

Thermoset Composites

Phenolics, Glass Epoxy and Laminates

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WARNING: These products can potentially expose you to chemicals including, 4-Dioxane, Acetaldehyde, Acrylonitrile, Bisphenol-A, Carbon Black, Chromium, Cumene, Dichloromethane, Ethyl Acrylate, Ethylbenzene, Ethylene Glycol, Formaldehyde, Glass Fibers, Hexachlorobenzene, Lead, Methanol, Nickel, Polyvinyl Chloride, Silica-crystalline, Styrene, Tetrafluoroethylene, Titanium Dioxide, and Toluene, which are known to the state of California to cause cancer and/or birth defects or other reproductive harm. For more information, visit www.P65Warnings.ca.gov



Phenolic C & CE

Canvas Based Industrial Laminate Grade

Phenolic C (NEMA C) consists of a cotton canvas fabric and general-purpose phenolic resin. The product is easy to machine and operates with less noise than metal. In addition, this material is not as abrasive as fiberglass alternatives when used in wear applications. Since it does not spark when struck, Phenolic C can be used in explosion-proof environments.

Phenolic C material is commonly used to make gears, pulleys, rollers, and guides. Phenolic C is a mechanical grade and does not have electrical properties comparable to Phenolic CE.

Phenolic C complies with the requirements of MIL-I-24768/16, Type FBM.

Phenolic CE (NEMA CE) consists of a cotton canvas type fabric and electrically insulating phenolic resin system. NP310E is easy to machine and operates with less noise than metal. In addition, this material is not as abrasive as fiberglass alternatives when used in wear applications.

Phenolic CE can be used in explosion-proof environments. This material is commonly used to make gears, pulleys, rollers, and guides, as well as electrically insulated parts such as control boards.

Phenolic CE complies with the requirements of MIL-I-24768/14, Type FBG

Typical Features:

- Good mechanical properties & toughness
- High impact strength
- Good wear resistance qualities
- Withstand up to 275°F
- Good machinability



Phenolic C/CE

Standard Thickness (inches) :	1/32" up to 4" thick
Standard Sheet Size (inches) :	36" x 48" 48" x 48" 48" x 72" 48" x 96" 48" x 120"
Rod/Round Diameter (inches) :	3/16" up to 6" diameter
Standard Rod Lengths :	24" and 48" long, varies by diameter
Tube/Hollow Bar Dia (inches) :	3/16"OD x 1/8"ID up to 2.50"OD x 1.50"ID
Standard Tube Lengths :	24" and 48" long, varies by diameter
Standard Color :	Brown (reddish-brown)

Phenolic LE

Linen Based Industrial Laminate Grade

Phenolic LE (NEMA LE) is used where better machining is needed compared to that offered by other canvas grades. This product consists of a fine-weave linen fabric and electrical grade of phenolic resin. Besides easy machining, Phenolic LE operates with less noise than metal. In addition, this physical material is not as abrasive as fiberglass alternatives when used in wear applications.

Since it does not spark when struck, Phenolic LE can be used in explosion-proof environments. Suitable for smaller and more intricate shapes than those made with Phenolic C, this product is commonly used to make gears, pulleys, rollers, and guides, as well as electrical insulating parts.

Phenolic LE complies with the requirements of MIL-I-24768/13, Type FBE.

Typical Features:

- Outstanding electrical properties
- Easily machined and fabricated
- Dimensionally stable
- Good wear characteristics



Product Applications:

- Gears
- Pulleys
- Rollers
- Guides
- Electrical insulating parts

Phenolic LE

Standard Thickness (inches) :	1/16" up to 4" thick
Standard Sheet Size (inches) :	36" x 48" 48" x 48" 48" x 96" 48" x 120"
Rod/Round Diameter (inches) :	1/16" up to 6" diameter
Standard Rod Lengths :	24" and 48" long, varies by diameter
Tube/Hollow Bar Dia (inches) :	3/16"OD x 1/8"ID up to 2.50"OD x 1.50"ID
Standard Tube Lengths :	24" and 48" long, varies by diameter
Standard Color :	Light Brown

Phenolic Rod

Molded vs Sheet Differences

Phenolic rod can be made in different ways, rod made from sheet and molded rod. The type of rod affects tolerances, standards length, cost, and performance in certain applications. The following explains the differences between the two methods.

Molded Rod features:

- Typically available in random 46" lengths
- Linen and FR4 natural are the only grades available
- From 1/4" diameter up to 5" diameter
- Tolerances consistent from most mills, tighter tolerances on molded
- Approximately 30% more expensive than sheet rod
- Molded and laminated, rolled, make for better compressive strength
- Preferred if machining a tube from rod, molded works better due to the circular lamination pattern from how it is made.

Sheet Rod features:

- Typically available in random 48" lengths
- Available in many grades
- From 1/16" diameter up to 6" diameter
- Tolerances consistent from most mills
- Approximately 30% less expensive than molded rod
- Made by cutting strips out of sheet material
- Majority of Alro in stock material is sheet rod



Molded Rod Sample



Sheet Rod Sample



Phenolic XX

Paper Based Industrial Laminate Grade

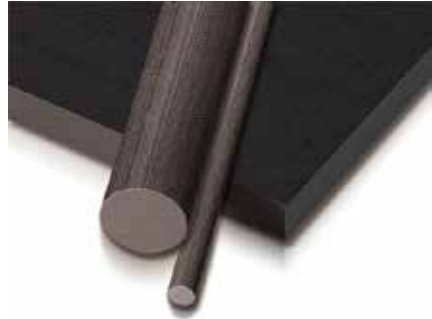
Phenolic XX (NEMA XX) is a paper based phenolic that is a machining grade with less robust electrical properties than those of Phenolic XXX (Phenolic XXX - not stocked, but can be special ordered). Designed for electrical insulation, the product can be used in dry or high humidity conditions.

Applications include barriers, breaker arms, switch panel boards, and relay and switch bases.

This product meets the requirements of MIL-I-24768/11, Type PBG.

Typical Features:

- Extremely high mechanical strength
- Low water absorption
- Superior electrical characteristics
- Good machinability



Product Applications:

- Terminal boards
- Washers
- Sleeves
- Structural components

Phenolic XX

Standard Thickness (inches) : 1/16" up to 4" thick
Standard Sheet Size (inches) : 36" x 48" 48" x 48"
 48" x 96" 48" x 120"

Rod/Round Diameter (inches) : 1/16" up to 2-1/4" diameter
Standard Rod Lengths : 24" and 48" long, varies by diameter

Tube/Hollow Bar Dia (inches) : 3/16"OD x 1/8"ID up to 2.50"OD x 1.50"ID
Standard Tube Lengths : 24" and 48" long, varies by diameter

Standard Color : Dark Gray

Phenolic Grades

	PAPER Phenolic XX	PAPER Phenolic XXX
Military / Fed Spec	MIL-I-24768/11 Type PBG	MIL-I-24768/10 Type PBE
Specific Gravity	1.35	1.38
Tensile Strength (psi)	17,000	13,000
Compressive Strength (psi)	35,000	35,000
Flexural Strength (psi)	34,000	22,000
Hardness, M Scale	120	101
Bond Strength (psi)	1,500	1,200
Shear Strength (psi)	11,500	12,800
Dissipation Factor 10 ⁶ Cycles, Cond. A	0.040	0.035
Dielectric Constant 10 ⁶ Cycles, Cond. A	5.30	5.10
Electric Strength V/Mil, Cond. A	750	700
Flammability Rating	94HB	94HB
Max Operating Temp. (°F)	284°	284°
Coefficient of Thermal Exp. in/in/°C x 10 ⁻⁵	1.20	1.50
Water Absorption, % 24 hrs	2.00	0.57
Izod Impact Strength (ft/lb/in) @49°C	0.80	0.55

All values given are average based on test samples. The performance characteristics attributed to the products described herein are based on assumptions of general and reasonable use. As results cannot be predicted or guaranteed for any specific set of conditions, each user should make their own determination of these products' suitability for their particular application. 08/2021



Phenolic Grades

CANVAS Phenolic C	CANVAS Phenolic CE	LINEN Phenolic L	LINEN Phenolic LE
MIL-I-24768/16 Type FBM	MIL-I-24768/14 Type FBG	MIL-I-24768/15 Type FBI	MIL-I-24768/13 Type FBE
1.35	1.37	1.34	1.34
11,200	10,000	14,000	13,000
37,000	36,000	35,000	36,000
22,000	17,000	23,000	18,000
103	100	105	100
2,000	1,900	1,700	1,900
14,000	14,000	13,500	13,500
---	0.048	---	0.065
---	5.50	---	5.70
---	550	---	625
94HB	94HB	94HB	94HB
257°	257°	257°	257°
1.10	2.00	1.04	1.80
1.60	2.00	1.04	1.90
1.95	1.70	1.70	1.35

All values given are average based on test samples. The performance characteristics attributed to the products described herein are based on assumptions of general and reasonable use. As results cannot be predicted or guaranteed for any specific set of conditions, each user should make their own determination of these products' suitability for their particular application. 08/2021

Phenolic G-10/FR4

Glass Cloth Epoxy Industrial Laminate Grade

Phenolic G-10/FR4 is a continuous woven glass fabric laminated with an epoxy resin. This grade is extremely high in mechanical strength, has low water absorption and dissipation factors and has superior electrical characteristics, which are exhibited over a wide range of temperatures and humidities.

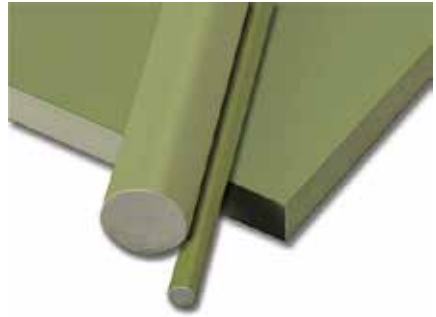
Grade G-10 is used for terminal boards, washers, sleeves, structural components, and parts where the strength to size ratio is critical.

Grade G-10 complies with the requirements of MIL-1-24768/2, Type GEE

Grade FR4 complies with the requirements of MIL-24768/27 Type GGE-F

Typical Features:

- Extremely high mechanical strength
- Superior electrical characteristics
- Low water absorption
- Dimensionally stable



Product Applications:

- Terminal boards
- Washers
- Sleeves
- Structural components
- Electrical insulating parts

Phenolic G-10/FR4

Standard Thickness (inches) :	1/16" up to 4" thick
Standard Sheet Size (inches) :	36" x 48" 48" x 48" 48" x 96" 48" x 120"
Rod/Round Diameter (inches) :	1/16" up to 2-1/4" diameter
Standard Rod Lengths :	24" and 48" long, varies by diameter
Tube/Hollow Bar Dia (inches) :	3/16"OD x 1/8"ID up to 2.50"OD x 1.50"ID
Standard Tube Lengths :	24" and 48" long, varies by diameter
Standard Color :	Green

Phenolic G-10/FR4

NEMA Grade G-10 vs NEMA Grade FR4

Although they are typically made from the same base material (E-Glass), the epoxy resin used for binding each material is different. This is due to the addition of bromine into the resin for FR-4. "FR" stands for flame retardant and indicates that the flammability of **FR-4 is in compliance with the UL standard 94V-0**.

The Mil-I-24768 & NEMA specs require similar mechanical and electrical properties for both material grades. However, modern FR-4 resins and manufacturing processes produce superior mechanical and electrical properties compared to G-10. One area where G-10 will actually outperform the FR-4 is when the material application is immersed in salt water.

G-10: Mil-I-24768/2 Type GEE
 FR4: Mil-I-24768/27 Type GEE-F

NEMA = National Electrical Manufacturers Association



Phenolic G7, G9, G11

Glass Based Industrial Laminate Grades

Phenolic G-7 (Glass cloth / Silicone)

Phenolic G-7 is a continuous glass fabric laminated with a silicone resin. Grade G-7 is unequalled for high heat and arc resistance applications, and where good mechanical and electrical properties must be exhibited in humid conditions in excess of 500°F.

Phenolic G-7 complies with the requirements of MIL-1-24768/17, Type GSG

G-7 applications include terminal boards, washers, sleeves and structural components. Please inquire for available shapes and sizes.



Phenolic G-9 (Glass cloth / Melamine)

Phenolic G-9 (NEMA G-9) glass melamine laminate is a very hard, flame resistant grade that has excellent arc resistance and electric strength properties even under humid or wet conditions. Phenolic G-5 and G-9 laminate sheet has high mechanical strength and machines well. This product also has good dimensional stability.

Phenolic G-9 complies with the requirements of MIL-I-24768/1, Type GME

G-9 material is especially suited for applications requiring arc and flame resistance as well as stiffness and high mechanical strength. Please contact your Alro sales representative for shapes and sizes.



Phenolic G-11 (Glass cloth / Epoxy)

Phenolic G-11 (NEMA G-11) is a high performance thermoset epoxy fiberglass composite that provides higher strength than similar products. Phenolic G-11 is chosen over high-temperature mat glass thermoset composites and high performance glass-filled thermoplastics because of its excellent machining characteristics, outstanding dimensional stability, superior creep resistance, and excellent high-temperature and performance characteristics.

Phenolic G-11 complies with the requirements of MIL-1-24768/3, Type GEB.

G-11 is considered the premier material for use as Class F insulation in electrical power generation and transmission equipment. Please refer to page #202 for more information on G-11. Please contact your Alro sales rep for shapes and sizes.



Phenolic G14

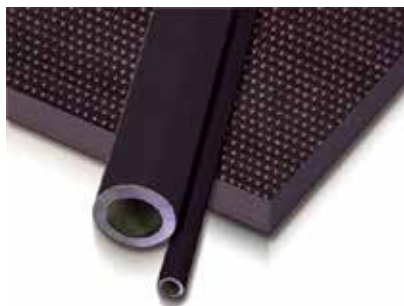
Acculam® Matrix HT™ Industrial Laminate Grade

Acculam® Matrix HT™ is a new thermoset composite comprised of woven fiberglass and a unique blend of high temperature resin binders developed for applications that demand superior performance over wide temperatures. It maintains a high percentage of mechanical and insulating properties up to 500°F.

Acculam Matrix HT has outstanding flexural and impact strength. It maintains rigidity with excellent dimensional stability and creep resistance over wide temperature ranges, as well as good resistance to moisture, chemicals, alkali and acids. It does not melt or soften at high temperatures, and offers users extended application capability beyond typical NEMA grades. Unlike thermoplastics, Matrix HT does not lose strength.

Typical Features:

- Maintains excellent physical properties up to 500°F
- Outstanding flexural and impact strength
- Creep resistance over a wide temperature range
- Good chemical resistance to alkali and acids
- Excellent dimensional stability
- Good moisture resistance



Product Applications:

- Spacers
- Arc chutes
- Stand-offs
- Control panels & fuses
- Structural supports
- Motor wedges
- Test boards
- Switch gears
- Motor mounts
- Flanges
- Shims
- Shields, Heat shields
- Framework
- Braking systems
- Thermal insulators

Acculam® Matrix HT™

Standard Thickness (inches) :	.016" up to 2" thick
Standard Sheet Size (inches) :	48" x 48" 48" x 96"
Tube/Hollow Bar Dia. (inches) :	.500"ID (minimum) .062" wall (minimum) Up to 10" Diameter (maximum)
Standard Tube Lengths :	48" (4 ft) randoms
Standard Color :	Eggplant (Purple) and Black

Phenolic Glass Grades

	GLASS Phenolic G-3	GLASS Melamine G-9
Military / Fed Spec	MIL-I-24768/18 Type GBG	MIL-I-24768/1 Type GME
Specific Gravity	1.85	1.85
Tensile Strength (psi)	42,000	39,000
Compressive Strength (psi)	76,000	70,000
Flexural Strength (psi)	55,000	55,000
Hardness, M Scale	110	115
Bond Strength (psi)	1,500	1,900
Shear Strength (psi)	18,000	18,000
Dissipation Factor 10 ⁶ Cycles, Cond. A	0.023	0.015
Dielectric Constant 10 ⁶ Cycles, Cond. A	7.30	7.00
Electric Strength V/Mil, Cond. A	600	450
Flammability Rating	94HB	94V-O
Max Operating Temp. (°F)	284°	284°
Coefficient of Thermal Exp. in/in/°C x 10 ⁻⁵	1.00	1.50
Water Absorption, % 24 hrs	2.00	0.60
Izod Impact Strength (ft/lb/in) @49°C	12.00	12.50

All values given are average based on test samples. The performance characteristics attributed to the products described herein are based on assumptions of general and reasonable use. As results cannot be predicted or guaranteed for any specific set of conditions, each user should make their own determination of these products' suitability for their particular application. 08/2021



Phenolic Glass Grades

GLASS Epoxy G-10	GLASS Epoxy FR4	GLASS Epoxy G-11	GLASS Silicone G-7
MIL-I-24768/2 Type GEE	MIL-I-24768/27 Type GEE-F	MIL-I-24768/3 Type GEB	MIL-I-24768/17 Type GSG
1.80	1.85	1.82	1.78
40,000	38,000	37,000	18,000
65,000	66,000	63,000	45,000
75,000	60,000	75,000	25,000
110	115	112	105
2,200	2,300	2,200	900
19,000	21,500	22,000	17,000
0.020	0.022	0.020	0.003
5.00	4.80	5.00	4.20
800	800	900	400
94HB	94V-O	94HB	94V-O
284°	284°	356°	428°
1.00	1.00	1.10	1.00
0.11	0.10	0.20	0.20
14.00	14.00	12.00	6.50

All values given are average based on test samples. The performance characteristics attributed to the products described herein are based on assumptions of general and reasonable use. As results cannot be predicted or guaranteed for any specific set of conditions, each user should make their own determination of these products' suitability for their particular application. 08/2021

Glasstherm HT

A fiberglass reinforced, mineral filled sheet, with heat resistant polyester thermo-setting resin. This material offers a high compressive strength and heat resistance with a service temperature of 550° F while also reducing heat loss. It is finished to a close thickness tolerance making it great for insulation between the fold and the press or within a mold.

It is completely Asbestos free and durable enough to withstand rough handling during the installation process. It can be cut, die-cut, machined and stamped with standard metal working equipment. Diamond cutting tools are recommended for longer life.

Typical Features:

- High Hot compressive strength
- Low thermal conductivity
- Oil and moisture resistant
- Helps control temperature
- Faster mold setup



Product Applications:

- Thermal barrier
- Thermal install
- Pipelines
- Chemical processing industry
- Oil and gas industry



Glasstherm HT

Standard Thickness (inches) :	1/8" up to 2" thick
Standard Sheet Size (inches) :	36 x 72 and 48 x 96
Standard Color :	Natural/White

Glastherm HT

Typical Properties

PROPERTY TESTED	ASTM	UNITS	GLASTHERM HT
PHYSICAL PROPERTIES			
Density	D792	lbs/ft ³	123
Water Absorption	D570	% by wt.	0.20
Coefficient of Therm Expansion	D696	in./in./°C x 10 ⁻⁵	11.62.21
Thermal Conductivity	C177	BTU•in./hr.•Ft ² •°F	1.90
Maximum Service Temperature	---	°F	550°F
MECHANICAL PROPERTIES			
Flexural Strength	D790	psi	31,000
Compressive Strength			
@75°F / 24°C	D695	psi	49,000
@302°F / 150°C	D695	psi	27,000
@392°F / 200°C	D695	psi	18,000
@550°F / 288°C	D695	psi	17,000
Compressive Modulus	D695	psi	1,800,000
IZOD Impact Strength (notched)	D256	Ft.lb./in.	8
ELECTRICAL PROPERTIES			
Electrical Strength-Perpendicular S/T in Air	D149	Vpm	50
FLAME and SMOKE			
UL Subject 94	UL 94	0.94 in	HB

All of the information, suggestions, and recommendations pertaining to the properties and uses of the Glastic products described herein are based upon tests and data believed to be accurate; however, the final determination regarding the suitability of any material described herein for the use contemplated, the manner of such use, and whether the use infringes any patents is the sole responsibility of the user. THERE IS NO WARRANTY, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Under no circumstances shall we be liable for incidental or consequential loss or damage.

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GPO-3

Electrical Grade Sheet Laminate

GPO-3 is an electrical grade sheet laminate. All grades of our electrical grade sheet laminates are produced using polyester resin and fiberglass reinforcement. They are U.L. recognized and are available in 36" x 72" and 48" x 96" sheet sizes. The sheets are manufactured in thickness ranging from 1/32" to 1" thick, with most sizes in stock for immediate shipment.

Polyply L-50: Track resistant, flame retardant laminate which meets or exceeds NEMA GPO-3 requirements.

U.L. Recognition File Number: Polyply #L50, NEMA Grade GPO-3, Red (color), #E82624.

Typical Features:

- Electrical insulation
- Track resistance
- Self extinguishing UL94 (V-0)
- Chemical resistance
- Impact & Abrasion resistant
- Good mechanical strength
- Low conductivity
- Low smoke

Product Applications:

- Mounting panels in switch bars
- Phase & End barriers
- Insulating supports
- Bus bar supports
- Transformers
- Antenna bases
- Spacers



GPO-3

Standard Thickness (inches) :	1/32 1/16 3/32 1/8 3/16 1/4 3/8 1/2 5/8 1
Standard Sheet Size (inches) :	36 x 72 and 48 x 96
Standard Color :	Red

GPO-3

Electrical Grade Sheet Laminate

PROPERTY TESTED	ASTM UL TEST#	UNITS	POLYPLY L50 GPO-3
GENERAL INFORMATION			
Polyply Grade	---	---	L50
NEMA Grade	---	---	GPO-3
Color	---	---	RED
U.L. Recognition File #	---	---	E82624
MECHANICAL PROPERTIES			
Tensile Strength	D638	psi	10,000
Flexural Strength	D790	psi	23,200
Compressive Strength	D695	psi	32,800
Flexural Modulus	D790	psi x 10 ⁶	1.23
Shear Strength	D732	psi	14,000
Izod Impact Strength (Notched)	D256	ft-lb/in	8.2
Water Absorption	D570	% by weight	0.21
Hardness, Barcol	D2583	---	50
Specific Gravity	D792	---	1.8
ELECTRICAL PROPERTIES			
Dielectric Strength	D149	volts/mil	400
Dielectric Strength (parallel in oil)	D149	kV	57
High Voltage Arc Resistance	D495	sec	200+
Dielectric Constant at 60 Hz	D150	---	4.8
Dielectric Constant at M Hz	D150	---	4.7
Dissipation Factor at 60 Hz	D150	---	0.013
Dissipation Factor at M Hz	D150	---	0.011
Comparative Tracking Index	D3638	volts	500+
THERMAL PROPERTIES			
Coefficient of Thermal Expansion	D696	in/in/°C x 10 ⁻⁵	2.0
Thermal Conductivity	C177	btu/hr/ft ² /in/°F	1.9
UL Temp Index - Electrical	UL746B	°C	120
UL Temp Index - Mechanical	UL746B	°C	140
FLAME RESISTANCE PROPERTIES			
U.L. Subject 94	UL 94	---	94V0

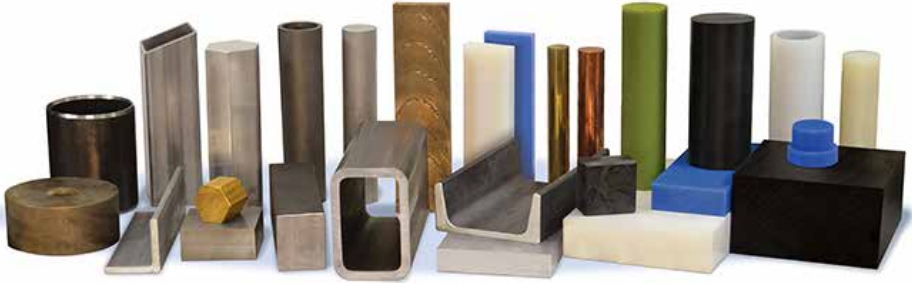
The numbers supplied for the testing of this product came directly from the manufacturer of this material. These numbers should be used as a reference only, they are not to replace the actual testing of the material in your specific application. Test results may vary from application to application.



Alro Online Store

MyAlro.com

Aluminum • Alloys • Carbon Steel • Stainless Steel • Red Metals • Plastics



Did you know Alro also offers online shopping and e-business solutions for all of our customers? Visit the Alro Online Store from your computer or mobile device 24 hours a day. Set up your company account and purchase metals and plastics from our vast inventory.

Alro utilizes systems technology to achieve the benefits of e-Business in raw material procurement processes.

- **Business to Business (B2B) – Helps reduce purchasing transaction costs.**
- **Web Ordering (MyAlro.com) – Helps with material selection, quoting and estimating.**
- **Automated Inventory Replenishment (APOS) – helps reduce Kan Ban replenishment costs**
- **Summary Billing – helps reduce admin costs of processing raw material payables**
- **Advance Shipping Notices – helps reduce receiving time**

Alro computers retrieve business information from customers/vendors computers via the internet. During the process we pickup and deliver electronic business documents. This process typically does not require any programming on the part of our customers, as Alro systems are designed to accept virtually any customer document format. Some examples of these documents are as follows:

- | | | |
|--------------------------|---|----------------------------|
| • Purchase orders | • POD - Electronic Proof of Delivery | • CAD drawings |
| • Invoices | • ACH Payment notifications | • Burn prints |
| • Quotes | • Mill Certifications | • Material releases |

