❏ **#3-401 Nitinol Wire 500 µm, 55-75 °C, 1 meter**
❏ **#3-088 Nitinol Wire 750 µm, 55-75 °C, 1 meter**
❏ **#3-402 Nitinol Wire 1000 µm, 55-75 °C, 1 meter**
❏ **#3-094 Nitinol Wire 1250 µm, 55-75 °C, 1 meter**

Mondo-tronics Nitinol Shape Memory Alloy Wire

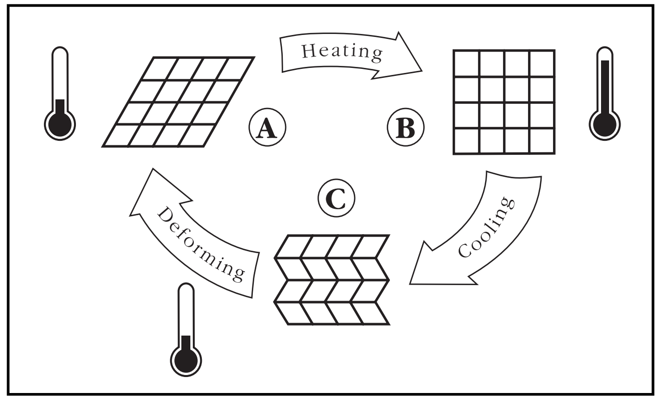
Introduction

The name “Nitinol” denotes any nickel-titanium shape memory alloy. First developed in the 1960’s, the name comes from Ni for *nickel*, Ti for *titanium* and NOL for *Naval Ordnance Laboratory*, its place of discovery.

Nitinol currently finds use in cell phone antennas, flexible eyeglasses, orthodontic braces, aerospace release mechanisms, medical devices like stents and endoscopic guide wires, greenhouse window openers, hot water scald-prevention valves, magicians tricks and many more.

We provide nitinol wires in their “as drawn” condition for experimenters who wish to form and train their own shapes. They must be “cooked” (formed and annealed) in order to exhibit their shape memory properties, and the many parameters of time, temperature and processing can give wide-ranging results.

This nitinol alloy is carefully formulated and precisely drawn to size. Wire dimensions are given in micrometers, µm (millionths of a meter). Note that 100 µm = 0.004 inches, so for example, the wire diameter of 500 µm = 0.020 inches.



The crystal structure of a Shape Memory Alloy (SMA) such as nitinol deforms easily when below Af, its transition temperature (A). Heating to above Af causes a phase change and the alloy returns to the original shape (B) with a large force — several times greater than the force needed to deform it. When again cooled below Af, the phase change reverses (C) and it can again be easily deformed. From the “Muscle Wires Project Book” (Mondo-tronics)

Visit the ***Mondotronics.com*** *web site for Material Information Sheets for each wire, as well as for preformed Nitinol springs, specially formulated and processed Flexinol® and BioMetal® brand wires designed for electrical activation, Muscle Wires® shape memory alloy books, demonstration kits, and much more.*

How to Work with Nitinol: Interesting and Useful Projects You Can Do with Shape Memory Alloy

By Dr. A. D. Johnson, TiNi Alloy Company - Reprinted by permission.

The physical characteristics of a sample of Nitinol depend markedly on the history of the sample. A freshly-annealed “naive” wire helix is very soft and pliable. The same helix becomes quite stiff and brittle after it has been cycled a few hundred times in hot and cold water. The effect is enhanced if the thermal cycling is accompanied by stress-strain cycling in which the helix is elongated while in cold water and allowed to contract against a constant force while it is in the hot water. This is the set of conditions obtained in the continuous-band or thermo-turbine type of heat engine.

In the first such engines built, it was observed that the helix gradually elongated, so that it was necessary to change the relative positions of the pulleys, or to shorten the helix, in order to maintain tension in the engine, as needed for a running configuration. It was also observed that power output from the engine actually increased in some instances as this gradual change in helix characteristics took place. This was because the force needed to elongate the helix in the cold bath was decreased with cycling, and in some conditions became zero. That is, the “trained” helix became adapted to the stress-strain-temperature cycle in such a way that it had a two-way shape memory: it contracted when heated and elongated when cooled.

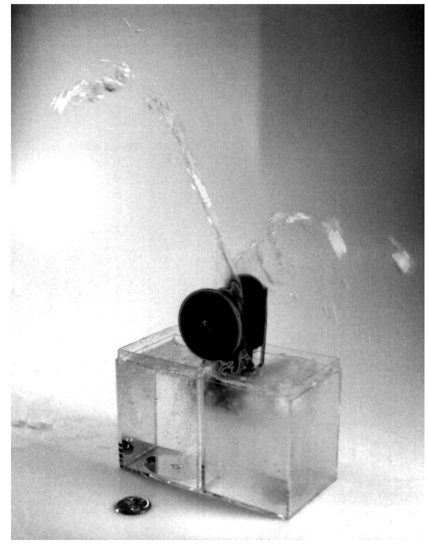
This was the origin of the term “training,” as applied to Nitinol, by a crude analogy with animal behavior in that behavior is modified as a result of experience so that a desired result is obtained even in the absence of the original stimulus.

If the helix were to continue to increase in length, reproducible results would be impossible, and such “training” would be a useless feature. It is now understood that Nitinol stabilizes, under certain conditions, so that a stress-strain-temperature cycle may be repeated indefinitely.

Nitinol, like other materials, has limitations. If a helix of wire is stretched too much, it will be permanently damages. If it is subjected to too great a force during thermal shape-memory recovery, it will lose its shape-memory. Specifically, if Nitinol is subjected to a cycle in which it is cooled, elongated by stretching, and heated without being allowed to contract (e.g., held at a constant length) the ability to do work will diminish in just a few cycles. If, on the other hand, the sample (e.g., a Nitinol wire in tension) is allowed to contract against a constant force during heating, the ability of the wire to do work may be enhanced with cycling, and the wire will quickly stabilize so that succeeding cycles are repeated.

Now consider a specific example. Suppose it is desired to “train” a 0.018 inch diameter wire so that it does a predictable contraction on each cycle. Put the wire in tension (for example, by means of a spring) so that when it is heated in hot water, it is subjected to a tensile force of not more than 10 pounds. After heating, reduce this force to zero, cool the wire in ice water, and gradually apply the tension to elongate the wire (up to a maximum tension of 10 pounds) and then heat it again.

Repeat this cycle: cool the wire (in ice water) and apply force to elongate it, heat (up to boiling water temperature) and allow the wire to contract at constant tension, then remove the tension. These steps should be repeated 20 times or more, taking up slack or whatever is necessary in the apparatus so that the hot force is always approximately the same.



TiNi Alloy Company’s TiNi-1 Engine (c 1980) uses a single coil of nitinol wire and can develop speeds of 1000 RPM on just hot and cold water.

Excerpted from the “Muscle Wires Project Book” (Mondo-tronics)

At the end of this “training” period, the wire will have been permanently stretched about 10 percent. It will elongate about 2 or 3 percent when cooled, and will contract the same amount when heated and allowed to pull against a force of up to 10 pounds. This cycle will be repeated so long as the wire is not subjected to forces or temperatures which are beyond the limits used during the training. That is, if ice water and boiling water are used with a 10-pound maximum force during training, the wire may be expected to behave reproducibly if the cold temperature is 10 degrees C and the tension is 7 pounds.

If the training limits are exceeded, training will resume to a new set of conditions (unless these conditions are so extreme as to cause failure of the training mechanism).

Training a helical spring made of Nitinol follows the same principle, except that the elongation is greater (as much as twice the original length) and the forces required are much smaller (of the order of one pound force for a helix made of 0.018 inch Nitinol wire wound into a 0.100 inch diameter helix).

Some relevant U.S. patents issued: Buehler #3,403,238, Banks #3,913,326, Cory #4,027,479, Hochstein #4,037,411, Johnson #4,055,955 & #4,281,513, Smith #4,086,769 & #4,117,680, Wayman #4,246,754.

Contacting Us:

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