

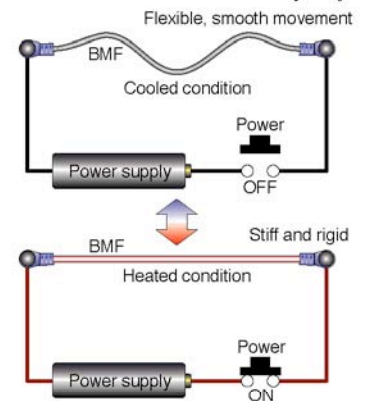
# Artificial Metal-Based Muscle

## BioMetal Fiber

### BMF series

The BioMetal Fiber is a fiber-like actuator (drive unit) designed to contract (tense) and extend (relax) like muscles. The key feature of this product is its flexible, smooth movements like those of real life. Although soft and pliable like a nylon thread under normal conditions, it becomes stiff like a piano wire and sharply contracts, when a current is fed through it. If the passage of a current is stopped, it will soften and extend to its original length. The BMF can also be moved by changing its temperature. It begins to contract when heated to about 70°C. If it is cooled to below the temperature, it will return to its original length. Because of its stable internal structure, the BMF has very high durability and exhibits stable operating characteristics. Being thin but capable of producing a powerful force, this product is ideally suited for milli and micro actuators.

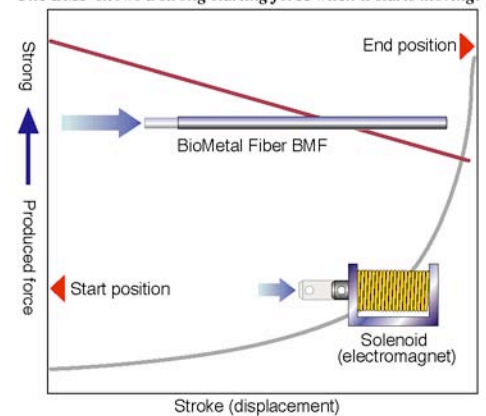
*The BMF can contract and extend by itself*



### Features of the BMF Series

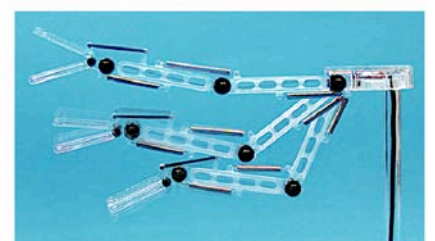
- ★ Current-driven type fiber-like solid-state actuator
- ★ Ultra lightweight, spacing saving design (one-several thousandths lighter and smaller than solenoids)
- ★ Maximum displacement (contraction or elongation) of over 4% of its total length and kinetic distortion
- ★ Strong shrinkage force and starting force
- ★ Capable of high-resolution micro movements
- ★ Vibration and noise-free, highly-dumped, flexible operation
- ★ High size and operating stability, and long service life
- ★ Can be driven at low voltage.
- ★ Involves no rush current, counter-electromotive force, or electromagnetic noise.
- ★ Usable as a temperature-activated device.
- ★ Chemically and structurally stable, allowing boiling.
- ★ Low cost

*The BMF shows a strong starting force when it starts moving.*



### Applications of the BMF Series

- Uses as a solenoid-like actuator  
Relays, electrically-driven valves, electric locks, shutters, dynamo-electric brakes, clutches, etc.
  - Uses as an analog actuator  
Servo actuators, servo valves, micro robots, etc.
  - Uses as a bimetal-like device  
Circuit breakers, intermittent switches, temperature-operated actuators, etc.
  - Uses as an electronic part  
Electric switches, electric volume controls, etc.
  - Uses as a general-purpose small-size actuator  
Ultra-thin actuators, small-size actuators for toys, silent alarms, etc.
  - Special applications  
Simplified electric discharge machines, simplified welding machines, etc.
- \* Since the BMF is an area force actuator, it exhibits best performance as a micro actuator.



Micro arm robot



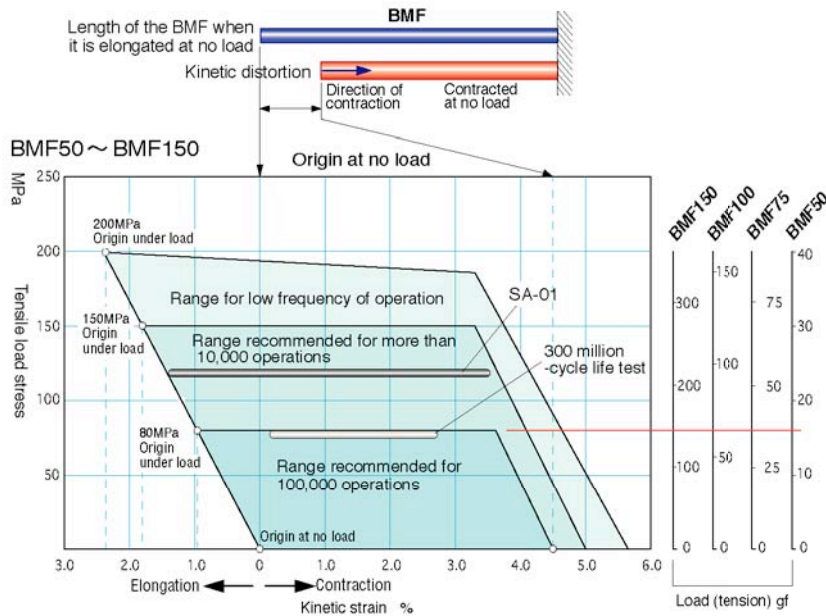
Micro servo valve

\*BioMetal (a trademark of TOKI CORPORATION) is a fiber-like actuator which is anisotropically structured by our own fabrication method from a Ti-Ni shape-memory alloy so as to deliver its superb performance characteristics in a specific direction. Since it is made of a metal and looks like a living thing because of its smooth movement, it is designated as BioMetal.  
\*The BMF differs from general shape-memory alloys in terms of basic characteristics in that it exhibits stable movement and high elasticity because it is rigidly structured in the fiber direction. It is not intended as a material for shape-memory alloys, and it is therefore used in a different manner. It is impossible to make BioMetal remember shapes, with its performance characteristics maintained, as in the case of general shape-memory alloys. If it is subject to ordinary memorization processing (machining, heat treatment), its original performance characteristics will be impaired.

# BioMetal Fiber BMF series

## Characteristics and Specifications of the BMF Series

### Recommended load and practical kinetic strain for the BMF



**KINETIC DISTORTION :**  
Ratio of the length of the contracted BMF to that of the elongated BMF

**LOAD :**  
Load in gf that can be applied to the BMF

**LOAD STRESS :**  
Load per unit cross-sectional area

**ORIGIN UNDER LOAD :**  
The origin used when the BMF is elongated under load

- The BMF is not made of a homogeneous substance of the same quality. It has a highly structured construction. The thinner the BMF, the greater tend to be its durability, elasticity, and other performance characteristics. For use as an actuator to be repeatedly operated, it is recommended to select a BMF thinner than the BMF150 except when a powerful force needs to be produced by a single fiber.
- The maximum kinetic strain of the BMF may reach 6%. When the BMF is to be operated repeatedly, it should be used within an appropriate range, referring to the diagrams shown above. For instance, the SA-01 Silence Arm, a micro robot of our company, which is designed to allow no more than 100,000 repetitive operations, utilizes 5.0% of kinetic distortion from the BMF100 under the stress of 80 MPa. Refer to the black bar in the above diagram.
- The service life of the BMF is closely associated with the magnitude of the load and the kinetic distortion. It has a track record of having made more than 300 million reciprocating motions under

- appropriate load and movement conditions. (Example: BMF100. 330,000 motions completed at the load of 80 gf and at the kinetic distortion of 2.5%. The test is still under way. The testing condition is indicated by the gray bar in the above diagram.)
- The BMF makes non-linear, asymmetric motions (contractions and expansions). It can be quickly contracted if it is heated in an adiabatic manner by feeding a large current through it. However, it cannot be quickly elongated without forced cooling because the rate of elongation depends on cooling speed. In the case of self-cooling the BMF is affected by the ambient temperature and the wind. The data shown in the table below are those obtained at the room temperature of 20°C under the windless condition.
- The upper limit of operating temperature is between 65°C and 70°C. It varies with the load condition. This limit can be increased to some extent by increasing the bias. In that case, however, the service life of the BMF may be shortened. There is no lower limit of operating temperature. The current required for driving by heat increases with decreasing ambient temperature.

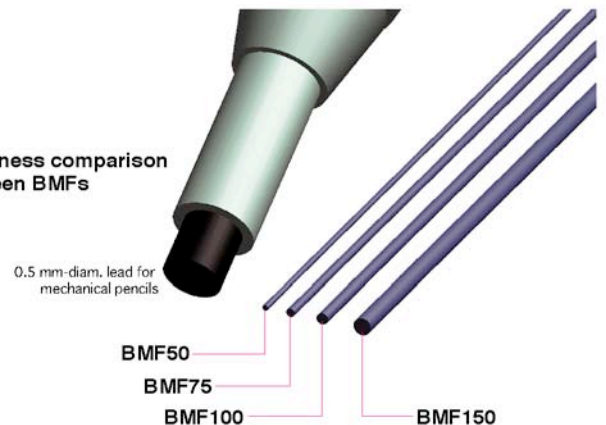
	BMF50	BMF75	BMF100	BMF150
Standard diameter (mm)	0.05	0.075	0.1	0.15
Practical force produced (load) (gf)	18	35	70	150
Practical kinetic strain (%)	4.0	4.0	4.0	4.0
Service life (times)	10 <sup>6</sup> <	—	10 <sup>6</sup> <	10 <sup>6</sup> <
Standard drive current (mA)	80	140	200	340
Standard drive voltage (V/m)	42.2	35.4	27	20.7
Standard power (W/m)	3.37	4.63	5.40	7.05
Standard resistance (Ω/m)	528	236	135	61
Tensile strength (Kgf)	0.2	0.45	0.8	1.8
Weight (mg/m)	12.5	28	50	112

- \*The number following BMF in the product name is the value of its diameter expressed in micrometers. For example, the BMF100 has a diameter of 0.1mm.
- \*The BMF is uniform in the longitudinal direction. For this reason, most of the numerical data in the table are determined with reference to the unit length (1 m) of the BMF.
- \*The kinetic distortion is represented by the ratio in percentage of the displacement (contraction or expansion) of the BMF to its total length.
- \*The numerical data in the table are standard values used as a guide for device design. The actual performance characteristics may differ from them, depending on the operating conditions.
- \*The numerical data in the table are not guaranteed values but reference values. The actual numerical data may be varied by improvement of the BMF. There are also slight variations between lots.

### Line-up of BioMetal Fiber BMF Series Sample Set

Product No.	Standard Diameter	CONTENTS
BMF50	φ0.05mm	BioMetal Fiber each 1.0 m Instruction manual
BMF75	φ0.075mm	Biasing spring 4 pcs.
BMF100	φ0.1 mm	Heat-resistant resin pulley 12 pcs. Small-size spectacle terminal 40 pcs.
BMF150	φ0.15mm	Ultra small-size eyelet terminal 40 pcs.

### Thickness comparison between BMFs



## TOKI CORPORATION

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- For technical inquiries, please use our inquiry form on our web-site. We may not be able to answer questions over the telephone.
- More detailed information on the BMF Series will be available on our company's home page.
- Specifications are subject to change without prior notice.