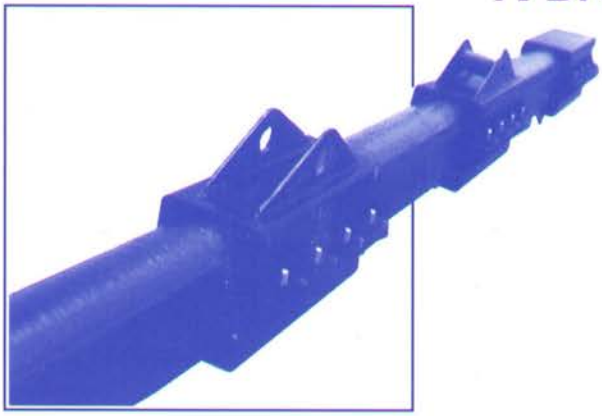
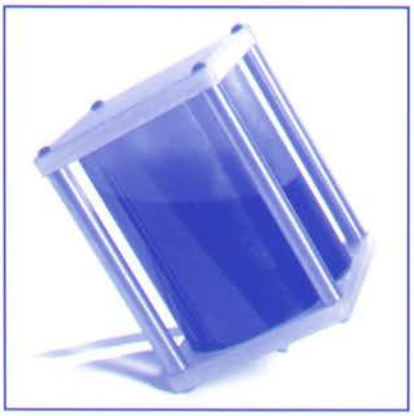
Innovative
Composite Structures
Since 1966

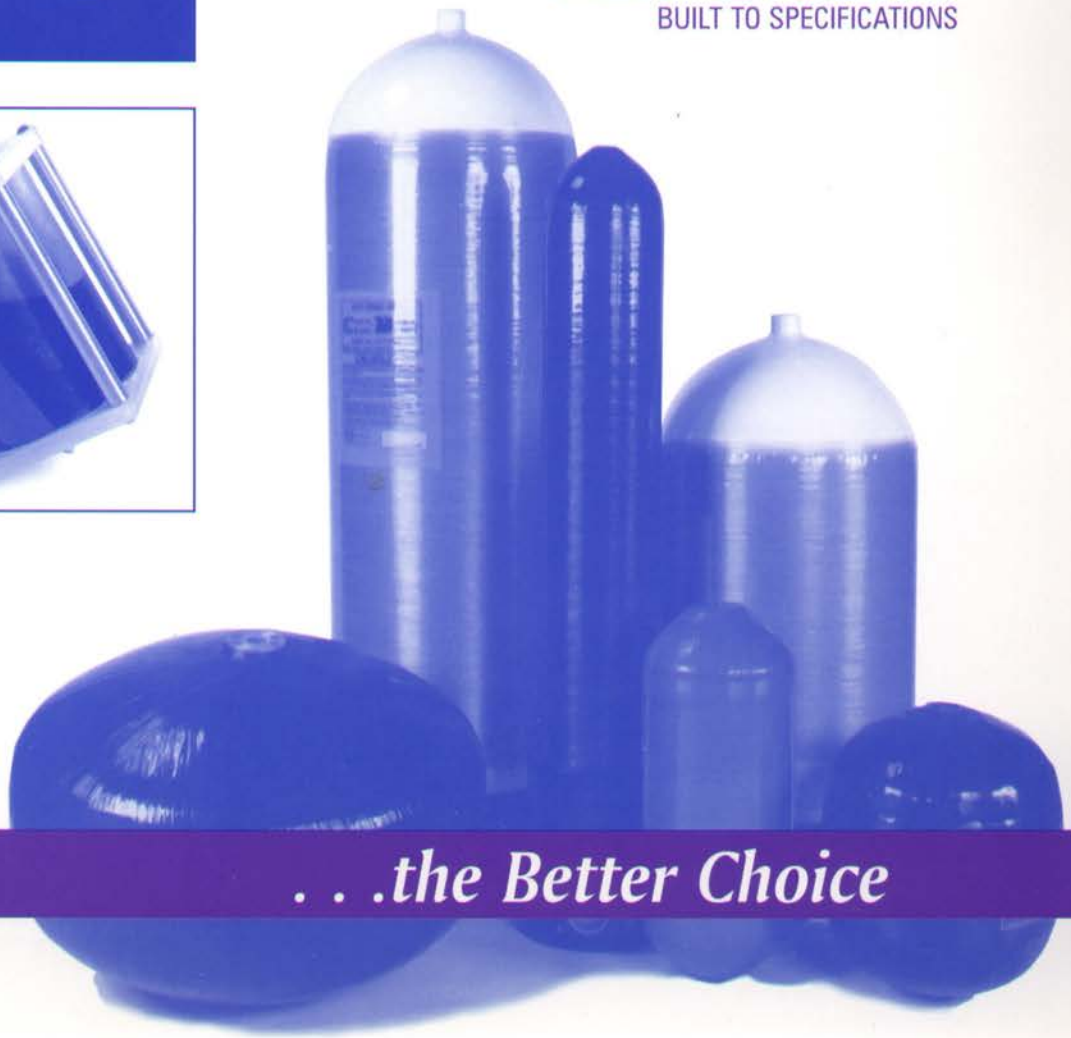
AMALGA COMPOSITES, INC.

A Broad Base of Applications





- PNEUMATIC CYLINDER TUBING
- RESERVOIR QUALITY TUBING
- FOOD GRADE TUBING
- PRESSURE VESSELS
- ELECTRICAL TUBING & FUSE COMPONENTS
- TUBULAR CORES, ROLLERS and SHAFTS
- BOOMS and MASTS
- MAGNETIC COIL FORMS
- LAUNCH TUBES
- DRIVE SHAFTS
- OTHER COMPOSITE COMPONENTS BUILT TO SPECIFICATIONS



. . .the Better Choice

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PRODUCT DATA SHEET

AMALGA COMPOSITES, INC.

MEMBER OF NFPA

BLACK AMALGON® (BA)

Pneumatic Cylinder Tubing

(Clear and Custom Colors Available)

COMPANY PROFILE

Founded in 1966, Amalga Composites, Inc., of Milwaukee, Wisconsin is a leader in the design, engineering and manufacturing of superior quality composite components. Amalga Composites is one of the country's largest independent filament-winding operations with:

- 80,000 sq.ft. manufacturing facility
- three coating/painting areas
- six separate production lines
- complete machining capabilities
- three 200 x 40-foot overhead crane bays

Doctoral-level engineering provides the design expertise to meet the toughest requirements and offer immediate technical support for our customers, from prototype through production. Our company provides high-volume output for both domestic and international customers.

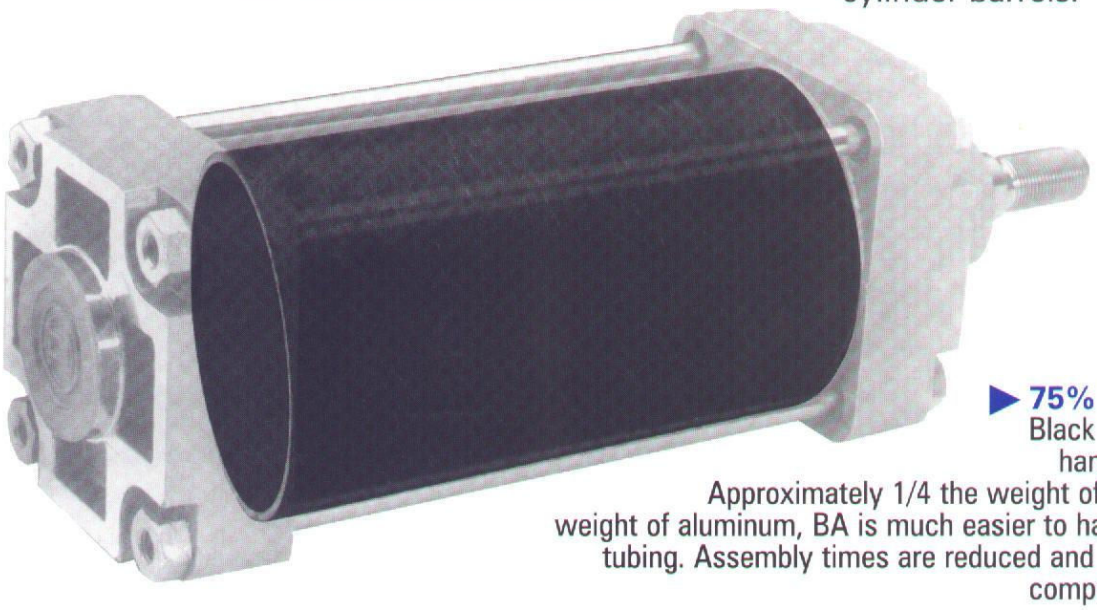
PRODUCT CAPABILITIES

- Pneumatic Cylinder Tubing
- Pressure Vessels
- Drive Shafts
- Magnetic Coil Forms
- Booms and Masts
- Food Grade Tubing
- Tubular Cores, Rollers and Shafts
- Reservoir Quality Tubing
- Electrical Tubing and Fuse Components
- Launch Tubes

The Alternative to Metal

For more than 30 years Amalga has produced an alternative to metallic pneumatic cylinder tubing.

Constructed of fiber reinforced thermoset epoxy matrix, Black Amalgon has an inner surface of evenly dispersed low friction additives. The results: A light weight, high strength, corrosion resistant composite material which replaces carbon steel, honed and chromed steel, stainless steel, aluminum or brass cylinder barrels.



. . .the Better Choice

▶ 75% Reduction in Weight. Black Amalgon reduces material handling and shipping costs. Approximately 1/4 the weight of steel or brass and 3/4 the weight of aluminum, BA is much easier to handle than traditional metal tubing. Assembly times are reduced and stress loads on connected component parts are decreased.

▶ Superior Corrosion Resistance. Trouble-free performance in chemical, high moisture and other adverse environments including salt and chlorinated water which results in significant reduction in life cycle costs.

▶ Reduced Maintenance Costs. No piston lock-up. BA's manufacturing process ensures a smooth, self-lubricating inside surface that prevents pistons from sticking, even after they have remained idle for months. Ongoing tests conducted on non-lubricated cylinders resulted in cycles of greater than a million strokes without requiring seal replacement.

▶ Storage Capacity. We can stock products to meet your JIT, MRP or KAN BAN requirements.

▶ Eliminate Honing Costs. A surface smoother than honed steel...without the cost of honing. A 5-15 Ra micro-inch inside surface finish performs just like a honed surface.

▶ Shape Stability and Impact Resistance. Ship, store and cut BA, it will retain its circular shape. Unlike metals, the product does not dent. Material impact strength is 40 Izod ft.- lbs.

▶ Excellent Thermal Stability. With a very low coefficient of thermal expansion, BA operates efficiently up to 275° F and customers have reported success in using our product at temperatures below -300° F.

▶ Non-Magnetic Material. Permits magnetic sensors to control piston movement directly through the wall thickness.

Innovative
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PRODUCT SELECTION GUIDE

AMALGA COMPOSITES, INC.

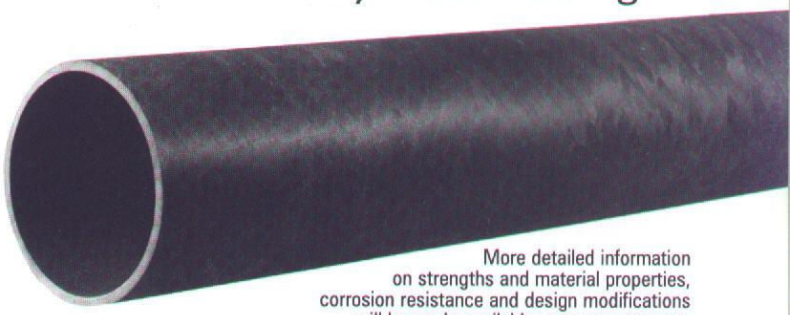
10600 West Mitchell Street • West Allis, WI 53214

414-453-9555 • 800-262-5424 • Fax: 414-453-9561

www.amalgacomposites.com • email: amalga@execpc.com

BLACK AMALGON® (BA)

Pneumatic Cylinder Tubing



More detailed information on strengths and material properties, corrosion resistance and design modifications will be made available upon your request.

Metric Measurement System

Model No.[1]	Standard Bore Size (mm)	Random Lengths to	Operating kPa Non-Tie Rod Design[2]	Operating kPa Tie Rod Design[2]	Kilograms Per Meter
MBA32	32	1.52 meters	6614	13298	0.492
MBA40	40	1.52 meters	5305	10680	0.805
MBA50	50	3.05 meters	4203	8544	0.969
MBA63	63	3.05 meters	3376	6752	1.223
MBA72	72	3.05 meters	3128	5822	1.059
MBA80	80	3.05 meters	2618	5305	1.640
MBA100	100	3.05 meters	2136	4272	1.938
MBA125	125	3.05 meters	1723	3445	2.385
MBA125 A	125	3.05 meters	2756	4754	3.578
MBA160	160	3.05 meters	1309	2687	2.982
MBA160 A	160	3.05 meters	2136	3721	4.622
MBA160 B	160	3.05 meters	2963	4685	6.262
MBA200	200	3.05 meters	1034	2136	3.727
MBA200 A	200	3.05 meters	1723	2963	5.665
MBA200 B	200	3.05 meters	2343	3790	7.604

FOOTNOTES:

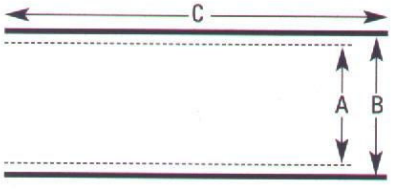
1. Under 1.000-inch tooling available. Tooling constantly upgraded. Call for availability.
2. Operating pressure calculated with minimum 4:1 safety factor.

Let Us Quote Your Application!

NAME: _____

COMPANY: _____

PHONE: _____



DIMENSIONS

A _____

B _____

C _____

CHAMFER: NO YES Angle _____

SHOULDER: NO YES Depth _____ Length _____

HOLES: NO YES Diameter _____ Location _____

OTHER OPERATIONS: _____

QUANTITY IN PRODUCTION: _____

TOLERANCE REQUIREMENTS: O.D. _____ I.D. _____

Length _____ Other _____

SAFETY FACTOR: _____ : _____

CYLINDER APPLICATION? YES NO

FAX this to: **414-453-9561**

Standard Measurement System

Model No.[1]	Standard Bore Size (Inches)	Random Lengths to	Operating PSI Non-Tie Rod Design[2]	Operating PSI Tie Rod Design[2]	Weight Per Foot LBS
BA100	1.000	5 feet	1220	2440	0.33
BA112	1.125	5 feet	1080	2170	0.37
BA125	1.250	5 feet	980	1950	0.41
BA150	1.500	5 feet	810	1620	0.50
BA175	1.750	5 feet	700	1390	0.56
BA200	2.000	10 feet	610	1200	0.66
BA225	2.250	10 feet	543	1000	0.75
BA250	2.500	10 feet	490	970	0.83
BA275	2.750	10 feet	440	890	0.91
BA300	3.000	10 feet	410	810	1.00
BA325	3.250	10 feet	380	750	1.10
BA350	3.500	10 feet	350	700	1.20
BA375	3.750	10 feet	330	650	1.30
BA400	4.000	10 feet	300	610	1.30
BA500	5.000	10 feet	240	490	1.70
BA575	5.750	10 feet	210	420	1.90
BA600	6.000	10 feet	200	410	2.00
BA700	7.000	10 feet	170	350	2.30
BA800	8.000	10 feet	150	300	2.70
BA1000 A	10.000	10 feet	190	330	5.00
BA1000 B	10.000	10 feet	260	430	6.70
BA1200 A	12.000	10 feet	160	280	6.00
BA1200 B	12.000	10 feet	220	360	8.00
BA1400 A	14.000	10 feet	140	240	7.00
BA1400 B	14.000	10 feet	190	310	9.30
BA1600 B	16.000	10 feet	170	270	10.70
BA1600 C	16.000	10 feet	210	320	13.40
BA1800 B	18.000	10 feet	150	240	11.50
BA1800 C	18.000	10 feet	190	290	15.00
BA2000 B	20.000	10 feet	130	220	13.50
BA2000 C	20.000	10 feet	170	260	17.00
BA2400 C	24.000	8 feet	140	220	19.10
BA2800 D	28.000	10 feet	120	220	36.00
BA3000 D	30.000	8 feet	100	200	41.40

Standard wall thickness: .125 to .500. Custom wall thicknesses available.

Innovative
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Since 1966

PRODUCT DATA SHEET

AMALGA COMPOSITES, INC.

MEMBER OF NFPA

RESERVOIR QUALITY (RQ™)

Translucent Pressure Tubing

COMPANY PROFILE

Founded in 1966, Amalga Composites, Inc., of Milwaukee, Wisconsin is a leader in the design, engineering and manufacturing of superior quality composite components. Amalga Composites is one of the country's largest independent filament-winding operations with:

- 80,000 sq.ft. manufacturing facility
- three coating/painting areas
- six separate production lines
- complete machining capabilities
- three 200 x 40-foot overhead crane bays

Doctoral-level engineering provides the design expertise to meet the toughest requirements and offer immediate technical support for our customers, from prototype through production. Our company provides high-volume output for both domestic and international customers.

PRODUCT CAPABILITIES

- Pneumatic Cylinder Tubing
- Pressure Vessels
- Drive Shafts
- Magnetic Coil Forms
- Booms and Masts
- Food Grade Tubing
- Tubular Cores, Rollers and Shafts
- Reservoir Quality Tubing
- Electrical Tubing and Fuse Components
- Launch Tubes

"At-A-Glance" Fluid Level Indication

Designed specifically for pressurized air-oil system reservoirs, translucent Reservoir Quality (RQ) Tubing provides the ease of "at-a-glance" fluid level indication from any angle. RQ Tubing is available in ID sizes ranging from 1 inch to 30 inches (metric sizes also available) and is typically used in systems of 150 psi or higher.

. . .Better Choice

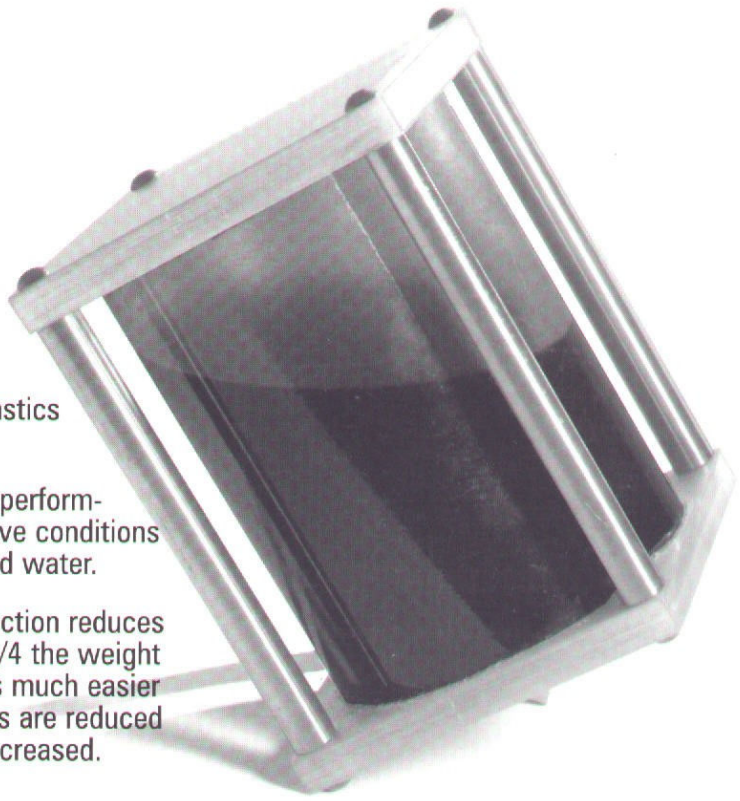
▶ Eliminates Costly Sight Glass.
RQ tubing is translucent, eliminating the need for an expensive and fragile sight glass.

▶ Shatter Resistant. RQ Tubing is formulated to withstand high impact and it is chip resistant. With an impact strength of 40 Izod ft.-lbs., unlike metals, RQ simply does not dent.

▶ 10 Times As Strong. RQ Tubing offers at least 10 times the tensile strength of conventional thermoplastics such as polycarbonate, polystyrene and acrylic.

▶ Superior Corrosion Resistance. Trouble-free performance in chemical, acid, high moisture and other corrosive conditions and adverse environments including salt and chlorinated water.

▶ 75% Reduction in Weight. Composite construction reduces material handling and shipping costs. Approximately 1/4 the weight of steel or brass and 3/4 the weight of aluminum, RQ is much easier to handle than traditional metal tubing. Assembly times are reduced and stress loads on connected component parts are decreased.



Uncompromising Quality and Service Includes:

▶ Large Inventory of Tooling. Amalga Composites has developed an extensive inventory of tooling to meet most needs. If not available, we will quote the cost of tooling separately.

▶ Storage Capacity. We can stock products to meet your JIT, MRP or KAN BAN requirements.

▶ Quality Products for the Fluid Power Industry. Amalga Composites, Inc. is a leader in designing, engineering and manufacturing filament wound composites to meet the tough environmental and performance requirements of the Fluid Power Industry.

▶ Responsive Service. Call for additional technical assistance on size and price for Reservoir Quality Tubing and other composite products. We are interested in helping you!

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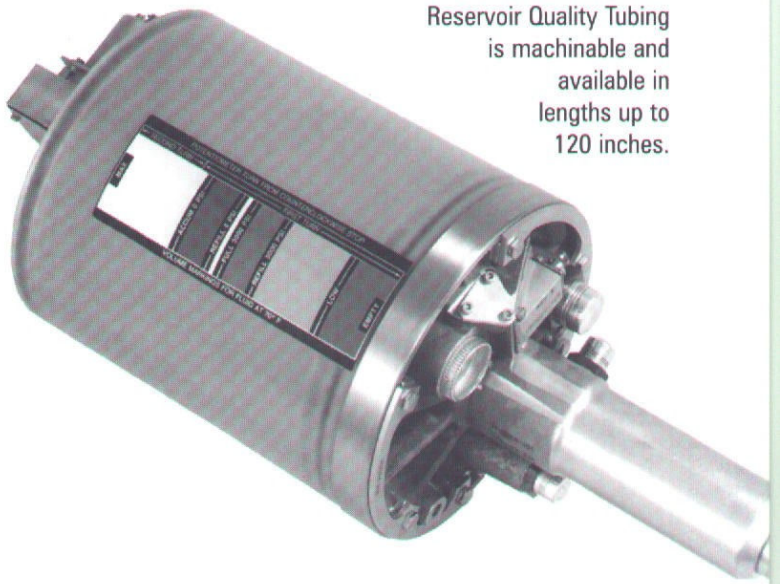
RESERVOIR QUALITY (RQ™)

Translucent Pressure Tubing



Reservoir Quality Tubing is machinable and available in lengths up to 120 inches.

Metric Measurement System

Model No.[1]	Standard Bore Size (mm)	Random Lengths to	Operating kPa Non-Tie Rod Design[2]	Operating kPa Tie Rod Design[2]	Kilograms Per Meter
MRQ32	32	1.52 meters	6614	13298	0.492
MRQ40	40	1.52 meters	5305	10680	0.805
MRQ50	50	3.05 meters	4203	8544	0.969
MRQ63	63	3.05 meters	3376	6752	1.223
MRQ72	72	3.05 meters	3128	5822	1.059
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MRQ125	125	3.05 meters	1723	3445	2.385
MRQ125 A	125	3.05 meters	2756	4754	3.578
MRQ160	160	3.05 meters	1309	2687	2.982
MRQ160 A	160	3.05 meters	2136	3721	4.622
MRQ200	200	3.05 meters	1034	2136	3.727
MRQ200 A	200	3.05 meters	1723	2963	5.665

FOOTNOTES:
1. Under 1.000-inch tooling available. Tooling constantly upgraded. Call for availability.
2. Operating pressure calculated with minimum 4:1 safety factor.

Standard Measurement System

Bore Model No.[1]	Standard Random Size (Inches)	Lengths to	Operating PSI Non-Tie Rod Design[2]	Operating PSI Tie Rod Design[2]	Weight Per Foot LBS
RQ100	1.000	5 feet	1220	2,440	0.33
RQ112	1.125	5 feet	1080	2,170	0.37
RQ125	1.250	5 feet	980	1,950	0.41
RQ150	1.500	5 feet	810	1,620	0.50
RQ175	1.750	5 feet	700	1,390	0.56
RQ200	2.000	10 feet	610	1,200	0.66
RQ225	2.250	10 feet	543	1,000	0.75
RQ250	2.500	10 feet	490	970	0.83
RQ275	2.750	10 feet	440	890	0.91
RQ300	3.000	10 feet	410	810	1.00
RQ325	3.250	10 feet	380	750	1.10
RQ350	3.500	10 feet	350	700	1.20
RQ375	3.750	10 feet	330	650	1.30
RQ400	4.000	10 feet	300	610	1.30
RQ500	5.000	10 feet	240	490	1.70
RQ575	5.750	10 feet	210	420	1.90
RQ600	6.000	10 feet	200	410	2.00
RQ700	7.000	10 feet	170	350	2.30
RQ800	8.000	10 feet	150	300	2.70
RQ1000 A	10.000	10 feet	190	330	5.00
RQ1200 A	12.000	10 feet	160	280	6.00
RQ1400 A	14.000	10 feet	140	240	7.00

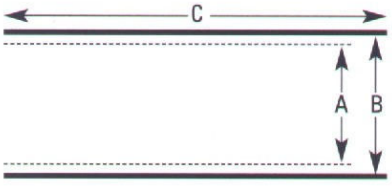
Reservoir Quality Tubing is limited to 0.187 wall thickness to retain translucency.

Let Us Quote Your Application!

NAME:_____

COMPANY:_____

PHONE:_____



DIMENSIONS
A_____
B_____
C_____

CHAMFER: NO YES Angle_____
SHOULDER: NO YES Depth _____ Length _____
HOLES: NO YES Diameter_____ Location_____
OTHER OPERATIONS:_____
QUANTITY IN PRODUCTION:_____
TOLERANCE REQUIREMENTS: O.D._____ I.D._____
Length_____ Other_____
SAFETY FACTOR:_____:_____
CYLINDER APPLICATION? YES NO

FAX this to: **414-453-9561**

Innovative
Composite Structures
Since 1966

PRODUCT DATA SHEET

AMALGA COMPOSITES, INC.

Composite Cores and Rollers

for Lightweight, High Speed

Composites. . . the Better Choice

- **Up to 75% lighter than metals.**
  Lighter rollers mean less inertia and higher speeds
- **High stiffness to weight ratio**
  Reduced machine wear
- **Increased Machine Life.**
  Less wear and tear on bushing, bearings and journals

Applications

- **Printing Press Rollers**
- **Process Rollers**
- **Idler Rollers**
- **Blown Film Lines**
- **Laminating Lines**
- **Paper and Film Machines**
- **Many other applications**

Features

- **FILAMENT WOUND CONSTRUCTION**
- **CARBON FIBER AND/OR FIBERGLASS CONSTRUCTION**
- **LARGE RANGE OF DIAMETERS.**
  From 1 inch to 42 inch
- **LARGE RANGE OF LENGTHS**
  Up to 30 feet
- **CUSTOM ROLL ENDS**
  Thru Shaft w/ bearings, Live Shaft, Internal Bearings w/shafts
- **DYNAMIC BALANCING**
- **WALLS AS THIN AS 0.060 INCH**
- **CUSTOM FINISHES AND COATINGS AVAILABLE**

COMPANY PROFILE

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- six separate production lines
- complete machining capabilities
- three 200 x 40-foot overhead crane bays

Doctoral-level engineering provides the design expertise to meet the toughest requirements and offer immediate technical support for our customers, from prototype through production. Our company provides high-volume output for both domestic and international customers.

PRODUCT CAPABILITIES

- Pneumatic Cylinder Tubing
- Pressure Vessels
- Drive Shafts
- Magnetic Coil Forms
- Booms and Masts
- Food Grade Tubing
- Tubular Cores, Rollers and Shafts
- Reservoir Quality Tubing
- Electrical Tubing and Fuse Components
- Launch Tubes

Amalga Composite Cores and Rollers are designed, engineered and manufactured to meet the toughest applications

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Innovative
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Since 1966

PRODUCT SELECTION GUIDE

AMALGA COMPOSITES, INC.

CORES/ROLLERS

Built for maximum stiffness.

Material Properties	E-glass	Commercial Carbon	High Modulus Carbon
Flexural Modulus Longitudinal, x 10^6 psi	5.5	14.0	21.0
Flexural Modulus Circumferential, x 10^6 psi	1.1	5.0	7.5
Tensile Strength Longitudinal, psi	115,000	130,000	130,000
Tensile Strength Circumferential, psi	N/A	36,000	36,000
Compressive Strength Longitudinal, psi	5,000	130,000	130,000
Compressive Strength Circumferential, psi	26,000	50,000	50,000
Shear Modulus, x 10^6 psi	1.0	1.0	2.2
Shear Strength, psi	8,000	8,000	8,000
CTE Circumferential, x 10^{-6} in/in/°F	8.6	7.1	6.4
CTE Longitudinal, x 10^{-6} in/in/°F	4.8	0.17	-43.6
Poisson's ratio, NUxy	0.27	0.24	0.69
Density, Lb/in^3	0.072	0.058	0.058

OVERWRAP REPAIRS

Existing Cores and Rollers can be overwrapped for extended life.

Material Properties	E-glass	Commercial Carbon
Flexural Modulus Longitudinal, x 10^6 psi	1.2	1.3
Flexural Modulus Circumferential, x 10^6 psi	8.0	19.0
Tensile Strength Longitudinal, psi	5,000	6,000
Tensile Strength Circumferential, psi	210,000	210,000
Compressive Strength Longitudinal, psi	17,000	35,000
Compressive Strength Circumferential, psi	138,000	185,000
Shear Modulus, x 10^6 psi	0.8	1.0
Shear Strength, psi	8,000	8,000
CTE Circumferential, x 10^{-6} in/in/°F	3.7	-0.09
CTE Longitudinal, x 10^{-6} in/in/°F	13.3	11.9
Poisson's ratio, NUxy	0.08	0.02
Density, Lb/in^3	0.072	0.058

Design Criteria

Web Material - _____

Web Width - _____

Web Speed - _____

Web Tension - _____

Operating Temp - _____

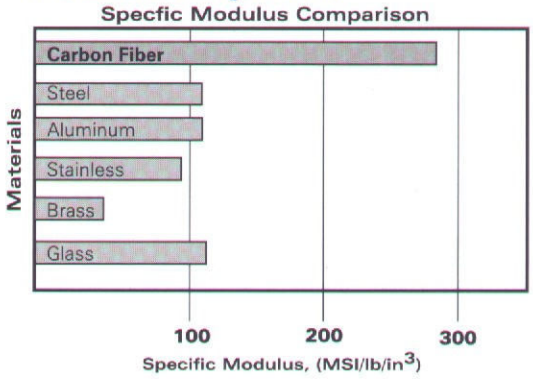
Max. Allowable Deflection - _____

Wrap Angle - _____

Nip width - _____

Nip Angle - _____

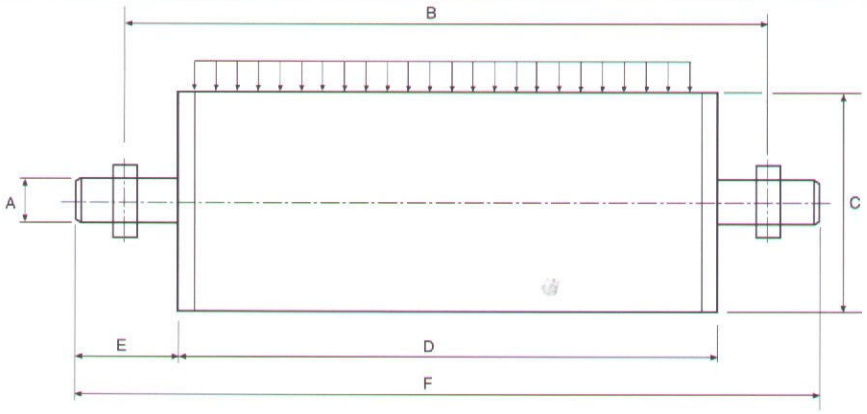
Material Comparison



Application Assistance

So that we can better assist you in developing the right product for your application, please contact us by calling 414-453-9555 or e-mailing: amalga@execpc.com. We will be happy to help you chose the product which best suits your application.

Dimension Requirements



A JOURNAL DIAMETER	B BEARING WIDTH	C CORE DIAMETER	D FACE LENGTH	E JOURNAL LENGTH	F OVERALL LENGTH
Tolerance + -	+ -	+ -	+ -	+ -	+ -

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Tensile Strength Longitudinal, psi	115,000	130,000	130,000
Tensile Strength Circumferential, psi	N/A	36,000	36,000
Compressive Strength Longitudinal, psi	5,000	130,000	130,000
Compressive Strength Circumferential, psi	26,000	50,000	50,000
Shear Modulus, x 10^6 psi	1.0	1.0	2.2
Shear Strength, psi	8,000	8,000	8,000
CTE Circumferential, x 10^{-6} in/in/°F	8.6	7.1	6.4
CTE Longitudinal, x 10^{-6} in/in/°F	4.8	0.17	-43.6
Poisson's ratio, NUxy	0.27	0.24	0.69
Density, Lb/in^3	0.072	0.058	0.058

OVERWRAP REPAIRS

Existing Cores and Rollers can be overwrapped for extended life.

Material Properties	E-glass	Commercial Carbon
Flexural Modulus Longitudinal, x 10^6 psi	1.2	1.3
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Tensile Strength Longitudinal, psi	5,000	6,000
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Compressive Strength Longitudinal, psi	17,000	35,000
Compressive Strength Circumferential, psi	138,000	185,000
Shear Modulus, x 10^6 psi	0.8	1.0
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Density, Lb/in^3	0.072	0.058

Design Criteria

Web Material - _____

Web Width - _____

Web Speed - _____

Web Tension - _____

Operating Temp - _____

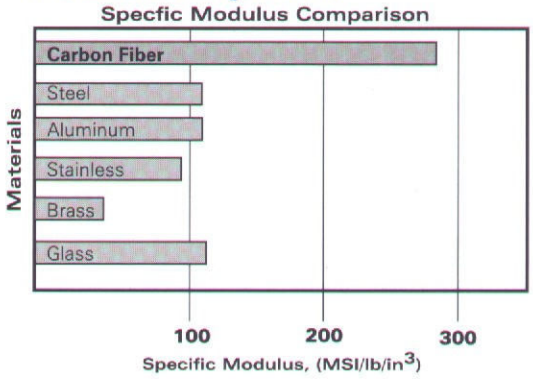
Max. Allowable Deflection - _____

Wrap Angle - _____

Nip width - _____

Nip Angle - _____

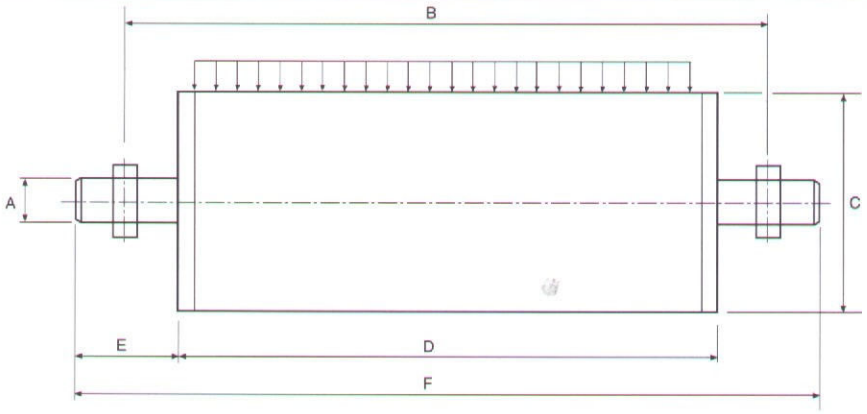
Material Comparison



Application Assistance

So that we can better assist you in developing the right product for your application, please contact us by calling 414-453-9555 or e-mailing: amalga@execpc.com. We will be happy to help you chose the product which best suits your application.

Dimension Requirements



A JOURNAL DIAMETER	B BEARING WIDTH	C CORE DIAMETER	D FACE LENGTH	E JOURNAL LENGTH	F OVERALL LENGTH
Tolerance + -	+ -	+ -	+ -	+ -	+ -

Innovative
Composite Structures
Since 1966

PRODUCT DATA SHEET

AMALGA COMPOSITES, INC.

FOOD GRADE AMALGON® (FGA™)

for Direct Food Contact Applications

COMPANY PROFILE

Founded in 1966, Amalga Composites, Inc., of Milwaukee, Wisconsin is a leader in the design, engineering and manufacturing of superior quality composite components. Amalga Composites is one of the country's largest independent filament-winding operations with:

- 80,000 sq.ft. manufacturing facility
- three coating/painting areas
- six separate production lines
- complete machining capabilities
- three 200 x 40-foot overhead crane bays

Doctoral-level engineering provides the design expertise to meet the toughest requirements and offer immediate technical support for our customers, from prototype through production. Our company provides high-volume output for both domestic and international customers.

PRODUCT CAPABILITIES

- Pneumatic Cylinder Tubing
- Pressure Vessels
- Drive Shafts
- Magnetic Coil Forms
- Booms and Masts
- Food Grade Tubing
- Tubular Cores, Rollers and Shafts
- Reservoir Quality Tubing
- Electrical Tubing and Fuse Components
- Launch Tubes

The Alternative to Stainless Steel

Food Grade Amalgon tubing is a fiber reinforced thermoset composite material specifically designed for use as a replacement for stainless steel tubing in direct food contact applications. The ultra-smooth interior surface finish of 15 Ra is ideal for any food service application. These materials are impervious to caustic cleaning solutions and can be sanitized using conventional cleaning methods. The composite material is 75% lower in weight than stainless steel and is easy to machine.

. . . the Better Choice

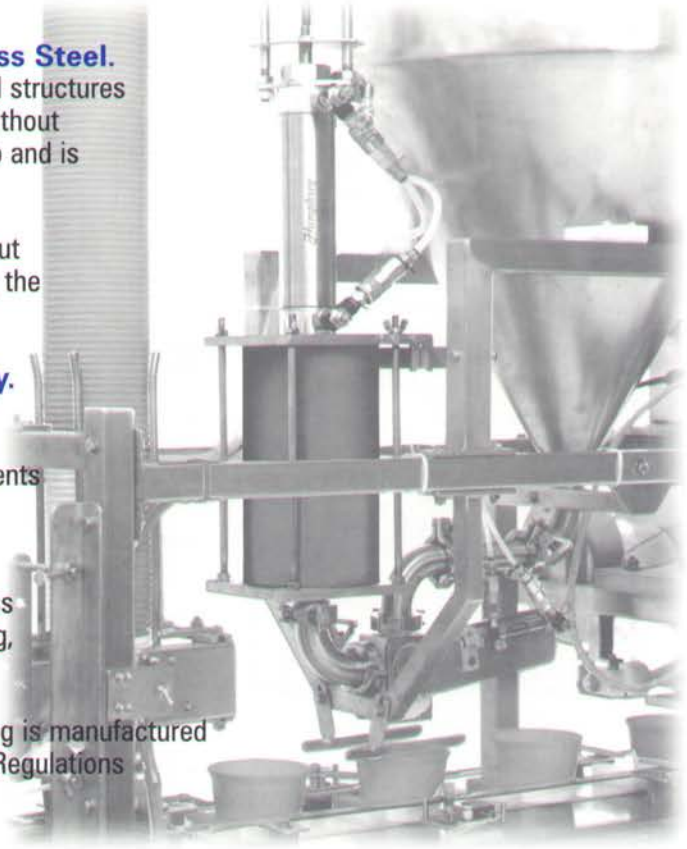
▶ Composite ID is Superior to Honed Stainless Steel. Lead times are always less than those required for metal structures because the self-lubricating, honed like ID is achieved without honing. Food Grade Amalgon eliminates bacterial buildup and is impervious to caustic cleaning solutions.

▶ Wide Range of Lengths. FGA tubing is sold in cut pieces or lengths up to 120 inches, therefore eliminating the need for costly joints and labor intensive assembly.

▶ In-House Tooling Affords Greater Versatility. Tooling for FGA tubing is available for diameters of 1 inch ID to 30 inch ID, as well as metric sizes. Wall thickness can be varied to meet pressure requirements or component geometry.

▶ More Cost Effective than Stainless Steel. FGA offers savings from 25% to 50% over honed stainless steel. FGA's use reduces material expenditures, handling, assembly time and shipping costs.

▶ Complies with FDA Requirements. FGA tubing is manufactured for direct food contact in accordance with FDA Code of Regulations Publication CFR 21, paragraphs 173.300 and 177.2450.



Food Grade Amalgon tubing is designed, engineered and manufactured to meet the tough environmental and performance requirements of the food processing industry.

Innovative
Composite Structures
Since 1966

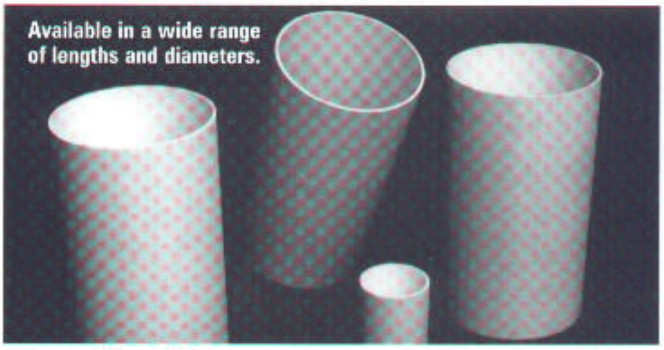
PRODUCT SELECTION GUIDE

AMALGA COMPOSITES, INC.

10600 West Mitchell Street • West Allis, WI 53214
414-453-9555 • 800-262-5424 • Fax: 414-453-9561
www.amalgacomposites.com • email: amalga@execpc.com

FOOD GRADE AMALGON® (FGA™)

for Direct Food Contact Applications



Metric Measurement System

Model No.[1]	Standard Bore Size (mm)	Random Lengths to	Operating kPa Non-Tie Rod Design[2]	Operating kPa Tie Rod Design[2]	Kilograms Per Meter
MFGA 32	32	1.52 meters	6614	13298	0.492
MFGA 40	40	1.52 meters	5305	10680	0.805
MFGA 50	50	3.05 meters	4203	8544	0.969
MFGA 63	63	3.05 meters	3376	6752	1.223
MFGA 72	72	3.05 meters	3128	5822	1.059
MFGA 80	80	3.05 meters	2618	5305	1.640
MFGA 100	100	3.05 meters	2136	4272	1.938
MFGA125	125	3.05 meters	1723	3445	2.385
MFGA125 A	125	3.05 meters	2756	4754	3.578
MFGA160	160	3.05 meters	1309	2687	2.982
MFGA160 A	160	3.05 meters	2136	3721	4.622
MFGA160 B	160	3.05 meters	2963	4685	6.262
MFGA200	200	3.05 meters	1034	2136	3.727
MFGA200 A	200	3.05 meters	1723	2963	5.665
MFGA200 B	200	3.05 meters	2343	3790	7.604

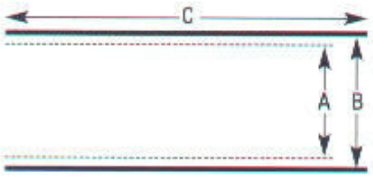
FOOTNOTES:
1. Under 1.000-inch tooling available. Tooling constantly upgraded. Call for availability.
2. Operating pressure calculated with minimum 4:1 safety factor.

Let Us Quote Your Application!

NAME: _____

COMPANY: _____

PHONE: _____



DIMENSIONS

A _____

B _____

C _____

CHAMFER: NO YES Angle _____

SHOULDER: NO YES Depth _____ Length _____

HOLES: NO YES Diameter _____ Location _____

OTHER OPERATIONS: _____

QUANTITY IN PRODUCTION: _____

TOLERANCE REQUIREMENTS: O.D. _____ I.D. _____

Length _____ Other _____

SAFETY FACTOR: _____ : _____

CYLINDER APPLICATION? YES NO

FAX this to: **414-453-9561**

Standard Measurement System

Model No.[1]	Standard Bore Size (Inches)	Random Lengths to	Operating PSI Non-Tie Rod Design[2]	Operating PSI Tie Rod Design[2]	Weight Per Foot LBS
FGA100	1.000	5 feet	1,220	2,440	0.33
FGA112	1.125	5 feet	1,080	2,170	0.37
FGA125	1.250	5 feet	980	1,950	0.41
FGA150	1.500	5 feet	810	1,620	0.50
FGA175	1.750	5 feet	700	1,390	0.56
FGA200	2.000	10 feet	610	1,200	0.66
FGA225	2.250	10 feet	543	1,000	0.75
FGA250	2.500	10 feet	490	970	0.83
FGA275	2.750	10 feet	440	890	0.91
FGA300	3.000	10 feet	410	810	1.00
FGA325	3.250	10 feet	380	750	1.10
FGA350	3.500	10 feet	350	700	1.20
FGA375	3.750	10 feet	330	650	1.30
FGA400	4.000	10 feet	300	610	1.30
FGA500	5.000	10 feet	240	490	1.70
FGA575	5.750	10 feet	210	420	1.90
FGA600	6.000	10 feet	200	410	2.00
FGA700	7.000	10 feet	170	350	2.30
FGA800	8.000	10 feet	150	300	2.70
FGA1000 A	10.000	10 feet	190	330	5.00
FGA1000 B	10.000	10 feet	260	430	6.70
FGA1200-A	12.000	10 feet	160	280	6.00
FGA1200-B	12.000	10 feet	220	360	8.00
FGA1400-A	14.000	10 feet	140	240	7.00
FGA1400-B	14.000	10 feet	190	310	9.30
FGA1600-B	16.000	10 feet	170	270	10.70
FGA1600-C	16.000	10 feet	210	320	13.40
FGA1800-B	18.000	10 feet	150	240	11.50
FGA1800-C	18.000	10 feet	190	290	15.00
FGA2000-B	20.000	10 feet	130	220	13.50
FGA2000-C	20.000	10 feet	170	260	17.00
FGA2400-C	24.000	8 feet	140	220	19.10
FGA2800 D	28.000	10 feet	120	220	36.00
FGA3000 D	30.000	8 feet	100	200	41.40

AMALGA
COMPOSITES, INC.

Engineering Assistance

Amalga's doctoral-level engineering expertise provides quick and detailed assistance in getting your ideas into production quicker than metal technology.

Why Choose Compression Molding?

1. Low Material Cost
2. Fast Cycle Rate
3. High Production Volume
4. Customized Compounds
5. Molded in Color
6. Surface Finish - cosmetic or textured
7. Combined Components - eliminate spot welded sub-assemblies
8. Strength - up to 55,000 psi
9. Corrosion Resistance
10. Fire Retardant
11. Food Grade
12. Weight Saving - 4 times lighter than steel

Compression Molding Processes

	Bulk Molding	Sheet Molding	Thick Molding	SMC Random Fiber	SMC- Chop/Continuous	Preform
Bosses & Ribs	Yes	Yes	Yes	Yes	No	No
Cosmetic Appearance	Good	Good	Good	Fair	Fair	Fair
Type of Part	Casting	Stamping	Cast & Stamping	Casting	Casting	Stamping
Size of Part	Small	Large	Medium	Large	Large	Large
Tensile Strength (psi)	5,000	12,000	10,000	23,000	55,000	14,000
Flexural Strength (psi)	15,000	26,000	22,000	37,000	85,000	28,000
Specific Gravity	1.90	1.75	2.00	1.85	1.80	1.20

Process Comparison to Steel

	Sheet Molded Compound	Injection Molded Thermoplastic	Aluminum
Part Consolidation	**Excellent**	Excellent	Fair
Comparable Mass	**75%**	70%	75%
Corrosion Resistance	**Best**	Better	Good
Impact Resistance	**Best**	Better	Poor
Tooling Cost	**40%**	60%	100%
Stiffness	**6%**	2%	30%
Thermal Expansion	**100-130%**	600-1000%	170-200%

Innovative
Composite Structures
Since 1966

PRODUCT DATA SHEET

AMALGA COMPOSITES, INC.

Compression Molding

Custom Designed Products

COMPANY PROFILE

Founded in 1966, Amalga Composites, Inc., of Milwaukee, Wisconsin is a leader in the design, engineering and manufacturing of superior quality composite components. Amalga Composites is one of the country's largest independent filament-winding operations with:

- 80,000 sq.ft. manufacturing facility
- three coating/painting areas
- six separate production lines
- complete machining capabilities
- three 200 x 40-foot overhead crane bays

Doctoral-level engineering provides the design expertise to meet the toughest requirements and offer immediate technical support for our customers, from prototype through production. Our company provides high-volume output for both domestic and international customers.

PRODUCT CAPABILITIES

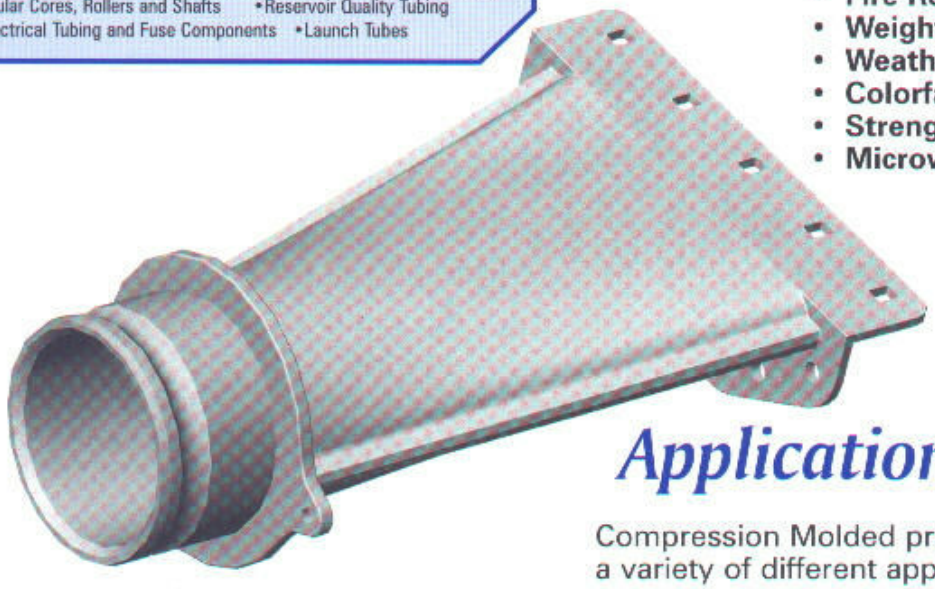
- Pneumatic Cylinder Tubing
- Pressure Vessels
- Drive Shafts
- Magnetic Coil Forms
- Booms and Masts
- Food Grade Tubing
- Tubular Cores, Rollers and Shafts
- Reservoir Quality Tubing
- Electrical Tubing and Fuse Components
- Launch Tubes

The Alternative to Metal

Compression Molded parts offer a strong, lightweight alternative to die-cast, stamped or other formed metal parts.

Fiber Reinforced Plastic molded components provide an excellent alternative to metal for:

- **Corrosion Resistance**
- **Chemcial Resistance**
- **Heat Resistance**
- **Fire Retardance**
- **Weight Reduction**
- **Weatherability**
- **Colorfastness**
- **Strength**
- **Microwave Transparency**



Processes...

Amalga has the ability to provide a variety of different manufacturing processes to meet the varying requirements of our customers. These processes, combined with a variety of different compounds, can provide products which meet your exacting specifications.

- ▶ **SMC: Sheet Molding Compound**
- ▶ **LPMC: Low Pressure Molding Compound**
- ▶ **BMC: Bulk Molding Compound**
- ▶ **TMC: Thick Molding Compound**
- ▶ **SSMC: Structural Molding Compound**
- ▶ **Preform and Mat Process**

Applications. . .

Compression Molded products are utilized in a variety of different applications.

- ▶ **Medical**
- ▶ **Electrical**
- ▶ **Mechanical**
- ▶ **Transportation**
- ▶ **Dishware**
- ▶ **Sanitaryware**
- ▶ **Sporting Goods**

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www.amalgacomposites.com • **email:amalga@execpc.com**

AMALGA
COMPOSITES, INC.

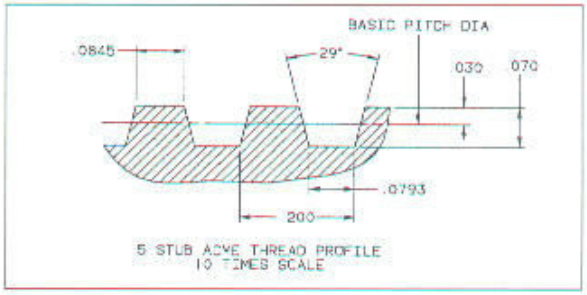
Cylinder Quality Tubing

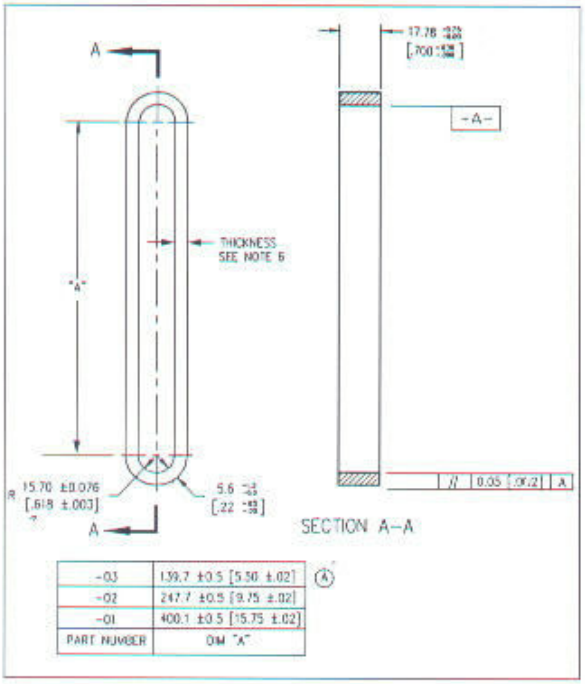
Precision inside diameter without the expense or delays of honing operations.

Precision tooling developed and maintained by Amalga Composites is a critical element in providing the close tolerance pressure tubing you demand. Cylinder tubing offered by Amalga Composites has the following inside diameter characteristics that improve piston performance. The table provides geometric characteristics and tolerances for the range of diameters available.

INSIDE DIAMETER SIZE RANGE	TOLERANCE
Greater than 1.00" to 3.25"	Plus .005" minus .000"
Greater than 3.25" to 6.00"	Plus .006" minus .000"
Greater than 6.00" to 8.00"	Plus .008" minus .000"
Greater than 8.00" to 10.00"	Plus .010" minus .000"
Greater than 10.00" to 14.00"	Plus .015" minus .000"
Greater than 14.00" to 20.00"	Plus .020" minus .000"
Greater than 20.00" to 30.00"	Plus .025" minus .000"

Microinch bore finish: 5-15 Ra
Straightness: .001 per foot
Circularity: 0.002 Inches
Cylindricity: 0.002 Inches





Machining to Blueprint Specifications

Outside diameter grinding

Amalga Composites uses centerless grinding as the standard OD finishing process. The table provides tolerances for the range of diameters available and the process features.

Closer tolerances available upon request.

OUTSIDE DIAMETER SIZE RANGE	TOLERANCE
Greater than 1.00" to 2.50"	Plus .006" minus .000"
Greater than 2.50" to 5.25"	Plus .010" minus .000"
Greater than 5.25" to 8.25"	Plus .012" minus .000"
Greater than 8.25" to 14.50"	Plus .025" minus .005"
Greater than 14.50" to 20.50"	Plus .030" minus .010"
Greater than 20.50" to 32.00"	Plus .040" minus .010"

Surface finish: 125 Ra **Circularity:** 0.010 **Concentricity:** 0.010

Cutting

Composite tubing produced by Amalga Composites is cut to blueprint specified lengths. Depending on tube diameter, either a horizontal stroke or abrasive cut off saw is utilized. The overall length of the cut part dictates the applicable machinable tolerance.

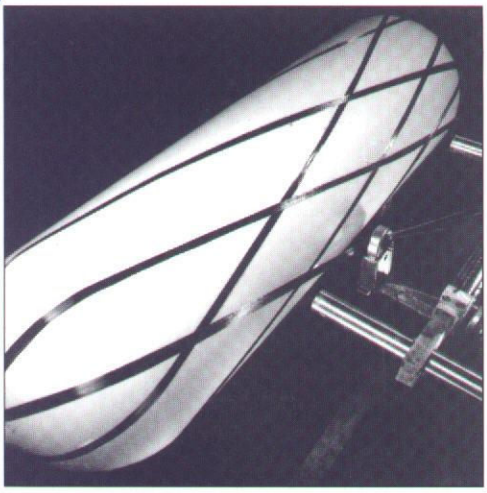
Chamfers, Shoulders and Grooves

Amalga Composites can offer a cylinder body that is completely machined and ready for assembly.

Cut to Length Tolerances and Geometric Characteristics
STANDARD INDUSTRY PRACTICE

AMALGA COMPOSITES, INC.

FILAMENT WOUND COMPOSITE STRUCTURES



TEXTBOOK DEFINITION:
A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them.

PRACTICAL DEFINITION:

A versatile solution to today's design problems.

Amalga Composites offers a variety of light weight and high strength structures that can solve your design challenges.

A wide variety of properties can be achieved through proper selection of fiber type, fiber orientation and resin matrix of the composite structure required for your application. Strong and stiff fibers carry loads imposed on the composite while the resin matrix distributes the loads across the fibers.

Resin Matrix

Amalga Composites has the technical background and experience to engineer a variety of resin systems for filament wound thermoset plastics.

The proven composite structures described on this page have been fabricated with anhydride cured epoxy systems.

Anhydride cured epoxy systems offer the following advantages: high strength/stiffness properties, low shrinkage, excellent corrosion resistance, impact and abrasion resistance.

Typical room temperature properties of the unfilled anhydride cured epoxy resin system.	
Tensile Strength, psi	12,300
Tensile Modulus, psi	450,000
Elongation %	6%
Flexural Strength, psi	12,000
Flexural Modulus, psi	425,000
Heat Distortion Temperature	265°F
Service Temperature	225°F or 325°F

Fiber Types

In the composite industry, over 90% of all fibers used are glass. Electrical or E-glass is the most commonly used and the most economical glass fiber while structural or S-type glass has slightly higher strength and corrosion resistance. Advanced fibers such as carbon and Kevlar exhibit higher tensile strengths and stiffness than glass fibers. Due to the higher cost of these fibers, they are typically reserved for applications demanding exceptional performance.

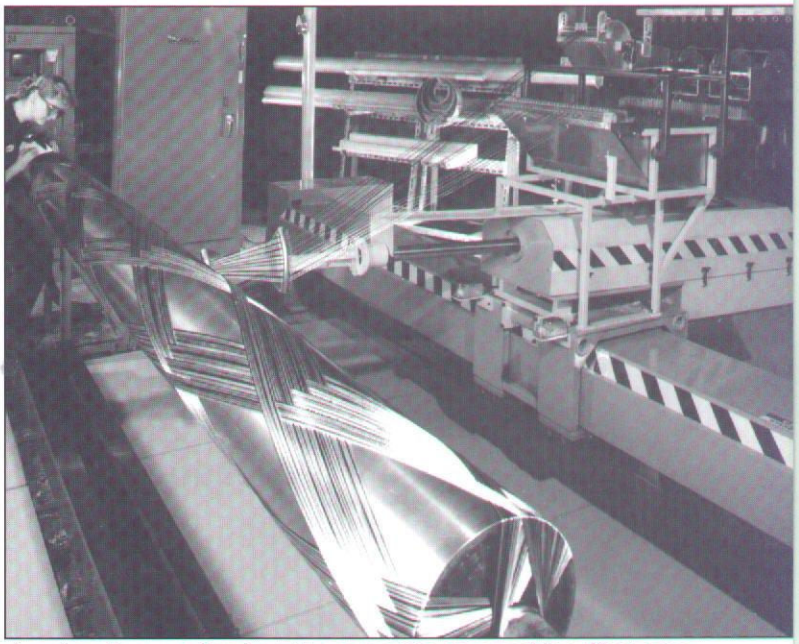
Typical room temperature properties of E-glass, S-glass and commercial carbon fibers.			
Properties	**E-glass**	**S-glass**	**Commercial Carbon**
Tensile Strength, ksi	500	665	650
Young's Modulus, x 10^6 psi	11.8	12.9	34.0
Elongation %	4.8	5.7	1.9
Volume Resistivity Ohm Mx10^{15}	0.402	0.905	conductive
Dielectric Strength V/mil	262	330	conductive
Dissipation Factor @ 60Hz	0.003	0.013	conductive

Fiber Orientation

Orientation is the basis of the fiber architecture of the composite structure. Orientation refers to the fiber direction in the laminate - typically near parallel (15°) to circumferential (85°) to the centerline of the part. Combining various fiber orientations with the available resins and fiber types creates a wide range of structural properties that can be manufactured by Amalga Composites.

Based on over thirty years of successful product development, Amalga offers standard laminate constructions for most common applications (see back page).

Custom design of laminates incorporating complex fiber orientation, hybrid fibers and exotic resins are available for your most demanding applications.



Amalga Composites has the expertise to combine fiber type, fiber orientation and resin matrix to create a filament wound structure that is lightweight, superior in strength and stiffness, and corrosion, impact and abrasion resistant.

Innovative
Composite Structures
Since 1966

FILAMENT WOUND COMPOSITE STRUCTURES

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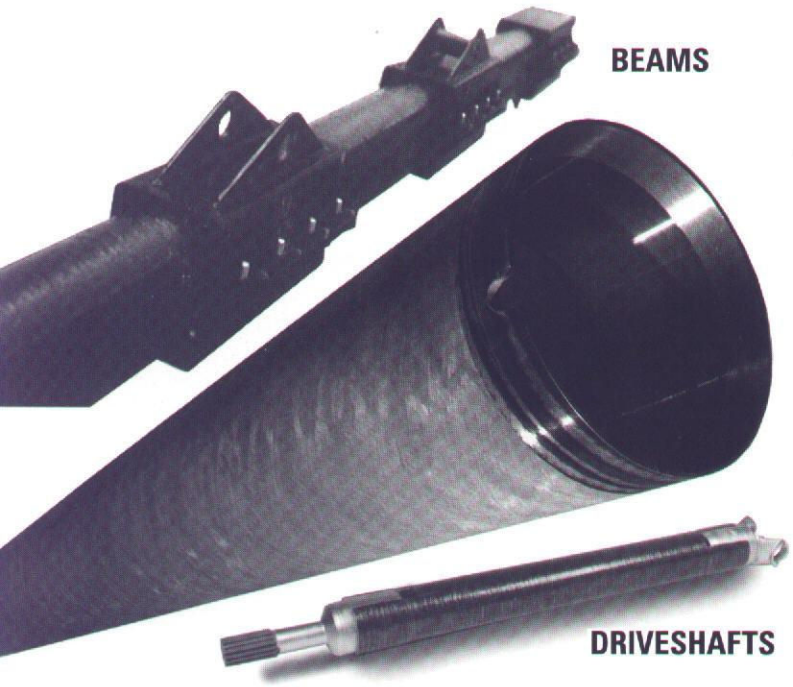
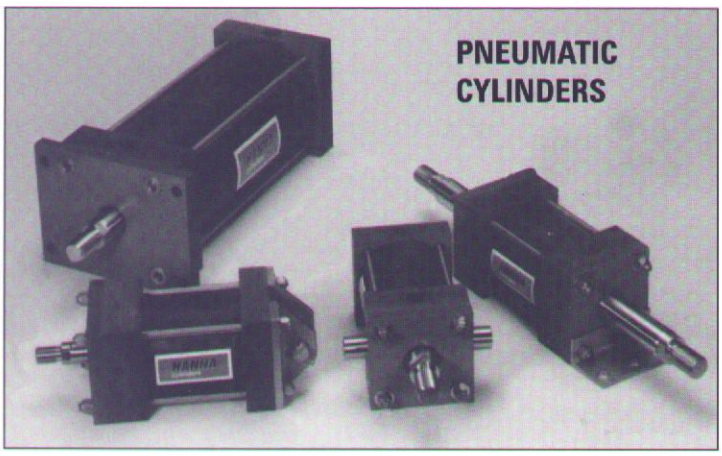


ELECTRICAL APPLICATIONS

Choose from fiber orientations listed on this page for mechanical properties.

Electrical Properties		E-glass	Applications
Dissipation Factor		0.015 max	FUSES
Power Factor 1MHz (ASTM D 150-64T)	60cps	0.30%	
	1mc	0.15%	LIGHTNING ARRESTORS
Dielectric Strength (ASTM D 149-61)			
Short Term Perpendicular Volts/mil	@ 60 Hz	500.00	INSULATED HOUSINGS
Step by Step Perpendicular Volts/mil	@ 60 Hz	400.00	
Dielectric Constant (ASTM D 150-64T)	60 cps.	4.70	
	1 mc.	4.50	INSULATED BUSHINGS
Arc Resistance (ASTM 495-61)		150.00 seconds	
Insulation Resistance (ASTM 257-61)			
96 HRS @ 35°C 2 x 10^7 meg ohms.		90.00% RH	
Water Absorption 24 hrs.		0.01% max	
Thermal Conductivity BTU/in/hr/ft^2/°F		2.50	



STANDARD LAMINATE CONSTRUCTIONS

BEAM STRUCTURES *Built for maximum stiffness.*

Material Properties	E-Glass	Commercial Carbon	High Modulus Carbon	Applications
Flexural Modulus Longitudinal, x 10^6 psi	5.5	14.0	21.0	PROCESS ROLLERS
Flexural Modulus Circumferential, x 10^6 psi	1.1	5.0	7.5	
Tensile Strength Longitudinal, psi	115,000	130,000	130,000	BOOMS
Tensile Strength Circumferential, psi	44,000	40,000	36,000	MASTS
Compressive Strength Longitudinal, psi	57,000	130,000	130,000	BEAMS
Compressive Strength Circumferential, psi	26,000	50,000	50,000	COLUMNS
Shear Modulus, x 10^6 psi	1.0	1.8	2.2	HIGH STIFFNESS
Shear Strength, psi	8,000	8,000	8,000	
CTE Circumferential, x 10^{-6} in/in/°F	8.6	7.1	6.4	
CTE Longitudinal, x 10^{-6} in/in/°F	4.8	0.17	-43.6	
Poisson's ratio, NUxy	0.27	0.24	0.69	
Density, Lb/in^3	0.072	0.058	0.058	

TORQUE APPLICATIONS *Built for maximum torque transmission*

Material Properties	E-glass	Commercial Carbon	Applications
Flexural Modulus Longitudinal, x 10^6 psi	2.7	3.0	
Flexural Modulus Circumferential, x 10^6 psi	2.7	3.0	AUTOMOTIVE DRIVESHAFTS
Tensile Strength Longitudinal, psi	22,000	20,000	
Tensile Strength Circumferential, psi	22,000	20,000	MARINE DRIVESHAFTS
Compressive Strength Longitudinal, psi	26,000	23,000	
Compressive Strength Circumferential, psi	26,000	23,000	COOLING TOWER DRIVESHAFTS
Shear Modulus, x 10^6 psi	1.8	5.5	
Shear Strength, psi	8,000	8,000	COUPLINGS
CTE Circumferential, x 10^{-6} in/in/°F	6.4	1.1	UNDERWATER HOUSINGS
CTE Longitudinal, x 10^{-6} in/in/°F	6.4	1.1	
Poisson's ratio, NUxy	0.47	0.7	
Density, Lb/in^3	0.072	0.058	

BLACK AMALGON® *Built for maximum internal pressure under a compressive load.*

Material Properties	E-glass	Commercial Carbon	Applications
Flexural Modulus Longitudinal, x 10^6 psi	1.3	2.5	PNEUMATIC & HYDRAULIC CYLINDERS
Flexural Modulus Circumferential, x 10^6 psi	3.6	8.7	
Tensile Strength Longitudinal, psi	16,000	12,000	
Tensile Strength Circumferential, psi	40,000	58,000	
Compressive Strength Longitudinal, psi	27,000	37,000	VALVE ACTUATORS
Compressive Strength Circumferential, psi	37,000	35,000	
Shear Modulus, x 10^6 psi	1.8	5.0	
Shear Strength, psi	8,000	8,000	PUMP HOUSINGS
CTE Circumferential, x 10^{-6} in/in/°F	4.6	-0.81	
CTE Longitudinal, x 10^{-6} in/in/°F	8.8	4.4	MARINE CYLINDERS
Poisson's ratio, NUxy	0.35	0.43	
Density, Lb/in^3	0.072	0.058	

OVERWRAP REINFORCEMENTS *Additional strength from overwrapping.*

Material Properties	E-glass	Commercial Carbon	Applications
Flexural Modulus Longitudinal, x 10^6 psi	1.2	1.3	
Flexural Modulus Circumferential, x 10^6 psi	8.0	19.0	HIGH SPEED ROTORS
Tensile Strength Longitudinal, psi	5,000	6,000	
Tensile Strength Circumferential, psi	210,000	210,000	REINFORCED TANKS
Compressive Strength Longitudinal, psi	17,000	35,000	
Compressive Strength Circumferential, psi	138,000	185,000	ANTI-CORROSION COVERS
Shear Modulus, x 10^6 psi	0.8	1.0	
Shear Strength, psi	8,000	8,000	CATHODES
CTE Circumferential, x 10^{-6} in/in/°F	3.7	-0.09	IMPACT PROTECTION
CTE Longitudinal, x 10^{-6} in/in/°F	13.3	11.9	
Poisson's ratio, NUxy	0.08	0.02	
Density, Lb/in^3	0.072	0.058	

Innovative
Composite Structures
Since 1966

CHEMICAL RESISTANCE DATA

AMALGA COMPOSITES, INC.

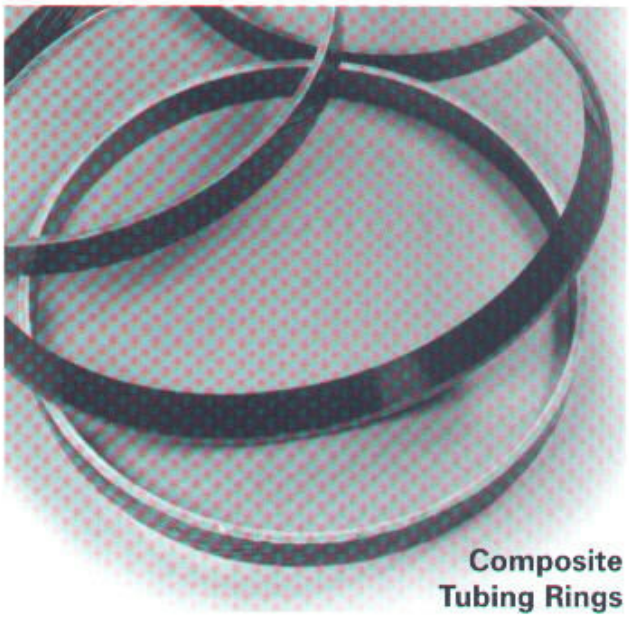
Reinforced composite structures have a long history of superior performance in various chemical environments. The resin matrix is the composite component that dominates the structure's chemical resistance capability. The chemical resistance of a given resin system is determined by its molecular architecture and by its chemical composition.

Amalga Composites offers several solutions to your chemical resistance problems. The anhydride cured epoxy system that binds the reinforcing fibers offers excellent resistance to all but the strongest acids and bases. The vinyl ester inner coating available from Amalga on most products offers even greater resistance to chemical degradation.

The following table lists various chemical environments. The listing includes the concentration of the chemical in the environment . The temperature cited is the limit for the specific chemical concentration when in continuous contact with either the anhydride epoxy or the vinyl ester coating.

CHEMICAL ENVIRONMENT	INNER SURFACE		ANHYDRIDE CURED EPOXY	
	°F	°C	°F	°C
ACETALDEHYDE	NR	NR	NR	NR
ACETIC ACID, 10%	200	93	175	79
ACETIC ACID, 20%	200	93	125	52
ACETIC ACID, 50%	150	66	NR	NR
ACETIC ACID, 75%	130	54	NR	NR
ACETIC ACID, GLACIAL	75	23	NR	NR
ACETONE, 1%	NR	NR	100	38
ACETONE, 10%	NR	NR	NR	NR
ACRYLIC ACID, 25%	75	24	NR	NR
AIR, WET OR DRY	200	93	200	93
ALUMINUM CHLORIDE, 1%	200	93	200	93
ALUMINUM NITRATE, 25%	160	71	150	66
ALUMINUM SULFATE, 25%	200	93	150	68
ALUM, ALL	200	93	150	68
AMMONIUM CHLORIDE, 25%	200	93	150	66
AMMONIUM HYDROXIDE, 30%	100	38	NR	NR
AMMONIUM NITRATE, 25%	200	93	150	66
AMMONIUM PHOSPHATE, 25%	200	93	150	66
AMMONIUM SULFATE, 25%,	200	93	150	66
AMYL ACETATE, 1%	125	52	75	24
AMYL ACETATE, 10%	NR	NR	NR	NR
ANILINE, ALL	NR	NR	NR	NR
BARIUM CHLORIDE, 25X%	200	93	150	66
BARIUM HYDROXIDE, 5%	150	66	70	21
BARIUM TETRASULFIDE, 25%	170	77	NR	NR
BEER	90	32	140	60
BENZENE, 1%	100	38	125	52
BENZENE, 10%	NR	NR	70	21
BENEZENE SULFONIC ACID, 50%	NR	NR	NR	NR
BENZOIC ACID, ALL	200	93	140	60
BLACK LIQUOR (PULP MILL)	200	93	100	38
BORIC ACID (ORTHO), 5%	200	93	150	66
BROMINE, 5%	170	77	NR	NR
BROMINE, 10%	NR	NR	NR	NR
BUTANE, 100%	NR	NR	75	24
BUTANOL, ALL	90	32	75	24
BUTYL ACETATE, 100%	NR	NR	75	24
BUTYL CALLOSOLVE	150	66	75	24
BUTYRIC ACID, 25%	200	93	75	24
CALCIUM BISULFITE, ALL	150	66	100	38
CALCIUM CHLORIDE, 37%	200	93	150	66
CALCIUM HYPOCHLORITE, 5%	150	66	100	38
CALCIUM NITRATE, 25%	200	93	150	66
CARBON DIOXIDE, DRY	200	93	200	93
CARBON DIOXIDE, WET	150	66	150	66
CARBON TETRACHLORIDE, 100%	90	32	NR	NR
CASTOR OIL, 100%	200	93	200	93
CHLORACETIC ACID, 10%	150	66	NR	NR
CHLORINE GAS, WET	NR	NR	NR	NR
CHLORINATED WATER, 1000ppm	175	79	150	66
CHLOROBENZENE, 100%	NR	NR	NR	NR
CHLOROFORM, 1%	100	38	75	24
CHLOROFORM, 10%	NR	NR	NR	NR
CITRIC ACID, 25%	200	93	150	66
COPPER CHLORIDE, 25%	200	93	200	93
COPPER NITRATE, 25%	200	93	100	38
AMALGA COMPOSITES	**Max. Temp.**		**Max. Temp.**	

CHEMICAL ENVIRONMENT	INNER SURFACE		ANHYDRIDE CURED EPOXY	
	°F	°C	°F	°C
COPPER SULFATE, 25%	200	93	150	66
CRUDE OIL, SWEET OR SOUR	200	93	200	93
DICHLOROBENZENE (ORTHO), 100%	NR	NR	NR	NR
DIESEL FUEL, 100%	170	77	150	66
DIETHYLENE TRIAMINE, 1%	100	38	75	24
DIETHYLENE TRIAMINE, 10%	NR	NR	NR	NR
ETHANOL, 100%	100	38	75	24
ETHYL ACETATE, 100%	NR	NR	NR	NR
ETHYLENE GLYCOL, ALL	200	93	190	88
FERRIC CHLORIDE, ALL	200	93	150	66
FERRIC NITRATE, 10%	200	93	100	38
FERRIC SULFATE, 10%	200	93	150	66
FERROUS CHLORIDE, 25%	200	93	150	66
FERROUS SULFATE, ALL	200	93	150	66
FORMALDEHYDE, 37%	100	38	NR	NR
FUEL OIL, 100%	170	77	150	56
GASOLINE, ALL TYPES, 100%	140	60	140	60
GLUCOSE, ALL	200	93	125	52
GLYCERIN. ALL	200	93	200	93
HYDRAULIC FLUID	100	38	100	38
HYDROBROMIC ACID, 10%	200	93	75	24
HYDROBROMIC ACID, 50%	150	66	NR	NR
HYDROCLORIC ACID, 3%	200	93	150	66
HYDROCHLORIC ACID, 10%	175	79	125	52
HYDROCHLORIC ACID, 20%	125	52	75	24
HYDROCHLORIC ACID, 37%	NR	NR	NR	NR
HYDROFLOURIC ACID	NR	NR	NR	NR
HYDROGEN CHLORIDE (DRY), 100%	150	66	100	38
AMALGA COMPOSITES	**Max. Temp.**		**Max. Temp.**	



Composite Tubing Rings

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Since 1966

CHEMICAL RESISTANCE DATA

AMALGA COMPOSITES, INC.

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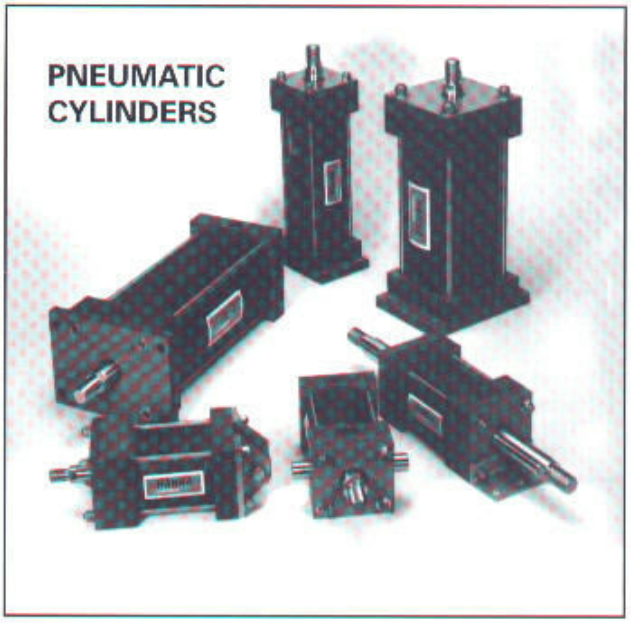

CHEMICAL ENVIRONMENT	INNER SURFACE		ANHYDRIDE CURED EPOXY	
	°F	°C	°F	°C
HYDROGEN PEROXIDE, 10%	100	38	NR	NR
HYDROGEN SULFIDE (DRY),100%	150	66	150	66
HYDROGEN SULFIDE (WET ,SATURATED),100%	125	52	125	52
ISOPROPYL ALCOHOL, 10%	150	66	100	38
ISOPROPYL ALCOHOL, 100%	80	27	75	24
JET FUEL, 100%	120	49	150	66
KEROSENE	150	66	150	66
LACTIC ACID, ALL	200	93	150	66
LEAD ACETATE, ALL	200	93	190	88
LINSEED OIL	200	93	200	93
LIME SLURRY	175	79	100	38
MAGNESIUM CHLORIDE	200	93	200	93
MAGNESIUM NITRATE, 10%	170	77	150	66
MAGNESIUM SULFATE, 10%	170	77	200	93
MALEIC ACID, 10%	200	93	150	66
METHANOL, 10%	140	60	100	38
METHANOL, 100%	NR	NR	NR	NR
METHYLENE CHLORIDE, 1%	75	24	NR	NR
METHYLENE CHLORIDE, 10%	NR	NR	NR	NR
METHYL ETHYL KETONE, 1%	NR	NR	75	24
METHYL ETHYL KETONE, 100%	NR	NR	NR	NR
METHYL ISOBUTYL KETONE, 100%	NR	NR	NR	NR
MINERAL OIL	200	93	200	93
MINERAL SPIRITS, 100%	100	38	75	24
MUD ACID, 5% (8 hr. maximum exposure)	150	66	125	52
NAPHTHA, 100%	125	52	100	38
NATURAL GAS	200	93	175	79
NICKEL CHLORIDE, 25%	200	93	150	66
NICKEL NITRATE, 25%	200	93	100	38
NITRIC ACID, 1%	180	82	120	49
NITRIC ACID, 5%	140	60	NR	NR
NITRIC ACID, 10%	140	60	NR	NR
OLEIC ACID, ALL	200	93	150	66
OXALIC ACID, ALL	200	93	150	66
PERCHLOROETHYLENE, 100%	90	32	70	21
PHENOL, 1%	100	38	75	24
PHENOL, 1%	NR	NR	NR	NR
PHOSPHORIC ACID, 10%	200	93	125	52
PHOSPHORIC ACID, 30%	160	71	100	38
PHOSPHORIC ACID, 50%	140	60	70	21
PICKLING ACID	200	93	100	38
POTASSIUM BICARBONATE, 20%	150	66	100	38
POTASSIUM BROMIDE, 25%	200	93	200	93
POTASSIUM CARBONATE, 14%	150	66	NR	NR
POTASSIUM CHLORIDE, 25%	200	93	200	93
POTASSIUM DICHROMATE, 3%	200	93	75	24
POTASSIUM NITRATE	200	93	150	66
POTASSIUM PERMANGANATE, 5%	200	93	75	24
POTASSIUM SULFATE, 10%	200	93	100	38
PROPANE	125	52	125	52
PROPYLENE GLYCOL, ALL	175	79	180	82
SOAPS, ALL	150	66	200	93
SODIUM ACETATE, 25%	200	93	200	93
SODIUM BICARBONATE, 5%	160	71	125	52
SODIUM BISULFATE, ALL	200	93	180	82
SODIUM BROMIDE, 25%	200	93	180	82
SODIUM CARBONATE, 10%	180	71	75	24
SODIUM CARBONATE, 25%	140	60	NR	NR
SODIUM CHLORIDE, ALL	200	93	200	93
AMALGA COMPOSITES	**Max. Temp.**		**Max. Temp.**	

CHEMICAL ENVIRONMENT	INNER SURFACE		ANHYDRIDE CURED EPOXY	
	°F	°C	°F	°C
SODIUM DICHROMATE, 25%	200	93	75	24
SODIUM HYDROXIDE, 5%	125	52	NR	NR
SODIUM HYDROXIDE, 10%	75	24	NR	NR
SODIUM HYDROXIDE, 25%	NR	NR	NR	NR
SODIUM HYPOCHLORITE, ALL	NR	NR	NR	NR
SODIUM NITRATE, 25%	200	93	100	38
SODIUM NITRATE, 50%	200	93	100	38
SODIUM SULFATE, 10%	200	93	100	38
SODIUM SULFIDE, 10%	200	93	75	24
SODIUM SULFITE, 10%	190	88	100	38
SODIUM THIOSULFATE, 25%	160	71	NR	NR
STANNIC CHLORIDE, 25%	200	93	100	38
STERIC ACID, ALL	190	88	150	63
STYRENE, 100%	NR	NR	NR	NR
SULFAMIC ACID, 25%	200	93	80	26
SULFUR DIOXIDE, DRY	200	93	150	66
SULFUR DIOXIDE, WET	150	66	150	66
SULFURIC ACID, 3%	200	93	125	52
SULFURIC ACID, 10%	150	66	100	38
SULFURIC ACID, 25%	100	38	NR	NR
SULFURIC ACID, 50%	NR	NR	NR	NR
TANNIC ACID, 15%	200	93	150	66
TARTARIC ACID, 10%	200	93	150	66
TARTARIC ACID, 15%	200	93	150	66
TOULENE, 100%	75	24	NR	NR
TRANSFORMER OIL	75	24	75	24
TRIETHANOLAMINE, 100%	150	66	NR	NR
TURPENTINE, 100%	80	26	80	26
UREA, 25%	200	93	NR	NR
VINEGAR	200	93	150	66
WATER, CHLORINATED, 100ppm	200	93	170	77
WATER, DIONIZED	180	82	125	52
WATER, DIMINERALIZED or CLOSED LOOP HEATING	200	93	100	38
WATER, DISTILLED	200	93	100	38
WATER, BRINE	200	93	170	77
WATER, HARD	200	93	170	77
WATER, SALT. ALL	200	93	170	77
WATER, SEA	200	93	170	77
XYLENE, 10%	100	38	75	23
XYLENE, 100%	75	24	NR	NR
ZINC CHLORIDE, 25%	200	93	150	66
ZINC SULFATE, 25%	200	93	150	66
AMALGA COMPOSITES	**Max. Temp.**		**Max. Temp.**	

NR = NOT RECOMMENDED

Call us for custom materials to meet specialized applications.

MACHINING TECHNIQUES

AMALGA
COMPOSITES, INC.

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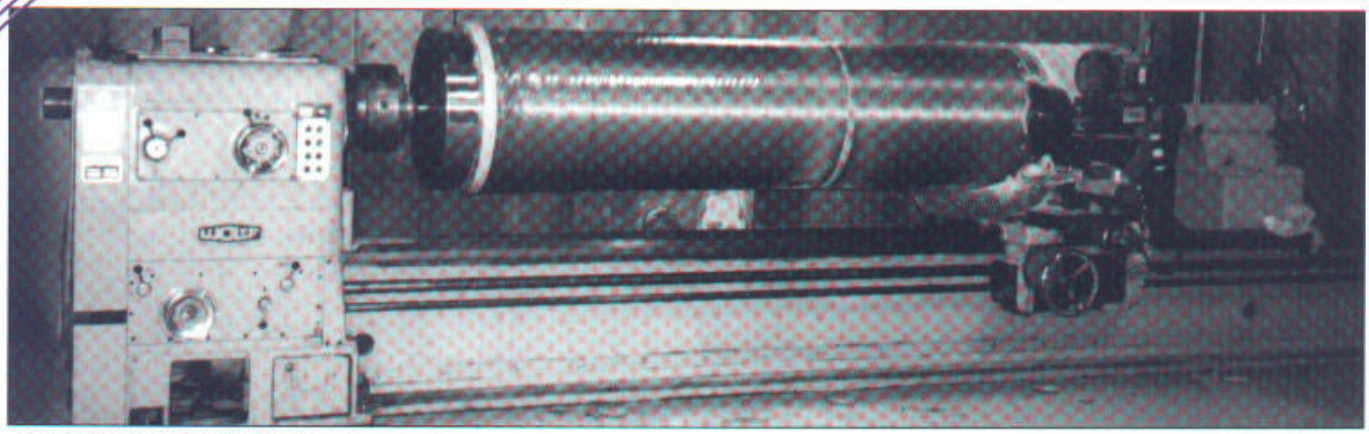


CONVENTIONAL MACHINING PRINCIPLES APPLY TO COMPOSITES. CALL US FOR INFORMATION ON TOOLING SPECIFICATIONS FOR MACHINING COMPOSITES.

Beveling & Drilling

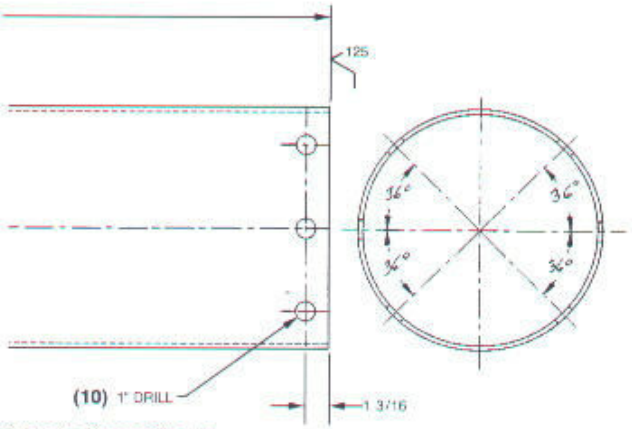
Beveling the cut-off can be achieved by several methods, depending on quantities and tolerances.

Short production runs require hand files or a shaped block sander using carbide chips brazed to metal.

Large volume production necessitates the use of a carborundum burr in an 8,000 RPM air motor.

Critical Production Details

- Forstner drill bits designed for composites provide the best results.
- Drill bits with specific helix angles, wide polished flutes and point angle for fiberglass reinforced thermosets limits chip packing and overheating.
- Helix angles of 10° to 50°, clearance of 9° to 20° and point angles of 60° to 120° are required.
- Vary drill speed with the size and depth of the hole.
- Carbide and diamond tipped tools are more responsive when operating at higher speeds and slower feeds, and will produce a smoother hole.
- A bit that is approximately .002" oversize is recommended.
- Support the backside of laminate with wood or plastic to prevent delamination and splintering.



Grinding, Milling and Turning

Standard metal working lathes and milling machines are sufficient for machining thermoset composites. High speed steel tools can be used effectively if maintained sharp, although carbide or diamond tipped tools will prove more economical for large production runs.

Composite structures can be finished to close tolerances by sanding and/or grinding. Belt and drum type sanding machines have been employed successfully with grit sizes from 30 to 240. Using coolants on conventional sanding and grinding machinery will prevent clogging and glazing of the abrasive. Grinding with silicone carbide or aluminum oxide grit wheels will require free flowing coolants to prevent the workpiece from overheating.

Speeds, feeds and tools sharpened for brass machining will work effectively. Honed cutters will extend service life. Cooling with water or air will increase cutting rates and lathe tools should maintain a high clearance–between 10° and 20°. Setting the rake at zero or negative will improve performance. Tool sets should be 1° to 2° above center. A surface speed of approximately 600 feet per minute is recommended.

Cutting

Fiberglass reinforced thermoset composites can be cut with hand saws, band saws and circular saws. Precautions should be taken to keep parts from overheating due to the material's low thermal conductivity. Vibration should be avoided to prevent delamination. Because of the abrasive nature of fiberglass, maintaining the tool's sharpness requires diligence. Cutting with 1/32" to 3/32" thick abrasive wheels containing carbide abrasive with a 36 to 60 grit range on an 8" diameter and rotating a 4,000 RPM is a proper method for thermoset composites. Band saw blades should be diamond tipped or fine tooth to reduce deformation of composite materials. Circular or radial arm saws should utilize diamond tipped or carbide edged blades. Spray mist, water or air jets with a vacuum pick-up is recommended for cooling and dust removal.

AMALGA
COMPOSITES, INC.

Engineering Problem Solving when Machining Thermoset Composites

▶ **Friction Heat**–Because composite materials are inherently thermal insulators, it is difficult to remove the heat that is generated by the friction of machining operations. Excessive heat build-up will damage the composite structure by degrading the epoxy matrix material. The use of a coolant, the appropriate cutting speeds and tool feed rates, and the proper selection of cutting tools will aid in the prevention of damage to the composite material resulting from frictional heating.

▶ **Abrasiveness**–Conventional tooling will wear rapidly because of the abrasive nature of fiberglass composites. If this tooling is used, periodic adjustments of the machine set are necessary as is a change-over of the cutting tools. Carbide or diamond tooling is recommended.

▶ **Delamination**–Composite structures are formed by the assembly of discrete layers of material called lamina. The assembly of lamina forms the composite laminate. Amalga Composites takes exceptional measures to prevent separating the lamina which results in a delamination of the composite laminate. Backing plates should be used when drilling through a structure, and excessive tool pressure should be avoided.

Complete Machining to Precise Specifications

The majority of the composite structures manufactured by Amalga Composites are machined to final engineering tolerances. Amalga has the production equipment to efficiently grind, cut, chamfer and mill composite material. Our machining capabilities allow us to deliver your part finished and ready to assemble, whether you require piston lead chamfers, milled snap ring grooves or any other secondary machining. Ask for a competitive quotation.

Conventional Machining Methods

▶ **Standard Metal Working Machining Equipment**– Excellent results are obtained when spindle speeds are high, material feeds are low and tooling is sharp. Machining techniques are similar to those used for marine brass.

▶ **Standard Cutting Tools**– suitable for low quantity production runs.

▶ **Tungsten Carbide or Diamond Tipped Tools**– used for large volume production runs.

▶ **Air or Liquid Cooling**– used to address low heat conductance and exceptional abrasiveness. Greater tool clearance is used to reduce friction.

▶ **Material Supports**– The greater resiliency of thermoset composites require greater support of the structure being machined.
- Use of I.D. plugs or O.D. rings may be necessary for chuck mounting.
- Metal shafts for internal support of long sections is recommended when machining center portions.
- Protection should be applied to the micro-finished inside diameter coating on cylinder tubing.

Operational Procedures for Safety and Efficiency

- **Control heat-up of the structure.**
  - –Use grind cutters similar to those used on brass.
  - –Use drills with slow twist, polished flutes and thin webs.
  - –Feed work at 100 to 150 surface feet per minute.
  - –Use light drill pressure.
  - –Replace tools when dull. Expect tools to wear faster than when machining metal.
  - –Coolants should be used to avoid softening of resin matrix.
- **Operate machinery at high speeds.**
- **Provide liberal clearance on cutting tools.**
- **Grind turning tools to provide rake angles that minimize cutting and thrust forces.**
- **Support the workpiece adequately to prevent distortion under cutting pressures.**
- **Allow for plastic memory to enhance machining accuracy.**

COMPANY PROFILE

Founded in 1966, Amalga Composites, Inc., Milwaukee, Wisconsin, is a leader in the design, engineering and manufacturing of filament wound composite pneumatic and hydraulic cylinder tubing, pressure vessels, food grade tubing, booms and masts, tubular cores, rollers and shafts, electrical tubing and fuse components, torque shafts, magnetic coil forms, launch tubes and other engineered composite components built to specification. Doctoral-level engineering provides the design expertise to meet the toughest requirements and also offer immediate technical customer support from prototype through production.

Amalga Composites is one of the country's largest independent filament winding operations. With an 80,000 sq.ft. manufacturing facility, consisting of three 200 x 40-foot overhead crane bays, six separate production lines, three coating/painting areas and complete machining capabilities, the company provides high volume output for both domestic and international customers.

MEMBERSHIPS and CERTIFICATION

CFA Composites Fabricators Association
The Source for Composites Education

NFPA
Solutions through motion technology

SECTION X CERTIFIED

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