Jameco Part Number 357641

Questions & Answers

Some commonly asked questions about Muscle Wires.

What are Muscle Wires?

Muscle Wires are thin, highly processed strands of a nickel–titanium alloy called *nitinol* – a type of Shape Memory Alloy that can assume radically different forms or "phases" at distinct temperatures. Muscle Wires come in *eleven* sizes and two transition temperatures: LT at 70°C (160°F) and HT at 90°C (200°F).

Wire Diameter (µm)	025	037	050	075	100	125	150	200	250	300	375
Resistance (Ω/m)	1770	860	510	200	150	70	50	31	20	13	8
Recovery Force (grams)	7	20	35	80	150	230	330	590	930	1250	2000
LT Cycle Rate (cyc/min)	52	52	46	40	33	23	20	13	9	7	4
HT Cycle Rate (cyc/min)	n.a.	68	67	50	50	32	30	19	13	9	5

How do Muscle Wires work?

At room temperature Muscle Wires are easily stretched by a small force. However, when conducting an electric current, the wire heats and changes to a much harder form that returns to the "unstretched" shape – the wire shortens in length with a usable amount of force.

How much do Muscle Wires shorten?

Muscle Wires can be stretched by up to eight percent of their length and will recover fully, but only for a few cycles. But when used in the 3 to 5 percent range they can run for millions of cycles with very reliable performance. And, with active position feedback they can be held at any position along the contraction range.

How strong are Muscle Wires?

Large wires are stronger than small ones, and strength varies with diameter. Our largest wire has 100 times the strength of the smallest size - from 20 grams up to two kilograms - so you can easily match wire strength to your specific needs.

In the table inside, *Recovery Force* shows the force exerted by a wire when heated. The *Deformation Force* indicates the amount needed to stretch a wire when cool – about one sixth the force exerted when the wire is heated.

What if I need more strength?

For more strength, use two or more wires in parallel. This gives you as much strength as needed, and still keeps the fast cycle times of smaller wires.

How fast can Muscle Wires activate?

Muscle Wires contract as fast as they are heated – in one thousandth of a second or less. To relax, the wire must be cooled, which depends on the conditions surrounding the wire, and its size. Our new Flexinol HT series of wires has a higher transition temperature and cools up to 50% faster than the LT wires. The table inside gives typical cycle rates for both LT and HT wires in still air. Moving air or immersing the wires in a fluid can increase these by ten times or more.

How much power do Muscle Wires use?

The power needed to activate a wire depends on its diameter, length, and the surrounding conditions. The table inside gives typical current levels for "room temperature" conditions. Power can be increased, but once the wire has fully shortened, power should be reduced to prevent overheating.

How long do Muscle Wires last?

When used in the three to five percent range under proper conditions Muscle Wires can run for millions of cycles. Often, other parts of a device fail or need adjusting long before the Muscle Wires do.

What are the advantages of Muscle Wires?

Compared to motors or solenoids, Muscle Wires have many advantages: small size, light weight, low power, a very high strength-to-weight ratio, precise control, AC or DC activation, low magnetism, long life, and direct linear action.

These features let you create whole categories of amazing new devices that would be difficult or impossible with anything other than Muscle Wires!

What are the keys to using Muscle Wires?

For longest lifetimes and best performance from your Muscle Wire devices, follow these key points:

- Have good electrical & mechanical connections
- Protect the wire from overheating
- Protect the wire from overstraining

Each of these can be accomplished in many different ways. These topics and more are covered in our *Muscle Wires Project Book*. See details inside.

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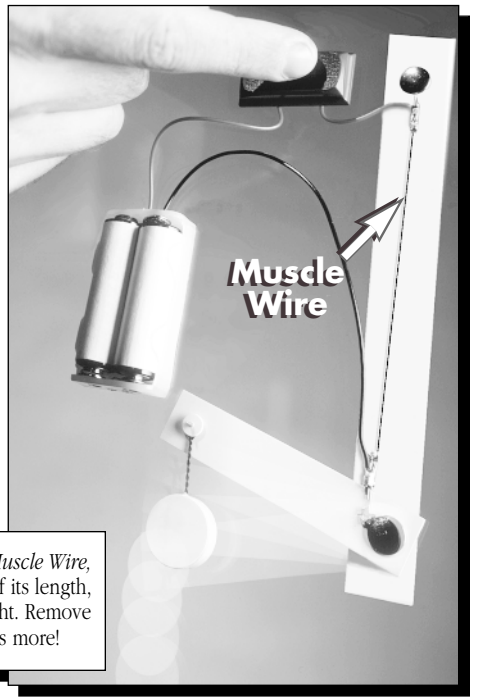
MUSCLE WIRES®

Metal alloy wires that actually shorten in length when powered!

Now you can create fast, silent, *motorless* motion with *Muscle Wires*. They contract in length when electrically heated.

Use them in robots, models, railroads, electronics, science projects and anywhere you need light weight, strong, all-electric *motion*.

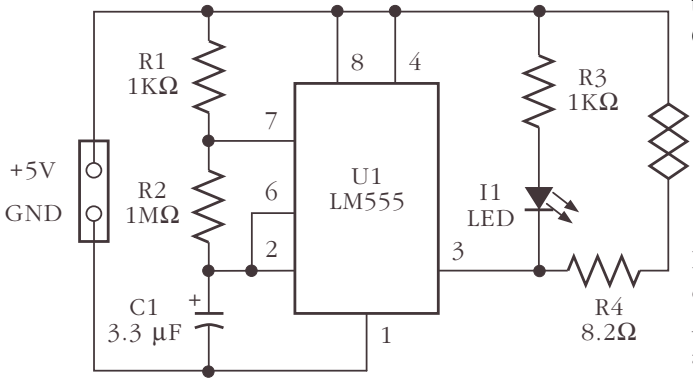
Think of the possibilities for moving your next project!



In this example one thin 100 µm (0.1 mm) diameter *Muscle Wire,* powered by 3 volts at 200 milliamps, contracts by 4% of its length, and pulls with over 135 grams to lift the lever and weight. Remove power and the wire relaxes, ready for millions of cycles more!

MONDO•TRONICS

A Simple Oscillator Circuit



R1, R2 and C1 set the oscillation rate (~6 cycles/minute).

Resistor R4 limits the current through *Muscle Wire* AA1 and thereby controls the heating rate.

Crimps

The heat from soldering or welding can damage a *Muscle Wires'* unique crystal structure, so use crimps or other connectors to secure them.

STEP 1

Crimp (N-scale railroad joiner)

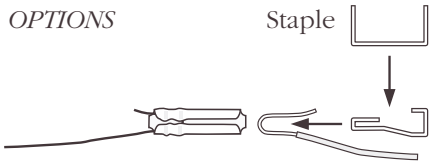
Muscle Wire

Bend wire and insert into connector.

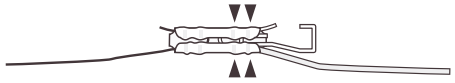
STEP 2 – Crush with pliers or cutters

OPTIONS

Staple

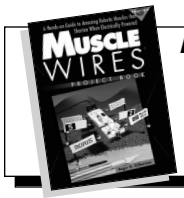


Thin conductive wire



Add a bent staple to make a solid end anchor point.

Add a thin conductive wire for an electrical connection.



Muscle Wires Project Book – *"A comprehensive, practical and clearly written user's manual." – Computer Craft Magazine*

Discover *Muscle Wires* motion! Explore amazing new devices from simple levers to complete *motorless* walking robots. 128 pages, extensively illustrated. Features circuits, devices, history, references, software listings, plus 15 fascinating hand-on projects and essential secrets for maximum performance. Pick it up today *and get moving!*

Flexinol® Muscle Wires® Properties

Adapted from "Muscle Wires Project Book"

Properties	Flexinol Name	025	037	050	075	100	125	150	200	250	300	375
Physical	Wire Diameter (µm)	25	37	50	75	100	125	150	200	250	300	375
	Minimum Ben Radius (mm)	1.3	1.85	2.5	3.75	5.0	6.25	7.5	10.0	12.50	15.0	18.75
	Cross-sectional Area (µm²)	490	1,075	1,960	4,420	7,850	12,270	17,700	31,420	49,100	70,700	110,450
Electrical	Linear Resistance (Ω/m)	1,770	860	510	200	150	70	50	31	20	13	8
	Recommended Current† (mA)	20	30	50	100	180	250	400	610	1,000	1,750	2,750
	Recommended Power† (W/m)	0.71	0.78	1.28	2.0	4.86	4.4	8.00	12.0	20.0	39.8	60.5
Strength*												
	Max. Recovery Weight @ 600 MPa (g)	29	65	117	250	469	736	1,056	1,860	2,933	4,240	6,630
	Rec. Recovery Weight @ 190 MPa (g)	7	20	35	80	150	230	330	590	930	1,250	2,000
	Rec. Deformation Weight @ 35 MPa (g)	2	4	8	815	28	43	62	110	172	245	393
Speed												
	Typical Contraction Speed†† (sec)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	LT Relaxation Speed†† (sec)	0.16	0.25	0.3	0.5	0.8	1.6	2.0	3.5	5.5	8.0	13.0
	LT Alloy Thermal Cycle Rate (cyc/min)	52	48	46	40	33	23	20	13	9	7	4
	HT Relaxation Speed†† (sec)	n.a.	0.09	0.1	0.2	0.4	0.9	1.2	2.2	3.5	6	10
	HT Alloy Thermal Cycle Rate (cyc/min)	n.a.	55	55	50	43	32	27	19	13	9	5

Thermal	*LT Alloy*	*HT Alloy*
Activation Start Temp. (°C)	68	88
Activation Finish Temp. (°C)	78	98
Relaxation Start Temp. (°C)	52	72
Relaxation Finish Temp. (°C)	42	62
Annealing Temp. (°C)	300	300
Melting Temp. (°C)	1,300	1,300
Specific Heat (cal/g°C)	0.077	0.077
Heat Capacity (Joule/g°C)	0.32	0.32
Latent Heat (Joule/g)	24.2	24.2

Material		
Density (g/cc)	6.45	
Maximum Recovery Force (MPa)	600	(~43 ton / in²)
Recommended Deformation Force (MPa)	35	(~2.5 ton / in²)
Breaking Strength (MPa)	1,000	(~71 ton / in²)
Poisson's Ratio	0.33	
Work Output (Joule/g)	1	
Energy Conversion Efficiency (%)	5	
Maximum Deformation Ratio (%)	8	
Recommended Deformation Ratio (%)	3-5	

Phase Related Phase	*Martensite*	*Austenite*
Resistivity (µΩcm)	76	82
Young's Modulus (GPa)	28	75
Magnetic Susceptibility (µemu/g)	2.5	3.8
Thermal Conductivity (W/cm°C)	0.08	0.18

† In still air, at 20°C *†† Depends greatly on local heating and cooling conditions.*
** To obtain force in Newtons multiply by 0.0098*
Martensite Phase = cooled & relaxed, Austenite Phase = heated & contracted