Fire Tech Tips

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DEET Mosquito Repellant Reduces the Flame Resistance of Firefighters' Nomex Clothing

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The Missoula Technology and Development Center was asked whether insect repellants containing *N,N*-diethyl-3-methylbenzamide (DEET) could affect the flame-resistant material (Nomex) in clothing worn by many wildland firefighters. Firefighters often are exposed to high populations of mosquitoes while working in the field. The arrival of West Nile virus (transmitted by mosquitoes) has increased the use of mosquito repellants (figure 1).

To test the effects of DEET on the performance of Nomex clothing, MTDC contracted with Underwriters Laboratories, Inc., to perform a flame-resistance test on materials after DEET products had been applied.

The tests were performed on the following materials:

- 5.5-ounce Nomex IIIA-Breezetone weave (used in flame-resistant shirts approved for use by Forest Service wildland firefighters)
- 7.5-ounce Nomex IIIA twill (used in flame-resistant pants approved for use by Forest Service firefighters)
- Advance 40-percent Nomex IIIA, 60-percent Kevlar, ripstop with Shelltite water-repellent finish (used in flame-resistant pants worn by some wildland firefighters).

All fabrics were washed five times before testing. Five material samples were tested after each treatment. Results are based on the average of the five measurements.

Each material was tested after an application of:

- 100-percent DEET liquid in a pump dispenser
- 40-percent DEET aerosol
- 0.5-percent permethrin aerosol

Each test also was run on untreated control samples.

The DEET aerosol and nonaerosol repellants were applied and tested in four different ways:

Highlights...

- DEET mosquito repellant reduced the flame resistance of NOMEX clothing worn by wildland firefighters.
- MTDC recommends that firefighters avoid applying DEET mosquito repellant to their Nomex firefighting clothing.
- Firefighters can apply DEET mosquito repellant to their skin, following manufacturer's recommendations.
- Firefighters can apply permethrin, an insecticide, to their Nomex clothing without destroying the clothing's flame resistance.

Figure 1—With the spread of West Nile virus, mosquitoes are more than a nuisance for wildland firefighters.

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1. One application—tested after 5 minutes.
2. One application—tested after 1 hour.
3. Two applications 5 minutes apart—tested 5 minutes after the second application.
4. Two applications 1 hour apart—tested 1 hour after the second application.

Finally, each material was tested 2 hours after application of a single treatment of 0.5-percent permethrin, an insecticide.

MTDC determined that the best way to establish the effect of using DEET or permethrin on clothing was to test the clothing using a standard test protocol that untreated garments are required to pass. The Textile Flame Test (Federal Test Method Standard 191, Method 5903.1) was performed as described in 6-3, NFPA 1977 Standard on Protective Clothing and Equipment for Wildland Fire Fighting, 1998 edition, except that the samples were washed five times instead of 100 times as described in the standard.

Test Results

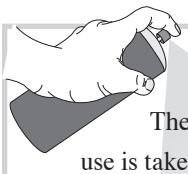
Performance in the flame-resistance test is determined by measuring char length (which must be no longer than 100 millimeters), and after-flame time (the time the material flames after the ignition source has been removed, which must be no longer than 2 seconds). In addition, the samples cannot melt or drip during the test.

Underwriters Laboratories, Inc., reported an additional result, dubbed *flash flame*, because they found that the entire length of many samples burned during the test. MTDC determined that such an event also would indicate a failure of the test, even though that phenomenon is not mentioned in NFPA 1977's performance requirements. No flash flames occurred on the control fabrics.

After the DEET applications, all samples of the treated 5.5-ounce and 7.5-ounce Nomex materials failed the flame-resistance test. Most material and application combinations failed because the after-flame time was too long and the material had a flash flame. The control materials passed all of the test requirements and had no flash flames.

After application, the treated 7.0-ounce Advance material failed the tests in all but one case because of a flash flame. The only case in which the Advance product passed was with a single application of aerosol DEET tested 1 hour after application. The control materials passed all test requirements and had no flash flames.

The application of permethrin to the materials did not cause them to fail the flame resistance-test, nor did any flash flames occur. After-flame time and char-length measurements were within the required limits. The material did not melt or drip.



Using Permethrin

The following information on permethrin use is taken from an article in the *Annals of Internal Medicine*:

"Pyrethrum is a powerful, rapidly acting insecticide, originally derived from the crushed and dried flowers of the daisy *Chrysanthemum cinerariifolium*. Permethrin is a human-made synthetic pyrethroid. It does not repel insects but works as a contact insecticide, causing nervous system toxicity that leads to the death or "knockdown" (out of the air) of the insect. The chemical is effective against mosquitoes, flies, ticks, and chiggers. Permethrin has low toxicity in mammals, is poorly absorbed by the skin, and is rapidly inactivated by ester hydrolysis.

"Permethrin should be applied directly to clothing or other fabrics (such as tent walls or mosquito nets), not to skin. The spray form is nonstaining, nearly odorless, and resistant to degradation by heat or sun and maintains its potency for at least 2 weeks, even through several launderings. The combination of permethrin-treated clothing and skin application of a DEET-based repellent creates a formidable barrier against mosquito bites. In a field trial conducted in Alaska, persons wearing permethrin-treated uniforms and a polymer-based 35% DEET product had more than 99.9% protection (1 bite per/hour) over 8 hours, even under conditions of intense biting pressures; unprotected persons received an average of 1,188 bites per/hour.

"To apply (permethrin) to clothing, spray each side of the fabric (outdoors) for 30 to 45 seconds, just enough to moisten it. Allow the garment to dry for 2 to 4 hours before wearing it."

Fradin, Mark S., M.D. 1998. Mosquitoes and mosquito repellents. Annals of Internal Medicine. 128(11): 931–940.

Cautions

The flame-resistance tests indicate a potential hazard with the use of DEET products on flame-resistant clothing. MTDC recommends that DEET not be applied to flame-resistant clothing. DEET could be applied to the skin so long as the application follows the manufacturer's instructions. Other products meant to repel mosquitoes also can be used on the skin, so long as the manufacturer's instructions are followed.

Tests indicate that permethrin products can be used on flame-resistant clothing without diminishing the protective performance of the clothing. Permethrin is to be applied to clothing following the manufacturer's instructions and allowed to dry before the clothing is worn. Permethrin should not be applied directly to the skin.

Although permethrin's toxicity to mammals and birds is low, it is known to be toxic to fish and bees. The Missoula Technology and Development Center is not taking a position for or against use of permethrin, but wants firefighters to be aware of the option. Additional information on DEET and permethrin is available at the Extension Toxicology Network (EXTOXNET). *http:pmep.cce.cornell.edu/profiles/extoxnet*

PESTICIDE DISCLAIMER—This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended. ***CAUTION:*** Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

About the Authors

Leslie Anderson began working at the Missoula Technology and Development Center (MTDC) as an equipment specialist in 1997, and has been a project leader for projects involving fire shelters and fire-resistant clothing. She is currently the Program Leader for the Fire and Aviation Program at MTDC. Leslie has a bachelor's degree in forestry from the University of California, Berkeley, and a master's degree in forestry from the University of Montana. She began working in wildland fire in 1979. Leslie was a smokejumper from 1984 to 1989 in Missoula, MT. She worked for 2 years in fire management with the Costa Rican National Park Service as a Peace Corps volunteer from 1989 to 1991. Leslie worked as an assistant district fire management officer on the Bitterroot National Forest from 1992 to 1997.

Tony Petrilli is an equipment specialist for the fire and aviation and safety and health programs at MTDC. He has a bachelor's degree in education from Western Montana College. Tony began working for the Forest Service in 1982 and joined the center full time in 2000. He has worked as a firefighter on the Lewis and Clark and Beaverhead National Forests and as a smokejumper for the Northern Region. He is also a division/group supervisor and type III incident commander.

Library Card

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Electronic copies of MTDC's documents are available on the Internet at:

http://www.fs.fed.us/t-d (Username: t-d, Password: t-d)

For additional information about DEET and flame-resistant clothing, contact Tony Petrilli at MTDC.

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Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, videos, and CDs on their internal computer network at:

http://fsweb.mtdc.wo.fs.fed.us/search

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