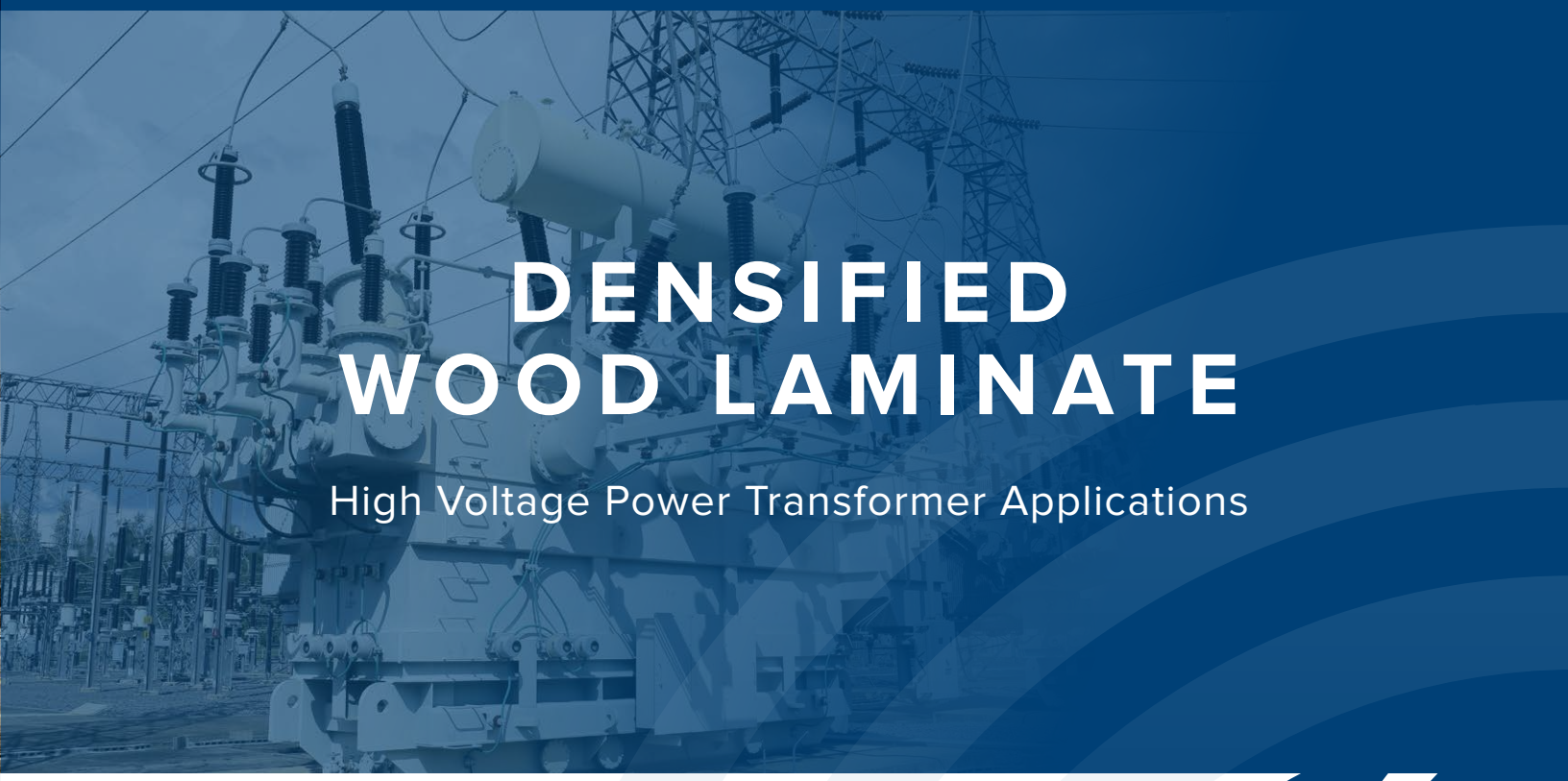
InsuLam®



DENSIFIED WOOD LAMINATE

High Voltage Power Transformer Applications

COMPOSITES
Cast. Wind. Press.

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About CK Composites

Situated in the foothills of the Laurel Mountains in Pennsylvania, near Pittsburgh, CK Composites has been supporting the high voltage electrical industry with innovative composites and engineering solutions since 1985. The company's origins extend further back to the 1950's when the European company, Permali Composites, expanded into the North American market by establishing a manufacturing plant for its wood composite materials and products. Over the years, the company added manufacturing capabilities in both epoxy molding and filament winding to provide a more complete solution to the industry. With decades of experience and development, CK Composites has evolved into a vertically integrated material and services company that specializes in custom engineered composite solutions.

Versatile Wood Composite

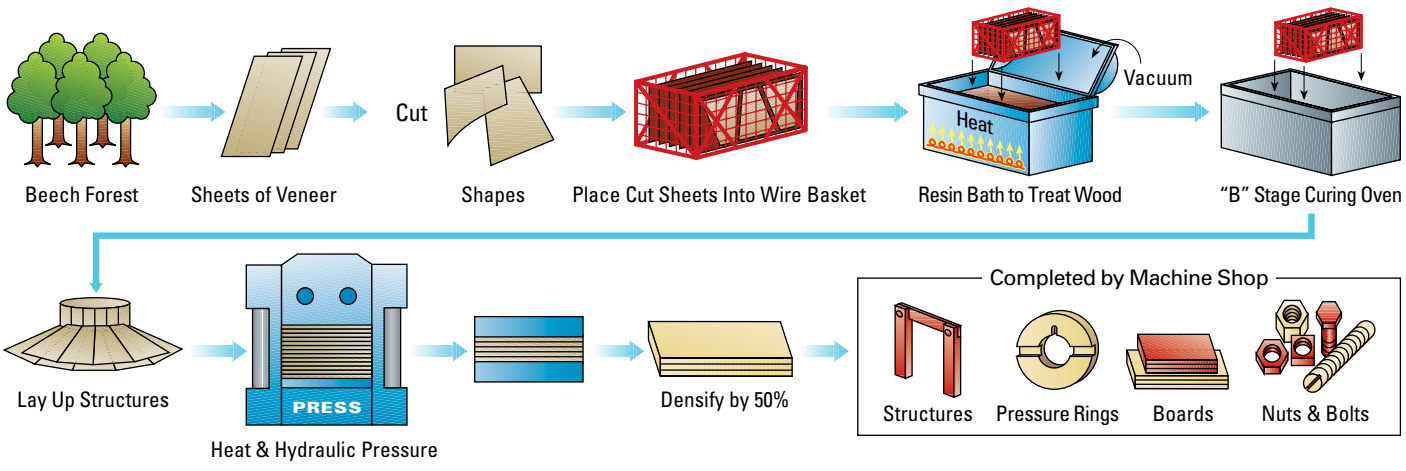
InsuLam® is a specialty wood composite product that combines the dielectric properties and stability of thermosetting resins with the strength and toughness of wood fibers. The result is essentially a wood reinforced plastic material whose mechanical properties can be engineered to meet the needs in a variety of applications.

InsuLam® offers high mechanical, thermal and dielectric strength as well as dimensional stability. The veneer grain can be arranged and pressed to put the greatest strength where it is needed. The density and impregnation levels can also be varied to match the desired properties for the application. The product is easily machined with good dimensional tolerances and it is compatible with most paint, varnish and transformer oil.

Manufacturing Process

The process begins with select thin red beech veneers from Europe where the wood is of the finest and most consistent quality. Depending on the desired properties, the veneers are either impregnated or surface coated with a specially formulated electrical grade phenolic resin. Following resin treatment, the veneers are dried or "B-staged" then arranged and stacked into the defined configuration and thickness. Lamination, densification, and curing are accomplished simultaneously in massive presses under high pressure and heat. After the pressing cycle, the material may be precision machined, assembled and finished per the requirements of the application.

Specialty Wood Process

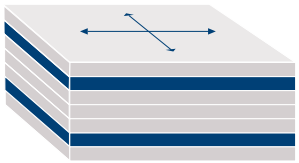


INSULAM® GRADES

General Applications and Grades Available

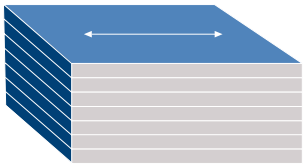
Property	Designation	Description	Properties	Transformer Applications
Resin Impregnation	LH	Surface Treated	Allows oil impregnation for improved electrical strength and cooling in transformers	Any application that requires oil impregnation
	EH	Impregnated	Low oil/moisture absorption and higher overall mechanical strength	Fasteners and dowel rod
Lamination Orientation (see Figure below)	2	Parallel (25% cross)	Tension or flexural requiring shear strength perpendicular to the wood grain	Lead supports and cross beams
	5	Parallel	Tension, flexural or torsion	Dowel and threaded rod
	6	Cross	Compression or multidirectional stresses	Core (step) blocks, top and bottom coil plates, and other miscellaneous blocking Top and bottom pressure rings
	7	Tangential	Flexural strength in a Circular Direction	Top and bottom pressure rings
Veneer Thickness	5	1.5 mm	Provides more strength in thin gage sheets	-
	7	2.5 mm	Standard veneer size	-
Specific Gravity*	P60	0.75 - 1.1	Basic mechanical strength	-
	P72	1.08 – 1.26	Medium mechanical strength	-
	P78	1.2 – 1.3	High mechanical strength	-
Example	**LH67P72**	**Surface treated, perpendicular orientation with 2.5 mm veneers at a specific gravity of between 1.08-1.26**		

*Used with LH grades only. EH specific gravity is 1.3 – 1.4.



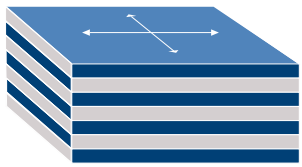
TYPE 2
Parallel Lamination (25% Cross)
For tensile applications requiring higher shear strength along the major axis

Lengths to 170”
Widths to 20”
Thickness in one pressing:
Type 25 ⅜” to ½”
Type 27 ½” to 3”



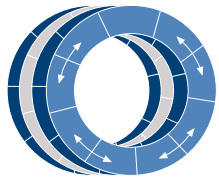
TYPE 5
Parallel Lamination
For components stressed in tension, flexure or torsion

Lengths to 165”
Widths to 10”
Thickness
Type 55 3⁄16” to ½”
Type 57 ½” to 3”



TYPE 6
Cross Lamination
For panels and components in compression or for parts stressed in more than one direction

Sizes to suit most applications:
Thickness
Type 65 3⁄16” to 1”
Type 67 ½” to 6”



TYPE 7
Tangential Lamination
For non-impregnated transformer clamping rings

Maximum Diameter 110”

Thickness in one pressing is 5”

*All materials can be bonded for greater thickness

Transformer Applications

- pressure rings
- blocking
- fasteners
- step and core blocks
- lead supports
- coil supports
- spacers
- beams

Tangential Grade Pressure Rings

The Smart Choice for Coil Compression

InsuLam® LH77, tangential grade, is the engineer's best tool to balance the necessary mechanical strength demanded by the application with the cost benefit of a smaller core window. The overall cost to benefit ratio makes LH77 the right solution in many transformer applications.

Since the wood grain of the material is oriented tangential to the diameter of the ring, the directional strength is much higher than ordinary cross laminated wood grades and laminated pressboard. The improved stiffness and flexural strength are beneficial in preventing coil movement during short circuit. As a result, the pressure ring/coil support can be engineered using the span to depth ratio graphs in this brochure to reduce the ring thickness and optimize the design. The result is a cost and performance benefit related to savings in oil, tank, core steel and reduced load losses because the transformer can be designed with a smaller window.

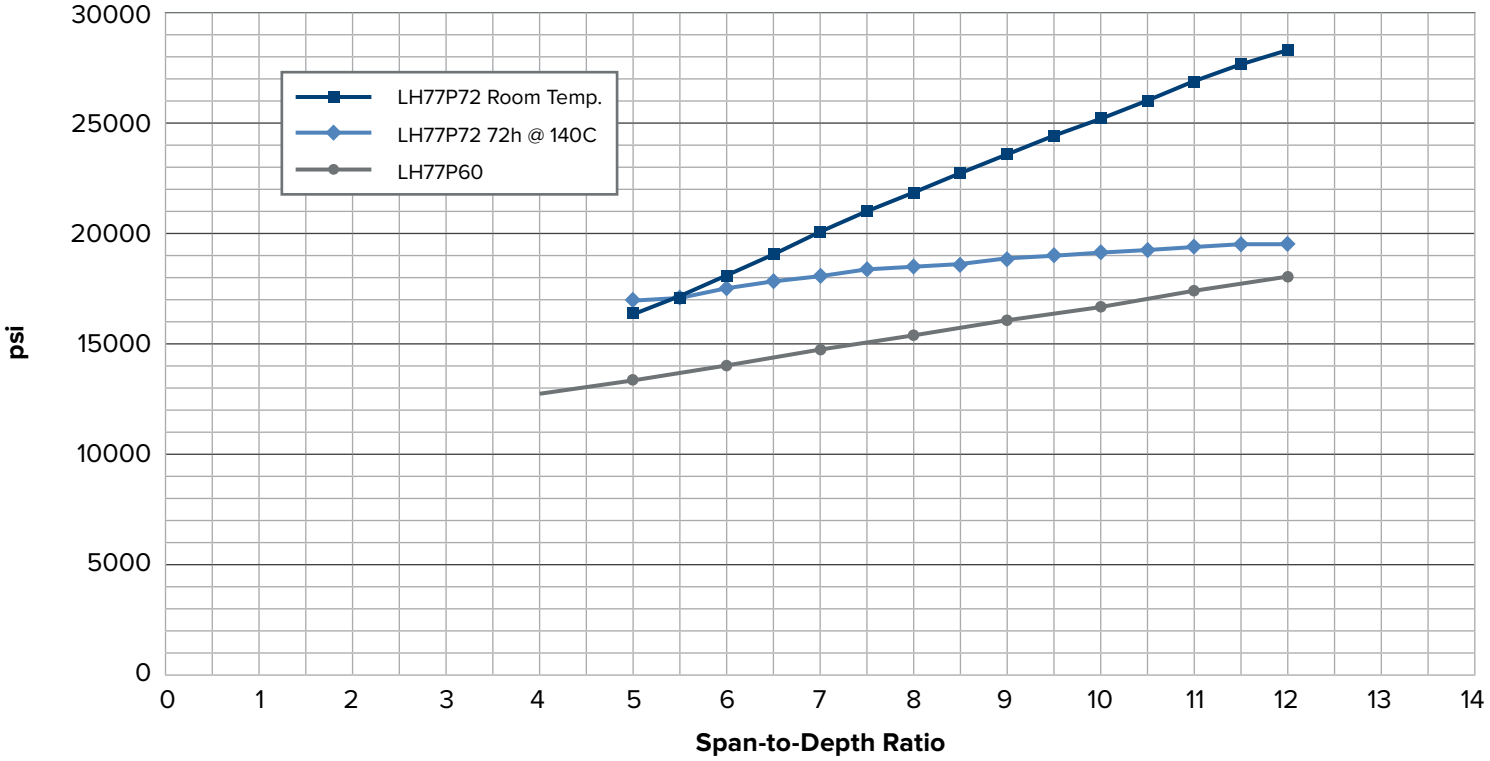
InsuLam® LH77 is commonly manufactured in two densities. Grade LH77P72 is a higher density that is especially suited to applications where higher axial forces, flexural strength and modulus are required such as top rings for medium to large transformers. A medium density grade, LH77P60, is available for applications with lower mechanical strength requirements. Typically, this grade is used for bottom rings in power transformers. Unlike laminated pressboard, both grades can be easily impregnated without the need for slots or holes that add to the cost and reduce the mechanical strength. Since the material is manufactured to a near net shape as the final part, there is less material waste in machining unlike milling a circular shape out of a rectangular sheet of cross laminated wood or laminated pressboard. This combined with the benefits of a smaller window clearly demonstrates that InsuLam® LH77 is the smart choice for both the transformer engineer and the material purchaser.

Tangential Grain Ring Properties***		
Grade	**LH77P72**	**LH77P60**
Density (Lb/ft³)	72	60
Specific Gravity (g/cm³)	1.08–1.26	.90–1.05
Flexural Strength (psi)	See Graph 1	See Graph 1
Modulus of Elasticity (psi)	See Graph 2	See Graph 2
Compressive Strength Parallel to Laminations (psi)	16,000	14,700
Operating Temp Continuous (°C)	105	105
Operating Temp Intermittent (°C)	140	140
Dielectric Strength 20C ll (kV/in)	70	70
Dielectric Strength 90C ll (kV/in)	60	60
Dielectric Constant	5 max.	5 max.
Oil Absorption (after drying)	15-20%	15-20%
Dielectric Loss Factor @ 50Hz 20° C (tan δ)	<0.02	<0.02

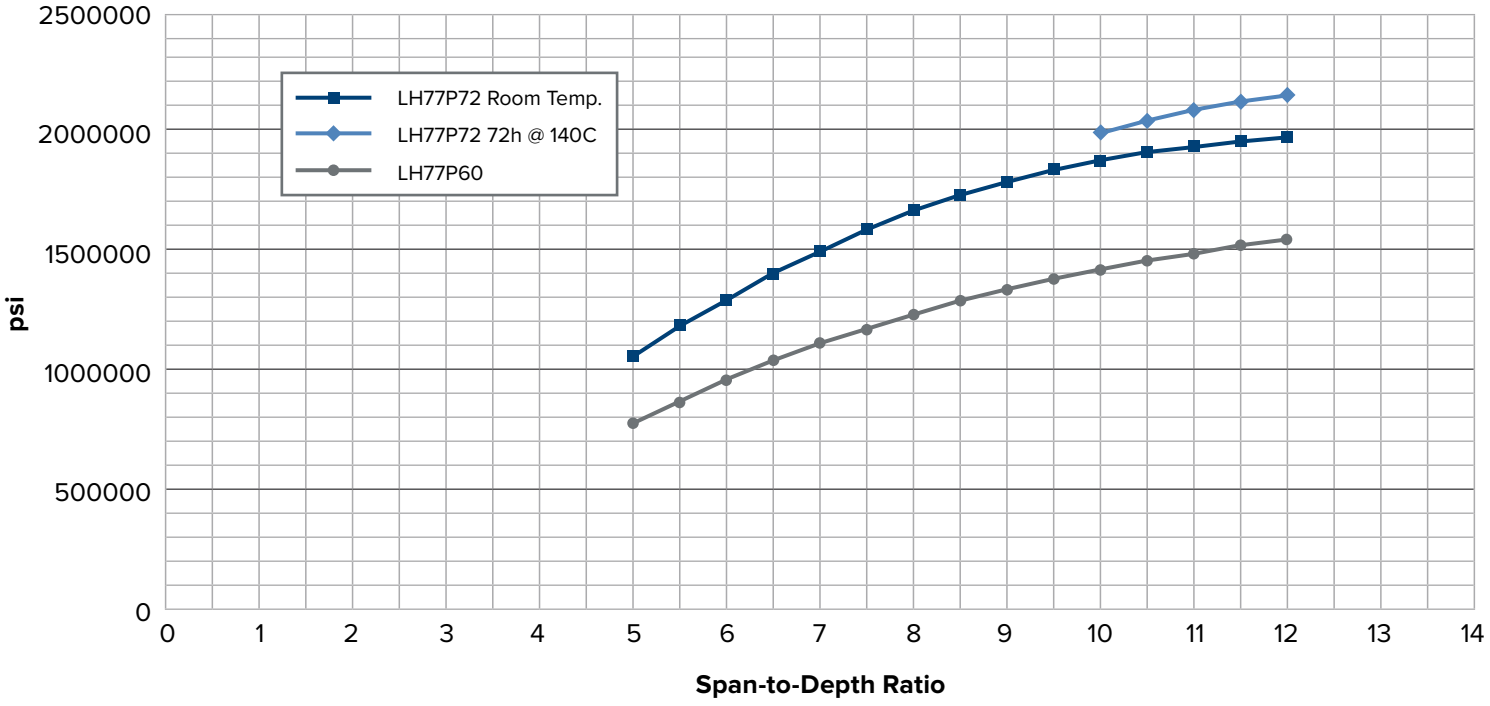
*** Mechanical Properties will vary depending on Ring Diameter and configuration. Mechanical values at 90° C are about 70% of those shown.

PRESSURE RING PERFORMANCE

Graph 1 **Flexural Strength LH77P72 & LH77P60**



Graph 2 **Modulus of Elasticity LH77P72 & LH77P60**



TECHNICAL DATA

Parallel and Cross Laminated Grades

InsuLam® LH27 is ideal for applications that require good flexural strength in the linear direction. Transformer applications include cross beams and lead supports. The common density for this material is LH27P60; however, if a higher density will give the customer the desired properties, CK Composites can meet the requirements with our LH27P78 specification.

In applications that require good compressive strength, **InsuLam® LH67** is an excellent choice. Applications such as core blocks and other miscellaneous blocking as well as bottom plates are well suited for the material. As in all the other grades, multiple densities are available and the most common is grade LH67P60.

Oil Impregnation is not an issue for any of these grades. Please consult with our engineers regarding specific applications to ensure the proper material is specified.

InsuLam®
Technical Data

			Designation	Parallel Laminated			Cross Laminated		
			CK Composites	LH27P60	LH27P78	EH55*	LH67P60	LH67P78	EH65*
			IEC 61061	P1R	P4R	-	C2R	C4R	-
			DIN 7707	KP20212	KP20214	KP20218	KP20222	KP20224	KP20228
Physical Properties		**Unit**	**Standard**						
Density		g/cm^3	IEC 61061	0.7 - 0.9	1.2 - 1.3	1.3 - 1.4	0.9 - 1.1	1.2 - 1.3	1.3 - 1.4
Oil Absorption		%	IEC 61061	30	10	<2	25	10	<2
Thermal Conductivity at 20° C		W/m•K	DIN 52612	0.2	0.2	0.3	0.2	0.2	0.3
Continuous Operating Temperature		°C	-	105	105	90	105	105	90
Max Temperature (for drying)		°C	-	140	130	100	140	130	100
Mechanical Properties		**Unit**	**Standard**						
Flexural Strength	⊥ or ‖	MPa (psi)	DIN EN ISO 178	145 (21,000)	200 (29,000)	220 (31,900)	115 (16,700)	138 (20,000)	150 (21,750)
Modulus of Elasticity	⊥	GPa (psi)	DIN EN ISO 178	13 ($1.9x10^6$)	16 ($2.3x10^6$)	18 ($2.7x10^6$)	10 ($1.5x10^6$)	12 ($1.7x10^6$)	15 ($2.2x10^6$)
Compressive Strength	⊥	MPa (psi)	DIN EN ISO 604	100 (14,500)	125 (18,100)	180 (26,100)	200 (29,000)	235 (34,100)	270 (39,150)
Compressive Strength	‖	MPa (psi)	DIN EN ISO 604	55 (7,900)	95 (13,750)	170 (24,650)	70 (10,150)	90 (13,050)	180 (24,100)
Tensile Strength	‖	MPa (psi)	DIN EN ISO 527	115 (16,700)	165 (23,950)	185 (26,825)	79 (11.500)	97 (14,000)	100 (14,500)
Impact Strength	⊥ or ‖	kJ/m^2	DIN EN ISO 179	40	50	32	28	33	12
Electrical Properties		**Unit**	**Standard**						
Electric Strength at 90° C	‖	kV/25mm	IEC 60243	70	70	32	70	70	32
Volume Resistivity		Ω·cm	IEC 60093	10^{12}	10^{12}	10^{11}	10^{12}	10^{12}	10^{11}
Dielectric Loss Factor @ 50Hz 20° C		tan δ	IEC 53483	0.01	0.01	0.01	0.01	0.01	0.01

‖ – parallel to lamination, ⊥ - perpendicular to lamination

*For thicknesses greater than 12 mm (1/2”), the last digit is replaced with a “7”

INSULAM® FASTENERS

Insulating Fasteners

InsuLam® fasteners are widely used in transformer and other electrical equipment due to its good mechanical and impact strength combined with its superior electrical insulating properties. The material can be found in lead support assemblies and other insulation assemblies in a transformer. The product is typically high density and fully impregnated for optimum strength but they can be engineered in other grades and densities. Five sizes are readily available. CK Composites can manufacture special sizes upon request.

InsuLam® dowel rods can also be manufactured to meet the needs of the industry.

Ultimate Tensile Strength

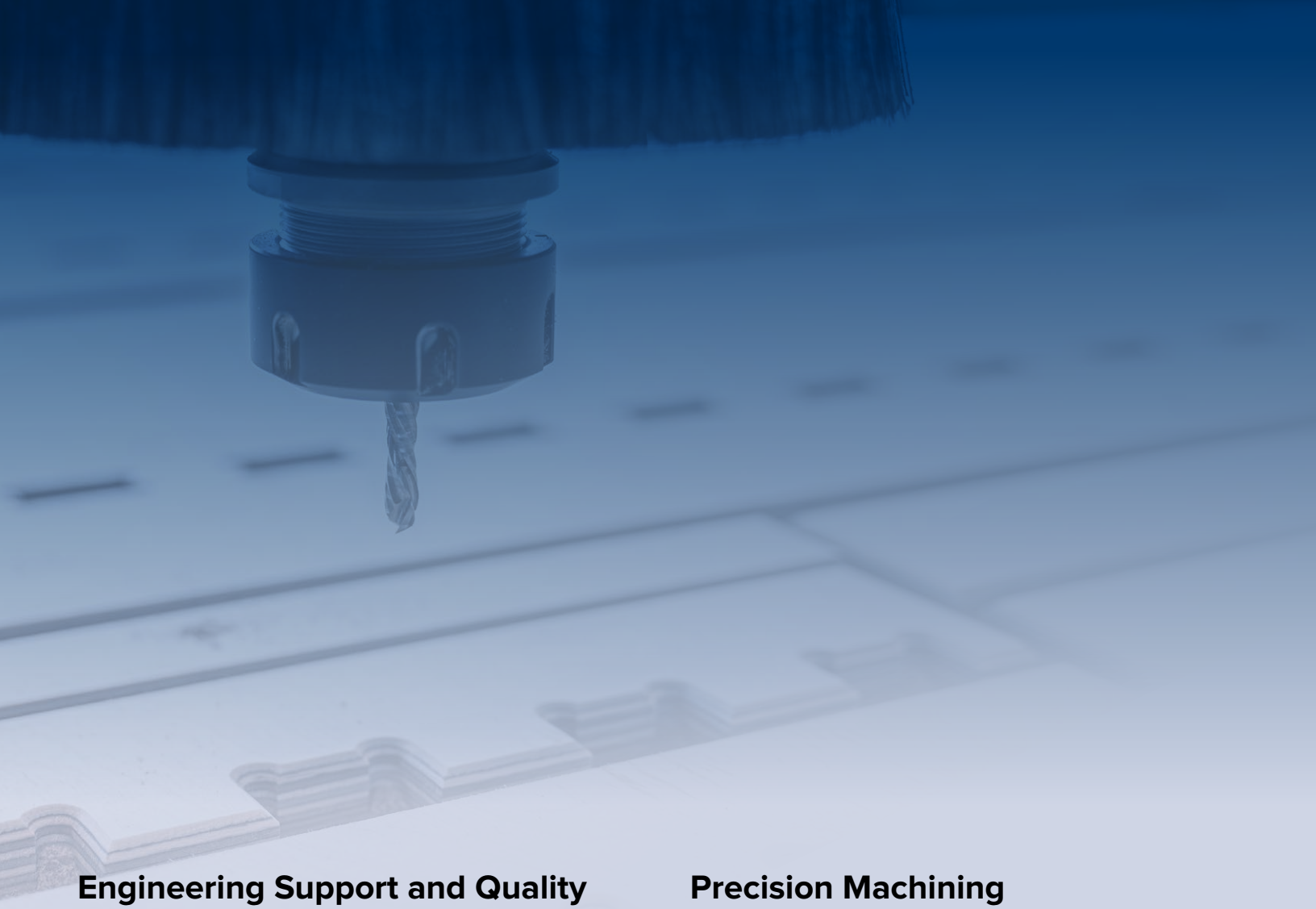
The following figures are based on the use of InsuLam® nuts.

Size	Type	Nut Thickness	Tensile Strength
5/16”-18	Jam	1/4”	470 lb.
5/16”-18	Full	3/8”	700 lb.
3/8”-16	Jam	5/16”	720 lb.
3/8”-16	Full	7/16”	1010 lb.
1/2”-13	Jam	3/8”	1180 lb.
1/2”-13	Full	9/16”	1770 lb.
5/8”-11	Jam	1/2”	1980 lb.
5/8”-11	Full	11/16”	2700 lb.
3/4”-10	Jam	5/8”	2900 lb.
3/4”-10	Full	13/16”	3800 lb.

Impact Strength

InsuLam® stud and nut assemblies have high impact resistance. The following table, which is based on test results, assumes the use of InsuLam® nuts.

Size	Type	Nut Thickness	Impact Strength
5/16”-18	Jam	1/4”	6.4 ft. lb.
5/16”-18	Full	3/8”	9.6 ft. lb.
3/8”-16	Jam	5/16”	9.7 ft. lb.
3/8”-16	Full	7/16”	13.5 ft. lb.
1/2”-13	Jam	3/8”	15.4 ft. lb.
1/2”-13	Full	9/16”	23.0 ft. lb.
5/8”-11	Jam	1/2”	25.5 ft. lb.
5/8”-11	Full	11/16”	35.0 ft. lb.
3/4”-10	Jam	5/8”	38.5 ft. lb.
3/4”-10	Full	13/16”	50.0 ft. lb.



Engineering Support and Quality

Because components and products we manufacture usually perform a critical function, CK Composites has strong technical capabilities and quality assurance procedures. Our staff includes several individuals with a background and work experience in electrical, mechanical and chemical engineering as well as skilled production technicians, programmers and machinists. With these resources, we are able to offer assistance to customers in the areas of material development, product design and manufacturing, quality test development, and technical problem solving.

Customer satisfaction is CK Composites' number one priority and we have a stringent Quality Assurance program in place to ensure the performance requirements of our materials and services used in the industry are exceeded on a routine basis. Quality assurance procedures include testing and inspection of incoming raw materials, in-process inspection and both destructive and non-destructive material testing. Specific electrical, mechanical, and hydrostatic testing is performed on the completed products to customer specifications. We pride ourselves on the quality of our products.

Precision Machining

Not only can CK Composites develop and engineer materials with the desired properties in the customer's applications, we can provide finished parts or assemblies as well. We have a complete machine shop with precision milling, routing, turning and assembly capabilities. We employ both manual and CNC equipment to ensure we efficiently produce parts with the proper fit and finish required. To complete our offering to the industry, we can paint or varnish the parts if desired. We can help design the parts or manufacture them to specific designs our customers provide.

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