O3-BASED CLEANING OF MILITARY AND LAW ENFORCEMENT PERSONAL AND PROTECTIVE EQUIPMENT

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A White Paper Addressing Critical Military and Law Enforcement Equipment Integrity Issues

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Contents

Introduction and Overview

U.S. military and law enforcement personnel utilize a variety of individual and personal protective equipment in performance of their duties.[1] Today's war fighters and police officers are outfitted with an array of advanced equipment that ranges from specialized belts, pouches, holsters, protective body armor, gloves and related tactical and military garments. Increased levels of comfort and performance provided by today's military and police personal equipment are the result of ergonomic-based product designs and advanced engineering materials. As a result, personal military and law enforcement equipment is expensive and represents a significant investment since today's soldier and law enforcement professional wears more personal equipment than any other time in history.[2] However, because of the design, physical size and materials of construction, most personal military and law enforcement equipment is not readily cleaned using traditional techniques. As a result, personal tactical and duty gear used by military and law enforcement personnel can, over repeated usage, develop high levels of harmful bacteria pathogens, as well as unpleasant odors. Additionally, personal equipment can become the unintentional carriers of harmful pathogens and bacteria from a variety of external sources relating to military deployments abroad. Moreover, bacteria can attack and degrade many materials used in military and law enforcement equipment. An effective and cost-efficient cleaning and sanitizing technique is therefore needed that can be safely used on a wide-variety of personal equipment consisting of various fabrics and other materials used in current military and law enforcement equipment.

Background

Historically, individual field equipment used by the U.S. Military included a limited number of load-bearing pouches and harness systems worn as a part of the general land-soldier combat ensemble. Basic systems used in the 1950s and 1960s consisted of a pistol belt with an attached suspenders system that supported two to three ammunition pouches, a first aid pouch, a compass pouch, a one-quart canteen, along with a small pack attached to the rear. A larger backpack system was worn for carrying heavier loads.[3] Most personal equipment in the 1960s and earlier was constructed of heavy canvas and nylon with a variety of metallic fasteners and closures. Later, more advanced personal equipment and systems were developed that significantly increased the load carrying ability of the soldier to transport additional types of ammunition, as well as a host of new military devices such as GPS systems, combat signaling devices, a larger first-aid kit, a radio, a hydration system and protective breathing equipment.[4] Modular

[1] For purposes of this paper, military and law enforcement personal protective equipment includes the broad categories of equipment traditionally referred to as individual field equipment, field gear, duty gear, tactical gear, kit, webbing and load bearing gear. Collectively, such equipment is generally considered as mission-essential since it fulfills and supports multiple tactical and strategic objectives including safety, convenience, comfort and load-carrying capability associated with modern warfare and law enforcement operations.

[2] This is particularly true since most personal protective equipment used by military and law enforcement personnel is commercially available for purchase by individual military and law enforcement personnel, with significant varieties of features and performance, and supplied by a large community of gear manufacturers. Hence, the open market provides an ever increasing variety of personal protective equipment with continual advancements in performance and comfort.

[3] The system used by the U.S. Military in the 1960s and the early 1970s was termed the ALICE system.

[4] The MOLLE system is the successor to the ALICE system and consists of fabric and metallic fastening systems based on an interlocking web grid system. The MOLLE system is in use today by the U.S. Military. Other types of personal protective and load-bearing equipment that may be used, depending upon mission requirements, include ballistic armor plate-rack carriers, ammo-carrier vest systems, rack systems and variants of load-bearing suspenders.

backpacks also evolved significantly throughout the 1980s and 1990s to include a variety of more specialized load carrying systems designed for specific purposes, such as EOD, medical, extended cold weather missions, communications and breaching applications. Significant advancements in personal protective body armor resulted in increased levels of ballistic protection, and were designed to incorporate the means of attaching various load-carrying pouches.[5] Other equipment used by modern military personnel includes advanced and effective weapons holsters, along with various means of carrying equipment in the thigh area. Similarly, composite material developments in head protection and safety culminated in lighter and more effective ballistic helmets with internal pad systems. Hand protection also progressed since the 1960s; gloves are now constructed of advanced fire-resistant, puncture-resistant and abrasion-resistant material blends.[6] As a result, the modern US land-soldier has become an advanced load-carrying platform that includes an average of 8 to 10 different pouches, a ballistic protective load-bearing body armor vest, a modular backpack with integral hydration system, an advanced combat helmet, advanced hand protection and a weapons holster along with a thigh rig. Other personal and protective equipment, depending on mission specifics, may include elbow and knee pads, specialized footwear, communications headsets, a personal respirator, eye protection or goggles, a balaclava and specialized cold/wet weather garments. Similarly, military aviators, as well as maritime personnel are also outfitted with an array of advanced personal and protective equipment.[7]

Law enforcement officers also wear a variety of load bearing and personal equipment, depending upon their specific job assignment. In general, a duty police officer wears a complement of personal equipment including, as a minimum, a duty belt, ammunition pouches, flashlight, handcuffs, radio and radio pouch, nightstick, and pistol holster.[8] Additionally, most police officers now wear advanced and concealable lightweight body armor vests under their uniform shirt. Duty police officers typically wear the entire complement of personal equipment on their belt, while specialized police units, such as SWAT, utilize personal equipment that is essentially the same as a combat soldier, including load-bearing body armor, pouches and combat type helmets. Security personnel and prison guards, in addition to duty gear, also use various combinations of other protective personal equipment, such as entry shields, face shields and shin guards.

Problem Description

Surprisingly, the advancement of military and law enforcement personal and protective equipment has not included the development of effective cleaning and sanitizing techniques in order to remove harmful bacteria pathogens and maintain overall gear integrity. Traditionally, military and law enforcement personal gear has not been readily sanitized or cleaned for several key reasons. First, owing to the ruggedized construction and combinations of advanced materials, metal snap closures,

[5] Most Military and law enforcement outer body armor vests employ the MOLLE system for load-bearing and pouch attachment purposes. The typical vest design consists of the outer-most portion, termed the carrier and the removable ballistic panels that are inserted into internal pockets. The ballistic panels can be easily removed and replaced as needed, along with ceramic ballistic plates that also fit into separate internal pockets.

[6] State-of-the-art military and law enforcement gloves consist of ballistic polyamide and fire-resistant polymer fabric blends, similar to that used in body armor and military pilot flight suits. Additional design elements include anti-scuff knuckle protection and the ability to cinch the glove tight for higher levels of dexterity.

[7] System with special features to accommodate advanced optics and computer systems that are worn and used in combat. While the Land Warrior program was cancelled, the system continues to be used in combat operations. The DOD is in the process of establishing follow-on systems that feature more advanced capabilities, but with similar load-carrying and personal equipment.

[8] Most load bearing and personal tactical equipment worn by police officers is constructed of heavy leather or nylon.

fastening systems, and other specialized features, most military and law enforcement personal field equipment cannot be washed using a traditional soap-and-water machine washer.[9] Machine washer cycles, harsh detergents and heat can damage the gear. Secondly, the physical size of some individual field gear prohibits cleaning, such as large backpacks and carry bags that will not fit in washing machines.[10] Third, some equipment such as police duty gear and specialized military boots are made from leather and other more advanced materials that cannot be subjected to soap-and-water type cleaning processes without damage.[11] Fourth, for gear that can at least be hand-washed, the inability to thoroughly rinse the detergents and cleansers from the item results in only limited removal of harmful bacteria. Additionally, residual cleansers left in the gear after cleaning can significantly degrade many materials used in tactical equipment. Adding to the many problems associated with manual washing of equipment, hand-washing is also time consuming and is inefficient, particularly for larger quantities of items to be cleaned. Access to potable water as well as waste-water effluent processing, treatment and disposal must also be addressed for any operations involving water-based cleaning.[12] Fifth, traditional washing using soap and water requires extended amounts of time for the gear to dry, usually taking hours depending upon the item. Depending on the time to dry, mold can occur, further negating the effectiveness of traditional soap and water cleaning. Based upon the preceding five key reasons, the U.S. military and law enforcement communities have not developed or adopted a recognized policy for cleaning and sanitizing personal field, protective and duty gear, other than to use basic hand-washing where possible and to replace excessively soiled equipment.[13]

Similar to uniforms and other clothing items worn by soldiers or police officers, a wide-variety of harmful bacteria can accumulate and exist on military and law enforcement personal equipment.[14] Personal equipment worn by soldiers and law enforcement personnel are subject to not only becoming soiled from the perspiration and bacteria from the person wearing the gear, but also from a number of external sources. Fabrics and other sewn items such as body armor vests and pouches can absorb perspiration and bacteria from the person wearing the gear, in addition to becoming soiled from other

[9] For example, a large military pack cannot be adequately cleaned using water-based techniques due to the difficulty in effectively cleaning, rinsing and drying the internal compartments. Most military backpacks contain a variety of internal pockets, pouches and compartments, with some pockets and pouches located one within the other, making water-based cleaning (and drying) even more difficult to perform. For this reason, most backpacks and similar gear items such as large carry bags or deployment bags are rarely cleaned and sanitized.

[10] Some countries have procedures for the cleaning of personal equipment for military personnel returning from service abroad as well as foreign militaries visiting a host country. For example, the Australian Military has various cleaning requirements. Among the various requirements for backpacks is the manual "wiping down" and scrubbing with water, followed by air drying. Additionally, helmets are required to be cleaned with water and scrub brushes. See Cleaning Instructions–Personal Equipment, Australian Defence Force, see www.daffa.gov.au.aqis/avm/military/cleaning-requirements, undated. The U.S. Government has similar requirements established by the U.S. Department of Agriculture, with close coordination with the U.S. Military and other federal agencies.

[11] As an example, cold weather boots used by various US military personnel are constructed of a heavy leather outer layer, with four to five layers of advanced thermal protective materials located inside. Cold weather boots are considered one of the most expensive items of personal equipment due to the advanced construction and variety of insulating fabrics. However, no practical and effective means of cleaning or sanitizing of such boots has been previously available due to their unique construction.

[12] Hand washing is also inherently inconsistent in terms of the end results due to the variability in personnel technique and lax adherence to procedures used in performing the cleaning.

[13] In some instances, the use of a dry stiff brush is also recommended by several equipment manufacturers where mud or heavy deposits of soil or other foreign materials must be removed from fabric and sewn items such as pouches or packs. This mechanical technique is widely recognized by military and law enforcement organizations, but the use of a dry brush does not address the sanitizing issues associated with personal equipment. Accordingly, the removal of only visible soil and debris from an article of personal equipment fails to render the equipment safe to use in terms of possible bacteria and pathogens.

[14] In stark contrast to personal protective equipment, most military uniforms and related garment systems are now designed for easy and routine cleaning and sanitizing using traditional water-based techniques. Additionally, some garments now used by the military contain odor-killing chemical agents or special odor absorbing fibers that are incorporated into the basic yarn or fabric. However, uniforms and related garments can also be cleaned using dry O3 techniques as later discussed in this paper.

personnel that may come in contact with the gear. Depending upon the specifics of a military operation, soldiers may also come in contact with bacteria and other micro-organisms from various environmental and external sources. Similarly, prison guards and security personnel are subject to bacteria present on prisoners and the public at large. Moreover, bacteria can continue to thrive and become potentially more harmful with increasing levels on personal gear that is not regularly cleaned, but is continually used. For example, a soldier who wears their personal gear on a daily basis will likely experience higher levels of bacteria and odor on their personal and protective gear as compared to a law enforcement agent who may only use their gear periodically.[15] Accordingly, personal equipment that is not cleaned or sanitized on a regular basis can foster and otherwise provide a breeding ground for bacteria to thrive. Studies of personal protective equipment used in professional sports indicates that a variety of harmful types of bacteria pathogens exist on typically used equipment.[16] Laboratory testing of typically used protective sports equipment indicated 15 different pathogen microbial species. Potentially harmful fungus and bacteria were found to exist on helmets, shin pads, shoulder pads and gloves. Methicillin-resistant staphylococcus aureus (MRSA), influenza, and streptococcus viridans were among the more hazardous and infectious bacteria reported. Additionally, odor was reported along with high levels of mold.

Logistical and Operational Aspects

A number of logistical and operational issues have evolved within the U.S. military and law enforcement communities from the lack of adequate and effective cleaning techniques relative to personal and protective equipment. Since traditional doctrine was based on hand-washing and replacement only, much of the personal equipment in use today by U.S. military and law enforcement personnel has likely never been cleaned. As a result, most personal protective equipment, even though advanced in terms of design and construction, can experience shorter life-cycles due to the lack of cleaning. Moreover, dirty, contaminated and soiled personal equipment reduces fighting force effectiveness. Accordingly, effective and cost-efficient cleaning and sanitizing capabilities can extend the life-cycle of personal and protective equipment, enhancing force effectiveness as well as reducing the overall cost to maintain a military or law enforcement organization. Not only could equipment replacement costs be reduced, but other costs could also be minimized, such as the overall administrative effort needed to procure new equipment, along with shipping, inventory and distribution costs. For example, training of military and law enforcement personnel is typically performed using the same personal equipment to be used in actual operations, partly due to the high cost of personal equipment, as well as achieving a high level of training and realism. However, depending upon the type of training, personal and protective equipment can become soiled and may need to be replaced before deployment. Unfortunately, military or law enforcement personnel are many times required to use the soiled gear for their regular daily use. Through the effective cleaning of equipment after training, soldier and law enforcement training operations can be routinely conducted and then the same equipment used for deployment and operational purposes after cleaning. Thereafter, the same personal and protective equipment can be periodically cleaned, further reducing equipment replacement costs as a matter of routine operations. Other operational issues associated with the lack of personal equipment cleaning includes the potential

[15] Some personal equipment such as backpacks, duffle bags and deployment bags are more likely to accumulate and foster bacteria since packs and bags are used to store and transport other soiled items, which can contain pathogens. For example, packs and bags used by deployed U.S. military ground combat forces are in many instances used to carry other dirty garments, similar to a dirty clothes basket. As a result, levels of bacteria are reasonably expected to be higher, especially for longer duration missions.

[16] BioMedco Testing Summary Brochure, undated, BioMedco, Montreal, Canada.

for odors giving away soldier positions, the practical fact that soldiers and law enforcement personnel are less likely to use personal equipment that contains offensive odors, and personnel safety risks brought about from equipment that can potentially contain harmful and infectious bacteria.

Ozone as a Cleaning and Sanitizing Agent

Ozone, also known as O3, is the free-radical form of oxygen used extensively for safely sanitizing and cleaning a wide variety of products on a commercial and industrial basis. O3 exists in the gas state, and is used as a cleaning agent in a wide variety of critical and sensitive applications such as the purification of water, as well as the cleaning of medical devices and delicate micro-electronics. O3 is also used for cleaning purposes in the food service industry and to preserve fresh flowers and produce. Since ozone is a free radical form of oxygen, it is a powerful oxidant. As a cleaning agent, O3 is up to 3000 times faster acting and up to 150 times more powerful than chlorine bleach. As a result, O3 rapidly kills bacteria, fungus and other pathogens. Ozone is inherently unstable as a free-radical, so the compound cannot be stored, and must be generated on-site at the time of use. O3 can be generated and applied through corona discharges, ultra-violet (UV) lamps and through water injection.[17] While efficient commercial laundry operations using ozone-injection water processes have been developed and implemented for large-scale applications such as hotels and hospitals, waterless O3 cleaning and sanitizing has obvious and key advantages over wet techniques. In combination with its proven ability to destroy bacteria, the waterless ozone cleaning and sanitizing process takes only about 12 minutes and does not produce liquid wastes, eliminating the need for costly waste-water treatment and disposal, sewer plumbing and potable water interfaces. Moreover, O3 cleaning process equipment is available that can facilitate large items to be cleaned, and large quantities of gear can be cleaned at one time. Hence, the dry O3 process is scalable and can be applied to production-line type operations. Such equipment has been developed by SaniDefenx (manufactured by Sani-Sport) and is in use currently by professional sports organizations, and is also used by the U.S. Government in a variety of federal law enforcement and security applications.[18] The SaniDefenx dry O3 cleaning system has been shown to provide about 99% reduction in antimicrobial effectiveness as reported by laboratory testing consisting of some 15 different infectious bacteria species.[19] Accordingly, the SaniDefenx cleaning system using waterless O3 as a cleaning agent enjoys acceptance among organizations who are involved in multiple applications, but with common, practical, logistical and safety issues, namely the effective, safe and efficient cleaning and sanitizing of personal and protective equipment.

O3 Performance Advantages

The cleaning of military and law enforcement personal and protective equipment using the SaniDefenx dry Ozone-based system has several key advantages. Relative to performance, the dry O3 technique is

[17] EPA Guidance Manual, Alternative Disinfectants and Oxidants, Ozone Chemistry, Chapter 3.1, Environmental Protection Agency (EPA), www.epa.gov., April 1999.

[18] The SaniDefenx (manufactured by Sani-Sport) line of dry ozone cleaning systems is available on GSA Contract No. GS-07F-016DA for purposes of addressing U.S. Military, U.S. federal agency, law enforcement and related procurement requirements. SaniDefenx systems are in use by the U.S. Department of Homeland Security, the U.S. Department of Defense and the U.S. Department of Justice.

[19] BioMedco Certificate of Analysis Laboratory Testing Reports, dated February 19, 2007, Report Nos. DUP-01 C-190207, DUP-01 E-190207, DUP-01 B-192207 and DUP-01 D-190207.

effective in killing a variety of dangerous pathogens and has been shown to be effective in applications involving both professional sports organizations and U.S. Government homeland security operations.[20] As compared to other traditional cleaning and sanitizing techniques, the dry O3 system provides consistent performance in terms of cleaning efficiency, and is readily adapted to large-scale or production-line type cleaning operations. Since the SaniDefenx O3 system uses the dry gas form of ozone as the cleaning and oxidizing agent, there is no waste-water disposal issues to deal with, and no costly plumbing or waterline hook-ups are required. Another key advantage of the dry ozone technique is that gaseous ozone readily permeates fabrics and similar materials used in personal equipment, interior surfaces and compartments of bags, packs, boots, and pouches. Accordingly the inside areas of most items are effectively cleaned, not just the exterior surfaces. With respect to processing times, process takes about 12 minutes. Cleaning equipment operating skills are minimal such that the SaniDefenx can be operated by an individual soldier or law enforcement personnel similar to an ordinary laundromat operation, or the SaniDefenx can be easily operated by dedicated personnel in a larger operation, such as a military depot or training facility.

O3 Economic Advantages

Today's military and law enforcement personnel are outfitted with an extensive inventory of personal protective equipment as a part of their duty, combat and non-combat ensembles. For example, the basic land combat soldier, depending upon mission needs, is issued about 20 different types of equipment that is traditionally excluded from routine cleaning.[21] The equipment is as follows: external body armor vest, helmet, load-carrying pouch complement[22], respirator, knee and elbow pads, load-bearing belt, gloves, thigh rig, side-arm holster, boots, pack, communications headset, hydration system, sleeping bag, a personal tent, balaclava, cot, safety lanyard and mosquito netting. Based on current equipment costs, the basic land-combat ensemble equates to about $5500.00 per soldier.[23] Conservatively, inclusion of administrative costs for purposes of equipment procurement and logistics planning, shipping, storage and gear distribution brings the total replacement costs to about $11,000.00 per soldier. Accordingly, for each 100 soldiers, $1.10 million is required for personal protective equipment.[24] Estimating an average military battalion size at 500 personnel, about $5.50 million is required for personal and protective equipment. However, as chronicled herein, this expensive and safety-related mission-essential equipment is currently not subjected to routine cleaning or sanitizing. Based on up-front equipment costs, continuing operating costs, and capacity of the smallest SaniDefenx cleaning system, estimated cleaning cost is about $0.18 per ensemble, per soldier.[25] Since total cleaning time is only 12 minutes there are no consumables to purchase and continually replenish, it is estimated that about 32 soldier equipment sets can be cleaned per 8-hour shift per single cleaning system. As a result, 100 soldier sets can be processed every 25 hours through a single cleaning system, given that the

[20] Ibid.

[21] This does not include other common equipment items issued to combat personnel such as weapons, night vision equipment, target acquisition lasers, flashlights, GPS units, radios, rescue strobes and garment systems such as uniforms and cold/wet weather garments.

[22] The average soldier pouch complement consists of about 8 -10 pouches.

[23] Current costs as contained in U.S. Government procurement systems, such as www.gsadvantage.gov.

[24] This amount does not include the items that are subjected to traditional and routine cleaning, such as uniforms and other garments that are issued as a part of the basic soldier equipment set.

[25] Based on capitalization of equipment over a 5-year period.

cleaning equipment can be operated on a 24-hour shift basis. Larger scale systems or multiple cleaning systems operating at one time could significantly reduce the time for cleaning.

Possible Applications

O3-based cleaning and sanitizing of personal and protective equipment used by military and law enforcement personnel has a wide variety of possible applications. A partial list of the possible applications is provided as follows:

Equipment Related to Military Units and Personnel Returning From Deployments in Foreign Countries – As a part of the process of units returning from combat deployments, personal gear and protective equipment can be carriers of dangerous and infectious bacteria pathogens. Recent case examples of military personnel in 2005 demonstrated the potential for infectious bacteria being transported via military personnel when returning from theater operations.[26] Moreover, the U.S. Department of Agriculture operates the Animal and Plant Health inspection Service (APHIS), which develops regulatory policy along with the U.S. Department of Homeland Security, Bureau of Customs and Border Protection for the entry of military assets into the USA. As a part of this program, U.S. Military policy and procedures govern the inspection and cleaning of all types of military materiel and personnel in order to prevent the introduction of or dissemination of exotic plant pests and animal disease agents.[27] Specific procedures and cleaning methods are established in the Armed Forces Pest Management Board document, Technical Guide 31, entitled, "Retrograde Washdowns: Cleaning and Inspection Procedures".[28] However, the current TD31 guide includes only water-based methods, as well as sweeping and brushing of equipment and the use of compressed air to remove debris. While TD31 is principally concerned with the large-scale cleaning of military equipment such as trucks, combat vehicles and tanks, this critical regulation also includes the general requirement for cleaning of personal equipment as well as tents and smaller items. Accordingly, O3-based techniques could be included as a cleaning technique in order to more effectively and efficiently clean gear and protective equipment.

Depot Level Equipment Cleaning and Maintenance – SaniDefenx cleaning systems could be placed at key depot facilities where personal and protective equipment is stored and distributed for return and reuse purposes.

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[26] www.forbes.com, The Iraq Infection, Herper, August 8, 2005.

[27] Protocol for Military Clearance, U.S. Department of Agriculture, Riverdale, Maryland, April 2004.

[28] TD31 is published by the Defense Pest Management Information Analysis Center, located at the Walter Reed Army Medical Center, Washington D.C. The current version of the document is dated March 2008. The document addresses invasive species such as snails and insects, as well as pathogens and micro-organisms. As a part of this over-arching document, the importance of cleaning military equipment upon return to the U.S. is described as follows, "Clearly, the potential importation of invasive species, such as snakes, insects, snails, and various crustaceans on military vehicles and equipment that are present in most of the world-wide areas frequented by the DoD is a primary concern of the USDA. DoD personnel are often required to re-deploy from anywhere in the world. Associated with this movement is an elevated risk for the inadvertent introduction of exotic plant and animal pests into the United States. Due to the characteristics of exotic pests, irreparable damage to human health, agriculture, forestry, or the environment may result. Plant debris, garbage, food, soil, and even fresh water from foreign countries may contain organisms of quarantine importance. Pathogens, insects, nematodes and a variety of other animals may be carried in such media. These organisms, if allowed to enter the United States, could proliferate to catastrophic proportions, unhindered by natural enemies. Because of this risk, it is DoD policy that all organizations and personnel involved in the movement of DoD sponsored cargo, personal property and accompanied baggage will take all steps necessary to prevent the spread of exotic pests from one location to another." The Department of Army (DALO-TSP) is the DoD Executive Agent for the Military Customs Inspection Program (MCIP-Applicable in EUCOM where there is a permanent APHIS Advisor). Overseas Unified Commanders are responsible for compliance with DoD Directive 4500.9 (establishes guidelines for processing and shipping DoD sponsored retrograde materiel).

Tropical Environment Equipment Maintenance – Personal gear and protective equipment used in moist, high humidity and warm tropical environments has long been an issue since fungus and mold grows readily. Without effective and periodic cleaning, personal equipment can become ridden with odor, with some equipment materials becoming significantly degraded over time. Since the SaniDefenx cleaning system does not require any sewer or external plumbing, the system could be easily placed at logistics or operating facilities in support of deployed units.

K-9 Units – K-9 units have traditionally been in special need of effective cleaning and sanitizing of equipment used in and around canines used for law enforcement and military purposes. K-9 unit animals live and work in close proximity with their handlers and other support personnel, providing a continuous source of bacteria and odor. Much of the animal handling equipment is not easily cleaned due to the materials of construction, such as heavy-construction nylon harnesses with integrated metallic fasteners. The SaniDefenx cleaning system could easily and safely clean and sanitize essentially all K-9 related equipment on a periodic basis.

Units Engaged in Medical Support Operations - Law enforcement and military units that provide medical support are particularly vulnerable to bacteria exposure. While most medical equipment is typically disposable or is sterilized before reuse, personnel and their personal equipment working in and around medical operations are likely to come in contact with a variety of harmful pathogens. Accordingly, personal gear that is normally not sterilized or disposed of can become bacteria carriers and breeding grounds for dangerous pathogens. For example, carry packs and bags that are used to transport medical devices, medicines and other emergency medical products are reused, but are not typically subjected to routine cleaning and sanitizing.[29]

Correctional Institutions – Law enforcement and military personnel who work in correctional institutions use a variety of personal protective equipment in performance of their duties. Equipment could be cleaned and sanitized on a periodic basis.

Training Facilities – Training facilities for law enforcement, homeland security and military personnel could be outfitted with SaniDefenx cleaning systems in order to clean personal and protective equipment used in training operations. Units could therefore have clean personal equipment to deploy with, subsequent to the completion of training.

Federal, State and Local Municipality Security and Law Enforcement Operations –
US Marshals, FBI agents, Homeland Security personnel, Border Patrol agents, Transportation Security Administration (TSA), police officers, sheriff deputies, and Military Police who are involved in operations related to security and law enforcement typically come into contact with a variety of personnel as a part of their duties. Personal gear and protective equipment could be cleaned periodically.[30]

[29] Personal equipment used by medics, emergency medical technicians, first responders and other emergency care providers consists of medic bags and emergency medical backpacks, as well as other related equipment. These equipment items are typically used on a continuing basis similar to a non-medical item. However, these items are not typically sanitized or cleaned as part of their use.

[30] As an example, hand-cuffs are particularly prone to becoming carriers of bacteria due to the fashion in which they are used. While some law enforcement and security agencies have hand-cuff cleaning procedures and policies in place, most agencies do not have the means of sanitizing the pouches that the hand-cuffs are routinely carried in after they are used. Hence, the un-sanitized hand-cuff pouch can become the source of bacteria and possible hazardous infectious agents. Other examples include the periodic cleaning of luggage and personal possession bins used in TSA passenger screening airport check-points.

Military Field Laundry Operations – U.S. Military units operating in forward deployed combat areas and theatres of engagement typically rely on mobile field laundry units for purposes of periodically cleaning basic uniform and under-garment items. Field laundry operations use significant amounts of resources including potable water, detergent and heated clothes dryers, which are typically set-up in a production line type operation. The SaniDefenx dry O3 system could provide effective cleaning and sanitizing of uniform items, as well as other personal items, without the problems, logistical issues and complexities associated with water, detergents, waste-water processing and extended garment drying time after cleaning.[31]

Final Step in Water-Based or Mechanical Cleaning Operations – For heavily soiled personal equipment items, water- and/or mechanical-based cleaning methods are sometimes used in order to remove visible dirt or deposits of oils or other foreign materials. While these methods can be helpful in removing obvious and visible areas of dirt or oil, little to no sanitizing of the item is realized. SaniDefenx O3-based cleaning could be used as the final step in cleaning processes that initially use water or mechanical methods in order to address the removal of harmful pathogens, bacteria and viruses.

Safety Issues

Just as any other cleaning oxidant, Ozone must be handled and processed safely, while optimizing the practicality and overall cleaning capability of O3 cleaning systems.[32] Ozone, depending upon concentration, can be toxic and corrosive.[33] As a result, the SaniDefenx O3 cleaning system has incorporated equipment design features and sub-systems that address the safety requirements of ozone. Indeed, the SaniDefenx system is the only O3 cleaning system on the commercial market that has safety systems incorporated to prevent personnel exposure to any residual ozone when opening the cleaning compartment after cleaning is complete. Areas of the SaniDefenx O3 cleaning system that generate the ozone, as well as the cleaning compartment for items to be processed, are safely isolated from human exposure while the equipment is operating. Hence, the SaniDefenx O3 system provides a safe and practical solution for dry ozone cleaning. **Moreover, the SaniDefenx is the only dry O3 cleaning system that is Underwriter Laboratories (UL) and CE tested and approved.**

The SaniDefenx Cleaning Process

The SaniDefenx cleaning system and process is the result of extensive engineering and product development, resulting in a safe, reliable and effective method of cleaning military and law enforcement

[31] While this paper has focused primarily on non-garment applications of the San-Sport O3 cleaning system, the advantages of the O3 system to clean and sanitize commonly used clothing items such as uniforms is readily apparent. However, several technologies exist for the water-based cleaning of military and law enforcement garments, but with significant problems such as wastewater disposal, the provisioning of potable water in austere settings, and the equipment needed to dry the washed uniforms once cleaning is complete. The SaniDefenx dry O3 system is not plagued by these significant disadvantages.

[32] Ozone is inherently short-lived such that ozone actually exists for short period times after produced. Accordingly, most of the ozone generated by the SaniDefenx O3 cleaning system is consumed during the cleaning process.

[33] The U.S. Occupational Safety and Health Administration (OSHA) defines the maximum permissible exposure to airborne concentrations of ozone to not exceed 0.1 mg/L (by volume), averaged over an eight hour work shift. See EPA Guidance Manual, Alternative Disinfectants and Oxidants, p. 3-40. Additional facility-level safety measures can also be added, such as ozone monitors in the area of cleaning operations, as well as adequate ventilation. Cleaning equipment that is used to generate, contain and handle ozone for cleaning purposes is typically constructed of 300 series corrosion resistant steel.

personal and protective equipment. The SaniDefenx equipment and cleaning process has been in use for over 13 years. With over 600 systems now in use by professional sports teams, the U.S. Government, as well as a variety of law enforcement organizations, the SaniDefenx system and cleaning process is a proven cleaning method.[34] Adding to the established track-record and precedence for use, the SaniDefenx cleaning equipment has been evaluated, tested and certified by Underwriter Laboratories and CE regarding performance and safety.

The SaniDefenx cleaning system is available in two (2) basic configurations that consist of the basic model, as well as the double-wide model. Both configurations operate on the same basic cleaning process. After loading the gear to be cleaned in the cleaning chamber, the SaniDefenx equipment is activated and the cleaning process is initiated. The process begins with a simple push button. The cleaning process consists of three (3) basic steps. First, after the start button has been pushed, the cleaning compartment is automatically locked and remains locked throughout the cleaning process.[35] Dry gaseous phase ozone is produced by the ozone generator, located at the bottom of the SaniDefenx. The ozone gas is routed into the cleaning chamber for approximately 10 minutes. This first phase accomplishes two key objectives, namely, the generation of the ozone cleaning agent needed, as well as the sufficient dwell time for the ozone to react and sanitize the articles to be cleaned. At the end of the 10 minute period, the light goes off on the control panel, indicating that the ozone generation has been completed. Next, a 1 minute dwell time allows for further reaction of the ozone with the articles to be cleaned. Lastly, the third portion of the cleaning process consists of an additional 1 minute to allow for the complete removal of residual ozone from the internal sanitization chamber. For units with the optional drier feature, the drier capability removes moisture during the sanitization cycle. At the end of the third portion of the cleaning process, the automatic safe-guard compartment door lock is deactivated, allowing for access to the cleaning chamber and removal of the cleaned gear.

[34] This includes professional sports organizations in North America as well as Europe, in addition to systems in use by law enforcement in the U.S and Canada. As a result, the SaniDefenx system is routinely used to address a variety of cleaning issues, encompassing a broad spectrum of protective equipment, materials, and applications.

[35] The automatic safety lock located on the cleaning compartment access door is a key safeguard to prevent exposure to ozone while the cleaning process proceeds. Additionally, the ozone generator located below the cleaning compartment is a sealed unit, safely containing the ozone before transferred to the cleaning compartment. Seals provide an additional level of safety around doors and equipment interfaces. The overall system design and operations regarding safety is a key issue in the UL and CE certification process.

APPENDIX

FREQUENTLY ASKED QUESTIONS

How does the Sani-Sport system work?

The SaniDefenx cleaning system works through the use of gaseous ozone. The ozone is generated within the SaniDefenx system and then forced into a large compartment where the items to be cleaned are located. The ozone gas flows in and around the articles to be cleaned where the ozone reacts with bacteria, pathogens and other micro-organisms, killing over 99% of the typical types of harmful species found on protective equipment. The total sanitization cycle time is about 12 minutes. Subsequently, an internal system evacuates the cleaning compartment of any residual ozone gas that may remain. Thereafter, the door to the cleaning compartment is opened and the cleaned articles removed.

Why is ozone used?

Ozone provides powerful cleaning capabilities since ozone is the free radical form of oxygen. The free radical structure comes about from a high-energy, free oxygen bond being available and "free" to combine with various micro-organisms. Through the chemical bond and combination process, harmful micro-organisms are destroyed. Hence, ozone is one of nature's most powerful cleaning agents.

Who uses the SaniDefenx system?

Professional sports organizations including the NFL and the NHL use the SaniDefenx system for the routine cleaning of all types of athletic protective equipment including pads, helmets and guards. The U.S. Department of Homeland Security, U.S. Department of Defense, the U.S. Department of Justice and various law enforcement agencies also uses SaniDefenx for cleaning of protective equipment.

Is the ozone reused in the SaniDefenx?

Ozone is inherently unstable and remains available for use as a cleaning agent for only a short period of time. As a result, most of the ozone produced by the SaniDefenx is consumed during the cleaning process. Any remaining ozone that remains after cleaning is evacuated and removed from the cleaning compartment for safety reasons. So, ozone is not reused in the SaniDefenx system.

Where does the ozone in the SaniDefenx come from?

The ozone used in the SaniDefenx system is generated within the equipment each time the equipment is operated for cleaning. The ozone is produced by reacting oxygen available in the air with ultraviolet light. Conveniently, the SaniDefenx makes its own ozone out of common air for each cleaning cycle. This means that no storage of ozone is required.

Has ozone-type cleaning been used in other applications?

Yes, ozone has been used as a cleaning agent for many years. For example, the Los Angeles public water system is sanitized through the use of ozone.