Fire
Tech Tips

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New Generation Fire Shelter Developed for Wildland Firefighters

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Beginning this summer, firefighters will carry a new wildland fire shelter developed by the Missoula Technology and Development Center (MTDC). The new generation shelter will provide improved protection from radiant heat and flames.

Wildland firefighters have carried fire shelters since they were developed during the 1960s. More than 1,100 firefighters have deployed their fire shelters. The shelter is credited with saving more than 300 lives and preventing hundreds of burn injuries. Although the original shelter (which this Tech Tip will call the standard fire shelter) was designed to reflect radiant heat, direct flame contact can cause damage. Fatalities have occurred when flame contact was severe.

In January 2000, MTDC was asked to develop an improved fire shelter. The goals of the project were to maintain the protection from radiant heat provided by the standard shelter while improving protection from direct flame. Other considerations included material strength, durability, flammability, weight, bulk, toxicity, and cost.

Development Process

The first step in the development process was to devise tests to evaluate the performance of the prototype shelter materials and designs. Small-scale laboratory tests were designed to allow screening for strength, flammability, thermal performance, and toxicity. Full-scale tests were developed to measure the strength, durability, flammability, thermal performance, and toxicity of the overall shelter designs. Over 60 materials and combinations of materials were considered. Seventeen full-scale designs were tested. The Federal Fire and Aviation Leadership Council selected the final shelter design in June 2002.

The New Design

The shape of the new generation shelter differs from that of the standard fire shelter (figure 1). The shelter is now shaped like a half cylinder with rounded ends. The new shape has a number of advantages.

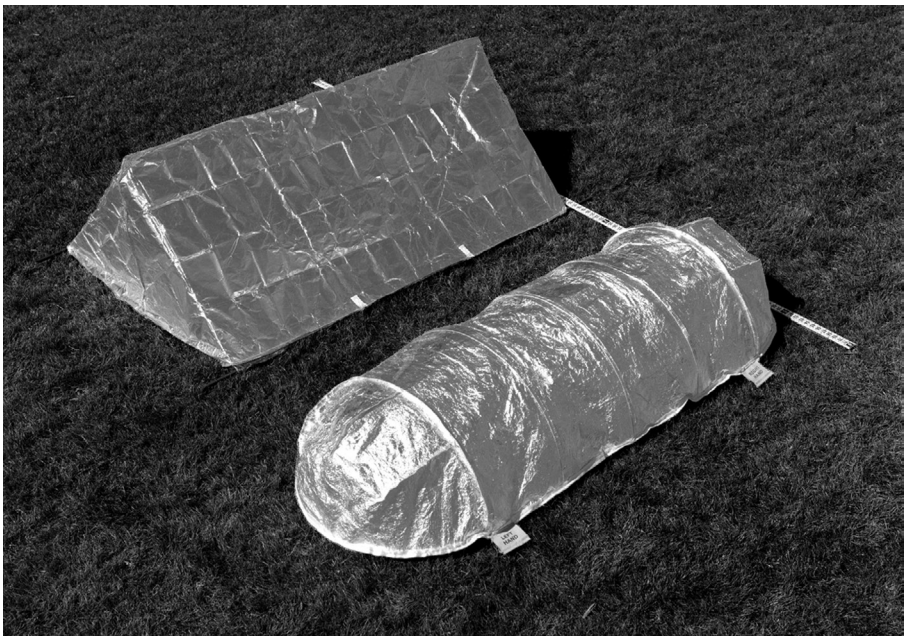

Figure 1—The new generation shelter (right) is longer, rounder, and lower than the standard shelter.

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The rounded design reduces the surface-area-to-volume ratio, decreasing the amount of material needed to provide enough volume inside the shelter. The new materials improve protection from flames, but they weigh twice as much as the old materials. If the new materials had not been used efficiently, the new shelter could have weighed more than twice as much as the standard shelter.

The new shelter is narrower and longer than the standard shelter. Overall, the shelter offers significantly more protection than the standard shelter, but it will feel smaller to users.

The new design's reduced surface-area-to-volume ratio improves protection because the shelter has less surface area to absorb radiant heat. The rounded ends also solve a problem noted during field testing of the standard fire shelter. Video footage taken during test fires showed that the flat ends of the standard shelter could reflect heat onto adjacent fuels, igniting them before the flame front arrived. Flames from adjacent fuels could damage the shelter, reducing its protection when the flame front arrived. The rounded ends of the new shelter scatter radiant heat to the atmosphere, rather than focusing heat on fuels next to the shelter.

The new shelter is made of two layers of material (figure 2). It weighs 4.2 pounds, compared to about 3.4 pounds for the standard shelter. The outer layer is woven silica laminated to aluminum foil. The inner layer is fiberglass laminated to aluminum foil. The outer layer of foil reflects radiant heat and the woven silica slows heat transfer to the inside of the shelter. The inner layer of foil prevents heat from being reradiated inside the shelter, and it prevents gases from entering the shelter. When the two layers of material are sewn together, the air gap between them provides additional insulation.

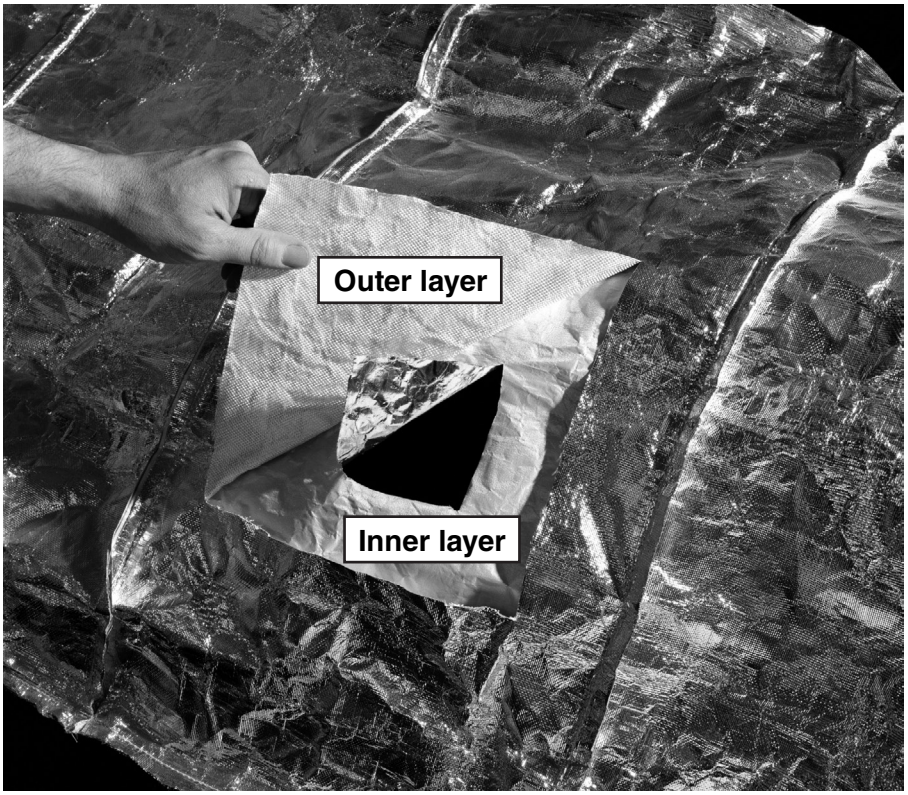

Figure 2—The new shelter has two layers of material. The outer layer is woven silica laminated to aluminum foil. The inner layer is fiberglass laminated to aluminum foil.

Seams across the top of the shelter support the shelter's main shell. The seams also help keep the outer foil layer in place. When the shelter is heated to 260 ÆC (500 ÆF), the ad-hesive that bonds the foil to the silica breaks down, allowing the layers to separate. In turbulent conditions, the foil can tear and peel away from the silica layer. Seams protect the foil layer because foil stops peeling when it reaches a seam.

The new shelter's carrying case is blue. The pull strap for removing the shelter from the case is yellow. The new shelter, like its predecessor, should always be carried inside its hard plastic liner. The new generation shelter will be available through the General Services Administration (GSA) Wildfire Protection Equipment and Supplies catalog by June 2003. See the ordering information at the end of this document.

Ease of Deployment

The holddown straps are in a different location in the new shelter. The straps on the standard shelter crossed the opening of the shelter. Sometimes these straps snagged when a firefighter was deploying the shelter. The holddown straps are now alongside the opening where firefighters can slip their hands through them when deploying.

The new shelter has "shake handles" to speed deployment. If the user grasps the handles and shakes, the shelter will unfold quickly. The handles are marked **Right Hand** (with red letters) and

Left Hand (with black letters). When the user grasps the correct handles, the shelter unfolds with its opening facing the user. Otherwise, the opening will face away from the user, slowing deployment slightly while the user turns the shelter over to reach the opening.

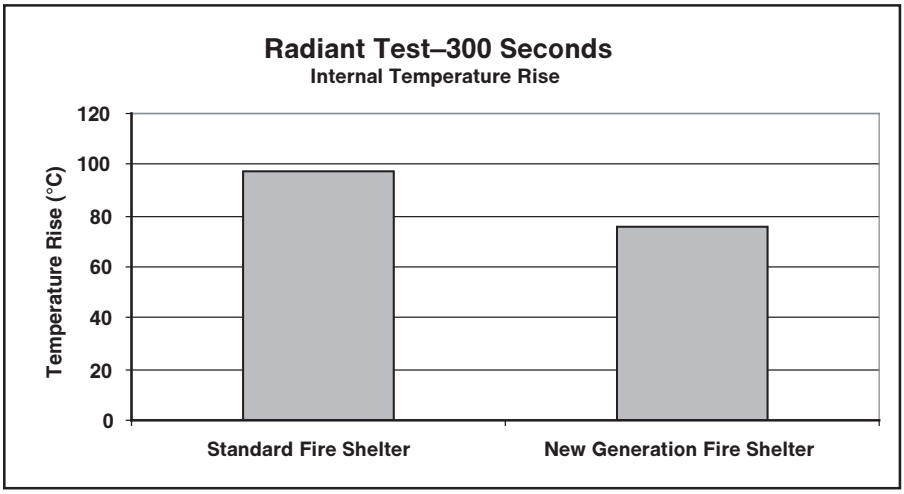

Figure 3—Temperatures inside the new generation fire shelter rose 22 percent less than temperatures inside the standard shelter during radiant heat tests of full-scale designs.

Performance in Radiant Heat and Flames

Radiant and convective testing is critical when assessing a shelter's ability to limit heat transfer. The greatest threats a firefighter faces during an entrapment are burns to the body and inhalation of hot gases which can cause asphyxiation. We assessed the inhalation threat by measuring the temperature at various locations inside the fire shelter. We assessed the potential for burns with temperature and heat flux measurements inside the shelter.

Scientific estimates of the maximum survivable air temperature vary, but dry air temperatures as low as 149 ÆC (300 ÆF) are considered survivable for only very short periods.

The new shelter provides improved protection from both radiant heat and direct flame. In radiant heat tests using full-scale designs, temperatures inside the new generation shelter rose 22 percent less than temperatures inside the standard shelter after 300 seconds. The temperature rose an average of 76 ÆC (169 ÆF) in the new generation shelter compared to 97 ÆC (207 ÆF) in the standard shelter (figure 3). In direct-flame tests, temperatures inside the new generation shelter rose 81 percent less than temperatures inside the standard shelter after 40 seconds. The temperature rose an average of 56.5 ÆC (134 ÆF) inside the new generation shelter, compared to 300 ÆC (572 ÆF) inside the standard shelter (figure 4).

Heat flux is a measure of the rate at which heat strikes a surface. A heat flux of 5 kilowatts per square meter would lead to second-degree burns in about 40 seconds on bare skin.

In radiant heat tests, the average peak heat flux was reduced 59 percent, from 3.7 kilowatts per square meter for the standard shelter to just 1.5 kilowatts per square meter for the new generation shelter (figure 5). In direct flame tests, the average peak heat flux for the new generation shelter was 97 percent lower, just 1.3 kilowatts per square meter, compared to 44.1 kilowatts per square meter for the standard shelter (figure 6).

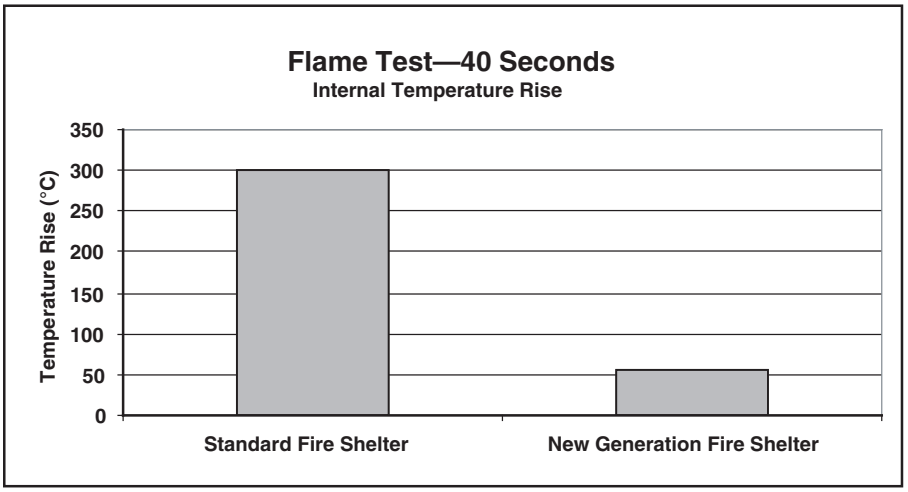

Figure 4—Temperatures inside the new generation fire shelter rose 81 percent less than temperatures inside the standard shelter during flame tests of full-scale designs.

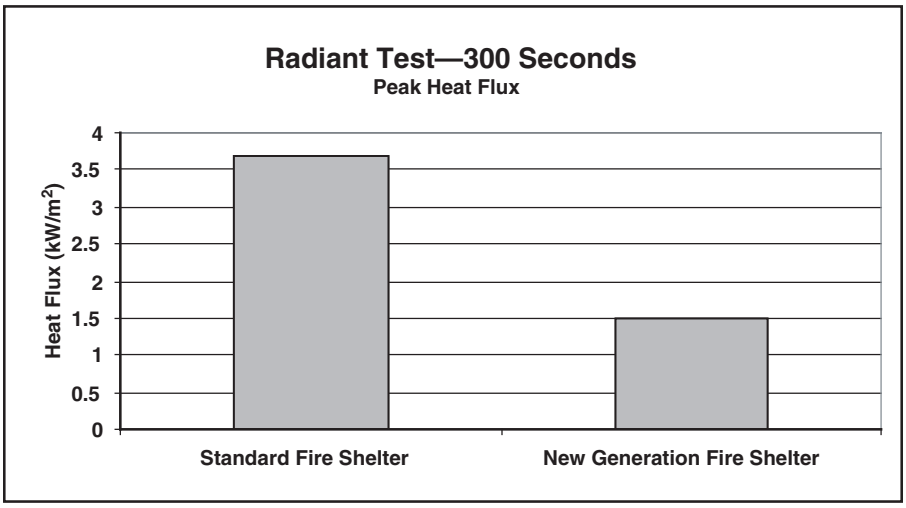

Figure 5—The average heat flux was 59 percent lower for the new generation fire shelter than for the standard shelter in radiant heat tests of full-scale designs.

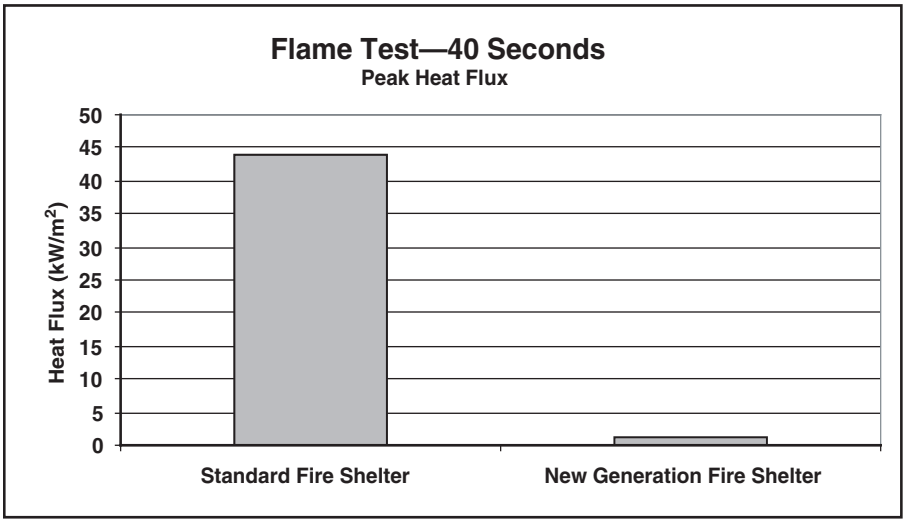

Figure 6—The peak heat flux for the new generation shelter was 97 percent less than for the standard shelter during the direct flame test of full-scale designs.

Caution

Although the new shelter offers significantly more protection from radiant heat and direct flame, firefighters must remember that the shelter cannot protect them in all circumstances. A firefighter's highest priority should always be to avoid situations that can lead to entrapment. The new fire shelter is not an excuse to take risks on the fireline.

Even though the new shelter offers improved protection from direct flame, you will improve your chance of survival if you deploy where the shelter will not be exposed to direct flame.

Training

Do not carry the new generation fire shelter until you are properly trained. Appropriate training includes, at a minimum, reading the new training pamphlet, viewing the new video or DVD, and practicing deployments with the new practice fire shelter. The video, DVD, and the pamphlet are all titled "The New Generation Fire Shelter." They are available through the National Interagency Fire Center's Publications Management System.

Fireline Pack Retrofit

The two layers of material in the new generation shelter have increased the shelter's bulk. In the past, the folded fire shelter fit inside a hard plastic liner that measured 9 by 5¾ by 3¼ inches. The liner for the new shelter is an extra 1¼ inches deep. The new liner is too large for many of the field pack sleeves that were designed for the standard shelter. If you have not received a new shelter, you can test the fire shelter sleeve on your field pack by cutting a block of lumber to the dimensions of the new hard plastic liner (9 by 5¾ by 4½ inches) and trying to push the block into the pocket.

The new shelter will come with a case that can be worn on a belt or on a chest harness. A new fireline pack that will accommodate the new generation fire shelter will be available for purchase through the GSA Wildfire Protection Equipment and Supplies catalog. Fireline packs that do not accommodate the new shelter can be retrofitted. Some field pack manufacturers will retrofit their packs. Another option is to retrofit your own field pack.

A common field pack design includes a fire shelter sleeve that is sewn to the bottom of the pack. Here is a simple way to retrofit such a pack.

Step 1: Cut lengthwise through the middle section of the fire shelter sleeve, 5 inches from the seams that attach the sleeve to the main body of the pack, and remove old Velcro.

Step 2: Cut a piece of nylon duck material (such as Cordura) 6¾ by 14 inches. Stitch a ½-inch hem along the 6¾-inch edges of the material. Attach a 2- by 5½-inch piece of Velcro pile along each of the 6¾-inch edges.

Step 3: Stitch the replacement panel to the side of the sleeve closest to the back pad.

Step 4: Fold and top stitch.

Step 5: Fold over ½ inch of the replacement panel and sleeve as shown and top stitch with two lines of stitching.

Step 6: Push the hard plastic liner into the sleeve and insert the fire shelter into the liner. Press the Velcro strip on the shelter's pull strap against the Velcro on the pack's sleeve. Close the flap so that the Velcro of the flap and sleeve are attached to the Velcro of the pull strap. This arrangement allows one pull on the strap to open the pocket and pull out the shelter.

If you have questions about retrofitting fireline packs, contact Tony Petrilli, MTDC, 406–329–3900.

Ordering Information

Training Video, DVD, and Pamphlet

The New Generation Fire Shelter (video)—NFES 2711

The New Generation Fire Shelter (DVD)—NFES 2712

The New Generation Fire Shelter (pamphlet)—NFES 2710

These items are available through the Publications Management System. Mail or fax orders to:

National Interagency Fire Center
Attn: Great Basin Cache Supply Office
3833 South Development Ave.
Boise, ID 83705
Fax: 208–387–5573 or 5548

The new fire shelter and practice fire shelter are available through the GSA Wildfire Protection Equipment and Supplies catalog beginning in June 2003.

New *practice* fire shelter

New practice fire shelter complete: (NSN 6930–01–499–0605, NFES 2678) Price: $65.23

Practice fire shelter only:
(NSN 6930–01–499–0608, NFES 2679)
Price: est. $50.00

Practice shelter case:
(NSN 6930–01–499–0614, NFES 2680)
Price: $14.07

Practice shelter PVC bag only:
(NSN 6930–01–499–0618, NFES 2681)
Price: est. $20.00

Liner:
(NSN 8465–01–498–3191, NFES 0928)
Price: $2.95

New fire shelter

New fire shelter complete:
(NSN 4240–01–498–3194, NFES 0925) Price: $256.74

Shelter only:
(NSN 4240–01–498–3184, NFES 0926)
Price: $226.69

Case:
(NSN 8465–01–498–3190, NFES 0927)
Price: $14.07

Liner:
(NSN 8465–01–498–3191, NFES 0928)
Price: $2.95

About the Authors

Leslie Anderson has been an equipment specialist at MTDC since 1997. She is a project leader for projects involving fire shelters and fire-resistant clothing. Anderson 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. Anderson was a smokejumper from 1984 to 1989 in Missoula, MT. From 1989 to 1991, she worked in fire management with the Costa Rican National Park Service as a Peace Corps volunteer. Anderson worked as an assistant district fire management officer on the Bitterroot National Forest from 1992 to 1997.

Tony Petrilli is an equipment specialist in the fire and aviation, and safety and health programs at MTDC. Petrilli began working at MTDC over the winters in 1992. He joined the center full time in 2000. He has spent more than 17 years as a firefighter for ranger districts on the Lewis and Clark and Beaverhead National Forests and as a smokejumper for the Northern Region. He is qualified as a division/group supervisor. He is a master parachute rigger and understands textiles and their uses in firefighting.

Library Card

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Describes the new generation fire shelter developed for wildland firefighters by the Missoula Technology and Development Center. Fire shelters provide some protection for wildland firefighters who become entrapped by wildland fires. The new generation fire shelter provides significantly more protection from radiant heat and direct-flame contact than the standard fire shelter it replaces. It does so at the cost of additional weight (4.2 pounds compared to 3.4 pounds), bulk (4½ inches deep when folded compared to 3¼ inches), and cost (about $250 compared to $50). The new shelter is longer, lower, and rounder than the standard shelter it replaces. It has two layers of fabric: an outer layer of woven silica laminated to aluminum foil and an inner layer of fiberglass laminated to aluminum foil.

Keywords: firefighting, packs, personal protective equipment, retrofitting, safety at work

Additional single copies of this document may be ordered from:

USDA Forest Service
Missoula Technology and Development Center
5785 Hwy. 10 West
Missoula, MT 59808–9361
Phone: 406–329–3978
Fax: 406–329–3719
E-mail: *wo_mtdc_pubs@fs.fed.us*

For additional technical information, contact Leslie Anderson or Tony Petrilli at MTDC.

Phone: 406–329–3900
Fax: 406–329–3719
E-mail: *landerson@fs.fed.us* or *apetrilli@fs.fed.us*

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

http://www.fs.fed.us/t-d

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