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14. ABSTRACT
This Test Operations Procedure (TOP) provides specific and general procedures for testing tracked and wheeled vehicles in a Cold Regions environment. The common characteristics of a cold region are cold temperatures, strong seasonality with distinct changes in insolation, frozen atmospheric moisture, frozen ground, and freeze thaw of water. These characteristics have moderate to high risk impacts on the operation of tracked and wheeled vehicles and are best addressed through natural environmental testing. Methods for testing vehicles for the effect of these cold-regions characteristics are a primary goal of this TOP.

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 2-4-002 22 September 2009
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Cold Regions Test of Tracked and Wheeled Vehicles

*This TOP supersedes TOP 2-4-002 Arctic Environmental Test of Tracked and Wheeled Vehicles, 10 July 1969

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1. SCOPE.

This Test Operations Procedure (TOP) provides specific and general procedures for testing tracked and wheeled vehicles in a cold regions environment. The common characteristics of a cold region are cold temperatures, strong seasonality with distinct changes in insolation, frozen atmospheric moisture, frozen ground, and freeze thaw of water. These characteristics have moderate to high-risk impacts on the operation of tracked and wheeled vehicles and are best addressed through natural environmental testing. Methods for testing vehicles for the effect of these cold regions characteristics are a primary goal of this TOP.

1.1 Purpose.

The purpose of this document is to provide a systematic approach to testing vehicles in the cold regions in order to ensure that vehicle performance in that environment meets requirements. This document provides uniform procedures for verifying system performance with specific emphasis placed on the moderate and high-risk environmental factors found in a cold region.

1.2 Applicability.

a. While most of the procedures in this TOP are applicable to both tracked and wheeled vehicles, the diversity in equipment design, vehicle missions, platform configuration, and the state of current technology integrated into the systems prevent any single TOP from addressing all possible scenarios. The procedures and subtests specified in this TOP are designed to address vehicle suitability while operating under varying conditions in a natural cold regions environment. Systems that are integrated into the vehicle platform are addressed in this TOP, if appropriate, or reference is made to TOPs which address the specific system. Although the procedures in this TOP are applicable to all wheeled and tracked vehicles, additional guidance for the testing of hybrid vehicles are presented in TOP 2-1-003[1**].

b. Appendix A lists some of the environmental conditions found in cold regions and the effects on various tracked and wheeled vehicles. Additional cold regions environmental considerations are presented in TOP 1-1-017[2] and 1-1-005[3]. Testing should be conducted as much as possible while wearing the appropriate layers of the Extreme Cold Weather Clothing System (ECWCS) or clothing of equivalent warmth and bulk. Appendix B provides a list of the current ECWCS components and issued cold weather clothing authorized for the military.

1.3 Limitations.

a. Tracked and wheeled vehicles are required to be tested in the natural cold regions environment to replicate the exposure the systems will have when used by the Soldiers in the field. If, during testing, the minimum temperatures required to address specifications are not realized, data may be supplemented by laboratory or chamber tests. Cold chamber tests may also be conducted prior to natural environment testing to develop cold start procedures and check operation of components. However, the chamber tests are not a substitute for tests conducted in the natural environment.

[**] Superscript numbers correspond to those in Appendix G, References.

b. The information and procedures contained in this document can be tailored for specific systems. Some of the subtests included are not normally conducted in the cold regions. However, to provide a comprehensive document, this TOP addresses all vehicle tests that would be conducted on vehicles which are developed for sole use in a cold region, e.g. over snow equipment. Although not all sections may apply to every vehicle, all safety related sections should be addressed.

c. The primary emphasis of this TOP is on testing in extreme cold during the winter months. However, testing should also address the changes in climate, terrain, and vegetation that occur seasonally. Some of these seasonal differences may be addressed through natural environmental testing in temperate or dry regions.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

2.1.1 Mobility Courses.

Access to off-road, paved test courses, and established road networks that allow tracked and wheeled vehicle mobility testing are required. Profiled driving courses and established test tracks are preferred if they meet the needs of the test requirements stated in the criteria, or other directives such as the Purchase Description/Performance Specification System Specification, Operational Requirements Document/Capabilities Requirements Document (ORD/CRD) and Operational Mode Summary/Mission Profile (OMS/MP) or agreed on by the Program Manager (PM) and/or evaluators. The selected course(s) must have pre-surveyed points to facilitate the testing of vehicle mounted position navigation systems and should be in an area that allows for natural and/or man-made accumulations of snow, drifting snow, and ice, are frozen to depths exceeding 60 cm. (2 ft.) during winter, and subjected to freeze/thaw cycles seasonally. Appendix C provides a map of trails used at Cold Regions Test Center. Specific testing areas need to be identified, and the surface prepared and groomed as needed to enable data collection on braking, acceleration, high speed operation, steering, handling, skid testing, split mu (split-friction), slope, and side slope testing under various terrain and environmental conditions. The areas selected should replicate the cold regions conditions that the vehicle will be exposed to when operated by the end item user. Following are characteristics of these courses:

a. A straight, level, paved road or oval test track with a lane width of not less than 3.7 meters (m) (12.1 feet (ft)), a longitudinal gradient ≤ 1%, and a side-to-side gradient ≤ 2% is desired. The road or test track should be sufficient to allow the test vehicles, at their required payload, to accelerate to their rated top speed and safely stop. Testers must pay particular attention to the weight of the vehicle and/or type of track used on the tracked vehicles when using either government or public paved roads, as restrictions will apply. The road/test track will also have seasonal restrictions; e.g. winter vs. summer testing.

b. A paved lateral acceleration pad of not less than 305 m x 244 m (1000 ft x 800 ft).

c. A paved skid pad of not less than 61 m x 366 m (200 ft x 1200 ft).

d. Test slopes of 5%, 10%, and 15% grades in gravel and asphalt and slopes of 20%, 30% and 60% in gravel and concrete, and an earthen side slope of 40%, 30 m (100 ft) in length and 15 m (50 ft) in height, as a minimum.

e. A level, and if possible, profiled dirt course with terrain of native soil that varies from moderately irregular to rough.

f. Access to public paved and gravel road networks (with proper state permits: e.g. oversize, weight, environmental, hazardous material etc.) which allow moderate to high-speed operation with grades of 11% or less.

g. A hilly cross-country course with moderate to rough native soils with grades less than 30%.

h. A mix of secondary improved gravel roads with grades of 5 to 30%.

2.1.2 Firing Ranges.

For vehicles with weapons systems, a controlled access firing range is required with the following characteristics:

a. Impact area that is usable from minimum high angle to the maximum range of the test weapon.

b. Surveyed fixed firing positions to provide data to address, if required, weapon criteria during live fire exercises in winter and summer environments.

c. Existing firing ranges should be used when possible as the range distances are known and automatic scoring can be provided.

d. Stationary and/or moving targets must be available or constructed for functionality testing of weapon systems, optical and thermal sighting devices, laser range finders, and other devices.

e. Mobile firing course used to exercise weapon stabilization system.

f. Bomb proof shelters may be required to support some tests and should be moved into place prior to the start of testing.

g. Ground, berm, or firing pad work on the ranges must be completed before the ground freezes and becomes unworkable.

2.1.3 Maintenance and Storage.

a. Maintenance facilities must provide adequate space for the inspection and repair of the test vehicles. These facilities must have adequate lighting, heat, accessibility, and physical security. The tester must ascertain whether the facility has the capability to remove power packs, turrets, and other components. An overhead crane rated to 25 tons with sufficient clearance for large component removal and for the weighing of large test items is required. For M1 tank maintenance actions, a 40-ton minimum capacity crane is recommended. A mobile crane of sufficient capacity can be used; however, this will require component removal outdoors which can be difficult or impossible to accomplish in extreme cold temperatures. Turret and engine stands are required depending on the scope and length of the test. These items should be shipped as part of the System Support Package (SSP) prior to the start of test.

b. The need for additional heated storage space may be required for Test Measurement and Diagnostic Equipment (TMDE), the issue of repair parts, and packing and crating of test items. Storage requirements also exist for Petroleum, Oils, and Lubricants (POL), fuel, and gasses. The types of loading/unloading requirements need to be addressed early in the test planning stage: e.g. forklift or mobile crane support, loading docks, vehicle scales, and ramps.

c. The distance from support facilities to test sites will dictate the quantity and type of recovery equipment needed to support the test and the time to recover disabled test vehicles. It may be desirable to locate recovery and road clearing/snow removal equipment closer to the planned test site when feasible.

d. Coordination should be made with the test center's hazmat coordinator for the collection and disposal of hazardous materials such as automotive batteries, used POL products, solvents, paint, oily rags, etc.

2.1.4 Facilities for Ammunition Storage, Handling, Transportation and Disposal.

a. A temporary Ammunition Supply Point (ASP) may be required to address compatibility issues during shipping and storage (Hazard Classification of U.S. Military Explosives and Munitions REV 12, October 2007[4]).

b. The amount and type of ammunition, propellants, and fuses required for the test must be determined and provided to the test center's ammunition manager with enough lead time to plan for the transportation and storage of the items.

c. Coordination with ammunition specialists for delivery from the ASP to the test site should be accomplished in sufficient time to ensure delivery. Ammunition can be cold conditioned then delivered to the test site if required.

d. If ammunition at the test site becomes colder than the allowed lower limit for firing, it must be transported back to the ammunition bunker and allowed to warm to acceptable temperatures.

e. Any issues with the ammunition such as exterior damage, disfiguration, frequent and/or unusual misfires, or short rounds are to be reported to the test center's Ammunition Manager who will coordinate with the Quality Assurance Specialist (Ammunition Surveillance) (QASAS) for inspection and if necessary, reclassification of the ammunition. For destruction of damaged ammunition, fuses, propellants, or duds coordination may be made through the Ammunition Manager for assistance from Explosive Ordnance Disposal (EOD).

2.1.5 Administrative.

a. Office space with adequate heat, lighting, and ventilation must be provided to the test team and vehicle crews. Existing facilities should be used when feasible. Telephones, computer access, office equipment, and any special requirements to support the test must be in place prior to the start of testing. Computer and network access requires approval and may require additional arrangements to accommodate non-government testers, customers, contractors, or support personnel. These approvals must be coordinated with the Information Security Officer early in the test planning process.

b. On some tests portable/mobile trailers, tents, and portable warm-up buildings may be used and should be positioned as close to the test site as possible. Briefing areas as close to the tested equipment as practical will facilitate the flow of information between the test officers and the test team members. Heat and generated power to support these mobile facilities must be available and able to function in temperatures as low as -46 °C (-50 °F).

c. Latrine facilities (portable toilets) need to be contracted for if needed at remote test sites.

d. Since some equipment may require testing in locations distant from the established test sites because of altitude, changing temperature, marine environment, considerations for temporary portable maintenance, and/or administrative facilities such as vans/expandable vans, trailers, and tents or tarps to support test operations should be made.

2.2 Instrumentation.

A wide range of instrumentation must be available to measure the performance of the components, subsystems, sensors and to capture required data. TOP 1-1-004[5] outlines special considerations for instrumentation requirements in a cold region environment. Table 1 highlights those data sets most commonly measured and collected. However, the list is not all inclusive and additional instrumentation may be required to test specific vehicles.

Table 1. Instrumentation Requirements.

Item	Data Required	Device for Measuring	Permissible Measurement Uncertainty (NOTE 1)
Vehicle	Gross/Combat Weight	Portable Drive on Vehicle Scales/ Fixed Scales	± 1% of Reading
	Axle Weight	Portable Drive on Vehicle Scales	± 1% of Reading
	Physical Dimensions	Common Measuring Tools	± 0.64 cm (0.25 in)
	Vehicle Speed	Global Positioning System (GPS) Based Vehicle Performance System	± 0.2 kph (0.1 mph)
	Stopping Distances	GPS Based Vehicle Performance System/ 5th Wheel as Backup	± 40 cm (16 in)
	Vehicle Slew	Common Measuring Tools	± 5% of Reading
	Tire Air Pressure	Transducer/Pressure Gage	± 2% of Reading
	Component Temperatures	Temperature Sensors	± 2 °C (3.6 °F)
	Doors/Handles/Hatches	Spring Gage/Dial Spring Gauge	± 1 Graduation
	Switches & Buttons	Spring gage	± 1 Graduation
	Slope/Side-Slope	Inclinometer	± 0.5 Degree
	Tire Wear	Tire Depth Gage	± 0.08 cm (0.0325 inch)
Engine and/or Transmission (Note 2)	Engine Temperature	Temperature Sensors and Recorder	± 2 °C (3.6 °F)
	Oil Sump Temperature	Thermocouple	± 2 °C (3.6 °F)
	Battery Specific Gravity	Battery Hydrometer	Specific gravity to ± 0.005
	Battery Voltage/Amp Draw	Volt/Amp Meter & Shunt	± 3% of Reading
	Cranking Speed	Tachometer	± 10 % of Reading
	Fuel Flow/Consumption	Flow Meter, Measure or Manual Tracking	Average ± 5%
	Vacuum	Vacuum Gages	± 1 Division
	Pressure	Pressure Gages (Liquids and Gases)	± 1 Division
Displays, Screens & Interior Lights	Illumination	Light Meter	Depending on Requirement
Winches/Hoists	Load Capacity	Load Cell	Capacity depending on weight of test vehicle ± 1%
Hearing Protection	Noise Levels	Sound Level Meter	± 5% of Reading
Toxic Fumes	% Concentration	Various Sensors	± 5% of Reading for most gas, some as high as 25%
Heater/Defroster Head/Hand/Foot Display Screens as needed.	Temperature, Air Flow, Start/Stop Times	Temperature Sensors, Air Flow Meter, Stop Watch	Temp ± 2 °C (3.6 °F) Air Flow ± 5% Time ± 0.1 second
NBC Collective Protective Systems	Outlet Temperature, Air Flow and Start/Stop times	Temperature Sensors Air Flow Meter Stop Watch	Temp ± 2 °C (3.6 °F) Air Flow ± 5% Time ± 0.1 second

Table 1. Instrumentation Requirements.

Item	Data Required	Device for Measuring	Permissible Measurement Uncertainty (NOTE 1)
Ride Quality		Accelerometer	Depending on Requirement
Ingress/Egress	Time	Stop Watch	± 0.1 second
Weapon System	Wear Limits	Bore Scope/ Pull Over Gage	IAW TM procedures
	Impact	Survey Equipment	± 15 m (50 ft)
	Pressure	Crush Gages	N/A
Primary and Secondary Weapons – Direct Fire	Boresight	Collimated Muzzle Boresight Device Applicable Gridboard	IAW TM Procedures
Met Data	Ambient Temperature	Temperature Digital Probe	-50 °C to +50 °C ± 2 °C (-58 °F to +122 °F ± 3.6 °C
	Relative Humidity	Digital Probe	20 to 80% ± 5% at 0°C to 100°C (32 °F to 212 °F)
	Atmospheric Pressure	Digital Barometer	500-1100 hpa ± 5%
	Wind Velocity	Digital Anemometer	0-100 Knots ± 2 Knots
	Wind Direction	Digital Anemometer	0-360° ± 5%
	Precipitation-Winter	Observer Collected	± 0.08 cm (0.03 in)
	Precipitation-Summer	Digital Tipping Bucket	± 0.05 cm (0.02 in)
	Solar Radiation	Digital Tyranometer	± 2 Langley or ± 5% Watts per Meter^2
Snow & Soil Firmness	Firmness (NOTE 3)	Hand Held Cone/Drop Cone Penetrometer Digital Temperature Probe Snow/Soil Kits Observer Record	Cone Penetrometer 300psi ± 10%
Snow & Soil Strength	Compactness & Strength (NOTE 3)	Bevameter & Drop Cone Penetrometer or Rammsonde Snow/Soil Kits Observer Record	Cone Penetrometer 300psi ± 10%
Human Factors Engineering		Anthropometric Measuring Kit	± 0.5cm (0.2 in)
Laboratory Support - Army Oil Analysis Program (AOAP)	Oil and Fuel Analysis Contamination Results	Spectrograph and Assorted Lab Equipment	Lab Determined

Note 1. The permissible measurement uncertainly is the two-standard deviation value for normally distributed instrumentation calibration data. Thus 95 percent of all instrumentation calibration data readings will fall within two standard deviations from the known calibration value.

Note 2. When feasible, a non intrusive approach should be used to instrument and collect data, for example using ADMAS to establish parameters and capture data from the vehicle data bus.

Note 3. Additional information can be found in CRRL Report 93-6 Terrain Characterization for Trafficability, June 1993[6]

3. REQUIRED TEST CONDITIONS.

3.1 Environment.

a. The test conditions of terrain, climate, and vegetation that are found in the cold regions provide the critical and moderately severe environmental effects on systems. During testing, the ambient temperature, soil conditions, frozen ground conditions, presence of snow and ice on the surface, and falling snow must be recorded. Table 2 shows the severity of the effect of these environmental factors on vehicles and the associated systems that may be on the vehicle. Dark grey cells in the table indicate environmental factors within the cold regions that have a critical effect on the systems listed. Light grey blocks indicate environmental factors within the cold regions that have a moderate effect on the systems. All testing in the cold regions should be concerned with those factors that have moderate to critical effects on the systems under test. In order to address critical factors, vehicles and the associated systems should be tested under conditions of cold temperature, falling snow, and surface snow and ice. Additionally, the systems should address the effects of rough terrain, slopes and rock, frozen soil, dense vegetation, and for specific associated systems, fog, ice fog, and white out.

Table 2. Risk Matrix for the Cold Regions.

	Wheeled, Tracked, and Special Purpose Vehicles	Unmanned Ground Vehicles	Direct Fire Weapons	Indirect Fire Weapons	Ammunition and Explosives	Electronics, C4ISR	CBRN
Low Temperature	Critical	Critical	Critical	Critical	Critical	Critical	Critical
Precipitation (Snow, Freezing Rain, Hail)	Moderate	Critical	Critical	Critical	Critical	Critical	Critical
Fog/Ice Fog/White out						Moderate	
Landforms (Steep Slope, Relief, Roughness)	Moderate	Moderate	Moderate			Moderate	Moderate
Exposed rock	Moderate	Moderate		Moderate			
Frozen Soil	Moderate	Moderate		Critical			
Surface Snow/Ice	Critical	Critical		Moderate		Moderate	Moderate
Dense Vegetation (Forest/Jungle)		Moderate			Moderate	Moderate	Moderate

b. This TOP makes use of three cold categories designated as C1, C2, and C3 that refer to corresponding climatic categories defined in Army Regulation (AR) 70-38[7]. These cold categories refer to the temperature conditions during the coldest day found in increasingly colder geographic areas. C1 category represents a day in which the ambient temperature ranges from a low of -32 °C (-25 °F) to a high of -18 °C (0 °F). C2 represents a day in which the temperature ranges from a low of -46°C (-50°F) to a high of -37 °C (-35 °F). C3 represents a day in which the temperature stays at the low of -52 °C (-60 °F) and is considered a storage temperature. During all testing the vehicles will be operated in as wide a range of temperatures as available. However, the test effort will also be focused on ensuring tests are conducted and data accumulated in ambient air temperatures from -18 °C (0 °F) to -32 °C (-25 °F) and when required to temperatures below -32 °C (-25 °F) to the lowest ambient temperature available. Operations below -52 °C (-60 °F) will not be conducted unless otherwise directed.

c. Testing will continue regardless of adverse weather conditions, except when conditions will compromise test results or endanger life or property. The vehicle(s) will be stored outdoors, exposed to the prevailing weather conditions, except for when indoor maintenance is required. Preventative Maintenance, Checks and Services (PMCS) will be conducted outdoors on the equipment to obtain PMCS data. The length of cold-soak[2] periods and ambient air temperatures will be recorded during each subtest, as appropriate. Appropriate actions must be taken to protect or remove any component or sub-system that has restrictions on the lower temperature limit for operation or storage. Record and report any mission limitations or mission aborts caused by reaching lower temperature threshold limits.

3.2 Test Item Configuration.

a. The vehicles should be tested in the most current configuration with all Engineering Change Orders (ECOs), Modification Work Orders (MWOs), and current software updates applied. Vehicles are tested at their rated payload and/or full combat load including Add-on Armor (AOA), unless otherwise specified. Follow the published or recommended loading plan. If no loading plan is published, stow items in the most logical place considering size, weight, and easy access to the most frequently used items. This plan should include any required items unique to a cold regions environment (i.e. tire chains, hand held heaters, snowshoes, cross-country skis, etc.). Document the item and stowage location and submit the information as a recommended loading plan at the completion of the test. During all mobility operations, combat vehicles will be operated in a full-up combat ready mode (all systems powered up) whenever feasible or as required by the OMS/MP.

b. An initial inspection will confirm the completeness of the test item to include all Basic Items Issue List (BIIL), On Vehicle Equipment (OVE), and attachments or special purpose kits, sets, or outfits.

[2] Cold soak is the effect of exposing equipment to low temperatures for an extended period of time, generally until the temperature of a measured point on the equipment is within ± 5 °F of the ambient temperature.

c. Sufficient testing should be conducted to demonstrate that the operator/crew, software, vehicle platform, control units, and all mechanical operating devices and applications are functioning as designed and work effectively together. As part of this effort, determine that the safety characteristics of the vehicle and its components are in accordance with (IAW) TOP 2-2-508[8].

d. Test conditions for each procedure are identified in paragraph 4 below, TOPs, or International Test Operation Procedures (ITOPs) referenced in this document.

3.3 Test Planning.

a. Criteria for each subtest data topic will be defined based on applicable contractual specifications and military requirements documents. Specific test criteria for natural environment cold region testing are limited in scope and often vague in context. Where the criteria are not clearly specified, criteria will be developed from the relevant TOP, Military Standard (MIL-STD), federal statute, or other controlling document. Developmental Test Command (DTC), Army Evaluation Center (AEC), or the PM may provide criteria. Test center created criteria may be used if all involved parties concur. Development of criteria should consider the logistics concept, employment concept, intended application, novel technologies, and threat environment as appropriate. Failures and successes should be defined to provide for a clear understanding of relevant conclusions for environmental performance, reliability, and safety. Appendix D provides additional guidance for test planning and supporting documentation needed for the cold regions testing of wheeled and tracked vehicles.

b. Data requirements and analytical techniques necessary to address objectives and criteria will be established. Data sheets for each subtest data topic should be designed or utilized from previous testing to provide data continuity.

c. Appropriate test procedures for each subtest topic relative to objectives, criteria and data requirements should be selected or developed.

d. Test officers must forecast and submit ammunition, fuel, and POL requirements far enough in advance of the start of test to ensure their delivery. Communications frequency allocation requests must be submitted to the local frequency manager for approval. Construction in support of the test may need to be done the summer before and often requires considerable coordination with the Department of Public Works (DPW) and environmental offices.

e. Construction of new vehicle courses, off-road trails, or other features may be required. Often, this work must be done in summer while the ground is thawed. For this reason, environmental documentation such as National Environmental Policy Act (NEPA), wetlands, and archeological documentation must generally be completed by late spring. Early coordination is critical. One to two years may be required for some construction projects.

f. Environmental testing requires a great deal of flexibility in planning, execution, and work hours. The environmental conditions cannot be controlled, so testers must be able to react to and take advantage of the conditions as they occur. Temperatures or other environmental conditions required for testing might occur late at night or in the early morning hours. Be prepared to adjust the work schedule and sequence of test events to maximize the available time allotted for the test. Tests that are dependent on cold temperatures are a priority. Do not assume that because it is early in the winter season, there will also be extreme cold temperatures later in the season. Attempt to accomplish all testing in which the temperature is the major variable whenever those temperatures are expected. Snow depth can also fluctuate quickly in a cold regions environment. The snow cover is normally light and dry and wind can blow the snow great distances. With strong winds, level snowfields will rapidly become drifted, hard-packed, or bare. Under the right conditions, high-speed warm winds, known as Chinooks, can raise the ambient temperature to above freezing in hours and melt all or most of the snow cover. If temperatures become too warm, testers must be cognizant of the high temperature limits of the lubricants used in the vehicle being tested. In some cases testing may have to be delayed until the temperature drops below the upper limit of the lubricants.

g. Various natural environmental conditions, cold, ice, snow, ice fog, freezing rain, and moisture all present their own unique challenges to the item being tested. Wet, heavy snow (near freezing) will affect the vehicle differently than new-fallen, fluffy snow at extreme cold temperatures. Pneumatic, hydraulic, and fuel systems as well as various materials can be affected differently by these environmental conditions. The potential for equipment problems being introduced increases even more when two or more of these conditions are combined. Appendix A lists some of the environmental conditions and the effects on various tracked and wheeled vehicles that must be considered during the test execution. Additional information can be found in TOP 1-1-017, Cold Regions Environmental Considerations. These problem areas are mostly unique to the cold regions; therefore, are seldom completely addressed in other documentation or publications. During the conduct of scheduled or unscheduled maintenance services, daily PMCS, or when a malfunction occurs, the tester must determine if the fault was caused or aggravated by one or more of the environmental conditions.

h. Review the test plan to take advantage of the cold soak requirements so that several subtests may be conducted at the end of the cold soak cycle without influencing the results of other subtests. When feasible, sequentially conduct engine cold starts, force measurements, heater performance, and toxic fume testing then continue into mobility testing as combined events rather than conducting each portion of the subtest separately.

i. If test support personnel are soldiers, they will be dressed for the task at hand in the appropriate layers of the Extended Cold Weather Clothing System (ECWCS) uniform worn by soldiers in a cold regions environment. A list of currently authorized ECWCS components and issued cold weather clothing for the military is found in Appendix B. If military personnel are not available to support cold regions environmental testing, tests will be conducted with the operator/crew wearing appropriate layers the ECWCS or similar civilian cold-weather clothing (e.g. Carhartt™ coveralls or the equivalent) that approximates the weight and bulk of the ECWCS uniform. Crewmembers are required to wear Vapor Barrier (VB) boots in temperatures lower than -18 °C (0 °F). Civilian finger gloves may be worn, unless another hand wear is specified. While the vehicle is in operation, crewmembers should wear the Combat Vehicle Crewman (CVC) helmets for most combat vehicle applications and the issued Kevlar helmet in tactical vehicles. Mission essential ensembles, such as NBC and body armor, if available, should be worn during the test when appropriate.

3.4 Test Controls.

Test controls are listed for each subtest data topic in accordance with the applicable ITOP, TOP, or MIL-STD.

3.5 Safety.

a. A complete safety and health hazard analysis should be made prior to and throughout the course of the test. A recommendation for a safety release must submitted and approved prior to using soldiers as operators or crewmembers of the wheeled or tracked vehicles. This recommendation for a safety release will focus on those issues unique to the testing in a cold regions environment if the vehicle(s) have a previous safety release. During the initial inspection and maintenance, observations should be made through visual examination and functional checks for compliance in design to assure personnel safety. During the course of testing, any potential hazard observed during operations or maintenance actions must be recorded. All scheduled subtests should be considered in the overall safety and health assessment. All components must be safe or the hazards controlled to an acceptable level.

b. A Safety Release indicates a system is safe for use and maintenance and describes the specific hazard of the system, operational limits, and required precautions, (reference Department of the Army (DA) Pamphlet (PAM) 73-1[9], paragraph 6-64.b). The Safety Release will have a specific start and end date, and is only valid for a specific time period or event. The test organization shall reference this document in locally developed hazard analysis and risk assessment documentation, required by AR 385-10[10] and DA PAM 385-10[11]. This local analysis should address likely additional risks posed by testing or operation in the cold regions. This analysis should be done in conjunction with the system safety analysis, as detailed below in paragraph 4.1.4.

c. During all main and secondary weapons firing applicable range safety procedures will be closely adhered to. A qualified range Officer in Charge (OIC), range safety personnel, medical personnel, and emergency equipment (depending on the caliber of the weapon or type of system) will be physically present on the firing range.

4. TEST PROCEDURES.

The following subtests are commonly used in the testing of track and wheeled vehicles, however; they are not all inclusive nor do they address all possible configurations. Subtests may be added or eliminated as applicable to the system, to fully assess the cold regions testing of tracked and wheeled vehicles.

4.1 Preliminary/Initial Inspection.

4.1.1 Receipt Inspection.

a. Upon receipt of the vehicles undergoing test, conduct a physical inspection, baseline operation, and inventory for completeness (Reference TOP 2-2-505[12]). The system, subsystems, attachments, OVE, BIIL, sets, kits, and outfits must be undamaged, complete, and ready for testing.

b. Inspect items included in the SSP for completeness, damage, and packaging.

c. Perform necessary maintenance to correct shortcomings and deficiencies. Verify, through signed documentation from the responsible maintainer (or through samples submitted to a lab if time permits), that the correct weight oils and greases have been installed in the test vehicle and that the anti-freeze protection is adequate IAW the applicable vehicle Lubrication Order (LO). If documentation is not available and/or any doubt exists that the vehicle has the correct weight fluids and cold weather protection, change all fluids to the correct winter grades. Prepare the vehicle(s) for operations in temperatures to at least -46 °C (-50 °F). Additional information on the cold regions environmental impact on tracked and wheeled vehicles is provided in Appendix A for consideration when preparing vehicles for cold weather testing.

d. Determine if the vehicle (and which components of the vehicle) should be enrolled in the Army's Oil Analysis Program (AOAP). Enrollment in the Army's AOAP program is currently limited to selected combat vehicles and aviation specific equipment. Vehicles undergoing test are often excluded from the AOAP program; however, fuel dilution and air induction problems such as silicone ingestion, unusual metal wear, and advanced indications of possible catastrophic failure can be readily detected by an oil analysis. To capture possible oil contamination data, all wheeled and tracked vehicles undergoing test will have oil samples submitted to the Yuma Proving Ground (YPG) lab for analysis if the tested vehicle is not currently enrolled in AOAP. As a minimum, oil samples should be taken from the engine, transmission, transfer case, differentials, hydraulic reservoirs, and final drives. Obtain initial samples from the applicable components after fifty miles of operation with the appropriate winter grade fluids. Package the sample bottles IAW the current procedures, and ship the samples to the supporting laboratory to establish an analysis baseline. Follow the recommended sampling intervals as indicated in the applicable AOAP reference, or if not specified, 1000 miles or 100 hours for wheeled vehicle and 25 hours or 60 days for tracked vehicles. Hydraulic systems are sampled every 365 days. If required, follow the lab's recommendations for the appropriate corrective action based on the submitted sample such as; filter and oil changes, re-sampling, or a maintenance action. Request an AOAP history report from the lab for each vehicle sampled and include the history report as an appendix in the final test report.

e. Install required instrumentation, record the nomenclature (model, serial number, date of calibration, physical location, etc.) of the devices used and verify their functionality.

4.1.2 Physical Characteristics.

Determine the dimensions and other physical characteristics of the test vehicles (Reference TOP 1-2-504[13], TOP 2-2-500[14] and ITOP 2-2-500(1)[15]). Include identification photographs, as necessary. Physical characteristics data are critical data used in mobility analysis and transportability. This task must be repeated for each configuration of the vehicle if the configuration can be changed (i.e. add-on armor, slat armor, mine plow, etc).

4.1.3 Stowage.

a. Determine the adequacy of onboard equipment stowage, fixtures, brackets, ammunition capacity, receptacles, compartments and labels in or on vehicles using TOP 2-2-802[16] or the latest version if revised.

b. Additional emphasis may be needed to adequately address the stowage of items needed in a cold regions environment. Items such as tire chains, extra Soldier cold weather clothing and equipment, survival equipment such as rations, water, tent shelters and tent stoves may require stowage space depending on the mission and role of the vehicle and the operator and/or crew requirements.

c. Testers often need to recommend changes to the vehicle load plan to accommodate the additional cold weather required items. The actual items, or a surrogate load in dimension and weight, should be stored on the vehicle during testing. Document any interference these items cause with access, vision, safety, or equipment operation.

4.1.4 System Safety.

a. Identify and evaluate any hazards associated with the test item (Reference paragraph 3.5c), particularly in regard to its use in the cold regions. Testing will provide a determination or assessment of any uncontrolled safety or health hazards to operators, maintainers, and support personnel either during testing or the lifecycle of the system, using MIL-STD-1472F[17] and MIL-STD-1474D[18] as guides. Vehicles must meet the requirements set forth in the Federal Motor Vehicle Safety Standards[19] (FMVSS) series, as applicable. Some standards may be modified or otherwise exempted depending on the military requirements.

b. All operator and maintenance operations should be attempted while wearing the appropriate cold weather clothing. Testers should determine if the cold weather clothing causes a safety issue with snagging, clearances, or the proper operation of controls and switches, etc. Specifically observe and record any problems the operator or crew has with the wearing of the VB boot such as the ability to operate foot controls, brake pedal, accelerator petal, etc. Certain subtests require that the worst case scenario of the wearing of full layers of ECWCS and protective equipment be combined to evaluate the soldier, equipment, and vehicle interface. Observe and record those tasks performed that require the removal of hand wear which increase the risk of frostbite or flash freezing. Testers should use TOP 1-1-060[20] and 2-2-508 or the latest version if revised.

c. If safety issues are found that have not been adequately addressed by previous Safety Releases or other documentation, a Safety Recommendation with emphasis placed on operations in a cold-regions environment will be submitted to the Developmental Test Command (DTC) at the conclusion of testing.

d. Hazards related to use and testing in the cold regions environment as well as any other unique hazards associated with the testing location or operation shall be tabulated and assessed by category (software or hardware) for severity and frequency IAW MIL-STD-882D[21] or latest version if revised. Each hazard discussed shall include a description, an Initial Risk Assessment Code (IRAC), the recommended mitigation, and a mitigated Risk Assessment Code (RAC).

e. Input submitted by the Test Officer as a Recommendation for Safety Release and safety issues documented in the Test Report will assist the responsible safety office in confirming whether previously identified safety issues have been corrected or controlled to an acceptable level, or if additional investigation is required. A Safety Confirmation will then be forthcoming from DTC and/or Army Test and Evaluation Command (ATEC), or the designated responsible agency, indicating if specific requirements have been met, including a risk assessment for hazards not adequately controlled, listing technical or operational limitations or precautions, and highlighting safety problems that require further investigation (DA PAM 73-1, paragraph 6-65). The Safety Confirmation indicates the system is ready for fielding, has a specific start date, and is valid indefinitely.

4.1.5 Human Resources Protection Program (HRPP).

The use of human subjects in testing sometimes requires the approval of command level Human Resources Protection Program (HRPP) committees. Safety personnel should screen the test to determine if personnel will be subject to direct experimentation, as detailed in DOD HRPP guidelines. If so, the test plan must be rewritten to exclude direct human experimentation. Otherwise, a complete HRPP review and mitigation must be implemented and approved by the appropriate HRPP committee. This can sometimes take many months as the boards typically only meet monthly or quarterly. Examples requiring HRPP review include things as innocuous as taking blood pressure readings or asking personnel how their experiences in the vehicle affected them emotionally. A more serious example is intentionally exposing personnel to a known or unknown hazardous atmosphere in a vehicle to determine the health and psychological effects on the individual.

4.2 Human Factors Engineering (HFE).

4.2.1 Design.

Tracked and wheeled vehicles must be designed to allow Soldiers ranging from the 5^{th} to the 95^{th} percentile to effectively operate, maintain and support the systems while wearing required environmental and mission essential ensembles (such as NBC, cold weather, helmets, weapons, body armor, etc.). Certain subtests require that the worst-case scenario of the wearing of full layers of ECWCS and protective equipment be combined to evaluate the soldier, equipment, and vehicle interface. A list of currently authorized ECWCS components and issued cold weather clothing for the military is found in Appendix B. Record the type of cold-weather gear worn by each crewmember during each trial. The Soldier machine interface should be considered during all aspects of testing. Use TOP 1-2-610 Part I[22], TOP 1-2-610 Part II [23], MIL-STD-1472F and MIL-HDBK-759C[24], or the latest version if revised, as guidance for this subtest.

4.2.2 Force Measurements.

a. The force required when opening and closing doors and hatches are directly affected by cold temperatures. More effort is required to compress cold soaked seals and gaskets. The force required when operating hatches, doors, latches, and controls should be measured and compared to MIL-STD-1472F for a particular movement activity. Measurements should be taken in both directions (e.g., open vs. close, push vs. pull, clockwise vs. counterclockwise).

b. Cold soak the vehicle at least 12 hours prior to conducting this test with all external hatches, doors, latches, storage boxes, and access panels closed. Using the appropriate push-pull spring gage measure the force required to open and close all external hatches, doors, latches, storage boxes, and access panels. Three measurement sets should be recorded in both C1 and C2 temperatures.

c. Record the force measurements for each item open or closed. If excessive force is required, repeat the force measurement during the next opportunity after the vehicle has been allowed to warm up in a heated environment, i.e., scheduled maintenance service, to verify if the excessive force required was caused by the cold.

4.2.3 Interior Lighting.

This portion of the subtest is mostly applicable to vehicles designed with interior workstations. Determine if the lighting levels are designed and adequate to facilitate the use of all Mission Equipment Packages (MEP) IAW MIL-STD-1472F. The light produced shall be adequate to provide en-route mission planning. Lighting should be available in the crew and squad area, which provides full white light and blackout interior illumination with protected, individual fixture switches and a master on/off switch that can be functioned with the current standard issue fingered glove. The blackout system shall incorporate an automatic shut off if there is an open hatch, door, or ramp.

4.2.4 Field of Vision (FoV).

Using TOP 3-2-812[25], determine the FoV at the driver, crew stations, and vehicle commander for track and wheel vehicles as appropriate. All crewmembers will be dressed in the appropriate cold weather clothing and mission essential ensembles. The FoV for any Drivers Vision Enhancement (DVE) device should be determined. Ensure that all cable and wiring for the device is covered to protect the DVE cable and wiring from Soldier and equipment damage. Determine if the Soldiers cold weather gear or survival equipment stored on or in the vehicle impedes the FoV.

4.2.5 Ride Quality.

a. Unless otherwise specified, the ride quality subtest will not normally be conducted as part of the cold regions environmental test. If this subtest is to be accomplished, a profiled course on natural terrain should be used. The course should be frozen to a depth of 30 cm (12 in) or more. If a profiled course is not available, a bump course may be used if adequate in length to allow operation at various speeds and constructed to withstand the weight of the vehicle to be tested. All ride quality testing will be accomplished in C1 and C2 temperatures. If the vehicle is available for testing prior to the ground freezing, conduct a ride quality subtest in temperatures above 0 °C (32 °F) for comparative purposes. Use the same course(s) that will be used for this subtest after freeze-up. Using accelerometers and applying calculations and analysis, determine and record the absorbed power (measured in watts). Vehicle speed will be recorded. TOP 1-1-014[26] should be used if a profiled course or bump course is available for conduct of this test.

b. If a profiled course or adequate bump course is not available, provide a narrative description of the course along with the instrumented data analysis. Provide ride quality questionnaires to the crewmembers. Subjectively quantify the extent to which the vehicle crew experienced performance degradation after riding over rough terrain in the vehicle. Crew participants should be physically cleared for testing through an Occupational Health Center at a minimum.

c. Cognitive Performance Assessment for Stress and Endurance (CPASE) can be used to assist in the assessment of the crew's ability to function while performing their assigned mission within the vehicle during the ride quality subtest. This assessment if required would be conducted in cases where the crew is operating mission equipment packages such as Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), NBC Suites, Radar Operations, etc. The crewmembers would be required to occupy their stations for extended periods, with the vehicle moving or stationary, and all doors and hatches closed. The internal environment would be adjusted by using the onboard environmental control system (heat, ventilation, air purification and air conditioning, etc.).

b. If CPASE is administered as part of this subtest, familiarize the crew with the parameters of the test, including the motion sickness questionnaire. CPASE tests and instructions for conducting the assessment can be found in Appendix E and by contacting the Army Research Laboratory/Human Research and Engineering Directorate (ARL/HRED).

c. Expose each vehicle crew to four hours of a moving vehicle environment with performance measures (CPASE) before the exposure, two hours into the exposure, and after the full four hours of exposure.

d. Record and present the data as prescribed by TOP 1-1-014.

4.2.6 Emergency Egress/Medical Evacuation.

a. Assess the ability of the crew wearing the required environmental and mission essential ensembles and equipment to egress the vehicle under emergency conditions if applicable to the vehicle design. Determine if an incapacitated driver or other crewmember as appropriate can be extracted from the vehicle without causing further injury. Assess the ability of the crew to move between crew stations with the hatches closed with the goal of rendering aid to an injured crewmember. The worst-case scenario of the wearing of ECWCS (Level VII) and protective equipment (Mission Oriented Protection Posture (MOPP)-4 and/or body armor) should be combined for this subtest.

b. The instructions for emergency procedures in the Operator's Technical Manual (TM) should be reviewed for the accuracy of the procedures listed, for the completeness of the information, and to determine if the procedures are appropriate when cold weather ensembles are worn.

c. With the vehicle closed up and all crewmembers at their assigned stations, seat belts fastened and CVC helmets plugged in as appropriate, determine the length of time for the crewmembers to reach and extract another crewmember from the vehicle. Record any interference caused by the wearing of cold weather gear, especially VB boots, the stowage of cold weather survival gear, etc. If a change in procedures is required from that stated in the TM to expedite the extraction, record and report the new recommended procedures.

d. Submit an On-Line DA Form 2028, Recommended Change to Publications if applicable at: http://edm.monmouth.army.mil/pubs/2028.html.

4.2.7 Infantry Squad Mount and Dismount.

a. Assess the ability of the crew wearing the required environmental and mission essential equipment to ingress and egress the vehicle under emergency conditions if applicable to the vehicle design.

b. With the vehicle closed up and all crewmembers at their assigned stations, seat belts fastened, and CVC helmets plugged in as appropriate, determine the length of time for the crewmembers and/or squad to egress the vehicle. Each crewmember's time will be recorded from the time the command to exit is given until they are on the ground. The crewmember will exit from the nearest hatch, door, emergency exit, or ramp to his assigned station in the vehicle.

c. For ingress, the procedure will be reversed with the crewmember entering the vehicle through the entrance they would normally use. The time is stopped once the crewmember is at their station with seat belts fastened, CVC helmet plugged in, and personal weapon stowed if applicable.

d. Record any interference caused by the wearing of cold weather gear, especially VB boots, the stowage of cold weather survival gear, etc. If changes in procedures are required from that stated in the TM to expedite the extraction, record and report the new recommended procedures.

4.2.8 Crew Station Design.

Using MIL-STD-1472 and MIL-STD-1474 as guides assess the vehicle characteristics and measurements specifically related to the Soldier/machine interfaces and determine if:

(1) The crew is able to perform all "on-the-move" required mission tasks while seat belted in the vehicle.

(2) The vehicle can accommodate the assigned operator (s), crew, and/or squad with individual equipment.

(3) The vehicle enables Soldiers ranging from the 5^{th} to the 95^{th} percentile (male and female unless not assigned to a combat vehicle), to effectively operate, maintain and support the systems while wearing the required environmental and mission essential ensembles (e.g., NBC, cold weather, helmets, weapons, body armor, etc.).

(4) The vehicle presents any uncontrolled safety or health hazards to operators, maintainers, and support personnel during the lifecycle of the system.

4.2.9 Sound Levels.

Steady-state, interior, and exterior noise tests on moving vehicles are conducted following the procedures outlined in TOP 1-2-608[27]. Exterior noise levels should include testing of the vehicle while moving over hard pack snow, ice, and frozen ground courses in both C1 and C2 temperatures.

4.3 Environmental Performance.

Testing should be accomplished in the natural environment as much as feasible; however, it may be necessary to artificially construct test courses if the natural conditions do not support the testing. Snow making equipment can be used to construct snow mobility courses; water tankers can construct skid pads and a split mu course, sweepers can clear the course of unwanted loose snow and ice, and jet engines are used to dry the course. The cost estimate for the test should consider the possibility of needing these assets to augment naturally occurring conditions. Heater and cold start procedures along with toxic fumes testing are addressed in paragraph 4.6 as these subtests are normally conducted in conjunction with one another when possible.

4.3.1 Acceleration, Minimum, and Maximum Speed.

Using TOP 2-2-602[28] and ITOP 2-2-602(1)[29] (for tracked vehicles), as a guide, determine the vehicle performance and safety characteristics while accelerating. The winter surface conditions may prevent the gathering of data in strict compliance with the referenced TOPs. It is still important to gather information on acceleration, minimum, and maximum speed on dry pavement if possible, at the start of the test, once during the test in C1 temperatures, once in C2 temperatures, and just prior to the final inspection. Determine the amount of degradation, if any that occurred during the course of the environmental testing.

4.3.2 Braking.

Using TOP 2-2-608[30] and ITOP 2-2-627(1)[31] (for tracked vehicles), as a guide, determine the performance and safety characteristics while braking. The winter surface conditions may prevent the gathering of data in strict compliance with the referenced TOPs. It is still important to gather information on braking on dry pavement if possible, as a minimum at the start of the test and just prior to the final inspection. Determine the amount of degradation, if any, which occurred during the course of the environmental testing.

a. Service braking trials on ice – Conduct testing on a prepared ice pad (minimum of 200’ x 1200’) and a split mu (300’ x 20’ ice pad centered over an asphalt surface at least 100’ wide). The split mu should be prepared to allow an approach and exit from either end. This will allow the left side of the vehicle to be on the ice and the right side to be on dry pavement in one direction and the reverse side in the opposite direction. Prior to each trial, measure the surface temperature of the ice. Drive the vehicle to exceed the desired appropriate speed of 10, 20, and 30 mph or more as specified in the test plan by approximately 5 mph, and then, when on the ice pad and split mu, release the accelerator allowing the vehicle to decelerate to the desired test speed, then apply the brakes. This simulates braking on an icy patch on a highway or roadway. Follow any operator TM instructions listed under “Operations under Unusual Conditions,” “Cold Weather Operation,” if applicable. The transfer case, if equipped, should be set in high. Trials should be conducted in each drive mode available i.e. 2X4, 4X4, 8X8 etc., and tested with Central Tire Inflation System (CTIS) setting in the Highway setting and Mud, Sand and Snow setting. Conduct the trials a minimum of three times at each speed as stated in the test plan in both C1 and C2 temperatures. The split mu trials should be conducted a minimum of three times at each speed as stated in the test plan in both C1 and C2 temperatures in each direction. If traction devices are to be tested, install and repeat the above trials.

(1) Note if the vehicle experiences engine stall during the brake application, and the ability of the operator to control the vehicle. Place a visible mark on each of the outside tires and video the vehicle from both sides as the brakes are applied to see the action of anti-lock brake system. Record the stopping distance data from the GPS Based Vehicle Performance System and record any slew from the centerline.

(2) Collect responses from the operator and instrumentation if installed, as to the length of time from brake pedal application until brake application was felt. Extreme cold may cause a delay in the time from when the operator applied the brake and when the brake application actually occurs due to the brake fluid viscosity becoming thicker. Note if the brakes released immediately after the brake pedal was released, the cold often slows the release action or moisture freezing in an air brake system preventing proper functioning.

(3) Tracked vehicle brake application is normally through braking within the transmission or final drives, therefore the vehicle should be operated until normal operating temperature is reached before conducting the braking tests. Caution must be exercised when braking of a tracked vehicle at high speed if using rubber track pads without grousers or ice cleats as it will be extremely difficult to control the vehicle. Always start the trials from the slowest speed, observing the vehicle handling characteristics and stopping the test if any dangerous conditions are observed.

(4) Note any unusual drop in air pressure in air brake systems and the length of time for the air pressure loss to recover. Ensure that all brakes release after application, especially on trailers. If the air pressure loss is below the specification, note if an alarm is sounded (visual and/or audio), stop the trials, and inspect the vehicle for air leaks, especially around quick disconnects and fittings which are subject to contraction of the "O" rings in extreme cold weather.

b. Service brake hold test, parking brake hold test, and the emergency brake test should be performed at least once in C1 and once in C2 temperatures on longitudinal slopes IAW the TOPS referenced in paragraph 4.3.2.

c. Record and present the data as prescribed by TOP 2-2-608 and ITOP 2-2-627(1) (for tracked vehicles).

4.3.3 Gradeability.

Normally gradeability testing would only be required if not previously tested, or if additional equipment is added or carried due to a cold regions operational requirement, i.e., installation of a snowplow, addition of soldier winter survival equipment especially, if top loaded on the vehicle changing the center of gravity, etc. If it is determined that this test must be conducted, use TOP 2-2-610[32] paragraphs 5.1 through 5.1.3.2, paragraph 5.3, and paragraph 6 as a guide to determine the performance and safety characteristics while operating on longitudinal slopes. This subtest would be conducted on dry blacktop of 5%, 10% and 15% grades and concrete paved test slopes of 20%, 30%, 40% and 60%. When conducting gradeability performance testing of the vehicles holding ability of brakes, engine and transmission performance and grade speed tests repeat the required number of trials for each performance test in both C1 and C2 temperatures.

4.3.4 Steering and Handling.

Normally complete testing of steering systems is not conducted as part of a cold regions environmental test unless the system has not been previously tested. In that case Use TOP 2-2-609[33] as a guide, to determine the performance and safety characteristics of vehicle steering systems as applicable.

a. The exceptions to the above paragraph are the procedures outlined in TOP 2-2-609, paragraph 5.8, Control on Adverse Terrain. All vehicles will be tested IAW this paragraph as part of the cold regions environmental test. Steering and handling trials will be conducted in C1 and in C2 temperatures during cross-country operations in loose packed snow at least 20 cm (8 in) deep but no deeper than 61 cm (24 in), on hard packed snow covered secondary roads, and on prepared or natural occurring ice pads as appropriate.

b. Note any noticeable variation in steering and handling characteristics of the vehicle especially between C1 and C2 temperatures. More than one operator should be used to assess the steering and handling characteristics since operator experience will influence any subjective findings or comments.

4.3.5 Mobility in Snow.

Using TOP 2-2-619[34] as a guide, determine the performance and safety characteristics while operating in snow. The TOP includes guidance for snow as well as mud, sand, swamps, and wet clay. Most conventional wheeled vehicles cannot travel satisfactorily over flat terrain or roads when the depth of uncompacted snow exceeds 30 cm (12 in) in depth. Most tracked vehicles are slowed by a snow depth of 60 cm to 75 cm (24 in to 29 in). Low-ground-pressure tracked vehicles can generally operate effectively in deep snow. However, snow of more than 76 cm (29 in) depth, especially when granular or powdery, can stop movement except for special oversnow vehicles.

a. The vehicle should be driven in powder snow, heavy snow and snow drifts to determine the depth that it is able of driving through without preparation or tire chains.

b. Select a permanent site that is not subject to foot or vehicular traffic and is representative of the general area.

c. Determine where the snow measurements are to be made or select point(s) along the course that best represent the snow conditions in 4.3.4a above.

d. If the vehicle is immobilized by the snow, measure and record the ambient temperature at the test site, snow depth, crystal composition, hardness, and density using the Snow Classification Kits, Hand Held Cone or Drop Cone Penetrometer, Digital Temperature Probe, and observer records as appropriate.

e. If the vehicle is so equipped, attempt to use the vehicle self-recovery mode to retrieve the vehicle. This will allow a real world assessment of the self-recovery capabilities. Gather comments from the operator on the ease of use and availability of the necessary equipment or accessories to affect self-recovery. Follow the procedures outlined in the vehicle TM for self-recovery. Record and report any procedural discrepancies in the TM noted during recovery. Obtain operator/crew comments on the ease of operation and safety features of the on-board self-recovery equipment.

f. Install the approved traction device(s), if any and operate the vehicle in powder snow, heavy snow and snowdrifts to determine the depth that it is able of driving through.

g. If the vehicle is immobilized by the snow repeat the procedures in 4.3.4d and e.

h. Record and report the nomenclature and National Stock Number (NSN) or part number of any traction devices used during the snow mobility trials.

i. Record and report tire or track manufacturer, size, NSN or part number, and any winterizing of the tire or track such as; studded or snipped tires, ice cleats, embedded traction compounds, etc.

j. For each incident obtain a completed copy of the Snow Observation data collection sheet, item 3, Appendix F and include the data in the test report.

k. Collect and report the same information during any vehicle trials in which the vehicle becomes mired.

4.3.6 Fuel Consumption.

a. Using TOP 2-2-603[35] as a guide, determine the fuel consumption during typical service operating conditions as specified in paragraph 3.2.2. The measurement and evaluation of fuel consumption under controlled operating conditions are normally not conducted as part of the cold regions environmental testing. During endurance, mobility or other tests representative of service operating conditions, measure the vehicle's fuel consumption.

b. To measure fuel consumed during these tests, either install a fuel-flow meter or carefully make all refills of vehicle fuel tanks to the same point. Before the tests are started, select a level that will assure no loss in fuel through spillage from vehicle movement or from thermal expansion. Determine total distance traveled and total operating time from instrumentation used for endurance tests or vehicle odometer.

c. Documenting the fuel consumption during typical service operation conditions are of special interest in a cold environment due to:

(1) Engine warm-up times are increased prior to operation.

(2) Idle times are extended to allow for proper crew compartment workstations and mission equipment packages to reach operational temperatures.

(3) The resistance encountered on the vehicle when operating in deep snow impacts fuel consumption (measured in miles per gallon) data.

(4) Silent watches may require more engine starts to maintain a battery charge in a cold environment.

(5) Continuous operation of a fuel fired personnel heater during operations.

4.3.7 Tire Performance, Tracks, Traction Devices, and Central Tire Inflation System (CTIS).

a. Using the applicable portions of TOP 2-2-704[36] for tires, determine the performance, safety and traction capabilities of the vehicle tires or tracks as follows:

(1) Tire performance

(a) Tire wear – Tread depth measurements are taken prior to the start of test and at intervals as specified by the test plan. All tread depth measurements are taken on a clean, dried tread surfaces and with a regularly calibrated tire depth gage. The tread depth is measured at approximately 2 cm to 5 cm (0.79 in to 2 in) (depending on tire size) from each side of the tire centerline and at three equally spaced stations around the tire circumference (0°, 120°, and 240°).

Each tire must be permanently marked at the measurement stations so that succeeding measurements may be made and recorded in thirty-seconds or decimals of an inch, depending on the measuring gage. Visual inspections are made throughout the test for unusual wear, tread splitting, stone cutting, bead chaffing, rubber separation, and weather checking. Pay particular attention to any damage attributed to the use of tire chains or other traction devices used during the test.

(b) Tire Traction – During operation, assess specifically the performance in snow and ice conditions as a subjective evaluation. If required, a tractive evaluation may be conducted by comparing test and control tire performance during cross-country operations in loose packed snow at least 20 cm (8 in) deep but no deeper than 61 cm (24 in), on hard packed snow covered secondary roads, and on prepared or natural occurring ice pads as appropriate. Testing on each surface condition consists of measuring maximum drawbar pull (TOP 2-2-604[37], paragraph 4.3.9). Sufficient tests are run to provide a sound basis and maximum opportunity for comparison of drawbar pull and wheel slippage.

(c) Run Flat Tires – TOP 2-2-704 paragraph 11 outlines the procedure for the testing of run flat tires. The procedure outlined calls for operation of the vehicle with the tire in the run flat mode until the tire is destroyed. This type of test is normally not conducted as part of a cold regions environmental test. If directed to evaluate run flat tires, deflate one or two tires completely then operate the vehicle for one mile on frozen, snow covered, cross country trails in both C1 and C2 temperatures. Cross country operation consists of two figure eights at minimum turning radius and maximum safe speed and at least two right and left 90 degree turns. The stability and handling characteristics are recorded along with any noted tire damage or inability to be inflated after operation.

(2) Track performance – Cold regions environmental testing of tracks on various vehicles are subjective evaluations unless otherwise specified. Performance observations should be documented throughout vehicle operations. Additional testing may be performed to assist in the evaluation of specific track characteristics as listed below:

(a) Ability to steer – On a dry, hard-packed dirt pad, measure and record the vehicle turning radius with the transmission placed in low gear. On a hard packed snow covered pad and on a solid smooth ice surface, measure and record the turning radius with the vehicle transmission placed in low gear. Compare and report the results.

(b) Track Traction without the addition of traction devices or modification - Unless otherwise specified, record the ability to maintain traction by towing a vehicle similar to that being tested with a load cell or other force measuring instrument installed at the test vehicle tow point rather than using a field dynamometer. Any drawbar pull testing should be accomplished in both C1 and C2 temperatures on hard packed snow, and glare ice. Determine the amount of force applied prior to any track slippage preventing forward movement.

(3) Traction Devices – If traction devices are available, such as ice cleats, install the device(s) and repeat the turning radius test (4.3.7.a. (2) (a)) and track traction test (4.3.7.a. (2) (b)) above. Record, compare and report the results.

(a) Tire chains, studded or sniped tires, tire traction cables, etc.

(b) Ice cleats for tracked vehicles using rubber block track or other modification to aid in steering and/or traction.

b. Validate whether additional information is provided in the applicable operator's manuals in "Operation in Unusual Conditions", specifically for instructions on tire chain installation, or other traction aid installation. The TM should address such topics as driving on snow and ice, gear and transfer case positions, and other characteristics designed to maintain safe control of the vehicle during operation in unusual conditions.

c. Submit an On-Line DA Form 2028, Recommended Change to Publications if applicable at: http://edm.monmouth.army.mil/pubs/2028.html.

d. CTIS operation is limited in a cold regions environment, however; on vehicles so equipped, testing should include the time to inflate and deflate tires at various settings and temperatures. A minimum of three trials should be performed in C1 and three trials in C2 temperature ranges.

e. Unless otherwise noted in the Interactive Electronic Technical Manual (IETM) Operator's Manual, the following procedure for testing the CTIS in the cold will be performed. The CTIS will remain off until the vehicle wheels are exercised on the chassis by driving a distance of 10 km (6 mi) or approximately 15 minutes. After completion of the wheel seal warm-up process, the CTIS will be powered up. Once the CTIS stabilizes at highway pressure, the tires will be deflated to emergency pressure. Once the tires are stabilized at emergency pressures, inflation to mud/sand/snow pressures will be initiated. Inflation and deflation times will be recorded. Once stabilized in mud/sand/snow pressure the CTIS will be inflated to highway pressure by slowly increasing speed to 48 km/hr (30 mph). Inflation time will be recorded.

f. Record and present the data as prescribed by TOP 2-2-704, TOP 2-2-705[38] and TOP 2-2-706[39].

4.3.8 Displays and Controls.

Using MIL-STD-1472F and MIL-HDBK-759C determine the ability of the operator and crew while dressed in the appropriate cold weather ensemble to observe all applicable controls and manipulate both internal and external controls. All controls should be able to be functioned while wearing the prescribed cold weather hand wear. Guards or other protective covers must be able to be manipulated without the removal of hand wear. Displays and controls must be located in such a manner that the operator and crew need not remove components of their cold weather ensemble to view or manipulate these devices.

4.3.9 Drawbar Pull.

Unless otherwise specified, the drawbar pull subtest will not normally be conducted as part of the cold regions environmental test. If this subtest is to be accomplished use TOP 2-2-604, as a guide to determine vehicle power available for acceleration, towing, or hill climbing. Drawbar pull test data may be required for Mobility in Snow (paragraph 4.3.5) and Tire Performance, Tracks, Traction Devices (paragraph 4.3.7) if determining traction is required as part of those subtests. Unless otherwise specified, any drawbar pull testing conducted as part of a cold regions test will consist of towing a vehicle with a load cell or other force measuring instrument installed at the test vehicle tow point rather than using a field dynamometer. Any drawbar pull testing should be accomplished in both C1 and C2 temperatures. Record and present the data IAW these referenced TOPs.

4.3.10 Full-Load Cooling.

During the summer months mobility over muskeg and tundra at slow speeds places an additional cooling load on vehicles. If the cooling system has not been previously tested for full-load cooling, use those test procedures outlined in paragraph 4.4 of TOP 2-2-607[40] for Road-load cooling (without the use of a field dynamometer) as a guide to determine the cooling characteristics of the engine, power train, and auxiliary components of the vehicles when subject to full and part throttle operations, repeated steering maneuvers, and exposure to extreme environments. (Note: Cooling tests are generally not conducted at ambient temperatures below 21 °C (70 °F) due to extrapolation error).

4.3.11 Winch Performance.

a. If the vehicle becomes mired during mobility operations attempt to use the vehicle self-recovery mode to retrieve the vehicle. This will allow a real world assessment of the self-recovery capabilities. Gather comments from the operator on the ease of use and availability of the necessary equipment or accessories to affect self-recovery.

b. Since cold weather will have little if any impact on electric or direct driven winches (i.e. PTO shaft, chain, or gear driven etc.) these types should be functional tested only. As a minimum, three trials each in C1 and C2 temperatures should be conducted using a fixed object as an anchor and a load cell to determine the load, determine if the winch reaches its maximum rated load. The winch cable should be laid out to the first layer on the winch capstan for the trial. Any portable handheld control units should be assessed for damage, difficulty with manipulating or connecting the electrical cabling or connectors caused by the cold.

c. The effects of extreme cold on hydraulic winch systems should be assessed. Use TOP 2-2-712[41] as a guide. Standard measuring equipment and a calibrated load cell will be used to determine the safe overload protection and characteristics of the main recovery winch. A fixed object will be employed in overload testing. Winch endurance testing is not normally assessed as part of cold weather environmental testing.

(1) To ensure that the proper diameter wire rope is being used, check the winch cable (wire rope) capacity to safely handle the loads specified for the winch. The ratio by which the rated breaking strength of the cable should exceed the capacity of the winch is the safety factor. This safety factor will be determined by laboratory testing and compared to the prescribed safety factor before any loads are applied to the cable. In lieu of guidance, the cable should have a minimum safety factor of 2:1. Nominal (design) breaking strengths for various types, classes, and sizes of wire rope are specified in Federal Specification RR-W-410D[42].

(2) Snatch blocks, pulleys, and drums will be inspected to ensure that they are correct for the designated cable type and size, as well as load, and that they are in suitable operating condition.

(3) Insure the hydraulic system contains the correct specified winter weight oil.

(4) Take all necessary safety precautions during testing. Snatch blocks may fail and be thrown great distances, or cables may fail and whip around any nearby object. Test personnel must wear gloves, safety hats, and safety shoes.

(5) All hazards will be categorized in accordance with MIL-STD-882D. All safety-related data will be reported in the safety and health section of the final test report.

(6) Winch line speeds (for all type winches) determined with the engine speed at the specified value for winch operation and the cable loaded to 25, 50, 75, and 100 percent of the rated winch capacity. A sufficient number of test runs (minimum of three full pulls) will be performed in each temperature range, C1 and C2, to provide repeatable data.

(7) The performance of the mechanical brake holding device will be determined by attaching the cable to a suitable loading device. While winding the first layer of cable, increase the load until the overload safety device functions, or if the winch is not equipped with such a device, increase the load until the maximum rated capacity or overload value is reached. At this time, check the automatic mechanical brake for its ability to stop and hold the load for five minutes after the removal of winch drive power.

(8) The capstans will be filmed during operations to determine if slippage occurs while maintaining higher loadings.

4.3.12 Software.

Using ITOP 1-1-056[43] as a guide, address the system's software functional capabilities. Systems, in particular automotive engines, use computerized controls to make the best use of fuel, engine timing and other settings designed to assist in cold starting. Attention must be given to the performance of the software parameters when the ambient temperature is colder than programmed operating temperatures. These colder temperatures can cause the software to set system parameters incorrectly, prevent proper functioning of computer controls, or shut down the computer completely. These software malfunctions can prevent the vehicle from starting, or if operating, can cause it to go into a pre-programmed low performance "limp home mode". These conditions can often be corrected by moving the vehicle into a heated facility and warming the equipment until the on board computer recognizes the temperature and the correct settings. In some cases the battery must be disconnected for several hours until the computer loses its stored memory. Disconnecting and reconnecting the battery then is similar to re-booting of the computer. This will also cause the computer to lose its fault codes, so download any required information prior to disconnecting the battery.

4.4 Logistical Supportability.

Unless otherwise specified, the logistical supportability subtest will not normally be conducted as part of the cold regions environmental test. If this subtest is to be accomplished use the applicable portions of TOP 1-1-030[44], determine the Integrated Logistical Supportability (ILS) for the test vehicle(s). The following data is normally collected during all testing unless otherwise specified:

a. Information as required for the completion of Test Incident Reports (TIRs).

b. Vehicle operating characteristics (miles, hours, rounds fired, etc.).

c. Information on the completeness and accuracy of the vehicle TMs, with an emphasis on operation in an unusual environment, and maintenance procedures that are affected by the cold.

d. Comments on the adequacy of tools issued with the vehicle.

e. Comments on the effectiveness of the Built-in Test, Built-in Test Equipment, and Fault Isolation Test (BIT/BITE/FIT) to correctly identify system faults.

f. Comments from the operators, crew, and maintenance personnel on the ease of operation and maintainability characteristics of the vehicle in a cold regions environment.

4.5 System Environmental Suitability Test (Limited R&M test).

a. Unless otherwise specified, a full Reliability & Maintainability (R&M) subtest will not normally be conducted as part of the cold regions environmental test. The amount of R&M testing and data obtained in a cold regions environment is limited and often specified by the PM.

b. A Systems Environmental Suitability Test (SEST) is a means of collecting data on the ability of vehicles to perform acceptably under the conditions found in the cold regions by exposing the equipment to the synergistic combination of key environmental factors of cold temperatures, snow, and frozen ground. The SEST would include conduct of a limited number of iterations of the OMS/MP under operationally realistic conditions, ideally a minimum of 15% of the miles required by a full R&M test. Performance of a SEST would provide risk mitigation of environmental effects, as well as reliability relevant data for the vehicle operating in the cold regions.

c. Repair parts information is collected and reported in a Test Incident Report (TIR). If this subtest is to be accomplished use the applicable portions of TOP 1-1-030. The following data is normally collected during all testing unless otherwise specified:

(1) Part nomenclature.

(2) Quantity.

(3) Part National Stock Number (NSN) and/or manufacturer part number.

(4) TM Number, page and item number for the part.

(5) Cause of failure (if known).

(6) Part life (Miles/hours/cycles, etc).

(7) Vehicle miles and hours.

(8) Data as required for TIRs.

(9) Preventative Maintenance Checks and Services (PMCS) times to conduct the checks.

d. If TIRs are submitted the above information is automatically collected on the Advanced Data Acquisition and Collection System (ADACS) system and can be downloaded from the ADACS database as a Supportability Analysis Chart (SAC) and a Supply Support Chart (SSC).

4.6 Climate Control System/Heating & Ventilation.

4.6.1 Heater Tests.

a. Test Conditions

(1) Toxic fume testing for fuel-burning heaters must be completed IAW TOP 2-2-614[45] prior to conducting heater testing. Test findings must be compared to the safe allowable levels of exposure during a normal mission. Any findings that exceed the recommended levels must be mitigated prior to continued exposure to the fumes by the operator/crew.

(2) Toxic fume testing is not only applicable to the heater tests, but to interior compartments during operation without heat. See the Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) standards (http://www.Osha.gov and http://www.cdc.gov/niosh/npg/) for detailed listings. Specific gases usually measured include Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), and oxygen (O_2) levels. Additional measurements that may be needed will

depend upon the potential contaminants given the design of the system but may include Particulate Matter (PM10 and PM100) and other contaminants. Toxic gas measurements should be taken upon receipt of the vehicle before it is operated by the crew and then confirmed upon operation by the crew.

(3) Using TOP 2-2-708[46], paragraph 5.2, Outdoor Climatic Tests, and MIL-STD 1472, paragraph 5.12.6.1 Heating, as a guide, determine the performance of the vehicle personnel, cargo, and engine heaters and defrosters.

(4) In addition to the information provided in the referenced TOP, instrumentation should be installed at the head, hand, and foot level of each crew work station on specialized tracked or wheeled vehicles. Vehicles with sophisticated mission equipment packages (MEP), specifically electronic packages, should have instrumentation located at or near the display screens as extreme cold temperatures affect the warm-up and display time.

(5) Windshields should be marked IAW TOP 2-2-708, paragraph 3.2.d. for defroster performance assessment. Vision blocks, periscopes, and other sighting devices found on tracked vehicles may use various types of heating elements for defrosting. The assessment of the defroster performance can be made in the same manner as that for windshields.

b. Test Procedures for Stationary, Mobile and Endurance Heater Testing

(1) The test should be repeated every 10 °C (18 °F) (starting at the warmest temperatures -34 °C to -46 °C (-29 °F to -50 °F) to determine the ambient temperature at which the crew compartment can be maintained at 4 °C (40 °F) or when applicable, a patient compartment at 10 °C (50 °F). For stationary trials in a natural environment, the heater will be operated in the high setting for one hour. If the vehicle has more than one heater or heat exchangers, ensure that all settings, to include fan speed, are set on high.

(2) During one trial (if sufficient personnel are available), situate the full vehicle crew at their assigned station in the vehicle during the cold start, dressed in the appropriate cold weather ensemble, to provide a moisture source for maximum frost formation. Close all vehicle hatches, doors, access panels, windows, etc.

(3) Power up electronic equipment, or other on board systems, when the internal vehicle temperature rises to the minimum temperature required for the equipment if specified in the TM or applicable documentation. If no lower temperature limit restrictions apply, power the electronic equipment up immediately after the engine starts and the normal idle speed is maintained as specified in the operator’s TM. This information will help to determine the overall warm-up time required for the vehicle to become fully mission capable.

(4) If cold or hot spots are noted at the completion of the test, determine if louvers or deflectors are adjustable. If so, adjust the position prior to conducting the next test and note if any improvement in heat dispersion was observed.

(5) Mobile heater trials are conducted after confirming that the heating and defrosting of the vehicle is safe for vehicle operation. Mobile heater trials are normally conducted in conjunction with vehicle mobility testing. Operate the heater on high for a minimum of one hour to allow the compartment temperatures to stabilize. Record the compartment air temperatures at 5-minute intervals, monitor the outside ambient air temperature continuously, photograph the windshield or vision device defrosting conditions at 5-minute intervals.

(6) During one of the mobile personnel heater trials open the commander's hatch on tracked vehicles or the air guard/machine gun mount hatch on wheeled vehicles, if so equipped, for 30 minutes to simulate a combat operation. The heater will be left on in the high position during these 30 minutes. The temperatures recorded during this 30-minute period will be identified to distinguish them from other temperatures when the vehicle is buttoned up.

(7) If the heater tests is being conducted in conjunction with a vehicle test (complete systems test), operate the heater continuously while the vehicle is conducting mobility or weapons firing in temperatures normally found in the winter in a cold regions environment.

(8) Record and present the data as prescribed by TOP 2-2-708.

4.6.2 Operating.

a. Subsystem Environmental Performance.

Prior to the commencement of any test activity on any day components and subsystems will be checked for proper function. Exceptions of certain components or subsystems may be allowed during instrumented cold starts due to the length of time for these components to power-up or reach their operational state. All subsystems will be observed throughout testing for cold weather performance. Any cold related degradation of subsystem functions will be addressed in more detail. Testing will be conducted to identify the temperature range at which the degradation occurs.

b. Cold Starts

(1) Test Conditions

(a) Use the appropriate methods from, TOP 2-2-650[47], MIL-HDBK-310[48], MIL-STD-810G[49], MIL-STD-1472F, TOP 2-2-819[50], and the applicable operator TM or IETM for the vehicle under test.

(b) An assessment will be made to determine if the engine can be reliably started in the natural environment in temperatures down to -32 °C (-25 °F) without additional aids and to temperatures as low as -46 °C (-50 °F) with the use of modifications (i.e., engine pre-heater, manifold heaters, glow plugs, etc.). Prior to any testing, ensure that all components have the correct weight oils, lubricants, fuels, and anti-freeze. Verify that the starting batteries are fully charged as stated in paragraph 4.6.2b (2) (a). If the type of fuel is changed to an arctic grade, operate the vehicle sufficiently to purge any summer grade fuel remaining in the fuel system or filters.

(c) A successful cold start is defined as a start of a cold-soaked vehicle without any external assistance (i.e. slave starting using starting aids not part of the vehicle). An engine start attempt consists of cranking attempts until the engine starts with a single set of batteries. If the batteries maintain adequate voltage for cranking the engine, multiple cranks can be performed and still be considered a successful start.

(2) Engine Cold Start Procedures.

(a) During the conduct of this subtest an assessment must be made on the effectiveness of the starting procedures outlined in the vehicle operator's (-10 level) TM or IETM. Supplementary instructions may also be included in the section of the Operator's TM under "Operation in Unusual Conditions". Submit an On-Line DA Form 2028, Recommended Change to Publications if applicable at: htpp://edm.monmouth.army.mil/pubs/2028.html.

(b) The type and specifications of instrumentation used will be recorded.

(c) Prior to any cold soak for each of the instrumented engine preheats/engine cold starts, determine the state of charge for the applicable starting circuit batteries being used (e.g., lead acid, (regular or deep cycle), Gel or Gelled Acid, or Absorbed Glass Mat (AGM)). TM 9-6140-200-14[51] should be utilized for battery charging and State of Charge (SOC) determination for batteries. Batteries are considered fully charged when the specific gravity of the electrolyte is higher than 1.260 or if a Cold Cranking Amps reading is greater than or equal to the Cold Cranking Amps rating of the battery. A higher specific gravity of 1.280 is often used in an extreme cold environment and should be used for tests being conducted according to this TOP if the specific gravity can be adjusted. Any weak battery(s) found (below a 75% charge) will be replaced with freshly charged batteries.

(d) Military vehicles are required to start unassisted in temperatures as cold as -32 °C (-25 °F). A kit or modification may be used when starting and operating below -32 °C (-25 °F). Testers must familiarize themselves with the location, function, and operation of these kits prior to conducting cold starts. If necessary install the heater and other kit components on the vehicle in accordance with the installation instructions provided in the kit. Operate the heater at ambient temperature IAW instructions in the applicable TM or system specification. If no instructions are given, operate the heater for a minimum of one hour prior to conducting the actual test to purge air from the system and to cycle any fuel or preservatives from the system.

(e) The vehicle will be cold-soaked at least 12 hours, or until all monitored temperatures (excluding the battery box, if insulated to retain heat) are within ±3 °C (5 °F) of the ambient temperature. This procedure is modified from that stated in TOP 2-2-650. The tester must monitor the ambient and component temperatures carefully, since the ambient temperature often changes rapidly before the desired component temperature can be reached. If difficulties occur with obtaining the cold soak temperature parameter for all monitored temperatures, commence the engine start once the engine oil sump temperature is within ±3 °C (5 °F) of the ambient temperature.

(f) Open hatch covers, access panels, etc., which are covering power train components (engine, transmission, transfer case, etc.), and use cold air blowers where feasible to facilitate cold soaking.

(3) Cold Starting without Engine Heater or Additional Kits or Modifications – Follow all the procedures found in TOP 2-2-650, paragraph 4.1 except for paragraph 4.1.1a. Instead of using this paragraph, use the cold soak procedures in paragraph 4.6.2.b (2) (e) above.

(4) Engine Cold Start Procedure using Engine Heater, kits or modifications.

(a) An assessment will be made of the procedures and effectiveness of any kits or modifications used to aid in cold weather engine starts.

(b) These kits may include some or all of the following components:

1 Engine coolant heater. (The heater may be a dual purpose heater used to pre-heat the engine and switched to a personnel heater once no longer required for engine start).

2 Oil pan heater (Engine, transmission or both).

3 Radiator cover(s) or louvers, manual or automatically controlled.

4 Insulated/heated battery box.

5 Exhaust restrictors.

6 Manifold pre-heaters.

7 Glow Plugs.

(c) All available combinations of preheating starting aids must be used in conjunction with each other, when feasible, when conducting instrumented or service cold starts below -32 °C (-25 °F).

(d) Cold soak the vehicle at -46 °C (-50 °F), to satisfy the cold (C2) condition of AR 70-38, unless otherwise specified. Follow the cold soak procedures in paragraph 4.6.2.b (2) (e) above.

(e) The test vehicle will be closed up prior to beginning the engine preheat to add authenticity to the events. The engine preheat test will start as soon as the engine preheater or other warming device is turned on and will be completed once the engine starts. If the heater is also used to heat the crew compartment, switch the controls to engine preheat only (if available), until a successful engine start is obtained.

(f) The engine preheat procedures will be conducted IAW the instructions set forth in the operator's manual for starting the vehicle in a specified temperature range. If the procedures are not specified, start the engine preheater and monitor the engine oil (sump) and coolant temperatures. When the engine oil temperature reaches the starting temperature specified in the test directive, or -32 °C (-25 °F) if not specified, turn off the heater and attempt to start the engine using the procedures in TOP 2-2-650, 4.1.1.b. If the engine fails to start, the procedures contained within the TM should be followed. If the engine still fails to start, repeat the test increasing the preheat time in half-hour increments until the engine starts or 2 hours of preheat time is accumulated.

(g) Record the engine coolant and ambient temperatures at the point of each successful start. This information will be useful in developing or modifying cold start procedures in the vehicle operator's TM.

(h) The cranking time and number of start attempts will be recorded. Do not exceed the TM's recommended engine cranking time or starter cool down time.

(i) Record and present the data as prescribed by TOP 2-2-650, paragraphs 5 and 6.

4.6.3 Non-Operating.

Document the full exposure of the system to ambient conditions throughout the test during both operational and non-operational periods: for example, any time the vehicle is parked outside with no systems operating.

4.7 Other Subsystems.

Vehicles may be configured with multiple subsystems which may both affect and be affected by the automotive system. These subsystems should be checked for functioning at least at the start, during, and at the end of the vehicle test to address the interaction of the subsystem and the vehicle when operated in a cold regions environment. Effects of cold environmental factors on these subsystems should be noted and reported. The suggested TOPs for each subsystem listed below can be used as a guide to address proper subsystem operation.

4.7.1 Nuclear, Biological, and Chemical (NBC) Protection System.

a. The complete testing of collective protection systems in vehicles are more suited to cold chamber testing where the temperature and humidity can be readily controlled. Chemical and biological testing of these systems will be completed by another designated test center with the appropriate facilities for NBC testing.

b. However; limited testing should be accomplished in the natural cold environment to determine any decreased availability of filtered air due to ice and snow, the ability to maintain and control filtered air outlet air temperatures and its impact, if any, on the ability of the vehicle crew compartment heater to maintain specified temperatures. The compatibility of the ventilated facemask or similar mask with the appropriate cold weather ensembles and protective gear will be assessed along with the crews' ability to control the filtered air inlet temperature. Note: not all vehicles are equipped with collective protection systems.

c. Testing of collective protective systems in a natural cold regions environment should consist of the operation of the system during mobility trials and major weapon firing.

d. Measure the air flow and air temperature at the filtered air outlet(s) as applicable.

e. Have all crewmembers don their ventilated facemasks and operate the protection system for a minimum of eight hours continuously during mobility trials, at least three times in C1 and three times in C2 temperatures. If conditions provide the opportunity, operate the system during periods of ice fog and/or blowing fine snow.

f. During one complete iteration of functional firing of the main weapon, if so equipped, (preferably in C2 temperatures), have all crewmembers don their ventilated facemasks and operate the protection system during firing.

g. Observe and record any drop of airflow as recorded by the instrumentation. Note if any system indicator warnings (audio or illuminated) are present during operation. If the airflow decreases or the filter clogged indicators alarm, record the current amount of airflow, then inspect the filter for the presence of ice crystals or snow ingestion.

h. Develop questionnaires to query the crew on the wearing of the ventilated facemask in relationship to non-compatibility issues with the cold weather clothing, eyepiece fogging, and movement ability. Have crewmembers rate the quantity and quality of the filtered air and the ease and effectiveness of controlling the filtered air temperature.

i. Data required

(1) Meteorological Data (Ambient temperature, wind speed, humidity, etc).

(2) Interior vehicle crew or workstation temperature.

(3) Power up and shut down times for collective protective system.

(4) Temperature and air flow of the filtered air outlet(s).

(5) Narrative of environmental conditions if the filter(s) become clogged.

(6) Listing of all crew cold weather clothing and protective gear worn.

(7) Anthropometric and demographic information on each crewmember.

(8) Completed crew questionnaires.

4.7.2 Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) System.

a. Follow the procedures as stated in TOP 2-2-709[52] as applicable. TOP 6-4-004[53] outlines procedures for the “Arctic Environmental Tests of Tactical Radio Communications” and will provide guidance for Cold Regions Testing; however, the rapid advances in communications technology will be the determining factor in the development and execution of C4ISR testing.

b. For the purpose of this TOP, the testing should be limited to functional testing.

c. All C4ISR system components will be allowed to cold soak in the vehicle, unless restricted by temperature limitations. After cold soaking, the systems will be powered up and remain operational for the duration of the mobility and/or firing mission.

d. If a base station or other compatible vehicle system is available to receive and transmit C4ISR data, use this system to send and receive a minimum of six transmissions, each, per mobility mission.

e. Record and report the findings IAW TOP 2-2-709 or 6-4-004 with particular attention given to warm up times required for all C4ISR components to become fully operational.

4.7.3 Position Locations and Navigation System (POS/NAV).

a. Follow the procedures outlined in TOP 6-2-598[54] as applicable: however, the rapid advances in technology, miniaturization, accuracy and versatility of GPS systems must be considered when developing meaningful test procedures and in the execution of the test plan.

b. For the purpose of this TOP, the testing will be limited to functional testing.

c. When conducting waypoint navigation missions over smooth, rough and mountainous terrain, at least five surveyed benchmarks must be established along the selected routes of the mission.

d. All POS/NAV components will be allowed to cold soak in the vehicle, unless restricted by temperature limitations, then powered up and remain operational for the duration of each mobility and firing mission.

e. At the start of each mobility or firing mission, position the vehicle next to the surveyed waypoint and record, or preferably transmit the location data via the appropriate C4ISR component to a base station or receiving vehicle.

f. Determine the accuracy by comparison of the surveyed waypoint location and that of the vehicle POS/NAV system being tested.

g. Record and report the findings IAW TOP 6-2-598.

4.7.4 Weapon Systems - Functional Firing of Main Weapon.

Note: This TOP addresses Functional Fire testing only. Weapon Accuracy is not addressed in this TOP.

a. Functional Firing

(1) Prior to functional fire testing, the fire control system, autoloader, recoil, and all related subsystems must be inspected according to the applicable TM. Dummy ammunition should be cycled through the system prior to loading live ammunition, whenever possible.

(2) Recoil pressure should be checked at firing temperature just prior to functional fire testing.

(3) All live rounds fired must also be conditioned to the same temperature as the autoloader to prevent misfeeding and round seating jams.

(4) If not otherwise specified, it is recommended that a minimum of 10 total rounds of multiple ammunition types be fired in 3 iterations in each temperature range (C1 & C2) for function fire tests. It is further recommended that function firing be conducted after every 250 mobility miles.

(5) Sighting may be obscured by vehicle exhaust as well as natural environmental conditions. Moisture from the exhaust may also form and freeze on sights and vision devices. Observe and report the conditions in which the obscuration occurs, the amount of degradation on sighting ability, and actions and length of time required for the condition to clear.

(6) Crews must be wearing the appropriate components of the extreme cold weather uniform when conducting a rate of fire exercise.

(7) Record the temperatures of the autoloader, ammunition, charge, date, time and meteorological data as applicable. Record the time required to load and ready the weapon for firing.

(8) Secondary Armaments. Functional firing of 100 to 200 rounds for three iterations in each temperature range (C1 & C2) is recommended. Follow the applicable procedures as listed in ITOP 3-2-075[55].

b. Autoloader (Direct and Indirect Fire Weapons)

(1) The autoloader may be pneumatic, hydraulic, electric or a combination system. The cold regions issues discussed in Appendix A for pneumatics, hydraulics, electric components and sensors must be considered.

(2) Prior to testing of the autoloader, cycle and eject a surrogate/dummy round which is at the same temperature as the autoloader, several times through the weapon to allow for warm up and function check of the autoloader.

(3) Following the procedures in the applicable TM, cycle the autoloader through at least three ammunition load cycles of a minimum three rounds of each type in both C1 and C2 temperatures.

c. Boresight Retention for Direct Fire Weapons

(1) Boresight retention is difficult to maintain in a cold regions environment; therefore, vehicles equipped with a direct fire weapon system (main and coax) should be tested for their ability to obtain and hold boresight. Using TOP 3-4-010[56] and the appropriate TM for the vehicle's weapon system(s) determine the ability of the fire control sighting system to retain boresight in C1 and C2 temperatures.

(2) Mount a collimated muzzle boresight device in the gun tube coincident with the centerline of the bore, for both the coax (if equipped) and main gun.

(3) Follow the boresight procedures as stated in the applicable TM, with all boresighting done outside in the ambient temperature. Record the ambient temperature.

(4) Record the system reference values for sight alignment including the Muzzle Reference Sight (MRS).

(5) Record the mileage, hours, rounds, date and time.

(6) Prior to conducting firing or non-firing testing, record the bore and sight alignments using the applicable gridboard for the system. Boresight alignment error is the difference between bore and sight gridboard readings; however, boresight retention is the difference between the current alignment and the alignment measurements when the system was last boresighted. Record the mileage, hours, rounds, date and time.

(7) Note any boresight error and for non-firing operations update the MRS if the boresight error is 0.3 mil or greater. For accuracy tests update the MRS if the error is 0.2 mil or greater. Use 0.5 mil or greater before re-boresighting for auxiliary sights. Record the updated MRS values. Measure the alignment using the gridboard and record the values. Re-boresight the system IAW the TM if the MRS update does not bring the system within tolerance.

(8) During non-firing mobility, boresight alignment should be measured prior to and after completion of every 300 miles of primary, secondary and cross-country operation in C1 and C2 temperature ranges.

(9) During functional firing missions, boresighting should be conducted before the firing mission and after the completion of any mobility operations conducted that day. An example would be; to boresight, move to range, fire, complete x miles of cross country and/or x miles of secondary mobility operations, return to staging area and check and confirm boresight.

(10) Aim Retention - With the turret power off, measure the aim retention throughout a 10-hour period of time in both C1 and C2 temperatures. Using a collimated muzzle boresight device inserted into the gun tube trained onto the applicable gridboard, measure and record hourly the amount of gun tube drop (if any). Note the ambient temperature at the same time.

(11) System Backlash. Align the gun tube to a reference point on an applicable gridboard for the system using a breech or muzzle scope. Record that reference point. Apply a force of 25 ft. lb. at the end of the gun tube in each direction of both the horizontal and vertical planes. While the force is being applied, take another gridboard reading. The difference between the gridboard readings represents the total system backlash. To measure the residual backlash (i.e., the amount of displacement after the release of the applied force), take another gridboard reading after the force is released. Perform these tests with the vehicle at approximately 0 degrees cant, in Normal and Stabilization modes. This test should be conducted at the start of test to establish a baseline, again in C1 and C2 temperature ranges to measure any cold related deficiencies, and once more at the end of test to measure degradation.

d. Gun Control Systems

(1) Follow the procedures in TOP 3-2-603[57] for major caliber weapon gun control systems for turret operations in a stationary vehicle or in a vehicle which halts to fire and TOP 3-2-602[58] for firing from moving vehicles (with a stabilized gun control system).

(2) For main and auxiliary weapons systems (as applicable), especially those in which hydraulic fluids provide the activation force, the following gun control system functions should be tested, and the response time measured and recorded. Functional tests should be conducted in both C1 and C2 temperatures, after proper system warm up IAW the appropriate TM.

(3) Measure and record, as appropriate for the system, the maximum slew rate, null zone, and angle deflection characteristics of the weapon controls with battery power only, low engine idle, high engine idle, with the Fire Control System off, on, and on with the stabilization system on for both the gunner’s and Commander’s handles.

4.8 <u>Final Inspection</u>.

a. Conduct a final inspection at the conclusion of all testing. Inspect the vehicle, MEP, and SSP as appropriate. Inspect and collect wear data for all traction devices used during the test.

b. Clean the vehicle of all mud, ice, snow, etc. to allow for a thorough inspection of all components.

c. Use the applicable portions of TOP 2-2-505 as a guide and follow the inspection procedures as listed in the vehicle TM or IETM/Operator's Manual and Organizational Level Maintenance Manual.

d. Carefully inspect all power train, suspension and steering components for evidence of cracks, looseness or other physical damage that may have occurred during testing but obscured by mud, ice or snow build-up.

e. Conduct a complete 10/20 standard final inspection, note any discrepancies not previously reported on DA Form 2408-14, "Uncorrected Fault Record."

f. If the vehicle was enrolled in the AOAP, or if directed to obtain special samples (Reference paragraph 4.1. d), obtain final samples from the applicable components and ship the samples to the supporting laboratory. Request an AOAP history report and include the AOAP report in the final test report as supporting documentation.

g. Change lubricants from an "Arctic" grade to the proper viscosity oils and grease as prescribed by the applicable LO for the vehicle's intended destination.

h. Prior to shipment of the vehicle tag the steering wheel with a warning if any operational limitations exist for the equipment.

5. DATA REQUIRED.

Where the test procedures are described in this document, the data required are identified in the individual test procedures above. For those test procedures that reference other TOPs, the data to be acquired are outlined in the referenced TOPs.

6. PRESENTATION OF DATA.

a. Describe the inspection, specific test procedures, and results for each item using narration, tables, photographs, charts, and graphs as appropriate or as outlined in the specific procedure methodology.

b. Reduce, summarize, and analyze data collected to address the subtest data topic and considering the failure definitions derived specifically for the item. When unique analytical tools (i.e., models, simulations, statistical techniques) are used, these should be described in sufficient detail to enable the reader to understand the basis for the analysis.

APPENDIX A. COLD REGIONS ENVIRONMENTAL EFFECTS ON VEHICLE SYSTEMS.

1. Cold Temperature.

a. Tires - When a wheeled vehicle is parked for extended periods (e.g. overnight) at temperatures of -29 °C (-20 °F) or colder, the tires will have hard flat areas where they are in contact with the ground. This requires the operator to drive slowly to minimize vibration and to allow the tire to warm and round out. If caution is not exercised, this vibration may cause damage to shock absorbers or suspension mountings.

The air pressure in tires will be substantially reduced as the ambient temperature drops and may not be visually apparent since the sidewalls may be very stiff due to the cold. Air pressure must be checked with a gauge. Tires should be slightly over pressurized during the winter months (approx 10psi).

After extended highway operation, tires often become warm enough, that if the vehicle is parked on ice, the tires may melt a thin layer of ice when first parked then refreeze. In some cases, if the tire is frozen to the ground, the tire will pull away from the rim causing a rapid loss of air. In other cases the tire may become damaged when attempting to move the vehicle by tearing off the portion of the tire that is frozen to the ground. To prevent this, try not to park on glare ice. If no other location can be found, place something underneath the tires when parking, i.e. floor sweep, pine boughs, or even a thick layer of snow. Another option is to move the vehicle a few inches after the tires cool to prevent them from freezing in place.

b. Lubricant and fuel viscosities - Waxes and tars in paraffin-based and asphalt based engine oils precipitate out in a week or so in very cold temperatures (cold soak) causing an increase in the amount of effort required to start the engine. Synthetic oils are derived from a base stock such as polyol ester and are formulated so that they contain little or no tars and wax. SAE 0W20 and 0W-30 synthetic engine oil is currently being used by the military in cold regions. It is recommended that synthetic oils such as SAE 75W-90 gear lube be used in transfer cases, differentials and other gear cases. Always refer to the lubrication order (LO) for the applicable vehicle for further information. Use quality synthetic SAE 0W-30 or 5W-30 engine oil if specific information is not available. The same weight oil may be used during the summer months as well unless otherwise directed by the L.O. Diesel Fuel Arctic (DFA) or JP8 is the current fuel for use in a cold regions environment. The lubrication properties of DFA and JP8 are less than that found in summertime grade fuels; however, the small amount of increased wear to fuel pumps and injectors is offset by the increased starting ability. Prior to testing verify that all oils and lubricants are the correct viscosity.

c. Engine wear – With modern automotive engines most wear occurs during starting & warm-up. The wear occurs from the lack of lubrication to critical components until the lubricants warm sufficiently to flow freely. The second contributor is caused by fuel dilution of the engine oil. Until the engine reaches its normal operating temperature, unburned fuel manages to pass by the pistons and collects in the oil pan. Over time the ability of the oil to properly lubricate is diminished unless changed frequently. Radiator covers or louvers to control the air flow through the radiator are often used to allow quicker warm-ups and to help maintain the proper engine temperature during operation. If additional cold weather aids are installed on the test vehicle, follow the instructions for their use; document the performance of the devices and the operating instructions. Liquid cooling systems should have anti-freeze protection to a minimum of -46 °C (-50 °F). If winterization kits have been installed, check to ensure that they allow for proper cooling under full-load.

d. Automotive Batteries - When fully charged, lead acid batteries will not freeze to approximately -68 °C (-90 °F); however, fully discharged batteries will freeze at -36 °C (-32 °F). Batteries are considered fully charged when the specific gravity of the electrolyte is higher than 1.260 or if a Cold Cranking Amps reading is greater than or equal to the Cold Cranking Amps rating of the battery. A higher specific gravity of 1.280 is often used in an extreme cold environment and should be used for tests being conducted in a cold regions environment if the specific gravity can be adjusted.

e. Diesel engine "Slobber" – During extreme cold conditions, unburned fuel may get into the exhaust system and dribble out the exhaust. As long as the vehicle is driven long enough to bring the engine to operating temperature, this condition is normally not serious. Bringing the engine to operating temperatures will allow any unburned fuel that may have collected in the oil pan to vaporize and vent from the system. It is recommended that the engine speed kept above 1200 RPM and extended periods of idling be held to a minimum. Follow the recommended oil change intervals in the applicable LO for operation under severe conditions, or as directed by the AOAP after sampling if the vehicle is enrolled in the program.

f. Manual transmissions and differential oil – Even with the correct weight lubricant, viscosity may become so thick that the operator may not be able to shift gears or move the vehicle. The most effective lubricants for cold weather are synthetic oils and greases especially formulated for the cold. Allow the engine to reach normal operating temperature then move the transmission gear selector through all gears several times, allowing the transmission to idle in each gear for approximately 30 seconds before shifting to the next gear. Drive slowly for the first few miles allowing all the components to warm. The high pressures generated in the transmission or between gears create enough heat that the oil will thin rather rapidly after a short period of mobility operation.

g. Shocks, struts, steering dampers, and attaching hardware – Oil filled shocks, struts and dampers become almost a solid unit in the extreme cold causing the operating rod(s) to bend or break or causing the attaching brackets and hardware to fail. This can be largely prevented by allowing the component to warm by operating at slow speeds and avoiding rough terrain as much as possible, for the first several miles of operation. Steering dampers may be warmed by turning the steering wheel from right to left in increments until the steering stops are encountered.

h. "V" and Serpentine Belts – Regardless of the design of drive belts, as they become cold soaked they may shatter, chunk out, or roll over when the engine is first started. Allow the engine to idle for a few minutes after starting allowing the belts to warm slightly and become flexible. "Arctic" grade belts are available in most cases; however, may not be installed. If they are available, ensure they are installed prior to the start of testing. The belts should be inspected daily as part of the Preventative Maintenance Checks and Services (PMCS).

i. Plastic and rubber parts, lines, hoses, etc. – Most materials become extremely brittle in cold temperatures. To prevent damage, corrective maintenance actions should be performed in a warm enclosure if possible. Testers should inspect all lines, hoses, and fittings daily as part of the PMCS, especially those that are required to flex constantly (brake lines, inter-vehicle connectors, coiled air or hydraulic lines, quick disconnects, etc.). All clamps and retainers must be secure to prevent unnecessary vibration or movement.

j. Electrical wiring harnesses – The protective sheathing of wiring harnesses and cables split and crack easily in extreme cold often exposing the bare wires within the harness. Inspect the clamps and connectors to ensure they are secure thereby minimizing movement of the harness as much as possible. If possible, avoid working on the electrical harness if the vehicle is cold soaked.

k. Hydraulics – Hydraulic brake and steering systems, hydraulic motors, cylinders and other hydraulic activated or controlled components are slower to respond until properly warmed. Some hydraulic components may have to be warmed with an external heat source if the hydraulic fluid does not circulate completely through the system where pump pressure helps to warm the fluid. The use of a hydraulic reservoir heater eliminates many of these problems. When operating in periods of extreme cold, it is advisable to periodically activate the brake to keep the fluids moving through the system.

Fluid seeps and minor leaks are common when first operating these systems in the cold. With the exception of brake systems, minor leaks of seals and connectors are not serious, and normally will stop, once the seals warm and components expand. The use of Arctic grade seal materials is advisable, realizing that there may be an increased wear rate due to the extremely pliable material (silicone is best) required. Repeated replacement of seals and gaskets is not cost effective unless the leak develops into a Class III leak or causes system degradation affecting mission completion. An accepted definition of a Class III leak is one in which the liquid is dripping 3 to 5 drops per minute, usually causing a noticeable wet spot on the ground.

l. Pneumatic Systems – Air dryers, desiccant filters, alcohol evaporators, the draining of air tanks, etc., help to eliminate moisture accumulation which in an automotive air system can be anywhere from inconvenient to catastrophic. The action of compressing air causes moisture to condense out of the air. Unless removed, the moisture can freeze and cause brake failure (i.e. no brake application, frozen brake drums, or brake lock-up due to the loss of air pressure).

Problems may develop affecting other air activated systems or components; such as central tire inflation systems (CTIS), park brake, air seats, windshield wiper motors, air activated control valves, periscope blowers, air impact wrenches and air tools found on recovery vehicles, air shift valves used on transfers or other gear cases. Good maintenance procedures are the best defense. Drain any air tanks daily after operation and keep alcohol dryer reservoirs full and replace or clean compressed air system filters frequently.

m. Seals – Materials used in the manufacture of dynamic seals are often made to withstand wear; therefore losing their elasticity and flexibility when cold soaked. Once the seal becomes warm, the material will normally soften and prevent fluid leaks. In some cases, the seal does not properly seal the component as long as it is continually exposed to the extreme cold. In this case, the seal needs to be redesigned using a more flexible compound. Observe and document leaking seals to determine if the seep or leak is temporary at a certain temperature and functions correctly after warming, or does the leak continue and worsen with continued operation.

n. Software and computers - Computers, including displays, have operational lower limits much warmer than the temperatures found in cold regions. Therefore, it will be necessary to warm computer equipment before it is turned on. This warm-up time will be partially dependant on the length of time the crew compartment heater takes to increase the workstation ambient temperature. Testers should record the length of time from heater start until computers and displays are operational.

If not programmed correctly to include extreme cold temperatures, software programs may fail as they attempt to operate outside of preprogrammed operating limits or to apply improper algorithms. Operation below the programmed or certified lower temperature limit cannot always be prevented. Testers should note the temperature and the symptoms which may indicate erratic computer functioning. In many cases the computer will automatically re-set once the vehicle or system controlled by the affected computer is allowed to warm.

o. Cracked windshields – (Non-ballistic glass) Gravel and stones thrown by other vehicles traveling on a road can hit the windshield with enough force to chip it leaving a pitted, round indentation. Water vapor in the air, temperature differences between inside and outside air, and vehicle motion can then cause cracks to run from the chip across the windshield. If caught early, the chip can often be repaired and the crack prevented. Windshield repair kits are available but need to be applied as soon as possible after a rock has chipped the glass so that the indentation doesn't fill with impurities that hinder the repair process. Clear tape placed over the chip helps keep impurities out until a repair can be made.

p. Inter-vehicular connectors, quick disconnects (pneumatic and hydraulic) – Hoses or lines become very difficult to stretch, uncoil and/or connect when exposed to extreme cold. External high pressure hydraulic connectors are especially difficult to connect as the tolerances on such connectors are minute (to prevent leaks under high pressure operation). Often pre-heating such connectors prior to coupling is the only option unless the vehicle and attachment is stored in a warm enclosure. If heating is required, caution must be exercised so that damage is not done to the "O" rings inside the connector. Testers should verify that coiled inter-vehicular lines are arctic grade or certified for use at temperatures to or below -46 °C (-50 °F).

q. Fogging of windshield, vision devices – Fogging of interior windows or display screens temporarily reducing vision.

r. Toxic Gases - Gases behave differently in extreme cold temperatures. Depending upon the gases and their density, they may settle in crew compartments or dissipate more slowly.

s. Sound and Optical Anomalies – Temperature inversions and the bending of light, common atmospheric effects in cold, still air, may cause objects and sounds to appear to be closer or more distant than they actually are.

2. Freezing Rain, Snow, Fog.

a. Sights, Scopes, DVEs – Fog and whiteout conditions decrease vision and field of view for the driver, commander, gunner, etc., including the effectiveness of sights, scopes and DVE's under certain conditions. Vision devices unless provided with some type of heater or deicer become unusable.

The loss of depth perception in either whiteout or greyout conditions increases the hazard in landing aircraft, driving a vehicle, skiing or even when walking, with the effect greatest when a person is fatigued. Under these conditions while driving, it is almost impossible to distinguish the road from the ditch or from the snow banks along the roadside.

Whiteouts occur over an unbroken snow cover and beneath a uniformly overcast sky so that light from the sky is about equal to that of the snow surface. Shadows, horizon, and clouds are not discernible and a sense of depth and orientation is lost. Only very dark nearby objects can be seen. Blowing snow can cause the same effect. Greyout is a similar phenomenon that occurs during twilight or when the sun is close to the horizon. Unlike whiteout, during greyout the horizon is distinguishable.

The phenomenon of ice-particle fogs, or icefog, is a very common occurrence around inhabited areas during cold winter weather. They are found most of the time when temperatures drop below -37 °C (-35 °F). Their origin, in marked contrast to that of ordinary super-cooled fogs, lies in the copious local production of water vapor by human activities, coupled with an inability of the stagnant air at such low temperature to hold the water vapor. Such sources of water vapor may include the exhaust from vehicles and aircraft, the vents of steam from permanent type heating systems, the air ventilated from humid rooms, and the stove pipe from space heaters. In the field, such a fog may appear over a body of troops, bivouac areas, motor parks, airfields, convoys, and gun positions when firing. Ice fog obscures the gunner's vision along the line of fire and may disclose the location of weapons, vehicles, and troops. During darkness ice fog limits or negates the effectiveness of night vision devices. Air filters can ingest ice crystals including vehicle NBC collective protection filters restricting or blocking air flow.

b. Traction, braking and steering – Freezing rain can coat road surfaces, vehicle vision blocks, doors, hatches, etc. It creates hazardous driving conditions that reduce traction, braking and steering. Tracked vehicles without some type of ice cleat become immobilized. Bridge surfaces often glaze over even if the road surface, before and after the bridge, is rather dry. Freezing rain can also coat the outside of the vehicle making working or climbing on the vehicle extremely slippery.

3. High Winds.

Although high winds can occur at anytime, anyplace, high winds in a cold regions environment cause additional problems such as:

a. Blowing snow causing snow drifts, whiteout conditions and wind-chill.

b. Many rivers in a cold regions environment are glacial rivers which carry huge amounts of glacier flour (ground rock) which is deposited on large braded gravel bars in the river bed. As the ground material dries out, high winds create large dust storms in the vicinity of the river bed and often for several miles from the river depending on the wind direction and velocity. This dust is very fine and abrasive. Electronics should be protected if operating in these conditions as well as the frequent inspection, cleaning or changing of equipment air filters.

c. High winds have caused damage to vehicle doors when opening if the operator fails to securely hold on to the door when entering or exiting the vehicle. To help prevent damage, head the vehicle into the wind when parking and opening the door(s).

d. Damage to trees and power lines make travel difficult or impossible.

4. Surface Snow and Ice.

a. Mobility – Deep snow impedes vehicle mobility, whether cross-country or on roads, because of increased resistance to compaction, dragging of undercarriage, and reduced traction. (Reference page 14, ERCS/CRREL TR-04-6). Snow cover also blankets terrain features, obscuring obstacles to movement such as brush, stumps, rocks, ditches, small streams, fallen trees, as well as mine fields or other manmade obstacles.

The effect of snow cover on mobility varies greatly with both depth and physical characteristics of the snow. Generally, conventional wheeled vehicles cannot travel satisfactorily over flat terrain or roads when the depth of uncompacted snow exceeds 30 cm (12 in) in depth. Most tracked vehicles are slowed by a snow depth of 60 to 75 cm (24 in to 29 in). Low-ground-pressure tracked vehicles can generally operate effectively in deep snow. However, snow of more than 76 cm (29 in) depth, especially when granular or powdery, can stop movement except for special oversnow vehicles with low ground pressure such as the Small Unit Support Vehicle (SUSV) or snowmobiles.

The physical strength of snow generally increases with colder temperatures. Frequently, movement across a snow covered area impassable during the day may become passable during the night after a sharp drop in temperatures. Because the depth and characteristics of snow cover can vary greatly within short distances and short spaces of time, up-to-date analysis of snow conditions in the selected test site is essential to the planning of mobility subtests (Reference paragraph 1-12, FM 31-71[59]).

Snow drifts, which occur frequently in a cold regions environment because of the light, dry snow and high winds, can also restrict or impede mobility.

Snow cover acts as a thermal insulator which retards the freezing or thawing of underlying ground. During the transitional period from the winter season to summer, snow melt saturates the ground and often makes it impassable. Problems include limited mobility and vehicle control due to daily freeze-warm cycles, heavy slushy snow, glazed road surfaces, water over ice & snow pack, mud & soft soil conditions, etc.

Overflow develops when water under ice breaks through and is either trapped by or saturates overlaying snow, creating a vehicle-trapping slurpee. It can develop on lakes, rivers, springs, creeks or grow on muskegs. This surface may appear to be undisturbed snow until a vehicle breaks through. It can be a very dangerous situation for vehicles and personnel and should be avoided.

b. Braking and Steering – Vehicle control on icy surfaces can be dangerous and difficult for wheeled vehicles and can be extremely difficult or impossible for tracked vehicles unless the vehicle is fitted with combat track (all steel track with grousers). All vehicles with rubber track pads have a difficult time steering and braking on hard pack snow and ice. If pads are removable, every fifth rubber pad can be removed to improve traction. On a track such as the M1 tank, a steel track block was designed with a “X” pattern as part of the grouser design and installed in place of every fifth rubber block to create an ice cleat. Traction on compacted snow is often better during extreme cold weather.

Ice may form under several environmental conditions. For example; Roadways may have a thin layer of ice caused by the temperature differential between the air and the pavement. When warm air overlies a cold surface, such as a paved road, moisture in the air may deposit directly onto the asphalt surface. This type of ice is most common when relatively warmer days alternate with cold nights or when the weather warms after a long cold spell has chilled the ground. Other causes are automobile exhaust or the compressed remnants of a snowfall.

Black ice (sometimes known as "glare ice" or "clear ice") refers to a thin coating of glazed ice on a roadway which allows the usually black asphalt/macadam roadway to be seen through it, hence the term. It is unusually slick compared to other forms of roadway ice. Because it contains relatively little entrapped air in the form of bubbles, black ice is transparent and thus very difficult to see (as compared to snow, frozen slush). In addition, it often is interleaved with wet road, which is identical in appearance. For this reason it is especially hazardous when driving or walking because it is both hard to see and unexpectedly slick.

Bridges and overpasses can be especially dangerous. Because air circulates both above and below the surface of an elevated roadway, the pavement temperature drops more rapidly and ice forms first on bridges and overpasses.

c. Acceleration – Four-by-four, 8X8 or all wheel drive vehicles provide a noticeable improvement over rear wheel drive vehicles when accelerating. This may give a false sense of control on ice and snow as there is no improvement in stopping distances over any other vehicle with the same number of wheels.

5. Frozen Ground.

a. Suspension Systems – Shock and impact are transmitted to the suspension system causing damage to components. Inspect suspension components frequently during test.

b. Ride Quality – Ride quality becomes harsher affecting crews and mission equipment packages. Inspect shock mounting bushings for flexibility (many bushings become extremely hard and stiff in a cold environment). Check components for security and or missing hardware.

c. Sensors – Acoustic and Seismic energy can affect algorithms of sensing equipment and distort perceived distances. Record and report any abnormalities and the temperatures in which they occur.

d. Communications – Frozen ground is a poor electrical conductor and transmitting and receiving antennas work best if set above highly conducting earth. Vehicle communication systems are grounded to the vehicle which serves as the grounding plane.

6. Low Humidity.

a. Most cold regions have very low absolute humidity in the winter which contributes to an increase in the build-up of static electricity. Any excessive build-up of static electricity presents a safety issue with ammunition handling, (especially any type of electrical fuse), the refueling and defueling of vehicles, aircraft, and fuel containers and other equipment. The proper grounding procedures, applicable regulations and unit safety SOP's must be closely followed.

b. Static can also destroy electronic equipment components. Personnel must be familiar with and follow the correct procedures to insure that any accumulation of static electricity has been discharged (i.e., wrist grounding straps) prior to the repair or disassembly of sensitive electronics.

c. Many of the newer synthetic clothing materials tend to increase the frequency and amount of static electricity, and require the wearer to insure the proper grounding/discharge procedures are followed.

7. High Latitude.

The view of satellites below the horizon, signals blocked by mountainous terrain, solar and magnetic interference become problematic for Position Navigation Devices, communications and other systems dependent on or influenced by satellite or magnetic fields.

Disturbances in the electromagnetic environment can cause erratic performance or malfunction of electronic devices. The visible aurora causes localized changes in ionospheric ion density which both absorbs and reflects radio waves in unexpected directions. Signals that normally propagate by reflection off the ionosphere can be affected by auroral activity. Frequencies commonly used for satellite communications are not as badly affected as the lower-range frequencies that typically bounce off the ionosphere.

APPENDIX B. EXTENDED COLD WEATHER CLOTHING SYSTEM (GEN III ECWCS).

GEN III ECWCS uses seven levels of insulation to provide a broad level of environmental protection in cold temperatures. Each piece fits and functions either alone or as part of the system to provide multiple options for cold weather protection with high performance.

Level I - Light-Weight Cold Weather Undershirt & Drawers.

Base Layer: Worn next to skin by itself or in conjunction with other levels for added insulation and to aid in the transfer of moisture.

Level II - Mid-Weight Cold Weather Shirt & Drawers.

Base Layer: Worn next to skin by itself or in conjunction with other levels for added insulation and to aid in the transfer of moisture. Worn in mild climates or as a base layer for colder climates.

Level III - High-Loft Fleece Cold Weather Jacket.

Primary Insulation Layer: Worn underneath shell layers or worn as an outer garment in cool conditions. This is the primary insulation layer for use in moderate to cold climates. It is also approved to wear as an outer garment.

Level IV - Cold Weather Wind Jacket.

Shell Layer: Worn with base and insulative levels in transitional environments to provide wind and sand protection. The Cold Weather Wind Jacket is a low volume shell layer, with moisture wicking properties and insulation layers when combined with Body Armor or the Army Combat Uniform.

Level V - Soft Shell Cold Weather Jacket & Trousers.

Shell Layer: Worn with base and insulative levels for use in moderate to cold conditions. The Soft Shell Cold Weather Jacket and Trousers are used in cold weather conditions as a soft shell layer combined with other base and insulative layers.

Level VI - Extreme Cold/Wet Weather Jacket & Trousers.

Shell Layer: Worn over other levels in cold wet conditions alternating between freezing and thawing. The Cold/Wet Weather Jacket and Trousers are used in cold, wet conditions as a hard shell layer combined with other base and insulative layers.

Level VII - Extreme Cold Weather Parka & Trousers.

Shell Layer: The outermost level of protection in the System is used during static operations in extreme cold, dry conditions.

Additional Components:

The following items are also worn as part of the ECWCS in a Cold Regions Environment.

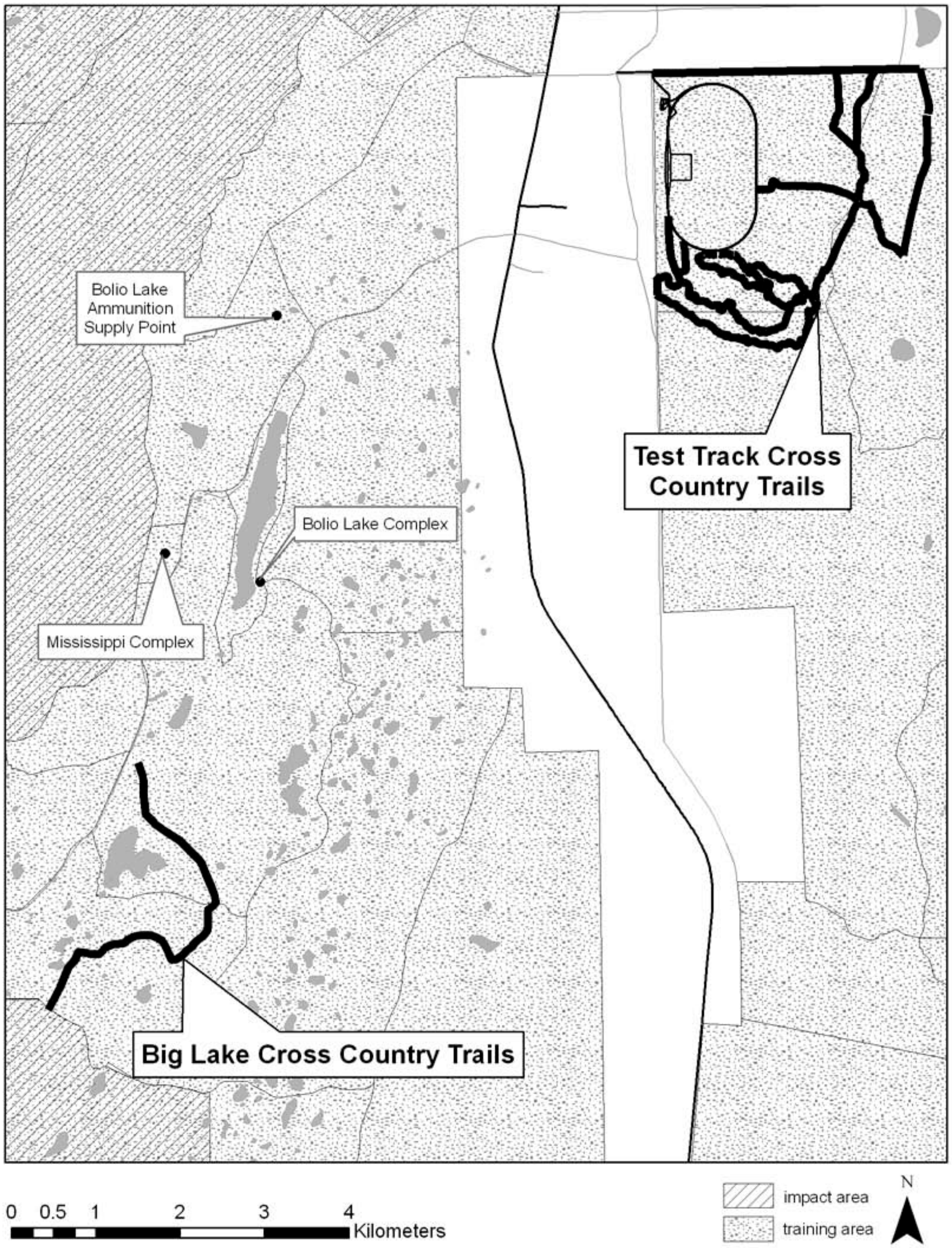
Vapor Barrier (VB) Boots.

Wool Socks.

Arctic Mittens (with thin Anti-contact gloves under the arctic mittens).

Balaclava.

APPENDIX C. CROSS COUNTRY TRAILS AT THE COLD REGIONS TEST CENTER.



APPENDIX D. TEST PLANNING AND SUPPORTING DOCUMENTATION.

1. Test Planning.

a. Test Planning should be initiated early in the acquisition process in order to yield the most cost effective approach to decision risk mitigation.

b. Computer controlled systems and software is used more and more to control and monitor critical functions of tracked and wheeled vehicles and must be rigorously tested.

c. Testing should be conducted to demonstrate the logistical concept is adequate. Issues in the areas of maintenance, transportation, storage must be addressed along with reliability, availability and maintainability (RAM) as directed, as well as accuracy and comprehensibility of associated vehicle publications.

d. Test planning should address the following:

(1) Purpose of testing.

(2) Test objectives.

(3) Test criteria.

(4) Test method.

(5) Data required.

(6) Data analysis techniques and presentation.

(7) Test Cost.

(8) Report Requirements.

(9) Communications Frequency Requirements.

2. Supporting Documents.

a. In order to properly assess the safety, performance and reliability of tracked and wheeled vehicles, a detailed documentation review must be conducted. This documentation review provides a more thorough understanding of wheeled and tracked vehicle characteristics and in some instances can reduce the amount of physical testing required and can assist in reducing the assigned risk assessment code reported in the safety confirmation. The documentation review is required to ensure that proper safety protocols are emplaced prior to the initiation of testing. The following documents should be included in the test item data package; it is preferable that these documents be provided as early as possible prior to the start of testing. The following are required documents:

(1) Safety Assessment Report (SAR) – The SAR is a formal, comprehensive safety report that summarizes the safety data that has been collected and evaluated during the life cycle of an item. It expresses the considered judgment of the contractor or developing agency regarding the hazard potential of the item and any actions or precautions that are recommended to minimize these hazards and to reduce the exposure of personnel and equipment to them. In addition, US Army Center for Health Promotion and Preventative Medicine (CHPPM) certifications must be provided for lasers, and Material Safety Data Sheets (MSDS) must be provided for batteries, fuels, and other hazardous material.

(2) Preliminary Hazard Assessment (PHA) – Broad hazard-screening tool that includes a review of the work that will be performed in a facility and identifies the hazards associated with the work and the facility. The results of the PHA are used to determine the need for additional, more detailed hazard analysis, serve as a precursor documenting that further analysis is deemed necessary, and serve as a baseline hazard analysis where further analysis is not indicated.

(3) Software Requirements Specifications (SRS) – Complete description of the behavior of the system to be developed. It includes a set of use cases that describe all the interactions that the users will have with the software. Use cases are also known as functional requirements. In addition to these cases, the SRS also contains nonfunctional (or supplementary) requirements. Non-functional requirements are requirements which impose constraints on the design or implementation (such as performance requirements, quality standards, or design constraints).

(4) Capabilities Requirements Document (CRD)/Operational Requirements Document (ORD) – Describes the overall mission area, the type of system proposed and the anticipated operational and support concepts in sufficient detail for program and logistics support planning and includes a brief summary of the mission need. If the mission need was not documented prior to the preparation of the CRD/ORD, the process that investigated alternatives for satisfying the mission need and developing the operational requirements is explained.

(5) Performance Specifications/System Specifications/Purchase Description – Communicates the user's requirements to the manufacturer. These documents translate operational requirements into more technical language that tells the manufacturer: 1) what will be considered an acceptable product, and 2) how it will be determined if the product is acceptable.

(6) Security Classification Guide – A documentary form of classification guidance issued by an original classification authority that identified the elements of information regarding a specific subject that must be classified and establishes the level and duration of classification for each such element.

(7) Test and Evaluation Master Plan – (TEMP) – This document identifies the high-level requirements and defines the objectives and overall structure of the Test and Evaluation for the system.

(8) Failure Definition/Scoring Criteria – (FD/SC) – The FDSC are a set of rules designed to provide consistency in the interpretation of reliability test incidents. The FD/SC define the required functionality and allowable levels of degradation and establishes a framework for classifying test incidents.

(9) System Evaluation Report (SER) – Reports on effectiveness, including suitability and survivability of milestone and decision reviews.

(10) Environmental Documentation must be provided in the form of a Record of Environmental Consideration, an Environmental Assessment, or, more rarely, an Environmental Impact Statement, as required by the National Environmental Policy Act (NEPA).

(11) Test Execution Directive – Creation of ATEC Decision Support System (ADSS) project number fulfills the requirement for a directive.

(12) Prior Human Resource Protection Program (HRPP) documentation, if any, should be provided.

(13) Approved Test Plan or Event Plan (for safari efforts).

(14) Local Directives, Standard Operating Procedures (SOPs) and Policy Letters applicable to testing.

b. Other documents that should be used to establish test criteria include programmatic documents that were developed for the system, or those preexisting documents that apply. These documents include documents that define the mission scenarios, climate conditions, operational, and electromagnetic environments in which the item must operate. Some of the most useful documents are listed below:

(1) Operational Mode Summary/ Mission Profile. (OMS/MP).

(2) Operational Requirements Document/Capabilities Requirements Document (ORD/CRD).

(3) Purchase Description/Performance Specifications/System Specification.

(4) Military Regulations, Standards and other controlling directives.

(5) Federal Statutes.

(6) Test Directives.

c. The following directives are desirable if they are available:

(1) Developer Software Functional Qualification Test Plans and Reports.

(2) Component Level Test Plans and Reports.

(3) System Operator Manuals and LO.

(4) System Maintenance and Repair Manuals (Hardcopy or Interactive Electronic Technical Manuals (IETM).

(5) Software Trouble/Problem Reports.

(6) System Safety – Critical Software Requirements.

(7) Software Traceability Analysis.

(8) Data Tap Locations and Interface Definitions.

(9) Software Design/Development Documents.

(10) Message Protocols/Definitions.

(11) Programmatic Environmental, Safety, and Health Evaluation.

(12) Configuration Management Plan.

(13) Interface Control Document.

(14) Vehicle Combat Load Plan.

APPENDIX E. COGNITIVE PERFORMANCE ASSESSMENT FOR STRESS AND ENDURANCE.

1. Introduction.

a. This appendix provides guidance for conducting Cognitive Performance Assessment for Stress and Endurance (CPASE) as related to the testing of tracked and wheel vehicles in a Cold Regions Environment. This assessment would normally be conducted only when specifically directed by higher authority; however, situations may arise during the testing of vehicles that make it advisable to administer CPASE to the vehicle operator and crew.

b. Each generation of combat and tactical vehicles become more complex. These modern systems provide an almost overwhelming amount of information to both the crew and operator such as; situational awareness, instant communications and vehicle operational information. Soldiers must be able to function under the stress of combat along with additional stresses induced by the operation of sophisticated mission equipment packages (MEP) for extended amounts of time. Because of the amount of equipment required for specialized missions or vehicle mounted major weapons systems, the crew work stations are often cramped compartments with limited exterior views and often unevenly or inadequately heated or cooled. Since these vehicles are normally operated “buttoned up,” the vehicle environmental control systems are required to be operating constantly to maintain a comfortable work temperature for both the soldier and the installed equipment. In a cold regions environment the operators and crew will also be wearing the applicable components of their cold weather clothing along with the specified level of MOPP protection. Vehicle noise, fumes and the viewing of display screens during vehicle movement are other contributors to a stressful environment.

c. Vehicles that are highly sophisticated, i.e., reconnaissance, command, NBC recon, radar, missile launchers and communication vehicles, and all vehicle mounted major weapons are excellent candidates for CPASE assessment during testing. Even if the CPSAE is not initially part of the test plan, the test officer should observe the performance of the crews and operators. If it is suspected that their performance is being degraded during vehicle operation, the administration of CPASE will assist in the documentation of operator/crew performance, safety, Human Factors Engineering (HFE), and the ride quality of the vehicle.

2. General Procedures.

a. Commence local Human Resources Protection Program (HRPP) review or board. Determine if there are portions of the test that could be construed as human experimentation and whether HRPP standards apply. HRPP standards may apply if direct measurements of human health (blood pressure, respiratory capability, etc) are taken, if participants are polled on personal or career issues, or if the effects of the vehicle on an individual’s psychological welfare are the focus of testing. CPASE generally will require at least a preliminary HRPP review. If it is determined that the test cannot be modified to exclude human experimentation, then the test and associated mitigations must be forwarded for review by the DTC HRPP review board.

b. Have each test participant checked by occupational health or military clinic, as appropriate, to ensure they are physically cleared for testing.

c. Each test participant's anthropometrical measurements are taken and recorded.

3. Training.

a. Familiarize the crew with the parameters of the test, including the CPASE cognitive battery and the motion sickness questionnaire.

b. Conduct the training within two weeks of the trials.

4. Test Conduct.

Expose each vehicle crewmember to four hours of a moving vehicle environment with performance measures before the exposure, two hours into the exposure, and after the full four hours of exposure. This testing may be conducted in conjunction with scheduled mobility or mission profile operations. A minimum of three trials should be conducted.

a. Have all crewmembers complete a pretest cognitive exercise.

b. Have each crewmember enter the vehicle and confirm that communications are working and that all crewmembers have their seat belts secured.

c. Expose each vehicle crewmember to 120 minutes of vehicle motion.

(1) During the last 60 minutes of vehicle motion, administer situational awareness cues to all crewmembers over the intercom.

(2) During the last five minutes of vehicle motion, require all crewmembers to complete the motion sickness and discomfort questionnaire.

d. Have each crewmember exit the vehicle, complete the cognitive performance battery, and return to the vehicle.

e. Expose each crewmember to another 120 minutes of vehicle motion.

f. Have each crewmember exit the vehicle and complete the performance battery and vehicle ride quality questionnaire.

g. Ensure that a minimum of 24 hours elapses between each exposure for any given crewmember to the test environment.

h. At the conclusion of the test day, debrief all crewmembers, and record any problems, observations, or suggestions that the crewmembers have. At the conclusion of the debriefing or one (1) hour after leaving the vehicle (whichever is longer), release the crewmembers from the test site unless they have persistent and severe symptoms.

i. Crewmembers are not allowed to eat during the ride quality portion of the test. Provide food during the debriefing.

5. Safety Considerations.

Cover all safety considerations in a safety brief prior to testing.

a. Prior to vehicle movement, check the vehicle's load to ensure that there are no loose or unrestrained items.

b. Provide emesis bags during vehicle motion.

c. During vehicle motion, the vehicle commander should observe the vehicle crewmembers to ensure that safety procedures are being followed.

d. Following vehicle operation, do not allow crewmembers to drive until they had been free of dizziness and vertigo for at least one (1) hour.

6. CPASE.

The CPASE battery of tests is designed to assess any performance degradation by the test subjects after participating in vehicle mobility trials. The CPASE tests consisted of the following sections:

a. Memory Test. The subjects are given a list of twelve (12) commonly used English words on a letter-sized piece of paper. Upon being instructed to start, the subjects have one minute to write each word one time and study the list. The list is then immediately turned upside down and collected by the test administrator. Each subject then turns to the page in their CPASE packet with twelve blank lines on it and is given one minute to write down as many of the original twelve words as they can remember. All subjects are given the same list of words for a given test, but new lists, prepared in advance by ARL/HRED, are handed out for every test.

b. Logical Reasoning. Before turning to the Logical Reasoning test, the subjects are allowed to read the Logical Reasoning instructions for as long as necessary. The instructions are summarized as follows:

(1) On one page, there are 32 short sentences, each followed by a pair of letters in a particular order, such as AB or BA. The sentences claim to describe the order of the two letters. The two letters are followed on that same line with the words True and False. The subject's task is to read each sentence and decide if it is a true or false description of the order of the letter pair which follows it. The subject then circles True or False, depending on whether or not he thinks

the sentence describes the order of the two letters correctly or incorrectly. Five examples, with the correct True or False answers, are presented for the subject to thoroughly understand the Logical Reasoning test.

(2) The subjects are then allowed to turn to the Logical Reasoning test and are given one minute to do as many of the 32 problems as they can. After one minute, the test is stopped and the page turned over.

c. Addition. The Addition test consists of 15 addition problems, consisting of adding two three-digit numbers together and writing the answer. The subjects are given two minutes to perform the test. At that point, the test is stopped and the page turned over.

d. Spatial Rotation. Before turning to the Spatial Rotation test, the subjects are allowed to read the Spatial Rotation instructions for as long as necessary. The instructions are summarized as follows:

(1) The Spatial Rotation task consists of rotated patterns. To the right of each pattern, in the left column, there are three similar patterns. One of the three patterns is identical to the original pattern on the left, except it has been rotated clockwise by 90, 180, or 270 degrees. The subject is to find that pattern which is like the one on the left and write its letter identifier (A, B, or C) to the right of the patterns in the space provided. Four examples are given for study by the participants, with the correct answers given. The Spatial Rotation test itself consisted of three pages with six different sets of patterns on each page, for a total of 18 problems to be solved.

(2) After sufficient review time of the instructions, the subjects are allowed to turn to the Spatial Rotation test and have two minutes to complete as many of the 18 items as they can. At the end of the two minutes, the subjects turn their CPASE packet over and the test administrator collects all of the test materials for grading.

e. The test subjects should be administered four tests for familiarization within a one-week period. The CPASE test is then given prior to each four-hour mobility trial for which data are desired. That first test is designated as the baseline test. The crew then enters the vehicle and performs the assigned mission for two hours. For a vehicle mounted major weapon system, the mission will include firing missions. The crew then exits the vehicle and takes the test again in a comfortable classroom atmosphere. Shortly thereafter, the crew re-entered the vehicle and conducts another two-hour primary mission. The crew again exits the vehicle and takes the CPASE test for the third time that day. Two or more questionnaires are also administered to the test subjects at the end of the two-hour periods.

7. Analysis.

The CPASE test scores for each crew stations after operating the vehicle for two and four hours are statistically compared to the baseline scores for all of the combined trial data. The statistical comparisons are made using Analysis of Variance (ANOVA) techniques, at a significance level of 0.05 or lower.

APPENDIX F. DATA COLLECTION SHEETS UNIQUE TO COLD REGIONS TESTING.

1. The sample data collection sheets in this Appendix are provided for the collection of data unique to the cold regions testing of wheeled and tracked vehicles. The diversity in equipment design, vehicle missions, platform configuration, and the state of current technology integrated into the systems prevent the development of data collection sheets that address all possible scenarios.

2. These data sheets may be modified to collect additional information as needed; however none of the data elements shown should be deleted.

3. Data collection sheets for subtests not unique to cold regions testing are found in the applicable subtest TOP.

Item 1: SAMPLE COLD START DATA COLLECTION SHEET

C1 or C2 COLD START # _____ DATE:______________________

VEHICLE: ___________ COLD SOAK LENGTH:______

A minimum of three C1 and three C2 cold starts are required.

	Start of Heater	1st Cold start attempt	2nd Cold start attempt	3rd Cold start attempt	Slave start
Time					
Ambient Air temp in °F					
Engine oil temp in °F					
Engine Coolant temp in °F					
Transmission Fluid temp in °F					
Auto battery voltage					
Aux battery voltage					
Auto / Aux battery interconnect switch					
Engine cranking time	N/A				
Low Battery indicator observed					

Battery	Auto one	Auto two	Aux one	Aux two
Time Checked				
Amps/Rated Amps (NASCAR)				
Volts (Load Tester) Good or Bad				
Specific gravity (As needed)	TL TR ML MR BL BR	TL TR ML MR BL BR	TL TR ML MR BL BR	TL TR ML MR BL BR

Item 2: SAMPLE METEOROLOGICAL DATA COLLECTION SHEET

Use for each Cold Start, Static Heater Test, Mobile Heater Test, Static Brake Functionality Test, and Mobile Brake Functionality Test (Circle One).

DATE: ____________________________ MILES: ___________________________

TIME: ____________________________ HOURS: ___________________________

VEHICLE: _________________________ SUBTEST: __________________________

COLD SOAK LENGTH: _____________ TEMPERATURE _____________________

Start of Testing:

Ambient air temperature (±2°F) at start of test	Relative humidity (±5 %) at start of test.	Barometric pressure (±1 mm Hg) at start of test.	Precipitation at start of test.	Wind speed (±1 knot) at start of test.

End of Testing:

Ambient air temperature (±2°F) at end of test	Relative humidity (±5 %) at end of test.	Barometric pressure (±1 mm Hg) at start of test.	Precipitation at end of test.	Wind speed (±1 knot) at end of test.

Item 3: SAMPLE SNOW OBSERVATION DATA COLLECTION SHEET

Use for Mobility (Without Traction aids), (With Traction Aids), (Snow Mired Vehicle – Recovery Operations) (Circle One).

TEST TITLE: ____________________ SUBTEST: _______________________

DD/MM/YYYY: __________________________ TIME: ___________________________

OBSERVERS NAME: ___________________________

LOCATION: _____________________ AMBIENT TEMPERATURE: ________F.
(Nearest 0.1 degree F.)

SKY CONDITION: ______________________________
(Scattered, Broken, Overcast, Obscured by Snow, etc.)

SNOW SURFACE: (Circle representative type)

1. SMOOTH – Continuous and smooth
2. RIPPLED – Gently undulating or slightly wavy, drifts common
3. PITTED – Melted snow pot marks or rills from melted snow
4. GULLIED – Extensive melting

DRIFT HEIGHT: _______________
(Average drift height, largest drifts)

SNOW DEPTH: ________________
(Average depth, same as depth of pit)

NEW SNOW: _____________________

1. If more than 3” of snow has fallen in the past 48 hours.
2. If no identifiable grain pattern enter: “fine grained”

PROFILE:

1. LAYER – Enter “top” and “bottom” to identify layers: ______________

2. THICKNESS – Depth of layer to the nearest half inch: ____________

3. CRYSTAL: (Circle one)

   a. Fa – Original crystal, definite geometric patterns
   b. Db – Fine grained, no geometric pattern, < 2mm diameter

c. Dd – Corse grained, granular, > 2mm diameter
d. De – Depth hoar, pronounced geometric patterns, 3-10 mm

4. DENSITY: ____________________________

a. Only for layers of 2” or more
b. Small scoop (100 cm3) weight x .01 = gm/cm3
c. Large scoop (200 cm3) weight x .005 = gm/cm3

5. HARDNESS ___________________________

a. Average of three readings
b. If layer is too shallow for normal reading, enter “vert” in remarks
c.

DISK	BLACK	RED
Large (1x)	0-10 gm/cm2	not used
Medium (10x)	11-100 gm/cm2	101 - 1,000 gm/cm2
Small (100x)	not used	1001 – 10,000 gm/cm2
None (500x)	not used	0 - 50,000 gm/cm2
Extension (1000x)	not used	10,001- 100,000 gm/cm2

d. Subjective Hardness Code:

(1) Ka – Very soft, back of hand penetrates
(2) Kb – Soft, 4 fingers penetrate
(3) Kcs – Medium soft, 2 fingers penetrate
(4) Kch – Medium hard, 1 finger penetrates
(5) Ke – Hard, knife penetrates

6. SNOW TEMPERATURE _____________C.
(Nearest 1 degree C.)

7. WETNESS CODE:

a. Wa – Dry, snowball cannot be made
b. Wc – Moist, snowball can be made, no liquid water
c. Wd – Wet, obviously contains water
d. We – Slushy, watery

8. REMARKS:

Item 4: SAMPLE STATIC HEATER TEST DATA COLLECTION SHEET

C1 or C2 STATIC HEATER TEST # ___ DATE:____________ VEHICLE:__________
A minimum of two C1 and two C2 Static Heater Tests are required for each vehicle.

	Start of Heater	**Change in Status**	**Change in Status**	**Change in Status**
Time				
Ambient Air Temp °F				
Engine Preheat Valve Position				
Crew Heat Valve Position				
Is Engine Running?				
Auto battery voltage				
Aux battery voltage				
Auto /Aux, battery interconnect switch position				
Low Battery Indicator Observed?				
Additional Comments or Heater Fault Codes				

Battery	**Auto one**	**Auto two**	**Aux one**	**Aux two**
Time Checked				
Amps/Rated Amps (NASCAR)				
Volts (Load Tester) Good or Bad				
Specific gravity (As needed)	**TL** **TR** **ML** **MR** **BL** **BR**	**TL** **TR** **ML** **MR** **BL** **BR**	**TL** **TR** **ML** **MR** **BL** **BR**	**TL** **TR** **ML** **MR** **BL** **BR**

Item 5: SAMPLE MOBILE HEATER TEST DATA COLLECTION SHEET

C1 or C2 MOBILE HEATER TEST # ___

DATE:____________ VEHICLE:__________

A minimum of one C1 and one C2 Mobile Heater Test is required for each vehicle.

	Start of Heater	**Start of Movement**	**Start of 30 Minute Time with Commander's Hatch Open**	**End of Movement**
Time				
Location				
Ambient Air Temp in °F				
Engine Preheat Valve Position				
Crew Heat Valve Position				
Is Engine Running?				
Auto / Aux and battery interconnect switch position				
Low Battery Indicator Observed?				
Heater Fault Codes (Give Time and Description of Incident)				
Additional Comments				

Item 6: SAMPLE RAMP TEST DATA COLLECTION SHEET

Indoor, C1, or C2 RAMP TEST # ___ DATE:____________ VEHICLE:__________
The four test procedures listed in the columns below will each be conducted a minimum of once Indoors, once at C1, and once at C2 for each vehicle. A separate data sheet will be used for each of the three test conditions, including the MET Data sheet below.

	Ramp Opened Prior to Heating Crew Compartment	**Ramp Closed Prior to Heating Crew Compartment**	**Ramp Opened After Heating Crew Compartment at Least One Hour**	**Ramp Closed After Heating Crew Compartment at Least One Hour**
Clock Time				
Ambient Air Temp in °F				
Temp at Head Thermocouple at the Left Rear Seat				
Temp at Hand Thermocouple at the Left Rear Seat				
Temp at Foot Thermocouple at the Left Rear Seat				
Time (sec) for Ramp to Open or Close				
Did Locking Cams Work Properly?				
Any Other Problems or Abnormalities				

APPENDIX G. ACRONYMS.

ADACS	Advanced Data Acquisition and Collective System
ADSS	ATEC Decision Support Center
AEC	Army Evaluation Center
AGM	Absorbed Glass Mat
ANOVA	Analysis of Variance
AOA	Add on Armor
AOAP	Army's Oil Analysis Program
ARL	Army Research Laboratory
ASP	Ammunition Supply Point
ATEC	Army Test and Evaluation Command
BIIL	Basic Items Issue List
BIT/BITE/FIT	Built-in Test, Built-in Test Equipment and Fault Isolation Test
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CBRN	Chemical, Biological, Radiologic, Nuclear
CMBT	Combat
CPASE	Cognitive Performance Assessment for Stress and Endurance
CRD	Capabilities Requirements Document
CRTC	Cold Regions Test Center
CTIS	Central Tire Inflation System
CVC	Combat Vehicle Crewman
DA	Department of Army
DPW	Department of Public Works
DTC	Developmental Test Command
DVE	Drivers Vision Enhancement
ECWCS	Extended Cold Weather Clothing System
ECO	Engineering Change Orders
EOD	Explosive Ordnance Disposal
FD/SC	Failure Definition/Scoring Criteria
FoV	Field of Vision
GPS	Global Positioning System
HFE	Human Factors Engineering
HRED	Human Research and Engineering Directorate
HRPP	Human Resources Protection Program
IAW	in accordance with
IETM	Interactive Electronic Technical Manuals
ILS	Integrated Logistic Supportability
IRAC	Initial Risk Assessment Code
ITOP	International Test Operations Procedure
LO	Lubrication Order
MEP	Mission Equipment Package
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MOPP	Mission Orientated Protection Posture

MRS	Muzzle Reference Sight
MWO	Modification Work Orders
NIOSH	National Institute for Occupational Safety and Health
NSN	National Stock Number
NBC	Nuclear, Biological, Chemical
NEPA	National Environmental Policy Act
OIC	Officer-in Charge
OMS/MP	Operational Mode Summary/Mission Profile
ORD	Operational Requirements Document
OSHA	Occupational Safety and Health Administration
OVE	On Vehicle Equipment
PAM	Pamphlet
PD/PSS	Purchase Description/Performance Specification System Specification,
PHA	Preliminary Hazard Assessment
PM	Program Manager
PMCS	Preventative Maintenance, Checks and Services
POL	Petroleum, Oils and Lubricants
POS/NAV	Position Location and Navigation System
QASAS	Quality Assurance Specialist (Ammunition Surveillance)
RAC	Risk Assessment Code
RAM	Reliability Availability and Maintainability
R&M	Reliability and Maintainability
SAC	Supportability Analysis Chart
SAR	Safety Assessment Report
SER	System Evaluation Report
SEST	Systems Environmental Suitability Test
SOC	State of Charge
SRS	Software Requirements Specifications
SSC	Supply Support Chart
SSP	System Support Package
TEMP	Test and Evaluation Master Plan
TIR	Test Incident Report
TM	Technical Manual
TMDE	Test Measurement and Diagnostic Equipment
TOP	Test Operation Procedure
VB	Vapor Barrier
YPG	Yuma Proving Ground

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[3] Note 1: The National Highway Traffic Safety Administration (NHTSA) has a legislative mandate under Title 49 of the United States Code, Chapter 301, Motor Vehicle Safety, to issue Federal Motor Vehicle Safety Standards (FMVSS) and Regulations to which manufacturers of motor vehicles and items of motor vehicle equipment must conform and certify compliance.

FMVSS 209, Seat Belt Assemblies, was the first standard to become effective on March 1, 1967. A number of FMVSS became effective for vehicles manufactured on and after January 1, 1968. Subsequently, other FMVSS have been issued. For instance, NHTSA has issued seven new FMVSS and has amended six FMVSS and two consumer information regulations and requirements since this booklet was revised in March 1999. New standards and amendments to existing standards are published in the Federal Register.

These Federal safety standards are regulations written in terms of minimum safety performance requirements for motor vehicles or items of motor vehicle equipment. These requirements are specified in such a manner that the public is protected against unreasonable risk of crashes occurring as a result of the design, construction, or performance of motor vehicles and is also protected against unreasonable risk of death or injury in the event crashes do occur.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Cold Regions Test Center, P.O. Box 665, Delta Junction, AK 99737. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.