INTRODUCTION

WHAT IS KEVLAR®?

DuPont KEVLAR® is an organic fiber in the aromatic polyamide (aramid) family. The chemical structure of aramids distinguishes them from other commercial man-made and natural fibers and gives KEVLAR® its unique properties. It has high strength, high modulus (stiffness), toughness and thermal stability. In addition, it is resistant to many of the chemicals and solvents encountered in today's industrial environment. This combination of properties makes it an exceptional fiber for use in tire reinforcement, ballistics applications, ropes and cables, and in protective apparel where high strength, and thermal, puncture, and cut resistance are required. Its value for use in gloves, chaps, and sleeves has been demonstrated repeatedly in many industrial, food, and medical applications. Literature on Protective Apparel of DuPont KEVLAR® brand fiber, manufacturers and distributors, as well as on other applications can be obtained by calling 1-800-4-KEVLAR.

Although KEVLAR® can be blended with other fibers of less cut resistance, these blends offer inferior protection than protective apparel made of 100% KEVLAR® fiber. Use of 100% KEVLAR® fiber allows use of lighter weight fabrics to obtain equivalent protection when compared to many other synthetic or natural fibers or blends. To ensure that your product is 100% KEVLAR® fiber, a Quality Assurance Program is in place for glove manufacturers, which provides assurance from DuPont that only KEVLAR® is present in the gloves. Licensed manufacturers apply a "Made of 100% DuPont KEVLAR® fiber" label to each glove containing 100% KEVLAR® fiber. Look for the quality assurance label attached to your gloves.

This Technical Guide discusses the cleaning of gloves of 100% KEVLAR® fiber. The procedures, however, are also applicable to sleeves, chaps, mittens, and other cut and thermal protective apparel manufactured from 100% KEVLAR® brand fiber.

Gloves of 100% KEVLAR® fiber with Quality Assurance Labels.

The procedures are representative of those being used commercially to clean cut protective apparel, and should be viewed as a starting point to define optimum conditions for each application. Before initiating a cleaning program, it is recommended your protective apparel supplier be consulted concerning any special cleaning requirements for your particular products. Agreement should also be obtained from your cleaning service as to the procedures used, the cleanliness level required, any repair service, inspections, and accounting for and removal of damaged apparel from service. The level of cleaning supplies used, and the cleaning cycle lengths, should be adjusted for the particular soil type and level encountered.

For example, gloves with a light soil level can be cleaned with a mild cleaning formula. This will result in a satisfactory appearance, lower cleaning cost, and will optimize glove life. Other cleaning supplies or methods which have not been evaluated may also produce acceptable results. No cleaning evaluations have been made on protective apparel using blends of KEVLAR® fiber and other fibers. It is important to ensure yourself that the method being used produces results acceptable for your particular application, adds value in use to your product, and that the gloves continue to maintain their performance level after cleaning.

HOW CAN KEVLAR® BE CLEANED?

Both dry cleaning and laundering are acceptable cleaning methods for gloves of 100% KEVLAR® fiber. Some differences in shrinkage, weight loss, yarn tensile strength, and color related to staining or the cleaning method may be seen, but there is no significant impact on cut resistance up to 30 cleaning cycles (without industrial use between cycles). Thirty cleaning cycles is considered to be more than can be expected because of normal wear.

Although the KEVLAR® fiber in the gloves or other protective apparel can be cleaned by either method, other materials in the gloves such as coatings, dots, cuff materials, or some soils, may require that one or the other be used. Consult your supplier or cleaning professional to determine if your protective apparel has any special cleaning requirements.

PROTECTIVE GLOVES MADE OF 100% KEVLAR® FIBER

KEVLAR® GLOVE FAMILY

Gloves of KEVLAR® fiber are produced from staple spun yarn, continuous filament yarn, or non-woven needled felts. They are manufactured in a variety of fabric weights and constructions and may be treated with coating materials for added abrasion resistance and reduced chemical penetration, or be dotted for improved gripping characteristics. Gloves made from certain filament and staple yarns are used for medical and food processing applications.

Gloves in the KEVLAR® family are used for general industrial applications which require a high level of cut or thermal protection. Gloves in the KEVLAR® Kleen™ family are low linting and may offer added value in food service, the medical field, and in some specific electronic operations where a low lint level is of particular importance. KEVLAR® Kleen™ gloves are also available in a range of colors in addition to the natural yellow KEVLAR®.

CUT RESISTANT FABRICS, REPAIR, AND GLOVE SERVICE LIFE

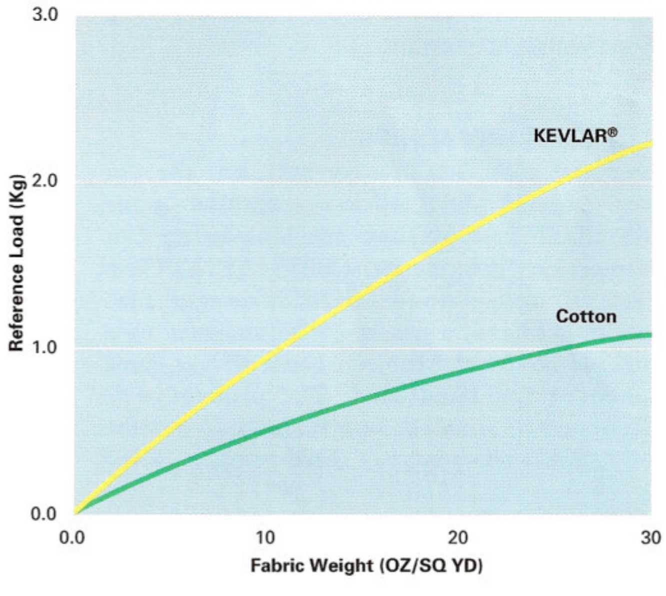
Although the fabrics used in the manufacture of gloves of KEVLAR® are constructed in a variety of ways, the base chemical structure of the fiber is unchanged. This base chemical structure determines how the individual fibers resist chemicals, abrasion, and heat, and behave under tensile and transverse loads. Glove construction and fabric weight define total glove cut and snag resistance, heat transfer, and aesthetics. Thus, all other factors remaining constant, heavier fabric weight gloves will have higher cut resistance (Figure 1) and a lower rate of heat transfer than lighter weight gloves. A woven fabric may be stiffer than a knit of the same weight. A loop-in vs. a loop-out terry knit may have preferred application areas where snag resistance or blunt trauma protection may be a factor.

The Glove Family of KEVLAR® consists of:

KEVLAR®	Excellent cut and heat resistance.
KEVLAR® KLEEN™	Low linting with same cut and thermal resistance as KEVLAR®.
KEVLAR® PLUS™	At least 18% more cut resistance.

Figure 1

Relative Cut Resistance of KEVLAR® and Cotton Gloves Made from Different Fabric Weights



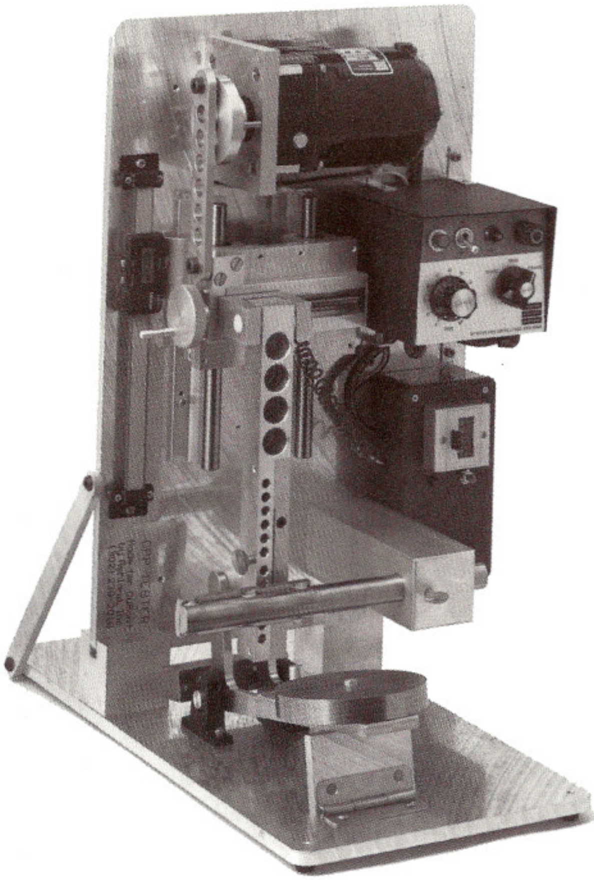
Some gloves are sold by the glove weight in grams rather than fabric weight in oz/yd2. The gram weight includes the cuff and cuff elastic and is not representative of the actual amount of fabric available to resist cutting, abrasion, or heat transfer in the exposure areas such as the palm or fingers. When specifying gloves or comparing performance, the fabric weight in oz/yd2 should be used, and not the actual weight of the glove in grams.

Gloves made of KEVLAR® fiber are highly resistant to cut damage from sharp edges such as on sheet metal and glass, however gloves made of KEVLAR® are not puncture proof. As with any protective material, wear caused by cuts, snags, and abrasion may occur with use. The selected glove weight, construction, nature of the exposure hazard, use of a cleaning and repair program, and the standards established for keeping gloves in service which users select, will define the average service life. Unless the gloves have been in service an extended time, abrasion causing thin spots is generally not a problem. If damage can be repaired, the gloves may be put back into service and the average life is extended. If no repair is attempted on damaged gloves, then average life is lower. Damage such as holes and snags often can be repaired by sewing over the damaged area with KEVLAR® thread, sewing on KEVLAR® patches, or thermally applying adhesive backed KEVLAR® patches. Life of an individual glove can range from one to as many as 25-30 cleaning cycles depending on the above variables. Although the initial cost of gloves made of KEVLAR® is greater than cotton, their wear life more than makes up for the cost difference, while providing superior hand protection.

CUT RESISTANCE TESTING

For the purposes of this bulletin, the cut resistance of glove fabric is measured by the Standard Test Method for Measuring Cut Protection Performance (CPPT), ASTM 1790. This test method was developed to determine the cut resistance of a material when mounted on a sample holder and subjected to a sliding blade under a specified load. The procedure is designed to simulate in a laboratory test the sliding of a sharp edge or blade across a gloved hand or other cut protected area. Weight is added to a platform above the blade to increase its cutting load. The weight in kilograms (Kg) which will cause the blade to cut through the fabric in one inch of travel is reported as the CPPT reference load value. To ensure uniform test results are obtained, a new blade is used for each test cut and multiple test cuts are made on each fabric sample. A correction factor based on Neoprene rubber standard is applied to the reference load results to correct for any blade sharpness differences. Thus material having a higher CPPT reference load value has shown a higher resistance to cutting by this test method.

The CPPT is used to compare the relative cut resistance of fabrics in a laboratory simulation of exposure to a sharp object. The results of these tests are only a prediction of cut resistance under these conditions. Because the dynamics of real exposures to sharp cutting or snagging objects may vary greatly, these results do not duplicate or represent glove or fabric performance under actual exposure conditions.



Cut Protection Performance Test (CPPT) Equipment

CHEMICAL AND THERMAL RESISTANCE

Aromatic polyamides, such as KEVLAR® brand fibers, are resistant to thermal degradation and to attack by many chemicals. Under severe conditions of high temperature and/or high concentrations, and for long times, exposure to some chemicals may cause damage to the aramid structure. However, most of these chemicals could be harmful to the body and hands. Woven, knit, and non-woven fabrics including fabrics made of KEVLAR®, used in gloves are not designed to be barrier fabrics unless coated, but rather are used for their cut and thermal resistance. Chemicals in contact with standard uncoated gloves will wick through the glove fabric and contact the hands, therefore uncoated gloves made of KEVLAR® should not be used in applications where exposure to hazardous materials can occur. Good safety practice dictates that for these end uses gloves be coated with the appropriate material to prevent exposure. If the gloves made of KEVLAR® are coated with an appropriate coating or chemical barrier gloves are worn over them, then chemical attack to the fiber can be prevented. It is essential that you consult with your glove supplier to ensure that appropriate coatings or barrier gloves are specified for your particular application where exposure to hazardous chemicals can occur.

Chlorine bleach can cause strength loss in para-aramids at low concentrations such as would be encountered in laundering, and therefore should not be used. In most industrial end uses the type of oily soil encountered cannot be removed by chlorine bleach so it is of no added benefit to the laundry formulation.

KEVLAR® is thermally stable up to 800 to 900°F as compared to cotton which starts to decompose at 300 to 400°F. It does not melt like nylon, polyester, and polyethylene, and can be used continuously at 400°F. When used in heat resistant gloves, the outer glove fabric may be a loop out knit or woven fabric. The thermal liner may be a felt composed of wool, cotton, or other fiber blends. Special procedures may be required to clean multi-layered thermal protective gloves. Contact your supplier for any special cleaning instructions.

CLEANING PROTECTIVE GLOVES MADE OF 100% KEVLAR®

CLEANING METHODS

Commercial glove cleaning is done with front loading washer/extractors. Different solvents and chemicals may be used as well as temperatures, and cycle types and lengths. The two basic cleaning methods are dry cleaning and laundering. Dry cleaning uses either Stoddards solvent (mineral spirits, of which there are two types) or perchloroethylene. Dry cleaning cycles have limited variations in their operation. The main variations other than solvent type are the optional addition of a wash cycle with fresh solvent, or the use of a single extended cycle with use of the same solvent. The cleanliness and surfactant content of the recovered solvent may impact the redeposition of soil onto the gloves during repeated cleanings. Laundering is done in similar equipment, but a variety of chemicals, alkalinities, temperatures, and cleaning and rinsing cycles may be used. Souring or neutralizing of any residual alkalinity after laundering is generally used to prevent skin irritation during glove use.

Whether dry cleaning or laundering is chosen should be determined by the particular gloves being used. Certain rubbers or plastics applied to gloves may be sensitive to some dry cleaning solvents and may harden after repeated cleanings. Some elastic materials used in the glove cuffs may also harden and loose their elasticity with time. Selection of the correct dry cleaning or laundering process will increase the life of these gloves. Your glove supplier should be consulted to determine whether there are any special cleaning requirements for your particular gloves.

Generally a dry cleaning or laundering procedure can be developed to remove most industrial soils. However, some gloves may become contaminated with epoxy, adhesives, paint, or other materials which cannot be removed in the standard cleaning process without creating excessive cleaning costs. A standard for cleanliness or contamination with these materials should be established.

Although KEVLAR® brand fibers are resistant to many chemicals and solvents, **chlorine bleach cannot be used in cleaning formulations for KEVLAR®. The chlorine will cause a rapid degradation of the fiber.** Chlorine bleach is not typically used for industrial cleaning of gloves since the removal of the heavy oily soils encountered in industrial end uses is not improved with its use.

Because of the wide variations in glove constructions including the use of coating materials, dots, and cuff materials, which may require special cleaning procedures, this bulletin has been directed at the impact of the cleaning procedure on the KEVLAR® fabric only. Specific requirements for materials other than the KEVLAR® fabric should be discussed with your supplier or professional cleaner.

SCREENING TESTS TO EVALUATE CLEANING METHODS

The long term effects of cleaning industrial gloves in actual work situations are impractical to assess because of the numerous combinations available in cleaning methods, levels of wear and cut exposure, and soils encountered. It is feasible however to study the effects of cleaning under controlled laboratory conditions. Laboratory screening tests using industrial cleaning procedures were conducted with heavily soiled industrial gloves. These identified conditions which resulted in acceptably clean gloves. From these tests a procedure representing each general industrial method of dry cleaning and laundering was selected for an extended study. New gloves were then processed through 30 cleaning cycles to identify the long term impact of the cleaning procedure on glove and fiber properties. The impact of the cleaning process on cut resistance, shrinkage, weight loss, fiber tensile strength, and color were used to evaluate the method's effectiveness. The impact of wear associated with normal industrial use or impact on coatings, dots, or other non KEVLAR® materials was not studied in this test.

Gloves soiled in an industrial sheet metal assembly operation were used to develop the laundering and dry cleaning procedures. Because of the heavy oily soil level (see photo) used for the screening test gloves, pre-wash/wash dry cleaning cycles using detergents (Attachment I) were used for all dry cleaning procedures. This process resulted in equivalent soil removal and minimized soil carry-over. The Stoddard solvent cleaning cycles were conducted by industrial laundries using standard commercial cycles.

Laundering has more possible cycle and chemical variables than dry cleaning. Phosphates, solvents, alkalinity, and temperature were evaluated. The screening tests showed that phosphates, high temperature and alkalinity were very beneficial in removing the soil. Although solvents may aid in soil removal, no major improvement was seen in the screening test. For this test both a high and low alkalinity formula were evaluated (Attachment II). Supply levels were increased beyond those normally used to assess the impact of the chemicals. Wash temperature was maintained at 170°F. The number of wash and rinse cycles was adjusted to give equivalent soil removal and remove residual chemicals. Because of the high supply levels used, and with a double suds/carry-over cycle, extra rinsing followed by addition of a sour was required to remove the residual alkalinity. Milder conditions will have less impact on glove characteristics and would shorten the wash procedure and cost.

The five different procedures selected for the long term cleaning evaluation were:

Dry Cleaning:	Stoddards 105 Solvent
	Stoddards 140 Solvent
	Perchloroethylene
Laundering:	Low Alkalinity, High Surfactant, Phosphated Formula
	High Alkalinity, Phosphated Detergent Formula