A NEW NAME! As a result of the merger of the Naval Ordnance Laboratory, White Oak, Maryland and the Naval Weapons Laboratory, Dahlgren, Virginia, we have a new name:

NAVAL SURFACE WEAPONS CENTER

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55 NITINOL ALLOYS

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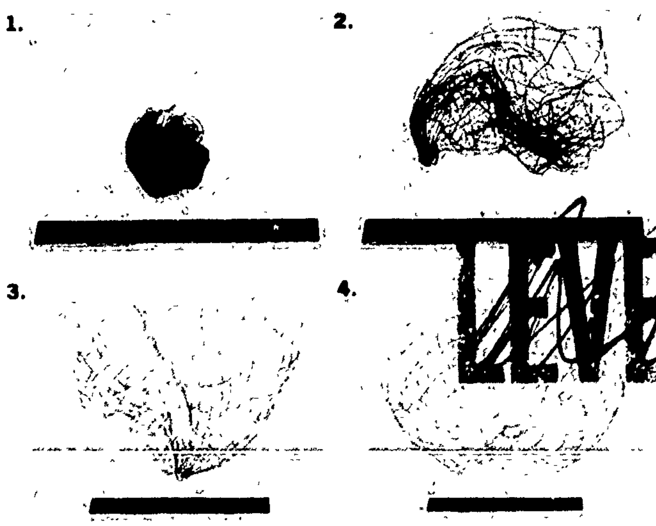

Photographs showing the unique mechanical memory upon the application of heat (courtesy of Goodyear Aerospace Corporation)

*Name derived from Ni-Ti-NOL. Prefix numerical value (e.g., 55-Nitinol) indicates the nickel content in weight percent. The balance is titanium.

BASED ON THE TITANIUM-NICKEL COMPOUND TiNi

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55 NITINOL

- Unique Mechanical Memory
- Mechanical Vibration Damping
- Non-Magnetic
- Corrosion Resistance
- Lower Density

PHYSICAL PROPERTIES

Density	6.45 g/cm³	0.234#/in³
Melting Point	1310°C	2390°F
Magnetic Permeability	< 1.002	
Mean Coef. of Thermal Expansion (24° – 900°C), (x 10^{-6})	10.4/°C	5.8/°F
Electrical Resistivity	Ref. 16	
Specific Heat	Ref. 17	

TENSILE PROPERTIES

	ULTIMATE TENSILE STRENGTH (psi)	YIELD STRENGTH AT 0.2% OFFSET (psi)	TOTAL ELONGATION (%)	REDUCTION IN AREA (%)	YOUNG's MODULUS (psi x 10^6)	SHEAR MODULUS (psi x 10^6)	POISSON'S RATIO
Annealed*	125,000	24,000	60	20	10.2	3.6	0.33
Cold Deformed	up to 222,000	up to 61,000	15 (min)	—	10.2	4.0	0.28

*Data obtained on hot wrought alloys employing 2-inch gage lengths

MECHANICAL MEMORY PROPERTY

55-Nitinol plastically deformed below its critical temperature (A_s) will recover its original shape when heated above its critical temperature. THIS PHENOMENA IS ILLUSTRATED ON THE COVER OF THIS BROCHURE. The critical transition temperature for recovery varies from −10°C to 100°C as a function of Ni:Ti ratio around the stoichiometric TiNi composition. Transition temperatures in the cryogenic range are also possible by partial substitution of cobalt for nickel. The range of recovery is controlled by mass and processing variables and may be held readily within a 10°C spread.

DAMPING PROPERTY

The specific damping capacity of 55-Nitinol is about 25 percent when measured at a stress level of 5000 lbs/in^2. This is about three times the damping capacity of gray cast iron (8%). Specific damping capacity is the percentage of vibration energy absorbed per cycle. A more complete description of Nitinol and other high damping materials is given in Reference 11.

FABRICATION

WORKING CHARACTERISTICS:

May be hot worked directly from the arc-melted ingot employing conventional tools, e.g., rolling, forging, swaging, etc. Recommended hot working temperature range 700° to 900° C. Room temperature working is possible with intermediate anneals at or below 800° C.

MACHINING

The Nitinol alloys are most satisfactorily machined with carbide tools using moderate speeds, light feeds and highly chlorinated cutting oil. Grinding, employing silicon carbide wheels, has been found to be highly satisfactory. By careful control of the grinding conditions very fine finishes are possible. A more complete guide to the machining of the Nitinol alloys is given in Reference 3 at the end of this Data Sheet.

MARINE CORROSION PROPERTIES

STRESS-CORROSION:

Employing the U. S. Naval Research Laboratory testing method, 55-Nitinol showed no susceptibility to stress-corrosion failure. 55-Nitinol, in both the annealed and the cold worked condition tested at stresses up to 100% of the yield strength exhibited no crack propagation in a sea water environment.

HIGH-VELOCITY MARINE CONDITIONS:

The 55-Nitinol alloy exhibited superior resistance to erosion by high velocity sea water. Sixty day jet impingement at 15 ft/sec. sea water and 30 day cavitation tests at 117 ft/sec. resulted in negligible erosion of this alloy.

POTENTIAL APPLICATIONS

APPLICATION	PROPERTY: NON-MAGNETIC	LOWER DENSITY	CORROSION RESISTANCE	VIBRATION DAMPING	LOW TEMPERATURE TOUGHNESS	MECHANICAL MEMORY
Noise and Vibration Reducing Components		X	X	X		
Temperature Sensing Devices	X		X			X
Outer Space and Hydrospace Erectable Structures	X	X	X			X
Cryogenic Equipment		X	X		X	

HARDNESS

CONDITION	ROCKWELL
Wrought (as received)	24 R_C
After Rolling at 950° C	87 R_B
1000° C, Furnace Cool	90 R_B
1000° C, Water Quench	89 R_B

IMPACT PROPERTIES

COMPOSITION	TESTING TEMPERATURE (°C)	IMPACT STRENGTH (ft-lb): UNNOTCHED	IMPACT STRENGTH (ft-lb): NOTCHED
55-Nitinol	Room -80	117 70	24 17
55.1 Nitinol (0.08 Fe)	Room -80	155 160	— —

Hot wrought material was used to produce standard Charpy impact specimens. Applications for Nitinol should follow normal design practice for notch sensitive materials.

FATIGUE PROPERTIES

STRESS (psi)	CYCLES	REMARKS
70,000	10 x 10⁶	No failure

Standard Rotating Beam (R. R. Moore) Test.

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16. "The 60°C Irreversible Critical Range in the TiNi Transition," to be published.

17. "Anomalous Heat Capacity of TiNi," to be published.

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