



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 help specifiers of protective apparel 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. Recent changes to some of the test methods make this imperative.

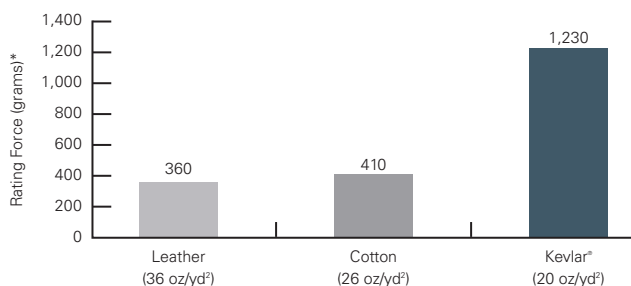
### The keys to cut protection

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®, 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, 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)

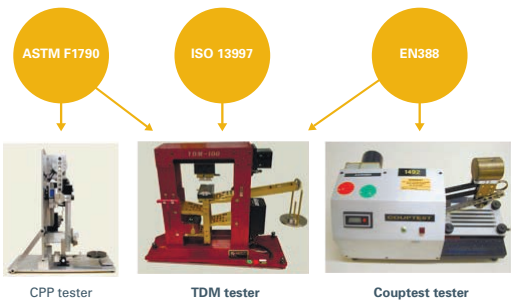
Some coatings are more cut resistant than others and thicker coatings provide more material to resist cut-through. However, it is important to note that in some cases, the application of a coating can actually *decrease* the cut resistance of an item slightly compared to its uncoated state. This phenomenon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

Remember, what protects people is an entire glove system, not just a single parameter. You should perform a complete hazard assessment to ensure that you select the most appropriate glove 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 cut testing equipment are used to support these standards. The TDM tester can be used for each of these methods. However, ASTM F1790 also allows the use of the CPP tester and EN388 allows the use of the Couptest tester.



In 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 reference distance of 20 mm (0.8 in.). 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).

Figure 1. ASTM F1790 and ISO 13997 test methods

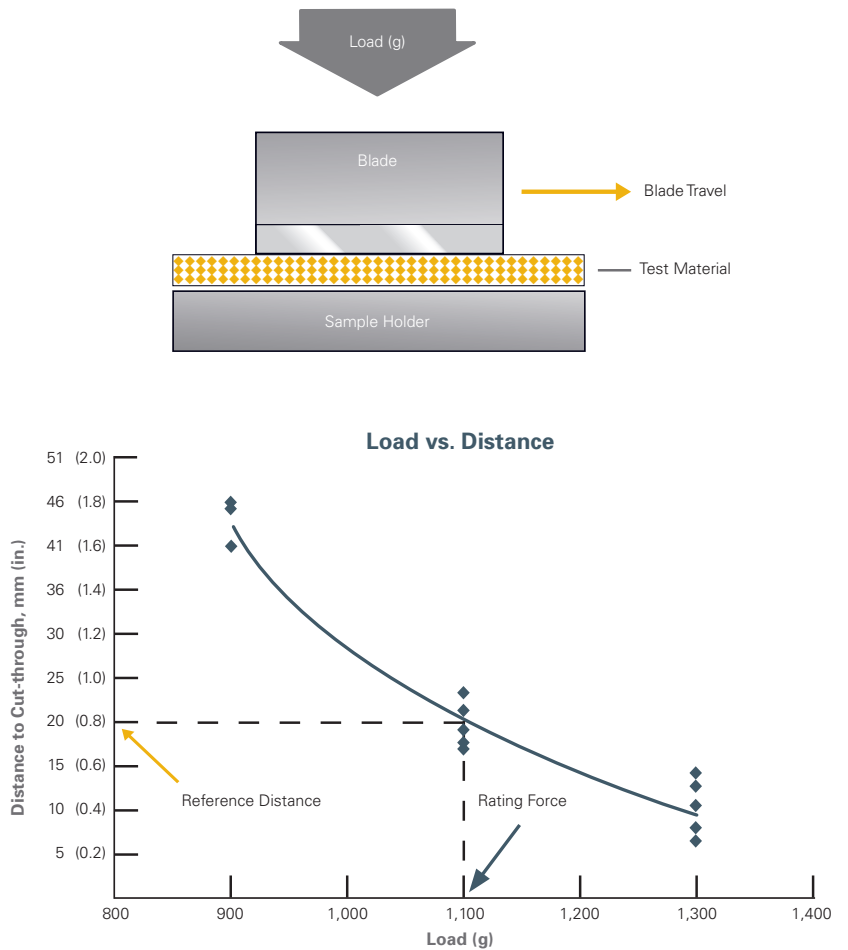
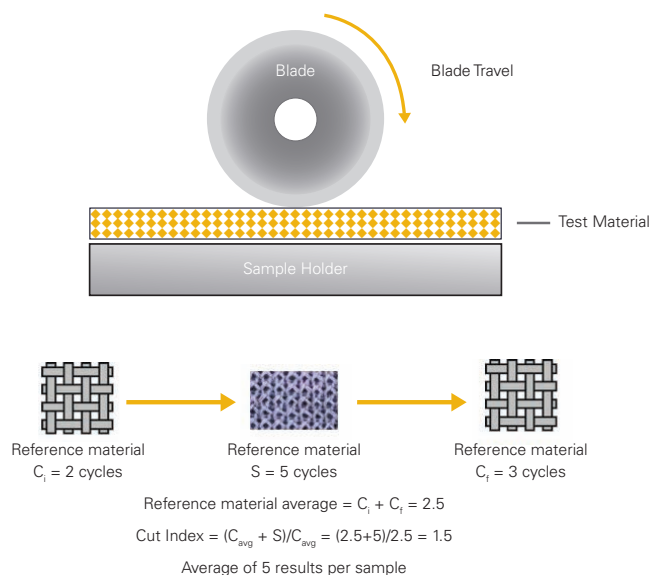


Figure 2. EN 388 test method



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.

Several years ago, the original ASTM F1790 standard (1997 test method) was changed to address concerns regarding the sample mounting and to harmonize with the ISO cut test method. As a result, there is some confusion in the industry about these changes and their impact.

Basically, all major changes to the ASTM cut test method were implemented in the 2004 version included:

#### Allowance of multiple testers

In the old version, only the CPPT could be used. 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.

#### Decrease of reference distance

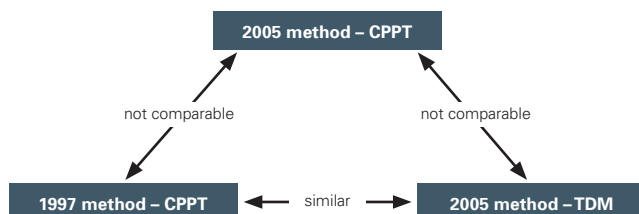
The reference distance was decreased from 25 mm (1.0 in.) to 20 mm (0.8 in.).

#### 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 has been significant. Currently, the active ASTM standard for measuring cut resistance is the 2005 method (ASTM F1790-05). When using a CPP tester, cut resistance values obtained using the 2005 version of ASTM F1790 are typically lower than the values obtained for the same sample using the 1997 version. This is primarily because the 2005 method does not require the blade to cut through the mounting tape to register a result. Values generated using the 1997 method are measurements of the cut resistance of the sample *and* the 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, some people in the industry have been reluctant to discontinue use of the 1997 method because a large amount of their historical data is based on this procedure. Their position is strengthened by the fact that the 1997 method is referenced in an industry hand protection performance standard.

Although ASTM is continually working to improve the test method and its application, at present there is a lot of information in the industry that 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).

**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
0	0–199
1	200–499
2	500–999
3	1,000–1,499
4	1,500–3,499
5	3,500–

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 enough information to adequately compare the performance of different products.

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.

Level ratings give a good idea of the general performance of a glove or sleeve, but the actual 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?

To add to the complexity, the ANSI/ISEA 105 cut performance levels are based on values obtained using the ASTM F1790-97 method. As previously stated, the changes implemented in the 2005 version of this standard result in different values than those obtained using the 1997 version. Therefore, **the levels in ANSI/ISEA 105 should not be used to rank the performance of samples unless they were tested using ASTM F1790-97.**

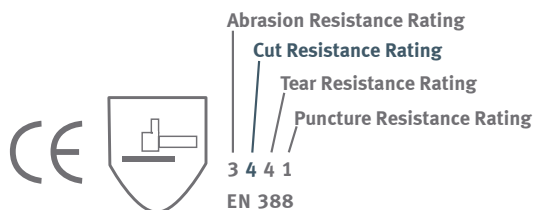
An additional cause for confusion when comparing performance levels of gloves is the fact that the European standard EN388, "Protective Gloves Against Mechanical Risks" uses different level groupings (Refer to Table 2) and a completely different method of testing than ANSI/ISEA 105. **EN 388 and ANSI/ISEA cut levels are not interchangeable.**

Therefore, when discussing product performance levels, make sure you clarify which standard is being used. Also, be aware that even though EN388 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.**



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DuPont Personal Protection

Customer Service:

United States 1-800-931-3456

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