FM 9-207
TO 36-1-40
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FIELD MANUAL
NO 9-207
TECHNICAL ORDER
NO 36-1-40

***FM 9-207/TO 36-1-40**

DEPARTMENTS OF THE ARMY
AND THE AIR FORCE
Washington, DC, 10 August 1989

OPERATION AND MAINTENANCE OF EQUIPMENT IN COLD WEATHER (O°TO -60°)

PREFACE

This field manual provides general doctrinal and technical guidance for operating equipment and ordnance materiel under extremely harsh cold weather conditions (0° to -65°F). It is primarily designed to familiarize operators and crews with the special procedures and techniques for working in subzero temperatures. Additionally, this circular is meant to assist maintenance personnel and supervisors (motor sergeants, battalion motor officers (BMOs), and commanders) in anticipating and planning for the onset of cold weather or deployment to an arctic region. Failure to follow this guidance has caused injury to personnel and damage to equipment in addition to limiting scope and accomplishment of training exercise.

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

The proponent of the publication is Headquarters, United States Army Training and Doctrine Command (HQ, TRADOC). Submit changes for improving this publication on DA Form 2028, Recommended Changes to Publications and Blank Forms, and forward to:

Commander
US Army Ordnance Center and School
ATTN: ATSL-DTD-DLD
Aberdeen Proving Ground, Maryland 21005-5201

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

* This publication supersedes FM 9-207/TO 36-1-40, 26 January 1978.

APPENDIX A

TABLE OF ANTIFREEZE MATERIALS, FUELS, HYDRAULIC FLUIDS, & LUBRICANTS FOR USE IN COLD WEATHER (0° TO -65°F)

ITEM	NSN	CONTAINER SIZE
Additive, Antifreeze Extender, Liquid Cooling System (MIL-A-53009)	6850-01-160-3868	l-gal can l-gal plastic 55-gal drum
Alcohol, Denatured, Grade III O-E-760	6810-00-543-7415 6810-00-201-0907 6810-00-201-0904	l-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	l-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	l-gal can l-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 Preservative (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	l-gal liquid l-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: (Ethylene Glycol Monomethyl Ether) MIL-I-27686	6850-00-753-5061 6850-00-060-5312	5-gal drum 55-gal drum
(Diethylene Glycol Monomethyl Ether) MIL-I-85470AS	6850-XX-XX-XXX	
Fuel Oil, Diesel:		
Regular Grade (DF-2) VV-F-800C	9140-00-286-5284 9140-00-286-5283	55-gal drum bulk
arctic Grade (DF-A) VV-F-800C	9140-00-286-5284 9140-00-286-5283	55-gal drum bulk
Gasoline, Automotive, Combat Type II	9130-00-160-1830 9130-00-160-1831 9130-00-221-0685 9130-00-240-8201	Bulk 5-gal can 55-gal drum, 16 gal 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 l-qt can
Lubricating Oil, General Purpose, Preservative (PL-S) VV-L-800	9150-00-231-6689 9150-00-273-2389 9150-00-281-2060	l-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 l-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	l-qt ca n 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	l-qt can 5-gal can 55-gal drum
Lubricating Oil, Internal Combustion Engines, Preservative and Break-In (OE-1O) 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 l-qt can l-gal can
Lubricating Oil, Semi-fluid (LSA)MIL-L-46000	9150-00-889-3522 9150-00-687-4241	4-oz bottle l-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 9150-00-985-7246 9150-00-985-7247 9150-00-935-4017 9150-00-985-7248	8-oz tube l-qt can l-gal can 4 1/2-oz cartridge 35-lb pail
Grease, Automotive and Artillery(GAA) MIL-G-10924	9150-00-190-0907 9150-00-190-0904 9150-00-190-0905 9150-00-935-1017 9150-00-065-0029	35-lb pail l-qt can l-gal can 14 1/2-oz cartridge 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	l-qt can
	9150-00-223-4004	l-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	l-qt can
	9150-00-935-9808	l-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	l-gal can
	9150-00-111-6255	5-gal pail
	9150-00-111-6256	l-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	l-gal can
	9150-01-054-6453	l-pt plastic
	9150-01-079-6124	4-oz plasticbottle
	9150-01-102-1473	l/2-oz plasticbottle
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	l-qt can
	9150-01-048-4593	l-gal can
	9150-01-035-5391	5-gal can

APPENDIX B

LIST OF SPECIAL MATERIALS FOR USE IN COLD WEATHER (O°F TO -65°F)

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. 0** 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)

7240-00-132-6433 Cap and Screen Assembly, Flexible Spout, for 5-Gal Fuel Can

7240-00-125-9061 Case, Military Water Can, 5-Gal

2530-00-859-7335 Evaporator, Alcohol (Vehicular Air Compressor)

4940-00-475-1574 Heating Torch, Gas (Blowtorch)

4720-00-542-3304 Hose, Natural Rubber, Yukon Stove (Fuel)

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, Steel, 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-Gallon 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

ACRONYMS AND ABBREVIATIONS

BFS	brake fluid, silicone
BMO	battalion motor officer
CLP	cleaner, lubricant and preservative
CUCV	commercial utility cargo vehicle
DA	Department of the Army
DFA	diesel fuel, arctic grade
DS	direct support
EOQ	economic order quantities
FASCAM	family of scatterable mines
FIST	fire support team
GAA	grease, automotive and artillery
GAI	grease, aircraft and instrument
GMD	grease, molybdenum disulfide
GS	general support
HF	high frequency
HHLRF	hand-held laser range finder
IAW	in accordance with
LO	lubrication order
LOS	line of sight
NICAD	nickel-cadmium
OEA	oil, engine, arctic
PMCS	preventive maintenance checks and services
POL	petroleum, oils and lubricants
QE	quadrant elevation

RF	radio frequency
RSR	required supply rates
SFL	solid film lubricant
SOP	standing operating procedure
TM	technical manual
TOW	tube-launched, optically tracked, wire-guided

ARMY REGULATIONS (AR)

AR 75-1 Malfunctions Involving Ammunition and Explosives

AR 310-25 Dictionary of US Army Terms

AR 385-10 Army Safety Program

AR 385-40 Accident Reporting and Records

DEPARTMENT OF THE ARMY PAMPHLETS (DA Pam)

DA Pamphlet 25-30 Consolidated Index of Army Publications and Blank Forms

DA Pamphlet 385-1 Unit Safety Management

DA Pamphlet 750-10 US Army Equipment Index of Modification Work Orders

DA Pamphlet 738-750 The Army Maintenance Management Systems (TAMMS)

FIELD MANUALS (FM)

FM 5-25 Explosives and Demolitions

FM 9-6 Ammunition Service in the Theater of Operations

FM 21-305 Manual for the Wheeled Vehicle Driver

FM 21-306 Manual for the Tracked Combat Vehicle Driver

FM 31-70 Basic Cold Weather Manual

FM 31-71 Northern Operations

FM 90-11 Cold Weather Operations

FM 100-10 Combat Service Support

SUPPLY BULLETINS (SB)

SB 9-16 General Supply: Personal Heater and Winterization Kits Policy for Tank Automotive Construction and Material Handling Equipment

SB-11-6 FSC Class 6135: Primary Battery Supply Data

SB 700-20 Army Adopted Items of Material and List of Reportable Items

TECHNICAL BULLETINS (TB)

TB Med 81 Cold Injury

TB Med 269 Carbon Monoxide Poisoning, Etiology, Systems, Treatment and Prevention

TB 750-651 Use of Antifreeze Solutions and Cleaning Components in Engine Cooling Systems

TRAINING CIRCULARS

TC 11-6 Grounding Techniques

TC 21-3 Soldiers Handbook for Individual Operations and Survival In Cold Weather Areas

TECHNICAL MANUALS (TM)

TM 9-1300-203/2 Artillery Ammuntion

TM 9-1300-206 Ammunition and Explosive Standards

TM 9-1375-213-12 Operator's and Organizational Maintenance Manual (Including Repair Parts and Special Tool Lists): Demolition Materials

TM 9-2610-200-24 Care and Maintenance of Pneumatic Tires

TM 9-3305 Principles of Artillery: Weapons

TM 9-6140-200-14 Operator, Organizational, DS and GS Maintenance Manual, Storage Batteries, Lead-Acid Type

TM 9-8000 Principles of Automotive Engines

TM 743-200-1 Storage and Materials Handling

TM 750-116 Purging and Charging of Fire Control Instruments

TM 750-254 Cooling Systems: Tactical Vehicles

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CHAPTER ONE

INTRODUCTION

SECTION I. GENERAL

OVERVIEW

This manual tells you how to prepare, operate, and maintain ordnance materiel for operations in cold weather (0°F to -65°F). Included are:

- Tank/automotive equipment
- Weapons and related fire control equipment
- Small arms

The chapter on automotive equipment is directed primarily towards tactical vehicles; however, the instructions and techniques equally apply to commercial type vehicles.

Use this manual with a -10 or -20 series TM when operating or performing maintenance on a piece of equipment. For example, cold starting procedures for equipment vary by item. These procedures are found in the operator's and unit maintenance manuals for specific pieces of equipment. Lubrication requirements and maintenance allocation charts differ between temperate and cold regions. These differences should be reviewed and cold procedures followed.

CONDITIONS

To operate and maintain equipment in cold regions, you must understand some of the phenomena/ conditions. You cannot perform operations and maintenance in severe cold if you are not prepared.

Cold. The coldest days in the arctic regions occur in winter under clear skies with no wind. They are caused by high pressure weather fronts, where cold air seeks the lowest level, moves warm air out, and brings about a condition called *temperature inversion.* Under this condition, you may actually find warmer temperatures by moving to higher elevation. Heavy inversion also degrades Frequency Modulated communications by acting as a line-of-sight (LOS) transmission block.

Condensation. Humidity and cold air combine to cause many problems. Any opening in a piece of equipment that allows air to enter can cause a condensation problem. Training in the following areas can overcome these problems.

- Teaching radio operators to speak indirectly into handsets which prevents moisture in their breath from freezing microphones
- Rapid movement of equipment in/out of the cold.
- Use of proper lubricants.

Frozen surfaces. These hinder the proper emplacement of tie-down stakes and grounding rods. Further, frozen surfaces create unstable firing surfaces for small arms bipeds, mortar base plates, and howitzer spades. They also cause traction problems for vehicles.

Snow. In addition to causing visibility problems, snow also causes moisture problems. While snow can also lessen the concussion and blast effects of surface munitions, it can create mobility problems for vehicles.

Visibility. Blowing snow and ice fog are serious conditions which occur in the cold regions.

- Blowing snow, caused by the combination of very dry snow and cold winds, is very fine and tends to get into everything while creating a serious obstacle to observation and movement.

- Ice fog is a type of fog composed of suspended particles of ice, 20 to 100 microns in diameter. It is formed by the introduction of water vapor in clear, calm air at temperatures below -20°F. Ice fog increases in frequency with decreasing temperature until it is almost always present at air temperatures of -50°F. Ice fog requires a source of water vapor. Ice fog may form over a body of soldiers, herd of animals, bivouac areas, motor pools, air fields, convoys, and gun positions during firing.

Electromagnetic and optical conditions. The northern lights, or *Aurora Borealis,* occur more frequently as one moves north in latitude. They occur over 200 days of the year at north latitude 64° whether they are seen or not. These magnetic storms play havoc with magnetic instruments and can both increase and reduce signals in the Radio Frequency band.

- In addition to aurora, one frequently encounters optical conditions which include various mirages, rainbows, sun dogs, and looming. Only looming hinders military operations. Looming occurs when looking across flat expanses through cold, dry air. Objects under these conditions will usually appear to be much closer and higher than they really are.

- Whiteout is a condition of visibility which exists when an overcast sky prevents shadows, and snow covered terrain reflects light at about the same intensity as the sky causing the horizon to be indistinguishable and the recognition of irregularities in terrain very difficult. Only dark objects can be seen. Fog, ice fog, and blizzard conditions will sometimes create a similar condition.

- Night fighting is the rule in the northern latitudes and not the exception. Troops must be trained to operate in total darkness and total daylight. On clear, cold, windless, moonlit nights, you can see and hear exceptionally well over open snow-covered terrain. However, in a deep snow-covered forest (taiga), it becomes extremely dark. Sunrise, sunset, and the amount of useable light available for military operations becomes relative to where you are physically located or going (for example, in the taiga or in a narrow north-to-south valley, there will be very little useable light for much of the winter season).

SECTION II. COLD WEATHER EFFECTS AND OPERATIONAL PROBLEMS

PERSONNEL

One major problem facing units unfamiliar with cold weather operations is the soldier's lack of adequate training in cold weather operations and maintenance. If troops presently stationed in temperate climates are to be expected to move to cold climates and perform their mission, cold weather training is of the utmost importance.

A large portion of a soldier's time and energy in cold weather areas is expended in self-preservation. This naturally reduces the efficiency of personnel in the operation and maintenance of materiel. In addition to operating their equipment, soldiers must learn the expedients and improvisations incident to living and moving in cold regions.

MATERIEL

Operating material in temperatures down to 10°F presents few problems. Conditions are similar to those experienced in the northern portion of the continental United States during the winter.

From -10° to -25°F, operations become more difficult (Figure 1-1). At the warmer end of this range, lack of winterization will result in only a slight loss of operating efficiency. Proper training will prevent many failures of materiel as well as injuries to operators.

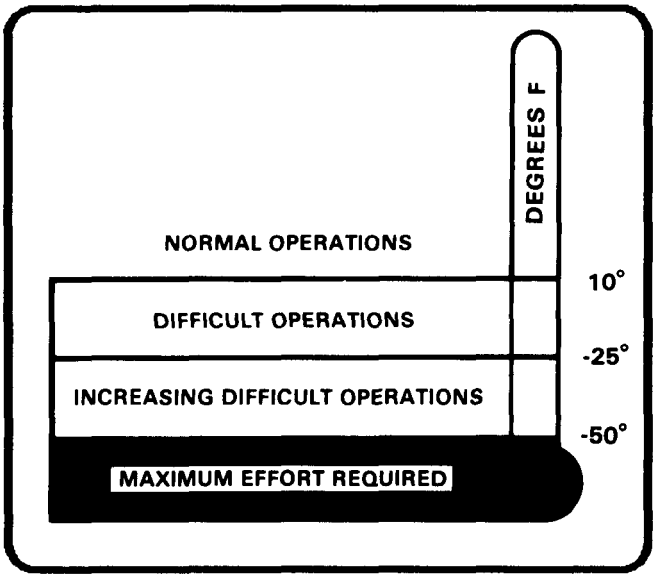


FIGURE 1-1. LEVEL OF DIFFICULTY, VS TEMPERATURE RANGE.

When temperatures drop below 25°F, operations become increasingly difficult. At temperatures in the vicinity of -50°F, the maximum efforts of well-trained personnel are required to perform even a simple task with completely winterized materiel. Nonacclimated troops will encounter difficulties at even the warmer temperatures above -l0°F.

Effects of cold weather on parts. Since metals contract at lower temperatures and expand as the temperatures increase, improper clearances may result in either binding or increased clearances.

Cleaning and preparing materiel. Before operating vehicles, crews should review appropriate operator's manuals for cold weather operations. All operator's manuals include a section subtitled *Operations Under Unusual Conditions (Cold).* Additionally, operators must know other basic skills, such as working with tire chains and slave starting.

Soldiers must maintain materiel in the best mechanical condition at all times to withstand the added difficulties and prevent failures in subzero operation. Commanders must place special emphasis on maintenance inspections.

Soldiers must carefully service various components of materiel before, during, and after each operating period in accordance with (IAW) the pertinent TM. They must promptly report all failures and repair them. Failure to give this extra service and maintenance will result in actual damage, lost time, unwarranted expense, and improper functioning.

Placing materiel in proper mechanical condition requires time for necessary and careful disassembly, repair, cleaning, and reassembly. Low temperatures must be anticipated far enough in advance to permit completion of the conditioning before the onset of cold weather.

Refer to pertinent operator and unit maintenance TMs for operation, lubrication, preventive maintenance, checks and services (PMCS), and maintenance under unusual conditions.

Initial operations. Operators must be very cautious when using materiel that has been inactive for a long time. For example, if lubricants congealed in the various components, parts could fail.

COLD EFFECTS ON MATERIELS

Metals. Metals become brittle in severe cold temperatures; thus parts cannot withstand the shock loads that they sustain at higher temperatures. Examples of such stress are illustrated in Figure 1-2.

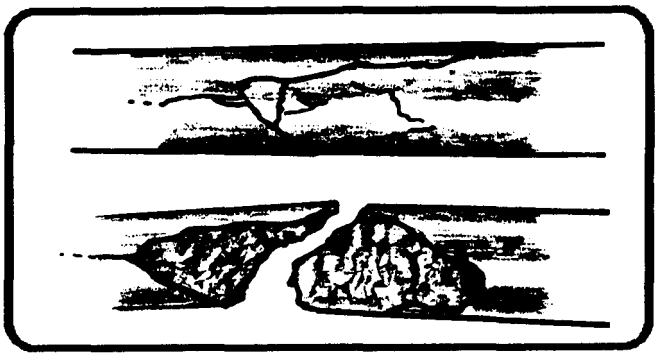


FIGURE 1-2. EFFECT OF COLD ON METAL

For example, at -20° F certain steels can stand only 50 percent of the shock load they can stand at room temperatures. For a given change in temperature, various metals will expand or contract different amounts. These characteristics will especially affect bearings in which the bearing and shaft are of different metals, parts of different type metals bolted together, and meshing gears of different metals. Special care should be taken in adjusting parts of this type for cold weather operations, especially when adjusting bearing clearances.

Rubber. In addition to natural and synthetic rubber, there are hundreds of rubber substitutes. These synthetic rubbers look and usually react like natural rubber, although most of them do not attain a greater flexibility at high temperatures. However, as it is cooled, natural rubber will gradually stiffen, although it retains a large part of its elasticity until temperatures below -20°F are reached.

Below -20°F, certain peculiarities are observed. When cooled gradually but continuously over a short time, the rubber will remain flexible until a temperature of approximately -60°F is reached; then it suddenly loses its elasticity and becomes very brittle. Furthermore, if the rubber is consistently kept at a temperature below -20°F for a long time, even though it does not approach lower temperatures, an effect similar to crystallization occurs, causing it to become brittle.

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 very brittle and break readily at low temperatures.

Tires. Tires become rigid in cold, causing flat spots on portions that come in contact with the ground



FIGURE 1-3. SIDEWALL CRACKED BY EXTREME COLD.

during shutdown periods. At severe cold temperatures, sidewalls become brittle and crack as shown in Figure 1-3.

Tires must be inflated to the appropriate pressure at cold temperatures. A tire inflated to 40 PSI indoors will change to 25 PSI when moved outside at -50°F. This can result in tire slipping on the rim and ripping the valve stem off the tube. In general, tires should be inflated in the motor pool 10 PSI over the normal pressure for winter operation.

Plastics. In general, plastics expand and contract much more than metal or glass. Any parts or materials made of plastic must be handled carefully. Many of the vehicular canvas covers have plastic windows which become very brittle and, in many cases, break due to a combination of cold and vibration.

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

Fabrics. Fabrics, in general, retain their flexibility even at extremely low temperatures provided they are kept dry. However, tarpaulins present difficulties in conforming to their intended dimensions due to shrinkage. This is usually the result of wrinkles that are extremely difficult to smooth out at subzero temperatures. Whenever possible, tarpaulins should be unfolded in heated enclosures.

SECTION III. LOGISTICAL CONSIDERATIONS

GENERAL

Frequently, vast distances, major climactic or terrain obstacles to air or ground movement, or a combination of these factors will separate combat service support elements from supported forces. As a result, logistical planning must be continuous, aggressive, and make use of all modes of transportation available. Unit's standing operating procedures (SOP) and training plans should address the following logistical considerations:

- Unit distribution will be the rule and not the exception.
- Many munitions have known firing and/or functioning limitations as a result of cold temperatures, snow, and soft ground conditions. Multi-option 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 the standard 180-day demand criterion.
- Special training and emphasis is required for use of heat sources and keeping water and other liquids (especially medical items) in a liquid state when temperatures dip below 0°F.
- At temperatures below 0°F, warm storage must be provided for power sources, command and control centers, latrines, messes, aid stations, maintenance shelters, and critical supplies such as medicines, batteries; and petroleum, oils, and lubricants (POL).

When preparing for sustained operations in the vast cold regions, logistical planners must understand the environment's conditions and the following characteristics of the cold regions:

- Year-round 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

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. Even shop maintenance cannot be completed with normal speed because the mechanic must allow the equipment to thaw out and warm up before he can make the repairs.

One important consideration in cold weather operations is the additional time required to perform tasks. This time lag cannot be overemphasized and must be included in all planning. Personnel efficiency is reduced by bulky and clumsy clothing that must be worn in extremely cold areas. Because it is dangerous to handle cold metal with a bare hand, operators/mechanics must wear some form of mitten or glove 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 requires up to five times the normal amount of time. Complete winterization, diligent maintenance, and well-trained crews are the keys to effective cold weather operations.

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

- Shelter for materiel requiring maintenance
- Proper clothing and tools for mechanics
- Adequate portable heaters
- Suitable methods to store and issue antifreeze materials, fuels, hydraulic fluids, and lubricants
- Sufficient lighting
- Supply of repair parts
- Sufficient equipment for snow and ice removal

WARNING

PROVIDE PROPER VENTILATION TO AVOID THE DANGER OF CARBON MONOXIDE POISONING CAUSED BY RUNNING ENGINES AND CONTAMINATED HOT AIR FROM DEFECTIVE HEATERS.

MAINTENANCE FACILITIES

Buildings and shelters. Heated buildings or shelters must be provided 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 will be from 25 percent to 200 percent above normal requirements.

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 A SERIOUS FIRE HAZARD.

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

Parachutes can 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.

WARNING

PERSONNEL MUST BE CONSTANTLY ON THE ALERT TO DETECT VEHICLE DEFICIENCIES THAT EXPOSE PERSONNEL TO CARBON MONOXIDE POISONING. PAS SENGER AND CREW COMPARTMENTS OF WHEELED AND TRACKED CARRIERS MUST BE INSPECTED AND TESTED IAW TB MED 269 AT REGULAR INTERVALS TO DETECT ANY SIGNS OF AIR CONTAMINATION FROM EXHAUST GASES CAUSED BY LEAKING GASKETS, IMPROPER EXHAUST INSTALLATIONS, CRACKED EXHAUST PIPES, DEFECTIVE PERSONNEL HEATERS, AND AUXILIARY GENERATORS. WHEN IDLING, ALLOW FOR FRESH AIR ACCESS TO PREVENT CARBON MONOXIDE HAZARD.

Lighting equipment. Sufficient 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 1-4).

As a minimum, a highly organized more intensive effort is required of generator/mechanics. Providing heated buildings or shelters for maintenance of materiel will increase work efficiency and morale.

An additional supply of battery chargers must be available to meet the heavy requirements for battery maintenance in subzero temperature. Soldiers must check the batteries charge using hydrometers and testers.

Handwear may become saturated with fluids when performing maintenance on fuel systems and cooling systems. This will reduce the insulating value of the handwear and possibly result in cold injury. Therefore, soldiers should carry extra handwear when performing maintenance in the field under arctic winter conditions.

Personnel should avoid leaning on cold-soaked equipment or kneeling and lying on the ground. Rapid body cooling caused by heat transfer to the equipment or ground may result in cold injury.

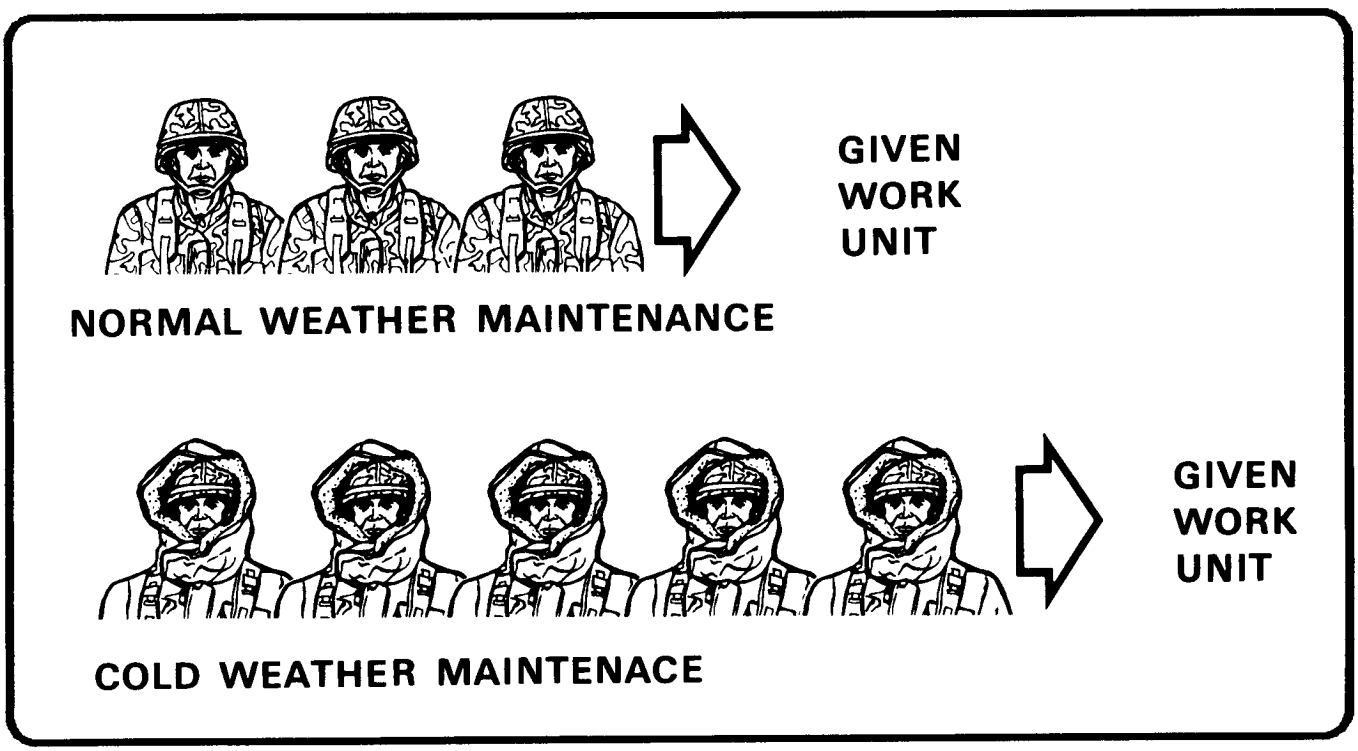


FIGURE 1-4. NORMAL VS COLD WEATHER MAINTENANCE.

The mechanic should place insulating material, such as fiber packing material, corrugated cardboard, rags, or tarpaulins between himself and the cold-soaked equipment.

When performing maintenance under arctic winter conditions, a box or pan should be used to hold small parts and a tarpaulin should be placed under the vehicle to catch parts which may be dropped. This prevents the parts from becoming lost in the snow (Figure 1-5).

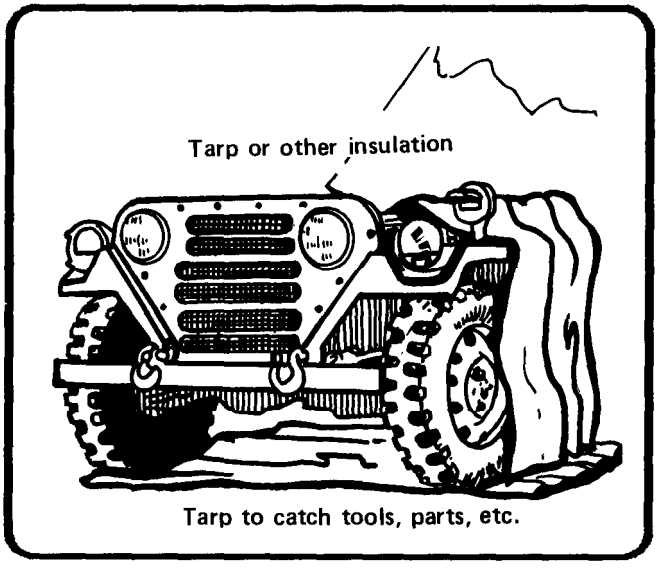


FIGURE 1-5. TARPS USED TO PROTECT FROM COLD AND TO CATCH DROPPED PARTS.

SECTION IV. ANTIFREEZE, FUELS, HYDRAULIC FLUIDS, AND LUBRICANTS

GENERAL

Antifreeze. The antifreeze materials specified for protection of liquid-cooling systems for operations in cold weather are listed in Appendix A.

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

Hydraulic Fluids. Hydraulic fluids specified for hydraulic systems, recoil mechanisms, and equilibrators are listed in Appendix A.

Lubricants. Lubrication required for Army equipment is specified in the lube orders or TM pertinent to the equipment. Lube orders are based on three an-

ticipated ranges: above 32°F, from + 40° to -10°F, and from 0° to -65°F.

NOTE: Oil, engine, arctic (OEA), is a synthetic SW20 lubricant intended for temperature range 100°F to -65°F. This lubricant is approved for use in engines, power steering systems, hydraulic systems, and both automatic and standard transmissions.

MATERIALS

The materials normally required in preparing equipment for operation in cold weather are indicated in Appendix B. These items are listed in Department of Defense Federal Supply Catalogs, FSC Group 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.

DEPARTMENT OF THE ARMY (DA) LUBRICATION ORDERS

The provisions of DA LOS are mandatory and will be adhered to at all times unless deviation is authorized by DA.

Increased service scheduling from that specified on LOS will be necessary to compensate for cold conditions that destroy the protective qualities of the lubricant. The commander may extend intervals during inactive periods, provided adequate preservation continues.

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 NATO and military symbol, the national stock number, specification nomenclature, and so forth.

SECTION V. BATTERIES

GENERAL

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

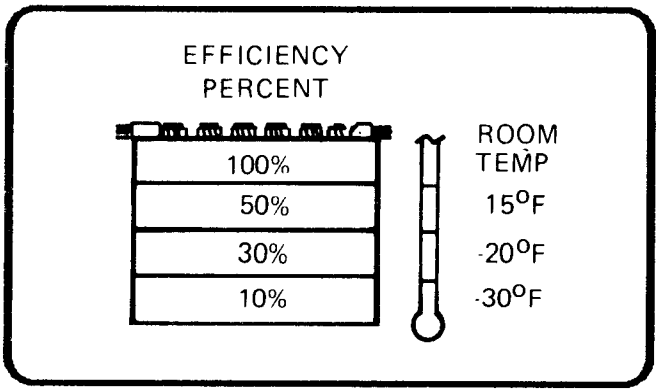


FIGURE 1-6. BATTERY EFFICIENCY AT VARYING TEMPERATURES.

VEHICLE BATTERIES

The storage battery is adversely affected by cold; its available energy decreases sharply when the temperature falls. Engine starting requirements, so far as current and voltage are concerned, are most severe when the battery is capable of delivering the least power. Current delivered at 15°F will be only 50 percent of that which would be produced at normal temperatures; while the amount delivered at 30°F will be only a little over 10 percent of that which would be produced at room temperature (Figure 1-6).

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

Frozen batteries rupture and break internally and externally. Table 1-1 shows freezing points of batteries at various specific gravities. Unless the storage

TABLE 1-1

FREEZING POINTS OF BATTERIES AT VARIOUS SPECIFIC GRAVITIES

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

battery is warmed to about 35°F, it will not receive an adequate charge from the generator. In constant cold weather, storage battery/batteries should be tested for state of charge every three days. Recharge the battery if the specific gravity is less than 1.1250.

If the vehicle is equipped with a 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 of time. Batteries should be filled with 1.280 specific gravity electrolyte, not the tropical electrolyte of 1.250. Deployment of tactical vehicles from a hot region to a cold region will require a change in electrolyte for maximum battery effectiveness.

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

CAUTION: One of the by-products of this procedure is hydrogen gas, which can cause the battery casing to explode due to blockage of the battery vent by ice. See Figure 1-7 for proper jump starting procedure.

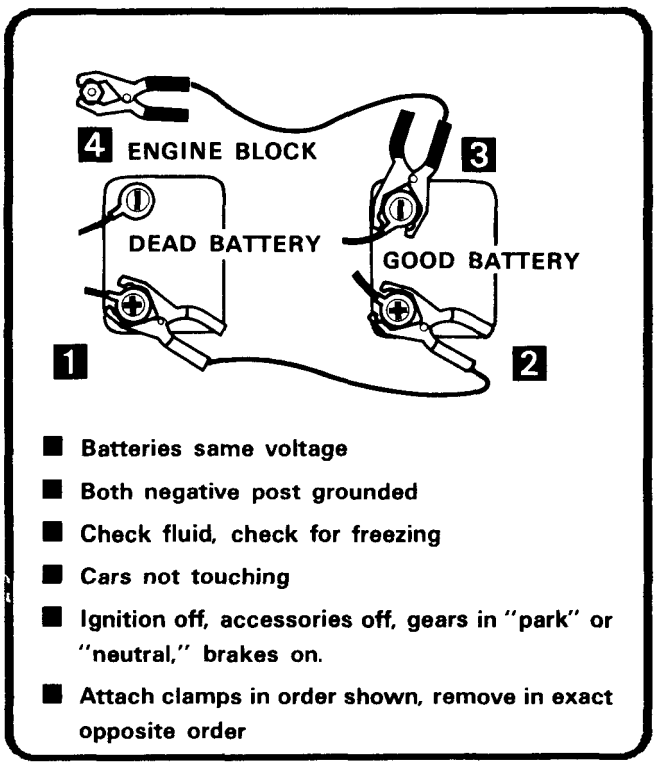


FIGURE 1-7. PROPER JUMP START PROCEDURE.

SMALL EQUIPMENT BATTERIES

For small equipment, alkaline batteries are far superior to the 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-419 (Oct 87) pg 10 for additional information).

NICKEL-CADMIUM BATTERIES

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

To get maximum effectiveness when charging NICAD batteries, one must destroy the *charging memory* characteristic of the battery. For example, if a NICAD 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. Operations must discharge the 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.

USE OF LITHIUM SULPHUR DIOXIDE BATTERIES

The lithium sulphur dioxide battery is recommended or use in the AN/PRC-77 and 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, and does not require special heating devices as do other types of batteries such as the magnesium battery.

SECTION VI. WINTERIZATION EQUIPMENT

GENERAL

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 SB 9-16.

Where the temperature falls only a few degrees below freezing for a short period of time, only ordinary preparations are needed such as changing engine oil to lighter grade and adding antifreeze to cool ant.

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

PERSONNEL HEATERS

Generally, vehicles using gasoline as fuel provide ample heat through personnel hot-water heaters until ambient temperatures drop below -25°F. Below these temperatures, fuel burning heaters are generally 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 causes carbonizing of the wick, igniter, burner, related burner components, or heat exchanger, accelerating heater failure. Contaminated fuel can block the flow of fuel to the heater burner causing low heat output and/or numerous heater stoppages, which can lead to premature igniter failure due to excessive start attempts.

The fuel burning heaters have a fairly low statistical mean time between failure because of:

- Contaminated fuel
- Low voltage
- Inexperienced operator and mechanic
- 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, the main problems with these heaters are:

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

Excessive current draw. Because the heater uses current during its run cycle, after a prolonged period of running, the battery may not have enough charge remaining to start the engine.

PORTABLE FUEL BURNING HEATERS

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

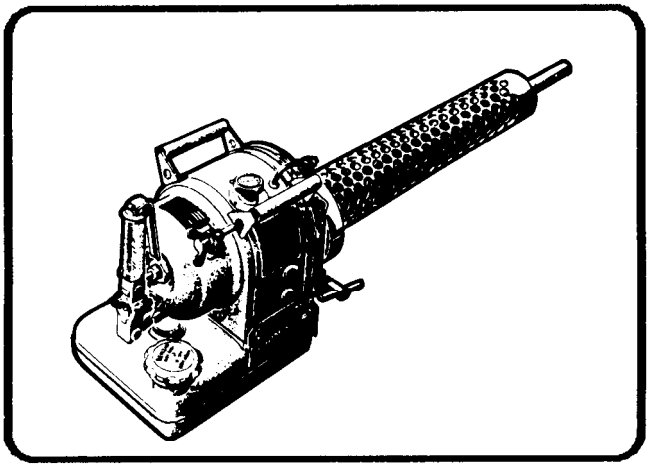


FIGURE 1-8. SWINGFIRE HEATER (NATO STANDARD).

The swingfire heater (Figure 1-8) is a pulse jet engine that burns gasoline, with less carbon buildup. It uses no external power in the run cycle and requires only 6 amperes at 24 volts for starting.

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

HARD-TOP CLOSURE KIT

A hard-top 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.

POWER PLANT HEATING SYSTEM

Quick heat system. Quick heat is a technique which allows quick warm-up and reliable starting when vehicle temperatures have dropped as low as the existing ambient temperature. Just prior to vehicle operation, sufficient heat is applied to the engine, batteries, and components raising their temperatures sufficiently to ensure reliable starting.

The time from initiation of quick heat until achievement of 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 permit the vehicle components to fall below a certain minimum temperature, regardless of the sent temperature. To accomplish this, the fuel burning heater is continuously operated during the standby period to maintain engine and battery electrolyte temperature at a level which provides 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 of time in subzero temperatures (-25°F to -65°F). However, in an emergency situation, the standby system can assist in obtaining an engine start if adequate time and auxiliary power is available.

AUXILLARY POWER (SLAVE) RECEPTACLE

This electrical outlet, located at some readily accessible place on the vehicle, receives current from other tracked or wheeled vehicles. This provides direct boosting of the cold vehicle battery current when starting an engine in cold weather. See Figure 1-9 for sample auxiliary power receptacles.

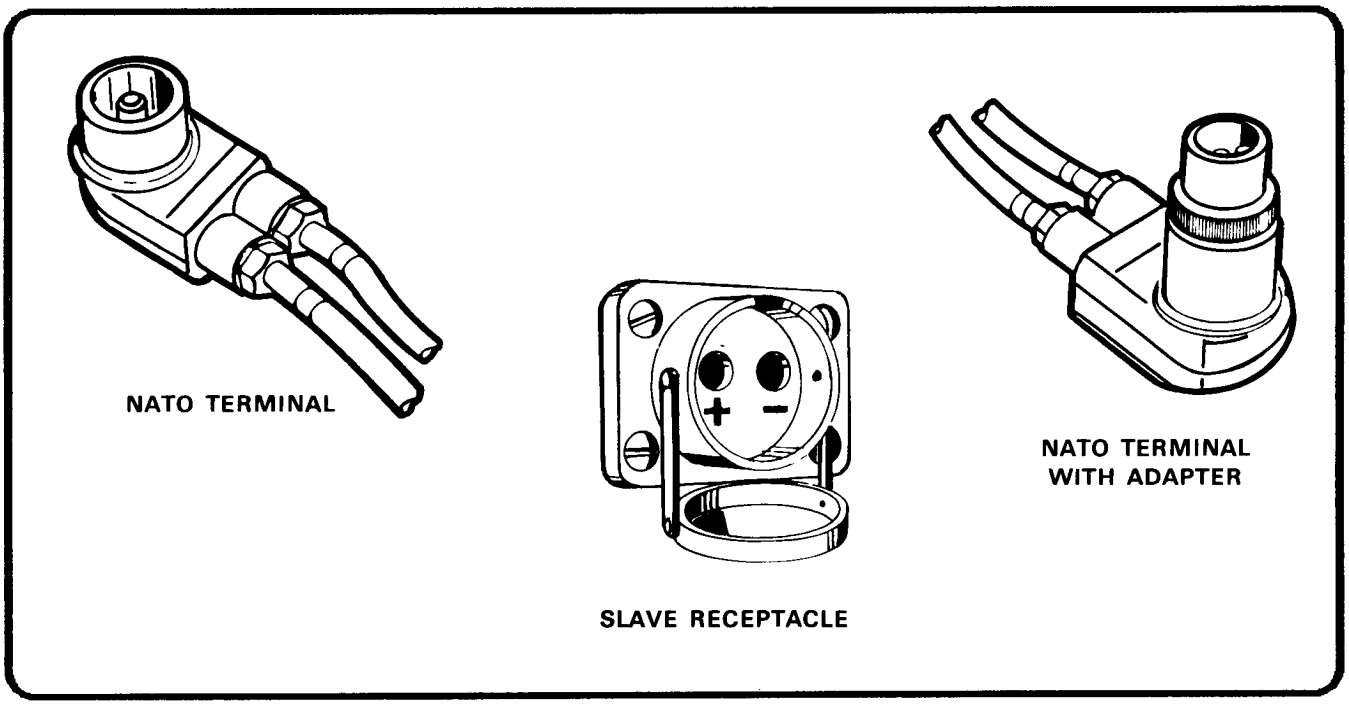


FIGURE 1-9. AUXILIARY POWER (SLAVE) RECEPTACLE AND TERMINALS.

CHAPTER TWO

PREPARATION FOR OPERATION

SECTION I. CHASSIS AND BODY COMPONENTS

GENERAL

Description. The component parts covered in this section are wheel bearings, brakes, shock absorbers, steering gear, tracks and track suspension, wheels, tires, springs, and cab closures.

- Air brakes. Frozen moisture in the air brake system will seriously affect operation. Brake lines, air brake filters, brake chambers, push rods, valves, and seals are subject to 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.

- Shock absorbers. Shock absorber fluid congeals in subzero temperatures, resulting in a hard ridinig vehicle or broken shock absorber.

- Steering gear. Improper lubricant will congeal making steering difficult or impossible. Hydraulic power steering reservoirs should be filled with hydraulic fluid, petroleum base, (OHT), or oil engine arctic (OEA), and not Dextron II.

- Track suspension wheels. Improper lubricant stiffens and extra power is required to obtain motion.

- Tracks. Ice and snow adhere to tracks, hindering operation. Cold contracts metals and makes rubber brittle. When operating in snow-covered and icy terrain, track pads may be removed at the commander's discretion and/or traction aids (such as reversing every third track center guide) employed.

- Tires. At -50°F tires become rigid enough to support a load at 0 pressure without apparent deflation. Sidewalls become brittle and crack. The valve stem on tubes can break if the tire is under inflated and the tire rotates on the rim.

- Springs. Springs break easily, as metal becomes extremely brittle at low temperatures.

- Cab closures. Operation is hampered unless soldiers are protected against subzero temperatures and wind by adequate clothing and cab closures.

PREPARATION FOR OPERATIONS

Wheel bearings. Inspect bearings 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 reservoir for proper 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. 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 open position. In the morning, build up pressure before moving vehicle. Make certain that the alcohol evaporator jar is filled with alcohol. During scheduled service, clean brake pads. Remove oil and grease from units to avoid hardening and splitting. This will help to ensure a good air seal under pressure.

CAUTION: Drain water from air filters and reservoirs after every 8 hours of continuous operation.

Steering gear. Examine arms, tie rods, drag links, seals and boots, pitman arm, gear column, and wheel for good condition and secure mounting. Ensure gear case is not leaking and gears are properly adjusted. Drain and refill gear cases with lubricating oil (G075W).

Shock absorbers. Make certain shock absorber bodies are securely mounted to the frame. Replace if shock absorbers are leaking or if action is unsatisfactory.

Track and suspension. Remove dirt and ice and inspect for good condition and proper lubrication for severe cold weather operation. Check track adjustment. Do not adjust tracks too tightly in a warm shelter, since they will contract and break easily in temperatures of -40°F and below. Adjust track so that slack is 50 percent greater than that specified for normal operation in applicable vehicle TM (Figure 2-l). Another method is to allow vehicle and track to cool to outside temperature before making adjustments.

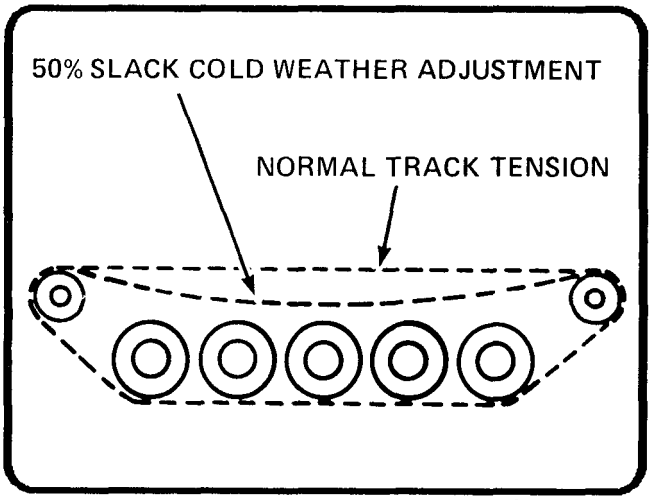


FIGURE 2-1. COLD WEATHER ADJUSTMENT.

NOTE: Field adjustments made on a cold vehicle while, it is operating under severe cold weather conditions, should allow only the normal amount of slack specified for temperature operations.

Tires. Check valve stems, and tighten core. Replace core if rubber seal is brittle or shows wear. Examine tire casing for cuts, bruises, or breaks. Caps must be installed on all valve stems. Increase tire pressure approximately 10 PSI as shown in the appropriate TM to compensate for the cold effects on tires for overnight or extended parking. Tires should be deflated to proper pressure before operations.

Springs. 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 securely. Tighten all assembly and mounting bolts.

Cab closures. Note whether mountings are secure and in good condition. Replace broken windows. Make certain that closures are tight fitting.

Fire extinguishers. All carbon-dioxide fire extinguishers will be winterized IAW the appropriate fire extinguisher technical bulletin.

SECTION II. POWER TRAIN

ENGINE.

Lubrication system. Using ordinary engine oils will increase the fluid friction of the oil on cylinder walls and bearings to the extent that it is not possible to crank the engine with the ordinary storage battery. Using lubricating oil (OEA) prescribed for cold weather operation by the LO will eliminate the above condition, and afford adequate lubrication 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 will eliminate disassembly of components for lubrication when low temperatures are encountered. OEA has been approved for use year round except in hot climates.

General procedures for preparing the lubrication system for cold weather operation 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 crankcase when lubricants are added. Use only newly opened cans of oil. This will 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 applicable operator's TM or LO. Run engine for 10 minutes and check for oil leaks. Stop engine and wait 1 to 5 minutes before checking oil level. This will be an approximate reading 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 is encountered, drivers will not change or vary their operation of the vehicle. Lubricant levels and lubrication points, however, will be closely observed and proper steps taken to replenish lubricants when required. Instructions in pertinent LOS will apply when a definite change to higher environmental temperatures is expected, such as a change of seasons (Table 2-l).

NOTE: When engine oil (SAE 10 or OE/HD010) is prescribed for gear cases, drain and fill with lubricating oil (OEA) or gear oil (GO75) as prescribed by pertinent LO.

TRANSMISSIONS

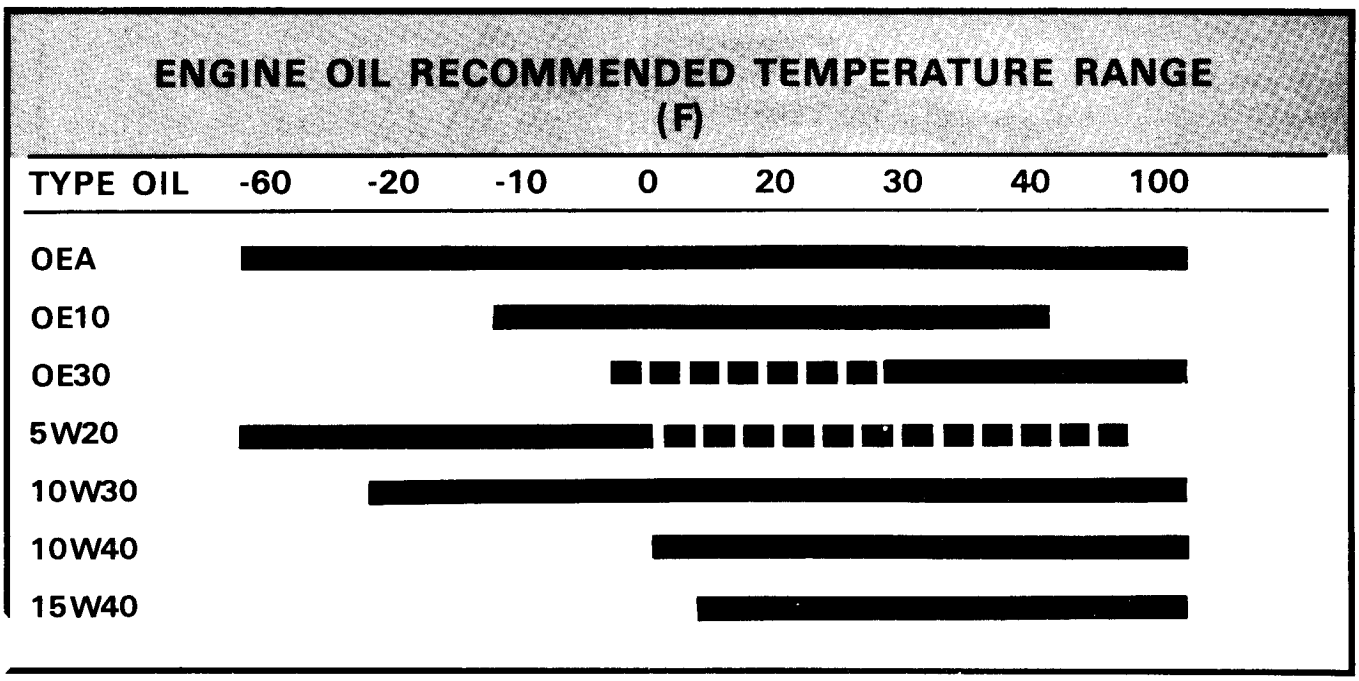
All transmissions will be drained, flushed, and completely refilled with lubricant prescribed in applicable LO.

COOLING SYSTEM

Liquid cooling system. For temperature range of 32°F and colder, cooling systems will be protected with antifreeze compound, ethylene-glycol, inhibited, heavy-duty single package (MIL-A-46153).

Cooling systems containing no ethylene-glycol-water or arctic anti- freeze solutions will be drained and flushed, if required, prior to the advent of freez-

TABLE 2-1



ing temperatures. Soldiers will then add the correct antifreeze solution.

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 will be inspected to be sure none are obstructed. If any drain hole has become obstructed by foreign material, a soft wire should be used to clear the obstruction from the hole to permit complete drainage.

Before adding antifreeze compound, it is necessary that the cooling system be clean and completely free from rust. The system will be cleaned with cleaning compound, using approved methods IAW TB 750-651, only if required.

Inspect and replace all deteriorated cooling system hoses and radiator cap gaskets. Hose clamps, plugs, and petcocks are inspected and tightened if necessary. Repair radiator leaks before adding antifreeze compound. Correct any exhaust gas or air leakage into the cooling system.

If there are any signs of coolant leakage at the cylinder-head, check the cylinder-head nuts for specified torque in the applicable TM. Replace the cylinder-head gasket if necessary. Check the applicable TM because 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:

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

The tag or stencil 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.**

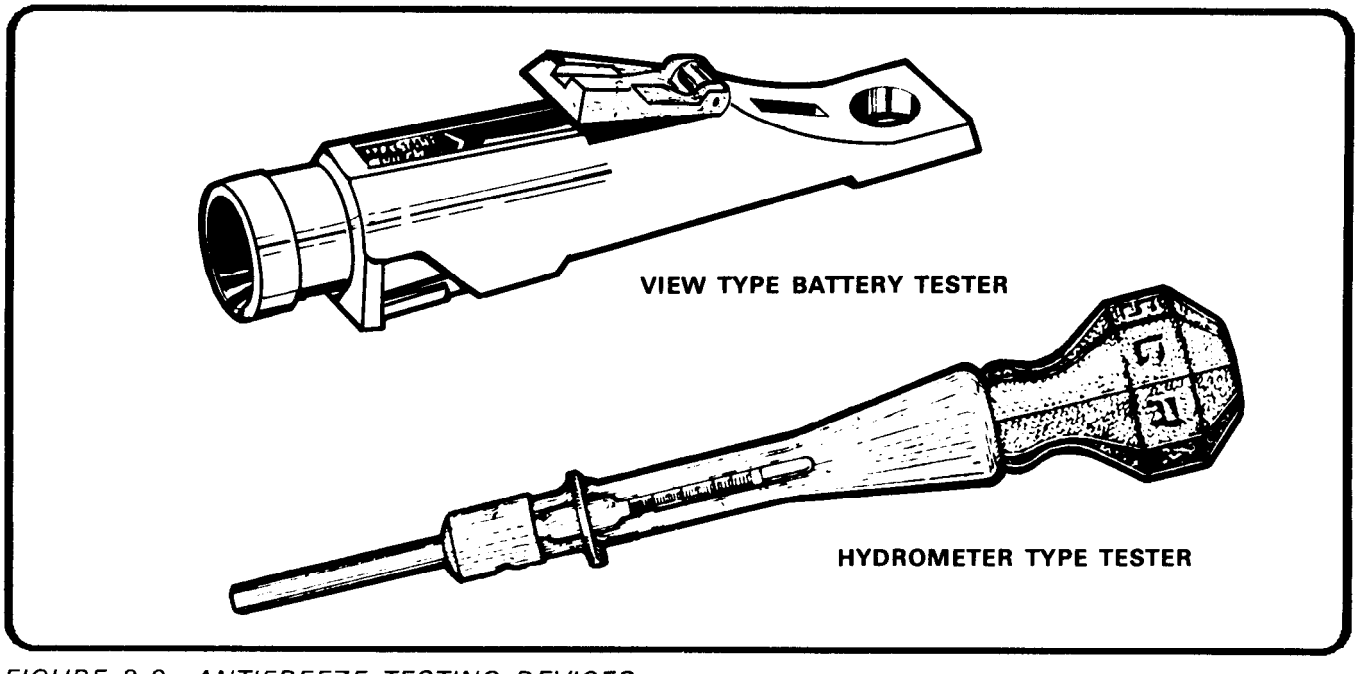


FIGURE 2-2. ANTIFREEZE TESTING DEVICES.

TABLE 2-2

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.

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

Air-cooled system. Since an air-cooled system does not employ a liquid coolant, it is often assumed that air alone acts as the cooling medium. This is not true, since the lubrication system also helps in cooling the engine and a transmission 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 as they do so. 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 System

For a satisfactory start, the engine fuel must be sufficiently volatile 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, will

provide only sufficient vaporized fuel for starting at a minimum temperature of approximately 0° F.

Diesel engines are particularly difficult to start in cold weather. Many fuels such as DF2 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 grade (DFA), does not contain as much wax and performs well in cold regions. JP 8 is a good low temperature diesel fuel, but consult the appropriate TM to determine if it can be used without excessive fuel injector pump wear.

Water will accumulate in tanks, drums, containers, fuel pumps, and carburetors because of condensation of water from the air. At low temperatures, this water will form ice crystals that will clog fuel lines, fuel filters, fuel pumps, injector nozzles, and carburetor jets.

NOTE: Fuel filters should be cleaned or changed at frequent intervals. Experience may indicate a requirement for 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 filter.

Preparation for operation. The general instructions listed below will be followed to prepare fuel system 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 methanol, technical, to gasoline. Additives will be mixed 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 additives in greater proportions than 2 pints of additive to 40 gallons of fuel will result in poor engine performance and possible engine damage.

Remove and service all engine and air compressor air cleaner ele- ments, 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 low-pressure air or with 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 as necessary.

TABLE 2-3

FUEL AND ADDITIVES

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

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

UNIVERSAL AND SLIP JOINTS

Thoroughly lubricate joints with grease, molybdenum disulfide (GMD)

SECTION III. ELECTRICAL SYSTEM

GENERAL

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

The breaker contact-arm bushing will freeze on its pivot unless it is clean and properly lubricated. This freezing prevents the breaker arm from returning when the cam separates the points. Improper oil or excessive dirt will cause automatic advance mechanisms on distributors to become inoperative.

Low temperatures will aggravate unsatisfactory performance of magnetos, due to pitted or unclean breaker contact points.

Ice caused by condensation will coat spark plugs and may prevent starting of engines.

Oil or dirt on brushes or commutator will cause unsteady or low generator output.

Contraction of the helical springs in subzero temperatures will affect generator regulator adjustments. This may result in high voltages.

Electric heater motors may operate unsatisfactorily when lubricant congeals in bushings at low temperatures.

Insulation on low and high tension cables may crack. Besides being a safety hazard, this condition can deteriorate overall equipment performance.

PREPARATION FOR OPERATIONS

Follow procedures below to prepare the electrical system for cold weather operations.

- Storage batteries. Battery capacity is greatly reduced by low temperatures, because the electrolyte is less active. To prevent freezing, operators must keep batteries fully charged in cold weather. Check specific gravity of the electrolyte to determine the state of charge of the battery.

- One of the best methods of testing specific gravity is with a visual battery/antifreeze tester. 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 required to take an accurate reading.

- To test battery electrolyte, close the plastic cover and put a few drops of the electrolyte onto 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. Liquid sample will divide scale showing light and dark area. Read scale at dividing area. 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, but the float will only measure the actual density of the solution without taking into account the temperature variations that make the electrolyte contract and expand. So, in cold weather a specific gravity reading must be corrected to a temperature of 80ºF. 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 80ºF.

Ensure batteries are initially filled with electrolyte of 1.280 specific gravity to minimize starting problems in temperatures below O°F. 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 specific gravity reading is corrected to 80°F (corrected reading 1.220). Preferably a battery should be above 20°F in order 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).

CAUTION: Add water to battery only when vehicle is to be immediately operated for 30 minutes or more.

Spark plugs. Clean spark plugs or replace as needed. Adjust gap 0.005 inch less than recommended by the applicable vehicle TM.

SECTION IV. AUXILIARY

GENERAL

Auxiliary equipment supplements standard components of a vehicle and aids in its operation. It also provides for extra or special functions. The auxiliary equipment discussed in this section includes:

- Air compressors
- Auxiliary engines and generators
- Power take-off assemblies
- Winches

Air Compressors

An air compressor is an engine-driven device used to compress air to predetermined and controlled pressures for use in air-brake and air-hydraulic brake systems on vehicles.

Moisture from condensation may freeze within the compressor. Follow after-operation maintenance procedures by draining condensation from the air compressor tanks. Report immediately if bleed valve is frozen. Some 900 series vehicles (M911 / 977) use air driers in the air brake system and must be checked for frozen vapors in the drip tube.

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

Preparation for operation. 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).

The crankcase of the self-lubricated air compressor must be drained, flushed, and filled to the proper level with lubrication oil (OEA).

Disassemble air strainer, wash and clean strainers, and reassemble.

NOTE: If oil-bath-type air cleaner is used on 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 pertinent vehicle TM. The engine coolant system must be adequately protected with antifreeze compound. Inspect compressor for any leaks.

AUXILIARY ENGINES AND GENERATORS

General. The auxiliary engine and generator is 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. Prepare the auxiliary engine, generator, spark plugs, and magneto in a manner similar to the main engine and pertinent components. An assist to starting air-cooled engines is to preheat the intake manifold using a propane type torch prior to starting. This technique should be used only on engines without ether injection, and may be the only successful method of starting generators and Herman Nelson heaters in temperatures below -25°F.

POWER TAKE-OFF ASSEMBLIES

Power take-off assemblies are usually mounted on the side of the transmission and sometimes 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 (e.g., earth-boring machine and crane.)

Effect of cold. Improper lubricants will solidify, making operation of the power take-off difficult or impossible.

Preparation for operation. As the power take-off operates from the transmission or transfer, the lubricant will be that specified for subzero temperatures for these units. Drain the gear cases while warm and fill with prescribed grade of gear lubricant.

WINCHES

Front winch. A front winch is mounted at the front of the vehicle, to frame side members, and is driven by a drive shaft connected to a transmission power take-off.

Midship winch. A midship winch is usually mounted behind the vehicle cab and is chain-driven from a pillow block assembly. The pillow block assembly, in turn, is driven by a drive shaft from the transfer, power take-off output shaft.

Rear winch. A rear winch is mounted on the rear of the vehicle. It can be chain, electrically, hydraulically (the most widely used method), or gear driven.

Hydraulically operated winch. A hydraulically operated winch is located in a position which enables winching operations to be performed from either the front or rear of the vehicle. Hydraulic pressure to operate the winch is supplied by a hydraulic pump driven by the transfer.

Effects of cold. Improper lubricants will solidify, making operation difficult or impossible.

Since the ability of metals to withstand shock loads becomes less as the temperature drops, cables and winch components will break if extreme care is not exercised.

Preparation for operation. Remove mud, dirt, and rust from exterior of winch. Inspect cable for rust and apply lubricating oil (POS). Flush and clean gear housing, and fill to level with recommended seasonal gear oil (G075W). Inspect safety brake for satisfactory operation. Check drum brake and adjust if necessary. Also check for iced bleeder and selector valves, controls and linkage, and winch cable sheaves.

CHAPTER THREE

OPERATING AND MAINTENANCE PROCEDURES

SECTION I. OPERATING VEHICLE ENGINES IN COLD WEATHER

OPERATING AND IDLING OF VEHICLE ENGINES

At temperatures of -20°F to -60°F, operators may have to start vehicle engines periodically to maintain them in a readiness condition. However, this should not be done if any other means are available to ensure engines are operable, that is, power plant heaters, external heat, and so forth.

Before commanders authorize periodic starting of engines, they must consider available fuel supplies and must establish a starting schedule to make certain engines are not allowed to run continuously.

Experience determines intervals of a starting schedule. Factors such as ambient or expected temperatures, vehicle condition, and readiness conditions also influence the starting schedule. The following must also be considered:

- Vehicles should only be cold started using the procedures outlined in the appropriate unit maintenance manual. Carefully read and follow the instructions for operation of the vehicle under unusual conditions (cold) found in the -10 series TM. This is particularly important in operation of both the engine starter and induction manifold. Although most equipment publications contain cautions relative to the time of engine starter engagement, it is sometimes necessary to exceed the recommended starter time. This is due to the cold starting characteristics of most internal combustion engines. Specifically, if a starter time limit is 30 seconds and engine firing is intermittent during cranking, it may be prudent 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 be sacrificed to maintain operational readiness of the vehicles.

Idling limitation. Vehicle engine idling is a wasteful and hazardous practice. It has detrimental effects on supply, tactical missions, and safety for the following reasons:

- Increases fuel consumption.
- Discharges batteries.
- Dilutes oil in crankcase.
- Causes excessive and unnecessary engine wear.
- Causes spark plug fouling.
- Causes carbon monoxide hazards.
- Is detrimental to concealment and camouflage.
- May cause excessive engine overheating.

Vehicle engines, except multifuel and diesel, must not be idled for excessive periods (never longer than 5 minutes) while vehicles are awaiting, discharging, or receiving passengers.

Vehicle engines must not be idled to operate personnel heaters.

Vehicle engines must not be idled to eliminate starting difficulties. Rely on efficient vehicle and power plant heater maintenance to eliminate starting problems.

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

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 warmup, an engine speed of 1,000 to 1,200 RPM, or as prescribed in 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 WITH THE NECESSITY FOR CLOSED HATCH DOORS. TO MINIMIZE THIS HAZARD, POSITION VEHICLE, WHEN POSSIBLE, SO THAT WIND WILL CARRY FUMES AWAY FROM CREW COMPARTMENT AND 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 WHEN THE TACTICAL SITUATION PERMITS.

Operation of vehicle engines equipped with power plant heaters. Vehicles equipped with liquid-cooled engines are provided with power plant heaters that 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 appropriate TM before operation.

Operation of vehicle engines not equipped with power plant heaters. Tanks and cargo tractors not equipped with power plant heaters must be operated at 1,000 to 1,200 RPM at intervals prescribed below when climatic and tactical conditions dictate. When temperatures fall below -20°F, engine compartments must be preheated using portable duct type heaters. If batteries are located in the engine compartment, slaving should not be required after preheating is completed.

When the temperature falls below -20°F, vehicle engines must be operated at intervals to ensure equipment is ready. Intervals between engine operations depend upon wind speed and temperature. Operate engines a minimum of 20 minutes each 2 1/2 hours.

Vehicles equipped with radios. Radio equipped vehicles that are in use should keep the engine operating at approximately 1,200 RPM to maintain a satisfactory battery charge. If these procedures are not followed, the high discharge rate necessary to operate heaters and radio equipment will disable the vehicle in a very short time due to dead batteries.

Radio-equipped vehicles must have the following warning stenciled in letters l/4-inch high on the instrument panel near the ignition switch: SHUT OFF ELECTRIC ACCESSORIES PRIOR TO STARTING (Figure 3-l).

Vehicle mounted radios must be marked with the decal provided for this purpose which reads.

WARNING

RADIO SET MUST BE TURNED OFF BEFORE STARTING ENGINE TO PREVENT DAMAGING ELECTRONIC EQUIPMENT

NOTE

INSTRUCTIONS CONTAINED IN WARNING NOTICES ABOVE WILL BE STRICTLY ADHEREED TO IN STARTING AND OPERATING RADIO EQUIPPED VEHICLES.

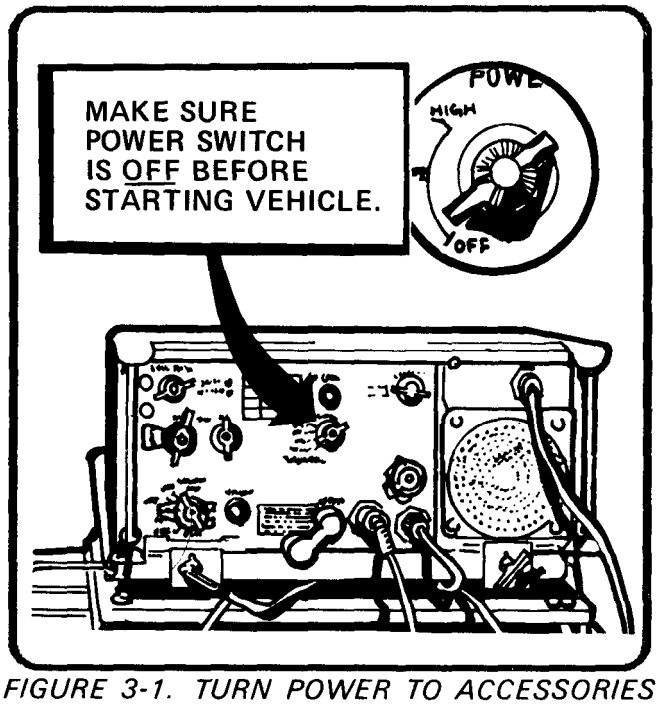


FIGURE 3-1. TURN POWER TO ACCESSORIES OFF BEFORE STARTING VEHICLE.

STARTING ENGINE WITHOUT TOWING OR WITHOUT USING AUXILIARYPOWER (SLAVE) RECEPTACLE.

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 necessary ignition current to the spark plugs. The fuel is often insufficiently volatile to supply proper fuel-air mixture to combustion chamber.

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

- The viscosity of the engine lubricating oil must permit 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 requiring lubrication.
- The battery must be fully charged and sufficiently warm to supply enough current to crank the engine and to supply the necessary spark for ignition.
- The ignition primary and secondary circuits must be clean and free of cracks, frost, and moisture to prevent shorting or current leakage.
- The distributor breaker points must be free of oxidation and moisture, in good condition, correctly adjusted, and checked frequently.
- If slave kit and/or portable heater are unavailable for preheating, use ether as an emergency starting aid. However, 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. Without preheating the intake air, diesel engines are particularly difficult to start in cold weather. 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 indicated below:

- Manifold air heaters should be used when the ambient temperature drops below +32°F. Employ this device only when the engine is turned over. Switch *off* the air heater when the engine starts.
- By warming the engine with external heat, sufficient preheating may also be accomplished.

USING AUXILIARY POWER (SLAVE) RECEPTACLE TO START ENGINE

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

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

- Start the engine of the vehicle supplying the auxiliary power and 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 and adjust engine idling speed to slow idle.
- Disconnect extension cable from both vehicles as soon as 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 vehicle to make sure that it shows that battery is being charged.

TOWING TO START ENGINE

Attempting to start a vehicle by towing is poor practice. The results of such efforts are demonstrated by Figure 3-2. Applying external power will not solve the problem of internal resistance due to *frozen* parts (i.e. lack of lubrication or hydrostatically locked engine). However, if other starting expedients have failed and the conditions below are met, the vehicle may be towed to start the engine.

- When the engine can be rotated through one complete cycle, the engine is not hydrostatically locked.
- Lubricants must be sufficiently fluid to allow the engine to turn over without excessive drag.
- The lubricants in the transmission and transfer case must be able to permit shifting gears and allow operation without excessive drag on the power train.

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. Do not tow-start vehicles with automatic transmissions. Consult the vehicle operator's manuals for specific instruction, procedures, cautions, and limitations.

Lubricants in the wheel bearings and differential must not be congealed.

Ensure that the hand brake is released and neither the hand brake and/or service brake linings are frozen to the brake drums.

CAUTION: When a vehicle requires towing, slave-starting, or other assists in getting started, supervisors must recognize that something is wrong with the vehicle. At the first opportunity they should correct it and not wait for the problem to surface again.

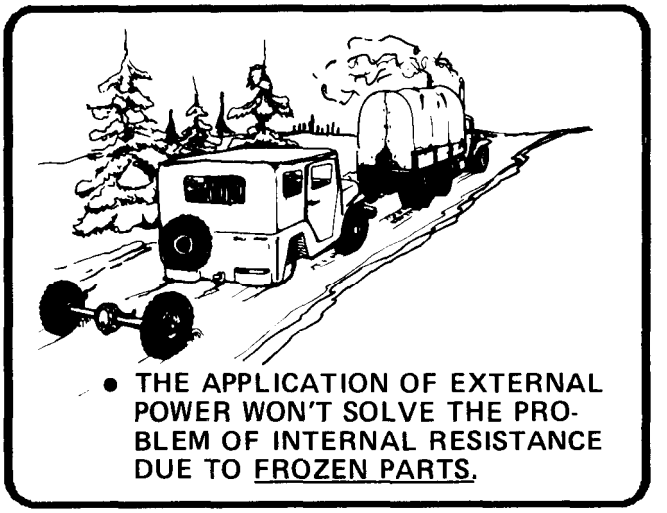


FIGURE 3-2. DO NOT ATTEMP TO START A VEHICLE BY TOWING.

CAUTION: Vehicles should never be started by pushing.

SECTION II. CHASSIS AND BODY COMPONENTS

OPERATION

General. Ice, mud, snow, and so forth, can build up to such an extent on operating vehicles that it can 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

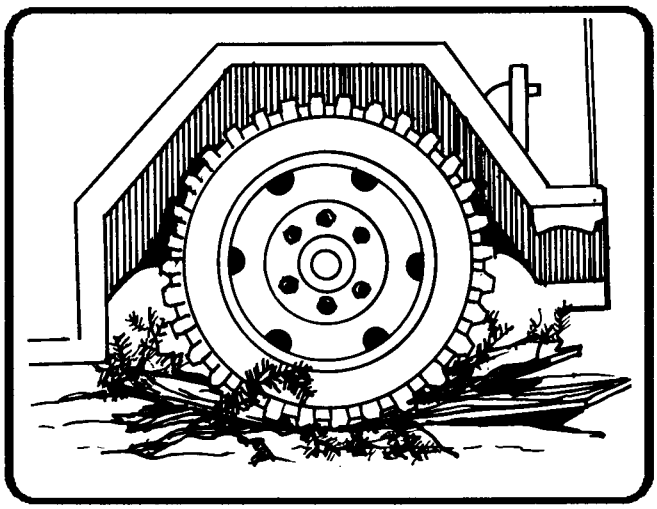


FIGURE 3-3. PLACE MATERIAL UNDER TIRES

slippage on ice and snow, as it can throw tracks and/or cause loss of control.

Tires. If tires have a flat spot where contact with the ground was made, use a light pressure on the accelerator and drive vehicle slowly until generated heat permits tires to round out. Also, during periods of freezing rain, or sleet, move vehicle around often. To prevent tires from freezing to the surface, place small branches or other insulating material under them before parking (Figure 3-3). If tires do freeze in place, a portable hot air heater must be used to melt them loose.

Tire selection. Two types of nondirectional tires are available for use on standard tactical vehicles. They are the cross-country tire and the mud and snow tire. It is best not to mix the tires on any one vehicle, but if tire stocks are depleted, both types maybe used as long as only one type is used on any one axle. Also, some of the commercial vehicles in the Army inventory (i.e. CUCV) use the commercial all-terrain radial tires.

Chains. Check vehicle chains to ensure that they are serviceable prior to operation. Drivers should be required to practice mounting and removing them. Remove the chains when not needed. This practice keeps the chains in good condition; chains will wear out in approximately 350 miles of asphalt road operation. Additionally, they can cause damage to vehicular and body suspension components (Reference: FM 21-305).

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

Cab enclosures. Employ 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.

Parking brakes. Do not park with brakes set since they may freeze in this position and may not release. Use chock blocks to hold wheels or tracks in place. If the 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

OPERATION

Starting, conventional-type transmission. Depress clutch pedal while starting engine with gear shift in neutral. After engine is running smoothly, release clutch cautiously and maintain engine at idle for 2 minutes or longer to warm up lubricant in transmission.

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

Idling. Adjust the hand throttle to the engine speed specified in operator's TM until the engine is running smoothly. Engage the engine clutch (where applicable) to allow gear case lubricants to warm up. With transfer case levers remaining in *out* position to prevent movement of the vehicle, depress clutch and operate trans- mission gear shift lever until 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 the tires are frozen to the ground. An attempt to operate with this condition will damage the power train, for example, the clutch facings, universal joints or gear teeth. When placing vehicle in motion, place transmission in low gear and transfer unit, where applicable, in low range. Drive vehicle approximately 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 period, place transmission and transfer shift levers in the neutral position. This prepares these units for the next start by preventing them from freezing in an engaged position.

SECTION IV. ENGINE LUBRICATION SYSTEM

GENERAL

The mechanical efficiency of an engine depends upon 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 an engine starts, check reading on the oil pressure gages. If engine oil pressure is not indicated within 30 seconds after starting, shut down engine and determine the cause. On those vehicles equipped with warning lights, stop engine and investigate the cause if engine-oil pressure warning light does not go out within 30 seconds after engine has started.

Vehicle engine temperatures ranging from 160° to 180°F must be maintained to afford normal operation. This temperature can be attained by proper adjustment of the air inlet shutters or covers and an efficient thermostat.

The oil pressure gage and/or warning light must be observed frequently during operation because of the increased failures in extreme cold. Consult the applicable operator's manual for normal oil pressures. 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 it should not stay on at higher RPM.

After each operating period, carefully inspect and service the system.

- Inspect oil pan, valve covers, gaskets, and any external units of the lubrication system for leaks; correct deficiencies or report them to maintenance mechanics.

- 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 shut down, the vehicle engine must be normalized to allow a coating of cooled oil to be retained on the cylinder walls and pistons and to prevent damage at time of restarting, The above can be accomplished by lowering the engine RPM to the prescribed high idling speed (see appropriate 10-series manual) and retaining it there for approximately five minutes. This procedure is of extreme importance to prevent engine damage and is a mandatory requirement 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, clogged strainer, defective oil pump, lack of lubricant, or engine component failure such as an engine bearing.

NOTE: Do not overlook the possibility that the oil pressure gage may be defective. If the oil pressure gage is working accurately, the oil is up to the full mark, and the oil filter element is not clogged, the failure is probably in the pump or lines.

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 all combine to create engine sludge (Figure 3-4). To correct a sludge condition, drain oil while engine is hot and refill with OEA.

After operation, inspect oil pan, valve cover, timing gear cover and gaskets, and external oil lines for oil leaks; correct as necessary.

SECTION V. ELECTRICAL SYSTEM

GENERAL

The storage battery functions as the heart of the electrical system especially during the starting phase.

When starting the engine, follow cold start procedures in the appropriate equipment TM, modified as necessary by those procedures outlined on page 3-1 of this manual.

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

DURING OPERATION.

Allow the engine to warm up to the recommended temperature for subzero operation (thermostat opens at 180°F).

Check operation of instruments during warmup, especially the oil pressure gages and warning lights.

Take advantage of any and all methods available to keep the batteries at recommended temperatures. If the battery is sufficiently warm 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. Belts should be inspected for any cracks prior to cold weather operation. Cracked belts should be replaced. Adjustable length belts are available for emergency road side repair. They come in sizes 3/8-, 1/2-, and 3/4-inch widths and require a connector tool to fit to size. The stock numbers are shown in Appendix C.

Note any unusual noise from the generator.

Notice if the lights are unusually bright, due to higher voltage when engine speed is increased above normal RPM. This condition indicates voltage regulator problems.

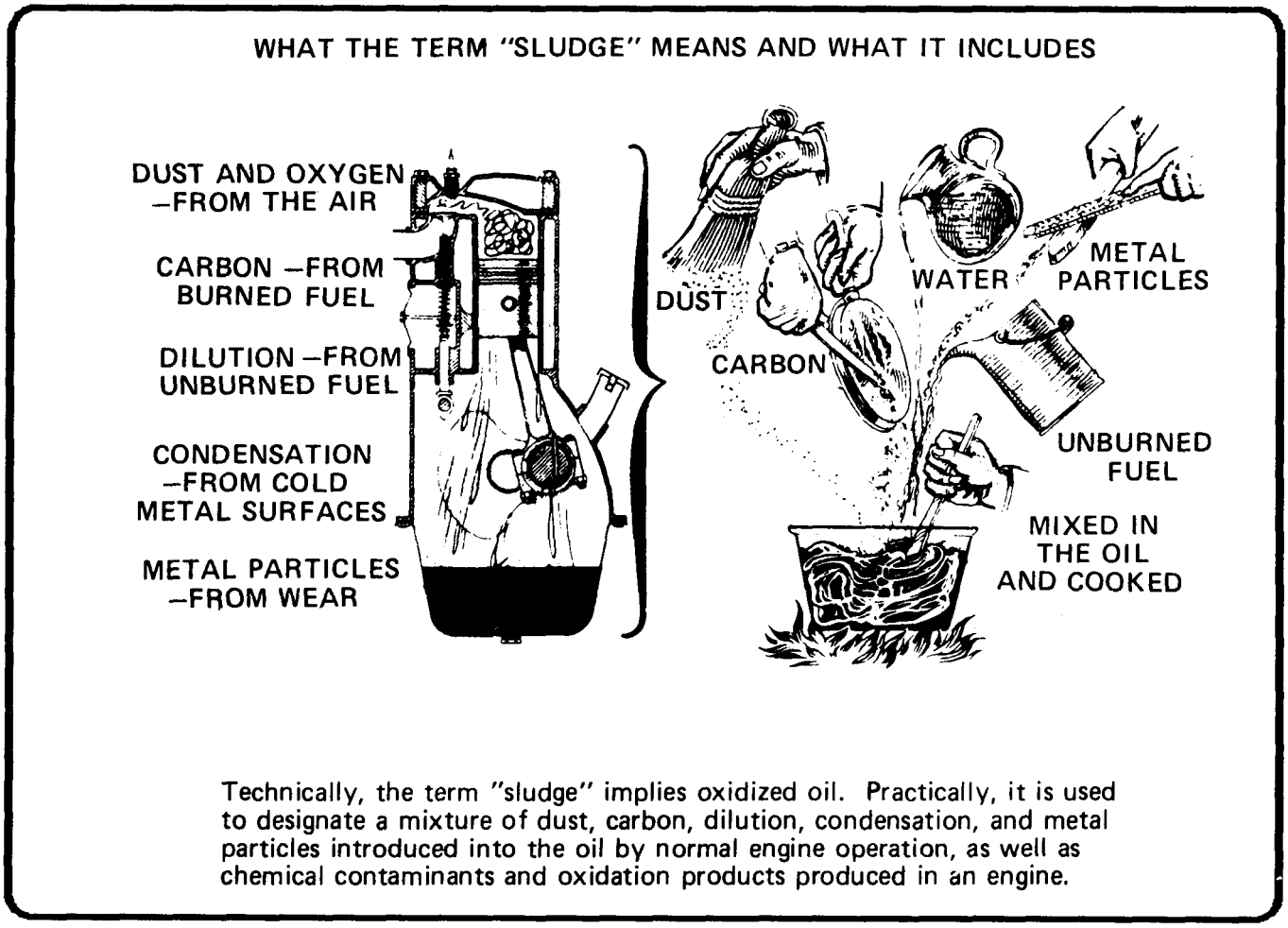


FIGURE 3-4. ENGINE SLUDGE.

MAINTENANCE

Special 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 will be considerably less than at higher temperatures and will, therefore, require a proportionately longer charging time (see TM 9-6140-200-14).

Thaw frozen batteries at room temperature prior to charging. Check the level of the electrolyte. It should not be above level indicated on cell cover vent plug.

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 when exposed to subzero temperatures and not 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.

NOTE: If water is added 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

GENERAL

Successful operation of vehicles at low temperatures will depend to a great extent upon the condition of the fuels used. Water in engine fuel can cause serious difficulties. Trouble will be encountered 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. This reduction of pressure in the venturi and vaporization of fuel causes a refrigerating action and the temperature may be lowered enough to freeze water or vapor in the fuel.

The ice will build around the jet until the fuel supply to the combustion chamber will be cut off and the engine will cease to operate. Water will settle to the bottom of fuel tanks and into the lowest parts of fuel lines so that fuel cannot reach the carburetor and, 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 warmer temperatures, or from fuel consumption during normal operation. The following precautions must be observed:

- Barrels should be stored with outlet end slightly higher than the other end in order to allow sediment and water to settle out (Figure 3-5.). 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 may be salvaged. Make sure all containers are thoroughly clean and free from rust before storing fuel in them.

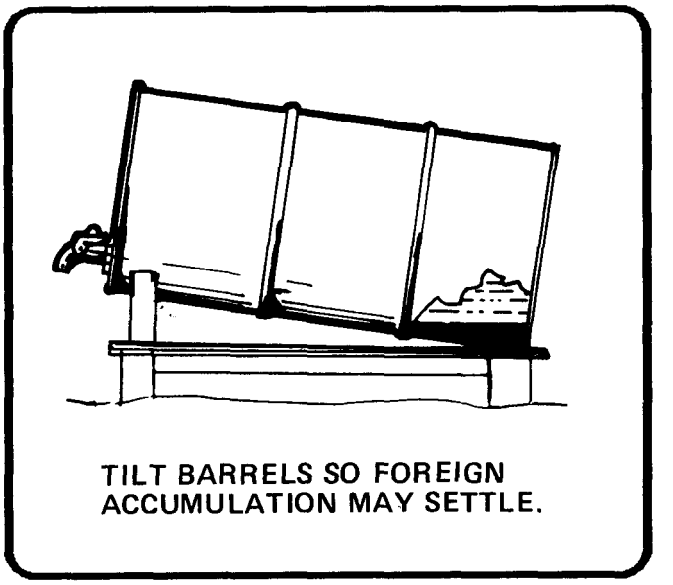


FIGURE 3-5. TILT BARRELS TO ALLOW FOREIGN ACCUMULATION TO SETTLE.

- 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 ELECTRICITY THAT MAY RESULT IN A SPARK UNLESS MEANS ARE PROVIDED TO GROUND THE ELECTRICITY. A METALLIC CONTACT BETWEEN THE CONTAINER BEING FILLED AND THE DISPENSING TANK MUST BE PROVIDED TO ENSURE AN EFFECTIVE GROUND. THIS HAZARD IS PARTICULARLY GREAT IN THE COLD, DRY AIR OF NORTHERN ENVIRONMENTS.

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

MAINTENANCE

Satisfactory performance of equipment in cold weather depends on careful servicing. Proper maintenance by the organization mechanic will preclude many malfunctions and failures that would otherwise occur in subzero temperatures.

- 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 unit TM. Wires should be cleaned with dry-cleaning solvent and thoroughly dried.

- Inspect fuel filters for good condition and replace contaminated elements. Clean the

CUNO (metal disc type) filters with dry-cleaning solvent, dry, and install. Make sure there are no leaks.

- Drain the fuel filters, where possible, at the end of each day of operations. Do not assume that filters are dry if nothing flows from the drain cock. If water is present, it could have frozen solid overnight.
- Note whether diesel-fuel injection pump, including any transfer pump, is in good condition, correctly assembled, securely mounted, and the connections do not leak.
- Observe whether diesel-fuel nozzles and lines are in good condition.
- Observe whether fuel gage is operating and registers amount of fuel in the tank.

SECTION VII. COOLING SYSTEM

GENERAL

Starting. 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 insure the auxiliary water circulation pump is running will most likely result in burst coolant hoses. When the engine is operating, observe the temperature gage to see 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.

During operation. Operate vehicles at normal engine temperatures as indicated in pertinent operator's TM (Figure 3-6). These temperatures can be maintained by proper adjustment of 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.

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.

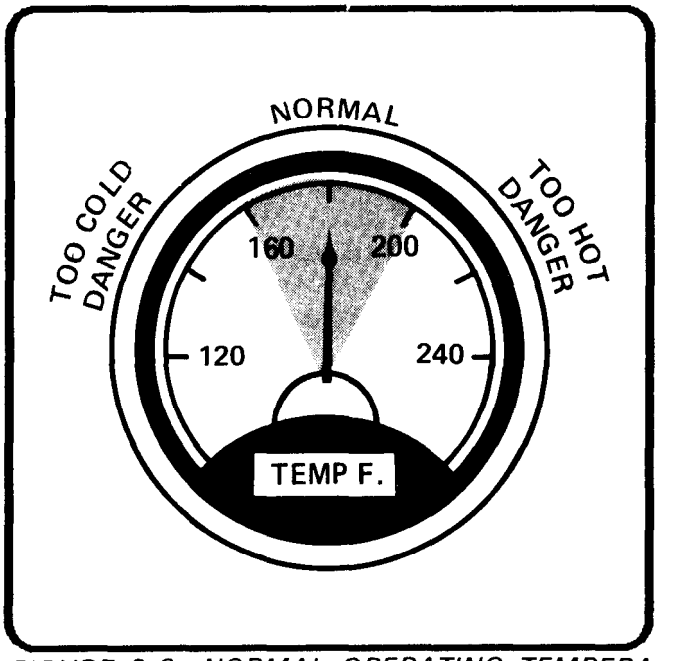


FIGURE 3-6. NORMAL OPERATING TEMPERATURE.

Lubrication failures may follow sludge formation and lead to serious engine damage. Burned fuel vapors also mix with water in the crankcase to form corrosive acids that attack engine parts.

After operation. Radiator should be checked after shutdown to determine coolant level. If coolant level is low, add antifreeze to return radiator to full level.

SECTION VIII. AUXILIARY EQUIPMENT

AIR COMPRESSORS

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

Maintenance steps:

- Examine air compressor to see that it is in good condition, properly aligned with is 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 within 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 on page 2-8 of this manual.

POWER TAKE-OFF ASSEMBLIES

See that the power take-off and control linkage are in good condition, securely mounted, and that seals are not leaking. Make certain that proper sub-zero lubricant is used and maintained at proper level. See that the transmission and/or breather and ventilation openings and lines are clear. Tighten all mounting bolts, power take-off assembly screws, and bolts to torque tightness specified in the pertinent TM.

WINCHES

Operation. Read all caution plates and estimate a 25-percent reduction in capacity when determining load. EXAMPLE: If capacity of winch is specified as 5,000 pounds on "Winch Caution Plate," lower the rated capacity for cold weather operation by 25-percent, making capacity 3,750 pounds. This safety factor is essential to prevent damage to winch (Figure 3-7).

When using the winch, operate vehicle engine at a reasonable speed IAW 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.

Maintenance steps:

- See that winch is in good condition, correctly assembled, and securely mounted. Test clutch for free movement in both engaged and disengaged position, and see that it latches securely.
- Inspect automatic brake for proper operation.
- Check drive shaft and see that the proper shear pin has been installed. The drive shaft front yoke should slide freely on the worm shaft in order to take full advantage of the safety feature of shear pin.
- If winch is chain driven, inspect chain and sprockets for good condition and proper adjustment.
- See if winch cable is in good condition. Note whether the cable has broken or frayed stands and flat or rusty spots. Clean and oil cable in accordance with instructions on page 2-9 of this manual.

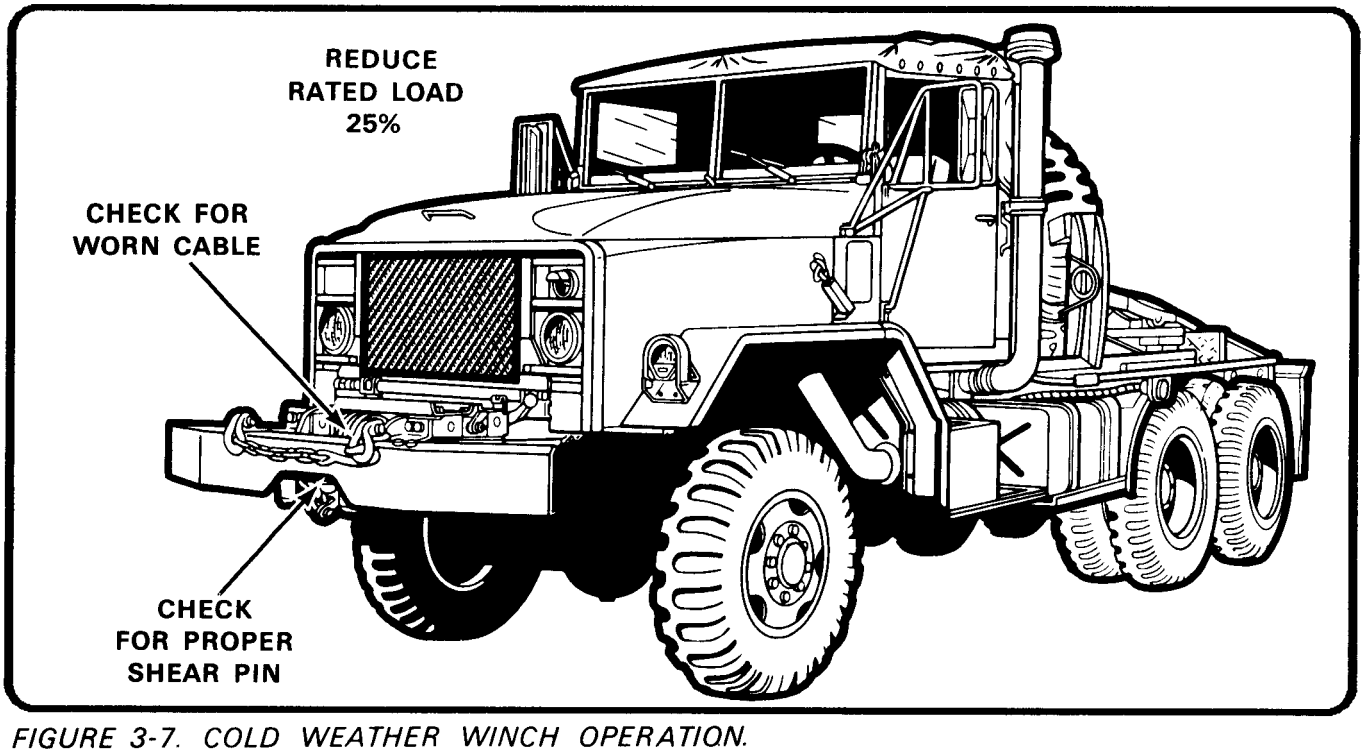


FIGURE 3-7. COLD WEATHER WINCH OPERATION.

CHAPTER FOUR

DIRECT AND INDIRECT FIRE WEAPONS, AMMUNITION AND MUNITIONS, AND SIGHTING AND FIRE CONTROL EQUIPMENT

SECTION I. EFFECTS OF COLD WEATHER

GENERAL

When operating materiel in freezing temperatures, soldiers should complete winterization measures as soon as these conditions are anticipated.

Operation of weapons, sighting, and fire control materiel at subzero temperatures presents problems that demand special precautions in servicing by operators and mechanics. Only through special care can casualties to personnel and poor performance or total functional failures of material be avoided. Particular emphasis must be placed on crew maintenance and on intimate liaison between the using unit and direct support (DS) or general support (GS) maintenance organizations.

Careful inspection and servicing of components must be accomplished before subzero weather. During these cold weather conditions, suitable inspection and servicing before, during, and after each travel and firing period is imperative. All exposed finished surfaces must be wiped dry and oiled daily. All failures or symptoms indicating potential failures must be detected, investigated, diagnosed, and promptly corrected or reported to the proper authority.

WARNING

FAILURE TO GIVE THIS EXTRA SERVICE AND MAINTENANCE MAY RESULT IN INJURY TO PERSONNEL, DAMAGE TO MATERIEL, UNNECESSARY AND UNWARRANTED EXPENDITURE OF CRITICAL PARTS, AND LOSS OF THE USE OF THE WEAPON.

Clean materiel is imperative for cold weather operations.

Since metals contract when the temperature decreases and expand when the temperature increases, the clearances between bearing surfaces are considerably different in cold weather than at higher temperatures.

Placing materiel in proper mechanical condition for severe cold weather operations requires additional time for assembly, disassembly, repair, and cleaning.

CONDITIONS

Cold-dry conditions. Exposed metal will require more frequent lubrication. Lighter weight lubricants and fluids will be required in the cold to offset sluggish motion and accompanying stress on parts. Rubberized parts and surfaces must be handled carefully to prevent cracking or breaking. Paint also tends to crack very easily when exposed over time to the cold.

Condensation. As stated on page 1-1 of this manual, humidity and cold air will combine and enter any opening in a weapon system and create problems for operators and crews. Mainly produced by rapid changes in temperatures, condensation will cause icing and corrosion of machined surfaces, especially in the bores of weapons. Also, a combination of body warmth and breathing clouds the optics of sights and fire control mechanisms. Sealed containers are provided for all army optics. Employ these cases to avoid humidity and condensation problems.

Frozen surfaces. Flat trajectory weapons, such as tank main armaments, will encounter movement in the opposite direction of fire on frozen surfaces. Emplacement of mortar base plates and howitzer spades becomes extremely difficult and time consuming. Firing of these weapons from frozen surfaces can be very damaging to the systems.

Snow and ice. Snow and ice tend to get into everything. Exposed gears and racks (for example, elevating arc, traversing rack, and pinions) can collect snow and ice in sufficient amounts to impede movement. Snow and ice also contaminate lubricants. In order to protect weapons, use gun covers when provided. Also, charges and propellants must remain covered until required for firing.

Visibility. Longer periods of darkness, blowing snow, and ice fog limit visibility greatly. Ice fog, caused when water vapor from a muzzle blast crystallizes (usually around -30°F or lower), tends to hang over the weapon and follow the path of the round. If the air is still, the ice fog will hover in one place and remain for some time, hindering second round engagement. Even a one round engagement will require displacement, since ice fog will serve as a target acquisition aid for enemy gunners. In addition, rain, snow, clouds, and fog limit the effective range of all lasers.

Magnetic conditions. The farther north one travels, the more care must be taken with magnetic instruments. They will be greatly affected by increasing declination changes and by Aurora Borealis.

FUNCTIONING

The problems or conditions of a general nature that affect operation of materiel and should be corrected are as follows:

- Hydraulic or recoil fluids offer greater resistance to motion because their viscosity increases with lowered temperature. This is indicated by stiffness of operation and lengthening of the recoil cycle.
- Recoil-cycle time is lengthened by increased viscosity of the recoil fluid. Greater resistance is offered to the motion of recoil and counterrecoil, resulting in greater stresses on the parts involved.
- Overlubrication in cold weather causes parts to bind, putting the weapon out of service. Overlubrication of the firing mechanism may cause misfires in cold weather.
- Handwheel effort is increased on both elevating and traversing mechanisms.
- Gas check pads fail to seal perfectly and deteriorate very rapidly. Scoring of the gas check seat is possible.
- Cable insulation, if not arctic-type, becomes brittle and may crack.
- Air hoses, if not arctic-type, fail when doubled or straightened.
- Hand brakes must not be left applied while towed weapons are parked. This may result in frozen brakes and render the weapon immobile or cause serious damage.
- Equalizing bars and travel locks of towed weapons must be covered or wrapped prior to towing the weapon over snow-covered terrain. Should the wrapping become wet, remove it without delay to avoid its freezing in place.
- In cross-country operations, a prime mover of the same tread/track width should be used to ensure tracking when possible.
- Firing lanyards must be kept dry and covered to prevent freezing and breakage.

SECTION II. LUBRICATION IN COLD WEATHER

GENERAL REQUIREMENTS

Keeping the weapon machine surface clean and not overlubricated is imperative in cold weather. Lack of lubricant may cause rust to form on uncoated surfaces and cause friction between rubbing surfaces, which will impede the functioning of the weapon.

It is essential that the lowest possible friction be maintained since the operating power of the gun cannot be increased to take care of this extra drag. 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.

It is equally essential that the proper type and grade of lubricant be used (See Appendix B). Cer-

tain 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 temperatures may become thick and therefore unsatisfactory at subzero temperatures, or may become thin and drip from the metal surfaces at high temperatures.

To provide satisfactory lubrication and protection against rust, clean and dry all bare metal parts before applying a lubricant or preservative. At subzero temperatures, the lubricant should be applied sparingly. Apply the oil by rubbing the parts with cloth that has been wet with oil and wrung out.

To ensure adequate lubrication and satisfactory performance of weapons materiel in subzero temperatures, the instructions included in this section must be followed.

GENERAL PROCEDURES FOR WEAPONS MATERIEL

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

Lubrication must be applied more frequently. Therefore, a biweekly interval may be changed to weekly.

GMD is prescribed for all temperatures.

Use petroleum-base hydraulic fluid (OHT) or FRH, as specified, in hydraulic gears as well as in hydro-spring and hydropneumatic recoil mechanisms. This oil replaces special-recoil and light-recoil oil for low-temperature operation. The changeover to petroleum-base hydraulic oil in recoil mechanisms will be accomplished as outlined below:

- Drain existing recoil oil. Raise, lower, and rotate the mechanism to aid in removing the original oil.
- Fill recoil mechanism with the OHT or FRH as specified. Establish oil reserve and install mechanisms on carriage or mount.

Wherever special lubricating grease is specified, molybdenum disulfide grease (GMD) will be used. Reason: GMD is a far superior grease at temperatures below -25°F than GAI.

CAUTION: Extreme care must be taken to ensure that moisture, snow, ice, and dirt are not introduced into the mechanism during the changeover process.

Whenever preservative lubricating oil, bore cleaner, or normal lubricating oil is specified, use cleaner, lubricant, and preservative (CLP) instead. However, do not use CLP in the bores of mortars. In this case, use CR and LAW. To put a temporary finish on corroded exterior metal surfaces, use solid film lubricant (SFL). SFL should not be used on moving parts, stocks, and so forth.

SECTION III. GENERAL OPERATION AND MAINTENANCE

GENERAL

It has been learned through experience that much maintenance can be avoided and greater service obtained from weapons if the user takes care of the weapon and exercises preventive maintenance. All equipment must be inspected daily to ensure that it is complete and in satisfactory operating condition. Further, user maintenance includes common sense.

Precautions for idle materiel. Whenever materiel is to remain idle for a period of time, care should be taken to secure all covers for protection. Wind will drive snow under the covers unless snugly and securely fastened, resulting in iced parts and inoperative equip- ment.

When weapons or fire control equipment are placed directly on the ground, ice, or snow, they will freeze in place. This makes it difficult, if not impossible, to move the materiel without digging or thawing them out.

To prevent materiel from freezing to ground, prepare a footing of planks, brush, or matting. Straw or hay may also be used for this purpose if available. 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.

Ensure that all parts are free of ice or snow and that all exposed openings are sealed.

Keep the ends of canvas tarpaulins off the ground to prevent them from freezing to the ground.

Prevention of 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 will condense on the cold parts. This condensed moisture may cause corrosion of the parts if not immediately removed by drying. In some cases, disassembly is practically impossible.

If the materiel is operated indoors while this moisture is present, the moisture will form an emulsion with the lubricants, which will necessitate removing all the grease and cleaning and lubricating the materiel. If the materiel is taken outside into low temperature before the condensed moisture is removed or has evaporated, the parts may freeze and become inoperable.

Do not bring fire control materiel indoors unless it is absolutely necessary. It is better to leave it outdoors, but covered to protect it from snow. Snowtight lockers maintained at outdoor temperatures are recommended as a place for keeping 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 the condensation of moisture on instruments. The containers can be specially made boxes, covered cans, or any other fairly airtight container with heat-conducting walls. Keep containers outside until it is necessary to bring an instrument indoors. Put the instrument into a container, close the container tightly, then bring it indoors and let it stand until the container inner temperature has had time to equal the room 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 the instrument and cause condensation. When the instrument and inner container reach room temperature, the instrument can be removed with no danger of moisture condensing on it.

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

OPERATOR PRECAUTIONS

When using sighting and fire control materiel at subzero temperatures, operators' hands will need protection. Recommend that gloves, with liners, trigger-finger shells with liners, or the arctic mitten set be worn. Ambient temperatures will dictate which handwear is worn.

For example, gloves may be worn around O°F, but the arctic mitten set or the trigger-finger mitten should be worn at colder temperatures. Since mechanical motions of most knobs and levers will be less free than at milder temperatures, adjustments will seem awkward and difficult, at first, to operators accustomed to working with bare hands.

Crews must practice using the instrument as much as possible under these conditions to overcome awkwardness and difficulties.

Because many knobs and handwheels are difficult to manipulate while wearing arctic mittens, it maybe 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 partially alleviated by wrapping adhesive tape around the knobs or handwheels (Figure 4-1).

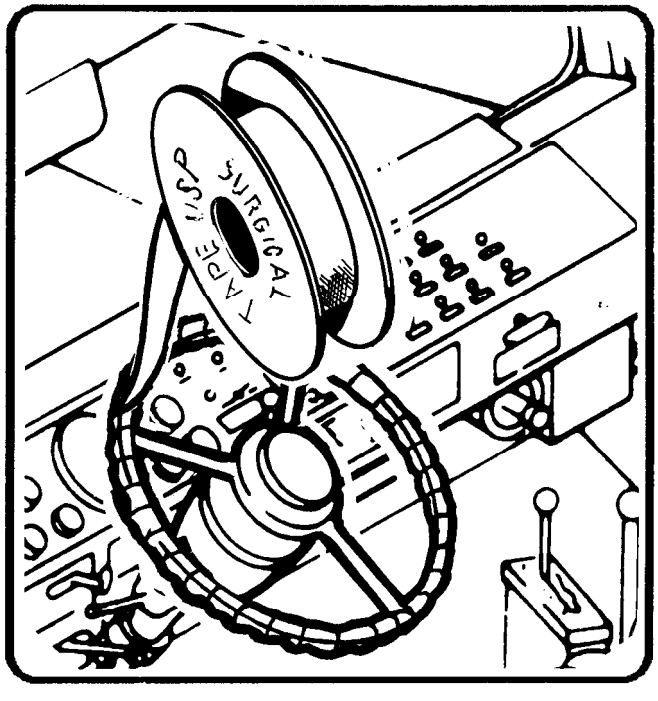


FIGURE 4-1. PROTECTIVE WRAPPING.

Cold, steel seats are extremely uncomfortable to sit on for any length of time. Insulating-type seat covers, such as felt or blanket pads, should be used so that the operator's body heat is not lost through contact with the cold metal.

Insulation such as felt or other materials should be provided on hard or metal cheek rests and eyepieces so that the operator's face will not touch these parts.

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

EXERCISING

The weapon should be elevated and traversed at intervals that will ensure operation when the weapon is needed. Where applicable, 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 subzero temperatures. Always exercise the recoil mechanism before firing to make sure the recoil parts are not iced up.

DAILY CARE

Inspect materiel daily. Whenever possible, use gun covers and shelters for protection. To provide maximum protection for the weapon, the following points cannot be overemphasized.

- Keep all parts thoroughly clean.
- Clean and oil the bore and 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.

- Be sure all covers are properly installed and securely lashed. If covers are inadequate, improvise additional covers by using canvas, burlap, or any other suitable or available materiel.
- Perform all the preventive maintenance operations and precautions prescribed in manuals pertinent to the materiel.

During travel, more than usual driving care should be taken because suspension assemblies become stiff

in cold weather and are easily broken. Refer to FM 31-70 and FM 90-11 for driver precautions.

EMPLACEMENT

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

Prepare a platform of pierced steel planking (materiel used for improvised airstrips, and so forth), boards, brush, and matting at the spot chosen for the emplacement, and 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 pit and spade positions as required. 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.

NOTE: Much more time will be required to prepare recoil pit and spade positions for emplacing a weapon on frozen ground than on ground that is *not frozen.*

Coat all metal parts of the trails and spades coming in contact with snow or frozen ground with waste lubricant. This will prevent freezing in place and facilitate subsequent shifting of the trails. The 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 tendency to buckle and break by placing logs between the spades and ground for 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. Manufacture of a stand that will rest 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 (Figure 4-2.). Use of the aiming light, equipped with dry cell batteries, will not be possible except for short periods of time. The battery is kept warm and in serviceable condition until used by carrying the batteries or light next to the body. Also, the appropriate size alkaline batteries should be used rather than carbon batteries.

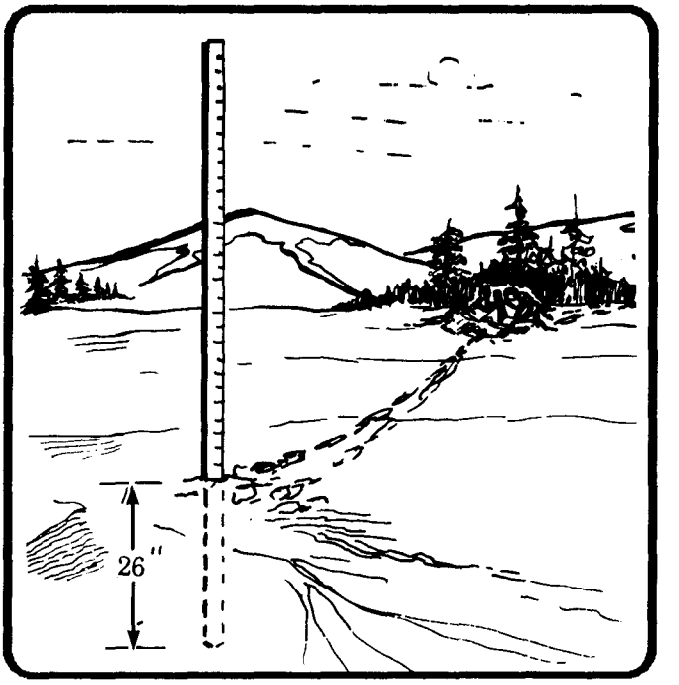


FIGURE 4-2. AIMING POST.

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 gas-check 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 gas-check pad. Simply wipe it clean and permit it to dry; do not lubricate.

Check manual and electric firing linkages. Frozen linkages will render a weapon useless. In particular,

check items such as solenoids that maybe frozen and, therefore, unable to close contacts for electric firing.

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

The asbestos covering of Gerdom-type gas-check pads becomes very brittle in cold. Inspect to see if the asbestos has cracked and if any of the wire mesh is exposed. If the wire is exposed, it will cause the gas-check seat to become scored and this cannot be repaired. Install a new pad 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 CLP, by wiping the surfaces of the parts with a clean cloth that has been wet with oil and thoroughly wrung out. Excessive lubrication of the firing mechanism will cause misfires.

BORES

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

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

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

After firing. CLP is the preferred cold weather bore cleaner and preservative. If it is not available, clean the bore evacuator, muzzle brake, bore, and chamber with rifle bore cleaner while the weapon is still warm. Do not apply rifle-bore cleaner to a weapon while the weapon is too hot to be touched with the bare hand. For temperatures below -20°F, warm the solvent cleaning compound before using so that it will be thin enough to use effectively. It is important that all cleaner be wiped off. Any cleaner 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 usual (mild, moderate) conditions in the pertinent LOS and TMs.

Daily care. In below-freezing temperature, wipe the bore dry every day and apply a light film of CLP.

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 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 THE GAS PRESSURE IN THE RECUPERATOR IS ADJUSTED. THEREFORE, ADJUSTING THE GAS PRESSURE IN THE RECUPERATOR WILL BE 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 TOCORRESPOND WITH THE EXISTING TEMPERATURE CONDITIONS.

Care of recoil mechanisms will be 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 must be wiped dry and lubricated lightly 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.

Parts such as recoil and counterrecoil rods and variable recoil cams are wiped dry daily. Protect these parts against corrosion by applying a film of CLP to all metal surfaces with a lightly oiled clean cloth.

A sticking recoil mechanism may result in severe damage to the weapon when it is fired, therefore:

- The recoil mechanism should be exercised frequently. Intervals of exercise will depend upon the existing temperature, becoming more frequent as the temperature decreases.

- In order to ensure that recoil parts are free from frost binding, exercise the recoil mechanism prior to firing whenever the weapon is subjected to a freezing rain, windblown snow and ice, or to 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 pertinent 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 contaminates the lubricant and destroys 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, but lubrication 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 operation 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 automotive and artillery grease (GAA), or if temperatures below -25°F are expected, use GMD, at the intervals prescribed in the LO and the TMs. Too much GAA at cold temperatures can 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 or:

- If a grease other than GAA has been applied to the bearings of an equilibrator, wash the bearing thoroughly with dry-cleaning solvent or mineral spirits paint thinner, dry thoroughly, and lubricate with GAA. It will be necessary to remove the equilibrator in order to wash bearings properly,

- Since GAA is satisfactory for all temperatures (-65° to + 225°F), it need not be removed when the temperature rises.

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 CLP. Wipe the metal surfaces with a clean cloth that has been wet with oil and thoroughly wrung out.

CAUTION: The newer howitzers use nitrogen to pressurize the equilibrators. Since temperatures will 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.

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

ELEVATING AND TRAVERSING MECHANISMS

Snow and ice particles will frequently collect on the arcs and pinions and cake under pressure of the gears. Since this will interfere with elevating and traversing operations, 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 CLP 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

GENERAL

Propellants will tend to burn slower in the cold. 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. Slower burning propellant causes a decrease in velocity.

As indicated on page 4-2 of this chapter, ice fog will seriously impair visibility and tactical concealment after firing.

TANK, MAIN ARMAMENT

One problem is the formation of ice fog when the weapon is fired. Lubrication and breakage problems are greatly diminished because most of the weapon's working parts are enclosed in a warm turret. Another major problem is the effect of temperature changes on the ammunition.

Ammunition stored inside the turret will be warm and has the same general ballistic characteristics of 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 will burn slowly and it will have completely different ballistic characteristics, thus 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 re-zero the weapon hastily. In either case, he will have to make slight adjustments.

If temperatures are consistently in the 0°F range, it may be advisable to operate the tank with an unheated turret. This will prevent an accumulation of condensed moisture on the interior surfaces of the vehicle, weapons, auxiliary equipment, and ammunition. This will prevent foggy sight problems and eliminate inadvertent firing errors that arise when firing cold ammunition that may have been zeroed warm. Additionally, the muzzle blast may blow up snow particles in front of the sights obscuring the visibility of the gunner.

WIRE-GUIDED 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 attempts 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 M17-series protective mask with the M-4 winterization kit installed.

Depending on the direction of the wind, activation of the launch drive motors after initial firing will create 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 additional burden for TOW units is the requirement to transport the TOW system in their ahkio (sled) groups in addition to their cold regions survival gear. This requires additional soldiers or a reduction of systems employed.

ROCKETS AND MISSILES

Rockets and missiles will generally operate satisfactorily in cold weather (0°F to -40°F); however,

consult the TMs applicable to a particular rocket or missile to determine exact firing limits.

Information concerning extreme-cold operating procedures for rockets and missiles materiel is contained elsewhere in this manual as follows:

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

CAUTION: Electrically powered systems will 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 V. INDIRECT FIRE WEAPONS

GENERAL

The cold regions phenomena which affect indirect systems the most are condensation, cold, dry air, and, especially, frozen surfaces.

Artillery

Most of the details involving operations and maintenance of artillery pieces are covered elsewhere in this chapter. However, the following aspects of artillery operations in cold regions should be considered:

- Always use lubricants sparingly. Overlubrication causes severe problems. For example, GAA slopped onto recoil/counterrecoil slides will prevent the piece from returning to battery after firing.
- Howitzer bores require more frequent cleaning at low temperatures as a result of residue left from incomplete burning of propellant charges.
- Congealed lubricants and grit will hinder movement of elevation and traversing handwheels.
- Prepare only that ammunition required immediately 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.
- Crews wearing the bulky cold region uniform, especially handwear, must practice drills and maintenance.

MORTARS

The matter of breakage in mortars is a minor one since there are few parts. The base plate must be solidly positioned to prevent sliding. It may be necessary to dig into the ground to accomplish this. When the weapon is emplaced on frozen ground, the combination of the cold making the metal brittle and the tremendous shock that the base plate receives when a round is fired may occasionally cause the base plate to crack.

Frozen ground has no resiliency, and the base plate and other bracing parts of the weapons absorb the entire shock of firing,

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

One field expedient that will reduce the possibility of a cracked base plate and sight damage is to place a brush matting under the base plate. The matting should be thick enough to act as a shock absorber, but not so thick as to cause the base plate to bounce out of its position.

Another method of positioning is to place bags of dry sand or snow beneath the base plate. The sandbags will provide the weapon with a solid, yet resilient shock absorbing base. The base plate is best seated by firing at a quadrant elevation (QE) of 1,200 roils and a middle charge.

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

An additional problem with the mortars is that they 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.

There are practically no lubrication or ice fog problems with mortars. However, due to incomplete burning of propellants, the mortar tube should be dry-swabbed after every tenth round or after each fire-for-effect.

The following tips will improve mortar gunnery when firing the system at low temperatures from frozen surfaces:

WARNING

USE OF GLOVES THAT ARE NOT ANTICONTACT RESULT IN A MORTAR SHELL NOT DROPPING PROPERLY DOWN THE TUBE DAMAGING EQUIPMENT, CAUSING INJURY OR DEATH.

The LOs for the current mortars (M29A1 and M30) are incorrect. Lubricate sparingly and do not use PL(SP) below 0°F. The new 60-mm, 81-mm, and 120-mm mortars should use LAW or CLP as lubricants and bore cleaners.

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

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

When seating the base plate:

- Select a position which has vegetation on the ground surface whenever possible.
- Use two men on the biped when seating on ice or at high elevation (1,300 mils or higher).
- At very low temperatures (below -40°F), crews may encounter sluggish movement of the fire control level vial bubbles and bubble separation or elongation. Other sections of this manual describe techniques for handling these situations.
- Gunners must be trained to operate the mortar without breathing on the optics.
- Boresight frequently.
- Practice using compensated sight picture, as this is the rule rather than the exception, when firing from frozen surfaces.
- Even though the M16 plotting board may become warped at temperatures below -40°F, fire direction procedures may still be performed on it.
- Mortar crewmen require anticontact gloves (CTA 50-900) which help prevent cold burns while still providing enough dexterity. To ensure personnel receive no cold related injuries from exposure all should be cautioned not to remove protective gloves at temperatures below -20°F.

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 roils rather than within two roils. This is especially true in cold regions where the mortar can be laid equally fast at zero mils as two roils when wearing correct handwear.

SECTION VI. AMMUNITION AND MUNITIONS

AMMUNITION

Large caliber ammunition. Moisture and humidity combine to make life miserable for the unwary tank, artillery, or mortar crew. Icing can cause misfires and damage to the pieces and injury to the crew. While the cold, dry conditions do not drastically alter the terminal effects of direct fire weapons, they dictate some additional training and planning for indirect systems, since range and burst effects drop off dramatically. 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, one may expect achieved ranges for indirect fire systems to be as much as 20 percent less at a temperature of -40°F over that indicated in the tabular firing tables (four rounds fired over a period of 1 to 3 minutes will warm the tube).

Snow-covered surfaces will 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 the cold region. Pouring a solution high in antifreeze content down the tube to force out a stuck round is one answer. Another technique involves the use of hydraulic fluid which will not freeze during the process and act like a penetrating oil to dislodge the stuck round. TM 60A-2-1-38 contains the only authorized procedure for this action.

Temperature limitation. Any temperature limitation at which certain ammunition may be used is stamped on the ammunition itself, along with the type, model, and lot number.

WARNING:

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

Combustible cartridge case ammunition. Personnel may have difficulty in removing the combustible cartridge case round from its fiber packing container. This is caused by a vacuum being formed in the container behind the cartridge when attempting 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.

Care must be taken when 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 in removing the neoprene barrier bag when the cartridge is on the loading tray. If difficulty is encountered, it may be advantageous to remove the bag while the cartridge is still partially in the rack.

Mortar ammunition is affected by cold in the same manner as other types of ammunition. Firing tables may be used provided the proper range corrections, based on cold weather conditions, are established through experience. TM 43-0001-28 and applicable firing tables should be consulted for charge restrictions at low temperatures.

While these comments address mortar rounds specifically, they are equally pertinent in principle when applied to artillery firing operations.

The following tips refer to ammunition in a winter warfare environment:

- Due to incomplete burning of propellants, one can 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 rounds 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, attempt to obtain an airburst. Snow decreases the effects of WP and fragmentation rounds dramatically.
- When firing into frozen surfaces, fuze delay will frequently produce better fragmentation in the form of a bounce airburst than a quick setting.

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

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

GRENADES

Hand grenades. No particular problems exist when using hand grenades in severe cold temperatures with the exception that they lose much of their effectiveness when detonated under snow. When throwing hand grenades during cold weather condi-

TABLE 4-1

Using the M732 Multioption fuze, the following results can be expected when firing into typical cold region terrain:

	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

tions, personnel wearing handgear must take the following precautions:

- Handgear must be completely dry. Handling of snow and ice may result in grenades freezing to the wet handgear.
- Grenades must be held near the neck of the fuze to avoid slipping or turning of the grenades when safety pins are removed.
- Place the grenade so that the safety lever rests between the first and second knuckles of the thumb to ensure a sensitive feeling of the safety lever.

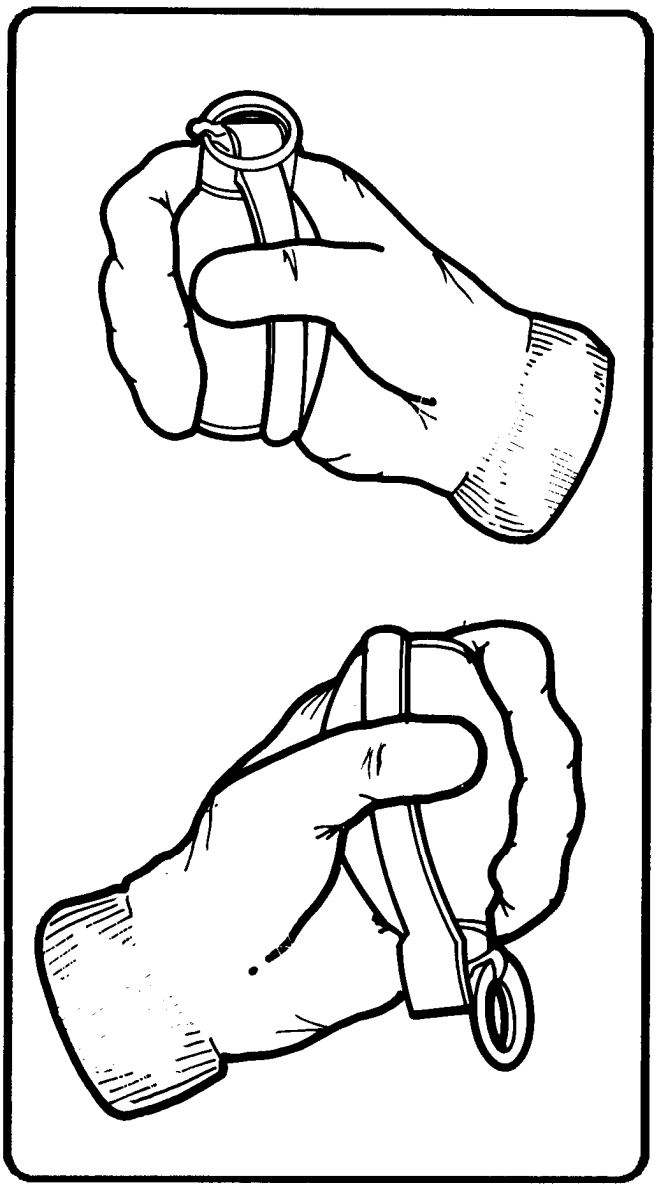


FIGURE 4-3. COLD WEATHER GRENADE PROCEDURES.

Left hand throwers can accomplish the above by holding the grenadeupside down. This procedure provides ready access to the safety pin ring (Figure 4-3).

MINES

Mine warfare in cold regions needs special precautions to be successful because of the conditions. As little as six inches of snow can virtually negate the effects of antipersonnel and antiarmor mines. Digging them in becomes impossible on frozen surfaces.

The rapidity and amount of snowfall in a single night makes marking a minefield crucial for recovering them if necessary. This also affects the decision whether to booby-trap them and how. When placing them 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. Further, care must be taken while emplacing mines when temperatures are changing, since recovery could be difficult if the mines were frozen to the ground.

The family of scatterable mines (FASCAM) is severely inhibited by snow. In addition to the decreased blast effects, the self-orientation characteristic of the mines is upset, since it is hard for them to determine *up* in the soft snow. Further, the trip wires may only be ejected 1 to 3 inches from the mines, thereby negating that capability.

DEMOLITIONS

Cold affects the ability to employ demolitions effectively. Handling becomes a partnership or team effort, due to the requirement for gloves by the demolitions team members, a practice discouraged by FM 5-25. Gloves are a must in the cold regions.

Plastic explosive, C-4, becomes very hard, making the insertion of an initiating device impossible unless done indoors prior to its use. Because of this, TNT is preferred because initiating device couplers are built into the blocks. Also, at temperatures of -40°F and colder, C-4 has been known simply to shatter from the explosion of its initiating device rather than detonate. Military dynamite or TNT blocks are excellent for use in the cold regions for projects like hasty fighting or firing positions.

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

Detonation cord becomes stiff in the cold, will not tie as easily as in temperate zones, and will break easily. Also, the time fuze tends to maintain its curl in the cold and break, if uncurling is attempted, except inside warm shelters.

Condensation also contributes to increased chance of misfire in the cold. Hangfire and misfire waiting times should be doubled in cold regions.

Static electricity, which easily develops as a result of the cold, dry conditions, leads to the preference of nonelectrical detonation techniques in lieu of electrical ones.

SECTION VII. SIGHTING AND FIRE-CONTROL EQUIPMENT

PRECAUTIONS

Sighting and fire-control materiel will operate satisfactorily at subzero temperatures if it is properly winterized and 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 will be difficult, especially where shop facilities are scarce. Therefore, thoroughly inspect and winterize all materiel before the onset of cold weather.

Regardless of 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.

Sighting and fire-control materiel should not be transferred suddenly 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. of this Chapter.

Do not put severe bends in interconnecting cables. All electrical cables should be removed periodically from beneath 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. In order to prevent heavy equipment from running over interconnecting cables, use stake markers to define the cable paths. Markers will also facilitate locating cables for repairs.

FOGGING OF EYEPIECES

When using optical instruments in severe cold weather, the operator should 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 eyepiece, making observation impossible.

There is no antifog solution that is satisfactory 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 4-4) is the most satisfactory method of keeping the breath away from the eyepieces. However, a face mask of any type is



FIGURE 4-4. COLD WEATHER MASK.

just as useful as long as it directs the breath away from the lens or absorbs the moisture from the breath.

A serviceable face mask can be made from any piece of cloth, the woolen scarf, or a piece of gauze tied across the face just below the eyes. Any of these will not only protect the operator's face from the wind but will also deflect the breath away 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 during which observation can be made from 2 to 3 minutes to about 20 minutes before eyepiece fogs.

Optical surfaces should be cleaned by using tissue lens paper moistened with a few drops of optical lens liquid cleaning compound.

NOTE: Ethyl alcohol may be used in place of 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: The alcohol should never be poured 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 instrument. Unit maintenance mechanics will purge and charge sighting and fire control materiel every 90 days or when condensation is evident in the instrument (TM 750-116).

POWERED FIRE CONTROL 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 pages 1-8 through 1-9 of this manual and to TM 9-6140-200-14.

Some systems require external power sources, either as primary or backup power sources. For the hand held laser range finder (HHLRF), for example, the prescribed batteries begin to lose their effectiveness very early as temperatures drop. At lower temperatures, one must discontinue battery operation and connect the power cable and adaptor which come with the HHLRF to a vehicle auxiliary power (slave) receptacle.

Temperate zone dry batteries may be expected 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 prior to use retain sufficient heat for an appreciable period of use before replacement is necessary. The period of use depends on the rate that heat is conducted away from the battery. The period of use can be extended if the batteries are insulated from cold-conducting surfaces by means of nonconductive materials.

When soldiers must carry replacement batteries, the following means may be used to retard heat loss. After preheating, the batteries may be placed in bags lined with kapok or spun-glass fiber materials, wrapped in woolen clothing or carried close to the body. Under certain conditions, it is advantageous to carry the batteries separate from the using equipment by the use of a connecting cord and plug. This arrangement may require certain modifications to the using equipment to permit installation of the connecting cord and plug. In most cases, the modifications will be minor and maybe accomplished readily 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 in transit.

PROTECTION OF TUBE EXTENSIONS AND EYEPIECES

Snow will collect in uncovered eyepieces and tube sunshades or extensions, rendering the instrument 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 putting loose wads of tissue lens paper into 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 in the tube.

LEVEL VIALS

When cold-soaked at temperatures below approximately -40°F, the level vials on sighting and fire control items will 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 into one bubble.

COMPENSATED SIGHT PICTURE.

For operations in cold regions, mortar gunners must practice firing using the compensated sight picture, as this will be the rule rather than the exception when firing from frozen surfaces (Figure 4-5).

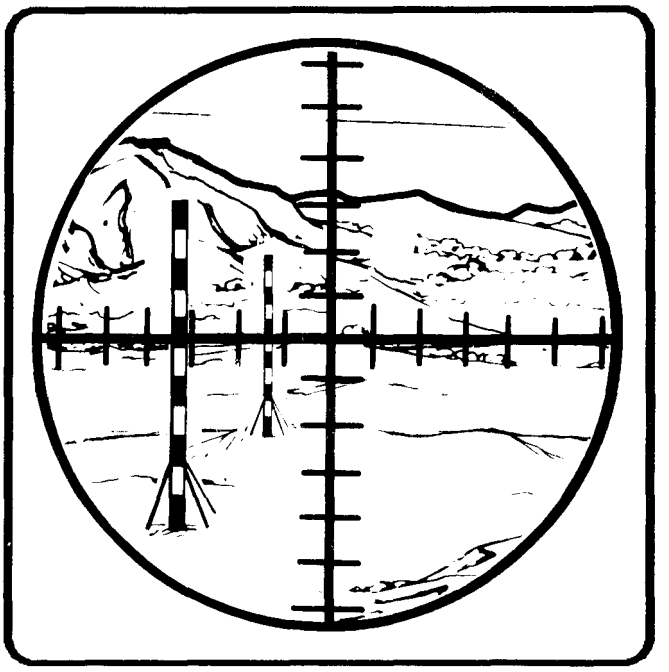


FIGURE 4-5. COMPENSATED SIGHT PICTURE.

LASERS

Laser sighting equipment is affected by visibility problems brought on by cold regions conditions such as ice fog and blowing snow. The HHLRF, for example, can only view for about 300 meters in heavy ice fog or heavy snow. The human eye can see about 500 meters under these same conditions. All army lasers will be limited by obscurant phenomena. However, when used in clear, cold, dry air, the HHLRF will allow accuracy to the fire support team (FIST) to within one meter at a range of 10,000 meters.

COMPASSES, BINOCULARS, AND OTHER OPTICAL INSTRUMENTS

The liquid in the lensatic compass in severe cold will become thickened. 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 in order to keep the liquid warm and thin. The dry-type compass is not affected by extreme cold weather.

Binoculars and other liquid-free optical instruments are not affected by cold weather. However, condensation does form when instruments are taken from cold air into warm air. Therefore, instruments should be left outside or *anticondensation* containers should be used.

Equipment, such as telescopes, should be covered while not in use. If a cover cannot be made to include the whole instrument, bag-type cloth covers should be made to go over the eyepieces and tube extensions. Cloth covers are better than airtight covers, such as the leather covers provided for some instruments, because the cloth covers allow breathing of the air in contact with the lens preventing condensation when the instrument is subjected to 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.

CHAPTER FIVE

SMALL ARMS MATERIEL

SECTION I. COLD WEATHER PROBLEMS

GENERAL

In cold areas, many climatic conditions will greatly affect the operation and employment of infantry weapons. All individuals must be well aware of these conditions so they may properly handle and care for their weapons under adverse circumstances.

CONDITIONS

Cold-dry conditions. As stated in earlier chapters of this manual, exposed metal surfaces will require more frequent applications of conservative 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 taken out into the cold air, the film of condensation freezes, especially in the internal parts, and stoppages and malfunctions result. When weapons are taken into heated shelter for cleaning purposes, *sweating* may continue for as long as one hour. Therefore, when time is available, wait one hour, remove all condensation and then clean the weapon.

Any opening which will allow air to enter can also be a condensation problem area. When in combat, winterized weapons should be left outdoors. In training, supervisors must enact special cleaning procedures to offset the phenomenon of condensation. During the attack or when enemy contact is imminent, the troop compartments of all transportation systems (especially helicopters and other aircraft) should have the heat maintained as close to freezing (32°F). This is done not only to avoid overheating of troops dressed in the cold regions uniform, but to preclude moisture from condensing and then refreezing on weapons as they debark from the warm transportation.

Commands in cold regions will have to realistically approach maintenance allocation in order to fight the problems created by condensation. For example, the operator is not normally allowed to disassemble the buffer assembly of his M16A1 rifle. Failure to modify maintenance allocation can result in many rifle stoppages.

Snow and ice. Blowing snow will tend to get into everything. Snow and ice cause the majority of breakages and malfunctions in smalls arms. Soldiers must ensure snow and ice do not get into the working parts, sights, barrel, magazines, or ammunition, especially when moving through the woods in deep snow under combat conditions. Muzzle caps should be used when available, but should be removed prior to firing.

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

COLD WEATHER FUNCTIONING DIFFICULTIES

Sluggishness. A common weapon 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. The prescribed application of CLP should then be made. These lubricants will provide proper lubrication during the winter and help minimize freezing of snow and ice on the weapons.

NOTE: CLP will be used as both lubricant and bore cleaner for all small arms at all temperatures. LAW may be used at temperatures below O°F until stocks are exhausted. Refer to Appendix B for complete information on lubricants and related materials.

Breakages and malfunctions. Another problem that faces the solder in the areas of severe cold is a higher rate of breakage and malfunctions. These can be attributed primarily to the cold, although snow in a weapon may cause stoppage and malfunctions. The hardened metal parts of automatic weapons are more brittle than soft metal in cold temperatures. When the weapon is fired at subzero temperatures, parts can break within the first few rounds. Short bursts will gradually warm the gun to a normal firing temperature. The 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 cyclic rate.

Emplacement. Most crew-serviced 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* and 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 is available, tripods should be positioned by expedient means to keep them from moving. Lashing the tripod feet to logs which rest on pine boughs or brush or using the ahkio (sled) as a firing platform are methods to stabilize the tripods.

SECTION II. EFFECTS OF COLD ON USE OF VARIOUS SMALL ARMS AND AMMUNITION

GENERAL

When using weapons or handling ammunition during severe cold weather, the operator should

wear gloves or trigger-finger mittens with liners. Under these conditions, it will not be possible to sustain operation for prolonged periods of time.

PISTOLS

The only difficulty that may be encountered is the damage of moving parts and the difficulty of firing a pistol wearing arctic mittens.

RIFLES

Malfunctions and breakages are caused in firing because of the cold or because of fouling of the weapon with ice or snow. Parts most subject to breakages are sears, firing pins, and operating rod parts that are moving or affected by recoil. Malfunctions in automatic rifles may be caused by snow or ice plugged magazines. Avoid the bipeds freezing in position by applying LAW. Although all rifles will create ice fog, the adverse affects of this are minimized since the firer can change his position.

GRENADE LAUNCHERS.

No particular problems exist in the operation of the 40-mm grenade launcher in severe cold temperatures. However, like the hand grenade, the grenade itself will lose much of its effectiveness when detonated under snow and a higher proportion of duds will result. The launcher should be fired dry or lubricated lightly with LAW.

MACHINE GUNS (MGS)

MGs have a high rate of breakages and malfunctions due to cold weather. Especially affected are sear and bolt parts. Gun crews must carry extra parts of this type. One common malfunction, occurring early in firing, is short recoil (bolt does not recoil fully to the rear).

Prescribed immediate action for the particular weapon should be applied. As the metal warms, the problem will diminish. A second malfunction is caused by freezing and hardening of buffers. This in turn causes great shock and rapid recoil, thereby increasing the cyclic rate. When this happens, generally, parts will break.

Condensation will cause parts to freeze as on most other weapons. All internal components and friction surfaces of MGs should be coated with LAW. These weapons will have fewer malfunctions when fired cold and dry if subzero 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.

AMMUNITION

Cold weather does not materially affect the performance of small arms ammunition. Ammunition should be kept at the same temperature as the weapon. It should be carried in bandoleers, and additional ammunition should be placed 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 its original container, raise off the ground, and cover with tarpaulins, ponchos, salvage tents, or any other material that will protect it from the snow. Ammunition so stored should be suitably marked to locate and identify it in the event it becomes covered with snow as seen in Figure 5-1.

Resupply of ammunition may be restricted. All soldiers must practice ammunition economy and fire discipline. Loaded clips, magazines, or single rounds dropped into the snow are quickly lost; therefore, careful handling of ammunition is essential.

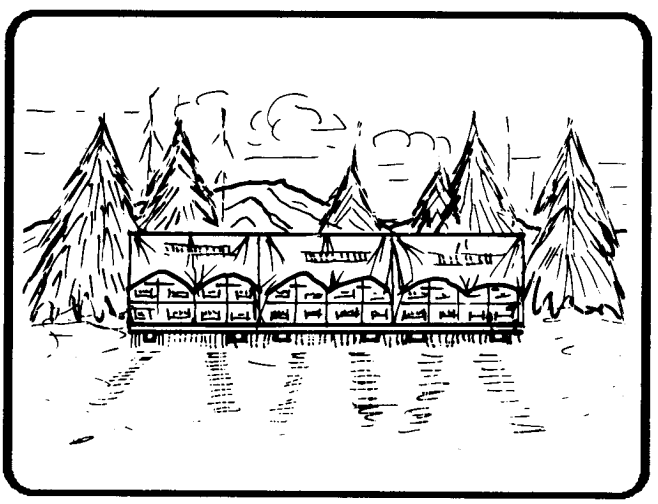


FIGURE 5-1. PROPER AMMUNITION STORAGE.

CHAPTER SIX

TACTICAL COMMUNICATIONS

SECTION I. COLD WEATHER PROBLEMS

GENERAL

Establishing and maintaining tactical communications in the cold regions requires increased attention to detail and the application of several special techniques.

CONDITIONS

The primary climatic conditions affecting communications and communication's equipment in cold regions include cold temperatures associated with dry air, condensation resulting from rapid, relative, temperature changes, frozen surfaces, snow and ice, visibility, and electromagnetic conditions.

Cold, dry air. Cold-soaked equipment is especially difficult to assemble for operation. Increased attention to detail, patience, and special preparation to prevent damage is required when working with tight connections, electrical contacts, inflexible cables, power cords, groundings, control knobs, rubber covers, binding posts, and a host of other moving parts. This problem is further complicated by the bulky handwear on the operators and maintainers.

As mentioned in Chapter 1, cold markedly lessens the operational life of batteries. 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 the operators and technicians as well as to the equipment. Temperature inversions which occur on the coldest days in cold regions degrade FM communications signal strength drastically and must be planned for in 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. Additionally, 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 provide one of the best means for penetrating frozen earth, coupled with water-saturated salt/soil backfill poured over the grounding device.

Extraction of grounding devices will more than likely be possible only after seasonal thawing. Use of existing grounds (pipes, established grounds, and buried steel) is desirable.

Snow and ice. Snow and ice 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 prevalent 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 disassemb-

ly in the dark are difficult and time consuming, especially when wearing required handwear. High frequency (HF) wave propagation markedly deteriorates with changes occurring in the ionosphere as darkness approaches. Lower frequency assignments which require longer antennas are also required. A good day of HF communications between stations 100 kilometers or more apart might be limited to only 6 hours.

Electromagnetic conditions. The Aurora Borealis activity can cause noise, suppress signals, and cause unusual wave propagation in radio communications. While equipment is not damaged by this electromagnetic interference, planners must anticipate this degradation in their choices of 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.

While units routinely assigned to cold regions have reported using Aurora activity to gain greater range for HF radio by reflecting directional signals off the light fields, this innovative use of the 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 requirement 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. EFFECTS OF COLD OPERATION AND MAINTENANCE OF COMMUNICATIONS SYSTEMS.

RADIO SYSTEMS

While several considerations for radio equipment have been addressed above, 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.

Even well-maintained equipment will require considerable warm-up time. For example, a cold-soaked AN/GRC-42 radioteletype system might require warming for 3 to 4 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 the Yukon stove. Electronic components and insulators can easily melt or burn, and some batteries can explode when thawed too close to a stove or heater.

Carry the handsets for portable manpacked radios inside at least one layer of the user's clothing to prevent push-to-talk switches from freezing. This requirement, in conjunction with the operator wearing a parka hood, severely hampers the ability to hear incoming transmissions. This may be overcome through use of external speakers such as the LS-454/U. Plastic coverings, such as battery packaging, should be used to cover the mouthpieces of handsets, even with the presence of moisture shields, to keep moisture of the operator's breath from freezing the handset. An excellent alternative is the use of a standard *nonlubricated prophylactic* slipped over the handset. A wool sock over the handset keeps snow and ice out while protecting the operator from direct contact with cold plastic and metal.

Anticontact gloves should be available and used when touching cold metal equipment. Cold injury and loss of surface skin can occur even in the briefest of contact with cold handles, knobs, and surfaces. Additionally, 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 require careful attention as well. Small physical shocks can cause whip antenna damage when in the upright position. Radios should be warmed for 3 to 4 minutes on low power prior to 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, or the high discharge rate necessary to operate both

the radio and the heater will soon wear out the vehicle's batteries.

ANTENNA SYSTEMS

Attention to proper cut 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 an adequate number of sections to ensure necessary height.

Erecting. Standard stakes are often useless in the frozen ground. Heavy 12-inch steel tent pins have been successfully used. Also, tree and rock tie-offs are acceptable. Another method for erecting an FM antenna is to guide the mast carefully alongside a tree and secure the mast 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 the 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, antennas should be exposed to the cold to prevent sweating and freezing. This prevents problems with disassembly.

Keep the mast sections clean and free of foreign matter. The male and female ends of each mast section should never be greased, as grease can freeze or thicken sufficiently to hinder proper disassembly. Silicone lubricant works well on element joint threads. After applying the silicone and joining the sections, the joints should be backed off approximately one turn as a precaution against sticking.

The RG-213 coaxial cable is recommended over the RG-8 cable, as the latter becomes brittle and cracks at temperatures below -20°F. Spare cable connectors and adaptors are recommended, since damage and loss are common. Coaxial antenna cable should be looped and taped near the top of the mast to ease pressure on the connector. Tape the cable intermittently along the mast to prevent whipping action of the wind from causing damage to the antenna. The mast should be tapped periodically to shake free snow and frost accumulation which can degrade

transmission signal strength. Guy lines should be marked in a manner to preclude interrupted signal and bodily injury if personnel trip on the antenna guys and disable the antenna.

Length. HF and long wire antennas sometimes 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 plane sections are given in table 6-1 on the following page.

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

WIRE AND CABLE SYSTEMS

Several methods applicable to use of wire and cable systems were addressed earlier in this chapter.

Laying wire over long distances in deep snow is greatly facilitated by the use of snow machines. These vehicles can also be the worst enemy of wire systems, in that 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 the cold regions as well as in the temperate zone. Aerial laying is advised when tactically feasible. Burial is desirable, but often proves to be difficult or impossible. Retrieving wire in the cold regions is tedious and usually results in excessive salvage work due to ice and traffic damage.

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 implies that additional wire is required if conventional distances of deployment are used.

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, however, when powered by alkaline batteries, such as the BA-3030/U, provides reliable communications and is the preferred instrument for wire troubleshooting teams.

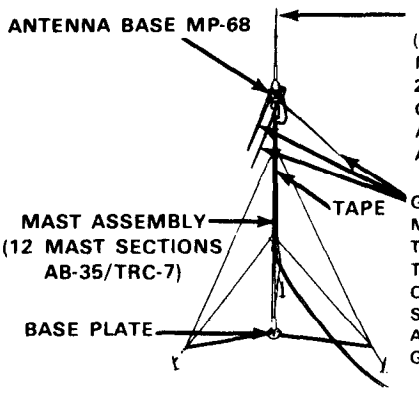
The newer type WD-1/TT field communication wire performs nearly as well in the cold environment as the old type of spiral wire. It is, however, less durable and more susceptible to damage by vehicle traffic and should be considered for use in less travelled areas. Another field wire which is available is WD-36/TT assault wire, which is lighter and easier to handle, man-pack, dispense, and splice than WD-l/TT in the cold, but 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 subzero temperatures. This is attributable to outdated LO and exposed batteries and other elements. Follow the below procedures for best results:

- Winterize the item using the correct cold weather lubricants.
- Find a way to keep the battery warm.
- Preheat using other heat sources when possible.
- Handle carefully.
- Provide shelter so that the item provides its own heat.
- 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.
- Check, drain, and clean filters at least daily, and at shut-down to prevent icing.
- Proper grounding of generators is important, but is seldom done satisfactorily. Expedient grounding in cold regions maybe performed by using an ice auger to cut through frozen surfaces, then submerging conductors into the water. Other techniques are discussed earlier in this Chapter.

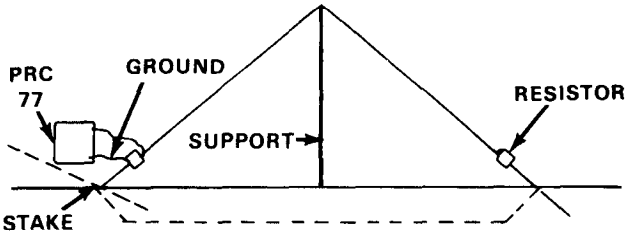
TABLE 6-1



ANTENNA EQUIPMENT RC-292

RC-292 ANTENNA CONFIGATIONS

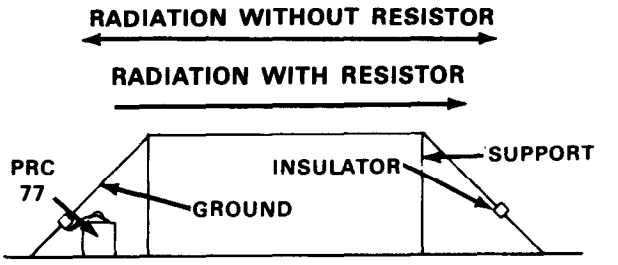
OPERATING FREQUENCY	Number of Antenna Sections Required	Type of Section Used				Number of Ground Plane Sections Required	Type of Ground Sections Per Element			
		AB 21/GR	AB 22/GR	AB 23/GR	AB 24/GR		AB 21/GR	AB 22/GR	AB 23/GR	AB 24/GR
20 to 27.9	6	3	1	1	1	18	3	1	1	1
27 to 38.9	4	1	1	1	1	15	2	1	1	1
38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



VERTICAL HALF RHOMBIC ANTENNA

Used primarily with FM Radios in lightly wooded areas.

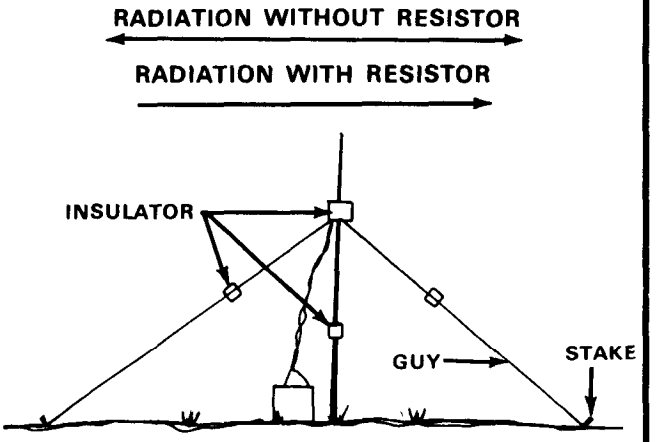
Length..... 4 wavelengths of operating frequency, with a 11-½ meter lead-in.
Range ..... 2 to 3 times normal range of set.
Height..... 13 wavelengths of operating frequency.
Resistor..... 400 to 700 ohms.



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 terrian 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
Radation..... WITHOUT resistor- off both ends of antenna.
WITH resistor- off resistor end only.



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.