° F are likely. Since some winterization kits require use at temperatures warmer than -25 ° F, consult the TM for the correct starting procedure.

PERSONNEL HEATERS

Generally, vehicles using gasoline as fuel provide ample heat through personnel hot-water heaters until the ambient temperature drops below -25 ° F. Below this temperature, fuel-burning heaters are normally used to provide more heat. Personnel heaters in military vehicles are only required to maintain a temperature of 41 ° F IAW MIL-STD-1472C.

Present personnel heaters have pot-type vaporizing burners. This means the pot must get hot enough to vaporize fuel at -65 ° F. Fuel carbonizes if the combustion chambers do not get hot enough. This accelerates heater failure by carbonizing the wick, igniter, burner, related burner components, or heat exchanger. Contaminated fuel can block the flow of fuel to the heater burner causing low heat output and/or numerous heater stoppages. This blockage also can lead to premature igniter failure due to excessive start attempts. Fuel burning heaters are generally unreliable because of--

- Contaminated fuel.
- Low voltage.
- Inexperienced operators and mechanics.

- Design characteristics of the heaters.

WARNING

PERSONNEL AND CREW CAB HEATERS SHOULD BE SHUT OFF AT LEAST 20 MINUTES PRIOR TO ENTERING ANY SHELTER. THIS PROCEDURE WILL HELP PREVENT THE FIRE HAZARDS CREATED FROM ACCIDENTAL PUMPING OF FUEL ON BUILDING FLOORS AND EMISSION OF GASOLINE VAPORS FROM HOT HEATER COMPONENTS IN THE EVENT OF FAULTY HEATER COMPONENTS.

POWER PLANT HEATERS

The present generation of power plant heaters are water coolant type, thermostatically controlled to heat the engine block and the water pillow below the batteries. These heaters are multifuel, pot-type burners. Because they are not used often, problems surrounding these heaters include:

- Low voltage.
- Contaminated fuel.
- Inexperienced operators and mechanics.
- Inattentive operators and mechanics.

PORTABLE FUEL-BURNING HEATERS

In some geographical locations, DA has approved the use of the NATO standard heater because of its improved arctic operating capability and lower maintenance requirements.

The swingfire heater (Figure 1-7) is a pulse jet engine that burns gasoline with less carbon buildup. It uses no external power in the run cycle and needs only 6 amperes at 24 volts for starting.

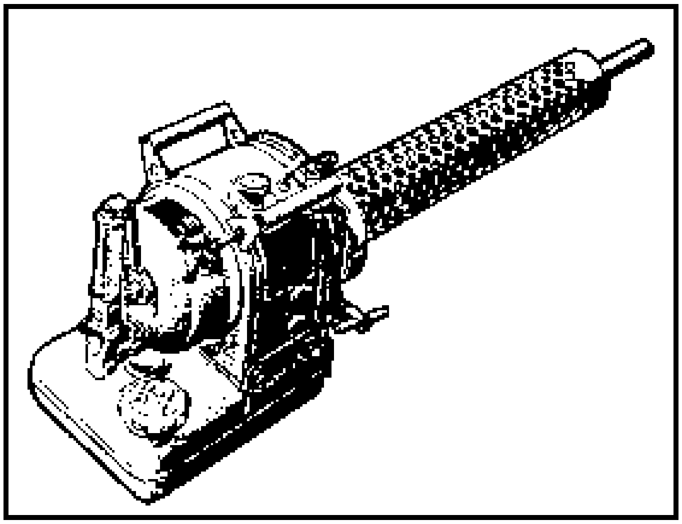


Figure 1-7. Swingfire heater

The heater can be used in 12 various exchangers, making it a versatile and useful tool. An operator can externally heat gear boxes, drive trains, transmissions, and oil pans on vehicles prior to operations.

HARDTOP CLOSURE KIT

A hardtop closure kit is provided for some vehicles. It must be added to protect the driver and assistant driver where colder temperatures are expected. All-around vision is provided by a glass window on each side and to the rear.

QUICK HEAT SYSTEM

Quick heat is a technique that allows quick warmup and reliable starting when vehicle temperatures drop as low as the existing ambient temperature. Just prior to vehicle operation, heat is applied to the engine, batteries, and components, raising their temperatures enough to ensure starting.

The time from initiating quick heat to achieving reliable starting temperatures can vary from a few minutes to one hour. The military objective is to achieve reliable starting within a maximum of one hour regardless of ambient temperature.

STANDBY HEAT SYSTEM

The standby heat concept does not allow vehicle components to fall below a certain minimum temperature. For this to happen, the fuel-burning heater is continuously operated during the standby period. Continuous operation maintains engine and battery electrolyte temperatures at levels that provide adequate cranking and battery recharging potential.

The standby system includes an engine coolant heater, hoses, control valves, fuel pump, battery heat exchanger (commonly known as a battery pad), and miscellaneous hardware. This system is not designed to start a vehicle engine after it has been cold-soaked for an extended period in extreme sub-zero temperatures (-25 ° F to -65 ° F). However, in an emergency, the standby system can assist in getting an engine start if adequate time and auxiliary power are available.

AUXILIARY POWER (SLAVE) RECEPTACLE

The auxiliary power (slave) receptacle is an electrical outlet located at a readily accessible place on the vehicle. It receives current from other tracked or wheeled vehicles. This provides direct boosting of the cold vehicle current when starting an engine in cold weather. See Figure 1-8 for sample auxiliary power receptacles.

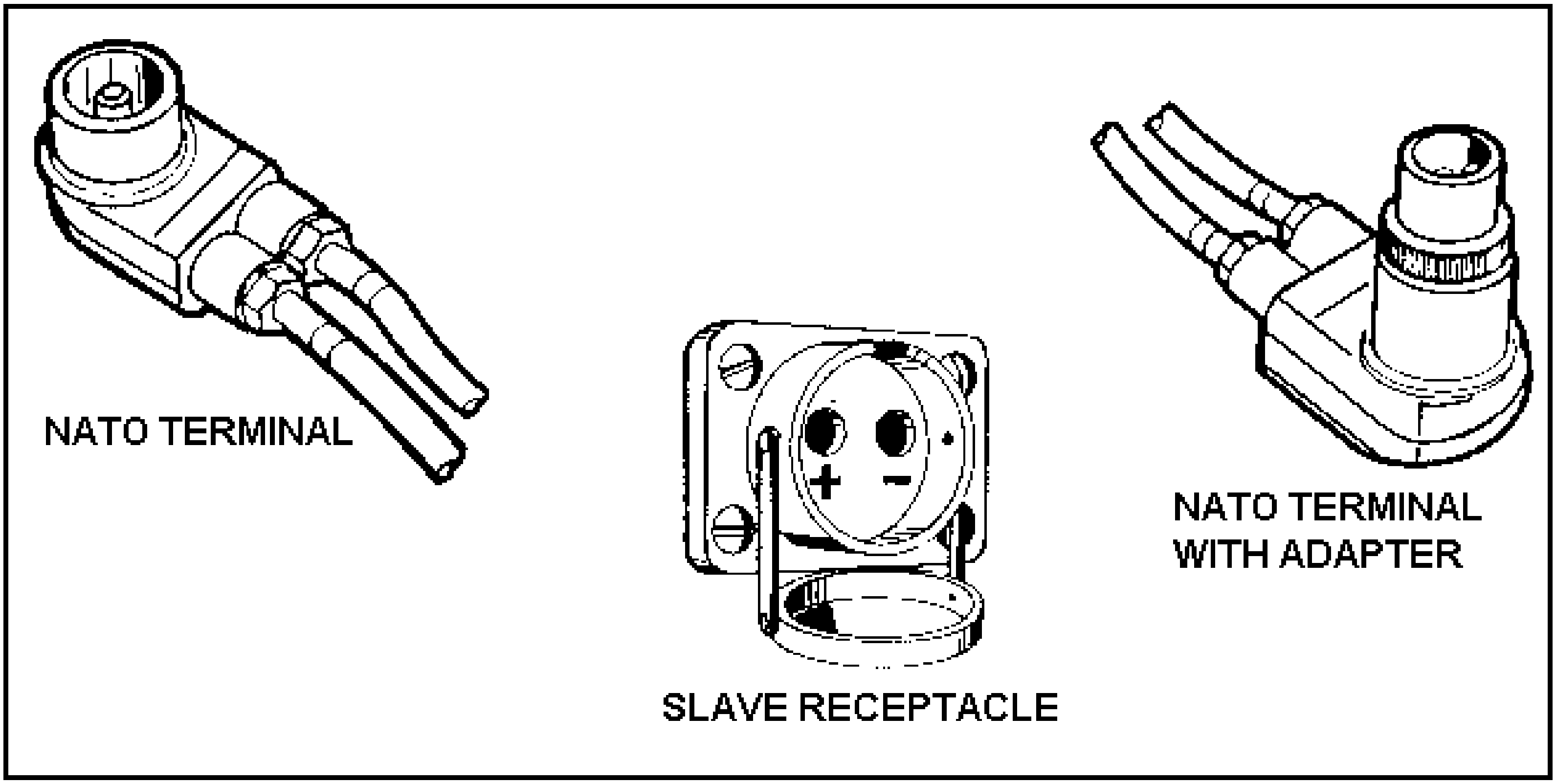


Figure 1-8. Auxiliary power (slave) receptacle and terminals

Chapter 2
Preparation for Operation

Section I
Chassis and Body Components

SPECIAL CONSIDERATIONS

As described in Chapter 1, cold weather can cause problems with equipment not normally encountered during operations in temperate conditions. This chapter contains added information to consider when conducting vehicle/equipment before-operations PMCS.

BEFORE-OPERATIONS CHECKS

Ensure that added care is taken during before-operations checks. Never touch cold metal parts with your bare hands. Brush snow or wipe water from the tops of fuel and lube containers, spouts, and plugs before using to prevent contamination.

Wheel Bearings

Wheel bearings should be checked for looseness and proper adjustment. No change of lubricants is required, since all wheel bearings are serviced for year-round operations with grease, automotive and artillery (GAA), which has a temperature range of from -65 ° F to +225° F.

Hydraulic Brakes

Check the reservoir of hydraulic brakes for proper fluid level. No seasonal change of fluid for hydraulic brake systems is required. Brake fluid, silicone (BFS), should be retained in the system for all-season use.

Air Brakes

Frozen moisture in the air brake system seriously affects operation. Brake lines, air brake filters, brake chambers, pushrods, valves, and seals are subject to more defects and failure in cold. Condensation between brake shoes and brake drums may freeze, making it impossible for the vehicle to move. When this happens, use portable heating equipment to thaw the brake shoes from the drums. Ensure the alcohol evaporator kit, if part of the system, is functioning. Check brake lines, brake chambers, relay valves, pushrods, seals, and slack adjusters. Check air compressor, unloader valve, and governor for good condition and satisfactory operation. With the air pressure at the governed maximum and the brakes applied, stop the engine. There should not be a noticeable drop in pressure within one minute. Drain reservoirs immediately after operation, and close drain cocks immediately after draining to prevent freezing in the open position. In the morning, build up pressure before moving the vehicle. Make certain that the alcohol evaporator jar is filled with alcohol or the desiccant cartridge is serviceable. During scheduled service, clean brake pads. Remove oil and grease from units to avoid hardening and splitting. This helps to ensure a good air seal under pressure.

The new fleet of Army vehicles--including the family of medium tactical vehicles (FMTV), heavy equipment transporter (HET), palletized load system (PLS), and high mobility multi-purpose wheeled vehicle (HMMWV) heavy variant--have central tire inflation systems (CTIS) that operate off an air compressor. It is not unusual for air valves to freeze resulting in locked brakes or flat tires.

CAUTION DRAIN WATER FROM AIR FILTERS AND RESERVOIRS AFTER EVERY EIGHT HOURS OF CONTINUOUS OPERATION.

Steering Gear

Improper lubricant congeals, thereby making steering difficult or impossible. Hydraulic power steering reservoirs should be filled with hydraulic fluid, petroleum base, (OHT), or OEA, and not Dextron II. Examine arms, tie rods, drag links, seals and boots, pitman arm, gear column, and wheel for good condition and secure mounting.

Shock Absorbers

Shock absorber fluid congeals in sub-zero temperatures, resulting in a hard-riding vehicle or broken shock absorbers. Make certain shock absorber bodies are securely mounted to the frame. Replace shock absorbers if they are leaking or if their action is unsatisfactory. To prevent damage to the shock absorber, the operating rod, or the mounting brackets during extreme cold, operate the vehicle slowly for the first three to five miles. This allow the oil in the shocks to warm up.

Track and Suspension

Ice and snow adhere to tracks, hindering operation. Cold contracts metals and makes rubber brittle. When operating in snow-covered and icy terrain, remove track pads as the commander directs, and/or employ traction aids (such as reversing every third track center guide). Remove dirt and ice and inspect for good condition and proper lubrication. Check track adjustment. Do not adjust tracks too tightly in a warm shelter, since they contract and break easily in temperatures of -40° F and below. Adjust track so that the slack is 50 percent greater than that specified for normal operation in the vehicle TM (Figure 2-1). Another method is to allow the vehicle and track to cool to outside temperature before making adjustments.

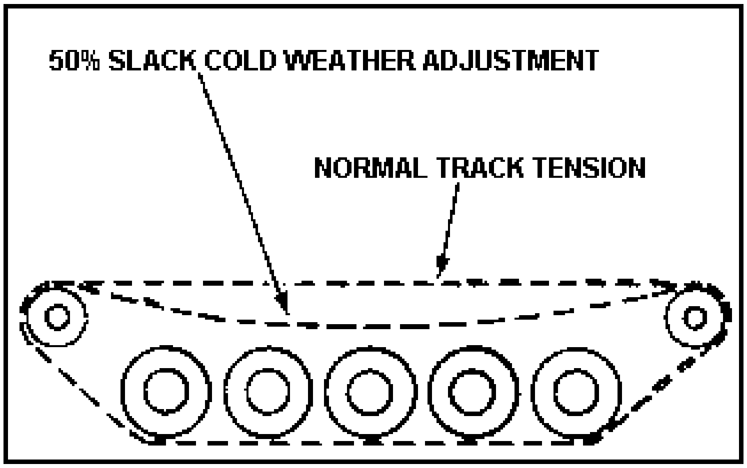


Figure 2-1. Cold weather adjustment

For the M-1 series tanks with T158 track, special ice cleats are available. For best performance, every fifth track shoe should receive a set of cleats. A total of 64 cleats per vehicle (32 per side) and 64 new self-locking nuts are needed. These cleats are for the T158 track only; they will not work with the T156 track. Also, cleats are not yet available for the T156 track.

Tires

At -50° F tires become rigid enough to support a load at 0 pressure without apparent deflation. Sidewalls become brittle and crack. Valve stems on tubes can break if the tires are under-inflated and the tires rotate on their rims. Check valve stems and tighten cores. Replace cores if rubber seals are brittle or show wear. Examine tire casings for cuts, bruises, or breaks. Caps must be installed on all valve stems. Increase tire pressure about 10 PSI, as shown in the TM, to compensate for the cold effects on tires for overnight or extended parking. Tires should be deflated to proper pressure before operations.

Springs

Springs become brittle and break easily at low temperatures. Clips, leaves, U-bolts, hangers, and shackles must be in good condition and correctly and securely mounted. Spring leaves should not be broken or shifted out of their correct position. Tighten all spring U-bolts, assembly, and mounting bolts securely.

Cab Closures

Cab closures protect soldiers from sub-zero temperatures and wind. Ensure cab closure mountings are secure and in good condition. Replace broken windows, and ensure that closures are tight-fitting.

Fire Extinguishers

Winterize carbon dioxide fire extinguishers IAW the appropriate fire extinguisher TB.

Section II
Power Train

ENGINES

Using ordinary engine oil increases the fluid friction on cylinder walls and bearings to the extent that it may not be possible to crank the engine with an ordinary storage battery. Using lubricating oil (OEA) prescribed for cold weather operation by the LO will prevent this condition during cold starts.

NOTE: OEA engine oil is listed as OES in some older LOs. Equipment being prepared for future cold weather operation must use arctic-type lubricants, even if considerable operation in warmer climates is involved prior to cold weather operation. This eliminates disassembly of components for lubrication when low temperatures are encountered.

General procedures for preparing the lubrication system for cold weather are as follows:

- If possible, store lubricating oils and grease in a warm place. Lubricants are much easier to pour or apply if they are warm. Prevent snow or moisture from entering the crankcase when lubricants are added. Use only newly opened cans of oil to eliminate the possibility of using contaminated oil.
- Keep lubricating equipment free of moisture, snow, ice, or dirt to avoid contamination.
- Inspect the engine oil pan and gasket for leaks.
- Drain the engine lubrication system when warm. Replace the oil filter element. When the system is clean, fill with lubrication oil (OEA) in the amount specified in the operator TM or LO. Run the engine for 10 minutes and check for oil leaks. Stop the engine and wait 1 to 5 minutes before checking the oil level. This reading will be approximate only and should be between the ADD and FULL marks. This is due to the many oil passages of the engine.
- When a temporary rise in temperature occurs, drivers should not change or vary their operation of the vehicle. Lubricant levels and points, however, should be closely observed, and proper steps taken to replenish lubricants. Instructions in LOs apply when a definite change to higher environmental temperatures is expected, such as a change of seasons (Table 2-1).

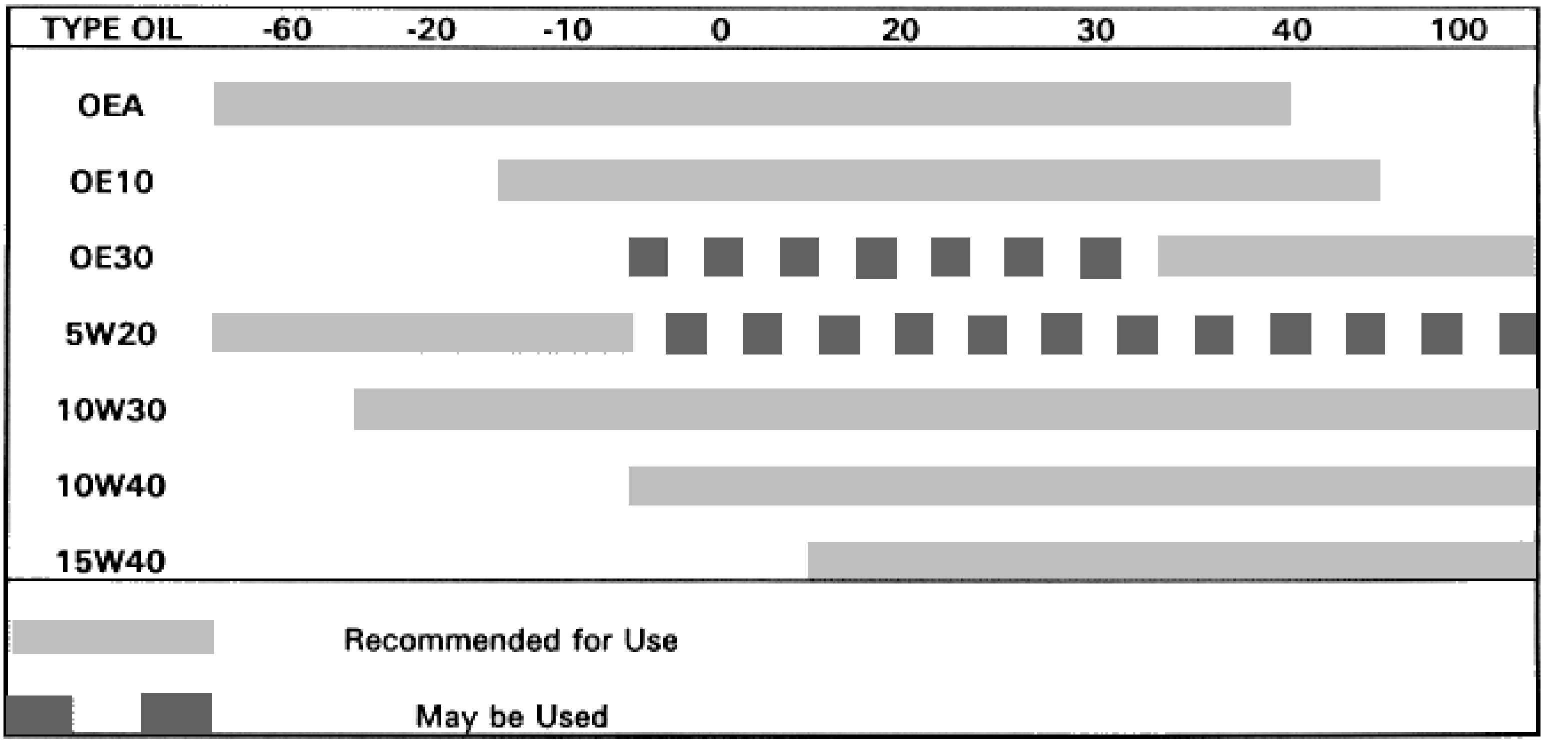


Table 2-1. Engine recommended temperature range (F)

NOTE: When engine oil (SAE 10 or OE/HDO10) is prescribed for gear cases, drain and fill with lubricating oil (OEA) or gear oil (G075) as prescribed by LO.

TRANSMISSIONS/TRANSFER CASES/DIFFERENTIALS/FINAL DRIVES

All transmissions should be drained, flushed, and completely refilled with lubricant prescribed in the LO. Some LOs require the use of Dextron III in the transmission. In cases where the prescribed lubrication is not readily available in the supply system, units may have to local-purchase the required lubrication.

COOLING SYSTEMS

Operators need to constantly check the engine's operating temperature. A cooling system should be able to reach 160 ° to 180° F no matter how cold it is outside.

Liquid Cooling System

For temperatures of 32° F and colder, cooling systems are protected with antifreeze compound, ethylene-glycol, inhibited, heavy-duty single package (MIL-A-46153).

Cooling systems containing no ethylene-glycol-water or arctic antifreeze solutions should be drained and flushed, if required, before the onset of freezing temperatures. Soldiers should then add the correct antifreeze solution. Propylene glycol-based antifreezes available commercially should not be mixed with ethylene glycol-based antifreeze.

CAUTION IT IS ESSENTIAL THAT ANTIFREEZE COMPOUNDS BE KEPT CLEAN. USE ONLY CONTAINERS AND WATER THAT ARE FREE FROM DIRT, RUST, AND OIL.

Procedures

When drain plugs have been removed, or drain cocks opened to remove liquid from the cooling system of any equipment, the drains should be inspected to ensure none are obstructed. If any drain hose has become obstructed by foreign material, use a soft wire to clear the obstruction and permit complete drainage.

Before adding antifreeze compound, the cooling system must be clean and completely rust-free. The system should be cleaned with cleaning compound IAW TB 750-651.

Inspect/replace all deteriorated cooling system hoses and radiator cap gaskets. Inspect and tighten hose clamps, plugs, and petcocks. Repair radiator leaks before adding antifreeze compound. Correct any exhaust gas or air leakage into the cooling system.

If there are signs of coolant leaks at the cylinder head, check cylinder head nuts for torque as specified in the applicable TM. Replace the cylinder head gasket if necessary. On some vehicles, the torquing of head bolts and replacement of head gaskets is the responsibility of direct support (DS) or general support (GS) maintenance. Check the applicable TM.

If the engine does not reach normal operating temperature, inspect the thermostat to see that it closes completely. Look for evidence of sticking in open or closed position. Replace the thermostat if it does not open or close completely or does not function freely. Where average temperatures are between 0° and -65° F, a +190° to +195° thermostat should be installed in cooling systems that use a 150° F thermostat for normal operations.

If premixed antifreeze is not available, use Table 2-2 as a guide for mixing. The antifreeze should then be tested with a hydrometer or the view-type tester (Figure 2-2).

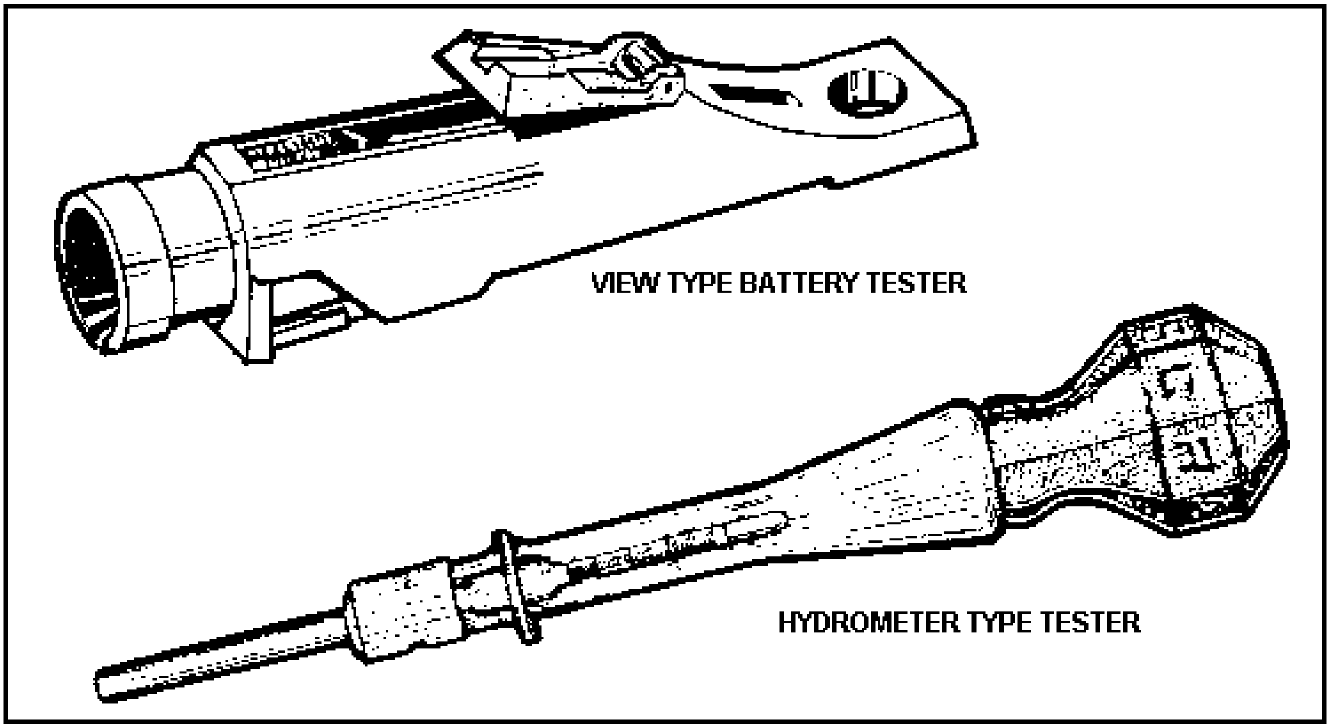


Figure 2-2. Antifreeze testing devices

The antifreeze tag should read: THIS COOLING SYSTEM IS FILLED WITH ETHYLENE-GLYCOL ANTIFREEZE SOLUTION. PROTECTS TO -40° F (or whatever the correct protection temperature should be); or, THIS COOLING SYSTEM IS FILLED WITH ARCTIC-TYPE ANTIFREEZE. PROTECTS TO -90° F. CAUTION: DO NOT ADD WATER OR ANY OTHER TYPE OF ANTIFREEZE.

Record the condition of the cooling system and the degree of freeze protection in maintenance records.

PROTECTION TABLE

Cooling System Capacity in Quarts	ANTI-FREEZE COOLANT REQUIRED IN QUARTS For Protection to temperature Points °F Shown Below											
	2	3	4	5	6	7	8	9	10	11	12	13
5	-12°	-62°										
6	0°	-34°										
7	6°	-17°	-54°									
8	10°	-7°	-34°	-69°								
9		0°	-21°	-50°								
10		4°	-12°	-34°	-62°							
11		8°	-6°	-23°	-47°							
12		10°	-0°	-15°	-34°	-57°						
13			3°	-9°	-25°	-45°	-66°					
14			6°	-5°	-17°	-34°	-54°					
15			8°	0°	-12°	-26°	-43°	-62°				
16			10°	2°	-7°	-19°	-34°	-52°				
17				5°	-4°	-14°	-27°	-42°	-58°			
18				7°	0°	-10°	-21°	-34°	-50°	-65°		
19				9°	2°	-7°	-16°	-28°	-42°	-56°		
20				10°	4°	-3°	-12°	-22°	-34°	-48°	-62°	
21					6°	0°	-9°	-17°	-28°	-41°	-54°	-68°
22					8°	2°	-6°	-14°	-23°	-34°	-47°	-59°
23					9°	4°	-3°	-10°	-19°	-29°	-40°	-52°
24					10°	5°	0°	-7°	-15°	-24°	-34°	-46°

Guide for Preparation of Ethylene-Glycol Antifreeze Solutions

Do not use without some water; 68% concentration gives maximum protection. Use at least 25% concentration for protection against rust and corrosion.

Table 2-2. Antifreeze mixing guide

Guide for Preparation of Ethylene-Glycol Antifreeze Solutions

Do not use without some water; 68% concentration gives maximum protection. Use at least 25% concentration for protection against rust and corrosion.

Air-cooled System

Since an air-cooled system does not use a liquid coolant, it is often assumed that air alone acts as the cooling medium. This is not true. The lubrication system also helps in cooling the engine and transmission. It often includes oil pumps that circulate the oil between the engine and the coolers and between the transmission and the coolers, removing heat from the engine and transmission. Some engine cooling also results from the fuel contacting metal parts prior to combustion.

The effects of cold on an air-cooled system are basically the same as the effects on the engine lubrication system.

FUEL SYSTEMS

For a satisfactory start, engine fuel must be volatile enough to produce a combustible mixture with air. Atomization, which increases the rate of vaporization of the fuel to produce a combustible mixture, is adversely affected by low temperatures. The maximum amount of vaporization obtainable with the regular grade of motor fuel--without the use of a primer or application of heat to the mixture--provides only enough vaporized fuel for starting at a minimum temperature of 0° F.

Diesel engines are particularly difficult to start in cold weather. Many fuels, such as DF-2, contain waxes that congeal at temperatures below 0° F. If this occurs, the filter will clog and the fuel will not flow. Diesel fuel, arctic (DFA) grade, does not contain as much wax and performs well in cold regions. JP-8 is a good low temperature diesel fuel; however, check the TM to make sure it can be used without excessive fuel injector pump wear.

Water accumulates in tanks, drums, containers, fuel pumps, and carburetors because water from the air condenses. At low temperatures, this water forms ice crystals that clog fuel lines, fuel filters, fuel pumps, injector nozzles, and carburetor jets.

NOTE: Fuel filters should be cleaned or changed at frequent intervals. Conditions may require daily cleaning under field use. Take special care to ensure 5-gallon fuel cans used in refueling are clean and serviceable. Fuel nozzles should be complete with filters.

Follow the instructions listed below to prepare fuel systems for operation in cold weather. Drain fuel systems and refill with arctic-grade fuel. Add inhibitor, icing, fuel systems (ethylene glycol monomethyl ether) to diesel fuels and add methanol, technical, to gasoline. Mix additives with the fuel, normally at a ratio of one pint of additive to 40 gallons of fuel, prior to refueling (Table 2-3).

NOTE: Using additive in greater proportions than two pints of additive to 40 gallons of fuel results in poor engine performance and possible engine damage.

Remove and service all engine and air compressor air cleaner elements, including oil-bath type. Clean with dry-cleaning solvent and reinstall. Fill oil-bath type cleaners with OEA. Dry-type air cleaners, both felt and paper, should be cleaned with either low pressure air or soap and water. When soap and water or dry-cleaning solvents are used, air cleaners should be dried thoroughly before reinstallation.

Check for any indication of fuel leaks. Trace all leaks to their source and correct or replace parts.

UNIVERSAL AND SLIP JOINTS

Thoroughly lubricate joints with grease, molybdenum disulfide (GMD). Remove dirt and ice and check for good condition.

FUEL	REQUIRED ADDITIVE	FUEL TEMP RANGE F°
MOGAS	Methanol, Tech.	ALL
DIESEL		
DF2	Ethylene, Glycol, Monomethyl, Ether	Above 25
DF1	Glycol, Monomethyl, Ethylerne, Ether	25 to -25
DFA	Ethylene, Glycol, Monomethyl, Ether	Below -25
JP8	Ethylene, Glycol, Monomethyl, Ether	Below -25

Check for any indications of fuel leaks. Trace all leaks to their source and correct or replace parts as necessary.

Table 2-3. Fuel and additive mixtures

Section III
Electrical System

SPECIAL CONCERNS

The drive mechanisms of starters are extremely susceptible to failure at low temperatures. Grease or dirt on the armature shaft, bendix drive, or other type of mechanical drive prevents gears from meshing properly. It can also cause them to remain in mesh after the engine is started, damaging the starter. An improper lubricant on bushings can congeal and cause the starter to operate poorly by placing an excessive drag on the armature. Solenoid plungers, unless clean and free of oil, bind in switch assembly housings. Oil and grease on brushes or commutator prevent the good contact needed to carry the large amount of current required to crank an engine.

The breaker contact-arm bushing can freeze on its pivot if it is not clean and properly lubricated. This freezing prevents the breaker arm from returning when the cam separates the points. Improper oil or excessive dirt causes automatic advance mechanisms on distributors to become inoperative. Other problems may include--

- Ice caused by condensation coats spark plugs and may prevent starting of engines.
- Oil or dirt on brushes or commutator causes unsteady or low generator output.
- Lubricant congealing in bushings at low temperatures causes electric heater motors to operate poorly.
- Insulation on low and high tension cables cracking. Besides being a safety hazard, this condition can impair overall performance.

SYSTEM PREPARATIONS

The following procedures prepare the electrical system for cold weather operations:

- Storage battery capacity is greatly reduced at low temperatures because the electrolyte is less active. To prevent freezing, operators must keep batteries fully charged. Check specific gravity of the electrolyte to determine the state of charge of the battery.
- To test specific gravity, the visual battery/antifreeze tester is one of the best products available. This tester is designed specifically for rapid and accurate checking of battery charge and permanent antifreeze protection. Only a few drops of electrolyte or coolant are needed for an accurate reading. A separate tester is required for propylene glycol antifreeze compared to ethylene glycol antifreeze.
- To test battery electrolyte, close the plastic cover and put a few drops of the electrolyte onto the measuring surface through opening in cover.
- Point the tester toward a bright light and look into the eyepiece. Read the scale on the left side. The liquid sample divides the scale showing light and dark areas. Read the scale at the dividing area. The tester automatically corrects for temperature.

Another method of checking specific gravity is with a battery hydrometer. The hydrometer uses a float to measure the density of the electrolyte. However, the float only measures the actual density of the solution; it does not take into account the temperature variations that make the electrolyte contract and expand. In cold weather a specific gravity reading must be corrected to a temperature of 80° F. The normal correction for temperature is 4 (0.004) points of specific gravity for each 10° F change in temperature of electrolyte above or below 80° F.

To minimize starting problems in temperatures below 0° F, ensure that batteries are initially filled with electrolyte of 1.280 specific gravity. TM 9-6140-200-14 gives specific information for the mixture of electrolyte. A battery apparently fully charged according to a hydrometer reading (actual reading 1.280) is, in reality, only half charged at -60° F when the specific gravity reading is corrected to 80° F (corrected reading 1.220). A battery should be above 20° F to deliver sufficient current for starting.

If the vehicle is equipped with a battery heater, it must be operated IAW instructions supplied with the winterization kit. If no winterization equipment is installed on the vehicle, the battery can be heated by removing the battery and placing it in a heated room, or by directing hot air on it from a portable heater. (Sufficient time must be allowed to warm battery internally.) Some vehicles, such as the M1 Abrams tank, have exposed batteries that are not heated. These batteries will not fully charge in operation; over time, they will need to be heated and recharged in a maintenance shop to maintain reliable starting.

CAUTION

ADD WATER TO BATTERY ONLY WHEN VEHICLE IS TO BE IMMEDIATELY OPERATED FOR 30 MINUTES OR MORE.

Section IV
Auxiliary Equipment

AIR COMPRESSORS

An air compressor is an engine-driven device used to compress air to predetermined and controlled pressures. It is used in vehicle air-brake, air-hydraulic brake, and central tire inflation systems.

Condensed moisture may freeze within the compressor. Follow after-operation maintenance procedures by draining condensation from air compressor tanks. If the bleed valve is frozen, report it immediately to maintenance personnel. Some 900 series vehicles (M911/977) and the new FMTV 2 1/2- and 5-ton trucks use air driers in the air brake system. These system must be checked for frozen vapors in the drip tube. The same system is also used on the PLS and the HET.

Alcohol evaporators, usually found near the air compressors of cargo trucks and semitrailers, should be filled with alcohol during operations in temperatures of -20° F and below. These evaporators are usually plastic bottles of alcohol included in winterization kits. They are designed to draw water out of the air going into the compressor to prevent freezing. Check the container before, during, and after operations.

Air compressors either have their own lubricating system (self-lubricated) or are lubricated from the engine lubrication system. No further preparation is necessary for the engine-lubricated, air-cooled compressor, provided the engine crankcase has been filled with lubrication oil (OEA).

NOTE: If an oil-bath-type air cleaner is used on a compressor, drain the oil, clean, and fill to proper level.

The cooling system of liquid-cooled air compressors is connected to the cooling system of the vehicle engine. Drain, flush, and clean the compressor cooling system and inspect for leaks. Ensure all connections are in good condition. Tighten cylinder head bolts to correct torque tightness specified in the vehicle TM. The engine coolant system must be adequately protected with antifreeze compound. Inspect the compressor for leaks.

AUXILIARY ENGINES AND GENERATORS

The auxiliary engine and generator are operated when batteries are being charged, when auxiliary electrical equipment is being used, while the main engine is not running, or when the current furnished by the main engine is inadequate for the imposed load.

Preparation for Operation

The auxiliary engine, generator, spark plugs, and magneto should be prepared in a manner similar to the main engine and components. Carefully warm the engine block with a swingfire heater, or with the duct from a portable heater, to assist in starting. Many small engines have a summer/winter air intake diverter which allows warm air to be pulled over the exhaust in winter and directly from the outside in summer. If the engine is so equipped, ensure the diverter is set for winter operation.

NOTE: Some small engines have a low oil pressure shutoff switch to stop the engine in case of low oil pressure. The oil in the engine block must be warmed sufficiently so the cranking revolutions per minute (RPM) can build up enough oil pressure to close the switch so the engine will start.

POWER TAKEOFF ASSEMBLIES

Power takeoff assemblies are usually mounted on the side of the transmission, but are sometimes mounted on the side of the transfer. They provide a means for taking power from the engine to operate a chain-driven winch, a hydraulic pump (for hydraulically-operated winch, dump mechanism, or gasoline delivery to tank), or other various auxiliary power-driven machinery (i.e., earth-boring machine and crane). In cold weather, improper lubricants will solidify, making operation of the power takeoff difficult or impossible.

Preparation for Operation

As the power takeoff operates from the transmission or transfer, the lubricant should be that specified for sub-zero temperatures for these units. Drain the gear cases while warm and fill with prescribed grade of gear lubricant.

Chapter 3
Operating and Maintenance Procedures

Section I
Operating Vehicle Engines in Cold Weather

Once vehicles are started and operations begin, operators must remain aware of the special problems cold weather can cause. This chapter provides added guidance to consider when performing vehicle/equipment during-and after-operations PMCS.

OPERATING AND IDLING

At temperatures below -20° F, operators may have to start vehicle engines periodically to maintain an acceptable state of readiness. However, this should not be done if other means are available, such as power plant heaters, external heat, or indoor parking.

Before commanders authorize periodic starting of engines, they must consider fuel supplies. Also, they must establish starting and shutdown schedules to ensure engines do not run continuously. At temperatures below -25° F, it may require a continuous idle of engines, especially heavy equipment, tracked vehicles, and heavy trucks. Idle speeds, as specified in the appropriate TM, must be followed.

Experience determines starting and shutdown intervals. Factors such as ambient or expected temperatures, vehicle condition, and readiness conditions influence scheduling. The following must also be considered--

- Vehicles should only be cold-started using the procedures outlined in the TM. Carefully read and follow the instructions for operating the vehicle under unusual conditions (cold). This is particularly important for operating the engine starter and induction manifold. Most equipment publications contain cautions relative to the time of engine starter engagement. However, it is sometimes necessary to exceed the recommended starter time. This is due to the cold-starting characteristics of most internal combustion engines. If a starter time limit is 30 seconds, and engine firing is intermittent during cranking, it may be wise to briefly extend the starter engagement time.
- Vehicles should not be allowed to become cold-soaked.
- Engines should be started periodically to keep lubricants warm.
- Batteries must be kept warm and fully charged.
- Depending on the situation, concealment and noise discipline may have to be sacrificed to maintain readiness of the vehicles.

Idling Limitations

Vehicle engine idling is wasteful and may be hazardous. It has detrimental effects on fuel supply, tactical missions, and safety for the following reasons:

- Increases fuel consumption.
- Discharges batteries.
- Causes engine wear and reduces engine overhaul periods.
- Causes spark plug fouling especially in two stroke cycle engines such as all terrain vehicles, snowmobiles, outboard motors, etc.
- Causes possible carbon monoxide hazards.
- Endangers concealment and camouflage.
- Potentially causes engine overheating.
- Potentially causes slobber of diesel engines. To reduce slobber of diesel engines, which is unburned diesel fuel and exhaust that builds up around the exhaust pipe in cold weather during idling, increase the idle speed. Otherwise, this condition should clear up after a short period of normal operation at normal operating temperatures.

Vehicle engines, except diesels, must not idle for excessive periods (never longer than five minutes) while vehicles are awaiting, discharging, or receiving passengers. Vehicle engines must not idle to operate personnel heaters. Vehicles with diesel engines may have to be idled to eliminate starting difficulties. Efficient vehicle and power plant heater maintenance eliminates starting problems.

NOTE: When it is anticipated that vehicles equipped with diesel engines will be in a static position for 30 minutes or less, operate engines at the prescribed idling speed.

NOTE: When temperatures are below -25° F, it may be necessary to operate diesel engines continuously to ensure operational responsiveness.

Operator Requirements

A licensed operator must be present in the driver's compartment whenever the main and/or auxiliary engine is being operated.

Engine oil and coolant levels must be checked daily prior to initial starting of engine. Battery electrolyte fill levels must be checked daily. When engine operation is required for battery recharging or engine warm-up, an engine speed of 1,000 to 1,200 RPM, as prescribed in the vehicle TM, must be maintained. Occasional variance of speed for short periods is authorized.

WARNING

OPERATION OF THE MAIN ENGINE OR AUXILIARY GENERATOR ENGINE WHEN A VEHICLE IS STATIONARY EXPOSES THE CREW TO POSSIBLE CARBON MONOXIDE GAS POISONING. THE POSSIBILITY IS GREATLY INCREASED WHEN HATCH DOORS ARE CLOSED. TO MINIMIZE THIS HAZARD, POSITION VEHICLE WHEREVER POSSIBLE SO THAT WIND WILL CARRY FUMES AWAY FROM CREW COMPARTMENT; THEN TURN ON TURRET VENTILATION BLOWER. BE SURE ENGINE COMPARTMENT BULKHEAD DOORS ARE SECURED BEFORE OPERATING ENGINES. WHEN THERE IS NO OUTSIDE AIR MOVEMENT, PERSONNEL MUST DISMOUNT FOR AT LEAST 10 MINUTES EACH HOUR (TACTICAL SITUATION PERMITTING).

Engines Equipped with Power Plant Heaters

Vehicles equipped with liquid-cooled engines are provided with power plant heaters. These must be used for standby heat or engine preheating when outside ambient temperatures are below -20° F. The power plant heaters must be properly maintained year round. Some power plant heaters must not be operated when vehicle engine is operating; check the TM before operation.

Engines not Equipped with Power Plant Heaters

When temperatures fall below -20° F, vehicles not equipped with power plant heaters must be operated at 1,000 to 1,200 RPM to ensure equipment is ready. Intervals between engine operations depend upon wind speed and temperature. Operate engines a minimum of 20 minutes every 2 1/2 hours.

Vehicles Equipped with Radios

When radios in radio-equipped vehicles are in use, keep the engine operating at approximately 1,200 RPM. This maintains a satisfactory battery charge. If this procedure is not followed, batteries will fail rapidly.

When starting radio-equipped vehicles, operators must protect the radios. Ensure that the power amplifier switch is in the OFF position, or that the radio function switch is in the OFF or STANDBY position when starting (Figure 3-1).

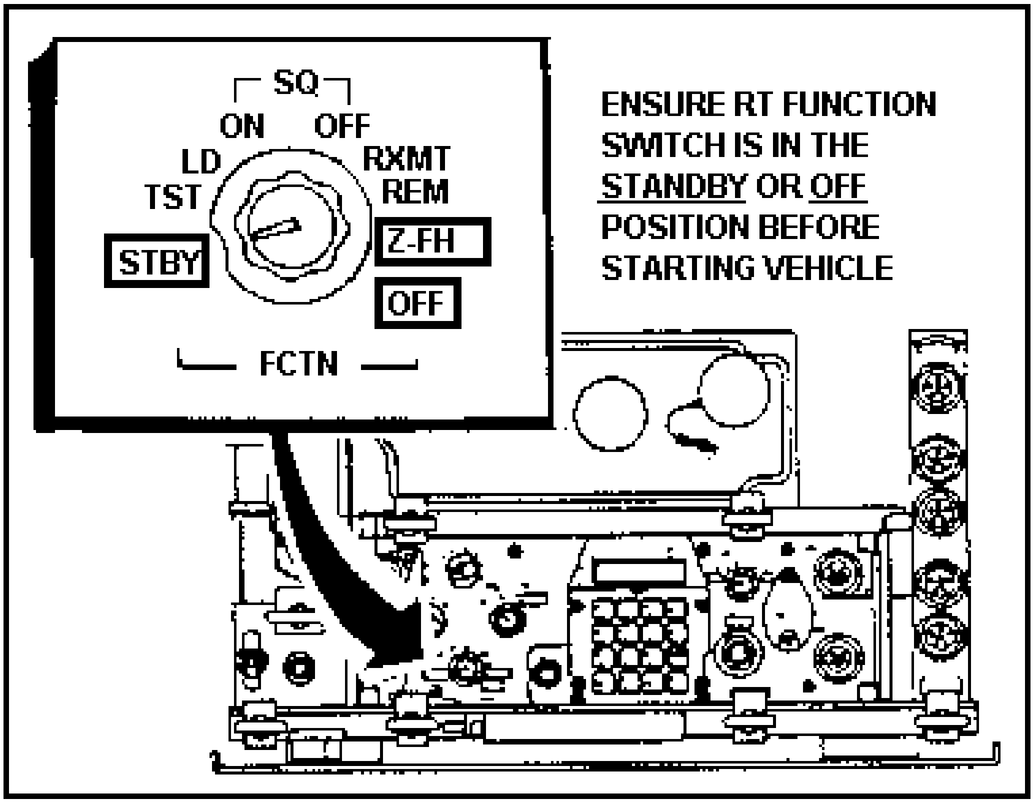


Figure 3-1. Protect radios when starting vehicles

STARTING WITHOUT ASSISTANCE

Starting a vehicle in severe cold can present a number of challenges. Ensure proper procedures are followed to safeguard personnel and equipment.

Gasoline Engines

In cold weather, storage batteries become less efficient and provide much less output. A cold battery cannot energize the starter to turn over the engine at the required cranking speed and also supply the current needed to ignite the spark plugs. The fuel is often not volatile enough to supply proper fuel-air mixture to the combustion chamber.

For a successful start in cold weather, ensure the following conditions exist:

- The viscosity of the engine lubricating oil permits cranking without overtaxing the capacity of the starting system. The engine oil must splash and be distributed easily by the oil pump to the various parts and bearings.
- The battery is fully charged and warm enough to supply current to crank the engine and the spark needed for ignition.
- The ignition primary and secondary circuits are clean and free of cracks, frost, and moisture to prevent shorts or current leaks.
- The distributor breaker points are free of oxidation and moisture, in good condition, correctly adjusted, and checked frequently.
- Ether is used as an emergency starting aid only if a slave kit and/or portable heater are unavailable for preheating. Exercise extreme caution and use ether only as a last resort to prevent mission

failure. Consult appropriate -10 series manual when using emergency starting aids.

CAUTION

ETHER SHOULD BE INJECTED INTO ENGINE AIR INTAKE SYSTEM ONLY WHILE THE ENGINE IS BEING TURNED OVER. OTHERWISE, FLASHBACK MAY OCCUR.

Diesel Engines

Diesel engines are particularly difficult to start in cold weather without preheating the intake air. Since the air is heated by compression, it must attain a temperature hot enough to ignite the injected fuel. This preheating can be accomplished as follows:

- Use air manifold heaters when the ambient temperature drops below + 32° F. Employ this device only when the engine is turned over. Switch off the air manifold heater when the engine starts.
- Warm the engine with external heat to preheat the engine.
- If so equipped, operate the engine coolant fuel-fired preheater for the prescribed amount of time before starting.

USING AUXILIARY POWER (SLAVE) RECEPTACLE

The auxiliary power (slave) receptacle is used to start a vehicle when its batteries are unable to supply starting current.

The procedures that follow generally apply to tactical vehicles, combat vehicles, and self-propelled weapons. Refer to the vehicle operator's manual for instructions and procedures.

- Start the engine of the vehicle supplying the auxiliary power; adjust the engine idling speed to 1,200 RPM.
- Connect the slave cable to the auxiliary power receptacle in each vehicle.

CAUTION

ENSURE THAT SLAVE CABLE IS CONNECTED POSITIVE TO POSITIVE AND NEGATIVE TO NEGATIVE. BATTERIES ARE CHECKED PRIOR TO SLAVE STARTING. IF THE DEAD VEHICLE HAS A MASTER SWITCH, IT MUST BE OFF WHILE CONNECTING THE SLAVE CABLE.

- Turn on the master switch in the receiving vehicle.
- Start the dead engine; adjust engine idling speed to slow idle.
- Disconnect extension cable from both vehicles as soon as the receiving vehicle idles at 650 RPM without stalling.
- Increase engine speed in receiving vehicle to 1,000 to 1,200 RPM. Check battery-generator indicator in the vehicle to make sure it shows that the battery is being charged.

TOWING TO START ENGINE

Attempting to start a vehicle by towing is ill-advised. Applying external power does not solve the problem of internal resistance due to frozen parts (i.e., lack of lubrication or hydrostatically locked engine). However, if all other expedients have failed and the following conditions are met, a vehicle with a manual transmission may be towed to start the engine:

- If the engine can rotate through one complete cycle, this shows that the engine is not hydrostatically locked.
- Lubricants are fluid enough to allow the engine to turn over without excessive drag.
- Lubricants in the transmission and transfer case permit gears to shift and allow operation without excessive drag on the power train.
- Lubricants in the wheel bearings and differential are not congealed. Check for wheel rotation by slowly towing the vehicle in neutral and ensuring all wheels are rotating. If towing the disabled vehicle on packed snow or ice, the wheels may slide. Try to find a dry or graveled surface; otherwise, if the wheels still refuse to rotate, warm the differentials with a swingfire heater or with the heat ducts of a portable heater; or if possible, move the vehicle slowly into a heated shelter and allow it to warm up.
- The hand brake is released, and neither the hand brake nor service brake linings are frozen to the brake drums.

CAUTION

TOWING A VEHICLE TO START ITS ENGINE WILL ONLY BE DONE IN AN EXTREME EMERGENCY. USE A TOW BAR WHEN TOWING. USE TOW CHAINS ONLY AS A LAST RESORT. THE OPERATOR'S MANUAL MUST BE CHECKED PRIOR TO TOW-STARTING ANY VEHICLE.. SOME VEHICLES CANNOT BE STARTED BY TOWING; IF ATTEMPTS ARE MADE TO TOW-START SOME EQUIPMENT, SEVERE TRANSMISSION DAMAGE MAY RESULT.

CAUTION

VEHICLES SHOULD NEVER BE STARTED BY PUSHING.

Section II

Chassis and Body Components

OPERATIONAL CONSIDERATIONS

Ice, mud, and snow build up to such an extent on operating vehicles that they overload vehicle components, reduce ground and other clearances, and prevent or interfere with normal operation of moving components. Buildup and freezing of slush and water around the wheels of an operating vehicle can cause a loss of steering ability.

Tracks

Check oil-lubricated road wheel bearings to ensure that water has not collected during operation. If significant amounts of water have collected, seals may rupture as the water freezes and expands. If possible, avoid quick starts, stops, sharp turns, and side slippage on ice and snow, as they can throw tracks and/or cause loss of control.

Tires

Tire pressure rises and falls with the temperature. Monitor tire pressure frequently to avoid flat tires or over-inflation. If tires have a flat spot where contact with the ground was made, use a light pressure on the accelerator and drive the vehicle slowly until generated heat permits tires to round out. Also, move vehicle often during periods of freezing rain or sleet. To prevent tires from freezing to the surface, place small branches or other insulating material under them before parking (Figure 3-2). If tires do freeze in place, use a portable hot air heater to unfreeze them.

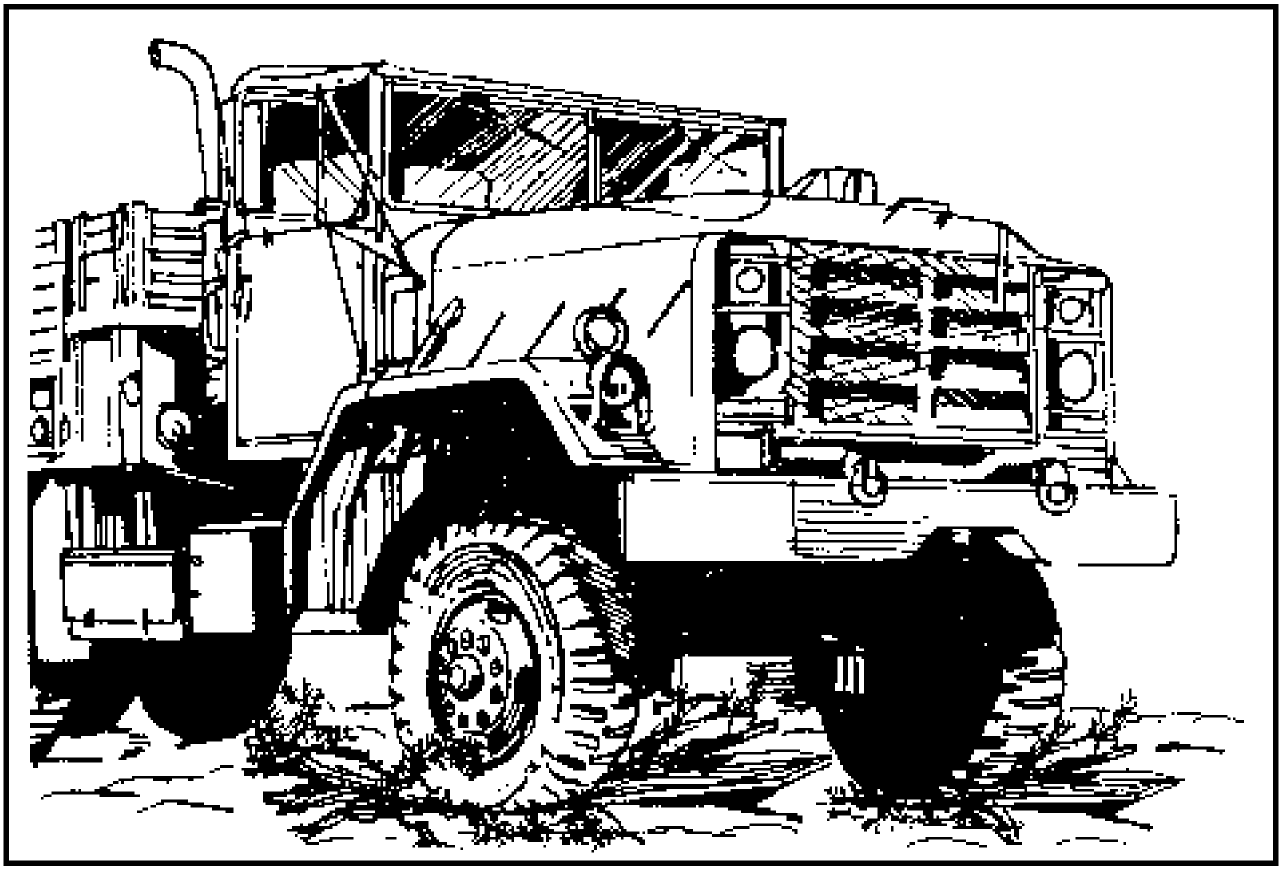


Figure 3-2. Place material under tires to prevent freezing

Tire Selection

Three types of nondirectional tires are available for use on standard tactical vehicles. They are the cross-country tire, the mud and snow tire, and the radial tire (as on the HMMWV). It is best not to mix tires on a vehicle. However, if tire stocks are depleted, different types may be used as long as only one type is used on any one axle. Some commercial vehicles in the Army inventory use commercial all-terrain radial tires. Early model HMMWV bias ply run flat tires mount on special rims. Later version radial tires are designed to run on newer style rims. These tire/wheel combinations should not be mixed on specific vehicles.

Chains

Check vehicle chains prior to operation to ensure that they are serviceable. Drivers should practice mounting and removing chains. Remove the chains when not needed; this practice keeps them in good condition. Chains wear out in approximately 350 miles of asphalt road operation. Also, they can damage vehicle and body suspension components.

Springs

When starting out, proceed with caution to allow springs time to attain flexibility. Avoid driving into depressions or over obstacles; this practice may create shocks that could break springs in extreme cold.

Cab Enclosures

Use heaters to maintain adequate temperatures within cab enclosures. When crossing frozen streams or other bodies of water, open cab doors to permit quick escape of personnel in case vehicle should break through the ice.

Note: Do not cross deep water obstacles covered with ice without checking with supporting engineer units for safe crossing ice thickness.

Parking Brakes

Do not park with brakes set; they may freeze in this position and not release. Use chock blocks to hold wheels or tracks in place. If brake components do freeze in the set position, use an external heat source (such as the portable duct heater) for thawing to prevent damage to the vehicle power train. For the small unit support vehicle (SUSV), parking brakes must be applied when stopped, since there is no neutral-park gear.

Section III Power Train

OPERATIONAL CONSIDERATIONS

In severe conditions, specific procedures must be followed to safeguard a vehicle's power train. Following these procedures will ensure smooth operations.

Starting Conventional Transmissions

To start a conventional transmission, depress the clutch pedal while starting engine with gear shift in neutral. Once the engine is running smoothly, release the clutch cautiously; maintain the engine at idle for two minutes or longer to warm lubricant in the transmission.

NOTE: If vehicle is equipped with a transfer having a selector lever, transfer lubricant may be heated the same way by placing selector level in neutral and transmission in low.

Starting Automatic Transmissions

Automatic transmissions warm up differently, depending on the type. Some warm up in park, while others only warm up if the selector lever is in the neutral position; still others must be placed in gear during warmup. In extreme cold (-25° F and below), many transmissions will not warm up unless placed in gear, allowing the torque converter to pump and preheat the transmission fluid. Forced movement of the vehicle prior to warmup can cause transmission failure. Always consult the operator manual for proper transmission warmup procedures.

Idling

To idle the vehicle, adjust the hand throttle to the engine speed specified in the operator TM until the engine is running smoothly. Engage the engine clutch (where applicable) to allow gear case lubricants to warm. With transfer case levers remaining in the out position to prevent movement of the vehicle, depress the clutch and operate the transmission gear shift lever until the lever moves freely.

During Operation

The driver must be extremely careful when placing the vehicle in motion when gear case lubricants or wheel bearing greases are congealed and tires are frozen to the ground. Trying to operate under these conditions damages power train components, such as clutch facings, universal joints, or gear teeth. When placing the vehicle in motion, put transmission in low gear and transfer unit in low range. Drive the vehicle about 100 meters, being careful not to stall the engine, then upshift. Continue slowly in the higher gears until the vehicle moves freely and tire thump ceases.

After Operation

When preparing a vehicle for shutdown, place transmission and transfer shift levers in the neutral position. This prepares the vehicle for the next start by preventing the levers from freezing in an engaged position.

Section IV

Engine Lubrication System

OPERATIONAL CONSIDERATIONS

The mechanical efficiency of an engine depends on the proper functioning of the lubrication system. Careful attention to PMCS by the driver and unit mechanic is required to keep the system in the best working condition.

Check engine oil prior to starting and fill to prescribed level. As soon as the engine starts, check the reading on the oil pressure gauge. If engine oil pressure is not indicated within 30 seconds after starting, shut down the engine and determine the cause. On vehicles equipped with warning lights, stop the engine and investigate the cause (if the engine-oil pressure warning light does not go out within 30 seconds).

Engine temperatures ranging from 160° to 180° F must be maintained for normal operation. This temperature can be attained by adjusting the air inlet shutters or covers and by having a serviceable thermostat.

The oil pressure gauge and/or warning light must be observed frequently during operation because of increased equipment failures in extreme cold. Consult the operator manual for normal oil pressure. Report to maintenance personnel if normal operating oil pressure cannot be maintained. Low oil pressure warning lights may blink on and off at 500 to 650 RPM using OEA lubricant at idle, but they should not stay on at higher RPMs.

After each operating period, carefully inspect and service the system as follows:

- Inspect oil pan, valve covers, gaskets, and any external units of the lubrication system for leaks; correct deficiencies or report them to maintenance mechanics. During periods of extreme cold, it is not uncommon to observe leaks from various seals on hydraulic systems and oil filled components upon start-up. After the component reaches normal operating temperature and the seal becomes soft and flexible, these leaks should stop. Reporting leaking components before allowing sufficient time for the seal to warm up causes an undue burden on the maintenance system and unnecessary seal replacement.
- Check engine oil and fill to prescribed level.

CAUTION

OIL CONSUMPTION IS MUCH HIGHER WHEN USING OEA. ENGINES MAY RUN OUT OF OIL BEFORE THE NEXT MAINTENANCE CHECK. CHECK FREQUENTLY.

- **At the end of each operating period, and five minutes prior to shutdown, normalize the vehicle engine to allow a coating of cooled oil to be retained on the cylinder walls and pistons. This prevents damage at the time of restarting. It can be accomplished by lowering the engine RPM to the prescribed high idling speed (see TM) and by maintaining it for about five minutes. This procedure is extremely important to preventing engine damage and is mandatory for all heavy-duty gasoline, multifuel, and diesel engines.**

MAINTENANCE

The two most common failures of the engine lubrication system are caused by low or no oil pressure and the accumulation of sludge in the lubricating oil.

Low or No Oil Pressure

Low oil pressure is normally caused by fuel-diluted oil, hot oil, or low viscosity oil. No oil pressure may be caused by cold, congealed, high viscosity oil; a clogged strainer; a defective oil pump; the lack of lubricant; or engine component failure (such as an engine bearing).

Note: Do not overlook the possibility that the oil pressure gauge may be defective. If the gauge is working correctly, the oil is up to the full mark, and the oil filter element is not clogged, the failure is probably in the pump or line.

Accumulation of Sludge in Lubricating Oil

Cold weather tends to prevent engines from reaching normal operating temperatures,

increases the development of carbon in the engine, and increases oil dilution and condensation. These factors combine to create engine sludge (Figure 3-3). To correct a sludge condition, drain oil while engine is hot and refill with OEA.

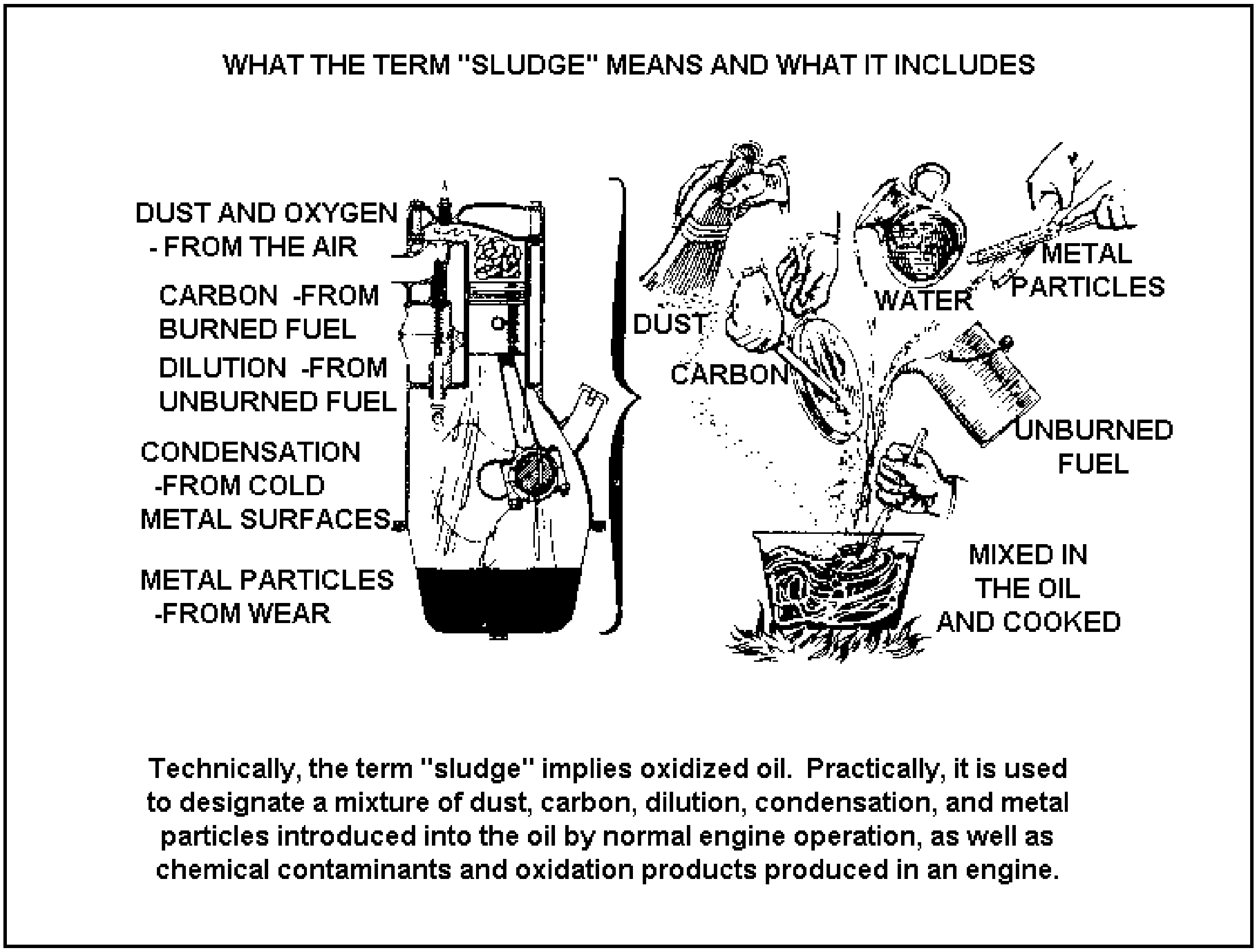


Figure 3-3. Engine sludge

After operation, inspect the oil pan, valve cover, timing gear cover and gaskets, and external oil lines for oil leaks; correct as necessary. To protect the environment, drip pans must be placed under all leaks. Turn in all used oil IAW host nation, federal, state, and local environmental laws and regulations and unit SOPs.

Section V
Electrical System

STARTING PROCEDURES

The storage battery functions as the heart of the electrical system, especially during the starting phase. Pay particular attention to the battery terminals and clamps during cold weather. A loose connection or a small amount of corrosion will add a lot of resistance flow. The current drop that would not even be noticed during warm weather can keep the starter from turning over when the engine is cold-soaked. Also, loose connections and dirty terminals prevent the battery from receiving a full charge when it needs it most. When starting the engine, follow cold-start procedures in the TM, modified as needed by procedures outlined in Section I of this chapter.

If the engine fails to start, discontinue starter operation and turn off all switches being used to start the engine. Wait a few minutes for the starter to cool before attempting another start; repeat the process.

DURING OPERATION

During vehicle operation, adhere to the following guidelines:

- **Allow the engine to warm up to the recommended temperature for sub-zero operation (thermostat opens at 180° F).**
- **Check operation of instruments during warmup, especially the oil pressure gauges and warning lights.**
- **Take advantage of all methods available to keep the battery at recommended temperature. If the battery is warm enough to accept a charge (above 35° F), the battery generator indicator should read in the high green immediately after starting.**
- **Note any unusual noise from the alternator. Fan belts break at a high rate below -50° F. Inspect belts for cracks prior to cold weather operation; replace cracked belts. Adjustable length belts are available for emergency roadside repair of "V" belts. They come in 3/8-, 1/2-, and 3/4-inch widths and require a connector tool to fit to size. Stock numbers are shown in Appendix C. Vehicles such as the HMMWV are equipped with serpentine belts, and only another serpertine belt can be used.**
- **Note any unusual noise from the generator.**

MAINTENANCE

Emphasis must be placed on the proper care of electrical systems to ensure efficient operation.

If it is necessary to recharge a storage battery under low-temperature conditions (electrolyte not frozen), the charging voltage should be low enough to prevent excessive gassing or boiling of the electrolyte. At low temperatures, the permissible charging current is much less than at higher temperatures and, therefore, requires a proportionately longer charging time (See TM 9-6140-200-14).

WARNING

WATER SHOULD NEVER BE ADDED TO A COLD BATTERY; ADD IT WHEN THE BATTERY IS WARM AND CHARGING, OR IT WILL NOT MIX. FREEZING COULD RESULT DUE TO REDUCED SPECIFIC GRAVITY.

If water is added to a battery that is exposed to sub-zero temperatures and is being charged, the layer of water will stay at the top and freeze before it has a chance to mix with the electrolyte. Never attempt to recharge a battery with frozen electrolyte. Never add water or electrolyte to a frozen or cold-soaked battery, an explosion may result.

NOTE: If adding water to a battery at temperatures of 32° F to approximately 50° F, do not fill to level indicated on cell cover or vent plug, since the electrolyte will expand as it is heated and the battery will flood. Acid or electrolyte should never be added to a battery once initiated into service. Use only distilled water.

Section VI
Fuel System

FUEL STORAGE

Successful operation of vehicles at low temperatures depends greatly on the condition of the fuels used. Water in engine fuel can cause serious difficulties. Trouble occurs in some engines even at temperatures above the freezing point of water. When air is drawn through a carburetor, the pressure is lowered and the fuel is sprayed or atomized by venturi action. The reduced pressure in the venturi and vaporization of fuel causes a refrigerating action that may lower temperatures enough to freeze water or vapor in the fuel.

The ice builds around the jet until the fuel supply to the combustion chamber is cut off, and the engine ceases to operate. Water settles to the bottom of fuel tanks and into the lowest parts of the fuel line; if it freezes, fuel cannot reach the carburetor or fuel injectors. As a result, the engine cannot be started. Moisture contamination of fuels is the source of many difficulties. Moisture can be the result of snow getting into the fuel, condensation due to breathing of a partially filled container when taken outdoors from a warmer temperature, or from fuel consumption during normal operation. Dry gas additives can be used if water has contaminated the fuel tank from condensation. To prevent contamination, the following precautions must be observed:

- Store barrels with outlet end slightly higher than the other end to allow sediment and water to settle out (Figure 3-4). Upright storage of barrels should be avoided to keep water and snow from accumulating. The last few gallons that remain in the barrel should be dumped into collecting barrels where foreign accumulation can settle and the usable fuel can be salvaged. Make sure all containers are thoroughly clean and rust-free before storing fuel in them. When barrels are stored, they must have secondary containment to prevent spillage to the ground.

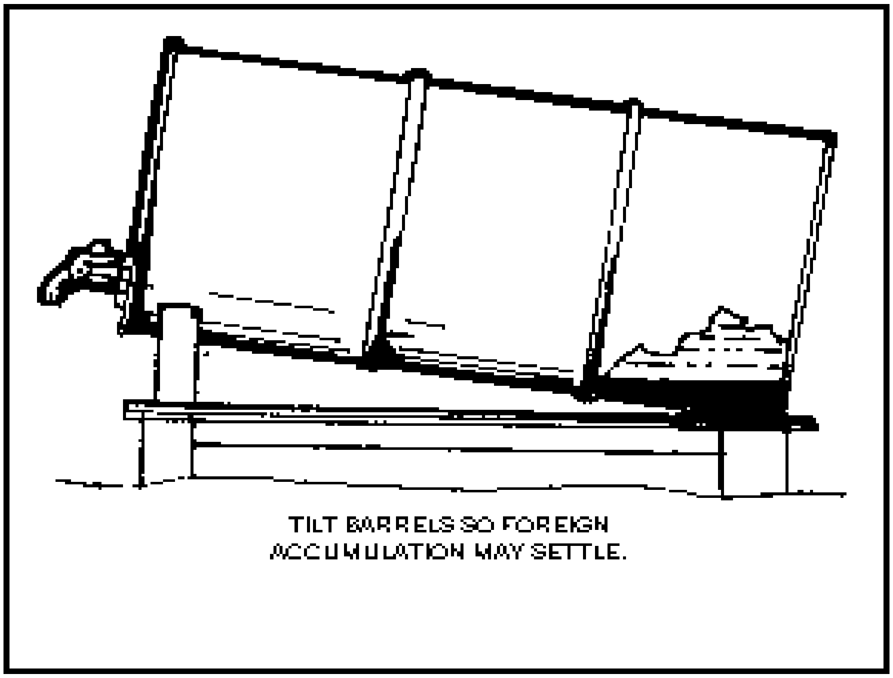


Figure 3-4. POL barrel storage

- **Wipe all snow or ice from dispensing equipment and around fill cap of fuel tank before removing cap. After filling tank, replace cap securely.**
- **Keep the fuel tank filled to proper markings at all times. Refuel only to the expansion marking immediately after halting to reduce condensation in the fuel tank. The more fuel there is in the tank, the smaller the volume of air from which moisture can be condensed.**

WARNING

FUEL FLOWING OVER A SURFACE GENERATES STATIC, WHICH CAN CAUSE A SPARK UNLESS MEANS ARE PROVIDED TO GROUND THE ELECTRICITY. A METALLIC CONTACT BETWEEN THE DISPENSING TANK AND THE CONTAINER BEING FILLED MUST BE PROVIDED TO ENSURE AN EFFECTIVE GROUND. THIS HAZARD IS PARTICULARLY GREAT IN COLD, DRY AIR.

Note: Secondary containment must be used under barrels to prevent spillage to ground.

The carburetor air intake must be protected from chilling winds in sub-zero temperatures. Hood, radiator, and louver covers are either provided in winterization kits or can be easily manufactured and applied. Properly installed, the covers keep out cold winds and materially aid in attaining and maintaining adequately heated engine compartments.

MAINTENANCE

Satisfactory cold weather performance of fuel-related systems depends on careful servicing. Proper maintenance by unit mechanics precludes many malfunctions and failures that would otherwise occur in sub-zero temperatures. Maintenance should include the following:

- **The throttle controls may operate with difficulty at low temperatures. If the engine does not respond properly to operation of controls, check for loose or broken controls, and for loose or broken control linkage or cable. Adjust linkage or replace defective parts as required IAW applicable TM. Clean wires with environmentally safe cleaning solvents and thoroughly dry them. Newer fuel injected systems are computer-controlled electronically, with no mechanical links to control throttle speed. These new systems are found on the PLS, FMTV, the new HET, and other tactical and combat vehicles. Operators must become thoroughly familiar with the cold weather starting procedures for these vehicles. For example, when starting and operating these vehicles, there is little or no throttle response until the engine temperature sensors send information to the computer that the engine is warm enough to operate. Other steps are also required, such as the use of an exhaust restrictor for the FMTV when starting in extreme cold.**
- **Inspect fuel filters for good condition and replace contaminated elements. Dispose of unserviceable fuel filters in an environmentally safe manner as outlined in the unit SOP. Clean the metal disc type filters with dry-cleaning solvent, dry, and install. Make sure there are no leaks.**
- **Drain fuel filters at the end of each day of operation. Do not assume that filters are dry if nothing flows from the drain cock. If water is present, it could have frozen solid overnight. Drain filters into an approved and appropriately marked and labeled container and turn in IAW unit SOPs for disposal.**

- **Check the diesel-fuel injection pump, including transfer pump, to ensure that it is in good condition, correctly assembled, and securely mounted, and that connections are not leaking.**
- **Check diesel-fuel nozzles and lines to ensure good condition.**
- **Check whether fuel gauge is operating and registering amount of fuel in the tank.**
- **Ensure filters are drained into a container and disposed of properly according to unit SOP. Identify any special HN disposal requirements in advance.**

Section VII
Cooling System

STARTING CONSIDERATIONS

Most winterization kits for starting below -25° F include a fuel-fired engine coolant heater such as the swingfire. It is very important to understand the operating instructions before use. Failure to turn on or ensure the auxiliary water circulation pump is running will most likely cause coolant hoses to burst. When the engine is operating, observe the temperature gauge to ensure that the temperature rises gradually. A sudden rise in temperature indicates either a frozen radiator, insufficient coolant, or an inoperative thermostat. Stop the engine immediately and determine cause.

MAINTENANCE

Cooling systems must be carefully maintained to ensure normal engine operating temperatures. Temperatures must be observed throughout vehicle operations.

Operating Temperature

Operate vehicles at normal engine temperatures as indicated in operator's TM (Figure 3-5). Temperatures can be maintained by properly adjusting the engine compartment air inlet shutters or radiator covers. Low engine operating temperature results in excessive fuel consumption, dilution of engine oil by unburned fuel, and formation of sludge from condensation of water in cylinders and crankcase.

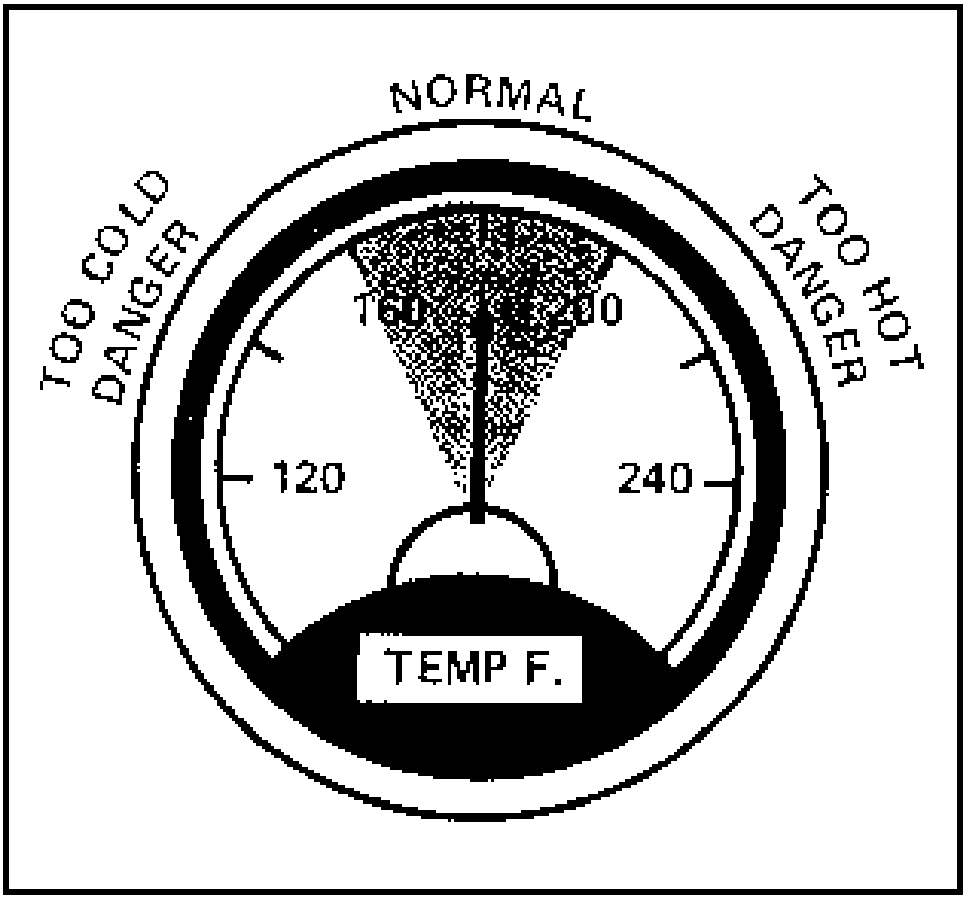


Figure 3-5. Normal operating temperature

> **CAUTION**
>
> **AN ENGINE THAT FAILS TO REACH NORMAL OPERATING TEMPERATURE OR OVERHEATS MUST BE REPORTED TO MAINTENANCE PERSONNEL FOR CORRECTION. FAILURE TO DO SO MAY RESULT IN SERIOUS DAMAGE TO THE ENGINE.**

After Operation

The radiator should be checked after shutdown to determine coolant level. If the coolant level is low, add antifreeze to return radiator to full level.

Section VIII
Auxiliary Equipment

OPERATIONAL CONSIDERATIONS

Auxiliary equipment cannot be overlooked in preparing for cold weather operations. Failure of these items can also lead to mission failure.

Air Compressors

The vehicle air compressor requires little attention for cold weather operation. Soldiers must check to see if the compressor is maintaining required pressure and that there are no coolant or oil leaks

or excessive noise.

Maintenance Steps

To ensure air compressors function properly, operators must:

- **Examine air compressor to ensure that it is in good condition, properly aligned with drive pulleys, and securely mounted. Equipment using air dryers must also be checked for frozen vapors in the drip tube.**
- **Ensure that all water, oil, and air lines in the engine compartment are in good condition and securely fastened, and that there are no leaks.**
- **Check oil in self-lubricated air compressors to determine proper condition and level.**
- **Check alcohol evaporators, as indicated in Chapter 2 of this manual.**

POWER TAKEOFF ASSEMBLIES

The power takeoff and control linkage should be checked to ensure they are in good condition, securely mounted, and that seals are not leaking. Ensure that the proper sub-zero lubricant is used and maintained at the proper level. See that the transmission and/or breather and ventilation openings and lines are clear. Tighten all mounting bolts, power takeoff assembly screws, and bolts to the torque tightness specified in the TM.

Chapter 4
Weapons, Munitions, and Fire Control Equipment

Section I
Effects of Cold Weather

CLIMATIC CONDITIONS

Severe conditions can interfere with the proper functioning of weapons, ammunition, and fire control equipment. Knowledge of these effects can minimize their impact on mission accomplishment.

Cold-Dry Conditions

Cold-dry weather causes sluggish motion and increased stress on moving parts lubricated by products manufactured for temperate climates. Rubberized parts and surfaces, as well as painted surfaces, are more likely to crack and break.

Condensation

Humidity and cold air combine to form condensation when temperatures change rapidly. Under extremely cold conditions, condensation will cause icing and corrosion of machined surfaces, especially in the bores of weapons. A combination of body warmth and breathing may cloud the optics of sights and fire control mechanisms.

Frozen Surfaces

Flat trajectory weapons, such as tank guns, may cause the vehicle chassis to move away from the direction of fire on frozen surfaces. Emplacement of mortar baseplates and howitzer spades is difficult and time-consuming. Weapons firing from frozen surfaces can damage the systems themselves and degrade accuracy.

Snow and Ice

Exposed gears and racks (i.e., elevating arc, traversing rack, and pinions)can collect snow and ice in sufficient amounts to impede movement. Snow and ice can also contaminate lubricants and ammunition.

Visibility

Long periods of darkness, blowing snow, and ice fog greatly limit visibility. Ice fog, caused when water vapor from a muzzle blast crystallizes (usually around -30° F or lower), can hang over the weapon and follow the path of the projectile. In still air, the ice fog lingers, hindering accurate second-round engagement. Ice fog can also serve as a target acquisition aid for enemy gunners. Rain, snow, clouds, and fog also limit the effectiveness of lasers.

Magnetic Conditions

The farther north one travels, the more care one must take with magnetic instruments. These instruments are affected by increasing declination changes and by Aurora Borealis.

WEAPONS FUNCTIONING

The following problems or conditions affect the operation of weapons:

- The increased viscosity of hydraulic or recoil fluids, caused by lower temperatures, offers greater resistance to motion. This results in stiffness of operation and shortening of the recoil cycle.
- Over-lubricating in cold weather may cause parts to bind, resulting in misfires.
- Handwheels on both elevating and traversing mechanisms require greater effort.
- Gascheck pads fail to seal perfectly and deteriorate rapidly. Scoring of the gascheck seat is possible.
- Cable insulation, if not arctic-type, may fail when doubled or straightened.
- Frozen hand brakes on towed weapons may be difficult to release, and attempts to move weapons without thawing may cause serious damage.
- Equalizing bars and travel locks of
- towed weapons must be covered or wrapped before towing over snow-covered terrain. The wrapping should be replaced, if wet, to prevent freezing of both the wrapper and the protected mechanism.
- In cross-country operations, a prime mover with the same tread/track width as the weapon should be used to ensure tracking.
- Firing lanyards must be kept dry and covered to prevent freezing and breakage.

Section II
Lubrication in Cold Weather

SPECIAL CONSIDERATIONS

It is imperative to keep machined surfaces clean and not over-lubricated. Lack of lubrication may cause rust to form on uncoated surfaces and create friction between rubbing surfaces. These conditions impede the functioning of the weapon. On the other hand, use of too much lubricant may impede the motion of the components or result in a buildup of solidified oil or grease.

The proper type and grade of lubricant must be used (Appendix B). Certain lubricants are selected for different temperature ranges because the physical properties of oils and greases vary with changing temperatures, usually becoming thick and viscous as the temperature drops. Thus, a lubricant designed for use at room temperature may become thick and unsatisfactory at sub-zero temperatures, or may become too thin to lubricate metal surfaces at high temperatures. Lubricants can also be selected because they are environmentally preferable.

PROCEDURES FOR LUBRICATING WEAPONS

DS maintenance facilities winterize artillery weapons. Prior to issue, recoil mechanisms must be modified to ensure satisfactory operations to -65° F. Often, preparation of artillery requires special winterization of component parts. Follow instructions in LOs and TMs with the following changes in emphasis:

- Lubricants must be applied in smaller quantities more frequently. For example, a biweekly interval may be changed to weekly.
- Grease, wide temperature range (WTR), is recommended for use on artillery at all temperature ranges. Use WTR whenever special lubricating grease is specified. It displays superior lubricating qualities at extremely low temperatures.
- Petroleum-based hydraulic fluid(OHT) or FRH, as specified, should be used in hydraulic gears as well as in hydrospring and hydropneumatic recoil mechanisms. These products replace special-recoil and light-recoil oil for low-temperature operation. The changeover to petroleum-based hydraulic oil in recoil mechanisms is accomplished as follows:
- Drain existing recoil oil. Raise, lower, and rotate the mechanism to aid in removing the original oil.
- Fill recoil mechanism with OHT or FRH as specified. Establish oil reserve and install mechanisms on carriage or mount.

CAUTION

EXTREME CARE MUST BE TAKEN TO ENSURE THAT MOISTURE, SNOW, ICE, AND DIRT ARE NOT INTRODUCED INTO THE MECHANISM DURING THE CHANGEOVER PROCESS.

Replace preservative lubricating oil, bore cleaner, or normal lubricating oil with cleaner lubricant and preservative (CLP) in cold temperatures. The exception is in the bores of mortars where CR and lubricating oil, weapons (LAW) should be used. To put a

temporary finish on corroded exterior metal surfaces, use solid film lubricant (SFL), except on moving parts and stocks.

Replace CLP with LAW when anticipating operations at temperatures below -10° F. Below -10° F, CLP fails to provide proper lubrication to individual and crew-served weapons.

Follow all federal, state, and local laws and regulations and unit SOPs regarding the storage, transportation, and final disposition of all greases, oils, and solvents. Spills of such materials must be promptly cleaned up and reported via the chain of command IAW the unit spill-plan.

Section III
Operation and Maintenance of Weapons

USE OF COVERS

Whenever materiel is to remain idle for a time, it should be covered for protection. Wind will drive snow under the covers unless snugly and securely fastened.

To prevent materiel from freezing to the ground, prepare a footing of planks, brush, or matting. Straw or hay may also be used for this purpose. Pedestals, rails, outriggers, skids, generating units, and points of tripods that go into the ground can be covered with grease to prevent them from freezing to the ground. Seal exposed openings to ensure that parts are free of ice or snow. Keep the ends of canvas tarpaulins off the ground to prevent them from freezing to the ground.

DEALING WITH CONDENSATION

When weapons, sighting and fire control materiel, parts, or assemblies are brought indoors after having been outside at low temperatures, water vapor in the warm air condenses on the cold parts. The condensation causes corrosion if not immediately removed.

If the materiel is operated indoors while moisture is present, the moisture forms an emulsion with the lubricants. This requires removing all the grease and cleaning and lubricating the materiel. If the materiel is taken outside into low temperatures before the condensed moisture is removed or has evaporated, the parts may freeze and become inoperable.

It is better to leave fire control materiel outdoors, but covered, to protect it from the snow. Snow-tight lockers or sealed containers issued with the materiel maintained at outdoor temperatures are recommended for storing binoculars, telescopes, and other fire control equipment.

If it is necessary to bring instruments or other materiel from low outdoor temperatures into higher room temperatures, use *anticondensation* containers to prevent condensation of moisture on the instruments. The containers can be specially made boxes, covered cans, or other fairly airtight containers with heat-conducting walls. Keep containers outside until time to bring an instrument indoors. Put instruments into a container, closing it tightly. Then bring the container indoors and let stand until its inner temperature has had time to equal the room's temperature. A stove can hasten a container's warmup.

If air in a container is cold and dry, it expands and presses outward when it is heated. Therefore, no warm, humid air from the room can come in contact with instruments and cause condensation. When the instruments and inner container reach room temperature, the instruments can be removed with no danger of condensation.

If *anticondensation* containers are not available, wrap materiel in blankets or similar material before it is brought into a heated enclosure. This will retard or impede the condensation process just described.

CREWMEMBER CONSIDERATIONS

When using sighting and fire control materiel at sub-zero temperatures, operators' hands need protection. Gloves with liners, trigger-finger shells with liners, or arctic mitten sets should be worn.

Gloves are appropriate around 0° F and higher, but the arctic mitten set or the trigger-finger mitten should be worn at colder temperatures. Since mechanical motion of most knobs and levers will be less free than at milder temperatures, adjustments will at first seem awkward and difficult to operators used to working with bare hands. Awkwardness and difficulties will lessen with practice.

Because many knobs and handwheels are difficult to manipulate while wearing arctic mittens, it may be necessary for operators to wear anticontact gloves. If anticontact gloves are not available and it is necessary to use bare hands, the discomfort of contact with cold metal can be lessened by wrapping adhesive tape around the knobs and handwheels.

Although personnel should go indoors as often as possible, they should avoid rapid warming over stoves or other heating units.

EXERCISING

Weapons should be elevated and traversed at intervals that ensure operation when the weapon is needed. The rammer should be cycled several times before ramming rounds and at intervals to ensure proper operation. The recoil mechanism can be moved only a short distance under sub-zero temperatures. Always exercise the recoil mechanism before firing to make sure recoil parts are not iced up.

DAILY CARE

Inspect materiel daily. Whenever possible, use gun covers and shelters for protection. The following points are important in providing maximum protection for weapons.

- Keep all parts thoroughly clean.
- Clean and oil the breech mechanism daily.
- Lubricate sparingly.
- Do not let snow and ice collect on moving parts.

TRAVEL

Before starting a road march, make a thorough inspection and provide as much protection as possible for all parts, as follows:

- Ensure all covers are properly installed and securely lashed. If covers are inadequate, improvise by using canvas, burlap, or any other suitable or available material.
- Perform all preventive maintenance operations and precautions prescribed in manuals pertinent to the materiel.
- During travel, take more than usual driving care because suspension assemblies become stiff in cold weather and break easily. Refer to FM 31-70 for driver precautions.

EMPLACEMENT

The selection and preparation of weapon sites in ice and snow require more consideration than when the weapon is to be emplaced on bare, level ground. If ice and snow are melting, select a site that will not become mired or flooded.

Prepare a platform of pierced steel planking (materiel used for improvised airstrips), boards, brush, and matting at the spot chosen for the emplacement. Push or tow the weapon onto the platform so that the platform is beneath the wheels and firing jack float (or auxiliary firing jack platform). Prepare recoil pits and spade positions. When an artillery piece is to be fired from a soft, spongy surface, a deeper recoil pit must be dug to prepare for the sinking of the weapon during firing.

Coat with waste lubricant all metal parts of the trails and spades coming in contact with snow or frozen ground. This prevents freezing in place and facilitates subsequent shifting of the trails. Waste lubricants may be used on any parts, except rubber, that touch the ground.

Special, large frost-spades or spade attachments may be improvised to suit local conditions. In hard, frozen ground, protect trails against the tendency to buckle and break by placing logs between the spades and ground. This provides added resilience.

The firing jack and its locking lug may become covered with ice and frozen mud in transit. Ice and mud must be entirely removed before the jack can be completely lowered and locked in firing position. Swab the exterior of the jack with GMD and see that all seals are tight and serviceable.

CAUTION
DO NOT PACK GREASE IN THE JACK HOUSING.

Aiming posts should not be driven into frozen ground. A hole should first be made with a pick or crowbar. Manufacturing of a stand that rests on top of frozen ground or ice is an approved method of supporting the aiming post for use in weapon alignment. An aiming post is self-supporting in about 26 inches of packed snow. Use of the aiming light, equipped with dry-cell batteries, is possible only for short periods. Batteries are kept warm and serviceable by carrying them or the light next to the body. Use alkaline batteries rather than carbon batteries.

BREECH AND FIRING MECHANISMS

A frozen breechblock usually cannot be forced to move. If ice prevents opening or closing the breech, use a portable heater for thawing. Remove the breechblock and dry it thoroughly. Keep the breech mechanism tightly covered.

Clean all parts daily, except gascheck pads, with dry-cleaning solvent or mineral spirits paint thinner and lubricate as prescribed in Section II of this chapter.

CAUTION

DO NOT USE DRY-CLEANING SOLVENT, MINERAL SPIRITS PAINT THINNER, OR RIFLE-BORE CLEANER ON GASCHECK PAD. SIMPLY WIPE IT CLEAN AND PERMIT IT TO DRY; DO NOT LUBRICATE.

Frozen manual and electric firing linkages renders a weapon useless. Frozen solenoids do not close contacts for electric firing.

After firing, the breech and firing mechanisms of weapons using fixed and semifixed ammunition should be disassembled, cleaned with dry-cleaning solvent or mineral spirits paint thinner, dried, and oiled sparingly. Mechanisms on weapons using separate loading ammunition should be disassembled. All parts, except gascheck pad and electrical ring mechanisms, should be cleaned with rifle-bore cleaner (MIL-C-372), dried, and oiled sparingly.

The asbestos covering of Gerdom-type gascheck pads becomes very brittle in cold. If the asbestos has cracked and the wire mesh is exposed, it causes the gascheck seat to become scored and impossible to repair. A new pad is required if wire is exposed.

The breech and firing mechanisms must be completely disassembled for cleaning and lubrication. Clean all parts, and apply a light film of LAW, by wiping the surfaces with a clean cloth that has been wet with oil and thoroughly wrung out. Excessive lubrication of the firing mechanism can cause misfires.

BORES

In severely cold weather, bores are susceptable to increased impact loads and may crack due to metal brittleness. Constant inspection and care is required to prevent failure.

Before Firing

Before firing, wipe the bore and chamber dry. Clean and coat bore evacuator, muzzle brake, blast deflector, and counterweight as prescribed in the TM.

During Firing

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

In severe cold, metal becomes brittle and more susceptible to failure under impact loads that a weapon receives when fired. Cracks generally indicate materiel deficiencies or metal fatigue. However, tool marks may be mistaken for cracks, and some cracks are not always visible. Cease firing when cracks develop; notify GS or DS maintenance support.

After firing

CLP can be used as a cold weather bore cleaner and preservative down to -10°F. Below that temperature, LAW is preferred. If it is not available, clean the bore evacuator, muzzle brake, bore, and chamber with rifle-bore cleaner while the weapon is still warm, but not too hot to be touched with bare hands. For temperatures below -20°F, warm the solvent cleaning compound before using so that it is thin enough to use effectively. All cleaner residue must be wiped off. Any residue remaining in the tube will freeze and make firing dangerous. Complete the second and third cleaning of the bore and chamber after firing, as prescribed for mild and moderate conditions in the pertinent LOs and TMs.

Daily care

In below-freezing temperatures, wipe the bore dry every day and apply a light film of LAW.

RECOIL MECHANISMS

All hydropneumatic and hydrospring recoil mechanisms will be filled with hydraulic fluid (OHT) or FRH as specified. Keep close check on length of recoil during extreme cold weather firing. Take precautions to prevent snow, water, or dirt from entering the reservoir.

Hydropneumatic mechanisms are affected by reduction of gas pressure at low temperatures, as well as thickening of recoil oil.

WARNING

THE POSSIBILITY OF INJURY TO PERSONNEL OR DAMAGE TO MATERIEL IS PRESENT WHEN ADJUSTING GAS PRESSURE IN THE RECUPERATOR. THEREFORE, ADJUSTING THE GAS PRESSURE IN THE RECUPERATOR IS A FUNCTION OF DS OR GS MAINTENANCE SUPPORT. THE PERSON IN CHARGE OF THE UNIT IS RESPONSIBLE FOR HAVING THE GAS PRESSURE IN THE RECUPERATOR ADJUSTED TO CORRESPOND WITH THE EXISTING TEMPERATURE CONDITIONS.

Care of recoil mechanisms is nearly the same during cold weather as it is under normal conditions. Using units must maintain a careful check on recoil mechanisms. On self-propelled guns, the recoil fluid surrounds the gun tube and is subject to a larger range of temperature changes and subsequent pressure variations. These pressure changes must be watched and adjustments made to keep within the required pressure range.

Condensation and ice tend to form on a weapon during freezing temperatures. Parts such as recoil and counterrecoil rods and variable recoil cams must be wiped dry and lubricated lightly with LAW every day.

While the oil is cold, the cycle of recoil may take longer than usual. As further firing is conducted, the action gradually warms the recoil oil and thins it so that normal cycle time is obtained. A sticking recoil mechanism may result in severe damage to the weapon when it is fired; therefore:

- Exercise the recoil mechanism frequently. Intervals of exercise depend on the existing temperature, becoming more frequent as the temperature decreases.
- To ensure that recoil parts are free from frost binding, exercise the recoil mechanism prior to firing whenever the weapon is subjected to freezing rain, windblown snow and ice, or fluctuating temperatures.
- Refer to pertinent weapon TMs for methods of exercising the recoil mechanism.

If the recoil mechanism is equipped with an adjustable respirator, it should be opened as far as possible when commencing fire in low temperatures.

CAUTION

EXTREME CAUTION MUST BE EXERCISED TO KEEP THE PARTS OF A RESPIRATOR FREE OF SNOW AND ICE.

Check the oil level of the recoil mechanism at the intervals prescribed in the applicable TM and whenever there is a marked change in temperature. Inspect all partially filled hydraulic fluid containers to avoid the possibility of using contaminated fluid. Discard all contaminated fluid.

RECOIL SLIDES

Friction between recoil slides and guides absorbs an appreciable amount of recoil energy. Thickened or congealed lubricants increase friction, shorten recoil, and retard counterrecoil. Snow and condensation on the slides contaminate the lubricant and destroy its lubricating properties. To ensure proper recoil and counterrecoil action, remove the old lubricant from the slides every day by using dry-cleaning solvent or mineral spirits paint thinner. Smooth all surfaces and lubricate lightly.

When exposed to windblown snow and ice, dry operation of the recoil slides and other exposed metal working surfaces may be necessary. Lubrication, however, should be applied during standby periods. Guns treated with dry lubricant need only be kept clean and free of ice and snow.

EQUILIBRATORS

Clean, dry, and lightly lubricate the piston rods or tubes of equilibrators every day during cold weather operations to prevent icing. Carefully examine and remove any corrosion or marring of the smooth, unpainted surfaces with crocus cloth.

Lubricate the designated equilibrator parts with WTR at the intervals prescribed in the LOs and the TMs. Too much lubricant at cold temperatures may cause the gun to stay out of battery after firing. This is compounded if the pressure in the equilibrators has not been adjusted for cold temperatures. Wash the bearing thoroughly with dry-cleaning solvent or mineral spirits paint thinner, dry thoroughly, and lubricate. It is necessary to remove the equilibrator in order to wash bearings properly.

After the daily cleaning and drying of the equilibrator piston rod or tube, protect the smooth unpainted surfaces against corrosion by applying a very light film of LAW. Wipe the metal surfaces with a clean cloth that has been wet with oil and thoroughly wrung out.

Adjust the nitrogen pressure of pneumatic-type equilibrators to provide proper equalizing action. If the equilibrator is equipped with a low-temperature control, make the adjustment IAW the temperature scale provided.

CAUTION

THE NEWER HOWITZERS USE NITROGEN TO PRESSURIZE THE EQUILIBRATORS. SINCE TEMPERATURES FLUCTUATE, EQUILIBRATOR PRESSURES REQUIRE FREQUENT CHECKS (SEE OPERATOR'S TM). IF A COLD HOWITZER IS BROUGHT INTO A WARM SHELTER, PRESSURES WILL INCREASE DRAMATICALLY, AND IF THE ELEVATION HANDWHEEL IS THEN RELEASED, THE HOWITZER WILL ELEVATE RAPIDLY, POSSIBLY CAUSING INJURY TO THE USER AND DAMAGE TO THE EQUIPMENT OR THE BUILDING.

ELEVATING AND TRAVERSING MECHANISMS

Snow and ice particles frequently collect on the arcs and pinions and cake under pressure of the gears. Since this interferes with elevating and traversing, remove the snow by brushing vigorously with a stiff bristle or wire brush.

After snow is removed, the parts should be left dry for firing or swabbed with a light application of LAW to permit smooth and easy operation and prevent rusting.

CRADLE, SLEIGH, CARRIAGE, AND MOUNT

Disassemble the mechanism as required to obtain access to all parts. Thoroughly clean all parts, ensuring that all rust, dirt, and old lubricant are removed before applying prescribed lubricant. Lubricate sparingly as prescribed in LOs and TMs.

Section IV Direct Fire Weapons

ARMOR VEHICLE MAIN ARMAMENT

Ice fog forms when the weapon is fired. Lubrication and breakage problems are not as frequent as those for artillery pieces because most of the weapon's working parts are enclosed in a warm turret. Temperature changes can have major effects on the ammunition.

Propellants tend to burn slower in the cold, reducing the velocity of projectiles. Therefore, the firing data for temperate climates cannot be used, and the weapon must be zeroed for the temperature in which it is being fired.

Ammunition stored inside the turret will be warm and have the same general ballistic characteristics as ammunition fired in temperate climates. The weapon is generally zeroed with this warm ammunition. Other ammunition is stored outside the tank where the temperature is extremely cold. When this ammunition is fired, the powder burns slowly and has completely different ballistic characteristics, rendering the initial zero useless. If possible, the ammunition brought in from the outside should be heated in the turret before firing. In a combat situation, this is not practical because the ammunition may have to be used immediately. The gunner must have his own data for cold ammunition or be ready to hastily re-zero the weapon. Either way, he will have to make a sight adjustment.

Section V
Indirect Fire Weapons

FIELD ARTILLERY

Most of the problems and precautions involving operations and maintenance of artillery pieces are the same as for weapons in general. However, consider the following aspects of artillery operations in cold regions:

- Recoil oil indicators may show low readings when pieces are cold. Firing a few rounds warms the oil and raises the indicator level.
- Howitzer bores require more frequent cleaning at low temperatures as a result of residue left from incomplete burning of propellant charges. However, bore cleaner can freeze in the chamber and prevent loading a round. CLP is an authorized alternative to bore cleaner, and is effective down to -10°F. Below that temperature, LAW is preferred.
- Special care is required for gascheck pads. A dry cloth is enough to clean the gascheck pad and electrical ring mechanism.
- Adjustable recoil respirators should be left open as far as possible before firing the first round in cold weather. Respirators should be kept clear of ice and snow.
- Congealed lubricants and grit hinder movement of elevation and traversing handwheels.
- Some towed weapons, like the M198 howitzer, use year-round lubricants, even in cold weather.
- Only the ammunition required immediately should be prepared for firing to prevent snow and ice from contributing to wet propellants.

- On frozen surfaces, stability and accuracy diminish at lower firing elevations.
- The choices for firing surfaces should be muskeg, gravel, frozen ground, and ice, in that order. Even with cushioning, firing from ice is one of the greatest causes of damage to artillery pieces in cold regions. Waste lubricants on trails and spades in snow and ice can prevent freezing to the ground. So can laying tree boughs or straw under trails and spades. Such cushions can also be placed under firing jacks and firing platforms.
- Crews wearing the bulky cold region uniform, especially handwear, must practice drills and maintenance to gain proficiency in cold weather cannoneering.

MORTARS

The mortar's baseplate must be solidly positioned to prevent sliding. It may be necessary to dig into the ground to accomplish this. Frozen ground has no resiliency, and the baseplate and other bracing parts of the weapon absorb the entire shock of firing. When the weapon is emplaced on frozen ground, the cold makes the metal brittle. The combination of brittle metal and the tremendous shock that the baseplate receives when a round is fired may cause the baseplate to crack.

Due to the tremendous shock and the extra weight of the sight, the mount will break if the baseplate is not solidly positioned. Remove the sight each time before firing until the baseplate is settled.

One field expedient that reduces the possibility of a cracked baseplate is to place a brush matting under the baseplate. The matting should be thick enough to act as a shock absorber, but not so thick as to cause the baseplate to bounce out of its position. Snowshoes under bipods will prevent them from sinking in the snow.

Another method of positioning is to place bags of dry sand or snow beneath the baseplate. The sandbags provide the weapon with a solid, yet resilient, shock-absorbing base. The baseplate is best seated by firing at a quadrant elevation (QE) of 1,200 mils and a middle charge. If the baseplate must be seated in snow, the bottom should be coated with waste lubricant.

Mortar baseplates should not be seated in frozen surfaces using maximum or near maximum charges. Even when the baseplate appears to be properly seated, the crew can expect the mortar to shift to the rear, and even collapse, when firing at elevations below 900 mils.

An added problem is that mortars cannot be handled without touching bare metal, as can other infantry weapons with wooden or plastic handles and stocks. The crew must keep their gloves or mittens on and avoid touching the metal surface with bare flesh.

Mortars present practically no lubrication or ice fog problems. However, due to incomplete burning of propellants, the mortar tube should be dry-swabbed after every tenth round or after each fire-for-effect. At least a half-hour should be allowed before cleaning after the mortar is moved from a cold to a warm location.

CAUTION

USE OF GLOVES THAT ARE NOT ANTICONTACT RESULTS IN A MORTAR SHELL NOT DROPPING PROPERLY DOWN THE TUBE, DAMAGING EQUIPMENT, AND CAUSING INJURY OR DEATH. THE WEARING OF BULKY OR LOOSE FITTING GLOVES MAY CAUSE THE GLOVE TO BECOME PINCHED BETWEEN THE ROUND AND THE BORE OF THE MORTAR TUBE AS THE ASSISTANT GUNNER FOLLOWS THROUGH IN DROPPING THE ROUND.

Lubricate mortars M29A1 (81mm) and M30 (4.2 inch) sparingly and do not use PL (SP) below 0°F. Use LAW instead of GPL below 10° F as a lubricant and bore cleaner on the newer 60mm, 81mm, and 120mm mortars. The bore should be kept dry, and lubricant kept away from the firing pin. All moving parts and the bore should be checked for snow and ice before firing. Never lubricate mortar shock absorbers.

NOTE: There is currently a restriction preventing CLP from being used in the bore of a mortar.

Mortar gunners and assistant gunners normally use the standing position to avoid cold ground. In this position, they must properly execute round-firing and be conscious of added noise problems inherent with firing the mortar in the cold, dry air. Ear protection is a must.

When seating the baseplate--

- Select a position with vegetation on the ground surface whenever possible. If you must set up the baseplate on snow, coat the bottom with waste oil to prevent freezing to ground surfaces.
- Use two men on the bipod when seating on ice or at high elevation (1,300 mils or higher).
- Train gunners to operate the mortar without breathing on the optics. Optical instruments should be kept sheltered but unheated when not in use, preferably in their cases. Doing this protects them against cold and shock.
- Boresight frequently.
- Practice using compensated sight picture (the rule rather than the exception), when firing from frozen surfaces.
- Ensure mortar crewmen do not remove anticontact gloves (CTA 50-900) when temperatures fall below -20°F. These gloves help prevent cold burns while still providing enough dexterity.

The new family of mortars and mortar rounds (with obturators) are very precise, indirect fire weapons systems. In fact, the systems are more precise than current mortar gunnery procedures. To improve gunnery, mortarmen should practice laying all fire control equipment to zero mils rather than within two mils. This is especially true in cold regions where the mortar can be laid equally as fast at zero mils as at two mils when wearing correct handwear. For best results, ammunition and mortars should be the same temperature.

Section VI
Antitank Wire-Guided Missiles/Rockets

MISSILES

The principal difficulties with wire-guided missiles, such as the TOW and Dragon, are target acquisition and tracking.

Moisture condensing on the eyepiece can literally *blind* the fire control system. When a gunner initially tries to gain a sight picture, moisture from his breath and his body heat near the lens may cause condensation on the lens. To offset this phenomenon, use the protective mask with the winterization kit installed.

Extreme cold causes distortion for the AN/TAS-4A night sight when cold hits the heat rising from the vehicle engine on mounted TOWs. Position the vehicle so the TOW is aiming away from the engine.

Depending on the direction of the wind, activation of the launch drive motors after initial firing creates some ice fog at -30° F and colder. This hinders the gunners' ability to track targets after firing, attempt second-round engagements, or acquire new targets.

An added burden for TOW units is the requirement to transport the TOW system in their ahkio (sled) groups in addition to cold region survival gear. This requires either more soldiers or a reduction of systems employed.

Wing nuts on the battery of the missile guidance set (MGS)freeze in place and then pop off when the battery is loaded. Prevent seized nuts by twisting each one before loading the battery.

Rubber eyeshields on optical and night sights freeze, collect ice, and crack, thereby leaving optics vulnerable to ice and snow. Snow and ice can also cause poor electrical connections on clamping surfaces on the traversing unit, sights, and missiles.

ROCKETS

Rockets and missiles generally operate satisfactorily in cold weather (0° F to -40°); however, consult the TMs applicable to a particular rocket or missile to determine exact firing limits. Information concerning extreme cold operating procedures for rocket and missile materiel can be found as follows:

- Antifreeze materials, fuels, hydraulic fluids, and lubricants - Chapter 1, Section IV.
- Heaters - Chapter 1, Section VI.
- Auxiliary equipment (air compressors, auxiliary engines, power take-offs) - Chapter 2, Section IV.
- Fire control materiel - Chapter 4, Section VII.

CAUTION

ELECTRICALLY POWERED SYSTEMS ENCOUNTER DIFFICULTIES IN OBTAINING AN EFFECTIVE ELECTRICAL GROUND WHEN FIRING FROM FROZEN SURFACES. THIS MAY BE OVERCOME THROUGH TRAINING OR USE OF EXPEDIENT GROUNDING TECHNIQUES.

Section VII
Field Artillery Missiles/Rockets

MISSILES

Missiles and rockets have minimum and maximum temperatures at which they can be fired. Most have this information printed on them. For others, consult each weapon's TM before firing them in extreme cold.

Section VIII
Air Defense Weapons

MISSILES

On the Chaparral system, proper cold-weather settings prevent poor air circulation, overheating, oil leakage, or failure to operate properly.

The oil pan baffle on the gas-powered main power unit (MPU) should be closed--or up--for temperatures that average 0° F or below. Secure the baffle with lockwire. The MPU's carburetor air inlet WINTER/SUMMER valve must be full left for temperatures below 35°F. Number-one and number-two ducts on the MPU air duct must both be open in sub-zero weather, and both should be closed above 35°F. Number-one stays open and number-two is closed between 0° and 35°F.

Set the battery box WINTER/SUMMER valve on WINTER during battery warmup when the temperature is below 35°F. Keep it on that setting for 5 to 60 minutes, depending on the temperature. Battery heater warmup time is in TM 9-1425-2586-10. After battery warmup, switch the battery box valve to SUMMER position. Set the oil pump WINTER/SUMMER valve to WINTER when it is below 35°F.

GUNS

Cold weather precautions for air defense guns are similar to those for guns in direct fire roles.

Section IX
Ammunition and Munitions

AMMUNITION

Cold weather not only affects personnel and equipment but ammunition as well. Failure to understand the possible problems and how to prevent them can make a unit combat-ineffective.

Large Caliber Ammunition

Moisture and humidity can make life miserable for tank, artillery, and mortar crews. Icing can cause misfires, damage to the pieces, and injuries to crewmembers. While cold, dry conditions do not drastically alter the terminal effects of direct fire weapons, they dictate added training and planning for indirect systems. That is because range and burst effects drop off dramatically.

Temperature Limitation

Temperature limitations are not stamped on all individual items of ammunition. However, all temperature limitations are contained in the applicable TM 43-0001 (Series), Ammunition Data Sheets.

CAUTION

WITH COLD ROUNDS IN A COLD TUBE, ACHIEVED RANGES FOR INDIRECT FIRE SYSTEMS MAY BE AS MUCH AS 20 PERCENT LESS AT A TEMPERATURE OF -4° F THAN THAT INDICATED IN THE TABULAR FIRING TABLES (FOUR ROUNDS FIRED OVER A PERIOD OF ONE TO THREE MINUTES WILL WARM THE TUBE).

Snow-covered surfaces tend to diminish the blast effects of rounds with point detonating fuzes. At the firing point,

condensation on a round which freezes in the breech may lead to a misfire. Misfire procedures employed in temperate climates for a round stuck in a howitzer must be modified in cold regions. Pouring a solution high in antifreeze down the tube may be effective in forcing out a stuck round. Another technique involves the use of hydraulic fluid, which does not freeze during the process and acts like a penetrating oil to dislodge the stuck round.

WARNING

DO NOT USE AMMUNITION AT AMBIENT TEMPERATURES BELOW THAT SPECIFIED ON THE AMMUNITION.

Combustible Cartridge Case Ammunition

It may be difficult to remove the combustible cartridge case round from its fiber packing container. This is because a vacuum is formed in the container behind the cartridge when attempts are made to remove the rear portion of the container. Tapping a small hole in the metal end of the fiber container at the using unit level is **"UNAUTHORIZED"** due to the possibility of striking the primer.

Take carewhen handling the combustible cartridge case round to protect it from damage. The case can be cracked or broken by dropping or hitting it against the side of a vehicle.

Loaders may have difficulty removing the neoprene barrier bag when the cartridge is on the loading tray. If difficulty is encountered, try removing the bag while the cartridge is still partially in the rack.

Cold affects mortar ammunition the same way as other types of ammunition. Firing tables may be used provided the proper range corrections, based on cold weather conditions, are established through experience. Consult TM 43-0001-28 and applicable firing tables for charge restrictions at low temperatures.

The following guidelines apply to ammunition in a winter warfare environment:

- Due to incomplete burning of propellants, expect a decrease in achieved range versus the plotted range. This decrease may be as much as 10 percent at -10° F and 20 percent at -40° F.

- Keep ammunition and tube dry. Only open as many rounds as required for the current fire mission and use the tube cover provided.
- Swab the tube after every tenth round or after every fire-for-effect.
- When firing into snow, try to obtain an airburst. Snow decreases dramatically the effect of white phosphorous and fragmentation rounds.
- When firing into frozen surfaces, fuze delay frequently produces better
- fragmentation in the form of a bounce airburst than a quick setting.

Table 4-1 shows expected results when firing into typical cold region terrain while using the M732 multioption fuze.

When firing at low temperatures, double misfire wait times due to the possibility of delayed ignition. The new 60mm and 81mm mortars employ a trigger mechanism that allows the firing pin to be recocked and fired. With these mortars, misfire times do not have to be increased.

GRENADES

Using hand grenades in cold conditions can present some unusual problems. Personnel wearing gloves or mittens must take added precautions.

Hand Grenades

The fragmentation effect of hand grenades in severe cold temperatures is diminished when detonated under snow. When throwing hand grenades during cold weather conditions, personnel wearing handgear must take the following precautions:

- Ensure handgear is completely dry. Handling of snow and ice may result in grenades freezing to the wet handgear.

HEIGHT OF BURST IN FEET ABOVE GROUND SURFACE

FUSE OPTION	EARTH	SNOW	LAKE ICE
NEAR SURFACE	1-3	1-3	1-5
PROXIMITY	9-15	1-5	10-25
SQ	0	0	0
DELAY	0-3	0-3	0-3

Table 4-1. Results of M732 multioption fuze

- Hold grenades near the neck of the fuze to avoid slipping or turning of the grenades when safety pins are removed.
- Right-handed throwers rest the grenade safety lever between the first and second knuckles of the

thumb to ensure a sensitive feeling of the safety lever. Left-handed throwers hold the lever with the thumb by holding the grenade upside down. This procedure provides ready access to the safety pin ring (Figure 4-1).

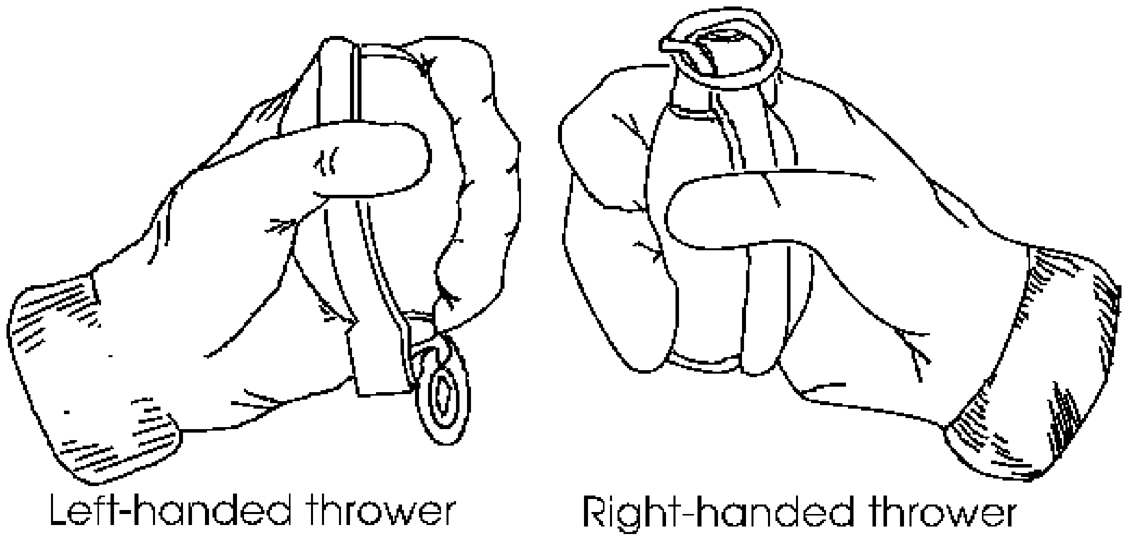


Figure 4-1. Cold weather grenade procedures

MINES

Mine warfare in cold regions demands special precautions to be successful. As little as six inches of snow can reduce the effects and detection of mines and unexploded ordnance (UXO). Emplacing and extracting mines in frozen ground becomes impossible in frozen surfaces.

The rapidity and amount of snowfall in a single night makes marking a minefield crucial for recovering them. This also affects the decision whether to booby-trap them and how. In deep snow, branches or crossed sticks placed under the mines provide a useful snowshoe effect. Otherwise, they may be simply pushed deeper into the snow by the passage of the enemy rather than detonated. Care must be taken while emplacing mines when temperatures are changing, since recovery is difficult when mines are frozen to the ground.

Snow severely inhibits the family of scatterable mines (FASCAM). Besides the decreased blast effects, the self-orientation characteristic of the mines may not successfully complete the arming sequences and will self-destruct to prevent improper detonation of the mine. Also, the trip wires may not be ejected properly, thereby negating that capability.

DEMOLITIONS

Cold affects the ability to employ demolitions effectively. Handling becomes a partnership or team effort. FM 5-25 discourages the handling of demolitions while wearing gloves, but gloves are a must in cold regions. Special considerations must be made for the type of munitions and type of gloves worn.

Thin leather gloves may provide some protection from the extreme cold and allow the dexterity required to manipulate the demolitions.

Plastic explosive, C-4, becomes very hard, making the insertion of an initiating device difficult unless done in a warm shelter prior to its use. For this reason, TNT is preferred because initiating device couplers are built into the blocks. Also, at temperatures of -40° F and colder, C-4 sometimes shatters from the explosion of its initiating device rather than detonating. Military dynamite or TNT blocks are excellent for use in cold regions for projects like digging hasty fighting or firing positions.

Shaped charges do not penetrate as far as indicated in FM 5-25 or TM 9-1375-213-12; as adjusted data are not readily available, experience must dictate their uses.

The detonation cord and time fuse become stiff in the cold. They do not tie as easily as in temperate zones, and break easily. Also, the time fuze tends to maintain its curl and break if uncurling is attempted, except inside warm shelter.

Condensation contributes to increased chance of misfire in the cold. Hangfire and misfire waiting times should be doubled in cold regions. Taping over ends of detonation cord, caps, and igniter may prevent condensation contamination of the firing system.

Static electricity easily develops under cold, dry conditions. Because of this, nonelectrical detonation techniques are preferred over electrical ones.

Section X
Fire Control Equipment

PRECAUTIONS

Sighting and fire control materiel operate satisfactorily at sub-zero temperatures if properly winterized and if certain adjustments are made.

When the LO for fire control materiel specifies oil, lubricate sparingly with instrument lubricating oil (OAI). In extreme cold weather operations, a thin film of oil is more effective for lubricating fire control mechanisms than a heavy application. It also affords adequate corrosion protection. When the LO for fire control materiel specifies grease, lubricate sparingly with aircraft and instrument grease (GIA).

Ordnance maintenance of fire control equipment in severe cold weather is difficult, especially where shop facilities are scarce. Thoroughly inspect and winterize all materiel before the onset of cold weather.

Whether it is planned to use a piece of equipment in a shelter or in a heated trailer, prepare the materiel to operate at the lowest expected temperatures.

Do not suddenly transfer sighting and fire control materiel from cold to warm or warm to cold temperatures. Condensation induced by this action may cause clouding of optics and rusting of internal parts. Use *anticondensation* containers as prescribed in Section III.

Do not put severe bends in interconnecting cables. All electrical cables should be removed periodically from under accumulated snow. This eliminates locating and digging out cables when preparing to shift the emplacement. Use a cable reel to take up cable when shifting positions, and take care not to allow kinks to form. To prevent heavy equipment from running over interconnecting cables, use stake markers to define the cable paths. Markers also facilitate locating cables for repairs.

FOGGING OF EYEPIECES

When using optical instruments in severe cold weather, do not breathe on the eyepieces. When warm breath comes in contact with the eyepieces, the moisture in the breath condenses on the lenses and turns to frost. The frost fogs the eyepieces, making observation impossible.

There is no satisfactory antifog solution for use on eyepieces of optical instruments at low temperatures. Some solutions prevent fogging, but they streak the lens, making observation difficult or impossible.

The cold weather mask (Figure 4-2) is the most satisfactory method of keeping breath away from eyepieces. However, a face mask of any type is useful only as long as it directs the breath away from the lens or absorbs the moisture from the breath.

Figure 4-2. Cold weather mask

A serviceable face mask can be made from any piece of cloth, woolen scarf, or piece of gauze tied across the face just below the eyes. A mask made from any of these materials not only protects the operator's face from the wind but also deflects the breath from the lens. Change the mask periodically to avoid freezing the face.

When using a range finder, a blanket thrown over the operator and part of the tube increases the time of observation from 2 to 3 minutes to about 20 minutes before the eyepiece fogs. Clean optical surfaces by using tissue lens paper moistened with a few drops of optical lens liquid cleaning compound.

NOTE: Ethyl alcohol can substitute for cleaning compound. If neither lens cleaning compound nor alcohol is available, use dry lens paper. Wrap lens paper around the end of a sliver of wood to make a swab. Dip the swab in optical lens liquid cleaning compound, shake off the excess, and clean lens. Wipe away any compound with lens paper, rubbing from the center outward in a spiral pattern.

CAUTION

NEVER POUR ALCOHOL DIRECTLY ON THE LENS SURFACES, AS EXCESS ALCOHOL WILL INJURE THE LENS SEALING COMPOUND. DO NOT USE ETHYL ALCOHOL NEAR AN OPEN FLAME OR EXCESSIVE HEAT SOURCE.

PURGING

Most sighting and fire control instruments are filled with dry nitrogen to prevent accumulation of moisture inside the instruments. Unit mechanics purge and charge sighting and fire control materiel IAW applicable TMs or when condensation is evident in the instrument.

The gunner's primary sight (GPS) on the M1 series tank has a defroster, which does not automatically shut off after clearing the sight's day window. Excessive heat so generated can crack the window.

POWERED SYSTEMS

While some fire control systems use nonpowered devices, most of the newer systems require a power source, either from batteries or external sources. For a full discussion of batteries, refer to Chapter 1 of this manual and to TM 9-6140-200-14.

Some systems require external primary or backup power sources. As temperatures drop, prescribed batteries begin to lose their effectiveness. At lower temperatures, operators may be required to discontinue battery operation and connect the power cable and adapter to a vehicle auxiliary power (slave) receptacle.

Expect temperate zone dry batteries to lose considerable electrical capacity because of decreased chemical activity. These batteries may be used to operate equipment at low temperatures if the internal temperature of every battery is kept high enough to permit normal chemical activity. Dry batteries preheated to approximately 70° F retain sufficient heat for an appreciable period before replacement is necessary. The period of use depends on the rate that heat is conducted away from the battery. It can be extended if the battery is insulated from cold-conducting surfaces by means of nonconductive materials.

When soldiers must carry replacement batteries, they can use the following means to retard heat loss. After preheating, place the batteries in bags lined with kapok or spun-glass fiber materials, wrap in woolen clothing, or carry them close to the body. Under certain conditions, it is advantageous to carry the batteries separate from the equipment by using a connecting cord and plug. This arrangement may require certain modifications to the using equipment to permit installation of the connecting cord and plug. Usually, the modifications are minor and readily accomplished by the using unit.

If replacement batteries can be carried in a vehicle, a well-insulated box that has small heater elements powered from the vehicle battery will ensure maximum usable life of the batteries without heat loss.

PROTECTION OF TUBE EXTENSIONS AND EYEPIECES

Snow can collect in uncovered eyepieces and tube sunshades or extensions, rendering instruments useless until the snow is removed. Do not try to blow the snow out of these parts or wipe it out with gloves or bare hands. Some of the particles of snow will melt and freeze on the lenses, causing further difficulty. Use a small, stiff brush or small, rubber bulb with nozzle to remove the snow.

A temporary method of keeping snow out of eyepieces and tube extensions is to put loose wads of tissue lens paper in them when the instrument is not in use. These wads can be removed easily. Care should be taken to prevent the tissues from becoming wet and freezing the tube.

LEVEL VIALS

When cold-soaked at temperatures below approximately -40°F, the level vials on sighting and fire control items encounter sluggish movement, elongation of the bubbles, and at times, bubble separation. Sluggish bubble movement and elongated bubbles do not affect the precision of the piece. However, bubble separation does affect accuracy. When bubble separation occurs, briskly rub the top surface of the level vial, and the bubbles will join to become one bubble.

COMPENSATED SIGHT PICTURE

For operations in cold regions, mortar gunners must practice firing using the compensated sight picture. This is the rule rather than the exception when firing from frozen surfaces (Figure 4-3).

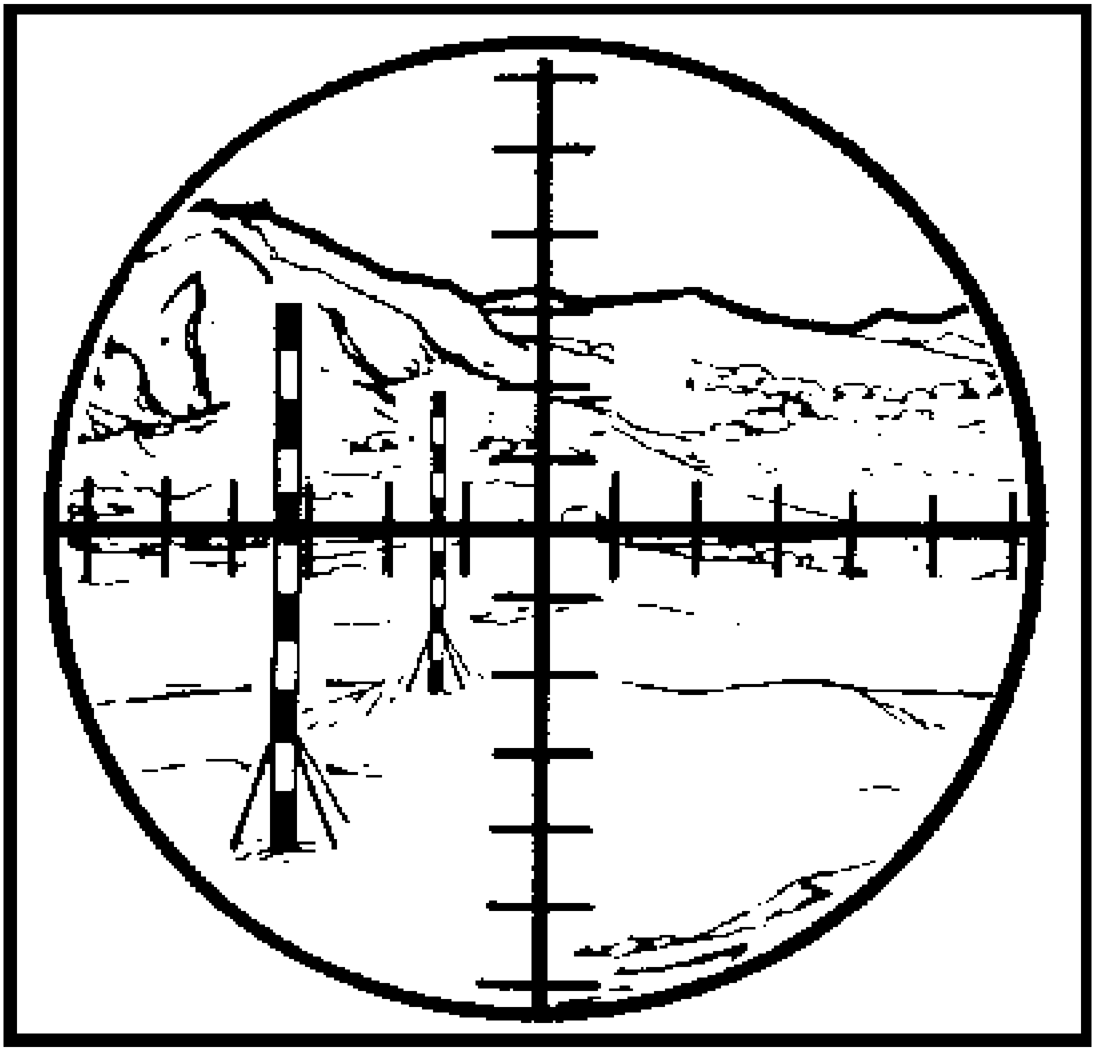


Figure 4-3.Compensated sight picture

LASERS

The effectiveness of lasers is reduced by rain, snow, clouds, and fog. This is due to the beam being diffused by the water molecules in the air.

COMPASSES, BINOCULARS, AND OTHER OPTICAL INSTRUMENTS

The liquid in the lensatic compass thickens in severe cold. The heavy liquid slows the action of the compass and may make it inaccurate. Carry this type of compass near the body in the inner clothing to keep the liquid warm and thin. The dry-type compass is not affected by extreme cold weather.

Cold weather does not affect binoculars and other liquid-free optical instruments. However, condensation does form when instruments are taken from cold air into warm air. Leave instruments outside or use *anticondensation* containers.

Cover equipment such as telescopes while not in use. If a cover cannot be made to include the whole instrument, make bag-type cloth covers to go over the eyepieces and tube extensions. Cloth covers are better than airtight covers, such as the leather covers provided for some instruments. The cloth covers allow breathing of the air in contact with the lens. This prevents condensation when the instrument encounters lower temperatures. Cloth bag covers can be made with a spring, elastic, or drawstring at the mouth so they can be held in place and easily/quickly removed.

When temperatures drop, the pressure on the hydraulic accumulator of the

independent thermal viewer must be lowered, or its pump will work too hard and wear out quickly. The image transfer assembly also needs attention when the seasons change to preclude excessive purging and desiccant changes. Proper pressures are listed in updated TM 9-2350-259-20.

DIGITIZED EQUIPMENT

Liquid crystal displays (LCD) are sometimes affected by extreme cold, causing erratic readings. Do not force switches and knobs on equipment. Thawing may be needed if accumulations of snow or ice have interfered with operations.

Chapter 5
Small Arms

Section I
Cold Weather Problems

CLIMATIC CONDITIONS

Just as with larger weapon systems, severe cold can adversely affect small arms. Special care and procedures must be followed to keep them functioning properly.

Cold-Dry Conditions

Exposed metal surfaces require more frequent applications of smaller amounts of lubrication in order to remain fully functional in the cold-dry air.

Condensation

Condensation forms on weapons when they are taken from the cold into any type of heated shelter. This condensation is often referred to as *sweating*. When the weapon is later taken out into the cold air, the film of condensation freezes. This is especially serious when it occurs in the internal parts of the weapon, and stoppages and malfunctions result. When weapons are taken into heated shelters for cleaning purposes, *sweating* may continue for as long as one hour. When time permits, wait one hour, remove all condensation, and then clean the weapon.

Any opening that allows air to enter can also be a condensation problem area. When in combat, leave winterized weapons outdoors and covered. An alternative method is to place individual weapons between the tent and tent liner. This method allows for rapid access to the weapons, provides security, and still protects the weapon from excessive condensation. Special cleaning procedures reduce problems caused by condensation. When enemy contact is imminent, the interior climate of troop compartments of transportation systems (especially aircraft) should be maintained close to freezing (32°F). This prevents overheating of troops dressed in the cold regions uniform. It also prevents moisture from condensing and refreezing on weapons as troops debark into the cold from warm aircraft and vehicles. Soldiers and aircraft crews must exercise caution when loading soldiers after periods of heavy exertion. Sweat buildup and body heat of soldiers loaded on an aircraft can cause extreme and rapid fogging of the aircrafts windshields, blocking pilot vision. Soldiers preparing for extraction should ventilate their uniforms and remove as much body heat buildup as possible.

Maintenance procedures may require modification to reduce problems created by condensation. For example, the operator is not normally allowed to disassemble the buffer assembly of his M16A2 rifle. However, such disassembly may be necessary to prevent rifle stoppages due to condensation and refreezing.

Despite precautions, weapons parts may still freeze. If they do, slow and careful manual operation may free them and prevent breakage.

Snow and Ice

Blowing snow tends to get into working parts, sights, barrels, magazines, and ammunition, especially when moving in deep snow under combat conditions. Use covers and muzzle caps when available, but remove them prior to firing.

Visibility

Blowing snow and ice fog inhibit soldiers' abilities to acquire and engage targets with small arms. Also, weapons fire creates a pall of ice fog that can hang over the weapon position, not only blocking the gunner's vision, but revealing the position to enemy gunners.

FUNCTIONING DIFFICULTIES

Cold adversely affects the functioning of small arms. Care must be taken to identify problems and apply corrective action.

Sluggishness

A common weapons problem in cold weather is sluggish operation. Normal lubricants thicken at low temperatures, and stopped or sluggish action of firearms results. During the winter, weapons must be stripped completely and cleaned with a dry-cleaning solvent to remove all lubricants and rust prevention compounds. Below 10°F, LAW helps moving parts slide better than CLP or LSA. These products provide proper lubrication during the winter and help minimize freezing of snow and ice on the weapons.

Breakages and Malfunctions

Another problem the soldier faces in severe cold is a higher rate of breakage and malfunctions. This can be attributed primarily to the cold, although snow in weapons can also cause stoppages and malfunctions. The hardened metal parts of automatic weapons are more brittle than soft metal in cold temperatures. When the weapon is fired at sub-zero temperatures, parts can break within the first few rounds. Short bursts warm the gun to a normal firing temperature. Weapons should first be fired at a slow rate of fire. Once the parts have warmed up, the rate of fire may be increased to the normal cyclic rate.

Emplacement

Most crew-served infantry weapons need a natural base or gun platform to fire accurately. In warm weather, the ground provides a solid base and yet has enough resiliency to act as a shock absorber. If the weapon is emplaced on solid, frozen ground, there is no "*give*". All the shock of firing is absorbed by the weapon itself, resulting in damage. Also, the slippery surface of the frozen ground may allow the weapon to slide.

If the snow is not too deep, and if time permits, tripods should be positioned by expedient means to keep them from moving. Lashing the tripod feet to logs that rest on pine boughs or brush, or using the ahkio (sled) as a firing platform, are methods of stabilizing tripods.

Section II
Effects of Cold on Small Arms and Ammunition

PRECAUTIONS

When using weapons or handling ammunition in severe cold, the operator should wear gloves or trigger-finger mittens with liners.

Sudden changes in temperature can cause plastic handgrips, like those on the M203 grenade launcher, to crack. Wrapping the weapon in a blanket or poncho before bringing it from a cold to a warm area helps warm it gradually.

PISTOLS

When using pistols in cold weather, difficulties that arise can include damage to moving parts and firing the pistol wearing arctic mittens. Malfunctions can be caused by snow or ice-plugged clips.

RIFLES

Malfunctions and breakages are 3 rifles may be caused by snow or ice-plugged magazines. Apply LAW to prevent bipods from freezing in position. Although all rifles create ice fog, the signature effects are minimized since the firer can change position.

MACHINE GUNS

Machine guns (MGs) break and malfunction at a high rate in cold weather. Gun crews must carry extra sears and bolt parts. One common malfunction that occurs early in firing is short recoil (bolt does not recoil fully to the rear). The prescribed immediate action for the particular weapon should be applied. As the metal warms, the problem will diminish. A second type of malfunction is caused by the freezing and hardening of buffers. This in turn causes great shock and rapid recoil, thereby increasing the cyclic rate. When this happens, parts usually break.

Condensation causes parts to freeze. All internal parts and friction surfaces of MGs should be coated with LAW. These weapons have fewer malfunctions when fired cold and dry if sub-zero lubricants are not available. Firing should consist of short, two- or three-round bursts fired at close intervals. Since ice fog greatly impairs the gunner's vision along his line of sight, crews must prepare two or three alternate gun positions.

After changing barrels, if the hot barrel is laid directly on snow or ice, it may warp or disappear in deep snow. A tarp or poncho keeps barrels from warping or disappearing.

AMMUNITION

Cold weather does not materially affect the performance of small arms ammunition. Ammunition should be kept at the same temperature as the weapon and should be carried in bandoleers. Additional ammunition should be protected in the pockets of the parka or rucksack.

Ammunition, clips, and magazines must be cleaned of all oil and preservative and must be frequently checked. Remove all ice, snow, and condensation. Keep cartridge containers, magazines, and ammunition drums closed to prevent the formation of rust or ice.

Store ammunition in original containers. Raise storage containers off the ground and cover them with tarpaulins, ponchos, salvage tents, or any other material that affords protection from the snow. Ammunition so stored should be marked to assist with relocating it if the storage containers become snow-covered.

Resupply in cold climates is also difficult, especially the resupply of heavy, bulky ammunition. All soldiers must practice ammunition economy and fire discipline to reduce resupply requirements. Loaded clips, magazines, or single rounds dropped into the snow are often lost. Careful handling of ammunition is essential.

Chapter 6
Communication and Information Systems Equipment

Section I
Cold Weather Problems

PHENOMENA

Certain climatic conditions affect communications and communications equipment in cold regions. These include: cold temperatures associated with dry air, condensation resulting from relatively rapid temperature changes, frozen surfaces, snow and ice, visibility, and electromagnetic conditions.

Cold-Dry Air

In cold-dry air,cold-soaked equipment is especially difficult to assemble. Increased attention to detail, patience, and special preparation to prevent damage is required. This includes working with tight connections, electrical contacts, inflexible cables, power cords, grounding, control knobs, rubber covers, binding posts, and other moving parts. Assembly of equipment is also complicated by the bulky gloves or mittens worn by operators and maintainers.

As mentioned in Chapter 1, cold markedly lessens the operational life of batteries. At -40° F the storage battery for the radio sets SINCGARS cease to operate, resulting in lost codes, and requiring reloading after rewarming. The dry air, coupled with the wind and cold, can cause considerable buildup of static electricity on nonconducting surfaces. This buildup can be a hazard to operators and technicians, as well as to equipment. Temperature inversions that occur on the coldest days in cold regions degrade frequency modulation (FM) communications signal strength drastically. This must be considered when planning troop dispositions and locations of command and control centers.

Condensation

Rapid changes in relative temperature cause cold-soaked equipment to sweat and frost up when moved rapidly between warmth and cold. Electrical contacts are especially susceptible. Also, frosting from the breath of the operators can render microphones inoperable.

Frozen Surfaces

Frozen surfaces serve as heat sinks and rapidly cool equipment. A good rule is to keep all communications equipment off the ground. Adequate grounding is important on many pieces of communications equipment, yet is very difficult to achieve on frozen surfaces.

> NOTE: Standard grounding systems will require considerable effort to construct, and in some cases prove to be impossible. Shaped charges, coupled with water-saturated salt/soil backfill poured over the grounding device, provide one of the best means for penetrating frozen earth.

Extraction of grounding devices is more than likely possible only after seasonal thawing. Use of existing grounds (pipes, established grounds, and buried steel) is desirable, as long as the pipes are not conduits for gas or flammable liquids.

Snow and Ice

Snow and ice can get into any unprotected openings in equipment. Use the equipment covers provided for most communications equipment. Signal attenuation due to ice on antennas is also

common in cold regions. Drip loops for overhead connections, especially power connections, are required. Since small items dropped in the snow are easily lost, more frequent inventory of sets and kits is advised.

Visibility

Prolonged hours of darkness affect communications equipment operation and maintenance in several ways. Inventory, assembly, and disassembly in the dark are difficult and time-consuming, especially when wearing required gloves or mittens. High frequency (HF) wave propagation markedly deteriorates with changes occurring in the ionosphere as darkness approaches. Lower frequency assignments that need longer antennas are also required. A good day of HF communications between stations 100 kilometers or more apart might be limited to only six hours.

Electromagnetic Conditions

The Aurora Borealis activity can cause noise, suppress signals, and cause unusual wave propagation in radio communications. While electromagnetic interference does not damage equipment, planners must anticipate this degradation in choosing unit locations. Fading and severe static can cause speech secure devices, such as the KY-7, to lose signal, requiring numerous retransmissions of long messages.

Units reportedly use Aurora activity to gain greater range for HF radio by reflecting directional signals off the light fields. However, this innovative use of conditions is the exception. The greater magnetic declination angles encountered as one moves farther north also greatly affect radio communications positioning and orientation of directional antennas. These problems increase the need for strict supervision.

The most effective tactical ground system for use in frozen ground is the Surface Wire Ground System (SWGS). This system consists of pins connected together with cable to form a grounding grid. Typically, the best grounding that can be obtained with either a six-foot grounding rod or the SWGS is about 3,000 ohms of resistance.

Section II
Operation and Maintenance of Communications and Information Systems

RADIO SYSTEMS

Several considerations for radio equipment were addressed in the previous section. A good rule to follow and enforce is to handle all communications/electronic equipment very carefully when cold. A radio dropped on cold ground or thrown into the back of a vehicle is easily damaged. Control knobs may be sluggish or even frozen and require careful handling.

Even well-maintained equipment requires considerable warmup time. For example, 15 to 20 minutes warmup before voice transmission may be required, and a cold-soaked AN/GRC-42 radioteletype system might require warming for three to four hours. Keeping equipment as warm as possible can be achieved with careful planning and innovation. Use chemical heat pads and styrofoam to keep equipment, especially speech secure devices, operational. Placement of radios and switchboards off the ground and away from exterior tent or shelter walls is advisable.

Another hazard is, ironically, too much heat. Needless damage to equipment is often incurred by improperly placing the equipment too near shelter heat sources, such as a stove or heater. Electronic components and insulators can easily melt or burn, and some batteries explode when thawed too close to a heat source.

Lithium batteries, like the BA-5598 for the radio set SINCGARS, are especially effective in cold weather and do not need warming at temperatures above -20° F. Dry cells should be kept warm until needed. Extra batteries can replace cold batteries in use; after warming, they can be used again. Batteries should not be installed in idle equipment. Plastic pins on battery connections get brittle in the cold; install them carefully.

Each user of a portable manpacked radio should carry the handset inside at least one layer of clothing to prevent the push-to-talk button from freezing. This requirement, combined with the operator wearing a parka hood, severely hampers the ability to hear incoming transmissions. This may be overcome by using external speakers such as the LS-454/U. Use plastic coverings, such as battery packaging, to cover the mouthpieces of handsets. These should be used even with the presence of moisture shields to keep moisture from the operator's breath from freezing the handset. An excellent alternative is the standard nonlubricated prophylactic slipped over the handset. A wool sock over the handset keeps snow and ice out and protects the operator from direct contact with cold plastic and metal. Placing an unthawed handset directly against lips or ears can cause physical injury.

Anticontact gloves should be available and used when touching cold metal equipment. Cold injury and loss of surface skin can occur after the briefest of contact with cold handles, knobs, and surfaces. Also, common tools, such as the TL-13A lineman's pliers, should have handles wrapped in plastic or tape to provide protection.

Spare connectors, cables, handsets, and antennas should be readily available for replacement when failures happen. Metals and plastic become remarkably brittle and crack and break easily in the cold. Friction tape is advised rather than plastic tape, which loses its adhesiveness in the cold.

Vehicular radios also require careful attention. Small physical shocks can cause whip antenna damage when in the upright position. Radios should be warmed for three to four minutes on low power before changing to high power settings or transmitting. The vehicle for the particular radio being used should be cycled periodically IAW its -10 series manual when temperatures dip below -30° F. The vehicle, when cycled, should be idled at approximately 1,200 RPM. Otherwise, the high discharge rate necessary to operate both the radio and the heater soon wears out vehicle batteries.

ANTENNA SYSTEMS

Attention to proper assembly of antennas is a commonly overlooked requirement in the cold and dark. Shortcuts and failure to follow prescribed instructions often result in interruption or degradation of communications and damage to equipment. The RC-292 and OE-254 antenna masts must be erected with enough sections to ensure necessary height.

Erecting

Standard stakes are often useless in frozen ground. GP-101 cold-weather stakes can be ordered for the RC-292, or the GP-112 for the OE-254. Because they are slimmer than standard stakes, they do not hold as well when the ground thaws. Heavy 12-inch steel tent pins have been used successfully. Tree and rock tie-offs are also acceptable. Another method for erecting an FM antenna is to guide the mast carefully alongside a tree and secure it to the trunk using one of the attached guy lines. Exercise care not to damage any of the elements, cable, or mast sections upon erecting.

Proper inventory of unused hardware is essential since parts are easily lost in snow and darkness. Care must also be taken not to let moisture accumulate due to condensation or precipitation and ground out the antenna against the trunk.

NOTE: Prior to assembly, expose antennas to the cold to prevent sweating and freezing. This prevents problems with disassembly.

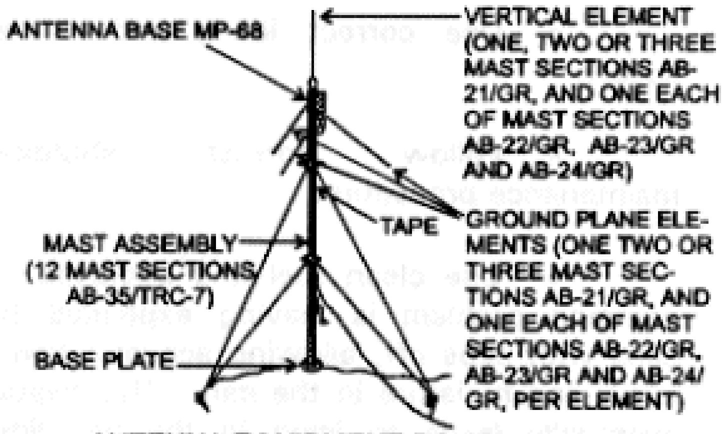
Keep the mast sections clean and free of foreign matter. Lubricate the male and female ends of each mast section only with silicone lubricant. After applying the silicone and joining the sections, back off the joints by approximately one turn as a precaution against sticking.

The RG-213 coaxial cable is recommended over RG-8 cable; the latter becomes brittle and cracks at temperatures below -20° F. Spare cable connectors and adaptors are recommended, since damage and loss are common. Loop and tape coaxial antenna cable near the top of the mast to ease pressure on the connector. Tape the cable at intervals along the mast to prevent the whipping action of the wind from causing damage to the antenna. Tap the mast periodically to shake free snow and frost accumulation, which can degrade transmission signal strength. Make guy lines in a manner to prevent tripping on the antenna guys and disabling the antenna.

Keep ceramic bowls dry because water collects in them during warm weather. When temperatures drop, they freeze, causing the more brittle glass to crack. Applying silicone where the two bowl halves join assists in sealing against further cold damage.

Length

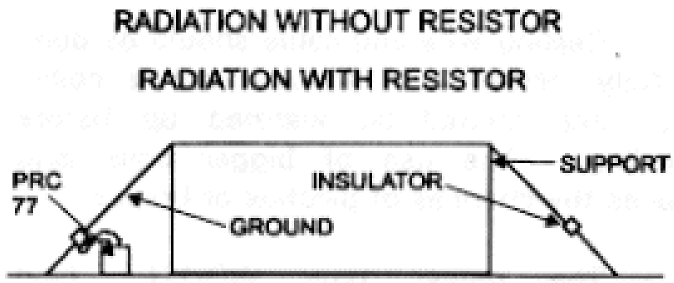
HF and long wire antennas can approach 75 meters in length, depending on the frequencies used. Attention to measurement is critical. The same applies to FM antennas. For the RC-292, the appropriate numbers of elements for radians and ground plan sections are given in Figure 6-1.



ANTENNA EQUIPMENT RC-292

RC-292 ANTENNA CONFIGATIONS

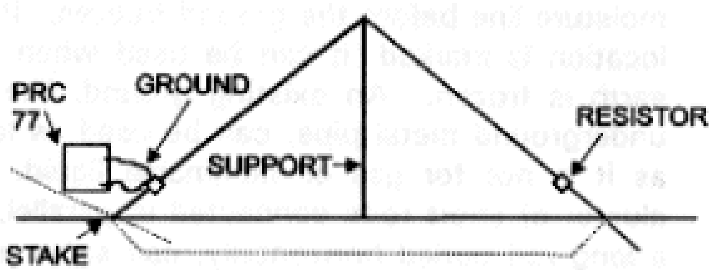
OPERATING FREQUENCY	Number of Antenna Sections Required	Type of Section Used				Number of Ground Plane Sections Required	Type of Ground Sections Per Element			
		AB 21/GR	AB 22/GR	AB 23/GR	AB 24/GR		AB 21/GR	AB 22/GR	AB 23/GR	AB 24/GR
20 to 27.9	6	3	1	1	1	18	3	1	1	1
27 to 38.9	4	1	1	1	1	15	2	1	1	1
38 to 54.4	3	0	1	1	1	12	1	1	1	1
30 to 36.5	4	1	1	1	1	15	2	1	1	1
36.5 to 50.5	3	0	1	1	1	12	1	1	1	1
50.5 to 75.9	2	0	1	1	1	9	0	1	1	1



LONG WIRE ANTENNA

LONG WIRE ANTENNA. This antenna is used with both AM and FM radios to increase the range. It is normally used in open terrain where it can be constructed with ease.

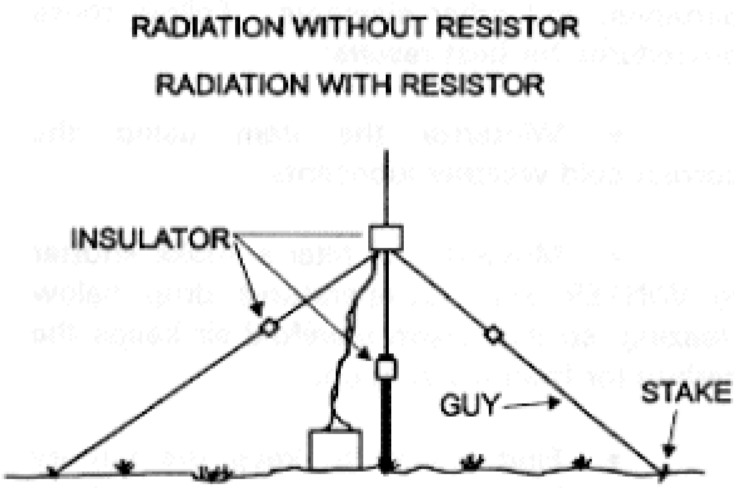
Length..........	2 to 7 wavelengths of operating frequency.
Height...........	3 meters.
Range...........	2 to 3 times operating range of set
Resistor.........	400 to 700 ohms
Radiation........	WITHOUT resistor- off both ends of antenna. WITH resistor- off resistor end only.



VERTICAL HALF RHOMBIC ANTENNA

Used with primarily with FM radios in lightly wooded areas.

Length..........	4 wavelengths of operating frequency, with a 11-meter lead-in.
Range..........	2 to 3 times normal range of set.
Height.........	13 wavelengths of operating frequency.
Resistor........	400 to 700 ohms.



GROUND PLANE ANTENNA

Used with FM radios when the RC-292 Antenna is not available.

Length..........	Antenna Element..........2 meters Ground Plane Elements...2½ meters.
Range..........	Under most conditions will increase the range of set.
Height..........	Not to exceed 13 meters.

Figure 6-1. Antenna dimensions

Orientation

Orienting an azimuth is important and often difficult because of the requirement to compute large declination angles in northern latitudes. Directional antennas are often required to compensate for other conditions causing range degradation.

WIRE AND CABLE SYSTEMS

Laying wire over long distances in deep snow is greatly facilitated by the use of oversnow vehicles. These vehicles can also be the worst enemy of wire systems. Their skis and tracks damage surface-laid wire and cable that they pass over, dragging away large sections and cutting critical circuits. Standard wire-laying techniques, ties, and tagging apply in cold regions as well as in temperate zones. Aerial laying is advised when tactically feasible. Burial is desirable, but often difficult or impossible. Retrieving wire in cold regions is tedious and usually results in excessive salvage work due to ice and traffic damage. Stringing wire overhead is preferred because the wire will not freeze to the ground.

Wire insulation is often brittle, and impedance is increased in snow or damp conditions. Splices performed in the cold are often done improperly, and fewer can be allowed for continued use of serviced wire. A slack factor of 30 percent is recommended for wire-laying teams instead of the 20 percent suggested in the TM. This allows for cold weather shrinkage.

The TA-1/PT voice-powered telephone tends to perform poorly in extreme cold on wire of lengths extending beyond squad or platoon boundaries. The TA-312/PT, when powered by alkaline batteries (such as the BA-3030/U), provides reliable communications and is the preferred instrument for wire troubleshooting teams.

Reeling wire and cable should be done carefully; reeled wire freezes into a coiled shape and should be warmed up before unreeling. The use of bigger coils also reduces the chances of pinches or breaks.

The newer type WD-1/TT field communications wire performs nearly as well in the cold as the old type of spiral wire. It is less durable and more susceptible to damage by vehicle traffic, however, and should be used in less traveled areas. The WD-36/TT assault wire is lighter and easier to handle, man-pack, dispense, and splice than WD-1/TT in the cold, but it is much less durable.

POWER SOURCES

Generators should be thoroughly inspected and winterized, since experience has shown that they develop a higher failure rate at sub-zero temperatures. This is attributable to outdated LOs, exposed batteries, and other elements. Follow these procedures for best results:

- Winterize the item using the correct cold weather lubricants.
- Move the air filter's intake shutter to WINTER when temperatures drop below freezing, so that warm manifold air keeps the carburetor from freezing up.
- Find a way to keep the battery warm, and prevent ice and snow from plugging battery cap vent holes. Keep one battery fully charged.
- Preheat using other heat sources when possible.
- Use the correct fuel icing inhibitor: technical methanol for gasoline; fuel system icing inhibitor for diesel fuel.
- Provide shelter so that the item provides its own heat. If a shelter is not available, use pallets or trailers to keep the generator off snow, ice, or frozen ground.
- Use correct idling and running speeds.

- Follow correct shutdown maintenance procedures.
- Use clean fuel and additives. A common problem is leaving expended fuel cans with caps off, allowing accumulation of snow and moisture in the can. This mistake eventually leads to icing in the fuel lines. Keep fuel tanks as full as possible to reduce condensation.
- Check, drain, and clean filters at least daily and at shutdown to prevent icing. Change oil more often in cold weather.
- Proper grounding of generators is important, but is seldom done satisfactorily. Perform expedient grounding by using an ice auger to cut through frozen surfaces, then submerge conductors in the water. TC 11-6, *Grounding Techniques*, is an excellent guide. If an area is used in summer and winter, bury a three-foot-square metal plate below the moisture line before the ground freezes. If its location is marked, it can be used when the earth is frozen. An existing ground, like an underground metal pipe, can be used as long as it is not for gas or flammable liquid. A cluster of short rods connected in parallel, or a long rod buried horizontally, can serve as a ground, as long as it reaches below the frostline. Ground rods work best if driven near a heat source, with a salt solution poured around it--about a pound of salt in a gallon of water.

COMPUTERS

Most computers are not designed to operate at extremely low temperatures and may become unreliable or unavailable for use (0° F for larger work stations, -30° F for small handheld devices). Liquid crystal displays (LCD), especially, may be affected by extreme cold. Frozen knobs, dials, and switches should not be forced.

LCD displays can freeze or break below 32° F. When initially turned on, an LCD display in cold weather is faint and hard to read. If it is left on it will improve over time due to self warming.

NICAD computer batteries do not last as long in below 32° F weather. Charge rate for cold-soaked batteries is slower.

Appendix A
Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants for Use in Cold Weather to -65°

This appendix contains a listing of antifreeze materials, fuels, hydraulic fluids, and lubricants for use in cold weather. Ensure LOs are checked before using or adding any materials.

ITEM	NSN	CONTAINER SIZE
Additive, Antifreeze Extender, Liquid Cooling System MIL-A-53009)	6850-01-160-3868	1-gal can 1-gal plastic 55-gal drum
Alcohol, Denatured, Grade III 0-E-760	6810-00-543-7415 6810-00-201-0907 6810-00-201-0904	1-gal can 5-gal can 55-gal drum
Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package MIL-A-46153)	6850-00-181-7929 6850-00-181-7933 6850-00-181-7940	1-gal can 5-gal can 55-gal drum
Brake Fluid, Silicone, Automotive, All-Weather, Operational and Preservative (BFS) (MIL-B-46176)	9150-01-059-2586 9150-00-102-9455 9150-01-072-8379	1-gal can 1-gal plastic 55-gal drum
Cleaner, Rifle Bore (CRC) MIL-C-372	6850-00-224-6656 6850-00-224-6657	2-oz can 8-oz can
Cleaner, Lubricant and Preservation (CLP)	9150-01-053-6688 9150-01-054-6453 9150-01-079-6123 9150-01-079-6124 9150-01-079-6125 9150-01-079-6126	1-gal liquid 1-pt liquid w/trigger/sprayer 1-oz liquid 4-oz liquid 16-oz aerosol 3-oz aerosol

Compound, Cleaning With Conditioner and Inhibitor for Engine Cooling Systems (MIL-C-10597)	6850-00-598-7328	package

Dry-Cleaning Solvent: P-D-680

Type I	6850-00-264-9037	55-gal drum, 16
Type I	6850-00-285-8012	55-gal drum, 18
Type II	6850-00-281-1986	55-gal drum, 16
Type II	6850-00-285-8011	55-gal drum, 18
Fuel System Icing Inhibitor, Diesel Fuel:	6850-00-753-5061	5-gal drum
(Ethylene Glycol Monomethyl Ether) MIL-I-27686	6850-00-060-5312	55-gal drum
(Diethylene Glycol Monomethyl Ether) MIL-I-85470AS	6850-XX-XX-XXX	
Fuel Oil, Diesel:	9140-00-286-5284	55-gal drum
Regular Grade (DF-2) VV-F-800C	9140-00-286-5283	bulk
Arctic Grade (DF-A)	9140-00-286-5284	55-gal drum
VV-F-800C	9140-00-286-5283	bulk
Turbine Fuel, Aviation, Kerosene Type, Grade JP-8 MIL-T-83133	9130-01-031-5816	bulk
Gasoline, Automotive, Combat Type II	9130-00-160-1830	bulk
	9130-00-160-1831	5-gal can
	9130-00-221-0685	55-gal drum, 16 gal
	9130-00-240-8201	55-gal drum, 18 gal

Lubricating Oil, Gear, Multipurpose, Arctic (GO-75W) MIL-L-2105	9150-00-257-5440	5-gal can
Lubricating Oil, General Purpose, Light (LO) VV-L-2105	9150-00-252-6173	4-oz can
Lubricating Oil, General Purpose, Low Temperature (GP) MIL-L-7870	9150-00-542-1430 9150-00-263-3490	4-oz can 1-qt can
Lubricating Oil, General Purpose, Preservative (PL-S) VV-L-800	9150-00-231-6689 9150-00-273-2389 9150-00-281-2060	1-qt can 4-oz can 55-gal drum, 18-gal
Lubricating Oil, Instrument (OAI) MIL-L-6085	9150-00-257-5449 9150-00-223-4129 9150-00-664-6518	4-oz can 1-qt can 1 1/2-oz can
Lubricating Oil, Internal-Combustion Engine, Tactical (OE/HDO-10) MIL-L-2104	9150-00-186-6668 9150-00-189-6728	5-gal can 55-gal drum
Lubricating Oil Internal-Combustion (OE/15W40) MIL-L-2104D	9150-01-152-4117 9150-01-152-4118 9150-01-152-4119	1-qt can 5-gal can 55-gal drum
Lubricating Oil, Internal Combustion Engine, Arctic (OEA) MIL-L-46167	9150-00-402-4478 9150-00-402-2372 9150-00-491-7197	1-qt can 5-gal can 55-gal drum

Lubricating Oil, Internal Combustion Engines, Preservation and Break-In (EO-10) MIL-L-21260	9150-00-111-3199 9150-00-111-3200	5-gal can 55-gal can
Lubricating Oil, Weapons (LAW) MIL-L-14107	9150-00-664-0038 9150-00-292-9689 9150-00-292-9687	4-oz can 1-qt can 1-gal can
Lubricating Oil, Semi-fluid (LSA) MIL-L-46000	9150-00-889-3522 9150-00-687-4241	4-oz bottle 1-qt can
Methanol, Technical (MOGAS Fuel Additive)	6810-00-275-6010	5-gal drum

Gasoline, Automotive Leaded or Unleaded, Volatility Class E:

Limited, Unleaded (VV-G-1690)	9130-00-148-7102	Bulk
Limited, Leaded (VV-G-1690)	9130-01-135-2507	Bulk
Regular, Unleaded (VV-G-1690)	9130-00-148-7102	Bulk
Regular, Unleaded (VV-G-1690)	9130-01-135-2507	Bulk
Premium, Unleaded (VV-G-1690)	9130-00-148-7102	Bulk

Grease, Aircraft and Instrument (GIA) MIL-G-23827	9150-00-985-7245	8-oz tube
	9150-00-985-7246	1-qt can
	9150-00-985-7247	1-gal can
	9150-00-935-4017	4 1/2-oz cartridge
	9150-00-985-7248	35-lb pail
Grease, Automotive and Artillery (GAA) MIL-G-10924	9150-00-190-0907	35-lb pail
	9150-00-190-0904	1-qt can
	9150-00-190-0905	1-gal can
	9150-00-935-1017	14 1/2-oz cartridge
	9150-00-065-0029	2 1/4-oz tube
Grease, Molybdenum Disulfide (GMD) MIL-G-21164	9150-00-935-4018	14 1/2-oz cartridge
	9150-00-754-2595	1-qt can
	9150-00-223-4004	1-gal can
	9150-00-065-2003	35-lb pail
Hydraulic Fluid, Petroleum Base for Preservation and Operation (OHT) MIL-H-6083	9150-00-935-9807	1-qt can
	9150-00-935-9808	1-gal can
	9150-00-935-9809	5-gal pail
	9150-00-935-9810	55-gal drum

NOTE: OHT should be used wherever previous documents have specified OHC.

Hydraulic Fluid, Fire-Resistant, Synthetic Hydrocarbon Base (FRH)	9150-00-111-6254	1-gal can
	9150-00-111-6255	5-gal pail
	9150-00-111-6256	1-qt can

NOTE: OHT should be used for temperatures below -25° F.

Lubricant, Cleaner and Preservative for Weapons Systems (CLP) MIL-L-63460	9150-01-053-6688	1-gal can
	9150-01-054-6453	1-pt plastic
	9150-01-079-6124	4-oz plastic bottle
	9150-01-102-1473	1/2-oz plastic bottle

Lubricating Oil, Exposed Gears and Wire Ropes (CW IIA) VV-L-751	9150-00-261-7891	35-lb pail

NOTE: CO-75W should be used for temperatures below -25° F.

Lubricating Oil, Gear (GO-75W) MIL-L-2105C	9150-01-035-5390 9150-01-048-4593 9150-01-035-5391	1-qt can 1-gal can 5-gal can

Appendix B
Special Materials for Use in Cold Weather
(0°F To -65°F)

This appendix contains a listing of special materials available for use in cold weather. Check appropriate publications before ordering any item.

NSN	ITEM
5950-01-134-3770	Adaptor, Battery Terminal, Finned (Positive)
5950-01-134-3771	Adaptor, Battery Terminal, Finned (Negative)
5935-00-322-8959	Adaptor Connector (NATO Slave Cables)
(See CTA 50-970)	Anticontact gloves
6135-00-930-0030	Battery, Dry, BA-3030/U
6135-00-926-3503	Battery, Dry, BA-398/U
6135-01-034-2239	Battery, Primary, Lithium, BA-5598/U
7240-00-132-6431	Bushing (Gasket), Synthetic Rubber, for 5-gal Can

Cable, Battery Booster, Consisting of:

- **6145-00-705-6674** No. 1 AWG Wire (Length Needed Per Foot)
- **5940-00-047-4610** Clamp,BlacK
- **5940-00-047-4613** Clamp,Red

2590-00-148-7961	Cable Kit, Special Purpose (NATO Slave Cables)
7240-01-318-5222	Can, Cradle (5-gal Fuel Can)
7240-00-132-6433	Cap and Screen Assembly, Flexible Spout, for 5-gal Fuel Can
7240-00-125-9061	Case, Military Water Can, 5-gal
2530-01-369-9994	Cleat, Ice for T158 Track (M1 Series Tank)
5310-01-102-2711	Nut, Self-Locking for Ice Cleat

2530-00-859-7335	Evaporator, Alcohol (Vehicular Air Compressor)
4940-00-475-1574	Heating Torch, Gas (Blowtorch)
4720-00-542-3304	Hose, Natural Rubber, Yukon Stove (Fuel)
4720-00-913-5222	Additional Stock Number for Same Type of Hose
5965-00-876-2375	Loudspeaker, LS-454/U (PRC-77)
8465-00-753-6335	Maintenance Kit, Rubber Patch, VB Boot
6530-00-786-4635	Pad, Heating, Chemical
8340-00-823-7451	Pin, Tent, Stell, 12-inch
6850-00-177-5094	Silicone Compound, 2-oz Tube
6850-00-880-7616	Silicone Compound, 8-oz
6850-00-295-7685	Silicone Compound, 10-gal
5970-00-240-0620	Tape, Insulation, Electrical, Low Temp, TL-600
6630-00-105-1418	Tester, Antifreeze/Battery
6850-00-001-4194	Water-Indicating Paste
5330-01-271-7621	Gasket, Synthetic Rubber, For 5-gal Can, -60°F
3030-00-224-8357	Belting Variable Link Adjustable, 3/8-inch
3030-00-224-8358	Belting Variable Link Adjustable, 1/2-inch
3030-00-233-9126	Belting Variable Link Adjustable, 3/4-inch
5935-00-224-8368	Connector Tool for Adjustable Belt
5820-01-263-1760	Grounding Kit, Surface Wire, MK-2551A/U

Appendix C
Environmental Protection Concerns

In spite of the difficulties cold weather may present to unit operations and maintenance, leaders must remember that units are still required to comply with federal, state, local, and HN environmental regulations.

Many cold weather areas contain fragile environmental ecosystems that could be damaged significantly by spills or improper hazardous waste and materials disposal. Increased fuel consumption coupled with the use of special oils, lubricants, batteries, and the failure of equipment from low temperatures increases the possibility of environmental damage.

In light of the increased risk, it is important that leaders conduct unit environmental self-assessments prior to deploying to a cold weather area. They must ensure that the resulting risks are made part

of the unit environmental awareness training program.

An example of a unit environmental self-assessment is contained in Appendix C, TC 5-400, *Unit Leaders' Handbook for Environmental Stewardship*. The self-assessment looks at the following: management, waste-oil storage, hazardous material/ hazardous wastes, solid-waste management, spill prevention, recycle program, washracks, and land management. It is the primary tool for conducting a unit environmental assessment and should be supplemented by local regulations. A copy of *Environmental Products, Chemical Alternatives, Recyclers, Aircraft Cleaners and More*, published by the DLA, should be used to choose environmentally preferred substitutes for the fluids, fuels, lubricants, and materials listed in Appendix A.

Appendix D
Sample Cold Weather Supplement to Unit Maintenance SOP

This SOP is provided as an example only. It should be modified to accommodate specific unit equipment and local procedures.

1. REFERENCES. FM 9-207, appropriate TMs, LOs, and local SOPs.

2. PURPOSE. Establish additional procedures for the operation and maintenance of unit equipment in cold conditions.

3. RESPONSIBILITIES

a. Commander

(1) Sets unit cold weather maintenance policy.

(2) Ensures that personnel comply with the provisions of the cold weather SOP and the above references.

(3) Ensures that super-visors, operators, and mechanics receive proper training in cold weather operations and maintenance.

(4) Ensures environmental compliance and that soldiers receive proper training in environmental awareness.

b. Maintenance Officer

(1) Plans, coordinates, and supervises cold weather maintenance and recovery efforts.

(2) Ensures that adequate cold weather maintenance support is provided to the unit.

c. Motor Sergeant. Supervises maintenance personnel in the proper performance of cold weather maintenance and services.

d. Mechanics. Perform cold weather maintenance and troubleshooting IAW appropriate TMs, LOs, and SOPs.

e. Equipment Operators. Operate vehicles and equipment IAW the cold weather sections of appropriate TMs and special instructions given by maintenance personnel.

4. GENERAL. Cold weather effects on unit maintenance can be placed into two major categories: personnel and material.

a. Personnel. Major problems encountered by maintenance personnel include:

(1) Increased time to perform maintenance tasks due to bulky clothing and adverse conditions.

(2) The requirement for maintenance personnel to spend a large portion of time on self-preservation.

(3) The need to train maintenance personnel on improvising and using expedient maintenance and recovery procedures to combat cold weather.

b. Materiel. Cold weather adversely affects almost all materiels. The lower the temperature, the more adverse the effect. Specific effects include:

(1) Vehicles/equipment re-quire extra warmup time for metal parts to reach operating temperatures.

(2) Vehicles/equipment may require warming from an outside heat source before starting.

(3) Caution must be taken when loading vehicles to prevent undue stress on brittle metal parts.

(4) Rubber becomes very stiff and brittle in extreme cold and also when exposed to moderate cold for long periods. Several hours of operation or preheating may be required to soften rubber.

(5) Wiring, cable, and rubber hoses may become brittle and crack. Handle these items with care to avoid damage.

(6) Plastics contract and become brittle. Plastic windows crack easily. Use care in handling.

(7) Windows may crack if defrosted too rapidly. Never use hot water to thaw windows in extreme cold.

(8) Glass can crack when ice scrapers are used with hard or violent jabs. Use scrapers with caution.

(9) Tarps made of heavy canvas appear to shrink. It may be difficult to fold or smooth wrinkles in the canvas. Plastic tarps become brittle and cracked. Store and unfold the tarps in heated shelters whenever possible.

5. OPERATING PROCEDURES. All unit vehicle operators and maintenance personnel will comply with operational checks outlined in vehicle TMs, as well as the following procedures:

a. Before Operations

(1) Check to ensure that brakes are not frozen and can be released. The use of portable heating equipment may be required.

(2) Check springs for cracking due to metal brittleness.

(3) Ensure tracks/wheels are not frozen to the ground. Park vehicles on wooden blocks, planks, or other materials to reduce freezing to the surface. When operating tracks in snow-covered and icy terrain, it may be necessary to remove track pads, install ice cleats, or

reverse track center guides to improve traction. Also, it may be necessary to spread sand, dirt, salt, or a combination of these materials over the traveled surface to aid traction.

(4) Remove built-up dirt and ice from the suspension system.

(5) Ensure track tension has been adjusted for cold operations by increasing the amount of slack.

(6) Check vehicle oper-ators manual for inflation pressure. Ensure tires are inflated properly for operation. Deflate tires to normal pressure if pressure was increased to compensate for extended parking. Do not over-inflate tires.

(7) Ensure all carbon dioxide fire extinguishers have been winterized IAW appropriate fire extinguisher TB.

(8) When adding lubri-cants to an engine, prevent snow or ice from entering crankcase.

(9) Ensure cooling sys-tems are protected with the correct antifreeze compound.

(10) Ensure vehicle is fueled with the proper grade arctic fuel or with JP-8, as specified by the TM or appropriate TB.

(11) If engine is difficult to start, check spark plugs for ice coating due to condensation. For diesel engines check battery for proper charge to insure glow plug operation.

(12) Ensure starter drive mechanisms are clean and properly lubricated to avoid freezing.

(13) Check batteries to ensure that they are fully charged by measuring the specific gravity of the electrolyte.

b. During Operations

(1) At temperatures of -20°F to -60°F, start vehicles periodically to maintain readiness. This practice should be avoided if any other means of keeping engines operable, such as power plant heaters or external heaters, are available.

(2) Avoid idling engines if at all possible. This practice tends to waste fuel and adds to engine maintenance cost.

(3) Ensure power plant heaters are used properly and maintained IAW the appropriate TM.

(4) Operate vehicles not equipped with power plant heaters at prescribed intervals. Also ensure that portable duct-type heaters are available for engine compartment preheating.

(5) Avoid starting a vehicle by towing if at all possible. If internal parts are frozen, applying external power will not solve the problem.

(6) Check chassis and body components for ice, mud, and snow buildup. Remove buildup at every opportunity to ensure proper ground clearance and to prevent interference with moving components.

(7) Check vehicle chains to ensure they are serviceable and properly fit the tires. As chains

become loose, retighten them to prevent damaged vehicle parts.

(8) Ensure engine oil pressure is maintained for safe engine operation. Also, check vehicle oil for the accumulation of sludge which can severely damage the engine.

(9) Maintain normal engine operating temperature through the adjustment of engine compartment inlet shutters or radiator covers.

c. After Operations

(1) At the end of each operating period, and for five minutes prior to shutdown, run the vehicle engine to normalize its operation and retain oil on cylinder walls.

(2) Do not park vehicles with the brakes set since they may freeze and not release. Use chock blocks to hold vehicles in place.

(3) Never park overnight where snow has melted that day; tracks and wheels will freeze to the ground.

(4) Park with tracks and wheels on brush, cardboard, or any similar material to prevent direct contact with the ground.

(5) Protect radiators from wind, snow, and ice buildup.

(6) Ensure the fuel tank is topped off to prevent condensation buildup.

(7) Drain air tanks.

Appendix E
NBC Defense in Cold Conditions

GENERAL EFFECTS

Many effects of nuclear, biological, and chemical (NBC) agents change in the cold weather environment. All NBC protective equipment and supplies must be kept from freezing. FM 3-4, *NBC Protection*, covers NBC defense.

Severely Degraded NBC Equipment Effectiveness

Materials of protective equipment become brittle, crack, and tear easily in extreme cold. Frozen detection and decontamination solutions clog and damage equipment. Because most decontamination solutions require water, heat must be supplied when conducting decontamination operations. Agent detection reactions are slow in the cold. Great care must be taken in donning and removing protective clothing to avoid contamination. Logistics requirements increase during NBC defensive operations in extreme cold. For example, quantities of fresh, potable water and heated protective shelters may be required.

Psychological Stress

Extreme cold and high altitudes produce psychological problems that numb the intellect and degrade personal and unit security. Current knowledge prevents precise assessment of the added impact on military operations. However, casualty rates will probably increase if psychological stress slows or stops normal reaction of individuals or units to NBC attacks.

Mountainous Areas

Breathing is more difficult at higher altitudes. There is little data concerning the effectiveness of NBC equipment in the extreme cold of high altitudes. At the lower barometric pressure of high altitudes, chemical agents evaporate or sublime much more rapidly. The increased elevation may, by localized surface heating, speed the vaporization of chemical agents. Contamination may be spread quicker by greater windspeeds at higher altitudes. Contamination may collect in depressions and small valleys.

EFFECTS ON NUCLEAR WEAPONS

Cold conditions can impact the effects of nuclear weapons. Leaders must understand these effects to properly plan for the protection of their soldiers.

Blast

Below -25° F, the effective radius of a nuclear blast may increase up to 20 percent. Icepack or hardened snowpack extends the distance of static overpressure, i.e., the crushing effect of the blast. Conversely, the distances of dynamic pressure may decrease due to the soft, absorbent characteristics of drifts and other snow cover. Tundra and ice formations can break up pressure waves. The cratering effects in ice and frozen ground may be reduced to those in solid rock.

Primary and reflected blast waves and ground shock from even small yield nuclear weapons may create earthquake-like fissures, crevasses, avalanches, and rock slides as far as 30 kilometers from ground zero. Secondary effects include snowstorms, avalanches, quick thaws, and ice breakup on lakes and rivers, which can interfere with troop movement. Blast will increase damage to equipment already inflexible from cold-soaking. In heavily forested areas, blown down trees can make large areas virtually impassable to vehicles and personnel. During winter months, trees freeze and become brittle; in a nuclear blast, they can be converted into many splinter-like projectiles. Personnel in heavy, layered clothing are less susceptible to injury from flying debris.

Thermal

Cold can significantly alter the effects of a thermal blast. Due to the high reflectivity of snow and ice and the increased density of cold air, minimum safe distances may need to be increased by as much as 50 percent. Cold conditions can produce other effects, to include the following:

- Cold temperatures, cloud cover or frost, ice, and snow may reduce thermal effects on combustibles.
- When ice and snow pack melt, flash flooding may occur in low lying areas. Thawing can greatly impede troop movement.
- Snow, ice, and cold temperatures may limit destruction from post-blast fires.
- The average reflecting surfaces of muskeg, tundra, and wet conditions are characteristic of a cold region that may reduce thermal radiation.
- Ice, fog, and snow cloud cover may lessen thermal radiation from airburst detonations.
- The snow’s highly reflective surface intensifies thermal radiation.
- The dilating of pupils in winter darkness increases the chance of permanent or temporary light blindness.
- Reflective, over-white camouflage clothing and netting may reduce injurious heat absorption by personnel and equipment.

Radiation

Weather significantly influences radioactive fallout patterns. Snow can mask radiological hot spots from detection. Snow deposition is erratic due to rapidly changing winds. High winds extend radiation fallout patterns, but at the same time, may reduce radiation dose rates due to the scattering of contamination. At extremely low temperatures, the increased density of the atmosphere may reduce the distances of initial radioactive fallout by as much as 25 percent.

Contaminated snow may spread the fallout. Amounts of induced radioactivity in the soil are reduced and even prevented by deep snow. Poorly drained areas, such as meadows, limit natural flushing and may act as collecting points for radioactive contaminants. Most of the arctic is poorly drained. New snow may lessen fallout contamination of areas, permitting safe crossing by personnel and equipment.

The need for detailed radiological surveying increases in cold weather. Levels of local radiation can change quickly in windy conditions, causing *hot spots* far removed from ground zero and very low-intensity areas nearer ground zero.

The extended cold weather clothing system (ECWCS) clothing provides excellent protection from fallout. Radioactive particles may be removed by vigorous shaking and brushing of outer garments. Snow caves and below-ground shelters provide excellent shielding against radiation.

Electromagnetic Pulse

Effects are expected to be the same as in temperate zones. Electromagnetic pulse (EMP) hampers or negates radio and tactical-satellite communication for extended periods. EMP mitigating practices, such as burying and recovering cables and wire links, may be difficult or impossible because of frozen ground.

EFFECTS ON BIOLOGICAL AGENTS

Biological attacks must be anticipated. Up-to-date immunizations, acclimatized personnel, and strictly enforced personal hygiene (often considerably more difficult in the cold) are the best ways to avoid secondary spread of any infection. Vectorborne agents are rare since the vectors rarely survive. Toxins are less susceptible to the cold, and the possibility of their use by covert means must be anticipated. The survival chances of most microorganisms decrease significantly below 32°F. Layers of snow and reduced sunlight lengthen the hazard period for biological agents. Organisms may remain alive but dormant. They become active when exposed to warmer temperatures. The most effective means of biological warfare in cold weather is to covertly deliver live organisms. After a known biological attack, precautions to prevent the spread of its effects must be taken just as they would in a temperate climate.

Temperature inversions frequently found over snow fields and bodies of water tend to prolong the lives of biological agent clouds. Aerosolizing live biological agents is more difficult at extremely cold temperatures. Only some spores form bacteria, and certain viruses survive.

Tents and other areas where temperatures are higher than outside are likely areas of biological contamination spread. Once established in one person, a biological agent is likely to spread rapidly in crowded living conditions. Troops suffering from lack of nourishment or rest, or from dehydration, are more vulnerable to the effects of biological attack.

EFFECTS ON CHEMICAL AGENTS

Chemical agents are especially effective in the cold (Figure E-1). Exposure to *any* chemical agent requires masking. Conditions for aerosol dispersal are excellent. Most agents freeze at -50° F. Chemical agents, either thickened or frozen on clothing or equipment, produce deadly *off-gas* concentrations once taken into heated areas.

Blood and Choking Agents

Blood and choking agents are extremely hazardous and nonpersistent throughout low temperatures. These agents may be spread as liquids, solids, or aerosols. Masks are required whenever they are used. Hazard times may be longer. The blood agent AC is extremely hazardous, even as low as -65° F.

Blister Agents

Blister agents freeze below 0° F. They can be brushed from clothing and equipment. However, some mixtures, such as HL, remain liquid hazards at fairly low temperatures. The standard winter blister agent is a mixture of mustard and lewisite. In areas that lack water, frozen or otherwise, this blister agent persists in liquid form for up to six months. If water is present, the agent decomposes to form a pure mustard that freezes at 58°: F.

Nerve Agents

Nerve agents freeze in severe cold. However, they present a very serious vapor hazard when brought into warm areas. When used to contaminate key facilities, nerve agents become long-term hazards. These hazards may require tremendous decontamination efforts, or even waiting for a change in seasons, to reduce contamination below lethal levels. Persistency is controlled by three factors: temperature, terrain surface, and windspeed. Nerve agents, particularly VX, are effective when absorbed through the skin or eyes, but the low volatility of VX makes the vapor hazard negligible below 32&3176; F. The physical behavior of persistent nerve agents is only slightly affected by decreasing temperature. As the temperature nears 32° F, persistent nerve agents dissolve in water, have reduced vapor hazard, and increase in persistency. Nonpersistent nerve agents (i.e., GB) tend to become semipersistent, lasting from two to ten days.

NUCLEAR, BIOLOGICAL, AND CHEMICAL DEFENSE

To effectively defend against the effects of NBC weapons, four fundamentals must be applied: detection, contamination avoidance, protection, and decontamination. In a mountainous cold weather environment, the first three fundamentals become extremely important, and decontamination, always difficult and time-consuming, becomes a logistical nightmare.

AGENT	DEGREE OF CONTAMINATION	TEMPERATURE °F	TEMPERATURE °C	PERSISTENCY (HOURS)
HD (BLISTER)	MOD	>90	>34	1-3
		75-90	24-34	2-6
		60-75	16-24	6-24
		32-60	0-16	12-36
		<32	<0	48-140
	HVY	>90	>34	4-8
		75-90	24-34	12-24
		60-75	16-24	24-48
		32-60	0-16	72-168
		<32	<0	168-4032
GD (NERVE)	MOD	>90	>34	08.5
		75-90	24-34	1.8
		60-75	16-24	.5-1.06-24
		32-60	0-16	2-4
		<32	<0	4-12

		>90	>34	.5-1
		75-90	24-34	1-3
	HVY	60-75	16-24	2-3
		32-60	0-16	4-12
		<32	<0	12-36
		>90	>34	4-12
		75-90	24-34	12-24
	MOD	60-75	16-24	24-72
		32-60	0-16	46-144
		<32	<0	168-336
VX(NERVE)				
		>90	>34	12-36
		75-90	24-34	48-96
	HVY	60-75	16-24	96-240
		32-60	0-16	168-504
		<32	<0	720-1440

Figure E-1. Persistency table

Detection

Automatic detectors must be heated. Detection is vital to identifying a hazard. The vapor hazard of chemical agents may be limited, making the M-256 chemical agent detector kit unreliable. Persistent agents can freeze into solids that may not be identifiable. This creates a potential hazard that does not materialize until temperatures rise. Reagents in the M-256 chemical agent detector kit freeze and provide inaccurate readings in temperatures below -25° F. These kits must be kept close to the body to prevent freezing. Cold slows the response of M-8 chemical detector paper. Extra time must be allowed for the paper to work. M-9 paper is of little value because all the substances that react to it are affected by the cold. Extreme cold, or the physical state of a chemical agent, may make the M-8 alarm system ineffective. Every 50 to 100 feet, detection teams should melt snow, heat it to 70° F, and test it with M-8 paper or CAM. If an agent is suspected, water is taken into a heated shelter and heated until a vapor is given off above 70° F. It is then tested with the M-256A1 kit; data is recorded, reported, and plotted according to unit SOP. Contaminated areas are marked with the standard NATO contamination signs.

Contamination Avoidance

Avoidance measures prevent offering the enemy a vulnerable target and prevent accidental contact with existing contamination. To enhance unit survival, employ the following measures:

- Harden positions by improving overhead cover.
- Disperse personnel, supplies, and equipment.
- Conceal positions.
- Provide early warning.
- Develop NBC environmental discipline.
- Remain mobile.

- Keep supplies and equipment covered.

Protection

Take active measures to protect units from contamination. Specifically, employ the following measures--

- Find and destroy enemy munitions and delivery systems.
- Use NBC reconnaissance teams to monitor contamination of specific areas.
- Use the standard warning and reporting system to warn others of hazards, or to pass the alarm locally.
- Prioritize the covering of mission essential equipment.
- Build collective protection shelters to provide contamination-free work environments.

Decontamination

Decontamination (decon) is the process of making any person, object, or area safe by absorbing, destroying, neutralizing, making harmless, or removing radioactive material clinging to or around it. Deliberate decon requires extensive time and logistical support. Temperatures below 32° F limit the effectiveness of decontamination operations. Current chemical decontamination procedures that require water rinses are impossible in freezing weather. Non-water decontamination procedures have not yet been developed. Decontamination must often be done in heated facilities. To decontaminate, soldiers must--

- Perform hasty decon.
- Continue to fight after hasty decon.
- Understand the effects of chemical agents.

SHELTER CONTROL

In cold weather operations, decon and some aspects of detection must be accomplished in heated shelters. One of the most challenging problems is preventing contamination from entering warm areas. For example, frozen agents on clothing are hard to detect because low temperatures slow the effects of the agents. If the temperature rises, or if contaminated individuals enter heated areas, the frozen agents will revaporize and become hazardous. It may be necessary to set up a thawing station for each warm shelter where agents can be isolated before individuals enter the main shelters and unmask.

INDIVIDUAL PROTECTION EQUIPMENT

Use of individual chemical protective equipment presents added challenges in cold weather. Failure to take specific precautions can result in equipment failure and possible contamination.

Field Chemical-Biological Masks

Wearing the M-17 or M-40 Series masks in cold weather requires special attention to ice formation and frostbite. Masks should be carried beneath outer garments, and care should be taken to wipe dry the inside of each mask after wear. After wear, soldiers should inspect for ice buildup in the inlet and outlet valve areas. To prevent frostbite, place small pieces of tape over the exposed metal rivets of the facepiece. During periods between repeated use, take the mask out of the carrier and shake or flex the facepiece to remove ice and snow. Warm the mask when you can, but do not warm close to a heater or open flame as the rubber parts of the facepiece could melt. Dry facepiece with cheesecloth in a warm indoor area.

M-4 winterization kit. The M-4 winterization kit consists of an ice particle prefilter fitted over inlet valves to prevent frost from accumulating on the inlet caps. It also includes two inlet valves and two nose cup valves made of a relatively soft rubber that does not become hard or brittle in the cold.

Mask carriers. The mask carrier should be adjusted to be worn in a side carry beneath the cold weather parka. Body heat helps keep the mask warm and flexible, but masking is slow and difficult. Soldiers must be aware of this requirement when donning their cold weather clothing. They must ensure that the ECWCS parka is large enough to accommodate insulating layers and the gas mask with its carrier.

Outserts. Two outserts are provided with the mask to prevent fogging of the eye lenses. Green- and amber-tinted outserts can be used for bright light and fogging. Avoid wiping eyepieces with gloves when firing because they will smear.

Donning Protective Masks

Hold your breath. Remove the mask from under your parka, lower the parka hood, and don the mask. Adjust the head harness only tight enough to create a good seal. Raise the parka hood and fasten the outer garment.

> NOTE: Do not clear the mask by exhaling a large amount of air because the lens will frost. Exhale slowly and steadily. The outlet valve may stick to the seal. If this occurs, lift the outlet valve cover and rotate the disk with a finger while exhaling only. After freeing the valve, reset the valve cover. Check the mask for leaks by pulling down the cheek flaps on the ice particle prefilter while covering the inlet valves with hands. Fasten the cheek flaps and resume normal breathing.

Removing Protective Masks

Remove gloves or mittens before removing the mask. Loosen the outer garment and lower the hood. Brush snow or ice particles from the mask. Remove the mask and immediately dry your face and the inside of the mask. Raise your parka hood and fasten outer garment. Wipe the mask thoroughly before storing to prevent ice formation. Store the mask in the carrier. Put on gloves or mittens. When possible, further dry the mask by placing it in a warm area, but not in direct heat.

Wearing the Chemical Protective Overgarment

Contamination avoidance measures may fail. The enemy may find and attack with NBC weapons. Soldiers may be downwind of an NBC attack, or the mission may require them to cross contaminated areas. Protection options must be available to survive and continue the mission.

Wearing the chemical protective overgarment presents a particularly difficult operational/logistics decision that com-manders must make before entering the operational theater. The impact of mission oriented protective posture (MOPP) conditions on operations must be considered. If the ECWCS parka is not needed because of the added warmth provided by the chemical protective overgarment, store and seal it in a plastic bag. If the ECWCS is worn outside the chemical protective overgarment, it permits the layering required for added warmth. However, it requires that the contaminated clothing worn over the chemical protective overgarment be removed before entering a heated shelter where the agents can revaporize. Upon decon, the external layers of the overgarment have to be discarded. Also, once the ECWCS is donned, it is not possible to adjust the overgarment. Replacement issues of cold weather clothing are needed. Stocks of ECWCS are not adequate to support this requirement. A method of decontamination of this cold weather clothing is necessary. The chemical protective overgarment produces internal moisture and condensation and dehydration problems that can lead to hypothermia. In full MOPP gear, speed is reduced by at least 50 percent (probably greater due to buildup of condensation and the potential danger of hypothermia).

Chemical Protective Glove Set

Vapor barriers (i.e., medical examination gloves, the wool insert, and the leather shell covered by the butyl-rubber glove) make up the chemical protective glove set. This set allows the insulator (the wool insert) to remain dry and warm. If either outer glove is punctured or torn, the glove set must be replaced.

VB Boots

Vapor barrier (VB) boots are an effective and adequate replacement for the normal overboots. However, the natural rubber composing the VB boot can be penetrated by chemical agents that contain mustard gas. After 50 hours exposure, they must be replaced and turned in for decontamination or discarding.

Decon Kits

The M-258A1 decon kit is good to 32°F. It must be kept next to the body to prevent freezing. Because it assumes surrounding air temperature, the solution should be used quickly once it is opened to avoid possible frostbite. The M-13 consists of a bag of Fuller’s earth for equipment decon. It is not affected by the cold. Neither are the components of the M291 skin decontamination kit (SDK) or M295 individual equipment decontamination kit (IEDK).

NAAK M-K1

The NAAK M-K1 should be protected from freezing. At temperatures below -40° F, remove from the mask carrier and store in a parka pocket.

UNIT PROTECTION

Units must be self-sufficient in NBC defense. Cold weather conditions impose many special considerations on defense planning. For example, adjacent units may not be able to provide mutual support, logistical support may be drastically reduced, and rapid movement may become more difficult.

Bivouac Location

Because of terrain and weather restrictions, bivouac location for effective NBC defense requires considerable planning. Gullies, ravines, ditches, natural depressions, fallen trees, and caves can reduce the effects of nuclear weapons, but low-lying areas are places where toxic clouds can settle. If feasible, positions should be constructed upwind of possible threats. The heat, light, and initial radiation of nuclear blasts are absorbed by hills, while the rest is deflected up by the slope. Likely targets such as MSRs and mountain passes should be avoided. Wooded areas present a mixed blessing. Biological agents persist longer as forests retain moisture and keep out sunlight. Coniferous forests of Europe and the northwestern US reduce the possibility of liquid contamination from chemical weapons. However, the chemical vapor hazard increases.

Special Concerns for Nuclear Protection

The primary concern for nuclear protection is shielding from gamma and neutron radiation. Gamma protection requires thick layers of dense, heavy shielding such as lead, iron, or earth. Light hydrogen-based materials such as water, snow, paraffin, or oil offer good neutron protection. However, the absorption of neutrons produces additional gamma radiation. Dark, rough materials, such as wool or canvas, should be used to cover potential reflecting surfaces. These may burn or char but do not present the hazard a melted poncho would. Avoid direct contact with these materials. View ports should be covered with metal window screening material that can block thermal radiation by up to 50 percent. Smaller openings reduce the amount of initial and residual radiation that enters.

Work Rate

Dehydration injuries are likely when soldiers must perform difficult physical tasks. Soldiers become more prone to suffering subsequent cold weather injuries. Freezing air inside protective clothing, or perspiration that cannot evaporate, leads to chilling or hypothermia. Generally, soldiers in MOPP-4 conditions at 20° F need twice the time required at higher temperatures to accomplish tasks. Added supervision of work loads is necessary to prevent cold weather injuries.

MOPP Gear Exchange

If a unit becomes contaminated, decon will be done by MOPP gear exchange (gloves and overgarment only). Two complete sets of MOPP gear and waterproof bags to seal contaminated clothing per person should be available. Care must be taken with packaging the overgarment. Tears and exposure to air will degrade protective qualities. Extra suits must be provided when crossing water obstacles or conducting amphibious operations. Any contaminated cold weather clothing item must be replaced.

DECON OF EQUIPMENT

Cold temperatures can be expected to adversely affect liquid solutions, pumps, sponges, swabs, brushes, etc.

Water, the most common ingredient in decon operations, is useless if frozen. It should not be used when temperatures are so low that it freezes on contact with equipment. In these temperatures, use undiluted DS2 but remember that DS2 corrodes equipment quickly. Equipment must be replaced quickly. Because of their low freezing points, solvents such as JP4, diesel fuel, or kerosene may be used to physically remove contamination. With present technology, equipment decon problems are hard to overcome in an arctic environment.

Commanders must consider fighting dirty in cold weather areas. Fresh units can be rotated into the contaminated areas so that dirty units can move to decon stations. DS2 and STB freeze at approximately -15° F. In temperatures less than -15° F, JP4 could be used to remove contamination. This removes but does not deactivate the chemicals. The ground and equipment used to remove contaminates must be destroyed or removed properly. JP4 is also highly flammable. The large amount of static electricity in cold dry climates can ignite the fuel. There is a definite risk of frostbite when fuel contacts exposed flesh. Rinse water must be heated, or antifreeze added to the rinse solution, to prevent freezing on contact with a cold vehicle. If the vehicle cannot be rinsed, the DS2 will quickly corrode the vehicle.

Use of the chemical agent monitor is limited by the cold's shortening of battery life. Two nitrogen cylinders may be required to expend the contents of the M-11 decon apparatus at temperatures below 32° F.

Difficulties develop in dispensing DS2 as temperatures near 0° F. To overcome this

problem, the decon apparatus portable (DAP) must be warm enough for the DS2 to pump through the brush assembly. Commanders should consider positioning a contingency supply of the M-13 inside heated vehicles and develop a plan to rotate the other DAPs into heated shelters as needed.

The M-17 sanator decon apparatus has problems in cold temperatures because the system relies on a water-based decon method. Normal engine cold-soaking problems have been observed along with internal pumps, lines, etc., cracking from the expanding freezing water. This system must be used within a heated shelter.

Decon stations should be sited in built-up areas, near road junctions, at intersections of forest lanes, or where they may be approached from several directions.

Snow can be used to cover contaminated areas. However, when the snow blows away or when vehicles or personnel break through this surface, the contamination will reappear. Snow cover provides some protection if left undisturbed, but this protection is unreliable.

Unfrozen earth may not be available to make STB dry mix. Use snow in place of dirt (same proportion) in shuffle pits and for other decon purposes. Burying contaminated materials in frozen ground is difficult. Mark burned or abandoned material with standard contamination signs.

GLOSSARY

ASOAP	Army Oil Analysis Program
BFS	brake fluid, silicone
BMO	battalion motor officer
CASCOM	Combined Arms Support Command
CLP	leaner lubricant and preservative
CONUS	continental United States
CTIS	central tire inflation system
CSS	combat service support
DA	Department of the Army
DAP	decon apparatus portable
decon	decontamination
DFA	diesel fuel, arctic
DLA	Defense Logistics Agency
DOD	Department of Defense
DS	direct support
ECWCS	extended cold weather clothing system
EMP	electromagnetic pulse
EOQ	economic order quantities
F	Fahrenheit
FASCAM	family of scatterable mines
FM	field manual, frequency modulation
FMTV	family of medium tactical vehicles
FRH	hydraulic fluid, rust inhibited, fire resistant, synthetic hydrocarbon base
FSC	Federal Supply Catalog
GAA	grease, automotive and artillery

GMD	grease, molybdenum disulfide
GPS	gunner's primary sight
GS	general support
HET	heavy equipment transporter
HF	high frequency
HHLRF	handheld laser range finder high mobility multi-purpose wheeled vehicle
HMMWV	high mobility multi-purpose wheeled vehicla
HN	host nation
IAW	in accordance with
IEDK	individual equipment decontamination kit
LAW	lubricating oil, weapons
LCD	liquid crystal displays
LO	lubrication order
LSA	lubricant
MG	machine gun
MGS	missile guidance set
MIL-STD	military standard
MOPP	mission oriented protective posture
MPU	main power unit
MSR	main supply route
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, chemical
NICAD	nickel-cadmium
NSN	national stock number
OEA	oil, engine, arctic
OHT	hydraulic fluid, petroleum base for preservation and operation
PLS	palletized load system
PMCS	preventive maintenance, checks and services
POL	petroleum, oils, and lubricants
PSI	pounds per square inch

QE	quadrant elevation
RPM	revolutions per minute
RSR	required supply rate(s)
SB	supply bulletin
SDK	skin decontamination kit
SFL	solid film lubricant
SINCGARS	single-channel ground-air radio system
SOP	standard operating procedures
SUSV	small unit support vehicle
SWGS	surface wire ground system
TB	technical bulletin
TM	technical manual
TOW	tube launched, optically tracked,wire guided
TRADOC	Training and Doctrine Command
US	United States
UXO	unexploded ordnance
vb	vapor barrier
WTR	wide temperature range

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DOCUMENTS NEEDED

These documents must be available to the intended users of this publication.

Operator's manual for the specific piece of equipment, vehicle, or weapon system to be operated.

READINGS RECOMMENDED

These publications contain relevant supplemental information.

FM 90-11. *Cold Weather Operations*. (when published)

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By Order of the Secretary of the Army:

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