

Chemical, Biological, Radiological, and Nuclear Operations in Extreme Cold Weather

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The U.S. Army's ability to operate effectively in subarctic and arctic regions is increasingly important as peer and nearpeer adversaries with chemical, biological, radiological, and nuclear (CBRN) capabilities and weapons of mass destruction (WMD) expand their presence in these environments. The United States Army Chemical Corps must renew its focus on countering these threats and protecting U.S. and allied forces conducting largescale combat operations (LSCO) in extreme cold regions.[1]

In January 2025, we (WO1 Vanessa Baker and CW2 Alejandra Gallego) participated in the Swedish CBRN Winter Course hosted in Umeå, Sweden. This immersive training exposed participants to subarctic winter conditions while conducting hands-on operations with live chemical agents. The course is specifically designed to enhance CBRN reconnaissance-and-detection capabilities in these extreme cold-weather environments.

Prior to this experience, we underestimated the operational complexities of extreme cold weather. What we observed during this course challenged many of our current doctrinal approaches. This article summarizes five field observations that revealed fundamental gaps in our detection capabilities; tactics, techniques, and procedures (TTPs); decontamination methods; training regimes; and leadership emphasis.

Detection Equipment Functionality

The challenges of CBRN operations in extreme cold weather are multifaceted. Most nonpersistent chemical-warfare agents become persistent at 32°F/0°C.[2] While the reduced vapor hazard appears diminished, this deceptive calm masks a more insidious danger. Reconnaissance, detection, and identification are severely restricted, and in many cases, agent detection is not possible.[3] The functionality

Photo from the FY25 Swedish CBRN Winter Course. From left to right: DoD civilian Charles Barton (DTRA, Germany); 1SG Schreurs (Luxembourg); CW2 Vanessa C. Baker (110th Chem BN, WA); CW2 Alejandra Gallego (22nd Chem BN, TX); and SGM Fern (Luxembourg). All photos in this article are property of the Swedish Armed Forces.



The CBRN Winter Course FY25 participants conducted a 5-kilometer movement in snowshoes.

of CBRN protective clothing and detection equipment is significantly degraded at temperatures below –25°F (–31°C). During the course, we observed that the M50 protective mask becomes stiff and brittle, leading to tears and cracking that prevent it from forming an effective seal. The Joint Chemical Agent Detector (JCAD) displayed extended selftest cycles and frequently reverted to the 'wait' status during operation, with drastically reduced vapordetection capability in cold weather. These limitations forced dangerously close proximity to potential hazards and increased detection times to 45 seconds or more. The Universal Chemical Detector (AP4C) experienced similar challenges; however, its flamespectrometry technology remained critical, requiring increased sampling frequency and affecting operational tempo to maintain accuracy. Additionally, M8 paper could not provide quick, accurate, or reliable guidance to commanders, placing ground forces at risk and slowing movement. These limitations create gaps in situational awareness and must be thoroughly considered during planning.



The cone method being utilized to aid the JCAD with detection.

Accurate environmental assessment becomes exceedingly difficult, hindering the ability to track the presence and movement of chemical agents. A 1960 Chemical Corps Study (Chemical Warfare Operations in Low Temperature Areas, p 66) states that "the employment of agents in cold, where ice and snow prevail, introduces a new aspect of agent behavior. The agent persistency is increased, and freezing agent droplets and aerosols contaminate the snow and are able to be transported over a wide area."[4] The possibility of Soldiers unknowingly being contaminated will impact the force in their most vulnerable moments of being unprotected and in close proximity with each other, such as being in heated vehicles, tents, and sleeping quarters. Within these confined, heated spaces, chemical agents start to off-gas and achieve their desired effects. The traditional CBRN operational paradigm of "detect to warn," allowing for preemptive protective measures, shifts to detect and react, which necessitates a fundamental reassessment of detection strategies, operational procedures, and risk-mitigation strategies.

TTPs for ECW Conditions

Current CBRN TTPs require substantial modification for effective execution in extreme coldweather environments. During the Swedish winter course, the Swedes shared several of their existing detection methods—the Cone, Bag, and Bag & Hot Water methods—which underscore the challenges posed by the low volatility of chemical agents in extreme cold. The Cone Method, which isolates suspected agents to capture vapors, becomes cumbersome and timeconsuming. The Bag Method (mashing snow with M8 paper) and the Bag & Hot Water Method (requiring the transport and heating of water) introduce logistical complexity and further delay detection. All of these adapted methods are significantly more timeconsuming than standard procedures. Reduced offgassing of chemical agents, combined with potential obscuration by snow, drastically increased sampling frequency during



The AP4C's flame spectrometer being utilized after failed attempts to detect vapors.



FY25 Swedish CBRN Winter Course participants conduct small group dismounted reconnaissance.

dismounted reconnaissance—potentially tripling the number of stops required compared to standard TTPs. Therefore, a comprehensive review and update of existing TTPs and standard operating procedures (SOPs) is essential to incorporate specific guidelines for CBRN operations in extreme cold weather. Integrating coldweather considerations into all levels of CBRN training will enhance the Army's overall readiness and effectiveness in Arctic operations.

Decontamination Challenges

Chemical decontamination processes are significantly less effective in cold weather. The Van't Hoff-Arrhenius theory indicates that an 18°F/10°C temperature decrease can reduce the rate of many chemical reactions by half, meaning that to achieve the same level of decontamination at lower temperatures, the contact time must be doubled. During the Swedish CBRN course, this theory was tested using the Reactive Skin Decontamination Lotion (RSDL). The results showed that RSDL neutralized the venomous agent X (VX) within seconds at room temperature, but at -15°C, it took over an hour to remove just 50% of the agent. Furthermore, RSDL can freeze at low temperatures, and the impact of freeze-thaw cycles on its effectiveness remains poorly understood. The traditional methods of decontamination become kinetically unfavorable in extreme cold-weather environments. To address these challenges, research into the temperature-dependent efficacy of our current decontaminants should drive the development and implementation of cold-weather-specific decontamination protocols such as mechanical removal, UV light, and the continued use of charcoal. Finally, training programs must be updated to specify cold-weather decontamination techniques.

Live-Agent Training

The compromised functionality of CBRN detection equipment in temperatures below 0°F/-17°C requires careful selection and administration of training stimulants to accurately reflect physiological responses to live-agent exposure in extreme cold. For example, methyl salicylate can simulate the evaporation of mustard at room temperature, while bis-(3-chloropropyl) sulfide can be used to study mustard evaporation at 37°F/3°C.[5] Although stimulants offer reduced hazards and lower training costs, they may not fully replicate the urgency and realism of live-agent training. Proficiency in handling actual CBRN threats within realistic scenarios is unattainable through simulation alone. Therefore, increasing the frequency and scope of live-agent training exercises in extreme cold weather is highly encouraged to enhance CBRN-training effectiveness. Integrating live-agent training with the judicious use of appropriate simulants will create a comprehensive and realistic training program, equipping Soldiers with the skills and confidence necessary to operate effectively in extreme cold-weather CBRN environments.

Leadership and Training Emphasis

The legacy Field Manual 3170, *Basic Cold Weather*, states that "the leader selected to guide Soldiers in



Swedish conscripts conduct personnel decontamination.



Participants conduct live agent detection training.

regions where extreme cold and rugged, trackless terrain make living and fighting far more difficult will face one of the greatest challenges of their lifetime."[6] Effective leadership is paramount to ensuring troop readiness in such environments. Currently, outside of units routinely operating in extreme cold weather, the average Soldier lacks sufficient education and experience in essential cold-weather skills, including layered-clothing systems and basic cold-weather survival techniques. Therefore, leaders must thoroughly understand the principles of layered clothing and the physiological and psychological effects of cold weather. Commanders should require training that emphasizes the unique challenges of cold-weather operations—from planning considerations through execution.

Conclusion

The survivability and operational effectiveness of CBRN operations in extreme cold weather hinge on addressing critical gaps across multiple domains: technological advancements in cold-weatherized detection and decontamination equipment, the development of robust and realistic training programs incorporating both live-agent training and the effective use of simulants, and a renewed focus on leadership development that stresses cold-weather expertise. Ultimately, success in this demanding operational landscape depends not just on technological solutions but on a force that is mentally and physically resilient, equipped with the knowledge, skills, and leadership to navigate the complexities of challenges posed by extreme-cold conditions. The challenges are significant, but by embracing innovation, prioritizing training, and fostering strong leadership, the Chemical Corps can ensure that the Army remains ready and capable in even the most extreme environments.

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Endnotes

1. U.S. Department of the Army, ***Army Training Publication (ATP) 3-90.96: Arctic and Extreme Cold Weather Operations*** (Washington, DC: Government Publishing Office, 2024).
2. Amnon Birenzvige, H. Yurow, and L. Parker, ***Tri-Service Workshop on Chemical Operations in Cold Weather***, CRDEC-SP-019 (Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory; Aberdeen Proving Ground, MD: Chemical Research, Development, and Engineering Center, 1990).
3. Birenzvige et al., ***Tri-Service Workshop on Chemical Operations in Cold Weather.***
4. Birenzvige et al., ***Tri-Service Workshop on Chemical Operations in Cold Weather.***
5. Birenzvige et al., ***Tri-Service Workshop on Chemical Operations in Cold Weather.***
6. U.S. Department of the Army, ***Field Manual (FM) 31-70: Basic Cold Weather Manual*** (Washington, DC: Government Publishing Office, 1968).

Photo sourced from the Swedish Armed Forces Facebook page 'CBRN Skolan,' illustrating the physiological effect known as cocooning.

