



NTDP Tech Tips

Modified Wildland Firefighter Flame-Resistant (FR) Shirt

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Highlights

- The U.S. Department of Agriculture, Forest Service, National Technology and Development Program reviewed and made improvements to wildland firefighter flame-resistant (FR) shirts.
- The new wildland firefighter FR shirts are more comfortable and durable.
- Reflective striping on pocket flaps and elbow patches enhances visibility in low-light conditions.

Introduction

The U.S. Department of Agriculture, Forest Service specification for wildland firefighter shirts was developed in 1962 and has gone through several revisions (figure 1). The lifecycle of equipment specifications dictates that periodic reviews of equipment occur, so Forest Service, National Technology and Development Program (NTDP) equipment specialists reviewed and improved the current wildland firefighter flame-resistant (FR) shirt design.

Feedback from wildland firefighters revealed that they generally liked the existing shirt design. However, they had a desire to improve shirt durability, fit, and comfort. The NTDP tech tip “[Changes for Firefighter Shirts and Pants](https://www.fs.fed.us/t-d/library-card.php?p_num=1351%202309P)” <https://www.fs.fed.us/t-d/library-card.php?p_num=1351%202309P> describes the 2011 specification revision of the firefighter FR shirt. Fabric and design were the two areas of focus for improvements in the latest revision.



Figure 1 – The cover of a 1973 issue of the Forest Service Equipment and Development Center's Equip Tips featuring the Nomex fabric firefighters shirt.

Fabric

NTDP specialists worked with FR fabric manufacturers to improve the shirt fabric. NTDP selected two fabrics for prototype shirts and wear tested the fabrics during 2017 and 2018. One fabric was touted for better breathability and improved comfort, whereas the other fabric was designed to improve comfort and durability. Both fabrics were made of the same meta-aramid blend (Nomex IIIA) fibers to maintain

flame resistance and had similar radiant heat protective performance (RPP) and total heat loss ratings (THL) (see Definitions). Wear testers preferred the 5.5 ounces per square yard meta-aramid blend fabric in a twill weave because it was more comfortable and durable.

NTDP asked the wear testers to compare the RPP of the shirt fabric against their reasonable maximum exposure. The reasonable maximum exposure is the maximum amount of radiant heat (from proximity to flames) a firefighter experiences while performing basic fireline work without suffering a thermal injury. Most wear testers rated the fabric as “just right,” but some felt the protection was “slightly too high”

(figure 2). The fabric has an average RPP rating of 7.5, somewhat above the National Fire Protection Association (NFPA) 1977 Standard on Protective Clothing and Equipment for Wildland Firefighting minimum RPP rating of 7.

Normally, FR fabric has a relatively stiff finish treatment, and many firefighters find new (unlaundered) garments uncomfortable to wear. The new fabric will be manufactured with a “soft hand” finish, so the shirts will be more comfortable to wear straight out of the bag. This should reduce the number of cases where firefighters are reluctant to exchange their worn, soiled shirts for new shirts at the supply units of larger fire camps.

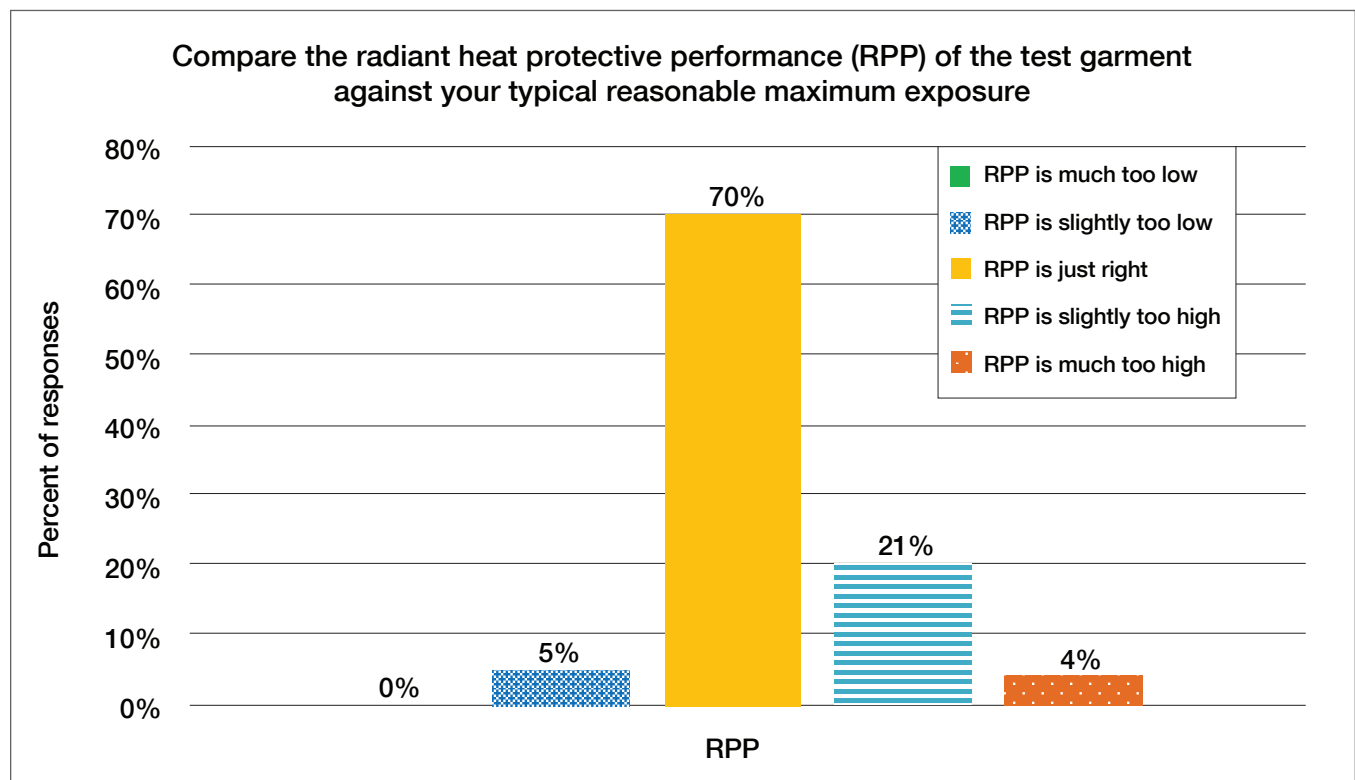


Figure 2—Results from a survey question asking respondents to compare the radiant heat performance of the test garment against their typical reasonable maximum exposure.

New Shirt Design

To address firefighter feedback, changes to the shirt design include (figure 3):

- A redesigned, more-streamlined collar with better aligned hook-and-loop (Velcro) fasteners.
- A longer shirt tail in the back helps keep shirts tucked in.
- An increased shoulder seam angle provides additional ease of arm movement and helps prevent shirt tails from pulling out.
- A smaller sleeve circumference addresses feedback that sleeves were too large.
- Smaller button and buttonhole placard widths reduce the amount of area reinforced with double-layered fabric.
- Smaller elbow patch sizes reduce the amount of area with double-layered fabric.
- An adjusted stitch pattern on all Velcro loop pieces increases durability.
- Reflective striping on pocket flaps and elbow patches enhances visibility.



Figure 3—The new flame-resistant firefighter shirt.

Reflective striping for clothing was historically bulky and stiff, making it uncomfortable and less durable. Advancements in this technology have resolved these issues. The new shirts have 1-inch-wide, segmented, reflective striping on pocket flaps and elbow patches, which manufacturers apply with heat and pressure. The reflective striping is relatively soft, pliable, and very durable, and has exceptional light-reflective properties.

Placing a small amount of segmented, reflective striping on the pocket flaps and elbow patches will increase the visibility of firefighters in low-light conditions. This improved technology will also limit the undesirable traits of reduced air permeability and the possibility of thermal stored energy.

Shirt sizing will remain the same, with seven sizes in both regular and long torso and sleeve lengths.

The new shirt design remains compliant with the National Fire Protection Association (NFPA) 1977 Standard on Protective Clothing and Equipment for Wildland Firefighting. The National Wildfire Coordinating Group (NWCG) Fire Shelter and Personal Protective Equipment Subcommittee (FSPPESC) and its parent committee, the Equipment Technology Committee (ETC), recommended the new shirt design for implementation. The NWCG Risk Management Committee (RMC) was also briefed on the new shirt design. Because there is no change to the shirts' National Stocking Numbers (NSNs) or National Fire Equipment System (NFES) numbers, the new shirt design will appear in normal orders from the Defense Logistics Agency (DLA) and national interagency support caches.

Related Current Work—Soiled Garments

NTDP is assisting the National Institute of Occupational Safety and Health (NIOSH) to further study what hazards may exist with soiled garments. Hazards may include:

- Less radiant heat protection
- Greater flammability (if soiled with gas and oil)
- Less breathability
- Less visibility
- Prolonged exposure to harmful toxins

It is important to educate wildland firefighters about the potential hazards of soiled garments; laundering or trading in soiled garments ensures a more effective shirt and reduces risks. Supervisors must take measures to make sure their firefighters wear relatively clean, serviceable garments.

Related Topic Reminder—Undergarments

According to Chapter 7 of the Interagency Standards for Fire and Fire Aviation Operations (Red Book), wildland firefighters should wear only undergarments made of 100 percent, or the highest possible content, of natural fibers (cotton, wool, or silk), aramid, or other flame-resistant materials. The NTDP tech tip “[Tests of Undergarments Exposed to Fire](https://www.fs.fed.us/t-d/php/library_card.php?p_num=0851%202348P)” <https://www.fs.fed.us/t-d/php/library_card.php?p_num=0851%202348P> reminds firefighters of the dangers of wearing fabric that may melt under normally survivable conditions.

Reportedly, most firefighters normally wear cotton undergarments to meet this requirement. In the past few years, fabric manufactures have produced FR knitted fabrics that are quick drying and comfortable. Wildland firefighters may consider wearing FR undergarments sold by private vendors.

Definitions

Flame resistance is determined by testing the fabric to American Society for Testing and Materials International (ASTM) D6413, Standard Test Method for Flame Resistance of Textiles (Vertical Test). The swatch of fabric must not have an afterflame time of more than 2 seconds and must have an afterglow time of less than 8 seconds. The fabric must not melt or drip, and the char length must be less than 4 inches.

Radiant heat protective performance (RPP) is determined by testing the fabric to ASTM F1939, Standard Test Method for Radiant Heat Resistance of Flame Resistant Clothing Materials with Continuous Heating. The fabric is exposed to a continuous and constant 21 kilowatts per square meter radiant heat source, and the time to a second-degree burn is determined. With no protection, skin will blister within 4 seconds. Both the previous and new shirt fabric with the same average rating of 7.5 will protect a wildland firefighter’s skin for 15 seconds.

Total heat loss is measured using the ASTM F1868, Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate. This test measures how well a fabric transports the body’s metabolic heat away from the wildland firefighter. The FR shirt fabric has a total heat loss value of 720 watts per square meter, which far exceeds the minimum requirement of the NFPA 1977 standard for total heat loss of 500 watts per square meter.

About the Author

Tony Petrilli (retired) was an equipment specialist for the Fire and Aviation Management Program at the U.S. Department of Agriculture, Forest Service, National Technology and Development Program (NTDP) in Missoula. He holds a bachelor's degree in education from Western Montana College. Petrilli began working for the Forest Service in 1982 as a firefighter for the Lewis and Clark and Beaverhead National Forests. He became a smokejumper in Missoula for the Northern Region in 1989. In 1992, Petrilli began working wintertime details at NTDP, and in 2000, he joined the program as a permanent employee. He was the fire shelter and firefighter clothing project leader from 2005 to 2021. Petrilli served on more than 40 fire entrapment safety review or investigation teams as a personal protective equipment specialist and maintains fire qualifications as a safety officer, division/group supervisor, and incident commander type 3.

About NTDP

The U.S. Department of Agriculture, Forest Service, National Technology and Development Program provides Forest Service employees and partners with practical, science-based solutions to resource management challenges. We evaluate, design, and develop new technologies, products, and systems to solve problems and deliver solutions.

Library Card

Petrilli, T. 2022. Modified wildland firefighter flame-resistant (FR) shirt. 2151–2312P–NTDP. Tech. Tip. Missoula, MT: U.S. Department of Agriculture, Forest Service, National Technology and Development Program. 6 p.

Firefighters asked for work attire changes to improve fit, comfort, and durability. This tech tip describes changes to flame-resistant firefighter shirts.

Keywords: fire, fire fighting, firefighting, flame-resistant, Nomex, PPE, protective clothing, safety at work, wear testing

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