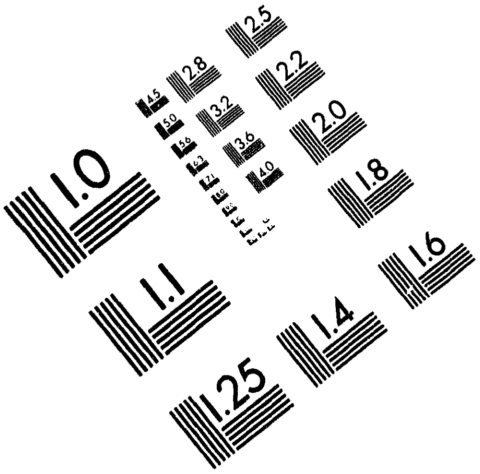

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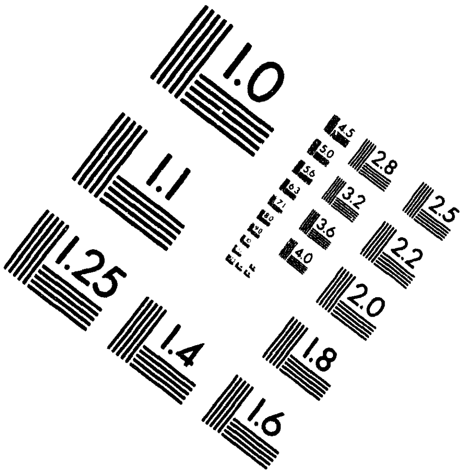

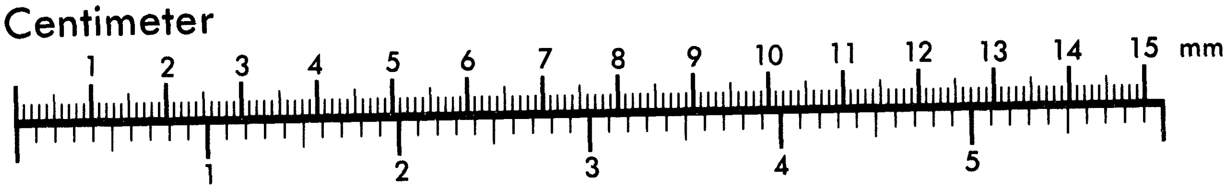

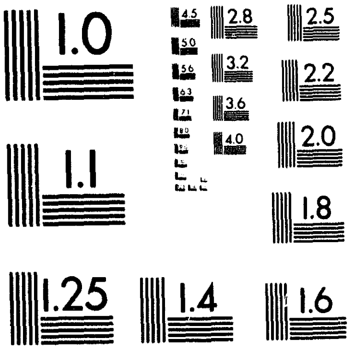

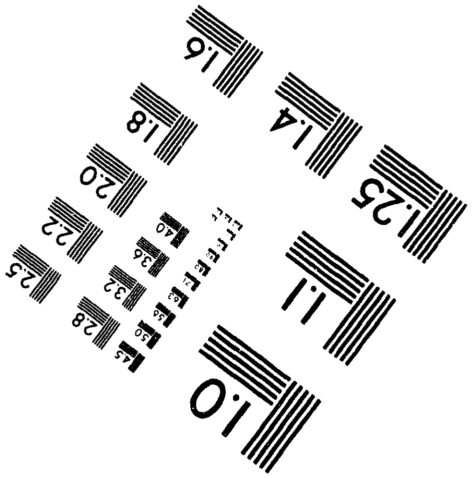

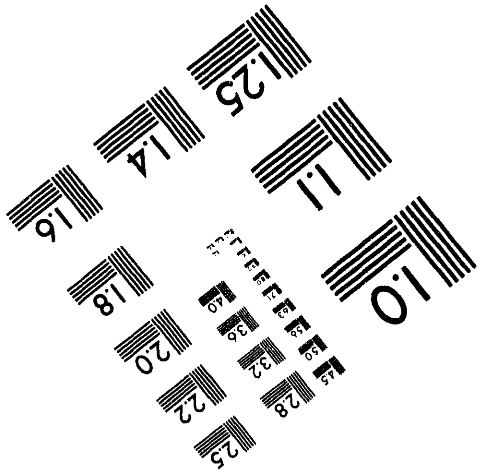

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STICKY FOAM TECHNOLOGY FOR LESS-THAN-LETHAL FORCE SITUATIONS

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Abstract -- Sticky foam is an extremely tacky, tenacious material used to entangle and impair an individual. It was developed at Sandia National Laboratories (SNL) in the late 1970's for usage in nuclear safeguards and security applications. 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 develop a dispenser capable of firing sticky foam, to conduct an extensive toxicology review of sticky foam (formulation SF-283), to test the developed dispenser and sticky foam effectiveness on SNL volunteers acting out prison and law enforcement scenarios, and to have the dispenser and sticky foam further evaluated by correctional representatives. This paper discusses the results of the project.

Sticky Foam

Sticky foams were developed by Peter B. Rand of SNL in the late 1970's for use 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. In addition, as sticky foam is manipulated it gains in strength. Sticky foam can be deployed either passively, as in wall panel designs, or actively through nozzles, as with the sticky foam dispenser.

Toxicology Study

In parallel to the development of the sticky foam dispenser and prior to any human subject testing with the dispenser, a toxicity study of sticky foam SF-283 was conducted [1]. The study reviewed and updated a preliminary evaluation of sticky foam based on the toxicity of its individual components. Since the deployment process is a physical process that does not involve a chemical reaction, no direct toxicological evaluations of sticky foam exposure to humans or animals were conducted. 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, petroleum oils and resins, and naphthenic oils. 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 dispenser 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. The heavy naphthenic oils contain materials that have been shown to cause cancer in humans following prolonged or repeated exposure. The study concluded therefore that there appears to be negligible carcinogenic risk following an exposure to these oils or to the SF-283, for the conditions proposed for its use in law enforcement and correctional situations.

Sticky Foam Dispenser Development

Requirements for the sticky foam dispenser were developed in conjunction with NIJ, the American Correctional Association (ACA), and the National Sheriffs' Association (NSA) [2]. A backpack-mounted dispenser was then developed and tested. Based on lessons learned from the backpack dispenser, a shoulder-slung dispenser was developed, tested and exceeded requirements. The shoulder-slung dispenser prototype [3] weighs approximately 21 pounds ready to fire (17 pounds empty), 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.

The shoulder-slung dispenser, depicted in the drawing in Figure 1, uses nitrogen pressure to push a piston in an accumulator to expel the sticky foam. Two nozzles were developed for usage with the dispenser: a standard nozzle for a hose-like sticky foam stream; and, a duckbill nozzle for producing a 1 to 2 feet wide, but very thin stream of sticky foam. The standard nozzle provides for distance and accuracy while the duckbill nozzle provides for rapid, wide-area coverage. Figure 2 shows the results of a typical firing of the shoulder-slung sticky foam dispenser with standard nozzle at a mannequin.

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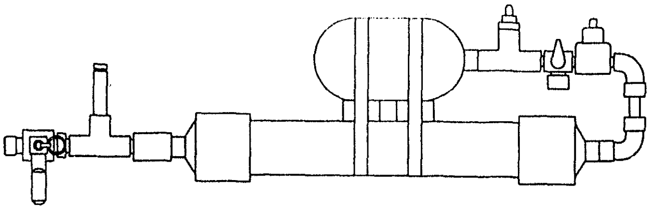

Figure 1 Shoulder-Slung Sticky Foam Dispenser

Figure 2 Dispenser Shot Results on Mannequin

On-Skin Human Subject 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 were to determine the adherence strength of the sticky foam to human skin, to determine which handcleaners recommended by SNL's Industrial Hygiene Department would be best at removing sticky foam from skin, to determine the level of effort and time required to remove the sticky foam from skin, and to determine if any hygiene materials available to inmates might have a detrimental effect on the performance of sticky foam. The on-skin testing was documented in a report [4] and had the following major results:

- sticky foam adheres immediately to skin,
- mineral oil (baby oil) is a relatively effective cleaner for removing sticky foam from skin,
- using mineral oil to remove sticky foam from skin requires approximately 15 to 50 seconds per square inch.

The on-skin tests were conducted on volunteer palms and forearms. Figure 3 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.

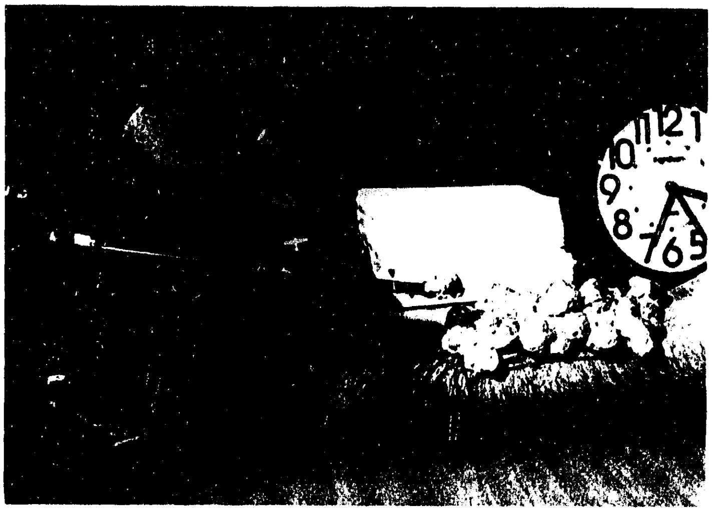

Figure 3 Sticky Foam Dispensing on Forearm For Timed Removal Testing

Prison/Law Enforcement 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 dispenser and sticky foam for prison situations. Of the prison scenarios, five were cell-based and four were day-room based. Five general law enforcement type tests were also conducted. 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, received extensive training prior to the testing, and wore full protective gear for the tests.

The scenarios conducted in a mock cell and day-room tested the usage 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 round-table discussion. The official evaluation is being written by the ACA with SNL providing a technical report [5]. SNL observations of the testing included the following:

- sticky foam exacerbates control and restraint problems involving multiple inmate situations such as fights.
- against single inmates there was some reduction in use of force required; however, some physical force was always required to subdue single inmates after the sticky foam was deployed, and there is the significant issue of weighing the reduction of force with the 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 dispenser 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 dispenser deployment or targeting above the waist of the volunteer inmate(s).
* most of the scenarios required the use of two sticky foam dispenser volumes; therefore, future prototypes should be made with increased sticky foam capacity.

Future Studies/Recommendations

Formal evaluations of sticky foam test results by the NIJ and the ACA are still in progress. The benefits of the technology are being weighed carefully against the potential risks of application before proceeding with any further significant testing or development. As with other new technologies that might be suitable for less-than-lethal applications in law enforcement, legal liability presents a significant hurdle to be overcome.

If the results of the ACA and NIJ analysis warrant further work, the following is recommended:

* Completely hands-off restraint using only sticky foam will require sticky foam formulation work to make the foam tackier and more tenacious more quickly.
* All future scenario testing should be conducted without protective suits. Volunteers in clothing appropriate to the testing should only be required to wear facial protection to prevent sticky foam application on the facial area.
* A large remaining issue is the demonstration of effective emergency procedures to rapidly remove sticky foam from the face, eyes, nose and mouth. The greatest liability associated with usage of the sticky foam dispenser is covering an individual's face and causing suffocation.
* Other sticky foam deployment schemes might be investigated such as incorporating nets into the dispensed sticky foam or using a sticky material in a non-foaming, liquid state.

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