



Glovepedia™ Series:
FIT & DEXTERITY



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BENEFITS OF PRECISION FIT GLOVES

Hand injuries are a massive problem in the workplace. They are costly to the employer and potentially devastating to the employee. In 2018, there were 124,000 hand injuries in the United States – that’s a whopping 2,385 hand injuries every single week. Unfortunately, 70% of all workers still don’t wear hand protection, according to data from the Occupational Safety and Health Administration. ‘Poor-fitting gloves’ is the single largest reason why workplace personnel don’t wear gloves – so you can see, if workers were provided with comfortable, precision-fit gloves, at the right level of protection, thousands of hands would be saved from injury every year.

We have identified five key components of Glove Fit, and defined the importance of each of them.

Key Takeaways:

► Hand injuries are a massive problem for workers and employers. OSHA registered 124,000 hand injuries in 2018, yet 70% of all workers DON’T wear hand protection.

► Workers choose to not wear gloves for one main reason – Poor Fit. The fit of a glove will directly affect its level of comfort, dexterity and performance.

► Glove Fit and comfort must be factored into the design of the glove at the very beginning, right along with hazard protection and task performance.

► There are many factors that affect Glove Fit: hand anatomy, choice of fabrics, glove and fabric patterns, dimensions and tolerances, and protective features.

► Once a glove have been designed, actual field testing is the best way to determine if a glove has the optimum blend of performance, protection, comfort and Fit.

THE IMPORTANCE OF A GLOVE THAT FITS

► Amazingly, gloves have been around for more than two thousand years. Ancient Greek and Roman texts describe gloves being worn for protection against the elements. Leather gloves were worn extensively for combat during medieval times. Even more amazing, however, is the fact that some gloves sold today aren’t much different from the gloves worn by knights and their squires, over a thousand years ago.

You might be asking yourself, ‘If some gloves haven’t changed in a thousand years, why should I care about the precise fit of a glove?’ or, ‘What’s so important about wearing gloves at all, when they just seem to get in the way of my work? Can’t I just grow thicker callouses?’

When you work with your hands, gloves are a double-edged sword. They protect you from an enormous amount of hazards - sharp edges, rough surfaces, vibrating tools, heavy impacts, damaging chemicals, high heat and deep cold, just to name a few. Yet they literally get in between you and everything you do – hammer, drive, cut, screw, fasten, carry, pull, grab, write, touch, lift, dial, turn, grind, climb, yank, position, move, steer, guide, pour, clean, hold, and on and on and on!

Simply put, you have to wear gloves to protect your hands from every day hazards, but you still have to have precise control over everything you do with them. To that endpoint, a glove that has a precision fit can be the most important item you wear to work every day.



1
COMFORT:
When flexing fingers, holding objects, hot and cold, etc.

2
EFFICIENCY:
Time = money. More boxes, more drywall screws, more framing erected, etc.

3
DEXTERITY & TACTILITY:
Gloves shouldn’t prevent you from grabbing small objects or turning knobs to do your job.

4
FUNCTION:
Gloves should be task specific and designed to do the job they need to do.

5
COMPLIANCE:
Keeping gloves on. Everything above determines if employees keep their gloves on.

HAND ANATOMY

Your hands - the most important tools you'll ever use. You use them at work, use them at home, use them to play. They are critical to virtually every single thing you do. In order to protect your hands, we first need to fully understand them. Each human hand contains 27 bones and 27 joints; each hand is controlled by 34 muscles and 120 ligaments, and has 48 major nerves and 30 main arteries. Hands are covered by about 80 square inches of skin, and have a remarkable 27 degrees of freedom between the fingers, thumb, and wrist. A large portion of your brain's motor cortex is dedicated to controlling your hands. They are amazing machines, and we each get to have two of them!

On top of all that, hands have a very wide range of dimensions, and no two hands are exactly alike. Measurements such as palm height and width, length of each finger and thumb, palm and wrist circumference, and overall hand length combine to make every hand different. When it comes to glove fit, you can see the complexity involved.

When considering a new glove design, there are several features of the hand that glove engineers factor in first:



Precurve

A hand at rest has a natural precurve; that is, the palm, fingers and thumb don't hang down straight. Instead, they gradually curve inward. This is a key feature of a Precision Fit glove design. A glove that is built with a precurve pattern will reduce hand fatigue, reduce excess fabric bunching in the palm, and improve grip on tools.



Opposable Thumbs

Humans are one of very few mammals with an opposable thumb - what does that actually mean? Your thumb flexes into your palm, like your fingers, but in a different plane of motion. When you flex your fingers and thumb, your thumb flexes opposite of your fingers, and allows you to grab or grasp objects with amazing precision and dexterity. This natural opposition of the thumb is important when designing a glove pattern.



Change in Dimensions

When you flex your hands (i.e. make a fist), several critical hand dimensions actually change. Specifically, the top surface of your fingers increase in length, the bottom surface decreases in length, and the circumference of your hand at the knuckles increases. Since gloves cover these surfaces, glove designers must take these dimensional changes into account when choosing fabrics and creating pattern dimensions.

GLOVE ANATOMY

For a glove to perform at its best, it must be made to match and work with the anatomy of the hand. The major areas of a glove that play a role in the fit of the glove are shown below.



TYPES OF GLOVES

Gloves are built using two different methods – cut and sew gloves, which are made from different swatches of fabric sewn together with thread; and seamless knit gloves, which are knit on a dedicated glove knitting machine, utilizing engineered yarns instead of fabrics and sewing thread. These two methods result in very different gloves types, with different features & benefits and pros & cons for each type.

Cut & Sew Gloves

These gloves are assembled similarly to apparel: multiple fabric swatches are cut, and then sewn together. That's where the similarity to apparel ends. Depending on their complexity, a single glove can be assembled from upwards of 25 different fabric panels and components, with different stretch, rebound, and flexibility characteristics. The glove must be sewn into a three-dimensional pattern, with extremely tight tolerances (+/- one tenth of an inch!).

PROS

- ▶ Ability to incorporate technical fabrics and components based on:
 - Requirements for the region of the glove (knuckle panel, palm, back of fingers and hand)
 - Environment and hazards encountered (heat, cold, wet, flame, sharp, rough, etc)
- ▶ Extremely wide range of options

CONS

- ▶ Complexity
- ▶ Tight tolerances
- ▶ Labor intensive assembly process



Knit Seamless Gloves

These gloves are assembled on technically advanced three-dimensional knitting machines. Yarns are chosen based on the level of protection required (typically, for cut resistance) and loaded into the knitting machine where a computer program guides the knitting process. After a glove has been knitted, it typically goes through a second process – a dipping line, where it will be drawn through a liquid polymer bath on a conveyor belt system. When the polymer cures, the glove will have a coated palm. Coatings are designed to enhance grip and durability in various conditions.

PROS

- ▶ Low cost, low-labor process
- ▶ Comfortable fit on hand
- ▶ No internal seams
- ▶ Wide variety of yarns to choose from

CONS

- ▶ Narrow range of options
- ▶ Cannot customize individual zones of the glove



TASK SPECIFIC FIT

Within Cut & Sew and Knit Seamless gloves, there are several different styles of gloves to meet several different functions. Each of these functions will have different factors that will affect the fit of the glove. Some of the more common uses that impact the fit are shown below.

LEATHER DRIVER



KNIT



HIGH PERFORMANCE



COATED KNIT



HYBRID LEATHER



IMPACT KNIT



IMPACT PROTECTION



FULL COATED / CHEMICAL



COLD WEATHER





MATERIAL FIT CHARACTERISTICS

When designing a glove, engineers are faced with immense choices when it comes to fabrics, yarns, coatings, and components. These choices should be driven by protection level, performance enhancement, as well as the effect on the fit of the glove - i.e., providing the best possible comfort, dexterity and tactility. Table 1 shows the fit characteristics of typical glove materials. These characteristics will determine how and where these materials are used on a particular glove.

TABLE 1: MATERIAL FIT CHARACTERISTICS

MATERIAL	STRETCH	REBOUND	FLEXIBILITY	SOFTNESS	CUT RESISTANCE	ABRASION RESISTANCE
NYLON	Medium	Medium	Medium	High	Very Low	Low
POLYESTER	Low	Low	Low	Medium	Very Low	Very Low
ELASTIC	Very High	Very High	Very High	Very High	Very Low	Very Low
ARAMIDS	Medium	Low	Medium	Low	Medium	Low
NEOPRENE	High	High	High	Very High	Very Low	Medium
LEATHER	Very Low	Low	Low	Medium	Very Low	Medium
SYNTHETIC LEATHER	Low	Low	Low	Medium	Low	Medium
RUBBER COATED FABRICS	Very Low	Low	Low	Very Low	Low	Very High
STEEL	Very Low	Very Low	Very Low	Very Low	Very High	Very High
FIBERGLASS	Very Low	Very Low	Very Low	Very Low	Very High	Very High
HPPE	Very Low	Very Low	Very Low	Low	High	Very High
PU COATING	High	High	Very High	Medium	Low	Low
NITRILE COATING	High	Very High	Very High	Medium	Low	High

CUT & SEW GLOVE PATTERNS

Cut and Sew gloves aren't one-size-fits-all. Additionally, they can be made in several different pattern configurations. Each pattern has unique attributes, which can be tailored for specific materials and glove uses.

CLUTE CUT

Attributes
Three long seams down the back of the glove, separating each finger. Separate thumb fabric panel. Separate knit cuff. Very old pattern.

Typical Use
Low price, single fabric gloves.

Pros
Easy to sew straight seams. Easy, low cost assembly.

Cons
Poor fit - low dexterity and tactility.

GUNN CUT

Attributes
Seamless panel back of hand. Two pieces on palm side - one piece for palm, index and pinky finger, one piece for middle and ring finger.

Typical Use
Full leather gloves.

Pros
No seams on the palm side of fingers, reducing wear and seam discomfort. Low assembly cost. Reduced waste during cutting of leather.

Cons
Poor fingertip tactility. Cannot build in a precurve.

KEYSTONE THUMB

Attributes
Thumb panel is sewn into the palm as a separate piece, with a hole cut into the palm panel.

Typical Use
Full leather gloves.

Pros
Allows for opposable thumb orientation. Reduced waste during cutting of leather.

Cons
Thumb seams on palm are exposed to abrasive elements and can fail early. Technical sewing requires highly skilled operators. Additional assembly cost.

PERFORMANCE FIT

WING THUMB PALM

Attributes
Separate panels for finger sidewalls (fourchettes). One piece palm with no seams.

Typical Use
High performance work gloves, synthetic and natural leather palms.

Pros
Seamless palm design eliminates wear points. High dexterity and tactility. Allows for precurve design. Can choose fingertip design (see page 12).

Cons
Technical sewing requires highly skilled operators. Significant assembly cost.



FINGERTIP EFFECT ON FIT, DEXTERITY, & TACTILITY

When designing a Performance Fit glove, engineers can choose which type of fingertip seams to integrate into the design. Why is that important? Your fingertips are one of the most sensitive areas on your body – each fingertip has more than three thousand touch receptors! Fingertips are critical to your sense of touch, which is defined as Tactility. Glove fingertips require seams, and these seams can interfere with your touch receptors, potentially reducing tactility and overall glove dexterity.

PINCH FINGERTIP



Attributes - One horizontal seam at the fingertip. Fourchettes, palm and top fabric join together at one seam.

Typical use - Gloves with single fabric layers at the fingertips.

Pros - Places seam away from major wear point. High durability design.

Cons - Technical sewing requires highly skilled operators. Thick fabrics could result in a bulky seam, reducing fingertip tactility.

BOX FINGERTIP



Attributes - Two horizontal seams at the top and bottom of the fingertip. Fourchette wraps around fingertip.

Typical use - Gloves with multiple fabric layers at the fingertips.

Pros - Increased area for fingertips. Simple sewing pattern.

Cons - Two seams reduce tactility. Fourchette fabric located at a major wear point. Bottom seam is a potential wear point.

ROLLTOP® FINGERTIP



Attributes - No seams across the fingertip. Palm fabric rolls up and over fingertip. Fabric panel typically has an hourglass shape to create a form-fitting fingertip.

Typical use - Gloves requiring very high levels of tactility and dexterity at the fingertip.

Pros - Seamless design results in maximum fingertip tactility. Form fitting to fingertips.

Cons - Requires very skilled sewing operators. Increases palm fabric usage. Higher cost to produce.

PRECURVE IN PERFORMANCE GLOVES

As discussed on page 6, your hand has a natural precurve to it. Let your hands hang down at your waist, and you'll see the natural, inward curve of your palms, fingers, and thumbs. In order to make a true Precision Fit glove, this precurve must be part of the three-dimensional pattern of the glove. A precurve glove has many benefits - it will fit your hand better, reduce palm fabric bunching, and reduce hand fatigue. Unfortunately, most gloves are not built with a precurve - it adds complexity and cost to the glove, and many glove manufacturers choose to build 'flat' gloves. So be sure to check the shape and pattern of your gloves next time you put them on! The figures below show how premium Cut & Sew gloves and Seamless Knit gloves integrate precurve into their design.

Fourchette Precurve

Precurve is built into the glove by modifying the fourchette of the glove to create a natural curve in the resulting glove.



Dipped Precurve

Precurve is built into the glove by utilizing curved hand molds during the dipping process, resulting in a natural curve when the palm coating dries.

HOW DO HIGH PERFORMANCE FEATURES AFFECT FIT?

Today's glove engineers have a variety of high performance features that they can add to a glove to increase protection and performance. However, each of these features will have an effect on fit – so it's critical for engineers to design them into the glove such that fit, comfort and dexterity are not compromised. After all, no matter how much protection a glove offers, if it doesn't fit right it won't get worn – and it can't protect at all.



1. Impact Protection

- ▶ Can be located on the fingers, knuckles, or metacarpal bones.
- ▶ Can be stitched or welded to the glove fabric.
- ▶ Problem – Reduces stretch and flexibility in critical flex zones.
- ▶ Solution – Detailed cross sectional topography to increase flexibility, increase dimensional specifications in key areas.

2. Insulation & Waterproof Inserts

- ▶ Typically used to add warmth to winter and cold storage gloves.
- ▶ Waterproof inserts keep hands dry in wet environments.
- ▶ Problem – Insulation adds bulk, waterproof inserts add extra layers; can result in poor dexterity and tactility.
- ▶ Solution – Use of bonded insulation layers, custom fit inserts, precurve shell design.

3. Cut-Resistant Inserts

- ▶ Can be an extra layer of fabric, located on the palm of the glove.
- ▶ Can be a full glove liner insert, with 360° of cut protection.
- ▶ Problem – Adds bulk to glove, can reduce overall flexibility.
- ▶ Solution – Use of lightweight, high strength, highly flexible, cut-resistant fabrics and yarns.

4. High-Abrasion Reinforcements

- ▶ Utilized to increase overall glove durability, especially when exposed to abrasive surfaces.
- ▶ Can be located on palms, fingers, and thumb saddle.
- ▶ Problem – Adds bulk to the glove, can reduce flexibility and tactility, creates exposed stitches.
- ▶ Solution – Locate reinforcements in high wear areas, add flex zones to pattern, use high-flexibility materials.



FIELD TESTED FIT

Fit is so important it is often the main driver for a new glove design. Many jobsites require protection from hazards such as cut and impact, but the tasks being performed at that jobsite require exceptional dexterity and tactility. Simply put, workers can't do their job if they can't accurately feel their tools and equipment. Below is an actual case study where fit was the driving factor in glove design.

- ▶ Location: fluid pumping facility at a large petrochemical plant, Houston, Texas
- ▶ High-dexterity task requirement: fine adjustments to small scale dials and gauges
- ▶ Hazards: sharp metal edges, heavy steel piping, tight-working spaces, light chemical residue
- ▶ Protection requirement 1: ANSI cut resistance level A2
- ▶ Protection requirement 2: ANSI impact level 1
- ▶ Protection requirement 3: palm protection from light chemical residue

Glove Solution:

- ▶ Seamless knit glove chassis – seamless fingertip allowed for enhanced sense of touch at fingertips
- ▶ 18 gauge yarn – thin yarn cross section improves fine motor feedback
- ▶ 46% HPPE/ 32% Nylon/ 17% Stainless steel core/ 5% spandex blend - provides ANSI level A2 cut protection with excellent stretch and rebound
- ▶ Polyurethane coating – smooth surface improved tactility and dexterity, is impervious to chemical residue
- ▶ Custom design impact protection – low profile, fits into small spaces. Large coverage, protects all bones and joints from ANSI level 1 impacts. Multiple flex zones, increases stretch and comfort

Result:

- ▶ Excellent fit, comfort, dexterity, and tactility
- ▶ Protection from all jobsite hazards
- ▶ Field tested and approved to meet all fine motor tasks
- ▶ Hand protection delivered to customer in Q4 2020



► The Ironclad Advantage

FLAWLESS FIT MEASUREMENT SYSTEM

Ironclad pioneered the Performance Fit work glove category in 1998. Ever since then, our customers have consistently given us the same feedback: "Once I put a pair of Ironclads on my hands, I just know it's an Ironclad glove. It fits better than any glove I've worn, and no matter which style of Ironclad I wear, it always fits the same."

We take an immense amount of pride in providing that perfect fit experience to our loyal customers. And yes, there is a 'Secret Sauce' to our amazing, consistent fit – and here it is! We call it our Flawless Fit measurement system. We create a new glove pattern, with new dimensions, for every glove we design. The dimensions are carefully analyzed and adjusted to account for every form factor – the different levels of stretch and rebound of each material, the location of every TPR flex point, the type of fingertips chosen, and the effects of each palm reinforcement, cut and insulation layer, etc. On top of that, we have extremely tight tolerances; our sewers are highly trained in the art of sewing a glove in a three-dimensional space, the most difficult level of sewing there is. See below for a glimpse into our Flawless Fit system, making Ironclad the best fitting gloves available.



IRONCLAD® FLAWLESS FIT VS INDUSTRY STANDARD FIT

EXAMPLE MEASUREMENT LOCATIONS		
SIZE GRADING	Unique set of measurements for each size	Single scale used across all measurements
TOLERANCES	Down to 2.5 mm	Up to 1 cm+
UNIQUE MEASUREMENTS	Up to 192 measurements per style (16 specs x 2 gloves/pair x 6 sizes)	20 measurements per style (2 specs x 2 gloves/pair x 5 sizes)

GLOVE SIZING

USE A RULER TO MEASURE YOUR HAND

WOMEN'S SIZE	PALM WIDTH (A-B)
XS (6)	2 1/8 in or less (5.4cm or less)
S (7)	2 1/8 - 2 3/4 in (5.4 - 7.0cm)
M (8)	2 3/4 - 3 1/8 in (7.0 - 7.9cm)
L (9)	3 1/8 in or more (7.9cm or more)

IF BETWEEN SIZES - SIZE DOWN FOR A SNUG FIT

IRONCLAD PERFORMANCE WEAR

GLOVE SIZING

USE A RULER TO MEASURE YOUR HAND

MEN'S SIZE	PALM WIDTH (A-B)
XXS (5)	2 1/8 in or less (5.4cm or less)
XS (6)	2 1/8 - 2 1/2 in (5.4 - 6.6cm)
S (7)	2 1/2 - 3 in (6.6 - 7.6cm)
M (8)	3 - 3 3/8 in (7.6 - 8.7cm)
L (9)	3 3/8 - 3 7/8 in (8.7 - 9.8cm)
XL (10)	3 7/8 - 4 3/8 in (9.8 - 11.1cm)
XXL (11)	4 3/8 - 4 7/8 in (11.1 - 12.1cm)
XXXL (12)	4 7/8 - 5 1/4 in (12.1 - 13.3cm)

IF BETWEEN SIZES - SIZE DOWN FOR A SNUG FIT

IRONCLAD PERFORMANCE WEAR

IRONCLAD GLOVES

Ironclad Performance Wear is the leader in high-performance, task-specific work gloves. We created the performance work glove category in 1998 and continue to leverage our leadership position in the safety, construction, and industrial markets. We design, develop, and distribute specialized, task-specific gloves for industries such as oil & gas extraction; automotive repair; police, fire, first-responder and military; construction and more. We engineer and manufacture our products with a focus on innovation, design, advanced material science, dexterity, and durability. Our gloves are available through industrial suppliers, hardware stores, home centers, lumber yards, automotive stores, and sporting goods retailers nationwide; and through authorized distributors in North America, Europe, Australia and Asia.

Ironclad: Built Tough for the Industrial Athlete™



Biomechanically Engineered

In order to make a glove fit just right, you have to fully understand the human hand – the dimensions, bone structure, flex zones, pressure points, musculature, nerve pathways, etc. Since 2001, Ironclad Performance Wear’s R&D team has been led by a biomedical engineer, with a degree in human biomechanics. Our focus is to engineer the world’s best gloves, with the best fit and performance, and to relentlessly innovate hand safety year after year. That’s what has led to our award-winning glove fit, and industry-leading 27 worldwide patents related to glove design.



Fully Launderable

Gloves can’t just fit you right the first few times you wear them. They have to fit every time you wear them, over and over again, even after washing. That just makes sense, right? But historically, gloves weren’t meant to be washed. They have been made primarily of leather, which typically shrinks and gets stiff after getting wet. Most glove suppliers tell you NOT to wash your gloves. That’s just plain wrong. Gloves get dirty, sweaty, and can smell. At Ironclad, we encourage you to wash your gloves! In fact, all of our gloves, leather or synthetic, are guaranteed not to shrink or stiffen up after washing. So go ahead, wash your gloves. Your hands deserve it.



Intensive Field Testing

At Ironclad, we understand that every job is different, every worksite is unique, and every hand is one-of-a-kind. We learn more by being in the field, with you, than we could ever know sitting in an office. That’s why we spend so much time at jobsites, with front line workers, watching, learning, testing our ideas, and listening to your feedback. This is how every one of our glove designs gets created. So we encourage you to field test with us. Chances are we have just the right glove for you. And if we don’t, we will build it.

Ironclad Flawless Fit is incorporated into every glove we make. To learn more about our gloves, or to find the right glove for your next job, please visit us online at:

www.IRONCLAD.com

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