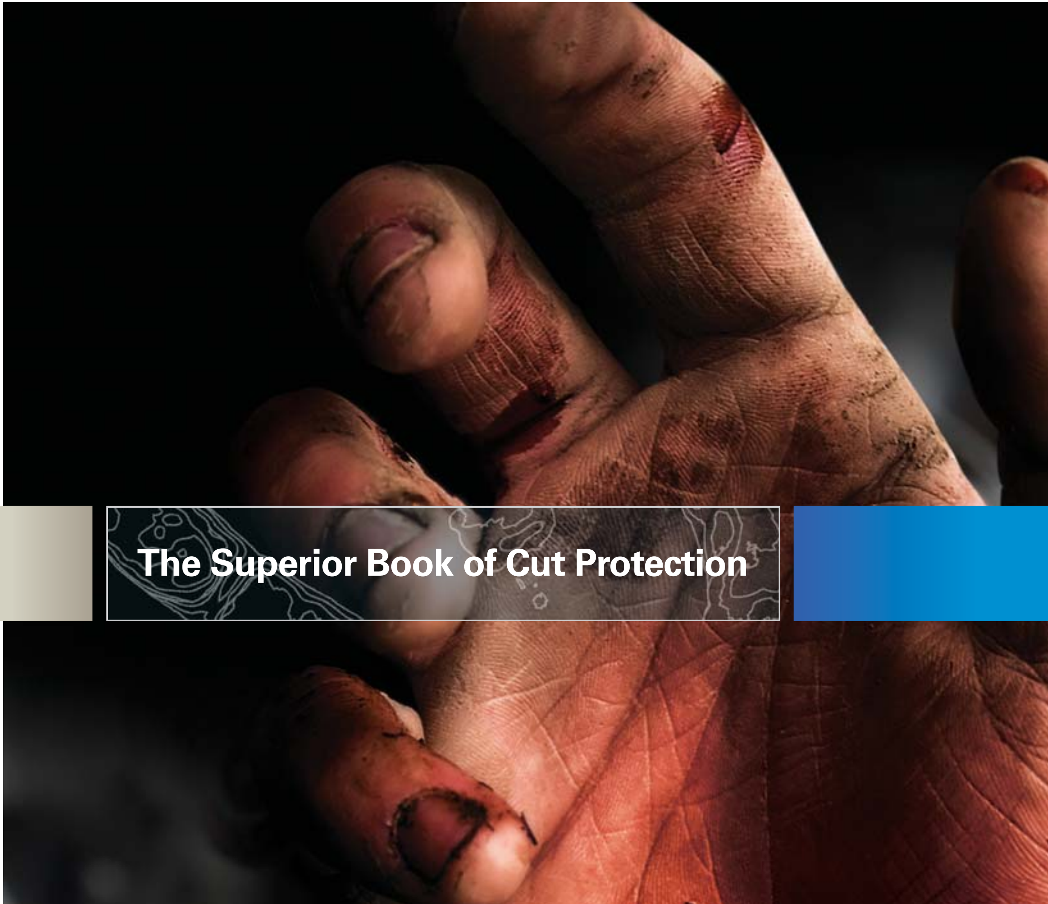
The Superior Book of Cut Protection



Workplace Hand Injury: Facts

- In a recent **U.S. Department of Labor study**, injuries to fingers and hands ranked in workplace accidents—more than 23% - making them the highest in preventable injuries. And in terms of lost workdays, they ranked second only to back and neck injuries. It was found that a vast majority of employees who suffered hand injuries were not wearing gloves at the time, and that many of those injured were wearing the wrong kind of gloves.
- Data from the **Bureau of Labor Statistics** support the above statement regarding non-use of gloves. As a result of non-compliance, hand injuries have increased more than two-and-a-half times. Medical costs and disability claims have escalated rapidly, and the cost of a single injury multiplies with each workday missed. **A National Safety Council study reports** that the cost of just one disabling hand or finger injury varies from $540 to $26,000 per patient, with a serious upper-extremity trauma averaging $730,000 per incident.
- According to a recent **Occupational Safety and Health Administration (OSHA) study**, 70.9% of arm and hand injuries could have been prevented with personal protective equipment (PPE), specifically safety gloves. At a major U.S. automotive assembly plant, the standard hand protection supplied to body shop workers (who routinely handled sharp-edged metal parts) was cotton and leather. Not surprisingly, 90% of the disabling injuries they sustained were hand and arm cuts. Plant officials estimated that the average cost per injury was $2,100.

Each fact above illustrates clearly why education about cut protection is so important. When it comes to choosing hand protection, the gulf between inadequate traditional materials and advanced scientific fibers is ultimately a battle between old perceptions and the right information. This book is intended to function as a reference guide for those searching for

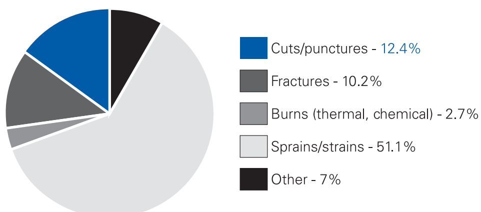
Workplace Hand Injury: Figures

Cut-resistance Statistics: Getting a Perspective.

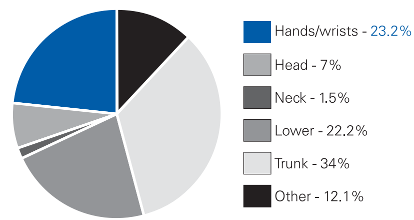
The first chart illustrates, in percentage terms, the incidence of cut injury to workers in the U.S. for the year 2006 - relative to other types of non-fatal injury. The second chart illustrates (also for the U.S. in 2006) the percentage of injury that occurs to the hands and fingers in the workplace - relative to other body parts. Both charts utilize only lost-time injury statistics.

When looking at the percentages, it is important to consider that not all injuries are preventable through the use of PPE, such as back injuries. Hand and finger cut injuries, however, are the most preventable.

Percentage of injuries, to the hand by type of injury U.S., 2006



Percentage of injuries, by body part U.S., 2006



Best Practice In Reducing Hand Injuries

by **Joe Tavenner,** CSP, CFPS

It's a common joke that duct tape can fix anything. We often believe our hands can do the same. When we don't have a wrench, our hands fit the bill. Can't get into a location with a standard tool? Our hands can get into the tight spot and fix the problem.

When our hands become our universal 'duct tape', we increase the risk of injury by losing focus. To reduce the risk of injury, one should take the following steps:

1. Find the right gloves
2. Keep your eyes on your hands
3. Make it visible
4. Utilize end-user leading indicators

Find The Right Gloves

Find an Expert

Safety gloves have been evolving quickly over the last few years. The number of options you have today far exceed those of just a few years ago. To ensure you have the best combination of protection and value, find an expert. Finding a salesperson who specializes, understands and has the knowledge to provide the best that's out there is a key component to reducing hand injuries.

Try, Try, Try

Have employees try gloves being considered for an extended period of time, asking for feedback along the way. Getting feedback from users involves them in the process, thereby increasing ownership. In many cases, the difference between a successful implementation and an unsuccessful one can be the amount of ownership employees feel they have. If you involve them in the decision-making process, address concerns, and utilize their feedback, a smooth transition often follows.

Say 'Thank You'

It is very easy to get caught up in day-to-day activities and forget to say thank you. When you have employees that take the time to help support the glove evaluation process, don't forget to say thank you. Often, small rewards, provided frequently, can keep them feeling valued and drive participation.

Stock Your Gloves

Many times we put all our effort into finding the right glove and forget to make it easy for users to access them. When employees can't find required gloves, their perception soon becomes negative, and a disconnect develops between management expectations and employee perceptions. Developing a successful glove-stocking program is critical to reducing hand injuries.

Keep Your Eye On The Hand

Many times, hand injuries occur when we take our eyes off the task. This is as simple as putting our hands into areas we don't have a line of sight of. To stay focused on the task, a mental checklist should be used. By taking the time to think through the task beforehand, safe alternatives can be considered. This 'visualization' technique is both tried and true. Some examples:

Do you have all the needed tools for the job? When you don't have the tools you need, it is common practice to substitute your hands. Think about what you need before you start the job. If you don't, your hand could quickly become the tool of choice.

Can you see your hands during the task? When one hand is out of sight, it can quickly enter pinch points or other high-risk areas. This is especially true when using two hands to complete a task while focusing your attention on only one. Think about what could go wrong and plan for it. You may think this is simplistic but it happens all the time.

Are good, safe practices being used? Following your business and regulatory requirements is a cornerstone of staying safe.

Make It Visible

When driving in a car, a red light means stop and a green light means go. When you see these colors, you react appropriately to avoid accidents. You can use the same methodology to reinforce safe behaviors.

When looking at the source of many lacerations, box-style knives are often brought up. In recent years, many styles have been developed that offer advanced safety features. While these are great solutions, you may want to consider adding a color trigger. Paint it red to let everyone know they are dangerous. Implement a slogan and develop a sustainable communication program to build repetition into the message. As the system matures, build on it to address new challenges.

Making high-risk tasks visible can help remind employees to stay focused on the task. Consistently repeating why they have been painted and how you want at-risk employees to behave keeps the message fresh on their minds. As the program grows, it soon becomes an easy way to remind employees to stay safe.

Utilize End-User Leading Indicators

When focusing on hand injuries, one of the best ways to help drive improvements is to develop leading indicators to measure them. Typically, leading indicators might involve looking at how many employees are wearing the proper hand protection or other like method. While that is valuable information, it typically yields a number that is meaningful to management but meaningless to end-user employees. Those that are at the most risk feel little-to-no ownership in the numbers being generated.

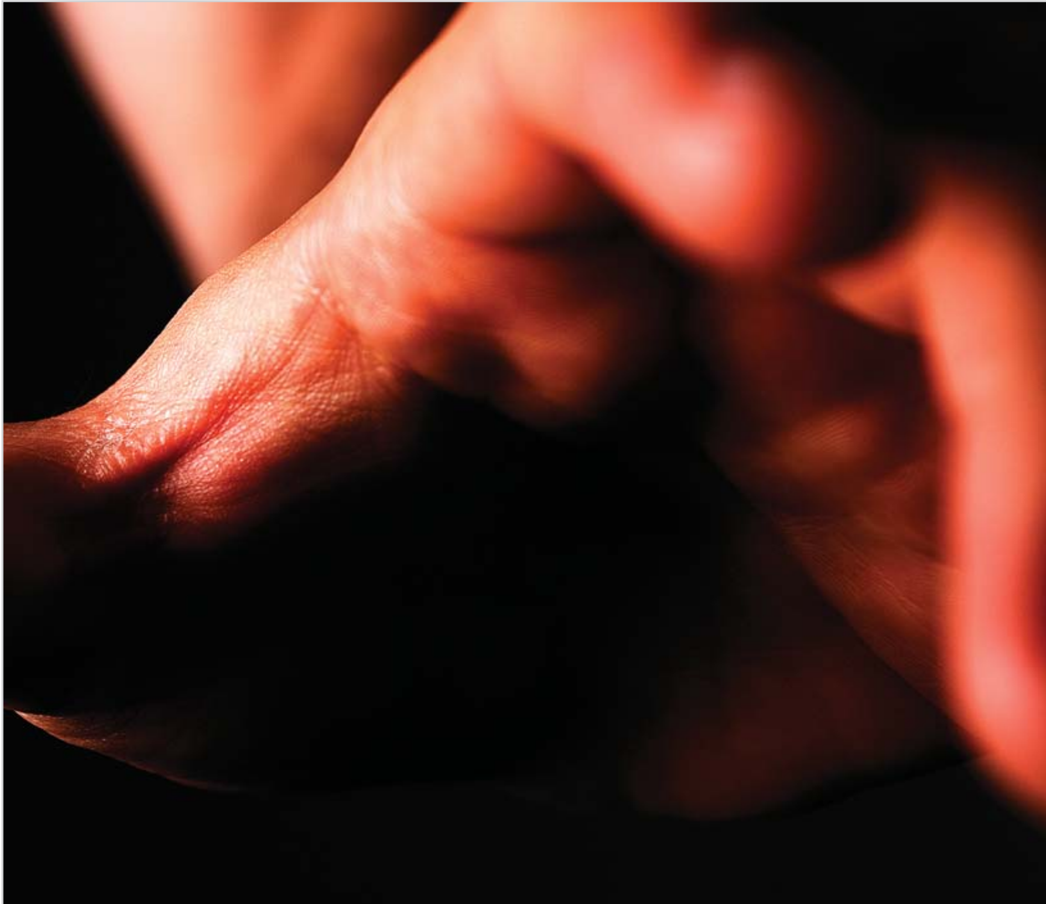
Consider bridging the gap by generating end-user leading indicators. When you develop metrics that have meaning to end users, it is very easy for them to get involved and drive safe behaviors. An example of an end-user leading indicator might be how many box-knife red lights were found during housekeeping inspections. As we reviewed above, we identified red with box knives, developed a slogan to communicate expectations and now measure it with a leading indicator called 'red lights'.

By using an end-user leading indicator, you close the loop in the implementation process by generating data that is easily understood and supported by all employees.

Conclusion

None of the approaches outlined in this article are meant to replace regulatory obligations or good, standard-operating procedures. However, supplementing your existing programs with solid approaches can help reduce hand injuries. Consider further developing these concepts to fit your organization's needs.

Joe Tavenner CSP, CFPS has years of experience, a bachelors and Masters degree in Occupational Safety Management and an MBA in Management. For more information contact him at josephtavenner@yahoo.com



Engineered (Composite) Yarns

by **John Simmons** of World Fibers

Engineered composite yarns are yarns made with two or more components (i.e Kevlar® and steel). These yarns have allowed glove manufacturers to make gloves with higher levels of cut resistance, without sacrificing comfort or dexterity, than with high-strength fibers, such as Kevlar® or Dyneema® alone.

Cut resistance in knitted gloves is influenced by four factors:

1. Strength: Examples of high-strength yarns would be Dyneema® or Kevlar®
2. Hardness (dulling): An example of hard yarn would be stainless steel, which is often a primary component in composite yarns.
3. Lubricity (slickness): slippery yarns such as Spectra® or Dyneema® allow a blade to slide over their surface without cutting through.
4. Rolling action (knit construction) : Most knit gloves allow the individual yarns to 'roll' as a sharp edge slides over them, producing somewhat of a ball-bearing effect. The edge slides across without cutting through the material.

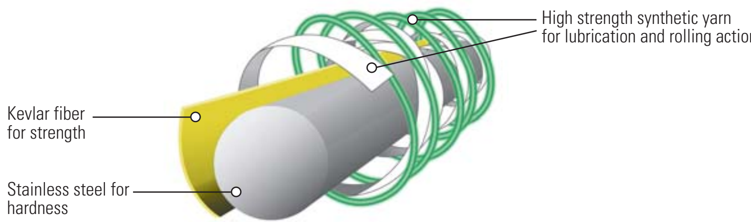
Typically, the more of these factors that can be engineered into a yarn, the more cut resistant it will be.

For example, an engineered yarn may consist of high molecular-weight polyethylene (HMPE) such as Dyneema®, which is both high strength and slick; and stainless steel, which is hard, and then knit in to a seamless glove, which provides 'rolling'. Taken together, these characteristics result in a material that is far more cut resistant than a material made with only one component.

Engineered Yarns

Further design considerations may be color, grip, moisture management, or other characteristics that engineered yarns can provide in a special-purpose glove.

Advanced Composite Yarn



Engineered yarns are typically used in applications requiring higher levels of cut resistance (ASTM Level 3 or higher), such as sharp or heavy sheet-metal handling, glass handling, or meat processing where sharp blades are used.

The Revolution in Cut Protection

By **Tony Geng**, President, Superior Glove Works Ltd.

Ask the average person on the street to describe a work glove, and they will likely describe something that looks like a garden glove, or the gloves they see in the big-box home- improvement stores. Ten years ago, the gloves they described would have been very different. The typical gardening glove was largely unchanged for fifty years, and now in the last decade, it is likely a seamless knit with a latex palm coat. Gloves popular with the DIY market now are form-fitting, mechanics-style gloves which did not exist ten years ago. These are not just cosmetic changes in styles and colors; these are fundamentally different constructions, resulting in better gloves for the job at hand in every measure of the word.The same revolution in hand protection for the home market has also taken place in the work world. Increasingly, the gloves you see in factories and at job sites around North America are not the same glove styles we grew up with.

So, what types of hand injuries do people sustain at work? After sprains and strains, the second most common hand injuries are cuts and lacerations. Thankfully though, tremendous strides have been made in the last few years in developing new cut-resistant gloves. To put it simply, your father would not recognize the new work gloves on the market today. In fact, these are not even your older brother's gloves.

Today's cut-resistant gloves are made from space-age materials that have revolutionized hand protection. Gloves utilizing materials that are ten-times stronger than steel, on an equal-weight basis. Gloves made from the strongest fibers known to man, some of which are so lightweight and dexterous, you can pick up a dime; yet are so cut resistant that they withstand repeated slashes from a box cutter. If this is sounding like science fiction to you, then you have not kept up with the advances in glove materials and technology in this new century.

Leather gloves - once the ‘king’ of work gloves - used to dominate all medium- and heavy-duty jobs. Cotton canvas - the ‘prince’ of gloves - was the undisputed choice for lighter-duty work. These gloves now account for about twenty-five percent of work-glove sales, a percentage that continues to drop year after year. Cost is a major factor among the reasons why: leather is a pricey material. And cotton canvas, while not expensive, is a labor-intensive glove style that has now been largely replaced by more cost-effective, string-knit glove styles.

It is, however, performance that is the bigger reason. For the important issue of cut protection, leather cannot hold a candle to the new glove materials. We think of leather as very tough and strong; after all, look at cowboys or motorcycle riders. Why do they continue to wear protective apparel made of it? Well, for abrasion, leather is hard to improve on. If you fall off a motorcycle at sixty miles per hour and are skidding across the pavement, it is indeed a very good material to be wearing. But for cut protection, it is no better than the skin on your hand - which is to say, very poor.

Kevlar® and Dyneema® are two competing materials you see a lot of work gloves being made from now. Both offer five-to-ten times the cut protection of leather. These space-age materials are both used in bullet-proof vests, and both are considerably stronger than steel on an equal-weight basis. Leaf through any safety magazine and you’ll encounter many pages advertising new glove styles made from these cutting-edge materials, few of which were available prior to the year 2000.
Very recently, the bar of cut resistance was raised even higher in hand protection, with the advent of more styles incorporating stainless steel into both Kevlar® and Dyneema®.

All of which might prompt you to ask: if Kevlar® and Dyneema® are stronger than steel, how would adding steel improve the overall cut resistance? Well, there are several reasons. For one, the claim of being stronger than steel is always prefaced by the words 'on an equal-weight basis'. But on a cross-sectional basis, steel wire is stronger than the equal volume of Kevlar® or Dyneema®. To put it a different way, pound for pound, Kevlar® is much stronger than steel, but a steel-mesh glove - though heavy - is stronger than a Kevlar® glove. Also, by engineering how these cut-resistant materials are twisted and plied together, textile engineers are able to get higher cut-resistance values than the sum of their parts would suggest. One can think of it as reinforcing concrete with steel rebar, making something already strong even stronger.

There are Kevlar®/steel and Dyneema®/steel combination gloves on the market now, offering twenty times the cut resistance of comparable-weight leather gloves. Now if that's not a revolution in hand protection, what is?

Material	**Cut Resistance**	**Abrasion**	**Grip (w/o coating)**	**Comfort**	**Heat Resistance**
Cotton	✷	✷ ✷	✷ ✷	✷ ✷	✷
Leather		✷ ✷ ✷ ✷	✷ ✷ ✷	✷	✷ ✷
Kevlar®	✷ ✷ ✷	✷ ✷ ✷	✷ ✷	✷ ✷ ✷ ✷	✷ ✷ ✷ ✷
Dyneema®	✷ ✷ ✷	✷ ✷ ✷ ✷	✷	✷ ✷ ✷ ✷	
Kevlar® Steel	✷ ✷ ✷ ✷	✷ ✷ ✷	✷ ✷	✷ ✷	✷ ✷ ✷
Dyneema® Steel	✷ ✷ ✷ ✷	✷ ✷ ✷ ✷	✷	✷ ✷	

Effects of Laundering on Cut Resistance

When a glove is described as being 'inherently' cut-resistant, it means that this protection is not simply on the surface, but rather, a characteristic of the fiber itself, and therefore throughout the glove.

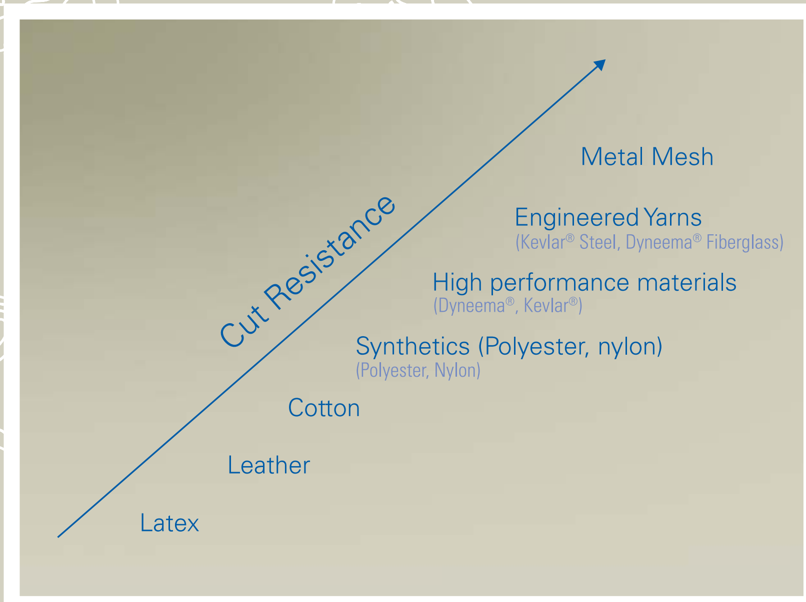
Kevlar®:

Laundering and dry cleaning have no significant impact on the cut resistance of gloves made of 100% DuPont™ Kevlar®, even after 10 consecutive cleaning cycles. A typical glove is expected to undergo less than ten cleaning cycles due to normal wear and tear. Shrinkage, weight loss, changes in yarn tensile strength and changes in color related to staining from soil or the cleaning method may be observed. Although the strength of Kevlar® yarns used in protective apparel, e.g. gloves, gradually decreases with successive cleaning cycles, the cut resistance is not impacted. The most important thing to remember is that Kevlar® will break down completely when exposed to bleach.

Dyneema®:

Thanks to its chemical structure Dyneema® is inert to most kind of aggressive agents used in industrial laundering and environmental influences such as UV. This enables you to wash Dyneema® under the most harsh conditions, such as dry cleaning and bleaching without affecting the specific properties of Dyneema®. Standard chemicals, typically used in industrial laundering such as detergents, ammonium, sodium hydroxides, hydrochloric acid, etc, do not affect the performances of the Dyneema® fiber. The most important thing to remember is that Dyneema® has a very low melt point, and cannot be laundered or dryed using temperatures greater than 145°C.

Chart Ranking Material Strengths



Cut Resistance Myths

by **Joe Geng**, Vice-president, Superior Glove Works Ltd.

1) **The number-one misconception our company runs into is the notion that leather is cut resistant**. The fact is, leather has even lower cut resistance than cotton. In other words, if you're handling sheet metal, and you have a choice between your average leather glove and a dish towel wrapped around your hands, you should go with the dish towel. Well, that's an exaggeration, but you get the point. To look at it another way, the primary reason you need cut-resistant gloves is because your skin cuts very easily. And, since leather is just the skin of an animal, it cuts just about as easily.

2) **Gloves made from Kevlar® and Dyneema® are cut proof.** Sometimes we run into the attitude that wearing a pair of Kevlar® gloves will make you invincible. This leads to workers becoming overly confident and endangering themselves by performing tasks they would not otherwise perform.

   We won't ever use the words 'cut-proof' to describe gloves. Nothing is cut proof, especially not a material you could hope to move your hand in. However, technology companies have brought us new materials that are amazingly strong and 'cut *resistant*'.

3) **Cut-resistant gloves are too expensive.** We encounter this objection all the time. Frankly, if you do the math, it doesn't hold up to analysis. Given the wages paid and the sheer productivity involved, it is highly worthwhile to consider the following:

- On average, automotive workers earn $33.90/hr.
- Hand injuries are the #2 leading cause of work-related injury and the most preventable.
- The average reported hand injury results in 6.1 days off work

- The average cotton glove costs 80¢ a pair
- The average leather glove costs $1.60
- The average Kevlar® glove costs $6 a pair

During a 10-week trial at a plant, (see Kevlar®case study on page 34) money spent on Kevlar® totalled $2,187, while the combined cost for the cotton and leather gloves used was $2,904. More importantly though, no hand injuries occurred when workers wore the Kevlar® gloves. Despite the higher purchase price, gloves made with Kevlar® saved 25% in total costs.

Kevlar® gloves last twice as long as cotton, and three times as long as leather. When tested in DuPont's 'torture chamber', which involves placing a variety of gloves full of beads into a sealed, rotating drum studded with razor blades, the Kevlar® glove out-lasted the other two gloves significantly, at an approximate ratio of twenty to one. Any way you slice it, if your workers are experiencing cuts, using cut-resistant gloves will save you a lot of money, as well as trauma. This is comparable to buying a luxury vehicle and never going for an oil change because you want to save $20-30.

4) **These gloves aren't cut resistant. I cut them with a pair of scissors.** Cutting fabric or yarn with a pair of scissors involves 'shear'. This is a very different force from the slicing type of cut faced in industrial applications. Scissors cut material by applying a local shear stress at the cutting location which exceeds the material's shear strength. They don't penetrate like a knife, since the material is cut on both sides between two knife-sharp straight edges that are perfectly aligned. A knife cuts using pressure and tearing actions created by a wedge with an edge.

5) **Strength = cut resistance.** Kevlar® is a case in point. Kevlar® glove supporters are quick to point out that cut resistance and the breaking strength of a yarn don't have a

direct correlation. For cut resistance, which is the property you really want in a glove, Kevlar® and Dyneema® are neck and neck. So when making the choice between the two for a glove application, it is often helpful to look at secondary issues, like whether there is heat or abrasion involved in the job application, as heat favors the choice of Kevlar® and abrasion the choice of Dyneema®.

6) **Another misconception: if <u>some</u> cut-resistant material is good, then <u>more</u> must be better.** This is not true, since highly engineered fibers are designed to reduce bulk and discomfort to a minimum in order to increase worker comfort and dexterity, which in turn increases compliance. The equation is simple: reduce worker injury, reduce costs.

7) **The use of fiberglass in gloves: fact vs. fiction.** One of the most misunderstood products on the industrial PPE market today is the fiberglass glove. The addition of fiberglass alone to yarns like nylon or polyester to increase cut-resistance is not only ineffective, but misleading. You have to know all the facts. Fiberglass does indeed add a tremendous amount of cut resistance to gloves. It has a high strength-to-weight ratio, and when used in textiles, withstands the multi-directional movement of knits, adding strength without additional bulk or weight. But, it is glass, and has some obvious limitations like brittleness. Simply put, glass of any size and form breaks down under impact. So, in the case of fiberglass-nylon gloves that are promoted as cut resistant, breakdown occurs when the forces of pressure and cut are applied. The type of cut test applied to such gloves invariably yields impressive ratings. The lab results look great, but the field results are disappointing. More than that though, they are potentially dangerous.

Myths

The truth about such gloves is that cutting them is alarmingly easy. Ratings achieved with the test used are one-dimensional, since it is the only cut test applied, resulting in a false sense of security for potential buyers and end-users.

Fiberglass yarns, in reality, rely completely on the support of other fibers in order not to break down. Continuous-filament fibers – such as Dyneema® - both support and protect the glass when wrapped around it. The basic structure of this class of high-strength yarns is long continuous strands created through extrusion, rather than spinning, (think of a monofilament such as fishing line) so that when used to wrap a brittle substance like glass, it not only supports the glass, but results in a slippery surface. Cut resistance is increased dramatically because a sharp edge will tend to slide across the slippery surface. Abrasion is very low with continuous-filament yarns, so glass stays in place too, and will not break down as quickly with this reduced impact and low abrasion.

As with any product on the PPE market today, it is ultimately education that protects us the best. The revolution in high-tech fibers becomes meaningless without a solid understanding of each fiber's specific applications, either on their own, or when combined with other materials and coatings. The use of fiberglass for increased cut resistance in gloves is a case in point.

Tips for Cut-resistant Glove Selection

by **Joe Geng**, vice-president, Superior Glove Works Ltd.

If you're reading this, there's a good chance your hand-protection program is falling short of expectations, or at least could stand some improvement. Two indicators that your hand-protection program isn't working, are lack of improvement OR increases in the following areas:

– number of injuries
– lost work hours

If this is the case, either the hand protection provided to your workers is inadequate, or they aren't wearing the gloves you have selected.

1) **The first step** is to determine the cut protection provided by your current gloves. A good glove manufacturer should be able to test your current hand protection to give you the cut-protection measurement in grams. We've found from experience that it is also a good idea to measure abrasion resistance, as this greatly affects how well the gloves will protect your employees over the long haul, and will provide you with a benchmark for improvement.

2) **Select a few styles for trial.** We recommend selecting two to five glove styles for your initial trial. Any more than five can get too confusing to track effectively. A good glove manufacturer and safety distributor will be able to help you in this process. You should look at the cut-protection numbers for each style (provided in grams) as well as the abrasion resistance. If your current hand protection is not up to snuff, choose gloves that have higher cut/abrasion test results than your current glove. I recommend selecting one glove with fifteen-percent higher cut resistance or more than the

incumbent, and one with thirty-percent or more increased abrasion resistance. This will help isolate the issue and prevent you from spending big bucks on a super cut-resistant glove, when more abrasion resistance is actually what's needed.

3) **Choose a variety.** Your application will determine the type of glove you choose. (For example, a foam-nitrile glove is a good option in oily applications.) As much as possible, choose a range of gloves such as dotted, leather palm, palm-coated, regular string knit, etc. to determine which style works best in your application. Too often, hand-protection decisions are made based on tradition, such as "We've been using this type of bulky, uncomfortable glove for the last twenty-plus years. We need another bulky uncomfortable glove to do the job." Not true, so make sure you don't fall into this type of thinking. Your safety distributor and glove manufacturer should be able to provide helpful advice as well.

4) **Don't underestimate fit.** Now that you've done your numerical glove homework, it's important to remember the 'soft' analysis. Without question, the single-most important factors in a successful glove program are the comfort and fit of the gloves chosen. Endless safety talks, rewards, punishments etc. will not succeed in getting a worker to wear a bulky glove when he is trying to pick up a small bolt or handle a small tool. If you choose a glove that is comfortable, conforms to the hand, and when wearing would allow you to tie your shoes or dial your cell phone, you will have contributed the single most important factor to your glove program. Several years ago, cut resistance meant wearing a clown-sized leather or cotton glove, but advancements in yarn science and glove manufacturing have allowed the words 'cut resistance' and 'comfortable' to exist in the same sentence.

5) **Run some in-house trials.** Now, it's time for the rubber to meet the road. Get your glove manufacturer and safety distributor involved in your trial, as well as your people

on the floor. Select a small area or line that best represents your entire facility. Make sure the gloves are easily identifiable; a good manufacturer will trim the trial gloves in different-coloured cuffs at the base of the cuff to make them easy to distinguish from the current gloves being used. This is especially important in dirty applications. Explain to your crew the reason for conducting the test and get their feedback. Provide a separate, preferably brightly coloured bin for the trial gloves to go in, being certain to include the current glove in the trial as a control (This is critical to determine if the gloves you are testing are actually any better than your current glove.) Ask your workers to wear each of the gloves for a defined period of time, such as one quarter of a shift. Provide a sheet for making notes, such as 'red-cuff glove wore though after only thirty minutes.' I also recommend trying a couple of different crews/shifts in order to arrive at an average that best represents your company as a whole.

6) **Inspect and record.** After employees have tested the gloves during the first trial shift, inspect and make notes of each style. *It is a good idea to note how many within each style of trial gloves have holes, and where they are forming. In this way, you can calculate a 'batting average' for each style. For example :

- At the start, if you chose to test twelve pairs of the first style of glove selected, and after the first shift, three of those twelve pairs developed holes, you would record that glove number one had a 'round-one scrap rate of twenty-five percent'.
- Get employee feedback after each trial shift, and record it.
- If your gloves are being laundered, send the gloves to your launderer with special instructions so the trial gloves don't get mixed with your regular gloves.

*For a simple glove-trial chart, email me at joe@superiorglove.com

- Ask the launderer specific questions related to your objectives, ie. "Do the gloves shrink?"

7) **Repeat.** Continue steps five and six until you feel you have a good indication of which glove is best for your application.

Performance Standards For PPE

by **Giovanni Henssen**, Application Manager, High Protective Textiles, DSM Dyneema

Due to globalization, products from different continents are sold in all parts of the world. Although you might expect the existence of a global standard for performances, such as the cut resistance of PPE, the contrary is true. Globally, there are two different performance standards for cut resistance: the European standard EN388, used in Europe, APAC, South America, Mexico and parts of Canada and the US; and the ANSI/ISEA 105 standard, mainly used in North America. These different standards are not identical and do not correlate, potentially causing confusion for end-users in their specification process for selecting the right glove for their application. It is important to understand the differences between these standards, as well as the test methodologies specified in these standards, in order to set the right expectations for performances and specifications. This document will explain these differences.

Methods for measuring cut resistance

Globally, three different standards accepted by industry exist to measure the cut-resistant properties using three different methods.

Standard	Test Method	Region
ASTM F1790 '97	CPP (old version)	North America
ASTM F1790 '05	CPP / TDM 100	North America
ISO 13997	TDM 100*	North America/Europe
EN388	Couptest	All regions except North America

CPP and TDM test method:

Both the ASTM F1790 ‘05 and ISO 13997 standard describe the same test methods for cut resistance: the TDM and the updated CPP test, while the ASTM F1790’97 only describes the old CPP test for measuring cut performance. From a principle point of view, the functionality of both the CPP and TDM method are identical. Simply said, both methods measure the amount of pressure one can apply to a razor blade, while moving the blade over the fabric without cutting through the fabric for at least 0.8 inch (20 mm). (See figure 1 below for the TDM schematic drawing.) These two methods simulate an accidental cut or slash with a sharp object.

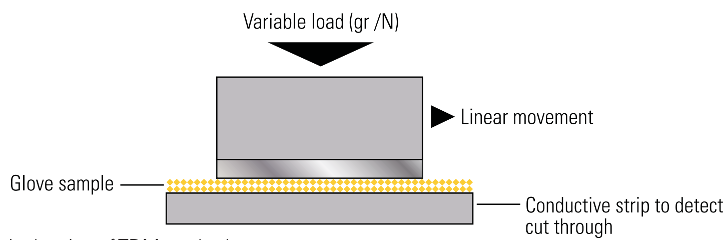


Figure 1 : Schematic drawing of TDM method

The higher the load (expressed in grams or Newton) one can apply to the blade without cutting through for at least 0.8 inch, the better the cut resistance of the fabric. ANSI / ISEA 105 defined cut-resistance levels for this, but are only valid for the old ASTM F1790 ’97 standard and are shown in below table 1.1. It is important to realize that these performance levels are NOT valid for the updated version of the ASTM F1790 ’05 and ISO 13997 test standard. It is known that the results using the ASTM F1790 ’97 method are slightly higher than the ’05 and TDM method.

Performance Level	Weight (in grams) needed to cut through with 1 inch (25mm) of blade travel
0	< 199
1	200 - 499
2	500 - 999
3	1000 -1499
4	1500 - 3499
5	> 3500

Table 1.1: ANSI/ISEA 105 performance levels

Couptest:

The EN388 standard describes the Couptest method for cut resistance, which is based on a totally different principle than the CPP/TDM method. In the Couptest, a circular blade is moving back and forth across the sample under a fixed load of 5N/500 gr, while rotating in the opposite direction of the linear movement.(see figure 2)

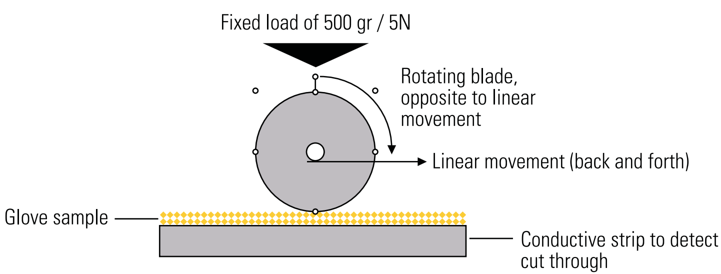
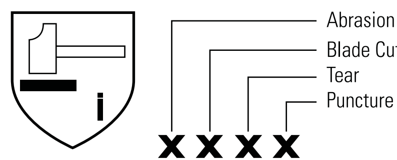


Figure 2 : Schematic drawing of Couptest method

Simply said, this method simulates the number of repetitive cuts needed to cut through the fabric on the same position in the glove using a constant load. This is compared to the resistance of a reference cotton fabric. The result of this test, the so-called 'Cut Index', tells you how much better the sample is compared to the reference cotton fabric. For example, a cut index of 5 means the sample has five-times better cut resistance than the reference cotton. The higher the number of cycles needed to cut through, the better the cut resistance of the fabric. EN388 has defined cut-resistance levels for this (see table 1.2), but are only valid for the Couptest method.

Performance Level	Average Cut Index (10 measurements)
0	< 1.2
1	1.2 - 2.4
2	2.5 - 4.9
3	5.0 - 9.9
4	10.0 - 19.9
5	> 20

Table 1.2: EN388 cut performance levels



Due to dulling of the blade during the test, especially with highly cut-resistant materials (e.g. steel), this method is not suitable for test gloves that contain steel wire. For those types of gloves, the EN388 standard recommends testing according to the ISO 13997 (TDM) standard. However, since there is no correlation between the two standards, certification is only allowed using the Couptest.

Also important to understand is that the EN388 standard describes more than just the cut resistance of a glove. The norm also describes the abrasion, puncture and tear resistance of a fabric/glove. If all tests have been performed by a certified lab institute, the glove may carry the CE certificate, together with the EN388 logo (see figure 3), which provides you with information about the total performance of the glove. All four individual performances are linked to each other. Low abrasion resistance of a glove will not only have a negative effect on cut protection during wear, but will also affect tear resistance. For low puncture-resistant materials (typical for gloves), it is important to have a high tear resistance to guarantee the longevity of the glove.

Comparing cut-resistant values

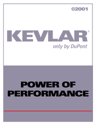
In your decision-making process for selecting the most suitable gloves for your application, it is important to understand the differences between the different standards and the methods described above.

It is important to understand that:

- EN388 cut-level X (Couptest) does NOT necessarily correspond to the same ANSI/ISEA105 level X (ASTMF1790'97)
- CPP/TDM indicates how much force/load is need to slash/cut through a fabric
- Couptest indicates how many repetitive cuts on the same position are needed to cut through
- CPP values measured with ASTMF1790 '97 give higher results than the 'ASTMF1790'05 and TDM test on the same glove, and this is purely due to an improvement of the standard.

Dupont: Kevlar® for Industrial Protective Apparel

by **David Kee**, Market Segment Leader, DuPont Personal Protection



Kevlar® fiber is incredibly strong, tough, light, flexible, heat, flame and cut resistant. This unique combination of high-performance properties makes Kevlar® fiber the solution for many demanding applications:

- Ballistic vests & hard armor
- Cut- and heat-resistant gloves & sleeves
- Firefighter turnout gear
- Ropes & cables
- Tires / Mechanical rubber goods
- Composites

In addition to its impressive list of inherent properties, Kevlar® is available in a wide range of fiber forms, providing protective-apparel manufacturers with plenty of design flexibility. Some of these fiber forms include spun yarns, textured filaments, and engineered blends that incorporate other fibers and colors. Consequently, end-users can rely on the fact that they will be able to benefit from the protection offered by Kevlar® regardless of their industrial application. As an example, the range of Kevlar® gloves goes from 15-gauge, lightweight cut-resistant gloves, all the way to heavyweight, heat-resistant mitts. Gloves made with 100% Kevlar® fiber provide good thermal-insulation properties for hot or cold working environments.

Another important performance criteria to consider when selecting the appropriate PPE is the care, cleaning and disposal of the product. The ability to launder and recondition gloves made of Kevlar® has been an important element of the overall value proposition and widespread industrial acceptance. Laundering to clean the most challenging greases and oils does not affect the cut resistance of Kevlar®. Some oleophatic fibers like HPPE can stain very easily upon exposure to oils and grease.

Kevlar® brand fibers are resistant to many chemicals and solvents. However, strong acids, bases, and certain oxidizers like chlorine bleach, cause rapid degradation of the fiber. Industrial launderers operate in the mid PH ranges (4-8), never lower or higher. In addition, the elimination of chlorine bleach in the cleaning of industrial apparel does not hinder the ability to clean it. Keep in mind that bleach would have to be avoided if the PPE contained spandex fibers anyway, so if it is absolutely necessary to bleach PPE, then oxygen bleaches can be used as an alternative without issue.

Case Study:

The following case study illustrates how technological advances have revolutionized cut protection:

A safety executive at an assembly facility had heard about the high-level protection of gloves made of Kevlar®. He suggested a trial, and a comparison study was set up at the auto assembly plant for a 10-week period, measuring durability, protection, and cost of Kevlar® gloves, versus leather and cotton gloves. The results were dramatic. The Kevlar® gloves cost approximately $6 a pair, while the leather gloves were $1.60 and cotton only 80¢ a pair, which meant that to be cost effective, the Kevlar® gloves would need to outlast the leather gloves by four times and the cotton by eight times. Despite the higher purchase price, the Kevlar® gloves tested measurably better on all fronts. The total cost for the Kevlar® gloves during the 10-week trial was $2,187, while the combined cost for the cotton and leather gloves used was $2,904 —a savings of 25% in total cost. And, most important, there were no hand injuries during the period to workers who were protected by gloves made of Kevlar®.

Two years later, having switched over to Kevlar®, those employees who adopted the new technology (75% of plant workers) experienced zero laceration injuries, while the shop's total hand and arm injuries were reduced from a previous total of 52 down to only 26. "In the three years of use here, we've yet to register a single serious laceration injury to a worker wearing these gloves," the safety engineer said. "In my opinion, they are an investment that offers a payout to everyone." It was clearly demonstrated that Kevlar® helped workers at the assembly plant avoid the pain and suffering of hand and arm injuries while increasing their productivity. "And, the plant cut tens of thousands of dollars from its body shop injury and medical costs," the safety executive said. "In that respect, it's like finding a new profit center."

Advantages of Dyneema® in Protective Gloves

by **Giovanni Henssen**, Application Manager, High Protective Textiles, DSM Dyneema

Dyneema® is fifteen times stronger than steel on a weight-for-weight basis, and is commercially produced by DSM Dyneema. It is made from ultra-high molecular-weight polyethylene (UHMW-PE) and has a very high cut resistance compared to both natural fibers (cotton, leather), and other man-made fibers. Protective gloves made withDyneema® yarn can provide the following benefits:

Cost Efficiency

The use of PPE should not be viewed as a cost, but as a cost-saver, preventing hand injuries and saving more money than not buying any gloves at all. If total system costs are taken into account, Dyneema® offers a cost-effective solution thanks to it's extremely high longevity which is related to:

High Abrasion Resistance

Thanks to the smoothness and high-crystalline properties of the Dyneema® fiber, the abrasion resistance is extremely high and cannot be matched by any other fiber.

Tests have demonstrated that gloves made with Dyneema® have up to twenty-times better abrasion resistance than gloves made, for example, with Aramid (spun) yarns. This characteristic has a significant and direct effect on the durability and longevity of the glove.

Protective gloves are often exposed to sharp objects that can abrade them. The more a glove is abraded, the less protection it offers. Naturally, the higher the abrasion resistance a glove offers, the longer the wearer is protected consistently during the lifetime of the glove. As can be seen in figure 1, gloves with Dyneema® offer this kind of consistent cut performance.

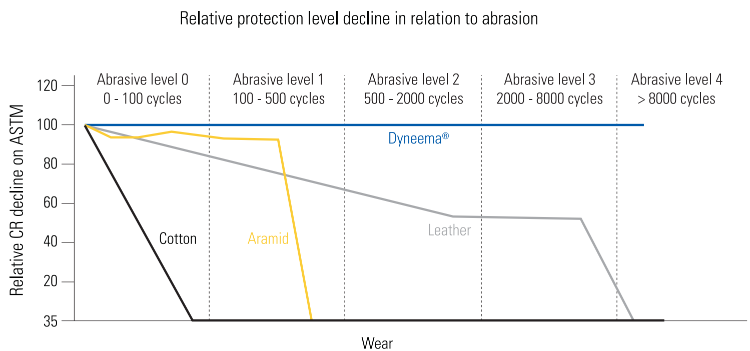


Figure 1: Correlation between cut-resistance consistency and abrasion resistance

For knitted products (like gloves), puncture resistance typically is very low, which increases the importance of the tear resistance of the fiber used in the glove. Puncture and tear resistance go hand-in-hand.

The combined performance of cut, abrasion, puncture and tear defines the actual performance of gloves in use. But the level of comfort a glove offers will define whether or not one will actually wear them.

Launder-ability and re-use

Thanks to its chemical structure, Dyneema® is inert to most of the aggressive agents used in industrial laundering, and environmental influences such as UV. This enables you to wash Dyneema® under the most harsh conditions, such as dry-cleaning and bleaching, without affecting its specific properties. Standard chemicals typically used in industrial laundering, such as detergents, ammonium, sodium hydroxides, hydrochloric acid, etc, do not affect the performance of the Dyneema® fiber. Since it has a low melt point, (145°C), this enables you to wash and re-use the gloves many times without relying on hot water to clean and sterilize gloves. Below, in figure 2, the effect of industrial washing on its cut and abrasion resistance is shown.

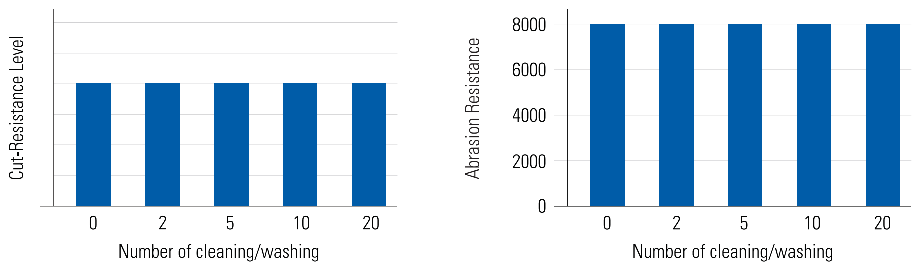


Figure 2: Effect of laundering on cut and abrasion resistance of Dyneema® (Note that cut resistance is unaffected.)

DSM Dyneema® fiber has a very high UV resistance, which means that cut resistance and comfort (softness of the knitted glove) are not affected by UV light. To demonstrate this, the effect on cut resistance - (CPPT) ASTM-F1790'05 - was measured after controlled UV exposure (according to ASTM G155 /ISO 4892-2). In figure 3 below, the various samples are shown after being exposed to UV for different periods. As one can see there is no discoloration of the fabric and there is no measurable effect on the cut resistance.

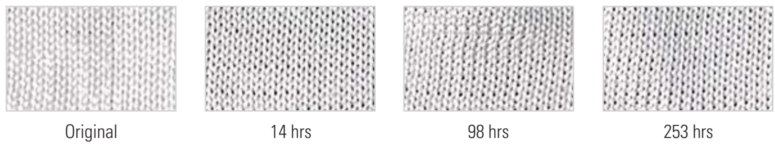


Figure 3: Several gloves with Dyneema® after constant UV exposure according to ASTM G155/ISO 4892-2

This means that Dyneema® will retain its protective properties (cut resistance) and comfort level (softness) even after being exposed for long periods to UV light.

Comfort

Today, comfort is as important an attribute as technical performance in protective gloves. If gloves are not comfortable to wear, employees won't wear them all the time, especially if they need to do other things (work or non-work related) where a high level of dexterity is required. The risk, therefore, of employees returning to their work stations and not wearing adequate glove protection is high, potentially leading to injuries (which can lead to 'indirect' costs).
Dyneema® fiber disperses body heat quickly to the outside of the glove more effectively

than natural fibers like cotton or leather. Tests have demonstrated that when wearing a glove with Dyneema®, the actual hand temperature stays very close to normal body temperature, while gloves with other fibers cause an increase in hand temperature of 3-4°C / 5.5 - 7.5°F degrees above body temperature, causing hands to sweat. (See figure 4)

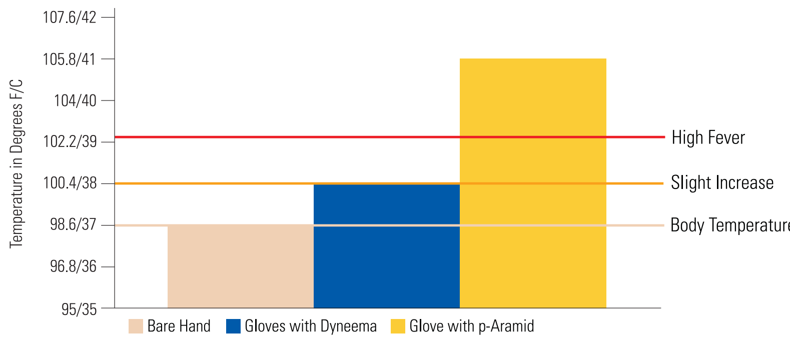
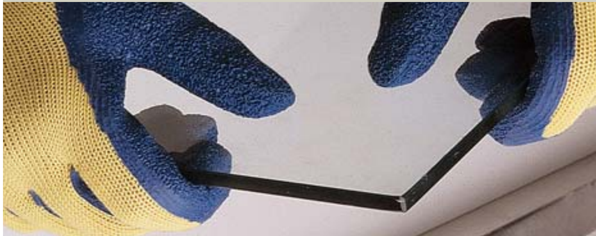


Figure 4: Hand temperature compared between wearing a glove with Dyneema® or p-Aramid.

Dyneema® yarn is extremely flexible and, in combination with the yarn's smooth surface and microfiber structure, feels comfortable on the skin while offering a high level of dexterity.




Tips for Choosing the Right Glove

David Kee, DuPont Personal Protection

1) Start with a hand and arm assessment
   - Assess hazards
   - Identify appropriate PPE for the hazards encountered
   - Select glove solutions for your specific applications
2) Involve workers in evaluating glove samples
   - Obtain their feedback
3) Select a qualified industrial launderer (if reusing gloves)
4) Monitor performance of the new gloves
   - Injuries
   - Comfort/dexterity
   - Worker confidence
   - Durability/usage (as compared to old glove system)
   - Productivity
5) Develop final glove specifications
   - Fiber type (e.g. Kevlar®, nylon, etc.)
   - Basis weight (oz/yd²)
   - Total glove weight by size
   - Glove construction
   - String knit, terry, etc.
   - Coatings, dots, leather palms
   - Ambidextrous (offers extended wear)
   - Reinforced thumb crotch
   - Cuff length
   - Yarn size
   - Glove sizing
   - Cut resistance (Rating Force and test method)
   - Other required performance values (thermal testing, abrasion testing, etc.)
   - Understand how gloves were tested to ensure correct comparison of results

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