DYMETROL®

Mechanical Drive Tapes

DYMETROL® Mechanical Drive Tapes offer exciting design opportunities for mechanical energy transfer. They can push or pull, lift or lower, and travel with ease around corners and curved surfaces when constrained in a channel or track.

Tapes can be perforated for indexing and use with manually or motor operated gear drives, converting rotary to linear motion in a highly controlled manner.

DYMETROL Mechanical Drive Tapes
Key Characteristics:

- High strength-to-weight ratio
- Toughness (shock resistance) over a wide range of temperatures
- Excellent low temperature performance, with good flexibility down to -40° C
- Operational at 80° - 100° C, depending on loading
- Excellent fatigue resistance
- Excellent creep and wear resistance
- Chemical and corrosion resistance
- Very low noise generation and transmission
- Good dielectric strength
- Low or no lubrication required

This unique combination of characteristics makes Dymetrol Mechanical Drive Tapes excellent candidates for enhancing the performance of many drives traditionally served by rubber or synthetic V belts, toothed timing belts, "bicycle" chain, linear screw drives or cable drive systems.

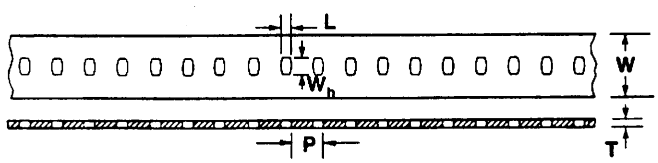
General Tape, Channel and Sprocket Configurations

DYMETROL Mechanical Drive Tapes are manufactured using a special orientation process. They can be produced in a range of tightly controlled cross sections to meet varying strength and flexibility requirements. Standardized widths range from roughly 8 mm (.3 in.) to 20 mm (.8 in.); thicknesses range from approximately .8 mm (.03 in.) to 2 mm (.08 in.). Customized configurations are possible in roughly the same width and thickness ranges.

A detailed list of specific Dymetrol tape configurations and sizes currently available for prototyping is shown separately.

Typical DYMETROL Mechanical Drive Tape Configurations

- 2000 Series - better low temperature flexibility
- 4000 Series - better high temperature performance



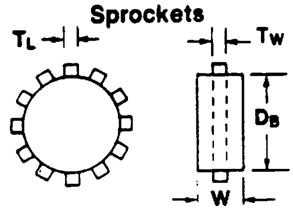
Typical Products and Dimensions

Designation	W Width (in./mm)	T Thickness (in./mm)	P Pitch (in./mm)	W_h Hole width (in./mm)	L Hole length (in./mm)
DETS*/DETP*-2001/4201	.800/20.3	.080/2.03	.319/8.1	.236/6	.150/3.8
DETS/DETP-2005/4205	.600/15.2	.076/1.92	.319/8.1	.236/6	.150/3.8
DETS/DETP-2000	.600/15.2	.071/1.80	.319/8.1	.236/6	.150/3.8
DETS/DETP-1086	.598/15.2	.05/1.27	.0319/8.1	.236/6	.150/3.8
DETS/DETP-2103	.531/13.5	.069/1.75	.364/9.25	.236/6	.150/3.8
DETS/DETP-1353/1070	.433/11.0	.047/1.2	.319/8.1	.142/3.59	.090/2.29

** DETS - solid tape*
DETP - punched tape, standard Dymetrol configuration

Typical Sprocket Configurations**

The following sprockets are available for use with DETP series tapes to aid in prototype development.



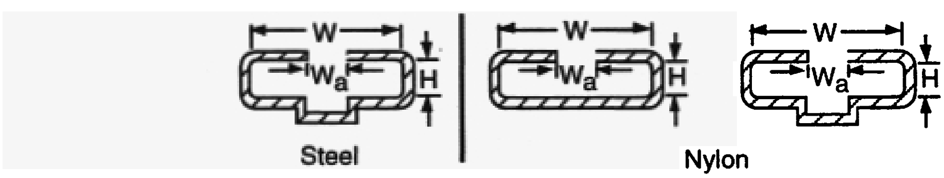
Designation	N No. teeth	D_B (in./mm)	W (in./mm)	T_H (in./mm)	T_W (in./mm)	T_L (in./mm)
DG-0001**	16	1.55/39.45	.60/15.2	.11/2.8	.21/5.3	.14/3.6
DG-0002**	16	1.55/39.45	.80/20.3	.11/2.8	.21/5.3	.14/3.6
DG-0003**	12	1.135/28.8	.80/20.3	.11/2.8	.21/5.3	.14/3.6
DG-0004**	10	.94/24	.73/18.5	.09/2.3	.21/5.3	.14/3.6

*** Tooth design details for standard Dymetrol punched tape are available on request.*
I. D. configuration .850 in. spline.

Ample clearance should be maintained between sprocket teeth and tape holes in order to accommodate tolerance stack and prevent binding.

Typical Channel Configurations***

Channel Type and Size



Compatible Tape	Type	W Inside Width (in./mm)	H Inside Height (in./mm)	Wa Access Width (in./mm)
DETP/DETS-1347/1269	Steel	.512/13.0	.095/2.41	.31/7.87
DETP/DETS-2005/4205	Steel	.70/17.8	.11/2.80	.31/7.90
DETP/DETS-2005/4205	Nylon	.656/16.7	.094/2.38	.281/7.14
DETP/DETS-2001/4201	Steel	.844/21.4	.109/2.77	.31/7.87
DETP/DETS-2001/4201	Nylon	.844/21.4	.109/2.77	.281/7.14

**** Selected channel configurations are available for prototyping.*

Sprocket Housings

For push-pull operation, a housing is required to prevent the tape from disengaging with the drive sprocket during compression. Minimum clearance possible should be maintained between the housing I. D. and the sprocket teeth O. D.

ENGINEERING DATA

Engineering data which will be helpful in designing Dymetrol Mechanical Drive Tape systems are provided in the following pages. It is, however, extremely important to test prototypes of any proposed design under realistic use conditions prior to commercialization.

General

General mechanical properties of unpunched standard modulus tapes are listed in Table I.

Table I **Mechanical Properties**

Mechanical Properties*	Units	ASTM Test	-40°C	23°C	80°C
Tensile Strength	kg/cm^2	D638	2500	1850	1430
	psi		35,600	26,300	20,000
Strain @ Ultimate Tensile Strength	0/0	D638	33	42	47
Modulus of Elasticity	kg/cm^2	D638	28,900	10,260	4320
	psi		411,000	146,000	61,400
Flexural Modulus	kg/cm^2	D790	31,500	10,100	4150
	psi		448,000	143,700	58,900
Shear Modulus					
Elastic (G")	kg/cm^2	D2236	10,700	4080	1530
	psi		152,000	60,000	21,600
Loss (G")	kg/cm^2	D2236	235	295	50
	psi		3280	4130	740
Tensile Impact Strength	$joules/cm^2$	D1822	–	>122	–
	$ft\text{-}lb/in^2$	D1822	–	>583	–
Poisson's Ratio					
Width Direction	–	E132	–	0.31	–
Thickness Direction	–	E132	–	0.67	–
Rockwell Hardness	–	D785	–	M37	–

**2000 Series unpunched tapes*

Strength

Strength of Dymetrol Mechanical Drive Tapes varies with cross section, perforation configuration and composition. Our separate listing of currently available tape sizes contains actual break strength for a wide range of currently available configurations. Depending on size and type, break strengths approaching 1500 lbs for unpunched and in excess of 550 lbs for punched tapes* are achievable.

**Four-tooth engagement. Higher values are achieved with higher numbers of engaged teeth.*

Figure A
Tensile Stress vs Elongation, Solid Tape

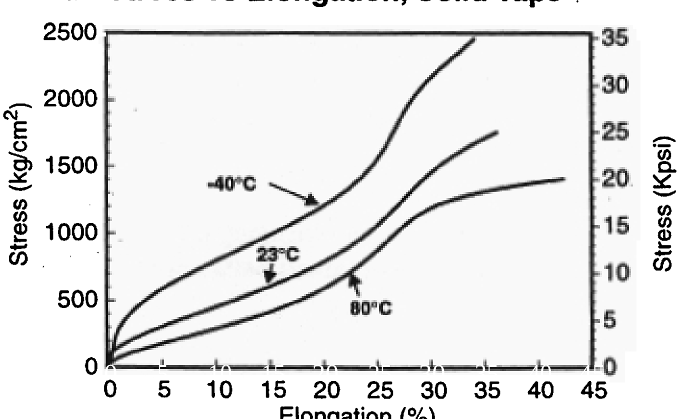
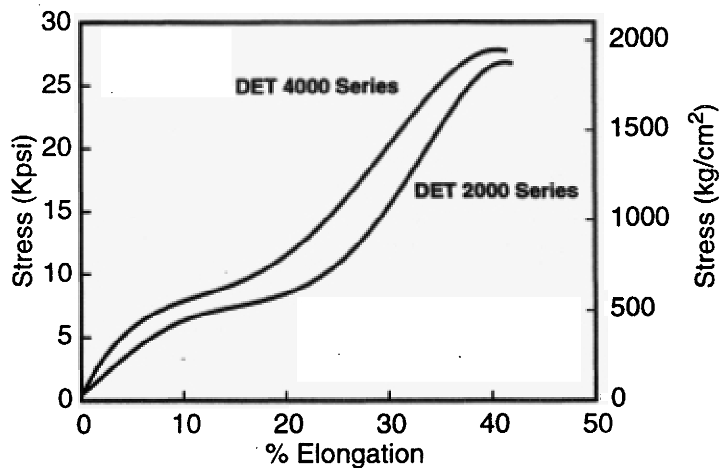


Figure A shows tensile strength vs elongation for solid 2000 type standard modulus tapes. It can be used for predicting elongation at various loadings as a function of temperature.

As shown in Figure B, high modulus tapes exhibit higher tensile strength than their standard modulus counterparts at equivalent elongations. This advantage is at the expense of low temperature flexibility where the standard modulus tapes excel. Comparison of standard modulus (DETP 2005) and high modulus (DETP 4205) punched tapes shows a roughly 25% higher stress at 7% elongation for the high modulus formulation. At break, the high modulus tape is 20% stronger. Both formulations exhibit essentially the same elongation at break.

Figure B
Tensile Stress vs Elongation



Most applications utilize punched tapes. Perforating a tape reduces its load bearing capability. The reduction in load bearing capability compared with solid tape varies with the relative size of tape-to-hole cross section, spacing of the holes as well as the number of drive sprocket teeth engaged with the tape. A test apparatus (Figure C) is routinely used to evaluate load bearing capability of punched tapes. The fixture is mounted in an Instron Testing Machine (where four teeth are engaged at each end of the tape) and the tape stretched to failure. Typical data from this test are shown in Figure D.

Figure C
Test Rig for Breakload of Punched Regulator Tape

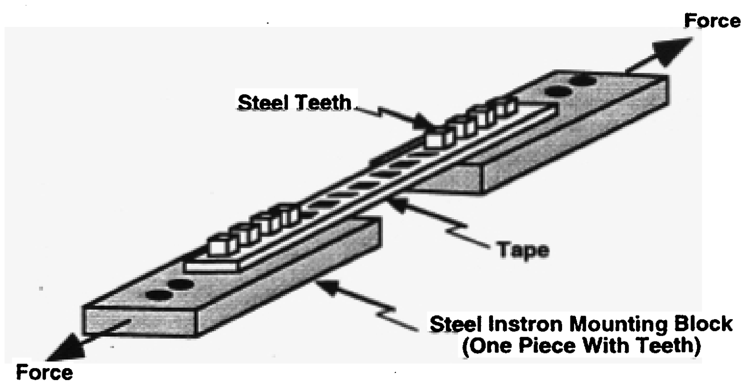
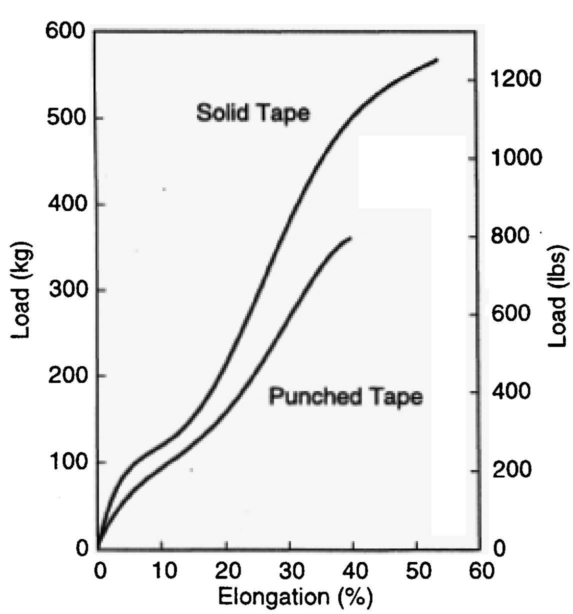


Figure D Load-Elongation/Solid vs Punched Tape at 23°C, (73°F)/50% RH



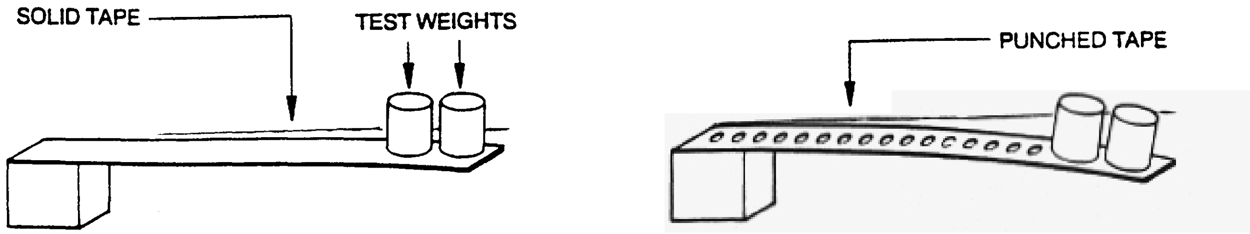
In general, the breakload has been found to be approximately linear (i.e. one tooth = 100 lbs, two = 200 lbs) until the breakload of the solid cross section is approached. From comparisons made on solid vs punched tape samples using a conservative simulation of 4 tooth engagement, a load bearing capability of roughly 40-50% of solid tape values is observed with punched tapes of the same size and composition.

Figure D specifically illustrates typical load vs elongation curves for the same tape (DETP 4205) unpunched vs punched with "standard" hole (8.1 mm pitch, 3.6 mm length x 2.3 mm width) configuration at 4 tooth engagement (worst case, i.e., small sprocket and/or less than 180° engagement).

Designers should strive to achieve maximum tooth engagement possible within the system configurational limits by employing the largest sprocket diameter and maximum possible wrap.

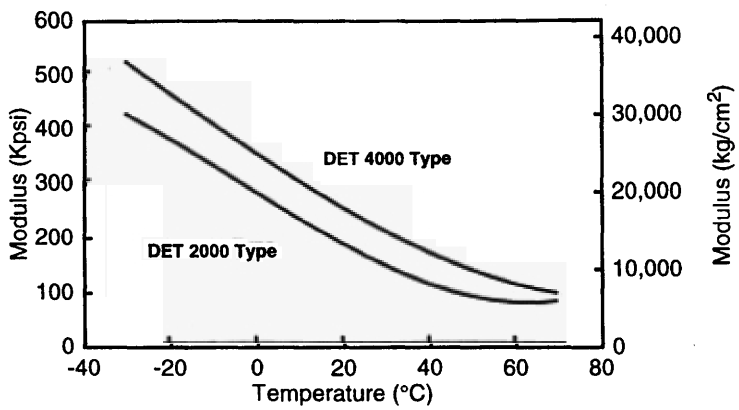
Flexibility

Figure E   Beam Flex for Punched Tape



Flexibility of Dymetrol Tape, as measured by the beam flex method, (Figure E), is shown in Figure F.

Figure F
Flexural Modulus vs Temperature - Solid Tape



Dymetrol tape compositions exhibit relatively low change in flex modulus over a wide temperature range compared to most plastics. Actual flexibility of a Dymetrol tape is a function of composition, as well as cross section and perforation pattern. Flexibility is increased as the thickness and width are decreased.

Using a cantilever beam stiffness test, a 2000 series unpunched tape with a geometry of .60 in. wide by .07 in. thick and a load span of 2 inches will deflect 1 inch under a .95 lb force at 23°C (ASTM test D747).

Figure G
Relative Beam Flex - Solid Tape

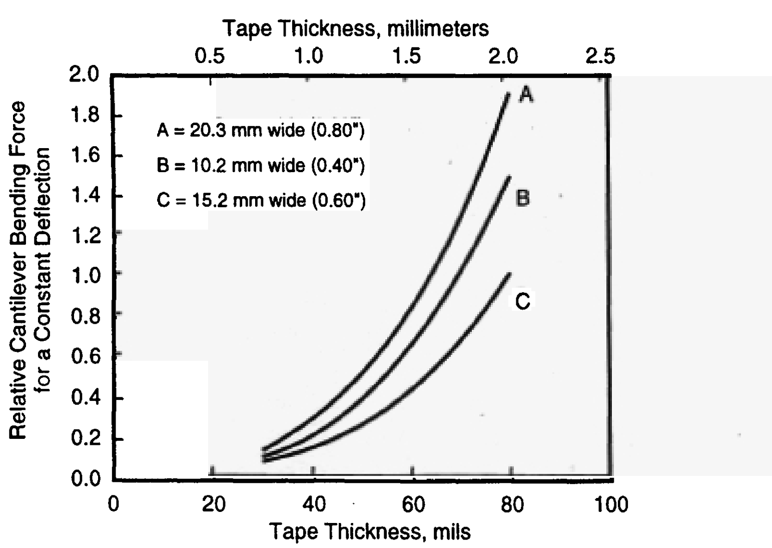


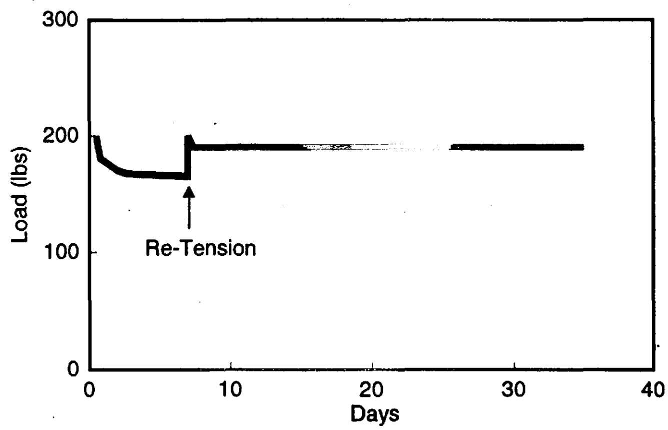
Figure G illustrates relative flexibility vs tape geometry using ASTM D747 as in the above example.

Creep Resistance

Creep resistance/stress relaxation characteristics of typical 2000 series tapes are illustrated in Figures H, I, & J.

In Figure H, a DETS 2000 tape was loaded to 200 lbs. Tension was monitored with time. The stress decayed to 163 lbs in seven days. The tape was then restressed to 200 lbs. The stress decayed rapidly to 193 lbs, then remained constant for the 30-day duration of the test.

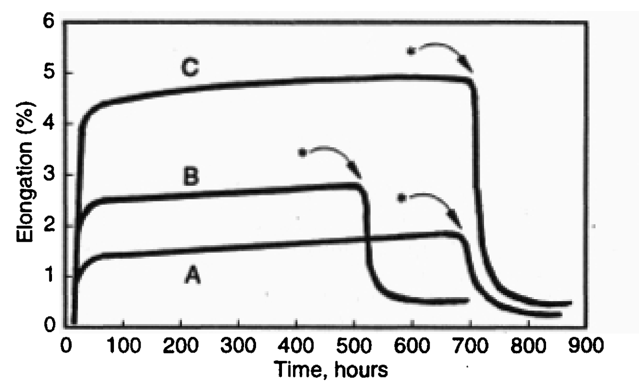
Figure H
Stress Relaxation - DET 2000



Both stress decay and creep have been found to be linear with log time. It is possible to insure certain tension levels are maintained by initially stressing above the desired amount. For all-tension type devices this feature is significant. While the initial elongation due to a given load is higher because of reduced modulus at elevated (80° C) temperatures, only a small increase in creep occurs.

These findings are shown in Figure I, curves A and B.

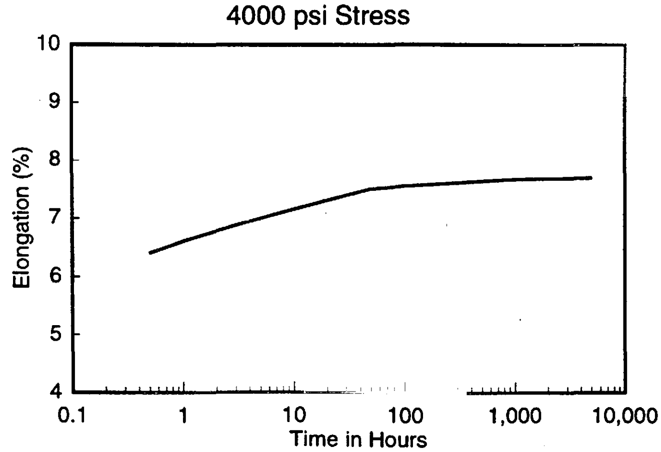
Figure I
Tensile Creep - Solid Tape



A - 75 kg/cm^2 (1067 psi) stress and 22°C (72°F)
B - 75 kg/cm^2 (1067 psi) stress and 80°C (176°F)
C - 180 kg/cm^2 (2560 psi) stress and 22°C (72°F)
*Stress removed

Longer term creep is illustrated in Figure J. An initial elongation of 6.3 percent due to the 4000 psi load stress increased by only 1.2 percent over 1000 hours. No further increase was noted after 8000 hours. This creep performance is outstanding for a polymeric material.

Figure J
Typical Creep - DET 2000 Type
Ambient Conditions
4000 psi Stress



Heat Aging

Heat aging behavior of polymeric materials can become important in applications involving higher temperature environments. The type of test generally run to determine life is measured by tensile strength versus time for a given temperature (Figure K). Tape is exposed to the hot air environment and samples are removed periodically for testing. The time at which the strength has dropped in half is designated as the tensile stress half-life. This point is then plotted for various temperatures, to produce a graph from which half-life at other temperatures is predictable, as seen in Figure L. One can see that from a heat aging standpoint, a useful life of many years is possible for Dymetrol tapes exposed continuously to temperatures under 100° C.

Additional thermal characteristics are contained in Table II.

Figure K
Maximum Tensile Stress with Heat Aging

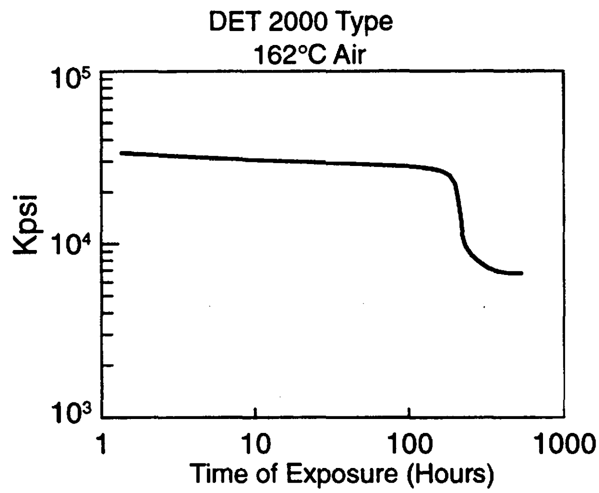
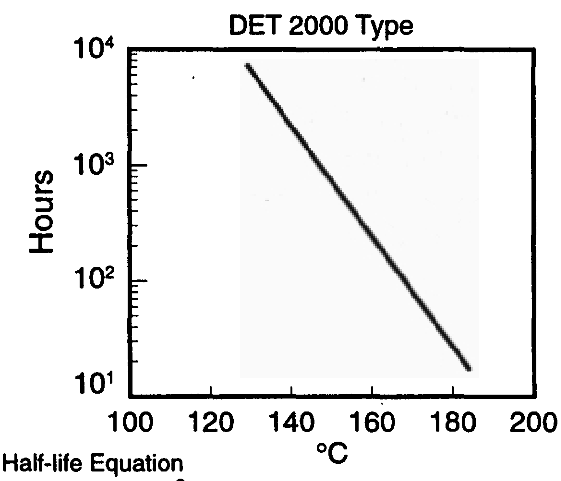


Figure L
Maximum Tensile Stress Half-life vs Temperature of Air Aging



Half-life Equation
$t_{1/2} = 32.76 \times 10^8 e^{-0.1046\,Ø}$

Table II **Thermal Properties**

Thermal Properties	Units	ASTM Test	-40°C	+23°C	+80°C
Melting Temperature	°C	D3418	-	218	-
Brittleness Temperature	°C	D746	-	<-70	-
Coefficient of Linear Thermal Expansion (10^{-6})	mm/mm/°C x 10^{-6}	E228	50	100	40

Chemical Resistance

Dymetrol Elastomeric Tapes are virtually unaffected by ozone, common detergents, lubricants, solvents, and rust-proofing products often used in and around mechanical drive systems. Strong bases, concentrated strong acids, and chlorinated hydrocarbons cause degradation of the elastomeric polyester resin. Lithium based or synthetic greases are very compatible with Dymetrol tapes. Sodium or potassium based greases should therefore be avoided. Table III rates the resistance of Dymetrol tapes to only a few of many acids, bases, salts and other chemical compounds. These findings should be used only as a guide, because they are based on laboratory and service tests which could not take into account all variables that may be encountered in actual use. Testing under conditions the tapes will see in actual service is therefore highly recommended. More complete data on chemical resistance is available on request.

Weatherability

Dymetrol tapes, like most thermoplastic parts, may be subject to U.V. degradation when used in applications involving outdoor exposure. Protection from significant exposure to sunlight is therefore essential. Where system design precludes such protection, U.V. resistant Dymetrol tapes must be used. Information on weather protection is available on request.

Additional characteristics are summarized in Table IV.

Table III

Chemical Resistance of Dymetrol Tapes

Chemical	Rating*
Acetic acid, 30%	A
Acetone	B
Ammonium chloride solutions	A
Amyl alcohol	A
ASTM oil #1 (149° C, 300° F)	A
ASTM ref. fuel A (70° C, 158° F)	A
Benzene	B
Butyl acetate	B
Carbon tetrachloride	C
Copper sulfate solutions	A
Dibutyl phthalate	A
Ethyl acetate	B
Ethylene glycol	A
Formaldehyde, 40%	B
Gasoline	A
Hydrochloric acid, 20%	B
Hydrochloric acid, 37%	C
Lacquer solvents	B
Methyl ethyl ketone	B
Nitric acid, 30%	C
Oleum, 20-25%	C
Potassium hydroxide solutions	A
Silicone grease	A
Sodium hydroxide, 45.5%	B
Steam (100° C, 212° F)	B
Sulfuric acid, up to 50%	A
Sulfuric acid, 50-80%	C
Tetrahydrofuran	B
Trichloroethylene	C
Zinc chloride solutions	A

**Rating Key: A - fluid has little or no effect.*
B - fluid has minor to moderate effect.
C - fluid has severe effect.

Unless otherwise noted, concentrations of aqueous solutions are saturated. All ratings are at room temperature unless specified.

Table IV **Miscellaneous Properties**

Misc. Properties	Units	ASTM Test	-40°C	23°C	80°C
Dielectric Strength	kV/mm	D149	-	18.1	-
	volts/mil			460	-
Volume Resistivity	ohms-cm	D257	-	1.8×10^{14}	-
Burning Rate	cm/min	D635	-	3.0	-
	in/min		-	1.2	-
Limiting Oxygen Index	%	D2863	-	21	-
Width	mm	-	-	15.2	-
	in	-	-	0.6	-
Thickness	mm	-	-	1.8	-
	in	-	-	0.07	-
Moisture Absorption		D570			
@ 24 Hr.	%		-	0.2	-
@ Saturation	%		-	0.5	-
Density	g/cm^3	D1505	-	1.27	-
Kinetic Coefficient of Friction	-	Weighted Sled			
Aluminum (30AA)			0.30	0.33	0.30
Steel (140 AA)			0.37	0.32	0.31
Nylon (32 AA)			0.25	0.23	0.27

DESIGN CONSIDERATIONS

Cycle Life

Cycle life, defined as the useful life of Dymetrol Mechanical Drive Tapes in various applications, varies with the flexural stresses (bending radius), tensile stresses (load), and rate of cycling. To simulate extreme cases, DETP 4205 tapes have been tested at 43 cycles per minute under various loadings employing a 180° wrap around rotating idler pulleys. Figure M shows how reduced load and increased diameter dramatically increase cycle life (defined as an incipient delamination between the holes of a punched specimen even though the tape is still fully functional). Unpunched or solid tape has generally 5-10 times higher cycle life than punched tape since essentially no stress-risers are present. Under lighter loads, such as experienced with, for example, windshield wiper systems, 1 to 10 million cycles have been demonstrated with punched tapes.

A second series of tests shown in Figure N illustrates how cycle life is increased as tape thickness decreases. This is a natural result of the lower flexural stress in thinner sections.

Drag Force

Drag force for tape in an unlubricated channel under load at 6 in./second testing speed has been measured. These data are shown in Figure O. As an example, if the tape were to carry a load of five lbs through a 90° twist taken in a 6-inch length, the drag force would be about two lbs. As a second example, the tape loaded to five lbs would have an additional 12 lbs drag load if it took a 90° flat bend with a 2-inch radius. The existing data are adequate for either compressive (push) or tensile (pull) loading. At speeds under 6 in./second, the drag forces are lower. We expect the tension-compression curves to diverge under high loading, and the drive system to be more efficient in a pull than a push mode. However under higher load, one might choose a thicker tape or the stiffer DET 4000 series in a compressive (push) dominated design. These data are preliminary and prototype testing is highly recommended in all cases.

Figure M
Cycle Life vs Spool Diameter - DETP 4205

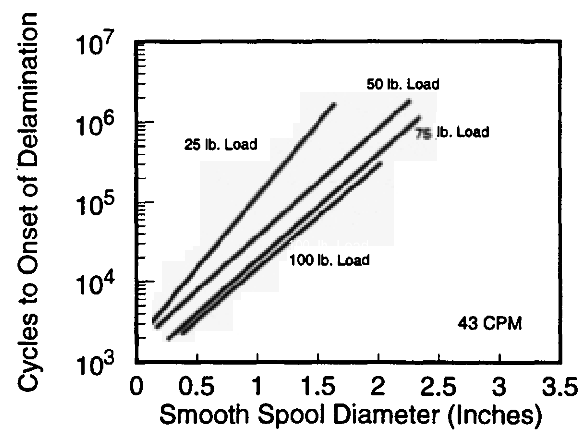


Figure N
Cycle Life vs Thickness - DETP 2005

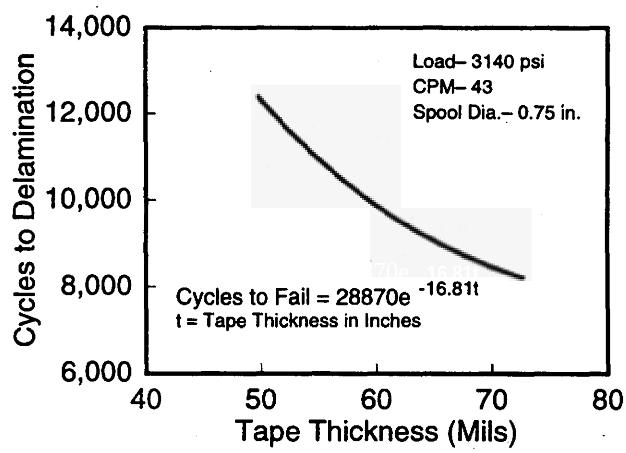
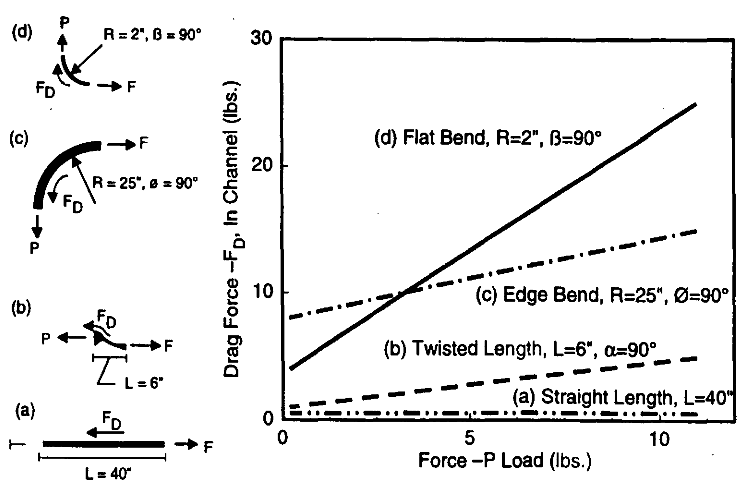


Figure O
Drag Force of Tape in Channels



The information in this publication has been prepared from laboratory tests on DYMETROL Mechanical Drive Tapes. However, because certain applications may involve conditions not present in the laboratory, the Dymetrol Company makes no warranty that any DYMETROL tape will perform satisfactorily in the customer's application, and it is the customer's responsibility to evaluate the suitability of any DYMETROL tape prior to use. Independent evaluation is particularly important where failure of a DYMETROL tape could cause injury or damage. Since no mechanical drive tape will last forever, customers using DYMETROL tapes in such critical applications should follow a regular program of inspection and replacement.

DYMETROL®

A FREE sample to set your ideas in motion

The Dymetrol Company welcomes the opportunity to work with you in developing tape drive concepts that set your designs in motion. For more information and a free sample, call our office nearest you today.

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