



DuPont™ Kevlar®

THE SCIENCE OF CUT PROTECTION



Kevlar®

Industry standards groups have made tremendous progress in testing and measuring the cut protective performance of gloves and apparel. DuPont has been a pioneer and active contributor to these efforts. It is now commonplace to have a wide range of performance data available for any protective apparel under consideration.

Although the availability of cut protection performance information is widespread, it is important to understand the different test methodologies in order to interpret the data and draw accurate conclusions. This guide is designed to provide specifiers with information of protective apparel that can help them make informed decisions about cut protective apparel performance. As a result, specifiers should take the time to better understand the sources of information and the critical factors that influence cut protection.

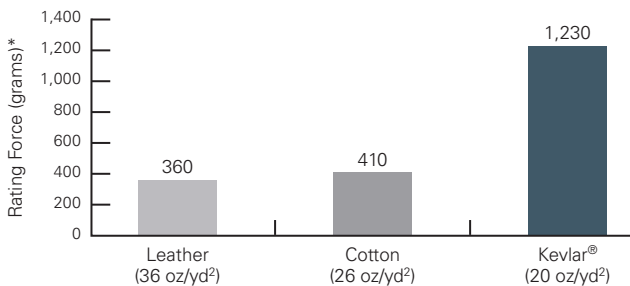
The keys to cut protection

Cut protection is a combination of many factors, not just the material of construction. Therefore, all of the following factors should be carefully considered when assessing the cut-resistant properties of a glove, particularly if you are developing a product specification:

Material of construction

(Kevlar® fiber, leather, cotton, steel, etc.) This has the greatest impact on the cut resistance of personal protective equipment.

DuPont™ Kevlar® is an ideal choice for cut-resistant protective apparel due to its strength, light weight and high degree of cut resistance, as illustrated in the chart below.



*Cut resistance measured in accordance with ASTM F1790-05 using samples from commercial gloves.

Basis weight (oz/yd²)

Defined as the fabric weight per unit area or areal density, not the overall glove weight. The higher the basis weight, the higher the cut resistance because there is more material present.

Fabric construction

Defined as the details of structure of fabric. Includes such information as types of knit or weave, threads/stitches per inch. This can affect yarn mobility and sample thickness, which can affect cut resistance.

Coatings (type and weight)

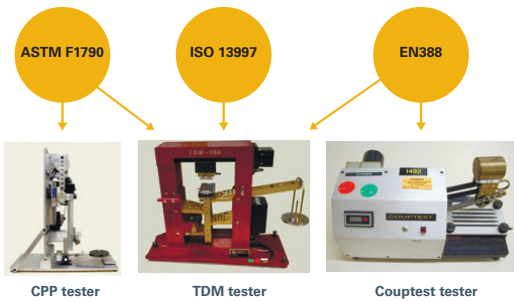
Some coatings are more cut resistant than others and thicker coatings provide more material to resist cut-through. However, it is important to note that in some cases, the application of a coating can actually decrease the cut resistance of an item slightly compared to its uncoated state. This phenomenon tends to occur with the application of thin coatings.

Remember, what protects people is an entire glove system, not just a single parameter. A complete hazard assessment should be done to ensure that the most appropriate glove is selected for your specific need.

THE SCIENCE OF CUT PROTECTION

Methods for testing cut resistance

Currently, there are three standardized methods for testing cut resistance: ASTM F1790 (U.S.), ISO 13997 (International) and EN 388 (Europe). Three types of cutting equipment are used to support these standards. The TDM tester can be used for each of these methods. ASTM F1790 also allows the use of the CPP tester and EN388 allows the use of the Couptest tester.



For the ASTM F1790 and ISO 13997 test methods, the sample is cut by a straight-edge blade, under load, that moves along a straight path. The sample is cut five times each at three different loads and the data is used to determine the required load to cut through the sample at a specified reference distance. This is referred to as the Rating Force or Cutting Force (Refer to Figure 1). The higher the Rating Force, the more cut-resistant the material. Neoprene rubber is used as the standard to evaluate blade sharpness.

In the EN 388 test method, a circular blade, under a fixed load, moves back and forth across the sample until cut-through is achieved. A cotton canvas fabric is used as the reference material. The reference material and test sample are cut alternately until at least five results are obtained. The cut resistance is a ratio of the number of cycles needed to cut through the test sample vs. the reference material. This is referred to as the cut index (Refer to Figure 2).

The higher the cut index, the more cut-resistant the material. EN 388 recommends using the ISO 13997 method for materials with very high cut resistance.

In 2005, the original ASTM F1790 standard (1997 test method) was revised to harmonize the ASTM cut method with the ISO cut test method. This has created confusion in the industry about these changes and their impact.

Figure 1. ASTM F1790-05 and ISO 13997 test methods

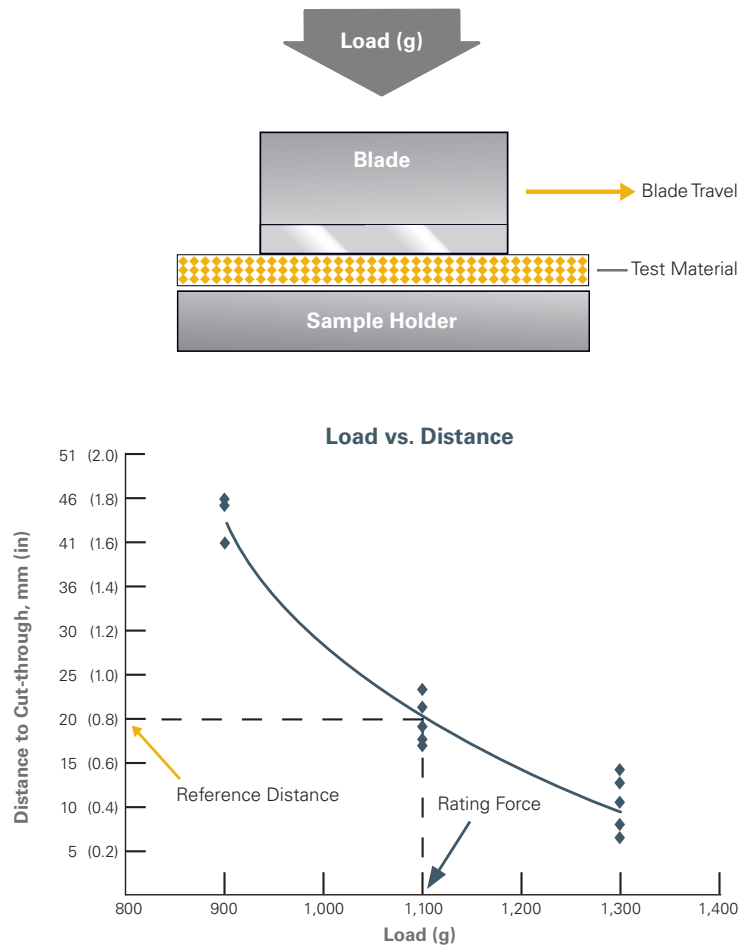
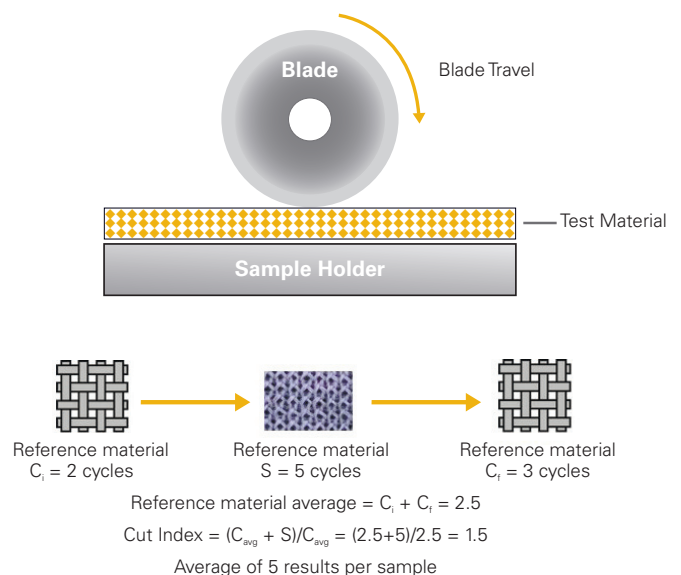


Figure 2. EN 388 test method



Changes to the original ASTM cut test method include:

Allowance for two cut testers

The original method, applied only to the CPPT. Now, the CPPT or the TDM can be used.

Addition of copper strip to sample mounting

There is no longer a need to cut through the mounting tape to register a result.

Different reference distance

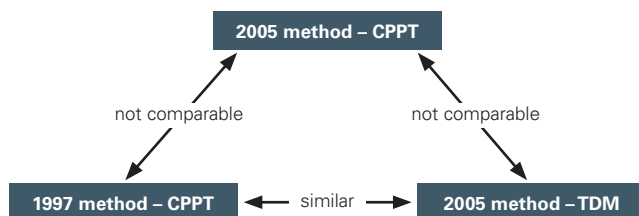
The reference distance was decreased from 25 mm (1.0 in) to 20 mm (0.8 in).

Modification of blade calibration

The calibration load was increased to 500 g and calibration distances were specified for each tester.

The impact of these changes was significant. The latest ASTM standard for measuring cut resistance is the 2005 method (ASTM F1790-05). When using a CPP tester with the ASTM F1790-05 method, cut resistance values are typically lower than the values obtained for the same sample using the original 1997 version and TDM tester values using the 2005 revision method. Although several factors could account for these differences, the primary cause for the lower values for the CPP tester does not require the blade to cut through the mounting tape to register a cut result (the 1997 method measures the cut resistance of the sample and mounting tape).

Comparison of results from the ASTM F1790 test methods



A good correlation has not been developed for the CPPT, TDM, 1997 method and 2005 method. As a result, those in the industry using the CPPT method have continued to use the 1997 method. This continued use is because a large amount of historical data is based on this procedure, literature and brochures are published using this information and cut values are understated relative to the TDM tester when using the 2005 method.

ASTM is actively working on a new revision(s) expected in 2012/2013 that addresses the issues related to the 1997 vs. 2005 methods and the CPPT vs. TDM cut measurement devices. A key consideration to these

revisions is current use; those industries that have the CPPT cut measurement device use the 1790-97 method, those industries that have the TDM cut measurement device use the 1790-05 method.

At present, information in the industry has been generated in a variety of ways. This makes it difficult to make accurate comparisons between various products.

Comparing cut-resistant values

When making direct comparisons between different finished products, it is essential to know the following:

- What is the test method?
- Which cut tester was used?

In order to make an effective comparison to specify a particular type/brand of material in the finished product you should also ask:

- Is the basis weight of each sample the same?
- Were sample constructions the same (e.g., string knit vs. string knit)?

You cannot accurately compare the cut resistance of different base materials in the different finished products unless the answer to all of the above questions is YES!

Ideally, the samples should be tested in the same laboratory to obtain the most accurate comparison.

Hand protection and industry standards and levels

ANSI/ISEA 105 "American National Standard for Hand Protection" defines levels for the mechanical, thermal, chemical and dexterity performance of hand and arm personal protective equipment (PPE). Performance levels for cut resistance are specified in this standard (Refer to Table 1).

2005 method – CPPT not comparable
1997 method – CPPT similar
2005 method – TDM

Some PPE manufacturers will refer to the ANSI/ISEA 105 performance level category for the cut resistance of their product instead of the absolute value. This is an acceptable practice; however, it does not provide complete information to adequately compare the performance of different products within the same performance level.

It's important to understand that products classified within the same performance level are not necessarily equal. Levels span a wide range of performance values to make them practical.

Table 1. ANSI/ISEA 105 performance levels for cut resistance

Performance Level	Weight (g) needed to cut through material with 25-mm (1.0 in.) blade travel for CPPT cut measurement device using the 1790-97 method or Weight (g) needed to cut through material with 20-mm (0.8 in.) blade travel for TDM cut measurement device using the 1790-05 method
0	0–199
1	200–499
2	500–999
3	1,000–1,499
4	1,500–3,499
5	3,500+

Level ratings give a good idea of the general performance of a glove or sleeve, but the actual cut performance values should be used when comparing products, particularly if they fall into the same or adjacent performance levels.

Consider this example: if the cut-off limit between level 1 and level 2 is a rating force of 500 g, a glove with a rating force of 499 g will be classified as level 1, while a different glove with a rating of 501 g is classified as level 2. Clearly these products have equivalent performance. On the other hand, the glove with a rating force of 501 g will fall into the same level as a glove with a rating force of 980 g. Would you really want to use these two gloves interchangeably?

The ANSI/ISEA 105 cut performance levels were revised in 2011 to include both ASTM F1790-97 and ASTM F1790-05 methods. Discussed earlier, the accommodation reflects current use in the Industry and cut machine bias within the ASTM 1790-05 method. Although the accommodation could be considered less than optimal, it was judged to be the best compromise until a new cut standard revision(s) is made.

Additional confusion is generated when comparing performance levels of gloves between the European standard EN388, “Protective Gloves Against Mechanical Risks” (Refer to Table 2) and the ANSI/ISEA 105 Hand Protection Standard. Adding to the confusions is they

both have similar performance levels; levels 1–5 for EN 388 and levels 0-5 for ANSI/ISEA. These EN 388 and ANSI/ISEA cut levels are not interchangeable.

The range of the levels and mechanism by which the materials are tested are different. For ASTM and ISO methods, load is varied to calculate the reference cut through distance at 20 or 25 mm. For low cut resistant materials, low loads are used to generate cut through at the reference distance. Conversely, for high cut resistant materials, high loads are used to generate cut through at the reference distance.

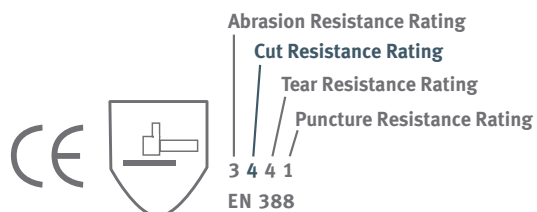
The EN 388 method uses a fixed 500 gram load for a range of low to high cut resistant materials. The difference between low and high cut resistant materials is measured by the number of cycles required to cut through the material. The mechanism by which the material is cut is different and includes cut and abrasion of the material. A provision allowing use of the ISO method for levels 4 and 5 helps in reducing the difference.

In summary, when discussing product performance levels, make sure you clarify which standard is being used. Also, be aware that even though EN 388 is a European standard, Global PPE manufacturers may refer to these levels on their product packaging, in their literature and on their web sites.

Table 2. EN 388 performance levels for cut resistance

Performance Level	Blade Cut Resistance (cut index)
1	1.2–2.4
2	2.5–4.9
3	5.0–9.9
4	10.0–19.9
5	20–

EN symbol used to describe performance of gloves rated for mechanical hazard protection.



PRODUCT SAFETY INFORMATION IS AVAILABLE UPON REQUEST. This information corresponds to our current knowledge on the subject. It is offered solely to provide possible suggestions for your own determinations. It is not intended, however, to substitute for any testing you may need to conduct to determine for yourself the suitability of our products for your particular purposes. It is the user's responsibility to determine the level of risk and the proper protective equipment needed for the user's particular purposes. The information may be subject to revision as new knowledge and experience becomes available. Since we cannot anticipate all variations in actual end-use conditions, DUPONT MAKES NO WARRANTIES AND ASSUMES NO LIABILITY IN CONNECTION WITH ANY USE OF THIS INFORMATION. Nothing in this publication is to be considered as a license to operate under or a recommendation to infringe any trademark or patent right.

Copyright © 2012 DuPont. The DuPont Oval Logo, DuPont™, The miracles of science™ and Kevlar® are trademarks or registered trademarks of E.I. du Pont de Nemours and Company or its affiliates. All rights reserved. K-17438-1 05/12

DuPont Personal Protection

Customer Service:

United States 1-800-931-3456

Canada 1-800-387-9326

Mexico (52) 55 57 22 1222

PersonalProtection.DuPont.com



The miracles of science™