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This Test Operations Procedure (TOP) provides background information on physiological and psychological effects of cold on the human. It is an overview TOP and is organized to provide information on some of the problems associated with conducting operations, training, testing, and living in a cold environment. Rather than test procedures, it provides needed knowledge to safely conduct tests in the cold environment.

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# COLD REGIONS: PERSONNEL EFFECTS


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## 1. SCOPE.

This is an overview TOP and is organized to provide information regarding the problems faced by personnel who are testing Army equipment in a cold environment. This document provides background information on the human's physiological and psychological responses to a cold environment. It discusses how the responses impact the conduct of tests in the cold environment. A brief overview of some of the problems of operation and the procedures used to overcome these problems are provided along with the techniques and requirements for tests involving the effects of a cold environment on personnel.

## 2. BASIC INFORMATION.

### 2.1 Effects of the Cold.

Test personnel must be aware of the effects of the cold environment on the human body in order to conduct tests safely. Cold weather can directly affect an individual's health and performance. Problems can be encountered by personnel as they attempt to work in any cold environment and these problems are compounded with snow, ice, humidity, and extreme cold temperatures. Information on the physiological processes and accommodations required to solve these problems and techniques to evaluate them under field conditions are discussed in Section 3. Information concerning the symptoms, methods of prevention, and treatment of various types of cold injuries is also provided.

### 2.2 Cold Weather Clothing.

a. Cold weather clothing is a system of clothing designed so that layers can be added or removed depending on the weather and activity level. Protection from the cold uses the principles of insulation, layering, and ventilation. Insulation reduces heat loss from the body by lowering the conductive heat transfer to the exterior of the garment. The clothing should also reduce convective heat loss by decreasing air exchange between the inside and outside of the garment. However, the ability to ventilate the garment is crucial to prevent moisture from accumulating and to prevent overheating. Clothing must be kept clean and dry, as moisture and dirt compress the insulation and accumulated moisture increases the conductive properties. Layers allow a person to adjust the amount of insulation that is worn based on how much heat the body is producing, e.g. a physically active person is producing more body heat than a sedentary one. Physical activity or too much clothing can cause overheating and sweating which can wet the garment. It is therefore also necessary to be able to ventilate the cold weather clothing and evaporate any sweat. A simple mnemonic to remember the properties is the word COLD

(1) C = Clean, keep clothing clean to maintain the insulating properties

(2) O = Overheating, avoid overheating by properly ventilating clothing

(3) L = Layers, wear clothing in loose layers so the amount of clothing (insulation) being worn can be easily adjusted to match activity levels or weather conditions.

(4) D = Dry; keep clothing dry by avoiding overheating and by ventilating clothing when necessary.

b. It is especially important to wear good head, hand and foot protection. Handwear and boots may seem especially bulky but since the extremities are most vulnerable to cold injuries, the loss of dexterity may have to be traded for the increased thermal protection. It is also necessary to protect the head and face. Covering the head is important since more heat is lost through the head than from any other part of the body. The face, in particular, may be exposed more to the cold unless face masks are worn. A head covering, like a hood or face mask, that reduces the exchange of air will also help pre-warm the air being breathed as well as protect you face and nose. Although breathing cold air may cause frost to accumulate on the small hairs in the nose, it will not freeze the lungs. Cold air that enters the nose or mouth will have warmed to body temperature by the time it reaches the lungs.

### 2.3 Testing in the Cold.

The cold environment that creates hazards for humans also creates problems for operations. Bulky clothing and handwear restricts movement and dexterity, cold-weather clothing and test items (especially personal equipment) can be difficult to integrate, equipment often malfunctions, travel can be difficult, and fogging and freezing of glasses, goggles, eyepieces, and windows occurs. Accommodation to the environment requires the understanding that the effect of cold on the health and well being of test personnel extends to their ability to conduct operations. It can be argued that it is not essential for a person to be warm to be effective, as the absence of complete comfort can induce increased effort. But that increased effort will eventually have serious consequences. While the body may remain effective as long as the caloric and fluid intake is adequate, fatigue will set in and the individual's mental attitude may degrade sharply. It is therefore critical to pay attention to the psychological as well as the physical well being of personnel when they are working in the cold environment.

## 3. EFFECTS OF THE COLD ON HUMAN PHYSIOLOGY.

### 3.1 General.

a. When a person is exposed to surrounding air temperatures colder than body temperature, the body will lose heat. Heat loss increases in wet or windy conditions. Perspiration and respiration also remove heat from the body. If the heat escapes faster than the body can produce it, the body temperature will fall. Protection from the cold is provided by avoiding or reducing heat loss through insulated clothing and/or heated shelters. If the protective measures are not adequate, the body will use biological defenses to help maintain the core body temperature. These include vasoconstriction and shivering both of which attempt to protect the core body temperature.

b. Vasoconstriction is the constricting of the blood vessels in the skin to conserve the core body temperature. The reduced blood flow conserves body heat but causes the skin temperature to fall, leading to discomfort, numbness, loss of dexterity, and eventually cold injuries. Shivering increases internal heat production just as physical activity does. Both may be sufficient to compensate for heat loss for the short term but are fatiguing and can lead to the serious consequences of hypothermia. In intense cold or when the human body is 'getting cold', a person may neglect tasks, take more effort and time to complete them, and generally have less focus and interest on the tasks. Under some conditions (particularly cold water immersion) hypothermia may occur very quickly.

3.2 Hypothermia.

a. Hypothermia is a term used to describe general lowering of the core body temperature due to a loss of heat at a rate faster than it can be produced. The occurrence of hypothermia is not restricted to extremely cold temperatures. It can also occur from exposure to temperatures above freezing, especially if combined with immersion in cold water or the effect of wind. The risk of hypothermia is increased by physical exhaustion and wet-cold conditions. Hypothermia must also be considered as a possible complicating factor in accidents or other emergency situations as injured persons are more likely to become hypothermic.

b. **Hypothermia is a medical emergency**. As central body temperature falls from the normal level of 37 °C (98.6 °F), various body processes are slowed. Circulation of blood is retarded, movements become sluggish, coordination is reduced, and judgment becomes impaired. Further cooling results in unconsciousness. At a deep body temperature below approximately 30° C (86° F), the risk of disorganized heart action or cardiac arrest increases and can result in death.

c. Prevention of hypothermia consists of all actions which will avoid rapid and uncontrolled loss of body heat. All operations in cold regions require that personnel be equipped with proper clothing and protective gear and that a warm shelter is available at test sites. Using a 'buddy' system to keep aware of all test personnel that are out in the field is also required. All personnel should watch each other closely for signs of hypothermia.

d. If a person shows signs of hypothermia, i.e. changes in coordination, slurred speech, violent shivering, lack of interest, it is important to reduce any further heat loss by providing additional layers of dry clothing and a heated shelter. As a medical emergency, medical staff is required without delay to attend any serious hypothermia patient since this condition is life threatening until normal body temperature has been restored. This is a serious cold injury which can be difficult to reverse without medical intervention.

3.3 Freezing Injuries: Frostnip and Frostbite.

a. Freezing limited to the skin surface is frostnip. Frostnip causes reddening and possible swelling of the skin and although painful, there is often no further damage after re-warming. However, frostnip must be treated seriously as it may be the first signs of impending frostbite.

b. When the freezing extends into the tissue beneath the skin, the injury is frostbite. With frostbite, the skin becomes numb and gray or waxy-white. The ice crystal formation and lack of blood flow to the frozen area damages the tissue. Frostbite may occur with or without hypothermia.

c. **Frostbite is a medical emergency**. If freezing of tissue has occurred, do not attempt to treat or thaw the frozen area in the field. Injured individuals must be evacuated to a medical facility as quickly as possible. If frostbite has occurred, the possibility of hypothermia must also be considered. As stated above both of these cold injuries require immediate medical attention. These are serious injuries which can be difficult to reverse without medical intervention.

3.4 Non-freezing Cold Injuries.

a. Non freezing cold injuries include chilblain and trench foot.

b. Chilblain is characterized by ulcers or red, swollen skin that is tender to the touch. It occurs in fingers and toes when an individual is exposed for prolonged periods to cold and humidity. It can develop quickly if skin is exposed to cold/wet conditions but it causes little or no permanent damage.

c. Trench foot (or immersion foot), caused by prolonged exposure of the feet to damp, unsanitary, and cold conditions above the freezing point, is a serious injury that may result in permanent nerve damage and gangrene if left untreated.

3.5 Snow-blindness.

Snow-blindness is caused by overexposure of the eyes to ultra-violet light, typically from bright sunlight reflected over an expanse of snow. The risk of snow blindness is increased at high altitudes since the level of ultra-violet radiation increases with altitude. Symptoms include a sensation of grit in the eyes, pain in and over the eyes made worse by eye movement, watering, redness, headache, and increased pain on exposure to light. Snow-blindness is usually not permanent and symptoms generally disappear in a day. It can be prevented by using sunglasses that block at least 90% of the UV radiation, that have sideshields or deeply wrapped lenses, and that provide protection under the eye as well.

4. HUMAN PERFORMANCE IN COLD ENVIRONMENT.

4.1 Effects.

When working in the cold environment, besides low temperatures, personnel have to work in snow, wind, blowing snow, and icy conditions. The effects of these environmental factors, singly or in combination, make routine tasks more difficult, more time consuming, and may adversely affect the test as well as the attitude of those conducting the test. All of the following are likely to occur:

(1) Equipment malfunctions occur more often during cold weather.

(2) Travel and movement can be difficult.

(3) Much testing is conducted in the dark or in low sunlight conditions with restricted visibility.

(4) The bulky clothing needed for adequate insulation restricts peripheral vision, movement, coordination and manual dexterity.

(5) Simply moving around can be hazardous because of ice, wind, and blowing snow. Slips and falls are more likely to happen.

(6) Fire and carbon monoxide dangers exist from heating equipment and exhaust.

(7) Body moisture is lost through respiration and perspiration, including unnoticeable perspiration that occurs in cold dry regions. Without adequate fluid intake, dehydration can easily occur and may increase susceptibility to cold injuries.

4.2 Minimizing the Effects.

To minimize the effects, precautions must be taken prior to and during cold weather operation.

(1) Make sure all equipment, whether personal items, instrumentation, support equipment, or systems under test, are well maintained and appropriate procedures for operation in the cold are taken.

(2) Compensate for decreased visibility by increasing vigilance and slowing down, and set up test sites so that vehicle traffic is restricted or controlled in the immediate vicinity.

(3) Develop and use a well outlined plan for the day's operations, so that everyone understands the tests that are to be completed.

(4) For tasks requiring manual dexterity, glove liners, or anti-contact gloves, can be worn inside heavier mittens. The bulky outer layer can be removed for short periods, allowing the person to perform a task using the thinner glove liners. This will prevent contact frostbite or frost nip.

(5) It may be necessary to divide tasks into shorter segments to allow for breaks to re-warm in a heated shelter. Heated shelters for this purpose are an important test site asset. Work should also be planned to avoid extensive periods of inactivity unless a heated shelter is available to keep personnel warm. A heated shelter must have adequate ventilation to maintain a fresh air supply.

(6). Establish a 'buddy' system to account for all test personnel on a test site. This keeps everyone checking on others for signs of fatigue, hypothermia, and general well being. It allows for safer test conduct.

(7) Dehydration is a problem in cold weather that must be avoided. Personnel might avoid drinking water and not realize they are becoming dehydrated. A suggested alternative is a flavored drink or warm soup which is preferred to coffee. Any warm drink can be satisfying if a person is cold.

4.3 Leadership.

Positive leadership is key to test operations in a cold environment. The test personnel at Cold Regions Test Center (CRTC) have extensive knowledge of the cold environment and provide the needed leadership to instruct and inform others on cold weather operations. The leadership will provide support at the test sites, clear plans for daily test activities, needed breaks and shelter, and guidance on clothing.

## 5. PREPARATION FOR COLD ENVIRONMENT TESTING.

It is important to anticipate and understand the effects of working in the cold environment on the equipment, the test team, and the individuals. Early planning is necessary to build efficiency into the test conduct and reduce wasted effort and the difficulties encountered when operating in a cold environment. Operating in the cold can affect the attitude and morale of the individual and the entire test team. As the duration and complexity of the operations performed in the cold increases, personnel may begin to disregard correct equipment operation or data quality. While these problems may be reduced by ensuring individuals are well trained in cold weather operations, even the best individuals may be affected when they get cold. It is important for the test director and the technical support staff to plan carefully together, to reduce last minute changes, and be constantly aware of the condition of personnel as they conduct testing in the cold. A well organized and well planned test effort will focus on the safety and well being of personnel as well as the test conditions and data collection.

## 6. SUMMARY.

Cold weather tests while difficult can be accomplished safely and accurately. With preparation and an understanding of the risks and the methods to mitigate those risks, a test can be successfully completed as planned.

# APPENDIX A. REFERENCES

For information only:

a. AMCP 706-116, Engineering Design Handbook, Environmental Series, Part Two, Natural Environmental Factors, April 1975, DTIC Accession Number ADA012648.

b. AMCP 706-118, Engineering Design Handbook, Environmental Series, Part Four, Life Cycle Environments, April 1975, DTIC Accession Number ADA015179.

c. FM 31-70, Basic Cold Weather Manual, April, 1968.

d. MIL-STD-1472 F (1), Human Engineering, 5 December 2003.

e. Technical Note No TN/02-2, Sustaining Health and Performance in Cold Weather Operations, U. S. Army Research Institute of Environmental Medicine, October 2001, DTIC Accession Number ADA395745

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: U.S. Army Cold Regions Test Center, ATTN: TEDT-YPC-CO, PO 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.