

CONF-961113--22

SAN096-2495C  
SAND--96-2495C

Sticky Foam As A Less-Than-Lethal Technology

Steven H. Scott

Sandia National Laboratory  
Albuquerque, New Mexico 87185

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### ABSTRACT

Sandia National Labs (SNL) in 1994 completed a project funded by the National Institute of Justice (NIJ) to determine the applicability of sticky foam for correctional applications. Sticky foam is an extremely tacky, tenacious material used to block, entangle, and impair individuals. The NIJ project developed a gun capable of firing multiple shots of sticky foam, tested the gun and sticky foam effectiveness on SNL volunteers acting out prison and law enforcement scenarios, and had the gun and sticky foam evaluated by correctional representatives. Based on the NIJ project work, SNL supported the Marine Corps Mission, Operation United Shield, with sticky foam guns and supporting equipment to assist in the withdrawal of UN Peacekeepers from Somalia. Prior to the loan of the equipment, the Marines were given training in sticky foam characterization, toxicology, safety issues, cleanup and waste disposal, use limitations, use protocol and precautions, emergency facial clean-up, skin cleanup, gun filling, targeting and firing, and gun cleaning. The Marine Corps successfully used the sticky foam guns as part of that operation. This paper describes these recent developments of sticky foam for non-lethal uses and some of the lessons learned from scenario and application testing.

**Keywords:** Sticky Foam  
Less-Than-Lethal Technology  
Operations Other Than War  
Peace Keeping Missions  
Prisons  
Non-Lethal

### 2. INTRODUCTION

Sticky foams were developed originally at Sandia National Laboratories (SNL) in the late 1970's for usage in nuclear safeguards and security applications. Sticky foam is a one-container, non-reactive foam which is stored under pressure and foams when released to atmospheric pressure. It is a very tacky and tenacious material that expands to over 30 times its stored volume when dispensed. It is comprised of rubbers, resins, oils, fire retardants and foam stabilizing chemicals. It also has high storage stability, contains a nonflammable solvent, is relatively volume-stable after dispensing, and requires effort and time to clean up. Sticky foam has an adherence tensile strength approximately an order of magnitude greater than common sticky materials such as molasses. Sticky foam can be deployed either passively, as in wall panel designs, or actively through nozzles, as with the sticky foam gun.

In late 1992, the National Institute of Justice (NIJ), the research arm of the Department of Justice, began a project with SNL to determine the applicability of sticky foam for law enforcement usage. The objectives of the project were to conduct an extensive toxicology and safety review of sticky foam (formulation SF-283), to develop a dispenser capable of firing sticky foam, to test the developed gun and sticky foam effectiveness on SNL volunteers acting out prison and law enforcement scenarios, and to have the gun and sticky foam further evaluated by correctional representatives.

In late 1994, Sandia was contacted by the Marine Corps to support material applications for non-lethal use in Operation United Shield. This support leveraged past material and application development sponsored by the

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Department of Energy, Defense programs, and by the NIJ in developing the sticky foam gun. The Marines were given extensive hands-on training with sticky foam and the use of the sticky foam guns prior to their deployment to Somalia.

### 3. SAFETY EVALUATIONS OF STICKY FOAM

#### 3.1 Toxicology

As part of the NIJ sponsored project and prior to any human subject testing with the guns, a toxicity study of sticky foam SF-283 was conducted. The study reviewed and updated a preliminary evaluation of sticky foam based on the toxicity of its individual components. It was assumed that the health effects of the sticky foam were estimable from the toxicities of the individual foam constituents. The results of an extensive literature search on the chemical constituents of SF-283 suggested that sticky foam deployed under normal conditions is essentially non-hazardous.

The constituents of concern prior to the study were: Freon-12, carbon dioxide, and several heavy petroleum oils and resins. Freon and carbon dioxide are considered simple asphyxiants when deployed in a confined space. Under normal conditions following deployment of SF-283, there is no risk of asphyxiation due to enhanced concentrations of Freon or carbon dioxide in a well ventilated area. Freons, in very high concentrations, have been implicated in the sensitization of cardiac tissue to epinephrine resulting in cardiac arrest. Freon measurements taken during sticky foam gun testing in a confined space were well below levels of concern. The petroleum oils and resins used in SF-283 have a very low vapor pressure and therefore result in little or no inhalation hazard associated with room temperature deployment. However, repeated skin contact may cause mild skin irritation or dermatitis. One of the heavy oils contains materials that have been shown to cause cancer in humans following prolonged or repeated exposure. The study concluded that there is negligible carcinogenic risk following an exposure to these oils for the conditions proposed for its use in correctional and other non-lethal application situations.

#### 3.2 On-Skin Sticky Foam Testing

Permission was sought and received from the SNL Human Studies Board and DOE Headquarters to conduct both sticky foam on-skin testing and prison scenario effectiveness human subject tests at SNL. The purpose of the on-skin tests was to determine the adherence strength of the sticky foam to human skin, to determine a reasonable cleaning material and procedure for skin removal, to determine the level of effort and time required to remove the sticky foam from skin, and to determine if any hygiene material available to inmates might have a detrimental effect on the performance of sticky foam. The results of the on-skin testing were the following:

- \* sticky foam adheres immediately to skin,
- \* mineral oil (baby oil) is a reasonable cleaner for removing sticky foam from skin,
- \* using mineral oil to remove sticky foam from skin requires significant mechanical effort and approximately 30 seconds per square inch.

The on-skin tests were conducted on volunteer palms and forearms. Figure 1 depicts one of the tests where sticky foam was dispensed on a volunteer's forearm. Twenty-four hours after the test, inspections of the volunteers by SNL Medical noted that all of the tested areas were clean and clear of any signs of a reaction due to either the physical stress applied during the testing, to the sticky foam exposure, or to the commercial cleaners used in the testing.

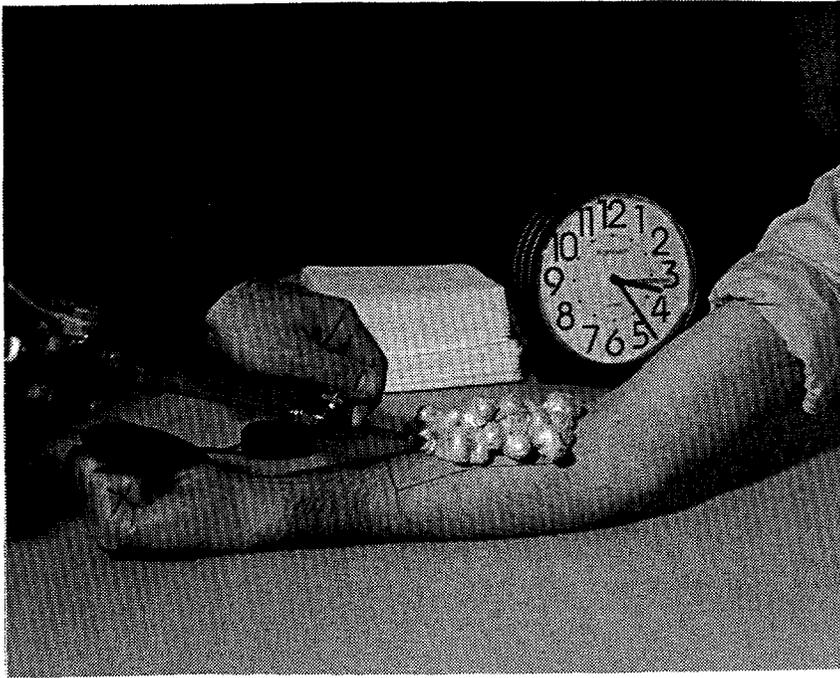


Figure 1. Sticky Foam Dispensing on Forearm for Timed Removal Testing

#### 4. STICKY FOAM GUN DEVELOPMENT

The original requirements for the sticky foam gun were developed in conjunction with NIJ, the American Correctional Association (ACA), and the National Sheriffs' Association (NSA) for application in correction scenarios. A backpack-mounted dispenser was first developed and tested to investigate range versus operating pressure and targetability issues (Figure 2). Based on lessons learned from the backpack dispenser, a shoulder-slung gun was developed, tested, and exceeded requirements. The shoulder-slung gun prototype weighs approximately 21 pounds ready to fire, is 30 inches in length, has a range of 5 to 35 feet, and can be fired in a single shot or multiple shot mode.

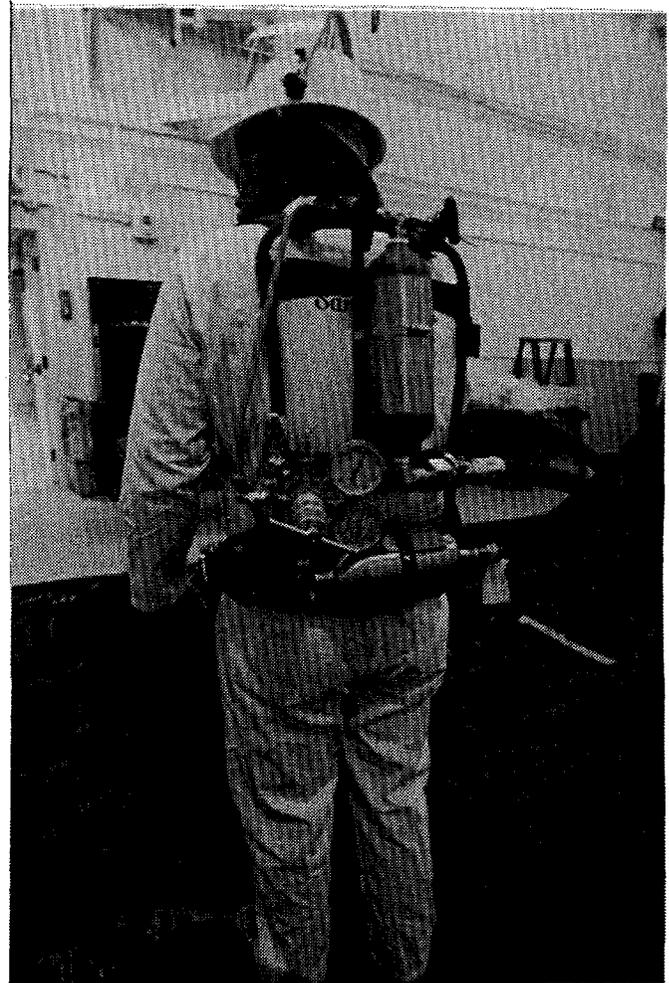


Figure 2. Backpack Sticky Foam Dispenser

The shoulder-slung gun, depicted in Figure 3, uses nitrogen pressure to push a piston in an accumulator to expel the sticky foam. Two nozzles were developed for use with the gun: a standard nozzle for a hose-like sticky foam stream, and a duckbill nozzle for producing a 1-to 2-foot wide, but very thin stream of sticky foam. The standard nozzle provides range and accuracy while the duckbill nozzle provides rapid, wide-area coverage. Figure 4 illustrates the results of a typical firing of the shoulder-slung sticky foam gun with standard nozzle at a mannequin.

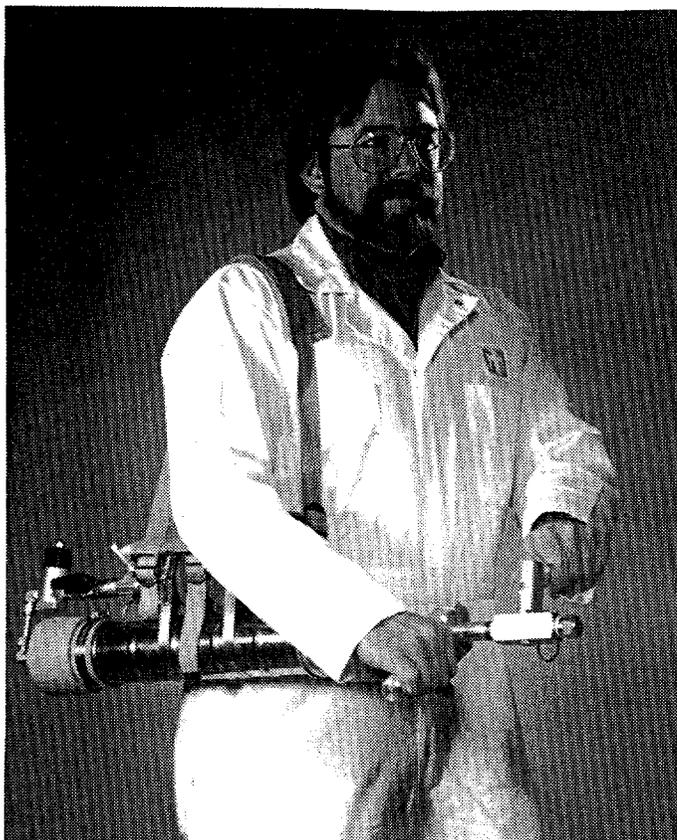


Figure 3. Shoulder-Slung Sticky Foam Gun

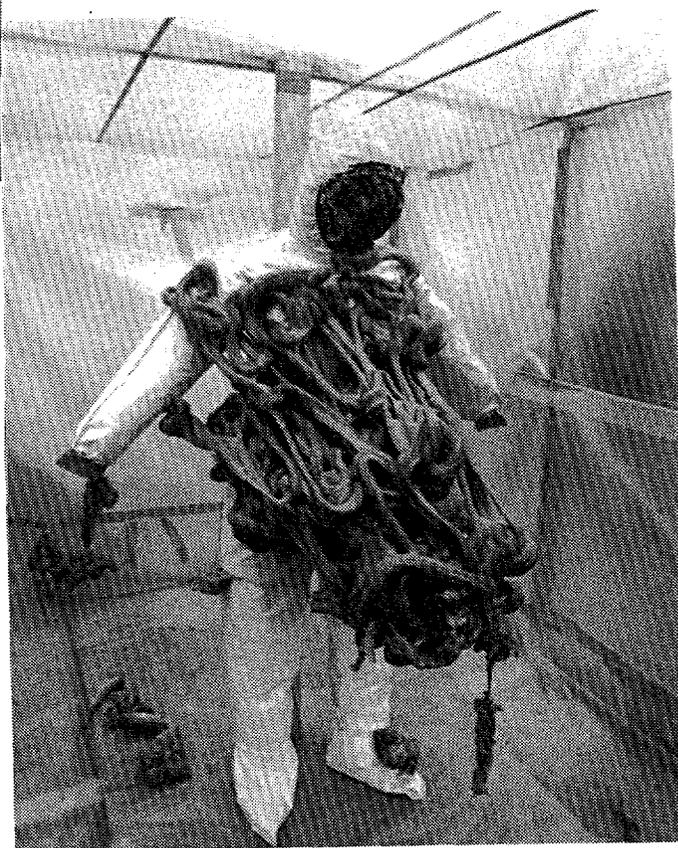


Figure 4. Sticky Foam Gun Test Shot

## 5. CORRECTIONAL SCENARIO TESTING

In late April 1994, nine scenarios selected by the ACA and the Florida Department of Corrections (FDOC) were used to evaluate the effectiveness of the sticky foam gun and sticky foam for prison situations. Of the prison scenarios, five were cell-based and four were day-room based. Five general law enforcement related tests were conducted also. The seven SNL volunteers who participated in the sticky foam restraining effectiveness tests were approved by the SNL Medical Department to participate in the testing, and received extensive training prior to the testing. The volunteers were required by the SNL Human Studies Board to wear full protective suits and use breathing apparatus to participate in the scenario testing. To meet actual safety concerns, the volunteers need only have worn facial protection to prevent an accidental covering of their face with sticky foam.

The scenarios conducted in a mock cell and day-room tested the use of sticky foam in situations involving armed and unarmed inmates, aggressive and non-aggressive inmates, and single and group disturbances. Each scenario had a specific goal for the SNL volunteers posing as correctional officers and inmates. At the end of each scenario, the participants as well as the observers from the SNL, ACA, and the FDOC evaluated the scenario both in writing and in a summary discussion<sup>1</sup>.

Figure 5 through 7 depict three of the prison scenario tests conducted. Figure 5 depicts testing of a multiple inmate disturbance in an open setting such as a day room. Sticky foam application in these scenarios could easily complicate regaining control of the situation due to physically adhering inmates together and forcing correctional officers to intercede and become involved with the material. Figure 6 illustrates the application of sticky foam against a single inmate in an open setting. These types of scenarios generally were the most successful forcing the inmate to direct his energy at the foam rather than opposing officers. Figure 7 represents a third type of scenario tested which was the use of foam to aid in cell extraction.



Figure 5. Multiple Inmate Disturbance Testing

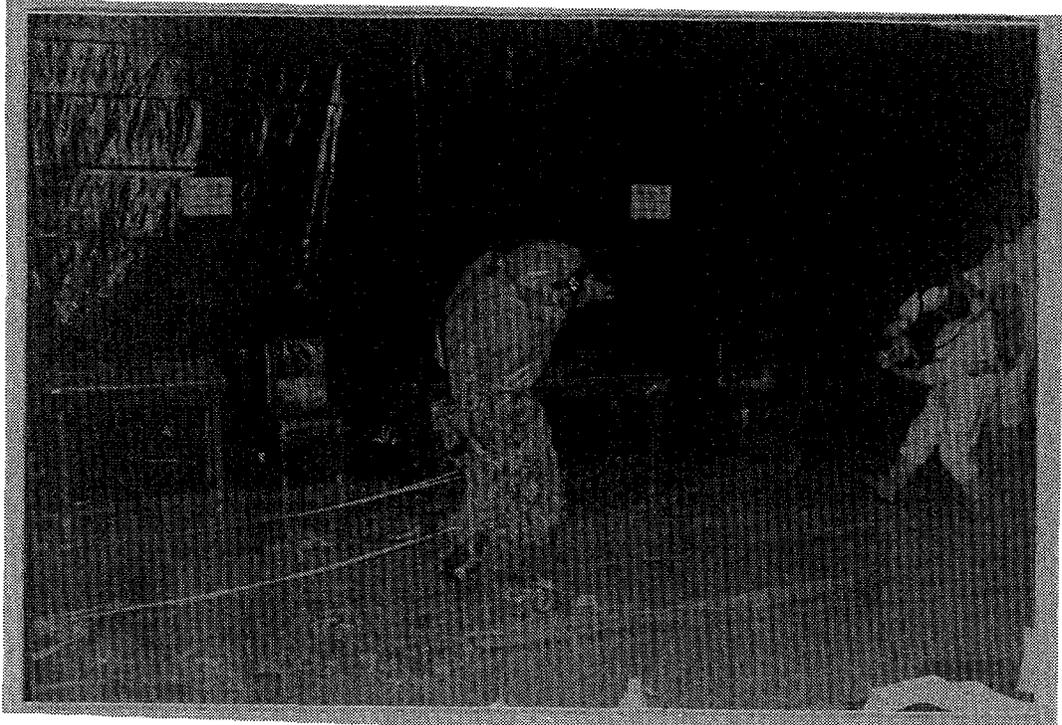


Figure 6. Single Inmate Disturbance Testing

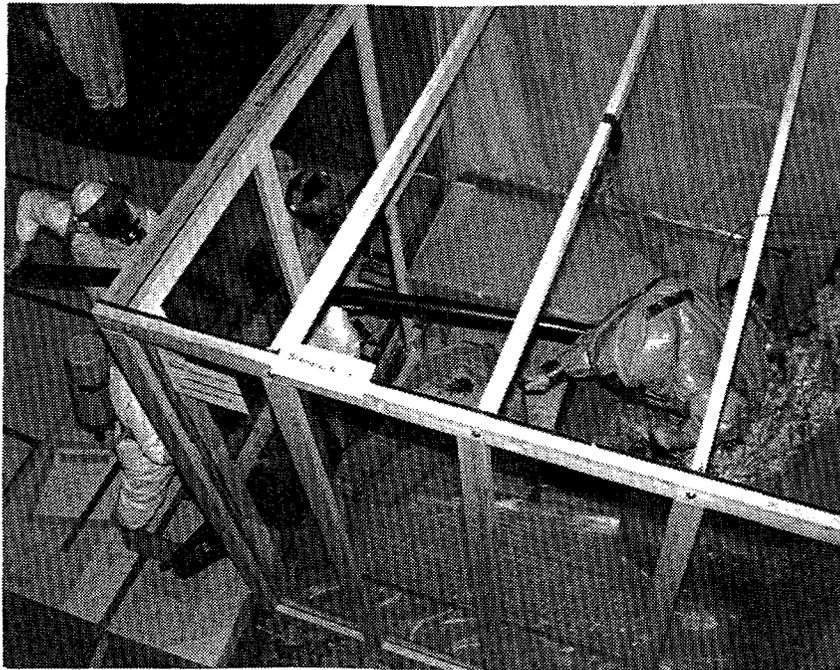


Figure 7. Prison Cell Extraction Testing

Summary observations of the correctional testing included the following:

- \* Sticky foam exacerbates control and restraint problems involving multiple inmate situations.
- \* Against single inmates there was some reduction in use of force required; however, some physical force was always required to ultimately subdue single inmates after the sticky foam was deployed, and there is the significant issue of weighting the reduction of force with the potential suffocation risk.
- \* Sticky foam dispensed on an individual, but not overlapped onto a floor or wall, will not restrain the individual but will somewhat reduce their mobility.
- \* The volunteer officers were able to effectively target the sticky foam gun with only one training shot prior to enacting the scenarios.
- \* Targeting was accurate up to 25 feet.
- \* In the scenarios conducted, there were no instances of sticky foam gun deployment or targeting above the waist of the volunteer inmate(s).
- \* Most of the scenarios required the use of two sticky foam gun volumes; therefore, future prototypes should be made with increased sticky foam capacity.

## 6. MARINE CORPS OPERATION UNITED SHIELD SUPPORT

In preparation for Operation United Shield to support the withdrawal of United Nation's peacekeeping forces from Somalia, the Marine Corps contacted Sandia to assist in the evaluation of SNL non-lethal material application technologies for potential use. Sticky foam was selected by the Marine Corps as a candidate technology for deployment. In support of the Marines, Sandia developed formal procedures and training materials covering foam toxicology and safety, material cleanup and disposal, use limitations and use protocols developed as part of the NIJ testing program, and sticky foam gun filling, firing, cleaning procedures. Sandia also developed an emergency facial foam removal procedure and safety kits to accompany the deployment of the guns.

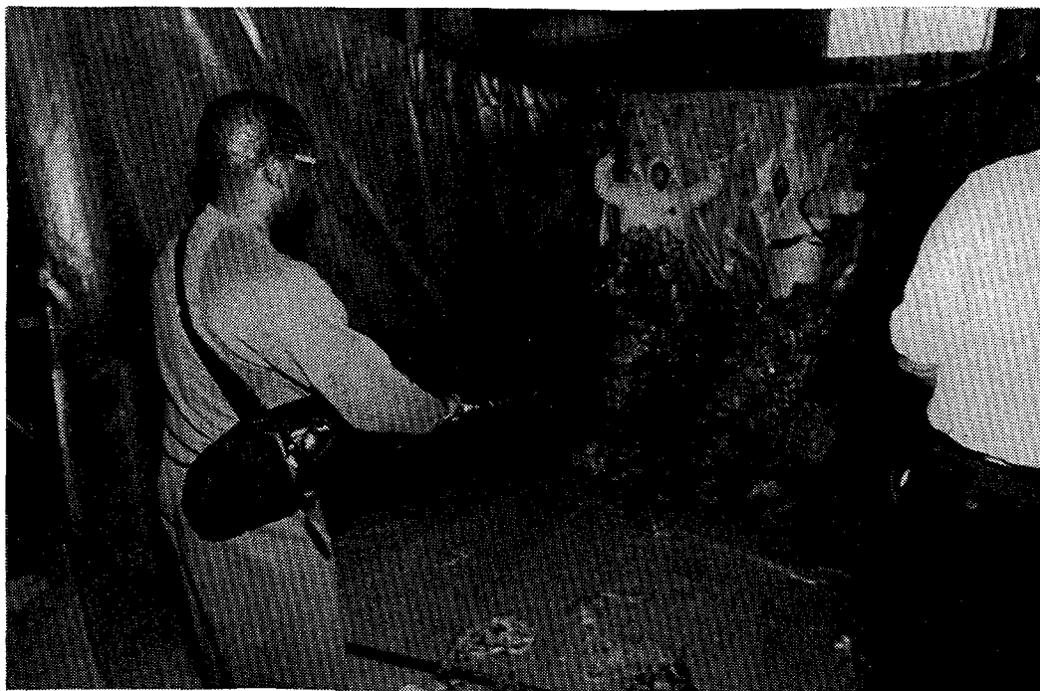


Figure 8. Marine Corps Sticky Foam Gun Training

The Marine Corps was loaned a number of sticky foam guns, 1000 pounds of sticky foam, two fill stations, and approximately a dozen safety kits for training, use protocol development, and ultimate deployment in Somalia. The Marine Corps performed extensive scenario testing, use-of-force protocol development, and toxicology/safety reviews prior to deployment of any of the non-lethal technologies to Somalia including sticky foam. These evaluations allowed the Marine Corps to develop escalating force response options for non-lethals and supported the successful use of sticky foam in blocking and access delay applications in Somalia.

## **7. SUMMARY**

Sticky foam has been used in past physical security applications to delay access by individuals into protected areas. Recent non-lethal uses of sticky foam have explored the utility of this material for reducing use of force in correctional disturbance situations and to provide alternatives to deadly force for the military. Results of the application testing and use to date are mixed. In correctional settings the use of sticky foam could reduce the level of force required to subdue individual inmates in disturbance situations. However, use in multiple inmate disturbances probably would make the situations worse; and legal liability concerns remain a significant issue limiting further development.

Military testing and application of sticky foams to date has focused on close-in defense, blocking, and access delay. Not surprisingly, these are essentially the same use scenarios employed for the material in security applications. There remains considerable interest in sticky foam for potential non-lethal uses with future applications probably addressing blocking choke points, protected area access delay, and area denial.

## **8. ACKNOWLEDGMENTS**

The work represented in this paper was supported by the United States Department of Energy under Contract DE-AC04-96AL8500, the National Institute of Justice under Military Interdepartmental Purchase Request 92-IJ-R-035, and a tasking by the Marine Corps 1st Marine Expeditionary Force Battalion.

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