

Appendix B

DuPont Customer Service can provide the following laundering instructions. Contact them at 1-800-931-3456, or write them at:

DuPont Company
Nomex® Customer Service
PO Box 278
McBee, NC 29101

The following is from the DuPont publication on laundering:

- a. Tests show that (commercial and industrial detergent) formulations designed for use at a temperature of 140 °F (60 °C) or less adequately clean NOMEX® and provide the best fabric color retention.
- b. Garments of NOMEX® must be adequately rinsed to remove residual wash chemicals.
- c. In some instances, tumble dry conditioning is the only finishing necessary for garments of Nomex®.”

In addition to these guidelines:

- a. Select temperatures to maintain color fastness except as necessary to clean heavily soiled items.
- b. The use of commercial cold-water process may be used in remote or field locations as necessary.
- c. Garments heavily soiled with petroleum products may require dry-cleaning.

**FOR MORE INFORMATION,
PLEASE CALL 1-800-453-8527 OR WRITE:**

DuPont
Advanced Fibers Systems
Chestnut Run Plaza
Laurel Run Building
Wilmington, DE 19880-0705

We believe that this information is the best currently available on the subject. It is offered as a suggested starting point for experimentation you may care to undertake in this area. It is subject to revision as additional knowledge and experience are gained. DuPont makes no guarantee of results and assumes no obligation or liability whatsoever in connection with this information. Those intending to use recommendations contained in this publication concerning equipment, processing techniques or chemical products should first satisfy themselves that the recommendations are suitable for their use and meet all appropriate safety and health standards. This publication is not a license to operate under, or intended to suggest infringement of, any existing patents.

Rapidly advancing knowledge of new, long-term toxic effects of many chemicals has emphasized the need to reduce human exposure to many chemicals to the lowest practicable limits. Special hazards with respect to chemicals mentioned in this bulletin that were known to us at the time of publication have been noted in the text or in footnotes, but we do not suggest or guarantee that other hazards do not exist. We strongly recommend that processors seek and adhere to manufacturer's or supplier's current instructions for handling each chemical they use.

Replaces and obsoletes Bulletin NS-12, 7/78
H-71605 Rev 2/97 Printed in U.S.A.



Nomex®
Only by DuPont

SECTION I: INTRODUCTION TO NOMEX® ARAMID FIBER

GENERAL INFORMATION

Garments of NOMEX® aramid fiber have been used for more than 30 years for protection against fire-related personal injury. During this time, the line of NOMEX® products has been expanded and improved to include products made from fiber blends, such as blends of NOMEX® with KEVLAR® and static-dissipative fibers. The family of NOMEX® aramid fibers now includes:

- 100% NOMEX® T-450, which is used in its natural, undyed state or dyed for sewing thread;
- NOMEX® III, a blend of NOMEX® and KEVLAR®;
- NOMEX® IIIA, a blend of NOMEX®, KEVLAR® and a static-dissipative fiber; and
- Producer-colored NOMEX®, which is supplied in a blend with KEVLAR® and may also be supplied with a static-dissipative fiber.

The introduction of new, low-temperature detergent formulations has resulted in improved washfastness for garments of NOMEX®. Accordingly, DuPont has modified its recommended procedures for laundering garments of NOMEX®. The revised procedures outlined in this bulletin are designed to remove flammable contaminants and maximize garment life.

Properly dyed and finished garments of NOMEX® are inherently flame resistant. No laundry procedures are known to remove the flame resistance of NOMEX®. However, thermal protection can be compromised by the presence of flammable contaminants on the garment, or on the fabric from which it is made. Even though garments of NOMEX® are inherently flame resistant, flammable contaminants on the garments can ignite and burn until consumed, thus increasing heat transfer to the wearer.

Laboratory tests have shown that the procedures recommended in this bulletin are effective in removing oil-based soils from garments while minimizing the impact on colorfastness and wear life. Users of textile items made of NOMEX® should ensure that the techniques they use achieve similar results.

This bulletin is intended to provide general recommendations on conditions and products for laundering garments of NOMEX®. Throughout the remainder of this bulletin, all variations of NOMEX® and blends of NOMEX® will be referred to as NOMEX®. The products and conditions described in this bulletin performed well in laboratory evaluations; other conditions and products may provide equivalent results. To achieve the best results for specific applications, assistance should be obtained from chemical suppliers for the chemicals used.

SECTION II: COMMERCIAL LAUNDERING GARMENTS OF NOMEX® ARAMID FIBER

SORTING AND WASH WHEEL LOADING

Garments of NOMEX® should be washed separately from other articles to avoid contamination with lint of flammable fibers. In addition, to avoid possible staining of light-colored garments, dark-dyed garments of NOMEX® should be sorted and washed separately from very light shades or undyed articles.

To ensure thorough cleaning, washer loads for garments of NOMEX® should be approximately ⅓ the weight of loads recommended by the wash wheel manufacturer for 100% cotton goods. However, because garments of NOMEX® generally weigh less than their all-cotton counterparts, no significant loss in the number of garments processed per wash cycle should be experienced.

WASHING SUPPLIES

A source list for laundering products is presented in Appendix I. Laboratory tests have shown these products to be effective; other products also may provide acceptable results.

Detergent

Many commercial and industrial detergent formulations have been evaluated in the laboratory for their cleaning effectiveness and impact on washfastness. Tests show that formulations designed for use at a temperature of 140°F (60°C) or less — such as high-surfactant, low-alkalinity products — adequately clean NOMEX® and provide the best fabric color retention. Color loss after 200 launderings in a commercial wash wheel using these formulations has been found to be minimal. The use of soaps for laundering NOMEX® is not recommended due to the potential formation of insoluble scums with hard water. Soap scums may be flammable and could adversely affect the thermal protective performance of the garment.

Alkalinity (pH)

The detergents listed in Appendix I have pH values ranging from 9 to 11 and have been found to effectively lift dirt and oil from the NOMEX® fiber. The use of higher wash temperatures and detergent formulations with higher alkalinity will improve cleaning; however, these harsher conditions can negatively impact the colorfastness of the garments. Users must choose appropriate laundering conditions to maintain the desired balance between garment cleanliness and color retention.

Bleach

Only oxygen-based bleach is recommended for use on garments of NOMEX® — *chlorine bleach should not be used*. Although chlorine bleach will not affect the inherent flame resistance of NOMEX®, it may cause strength and color loss in garments over time.

Sour

When laundering items of NOMEX®, the use of a sour after thorough rinsing helps ensure that any remaining traces of alkalinity are neutralized.

Softeners, Anti-Stats and Wicking Agents

The following wash wheel supplies perform useful and often highly desirable functions when applied to the load in the last operation:

- *Fabric softeners** impart a softer “hand” to the fabric and assist in wrinkle removal when articles of NOMEX® are tunnel or tumble dried.
- *Anti-stats** reduce the effects of nuisance static electricity, such as clinging and lint pick-up. Nuisance static is fairly common with textiles, especially in low-humidity environments. Under normal conditions, garments of NOMEX® IIIA do not require the use of anti-stats because NOMEX® IIIA contains a proprietary static-dissipative fiber.

*Some materials when added to garments may have a negative impact on thermal protection. The impact of fabric softeners, wicking agents and anti-stats should be evaluated at the intended use level prior to routine use.

NOTE: Although certain anti-stats can provide a high degree of static control when properly applied in the wash wheel, they cannot ensure safety in situations where a discharge of static electricity could create a hazard to life or property, such as in an explosive or highly flammable environment. For this reason, it is important that personnel and equipment be properly grounded for maximum safety.

- *Wicking agents** help fabrics adsorb and spread moisture. Experience suggests that these characteristics contribute to comfort in warm, humid environments by helping to rapidly dissipate perspiration, thereby taking full advantage of the cooling effect of evaporation.

Non-Durable Water and Oil Repellents

Water and oil repellency may be a desirable feature in some industrial applications. If the original fabric has not been treated with a repellent, water and oil repellency can be obtained by using sprays or laundry-applied chemicals. Laboratory tests have shown that fluorocarbon sprays, such as Winsol® Fireline Water Repellent, and laundry additives, such as ZONYL® 6991, when applied according to manufacturers' recommendations, will impart water and oil repellency to garments of NOMEX® with minimal effect on the thermal protection of the garment. These materials will cause liquids to bead on the fabric surface and minimize wicking into the fabric. They will not, however, prevent liquids from being forced through the open structure of the fabric.

For example, ZONYL® 6991 may be applied in conjunction with AVITEX® DN without reducing its anti-static activity. However, the wicking action of the AVITEX® DN will be compromised due to the repellency imparted by the ZONYL® 6991. The use of these or other chemicals should be evaluated with respect to the particular oils and/or solvents encountered to determine if they meet the required chemical and thermal protective performance criteria. In addition, because these water repellents may wear away or wash out, re-treatment may be necessary, especially after garment cleaning.

*Some materials when added to garments may have a negative impact on thermal protection. The impact of fabric softeners, wicking agents and anti-stats should be evaluated at the intended use level prior to routine use.

WASHING PROCEDURES

General Wash Formulas

The formulas in Appendices II and III have been developed to wash garments of NOMEX®. Within the limits of these general procedures, modifications should be made to meet the needs of particular types of wash loads and other specific quality standards. To achieve desired results, assistance should be obtained from chemical suppliers.

Wash Temperatures

The detergents listed in this bulletin are primarily designed to work at 140°F (60°C). At this temperature, these surfactant-based formulas effectively lift oily soil while maximizing color retention. For heavily stained and oily garments of NOMEX®, a higher temperature wash formula may be required for adequate cleaning. The use of higher temperature formulas will not affect the inherent flame resistance of the garments or their overall wear life. However, higher wash temperatures or alkalinity levels may adversely affect garment colorfastness. Where color loss is a concern, dry cleaning is an alternative method of removing heavy soil and may be preferable to repeated high-temperature washing.

Prevention of Soil Redeposition

To improve soil removal and minimize soil redeposition in heavily soiled loads, a "multiple add" procedure is recommended. Adding washing supplies to the suds cycle ensures that the concentration is kept high enough to keep the soil in suspension.

Rinsing

Garments of NOMEX® must be adequately rinsed to remove residual wash chemicals. Rinse cycles should be continued until the pH of the rinse closely approaches that of the water supply. To minimize washer-induced wrinkles, water temperature should be reduced in each succeeding rinse cycle until the last operation (sour), where it should be 90°F (32°C) or lower.

Souring

Residual alkalinity in garments of NOMEX® can cause skin irritation and other problems. To ensure that all traces of wash chemical alkalinity are neutralized, sour can be added to the final rinse cycle in the wash wheel. Garments should not be rinsed further after the sour is added. Overuse of sours should be avoided because it will result in highly acidic fabrics. Any standard or buffered sour is acceptable for use with garments of NOMEX®.

Softeners, Anti-Stats and Wicking Agents

Generally, softeners and anti-stats are not permanently affixed to fabrics. Instead, they should be applied in the last wash wheel operation, then reapplied at the end of each subsequent wash cycle. Most are compatible with sours and can be applied in the sour bath. When applying any proprietary laundry product in the wash wheel, it is essential to seek the supplier's advice on its exact use and possible effect on the flammability and thermal protection of the garment.

Although the use of anti-stats may not be required with garments of NOMEX® IIIA, the "feel" and wickability of such garments can be improved with softeners and wicking agents. For example, tests have shown that AVITEX® DN softens fabrics of NOMEX®, reduces static propensity and significantly improves wicking, without adversely affecting thermal protection.

When using AVITEX® DN, the following should be noted (see Appendices II and III):

- AVITEX® DN does not permanently attach itself to the NOMEX® fiber; therefore, it must be reapplied or "added on" at the end of each wash cycle.
- AVITEX® DN is compatible with sours and can be conveniently applied during the souring step.
- AVITEX® DN tends to foam profusely. To control this foaming action, a very small amount of an effective anti-foam agent can be applied to the bath.
- As with sours, garments should not be rinsed after AVITEX® DN is applied.
- When applying AVITEX® DN, the cycle time should be extended to ensure complete and uniform distribution on the garments.
- Within the limits recommended, AVITEX® DN does not adversely affect the thermal protective performance of garments of NOMEX®.
- The "add-on" of AVITEX® DN is a function of both the concentration in the final cycle and the percentage of "wet pickup" (the moisture retained after the final cycle and extraction).
- AVITEX® DN add-on can be improved by raising the concentration in the final rinse and/or increasing the percentage of wet pickup.
- The amount of AVITEX® DN added to the wheel should not be reduced for partial loads. Always add AVITEX® DN in the amount calculated for a full load, unless the water level in the final bath cycle has been reduced.
- Contamination of the AVITEX® DN supply by detergents should be avoided because it can destroy the anti-static property. Keep the supply container closed to avoid evaporation and drying out. Gelling or thickening of the AVITEX® DN indicates product alteration or deterioration. In such cases, the supply should be replaced.

CAUTION: When using AVITEX® DN, avoid contact with the eyes or skin. In the event of contact with the eyes, flush the eyes thoroughly with water for at least 15 minutes and consult a physician. In the event of skin contact, wash thoroughly with soap and water. For detailed use instructions, consult the DuPont Material Safety Data Sheet for AVITEX® DN.

Effective softening, static suppression and wicking are achieved with garments of NOMEX® when AVITEX® DN is applied, as recommended, to give a calculated 0.50% to 0.75% add-on, based on the dry weight of the garment. Achieving the desired add-on depends on a number of factors that vary with different laundry procedures. Appendix IV provides definitions of the essential terms employed and gives two examples of how to calculate the amount of AVITEX® DN softener necessary to achieve the desired add-on. Appendix V contains a chart that can be used when the percentages of wet pickup and wheel volumes are known.

AVITEX® DN tends to cause foaming, which may overrun the wash wheel. Excessive foaming reduces agitation and will retard or prevent the uniform distribution of the softener/anti-stat in the wheel. If foaming is excessive, it can be controlled by adding approximately 0.005% of Dow Corning® Antifoam 1430 to the wheel when the softener/anti-stat is added. This level of antifoam is equivalent to approximately 0.67 oz/100 gal. (5 g/100 L) of liquid in the wash wheel. Silicone anti-foams can result in water treatment problems because they are not easily biodegradable. Check manufacturers' recommendations before using these products.

Repellents

Some fabrics are treated with water repellents during the manufacturing operation prior to the fabrication of garments. These treatments may last for many cleanings, but are not considered permanent. Other repellents are available that can be applied during or after laundering to previously untreated garments, or to previously treated garments that have lost their repellency. Repellent applications will reduce moisture wicking and can make garments that come in contact with the body less comfortable in hot, humid weather. In addition, repellent chemicals may be flammable. Before applying any repellent, it should be evaluated to determine if it will impact the thermal protective performance of the garment.

Repellents can reduce the penetration of oils, solvents and water through the fabric by causing them to bead up on the fabric surface. The level of repellency depends on the type and level of the material being applied, as well as the characteristics of the soils coming into contact with the garment. Fabrics used in industrial work or laboratory garments are not designed to be chemical or liquid barriers. Thus, where exposure to hazardous materials must be prevented, an appropriate chemical barrier suit must be worn.

Winsol® Fireline Water Repellent is available as an aerosol spray or in bulk form. It is an example of a repellent that can be sprayed onto the surface of a clean, dry garment. It must be applied in a well-ventilated area, and the solvent must be allowed to evaporate before garment use. This material will wash out com-

pletely after several launderings and must be reapplied to maintain repellency. The amount applied should be the minimum required to obtain the desired repellency. Repellency can be determined by applying a drop of liquid (water, oil or solvent) to the fabric surface to determine whether it wicks into the fabric or beads on the surface. Not all liquids will be repelled. Contact the manufacturer for applicability and impact on fabric flammability.

Another repellent, ZONYL® 6991, is applied in the final wash wheel rinse and is exhausted onto the fabric by adjusting the pH and increasing the water temperature. Garments must be hot-air dried after application for this repellent to be effective. Under the conditions shown in Appendix VI, approximately 80% of the material added to the final rinse will be exhausted onto the garments. An initial level of 2% to 3% on the dry weight of the garment is required for noticeable repellency of water or motor oil. ZONYL® 6991 may or may not be removed during the cleaning process, depending on the procedures used. Additional repellent should not be added during subsequent cleaning cycles unless indicated by a repellency test. Buildup or application of excessive levels of repellents can increase the level of flammable material and compromise the thermal protective performance of the garment. Use for specific applications should be evaluated prior to general adoption.

If AVITEX® DN is normally used for static control, it should be added with ZONYL® 6991 in the final rinse. If AVITEX® DN is added earlier in the wash procedure, it can be removed during further rinsing. The same holds true for ZONYL® 6991.

DRYING AND FINISHING

General Guidelines

Garments of NOMEX® can be rapidly dried and finished with good appearance using several methods. Economic savings are possible if drying and finishing are combined into one step, as with the wet-to-dry tunnel method.

No matter which method is chosen, every effort should be made to avoid introducing hard-set and unnecessary wrinkles during washing or extraction. For best results,

garments should not be bagged. However, if bagging is necessary, the bags should not be filled to more than half their capacity to ensure that the garments have adequate freedom of movement. Similarly, the wash wheel should not be overloaded. After the break and suds cycles, the water temperature should gradually be reduced through several rinse cycles to avoid introducing "thermal shock" wrinkles, which can be very difficult to remove. The final operation (sour) should be carried out at a temperature of 90°F (32°C) or lower.

Garments should not be fully extracted unless they are to be pressed. If an extraction is used as a preliminary step to other finishing methods, garments should be cold and subjected only to very brief and light hydraulic or centrifugal pressure. Extraction will reduce softener add-on by diminishing water carry-over; thus, a higher softener concentration in the final rinse will be required to achieve the desired add-on.

Tumble Dry Conditioning/Finishing

In some instances, tumble dry conditioning is the only finishing necessary for garments of NOMEX®. Tumble dry conditioning also can be done prior to dry-to-dry tunnel finishing or pressing. Adequate tumbling action is necessary for good wrinkle removal; therefore, tumble dryers should not be overloaded. Garments will dry rapidly and satisfactorily at exhaust air temperatures between 140°F (60°C) and 160°F (71°C). Garment temperature measured in the basket should not exceed 280°F (138°C). Excessive shrinkage and color loss can occur if higher temperatures are encountered. Tumbling without heat for an additional 10 minutes at the end of the drying cycle will cool the garments and help avoid dryer-induced wrinkles. To avoid set-in wrinkles, garments should not remain in a hot tumbler when it is not in motion, nor should they be folded or stacked.

Wet-to-Dry Type Tunnel Drying/Finishing

With this method, wet garments from the wash wheel are hung on hangers, placed on a conveyor and passed through a tunnel containing forced air supplied at 300°F (149°C) dry bulb and 190°F (88°C) wet bulb. Garments subjected to this combination of heat and air movement dry and finish wrinkle free and ready to wear. Garment temperature should not exceed 280°F (138°C). After exiting the tunnel, garments should hang freely and should not be compressed against other garments until they have cooled to below 100°F (38°C).

Dry-to-Dry Type Tunnel Drying/Finishing

After being conditioned in a tumble dryer, garments can be hung on hangers and rapidly and continuously conveyed through an abbreviated finishing cabinet. Steam, heat and forced air agitation minimize wrinkles and allow processing in a short period of time.

Pressing

If pressing is required, a steam-heated hot head press is recommended with a steam pressure of 80 psig (325°F [163°C]) and a steam/bake/vacuum cycle of 5/10/5 seconds. If an electrically heated hot head is used, a temperature of 375°F (191°C) should be used for 20 seconds as a starting point. Garments should be examined for glazing and dye sublimation before adopting these methods on a commercial basis.