POLYGON
COMPOSITES TECHNOLOGY

CYLINDERS DESIGN GUIDE

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COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

INTRODUCTION

PolySlide® cylinder tubing offers many unique features to the Fluid Power Industry for pneumatic and hydraulic applications. By providing the industry with a more versatile cylinder material than traditional metallic cylinder tubing, the PolySlide cylinder can not only be a direct replacement for current applications, but opens new cylinder design opportunities by eliminating limitations common to metals.

PolySlide cylinders can be provided in various ways, from a simple cylinder tube cut to length for customer assembly, to a completely designed cylinder system according to customer specifications.

Polygon not only has the technology to assist cylinder manufacturers in the use of PolySlide cylinders but also has the internal testing facilities to validate most cylinder designs according to our customers' satisfaction. Polygon's in-house capabilities range from cycle testing, burst pressure chamber with video analysis of failure mechanisms, to in-use frictional analysis.

PolySlide® cylinders, are lightweight, resist dents, and offer superior seal wear.

UNIQUE FEATURES OF POLYSLIDE® TUBING

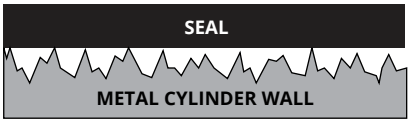
SEAL-FRIENDLY BORE SURFACE

The patent pending bore surface of the PolySlide cylinder is designed to reduce the common causes of seal wear. Friction is the primary cause of seal wear. There are two types of friction that tend to oppose each other in the design of the bore surface. These are adhesion and interlocking friction.

Adhesion Friction is the physical attraction of two smooth surfaces brought into close contact with each other. As the contact area increases so does the adhesion between the surfaces. A smooth surface reduces the gap between the surfaces resulting in higher adhesion. Adhesion acts as a frictional force when the one object slides against the other. The friction between O-ring seals and bore surfaces increases significantly as the surface finish of the bore is reduced from 16 Ra to 6 Ra. Therefore, a higher Ra bore surface finish will reduce the seal adhesion friction and thereby extending seal life.

Interlocking Friction is the result of shear forces encountered from the interlocking of irregularities between contacting surfaces during sliding motion. By the nature of machined surfaces such as boring or honing of metallic cylinders, microscopic rough edges exist that tend to penetrate and shear the softer seal material, thereby reducing seal life. Obviously, for metallic cylinders a lower Ra bore finish specification (smoother surface) is desirable to reducing the interlocking friction resulting in extended seal life.

Typically, the means of achieving the optimum Ra finishes for the two types of frictional conditions oppose each other. Historically, users of metal cylinder tubing must compromise their specification of the Ra value for an ideal bore finish in metallic cylinders. One of the unique features of the PolySlide bore surface is that it is not formed by a machining process, but by a molding process. Another feature is the wear resistant material at the bore surface is microscopically round in nature. Taken together, these features allow the seal to naturally slide over the bore surface contour. These two features minimize interlocking friction.



PolySlide's smooth bore surface reduces seal wear, unlike the microscopic jagged edges of metal cylinders.

"Composite tubing offers cost-effective technology capabilities to a market that is desperately seeking differentiation in a sea of commonality."

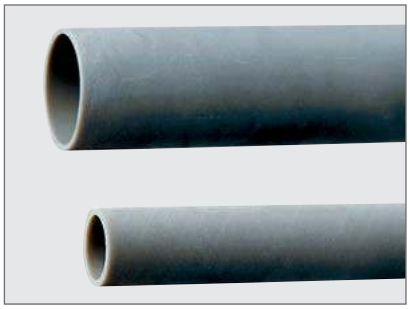
UNIQUE FEATURES OF POLYSLIDE® TUBING

SEAL-FRIENDLY BORE SURFACE (CONTINUED)

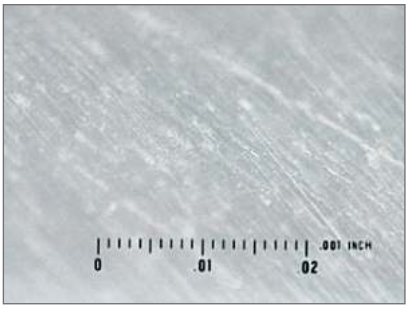
Since interlocking friction is not a significant issue with the PolySlide® bore surface, the Ra finish does not play the same role as in conventional metals. PolySlide cylinder contact surfaces are undulating; rounded and cylindrical in nature.

In addition to the topographic advantages of the PolySlide bore surface, is the actual material composition of the sliding surface itself. Wear-resistant additives are incorporated within the bore surface material that result in a very hard wear surface equivalent to Vickers 34. It is not unusual for PolySlide cylinder tubing to improve seal life by over 2x.

These features provide a seal-friendly bore surface. Examples of actual specific performance studies will be presented throughout this design guide in further detail.



PolySlide's® bore surface reduces interlocking friction due to it's inherently smooth nature.



1/16th PolySlide bore surface at 250x PolySlide's ability to significantly extend seal life is due to the unique feature of its surface—specifically the elimination of the sharp peaks and valleys common to the tribology of metal cylinder surfaces. This picture shows a magnified section of the PolySlide surface, showing the rounded smooth undulating surface as opposed to a granular metal surface with sharp peaks and valleys.

HIGH STRENGTH/NON-METALLIC CYLINDER MATERIAL

The strength of the PolySlide cylinder comes from continuous fiberglass filament reinforcement within an epoxy matrix that are filament wound into a composite cylinder. The cylinder exhibits orthotropic material properties as compared to isotropic properties for metals. An orthotropic material means the physical properties vary with the geometric coordinates of the cylinders. The ability to vary the orthotropic properties of a filament wound structure within a specific geometry gives versatility to a composite cylinder, a versatility that can not be accomplished with isotropic metallic cylinders. Typical physical property values of an PolySlide cylinder are shown in chart at bottom of page. Consult a Polygon Sales Engineer for information relating to specific applications.

CORROSION RESISTANCE

PolySlide cylinders do not rust and are resistant to many chemicals that corrode metallic cylinders. Galvanic corrosion is not a problem with composite cylinders. In addition, PolySlide is not limited to the use of non-corrosive lubricants or fluids common to hydraulic fluids. As an example, water could be used as a replacement to hydraulic fluid because PolySlide is compatible with water. A separate tech data sheet and resistance guide with compatibility to various types of chemicals is available from Polygon.

TYPICAL POLYSLIDE® SPECIFICATIONS FOR STANDARD PNEUMATIC APPLICATIONS*

Physical Properties:		
Hoop Strength – T_y	ksi	31.5
Hoop Modulus of Elasticity – E_y	Msi	3.7
Axial Compression Strength – C_x	ksi	20.4
Axial Tensile Strength – T_x	ksi	8.4
Axial Modulus of Elasticity – E_x	Msi	2.0
V_{xy}, Poisson's Ratio		0.30
V_{yx}, Poisson's Ratio		0.56
Density	lb/in^3	0.075

Thermal Properties:		
Thermal Conductivity	BTU-in/hr-ft^2-°F	1.8 to 2.3
Specific Heat	BTU/lb_m-°F	0.27
a_y, Coefficient of Thermal Expansion	in/in/°F	5 to 7 x10^{-6}
a_x, Coefficient of Thermal Expansion	in/in/°F	10 to 15 x10^{-6}

*Note: The above values are typical properties. These values may vary

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

UNIQUE FEATURES OF POLYSLIDE® TUBING

CORROSION RESISTANCE (CONTINUED)

Polygon's chemical exposure recommendations are based on long term exposure by physical containment of these chemicals in question. For short term exposures, PolySlide® cylinders may work fine even for those not recommended chemicals. Contact Polygon's Sales Engineers with any questions concerning chemical exposure.

DIELECTRICALLY INSULATING CYLINDER

The PolySlide cylinder is a dielectrically insulating material. It will not conduct electricity. It is ideal for external limit switch positioning controls and other types of electronic positioning devices.

STATIC DISCHARGE

Due to the versatility of composite materials, PolySlide cylinders can be specially designed to meet most static discharge requirements.

LOW THERMAL CONDUCTIVITY

Due to the low thermal conductive nature of PolySlide the cylinders work well in hot environments without seal degradation. This property also improves the ability of PolySlide to perform consistently across a wide temperature range.

IMPACT RESISTANT

The high strength filament wound composite structure resists impact damage from debris, as in railroad brake or dump cylinders, without causing a permanent deformation in the cylinder wall. The high impact resistance of the composite structure makes it ideal for applications where moderate velocity debris can cause metal cylinders to fail due to impingement problems.

LIGHT WEIGHT

Density advantages allow composites to outperform aluminum and steel.

SMOOTH CYLINDER WALLS

Very smooth cylinder walls help prevent material build-up and piston leakage. This also provides an improvement over traditional stick/slip phenomena common when metal cylinders sit in a static condition for extended periods of time. Typical inner surfaces measure 6-20 µ-inch.

APPLICATION CONSIDERATIONS

- Conventional end seals and closures can be used. Steps and shoulders may be machined if required.
- Non-metallic seals on the piston must be used.
- For tie rod designs, compression of approximately 0.006 inches per each inch of cylinder length should be used when and where the maximum pressure is required.

Composite cylinders resist corrosion, including harsh cleaning solutions.

APPLICATIONS:

- *Pneumatic actuators for valves*
- *Respirators for medical applications*
- *Hydraulic actuators for aircraft*
- *Pressure pumps for spray applications*
- *Dump mechanisms for railroad cars*
- *Waste water treatment flow control mechanisms*
- *Pneumatic/fluid shock absorption or energy diversion*
- *Replacement for aluminum, steel and brass cylinder tubing*

PolySlide® can be machined to accept sealing rings for endcaps.

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

POLYSLIDE® INTERCHANGEABILITY WITH METALLIC CYLINDERS

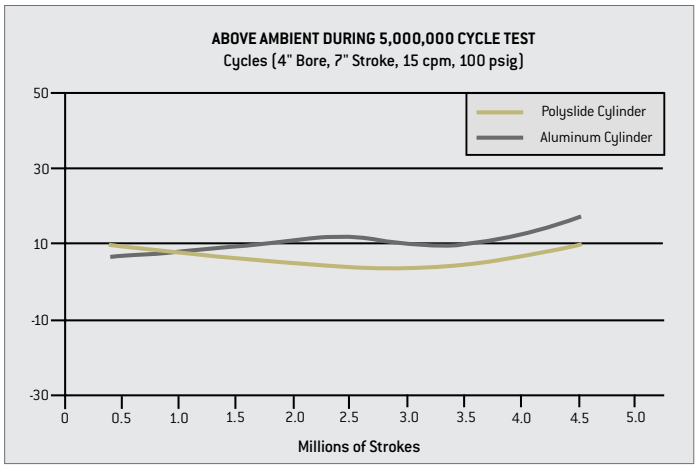
HARDWARE INTERCHANGEABILITY

Case studies have shown that PolySlide® cylinder tubing can directly replace metallic tubing while keeping all the remaining cylinder components. This includes piston, seals, wear band, and other components. Pre-lubrication and cylinder assembly techniques can also remain the same. Polygon recommends each case be tested and approved by the customer.

PROPERTY COMPARISONS

The General Property table at the bottom of this page gives a basic comparison and overview of various cylinder materials in relation to PolySlide products.

On this table the strength properties for PolySlide are based on a standard cylinder design. However, for special applications, the strength properties can be varied significantly and in some cases the hoop strength can be doubled.



Cylinder temperature rises over cycles.

CASE STUDIES

The following are case study summaries of performance comparisons between PolySlide and other cylinders types under various conditions.

CASE STUDY 1: HIGH LOAD PNEUMATIC TEST – ALUMINUM AND POLYSLIDE CYLINDERS

This test compared the performance of PolySlide cylinders with high quality aluminum cylinders. The test evaluated the cylinder temperature resulting from seal friction under high load conditions through a 5,000,000 cycle life test. Three sets of two cylinders were tested simultaneously under the same conditions for the purpose of reliable statistical data. In each set, the piston rods of each cylinder type were attached end-to-end so they would oppose each other in a similar manner as a SAE J214 setup. The 4" bore cylinders were stroked 7" at an average cycle rate of 15 cpm at shop pressure of 100+ psig. The above chart plots the average cylinder temperatures resulting from heat energy being generated from friction between the cup seals and the bore surface throughout the test. As can be observed from the chart the aluminum cylinders temperatures were higher than the PolySlide cylinders throughout the latter 75% of the test.

Polygon can assist in designing endcap systems for your cylinder assemblies.

GENERAL PROPERTY COMPARISON POLYSLIDE® WITH OTHER CYLINDER MATERIALS

Material Type	Tensile Hoop $x10^3$	Elastic Modulus Hoop $x10^6$ psi	Elastic Modulus Axial $x10^6$ psi	Density lbm/in^3	Material Specifications
PolySlide*	31.5	3.7	2.0	0.075	N/A
Aluminum	40	10	10	0.098	6061
Brass	20	15	15	0.316	C932 (SAE 660)
Stainless Steel	35	28	29	0.286	304
Steel	47	29	29	0.282	A513 T5(1026)

*The data for PolySlide® is based on a 55 degree wind angle.

POLYSLIDE® INTERCHANGEABILITY WITH METALLIC CYLINDERS

CASE STUDY 2: BORE SURFACE WEAR RESISTANCE CHARACTERISTICS – ALUMINUM VERSUS POLYSLIDE CYLINDERS

In this example, Polygon was designing to replace an installed cylinder where minimal on-site maintenance can be expected. Polygon completed a test comparing wear characteristics of a 3" bore by 7" stroke aluminum and PolySlide® cylinders, cycling at 60 cpm continuously for 7,000,000 cycles. The test pressure was 80 psig.

The result showed both cylinders suffered from O-ring seal destruction. However, the aluminum bore surface was deeply scored, while the PolySlide surface did not have a scratch and was suitable to continue the test after O-ring replacement.

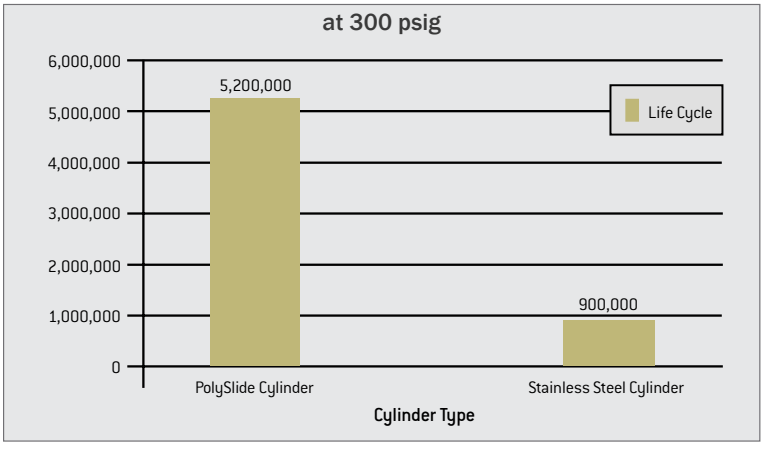
CASE STUDY 3: FATIGUE CHARACTERISTICS OF DISPOSABLE STAINLESS STEEL VERSUS POLYSLIDE CYLINDERS

A 300 psig hydrostatic impulse test was performed on 1.06" bore non-tie rod stainless steel and PolySlide cylinders until failure. The chart below shows the number of cycles completed by each cylinder before failure.

The failure mode for the stainless steel cylinder was a catastrophic failure in which the end cap blew off due to metal fatigue at the crimped joint connecting the end cap to the cylinder tube.

The failure mode of the PolySlide cylinder was a weeping condition near the end cap. The end cap remained in place and the joint did not separate. This weeping condition is a common failure mode of the composite cylinder when the ultimate strength is being approached. It is a built in safety feature of PolySlide in most applications by allowing for pressure to relieve before catastrophic failure.

LIFE CYCLES HYDROSTATIC IMPULSE TEST



CASE STUDY 4: LARGE CAST IRON CYLINDER STUDIES

A series of tests have been conducted comparing the performance of 10" bore PolySlide with cast iron cylinders of the same size having a 150+ Ra bore finish. The cylinders were cycled 200,000 times at a cycle rate of 4 cpm with 80 psig test pressure. By-pass leakage was monitored at both high and low pressures. Various types of lubricants were evaluated in the various tests. Seal wear was considerably less in the PolySlide cylinders than in the cast iron cylinders.

PolySlide® is available in many sizes from miniature to over 20.

PolySlide's low friction makes it ideal for small actuators, as illustrated by this 0.312" ID cylinder assembly.

"PolySlide's® liner features a low coefficient of friction. This reduces generated heat, allowing for rapid cycling combined with long seal life. Testing has confirmed over 200 million cycles with negligible seal wear."

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

POLYSLIDE® COMPARISON WITH GELCOATED COMPOSITE CYLINDER

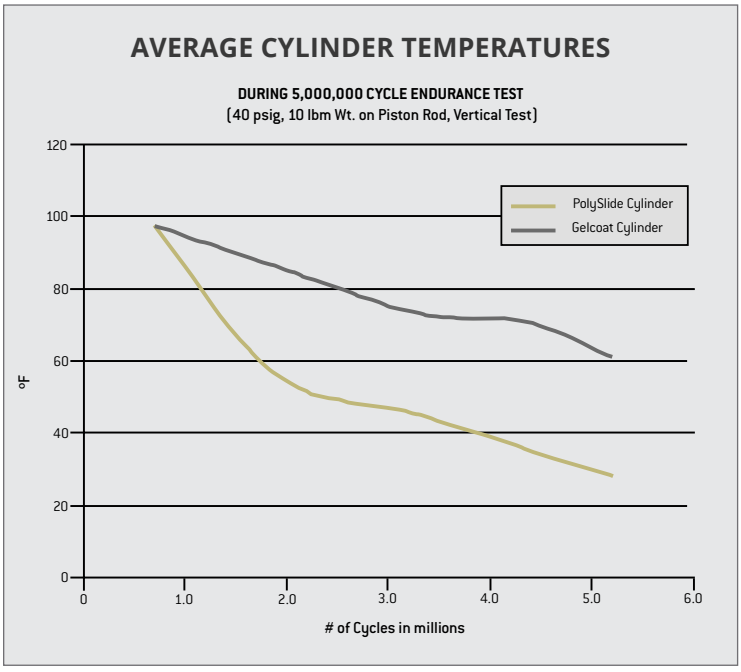
In the mid 1990's, Polygon began a development program to redesign the existing composite cylinder tubing material being supplied to the fluid power industry.

For decades, the conventional composite cylinder tubing had been a gel coated, filament wound structure. While this provided some performance advantages, it also was a costly solution due to the multi-stage manufacturing process required to make a complete composite cylinder.

In addition, new EPA regulations had begun to limit the production rates possible for the styrene-related gel coat itself. The result was that Polygon felt its existing Existing cylinder material did not present a long term, design driven solution to the market's needs.

This new product, PolySlide® composite cylinder tubing, eliminates known problems with gel-coated composite cylinder tubing. Advantages of Polyslide cylinder tubing include:

- Lower coefficient of friction during cycling
- Longer seal life during operation
- Eliminates manufacturing concerns related to EPA regulations
- No delamination of gel-coated liner is possible
- Impact and fatigue resistance of liner is improved
- Higher degree of embeddability of wear surface
- Easier to fabricate and machine



The above chart indicates the friction between the seal and gelcoated cylinders increased significantly more than the PolySlide® cylinders during the endurance test.

The uniqueness of the PolySlide® bore surface provides advantages over the gelcoated cylinders. These advantages include the elimination of delamination concerns of the gelcoat with the backing material. The adhesion friction is normally greater with gelcoated surfaces. The following case study compares the performance of PolySlide and a gelcoated composite cylinder.

PolySlide, shown here in gray, is available in a wide variety of sizes. Custom colors available.

"PolySlide® cylinder barrel wall materials are approximately four times lighter than steel, weigh less than aluminum, and about the same as magnesium."

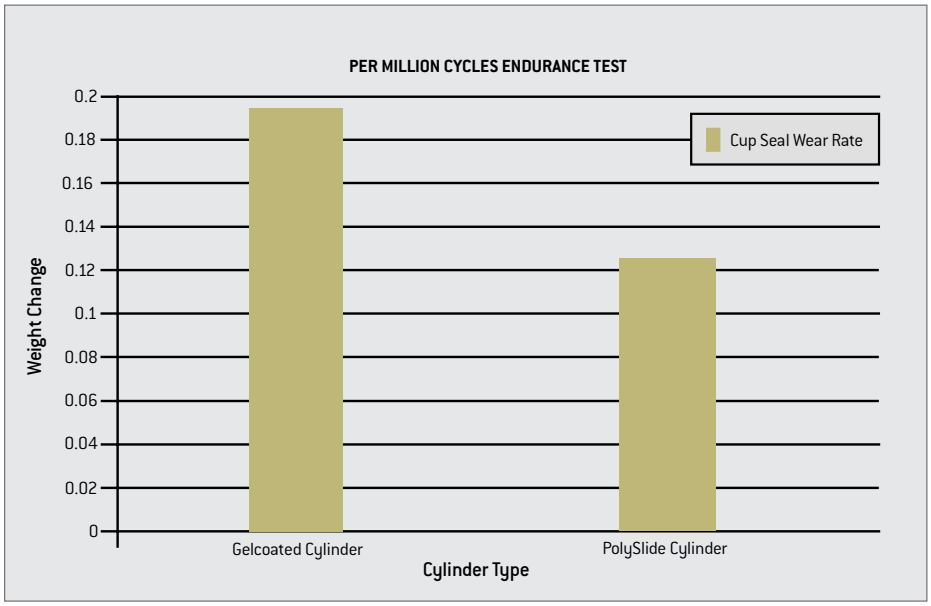
COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

POLYSLIDE® COMPARISON WITH GELCOATED COMPOSITE CYLINDER

CASE STUDY: ENDURANCE TEST OF LEGACY-ERA GEL-COATED VS. POLYSLIDE

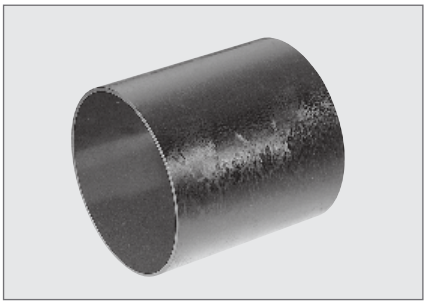
In this study, three 4"x10" stroke cylinders of a gelcoat and PolySlide® cylinder were mounted vertically with a 10 lb. weight attached to the rod end. The test pressure was set at 42 psig and the cylinders were allowed to cycle freely through a 7" stroke for 5,000,000 cycles. The cycle rate was primarily governed by the seal resistance due to friction between seals and bore surfaces. The chart below shows how the average cycle rates changed throughout the tests between the two types of cylinders.



Non-gel coated surfaces demonstrate improved wear performance.

Polygon has patented many unique end cap designs.

Polygon has the experience to meet the engineering challenges for actuators.



PolySlide's® integrated wear surface will not delaminate.

"Polygon Company invented the non-gel coated composite cylinder and is now an industry leader in their production, with over 250,000 finished cylinders produced annually."

POLYSLIDE® SEAL SELECTION GUIDE

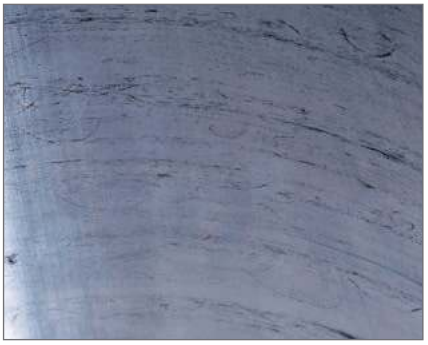
The same conventional design criteria being used in normal fluid power cylinder application are applicable with PolySlide® cylinders.

For current applications where PolySlide is a direct replacement for a metallic cylinder tube, the same piston seal design can normally be used.

The PolySlide wear surface shown below (at magnification) after a high cycle speed test against legacy-era gel-coated tubing. After 300,000 cycles, the PolySlide surface retained its smooth surface with minimal deposition of seal material.

PolySlide's corrosion resistant cylinder characteristics make it an excellent choice for use in industrial valve assemblies.

PolySlide® cylinder materials often do not require re-engineering of piston seals.



PolySlide cylinder wall surface showed minimal wear.

The seal after 1 million cycles shows virtually no wear.

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

DESIGNING WITH POLYSLIDE®

PolySlide® product can be supplied in various forms ranging from a cylinder tube ready for assembly to a completed cylinder designed for a specific application. It is available in standard sizes or can be custom designed to customer's requirements.

Polygon's internal design capability goes beyond evaluation of the cylinder tubing material itself. Within our business portfolio is included a number of complete cylinder designs ranging from critical care respirator systems for paraplegics to rigid cylinders designed to be consistently exposed to road salt and wide temperature ranges.

The ability to design with PolySlide has also allowed various food processing companies to explore composite tubing into caustic environments where sodium hypochlorite washdowns made any metal cylinder, even stainless steel, an unreliable solution.

"The PolySlide® bore surface is microscopically round in nature because it is formed by a molding process. A wear resistant material incorporated into the bore surface further increases lifespan. Together, these features allow the seal to slide over the bore surface contour, minimizing interlocking friction."

THE ROD DESIGN GUIDE FOR STANDARD POLYSLIDE® CYLINDERS

Model Number AS-6001	Cylinder Bore inches	Cylinder OD inches	Design Pressure psig	Test Pressure psig	Tie Rod Nominal OD, inches	Tie Rod Thread threads/inch	Tie Rod Material A.I.S.I.	Number of Tie Rods	Torque in*lb.	Cylinder Axial Compression Strain, in/in
-150	1.50	1.70	150	225	1/4	-28 NF	1050	4	8	0.0008
-200	2.00	2.25	150	225	5/16	-24 NF	1050	4	16	0.0008
-250	2.50	2.75	150	225	5/16	-24 NF	1050	4	25	0.0010
-325	3.25	3.50	150	225	3/8	-24 NF	1050	4	52	0.0012
-400	4.00	4.25	150	225	3/8	-24 NF	1050	4	81	0.0016
-500	5.00	5.25	150	225	1/2	-20 NF	1050	4	165	0.0019
-600	6.00	6.25	150	225	1/2	-20 NF	1050	4	237	0.0024
-800	8.00	8.50	150	225	9/16	-18 NF	1050	4	590	0.0018
-1010	10.00	10.50	150	225	3/4	-16 NF	1050	4	1074	0.0022

*These values are intended as an initial design guide. It is the customer's responsibility to test and approve the actual values. *For sizes other than listed or for assistance contact Polygon's Sales Engineers. *Good assembly practices to be employed in applying torque to the tie rods so as not to unequally stress cylinder.

PolySlide® cylinders combined with plastic endcaps are highly corrosion resistant.

PolySlide cylinder showed minimal wear and virtually no seal wear.

Patented thermoplastic ends reduce weight and require no pins.

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

END CAP DESIGNS

End caps can be designed in various ways to meet specified requirements. The simplest means of attaching the ends to the cylinder is by the use of tie rods; however, Polygon has experience with other end cap attachment techniques.

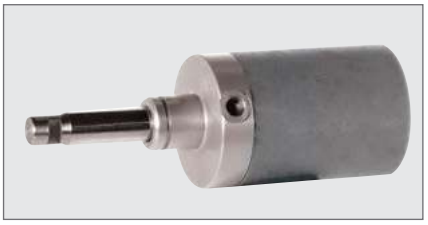
For common cylinder sizes using tie rods see the table on the previous page for design details. Pre-load torque values are given here.

PolySlide® cylinders offer smoother walls, excellent impingement resistance, a wide temperature range, are resistant to corrosion and are lighter weight than their metal counterparts. The perfect combination for your next cylinder design project.

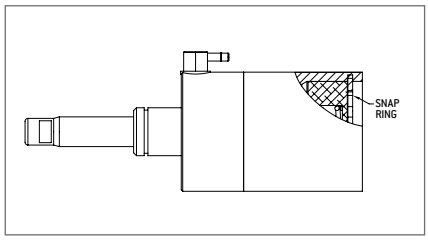
POLYSLIDE® LUBRICATION GUIDELINES

For normal application the same lubrication and methods of application used for metallic cylinders can be used with PolySlide cylinders. Normal pre-lubrication procedures are also recommended. In line or in service lubrication is acceptable but often not required.

For assistance in new application or questions relating to lubrication related to PolySlide cylinders contact a Polygon Sales Engineer.

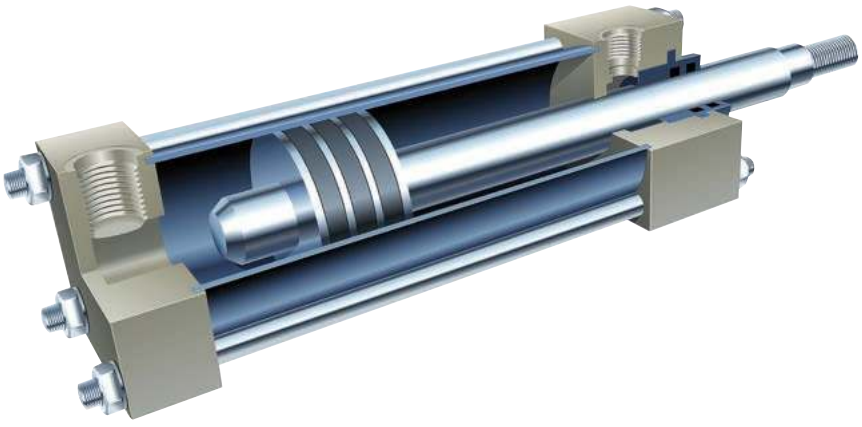


Composite cylinders can accept threaded end caps.



Polygon has patented several unique methods to attach endcaps without screws.

Methods such as this snap ring can be used to secure endcaps.



Tie rod endcap mounting systems allow for drop-in PolySlide® replacement.

"PolySlide® cylinder tubing provides the actuation market a new material with significantly improved performance features. It brings new vitality to a mature market."

COMPOSITE CYLINDER TUBING

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POLYSIGHT® PRODUCT DESCRIPTION

PolySight® composite tubing is a perfect alternative to conventional sight glass. Polygon engineers developed PolySight years ago for use with oil reservoir systems. The extra strength of these filament wound composites will keep PolySight tubes from denting or chipping. Thanks to their high strength, low cost and light weight characteristics, they are ideal substitutes for most of today's metal and thermoplastic products. The distinct translucent benefits are a result of Polygon's design and manufacturing strengths, which work to your advantage when used in highly-pressurized, critical oil systems.

PolySight® is lighter than glass and can be shipped without fear of breakage.

POLYSIGHT PRODUCT ADVANTAGES

Polygon's composite construction benefits also extend to an advanced corrosion resistance nature. Acids, moisture, salt water and other corrosive environments will inhibit performance and longevity in most other products. PolySight composite tubing will withstand even the harshest of conditions.

PolySight's reinforced structure can withstand rough conditions without chipping.

POLYSIGHT BENEFITS & VALUE

Significant weight reduction is another benefit of PolySight composite tubing. Steel, brass and even aluminum are all substantially higher in weight than composites. And shipping costs will be less along with material handling and assembly. It also completely eliminates the cost in labor and materials to assemble traditional secondary sight methods.

PolySight's translucent walls provide for easy oil level checks.

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

POLYSIGHT® TEST DATA (TAKEN AT ROOM TEMPERATURE)

MODEL NUMBER	NOMINAL BORE (in)	BORE ID (in)	BORE ID (mm)	OD (in)	OD (mm)	OPERATING PRESSURE (psig)	OPERATING PRESSURE (kPa)	ALLOWABLE END COMPRESSION FORCE (lbf)	ALLOWABLE END COMPRESSION FORCE (N)	RANDOM LENGTH TO (ft)	WEIGHT (lb/ft)	WEIGHT (kg/m)
PGP-6002-100	1.00	1.000 1.003	25.40 25.48	1.250 1.253	31.75 31.83	2440	16823	2000	8896	5	0.38	0.56
PGP-6002-125	1.25	1.250 1.256	31.75 31.90	1.500 1.504	38.10 38.20	1970	13583	2430	10809	5	0.46	0.69
PGP-6002-150	1.50	1.500 1.506	38.10 25.55	1.750 1.754	44.45 44.55	1660	11445	2860	12722	4	0.55	0.82
PGP-6002-175	1.75	1.750 1.756	44.45 44.60	2.000 2.004	50.80 50.90	1390	9584	3230	14368	4	0.63	0.94
PGP-6002-200	2.00	2.000 2.006	50.80 50.95	2.250 2.256	57.15 57.25	1230	8480	3680	16369	10	0.72	1.07
PGP-6002-225	2.25	2.250 2.258	57.15 57.35	2.500 2.506	63.50 63.65	1100	7584	4100	18238	10	0.80	1.19
PGP-6002-250	2.50	2.500 2.508	63.50 63.70	2.750 2.760	69.85 70.10	980	6757	4500	20017	10	0.89	1.32
PGP-6002-275	2.75	2.750 2.758	69.85 70.05	3.000 3.010	76.20 76.45	890	6136	4920	21885	10	0.97	1.44
PGP-6002-300	3.00	3.000 3.008	76.20 76.40	3.250 3.260	82.55 82.80	820	5654	5340	23753	10	1.05	1.57
PGP-6002-325	3.25	3.250 3.258	82.55 82.75	3.500 3.510	88.90 89.15	750	5171	5740	25533	10	1.14	1.69
PGP-6002-350	3.50	3.500 3.508	88.90 89.10	3.750 3.760	95.25 95.50	700	4826	6160	27401	10	1.22	1.82
PGP-6002-375	3.75	3.750 3.758	95.25 95.45	4.000 4.010	101.60 101.85	650	4482	6580	29269	10	1.31	1.95
PGP-6002-400	4.00	4.000 4.010	101.60 101.85	4.250 4.260	107.95 108.20	610	4206	7030	31271	10	1.39	2.07
PGP-6002-450	4.50	4.500 4.510	114.30 114.55	4.750 4.760	120.65 120.90	530	3654	7820	34785	10	1.56	2.32
PGP-6002-500	5.00	5.000 5.010	127.00 127.25	5.250 5.260	133.35 133.60	480	3309	8670	38566	10	1.73	2.57
PGP-6002-550	5.50	5.500 5.510	139.70 139.95	5.750 5.760	146.05 146.30	440	3034	9510	42302	10	1.90	2.82
PGP-6002-575	5.75	5.750 5.760	146.05 146.30	6.000 6.012	152.40 152.70	420	2896	9900	44037	10	1.98	2.95
PGP-6002-600	6.00	6.000 6.010	152.40 152.65	6.250 6.262	158.75 159.05	400	2758	10360	46083	10	2.07	3.07
PGP-6002-700	7.00	7.000 7.012	177.80 178.10	7.250 7.262	184.15 184.45	340	2344	12030	53512	10	2.40	3.57
PGP-6002-800	8.00	8.000 8.015	203.20 203.58	8.250 8.265	209.55 209.93	300	2068	13640	60673	10	2.74	4.08
PGP-6002-1000	10.00	10.000 10.020	254.00 254.51	10.375 10.410	263.53 264.41	360	2482	25840	114941	10	5.15	7.67
PGP-6002-1200	12.00	12.000 12.020	304.80 305.31	12.375 12.410	314.33 315.21	300	2068	30760	136827	10	6.16	9.17
PGP-6002-1400	14.00	14.000 14.020	355.60 356.11	14.375 14.410	365.13 366.01	260	1793	35740	158979	10	7.18	10.68

1. Special sizes available upon request. Machining capacity up to 30" diameter by 10 ft long. Contact a Polygon Application Engineer for further information.
2. Operating pressure and allowable end compression force is calculated on a 4:1 factor of safety.
3. The operating pressure is based on rod design with minimal end compression force. For other designs consult the Polygon Engineering Department.

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

POLYSLIDE® TEST DATA (TAKEN AT ROOM TEMPERATURE)

Model Number	Nominal Bore	Bore ID		OD		Operating Pressure		Allowable End Compression Force		Random Length, max		Weight	
	(in)	(in)	(mm)	(in)	(mm)	(psig)	(MPa)	(lb.)	(kN)	(ft)	(m)	(lb/ft)	(kg/m)
PGP-6001-044	0.44	0.437 0.440	11.10 11.18	0.562 0.565	14.27 14.35	3,239	22.33	503	2.2	4	1.22	0.09	0.13
PGP-6001-050	0.50	0.499 0.502	12.67 12.75	0.625 0.628	15.88 15.95	2,554	17.61	521	2.3	4	1.22	0.10	0.15
PGP-6001-056	0.56	0.562 0.565	14.27 14.35	0.687 0.690	17.45 17.53	2,530	17.44	594	2.6	4	1.22	0.11	0.16
PGP-6001-075	0.75	0.750 0.753	19.05 19.13	0.875 0.878	22.23 22.30	2,420	16.69	882	3.9	4	1.22	0.14	0.21
PGP-6001-088	0.88	0.875 0.878	22.23 22.30	1.000 1.004	25.40 25.50	2,307	15.91	992	4.4	4	1.22	0.16	0.24
PGP-6001 -100	1.00	1.000 1.003	25.40 25.48	1.125 1.129	28.58 28.68	2,196	15.14	1,175	5.2	4	1.22	0.19	0.28
PGP-6001-106	1.06	1.062 1.065	26.97 27.05	1.187 1.191	30.15 30.25	1,916	13.21	1,172	5.2	4	1.22	0.19	0.29
PGP-6001-125	1.25	1.250 1.254	31.75 31.85	1.375 1.380	34.93 35.05	1,521	10.49	1,334	5.9	4	1.22	0.23	0.34
PGP-6001-137	1.38	1.375 1.380	34.93 35.05	1.500 1.505	38.10 38.23	1,596	11.00	1,538	6.8	4	1.22	0.25	0.38
PGP-6001-150	1.50	1.500 1.506	38.10 38.25	1.695 1.700	43.05 43.18	1,681	11.59	2,380	10.6	4	1.22	0.44	0.65
PGP-6001-175	1.75	1.750 1.756	44.45 44.60	2.000 2.005	50.80 50.93	1,848	12.74	3,574	15.9	4	1.22	0.66	0.98
PGP-6001-200	2.00	2.000 2.006	50.80 50.95	2.250 2.258	57.15 57.28	1,651	11.38	4,078	18.1	10	1.22	0.75	1.11
PGP-6001-225	2.25	2.250 2.258	57.15 57.35	2.500 2.508	63.50 63.65	1,594	10.99	4,681	20.8	10	3.05	0.83	1.24
PGP-6001-250	2.50	2.500 2.508	63.50 63.70	2.750 2.760	69.85 70.10	1,412	9.74	5,086	22.6	10	2.74	0.92	1.37
PGP-6001-275	2.75	2.750 2.758	69.85 70.05	3.000 3.010	76.20 76.45	1,315	9.07	5,613	25.0	10	3.05	1.01	1.50
PGP-6001-300	3.00	3.000 3.008	76.20 76.40	3.250 3.260	82.55 82.80	1,132	7.80	5,955	26.5	10	1.83	1.10	1.63
PGP-6001-325	3.25	3.250 3.258	82.55 82.75	3.500 3.510	88.90 89.15	1,089	7.51	6,537	29.1	10	3.05	1.19	1.77
PGP-6001-350	3.50	3.500 3.508	88.90 89.10	3.750 3.760	95.25 95.50	914	6.30	6,708	29.8	10	3.05	1.27	1.89
PGP-6001-375	3.75	3.750 3.758	95.25 95.45	4.000 4.010	101.60 101.85	914	6.30	7,341	32.7	10	3.05	1.36	2.03
PGP-6001-400	4.00	4.000 4.010	101.60 101.85	4.250 4.260	107.95 108.20	917	6.32	8,022	35.7	10	3.05	1.45	2.16
PGP-6001-425	4.25	4.247 4.257	107.87 108.13	4.500 4.510	114.30 114.55	826	5.70	8,368	37.2	10	3.05	1.54	2.29
PGP-6001-500	5.00	5.000 5.010	127.00 127.25	5.250 5.260	133.35 133.60	754	5.20	10,012	44.5	10	3.05	1.80	2.68

- Operating pressure values are based on theoretical ultimate burst pressures with a factor of safety of four.
- Allowable end pressure force is based on ultimate compression force with a factor of safety of four. Column buckling effects are not considered in these values.
- Other pressure ratings and wall thickness are available upon request.
- These cylinders are designed for pneumatic and low pressure hydraulic applications.
- These are typical ratings for design purposes. Final testing and approval is the customer's responsibility for their application.
- Pressure and compression ratings do not consider the effects each has on the other.

COMPOSITE CYLINDER TUBING

COMPOSITE PNEUMATIC AND HYDRAULIC CYLINDERS

POLYSLIDE® TEST DATA (TAKEN AT ROOM TEMPERATURE)

Model Number	Nominal Bore (in)	Bore ID (in)	Bore ID (mm)	OD (in)	OD (mm)	Operating Pressure (psig)	Operating Pressure (MPa)	Allowable End Compression Force (lb.)	Allowable End Compression Force (kN)	Random Length, max (ft)	Random Length, max (m)	Weight (lb/ft)	Weight (kg/m)
PGP-6001-540	5.40	5.400 5.410	137.16 137.41	5.625 5.635	142.88 143.13	616	4.25	9,620	42.8	3	0.91	1.74	2.59
PGP-6001-550	5.50	5.500 5.510	139.70 139.95	5.750 5.760	146.05 146.30	695	4.79	11,044	49.1	10	1.83	1.98	2.94
PGP-6001-575	5.75	5.750 5.760	146.05 146.30	6.000 6.010	152.40 152.65	626	4.32	11,232	50.0	10	2.74	2.06	3.07
PGP-6001-600	6.00	6.000 6.010	152.40 152.65	6.250 6.260	158.75 159.00	588	4.05	11,618	51.7	10	3.05	2.15	3.20
PGP-6001-700	7.00	7.000 7.012	177.80 178.10	7.250 7.262	184.15 184.45	527	3.63	13,733	61.1	10	3.05	2.50	3.72
PGP-6001-701	7.00	7.000 7.012	177.80 178.10	7.500 7..512	190.50 193.55	838	5.78	26,008	115.7	10	3.05	5.09	7.58
PGP-6001-800	8.00	8.000 8.015	203.20 203.58	8.250 8.265	209.55 209.93	460	3.17	15,633	69.5	10	3.05	2.85	4.24
PGP-6001-801	8.00	8.000 8.015	203.20 203.58	8.500 8.515	215.90 216.28	733	5.05	29,572	131.5	10	3.05	5.79	8.62
PGP-6001-1000	10.00	10.000 10.015	254.00 254.38	10.375 10.390	263.53 263.91	548	3.78	29,346	130.5	10	3.05	5.37	7.98
PGP-6001-1010	10.00	10.000 10.015	254.00 254.38	10.500 10.515	266.70 267.08	657	4.53	38,032	169.2	10	3.05	7.20	10.71
PGP-6001-1200	12.00	12.000 12.020	304.80 305.31	12.375 12.390	314.33 314.71	444	3.06	34,717	154.4	10	3.05	6.42	9.55
PGP-6001-1210	12.00	12.000 12.020	304.80 305.31	12.500 12.515	317.50 317.88	542	3.74	45,068	200.5	10	3.05	8.60	12.80
PGP-6001-1400	14.00	14.000 14.020	355.60 356.11	14.375 14.390	365.13 365.51	368	2.54	39,903	177.5	10	3.05	7.47	11.12
PGP-6001-1410	14.00	14.000 14.020	355.60 356.11	14.625 14.640	371.48 371.86	535	3.69	64,037	284.9	10	3.05	12.56	18.70
PGP-6001-1600	16.00	16.000 16.020	406.40 406.91	16.500 16.520	419.10 419.61	402	2.77	59,462	264.5	10	3.05	11.41	16.98
PGP-6001-1610	16.00	16.000 16.020	406.40 406.91	16.750 16.770	425.45 425.96	542	3.74	87,133	387.6	10	3.05	17.25	25.67
PGP-6001-1800	18.00	18.000 18.025	457.20 457.84	18.625 18.650	473.08 473.71	420	2.90	82,088	365.1	10	3.05	16.08	23.92
PGP-6001-1810	18.00	18.000 18.025	457.20 457.84	18.750 18.775	476.25 476.89	485	3.34	97,640	434.3	10	3.05	19.36	28.80
PGP-6001-2000	20.00	20.000 20.025	508.00 508.64	20.750 20.775	527.05 527.69	442	3.05	108,668	483.4	10	3.05	21.46	31.94
PGP-6001-2010	20.00	20.000 20.025	508.00 508.64	21.000 21.025	533.40 534.04	552	3.81	143,413	637.9	10	3.05	28.79	42.85

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- Allowable end pressure force is based on ultimate compression force with a factor of safety of four. Column buckling effects are not considered in these values.
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- These cylinders are designed for pneumatic and low pressure hydraulic applications.
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POLYGON
COMPOSITES TECHNOLOGY

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(574) 586-3145 | polygoncomposites.com | sales@polygoncompany.com

103 Industrial Park Dr.
Walkerton, IN 46574 USA