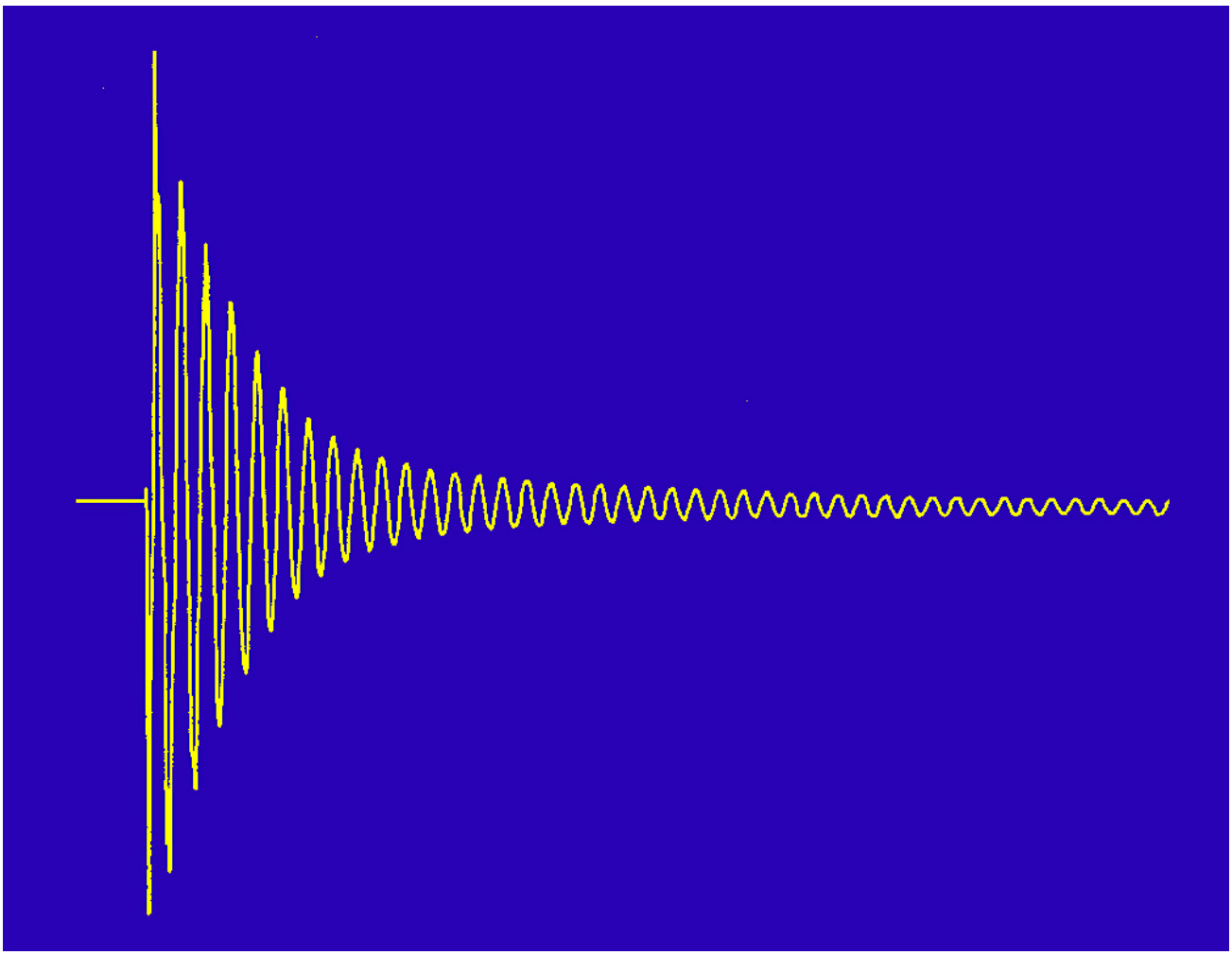
Damping/Heat-resistant/Magnetize

ALFE(Fe-8Al Alloy)



Ver.0409

Developed by Urban Materials co.

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Ⅰ What is ALFE?

1. Damping mechanism of ALFE

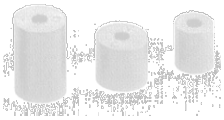
Applying processing (stress) and thermal treatment (annealing) to iron-aluminum alloy of a certain composition rate forms "short-range order" (SRO) on a electron level. The "short-range order" (SRO) absorbs vibrational energy and constitutes the basis of its damping mechanism.

2. Positioning of Intellial

ALFE（Fe-Al alloy） is the only material with high damping quality and the strength that can be used as a structural material. In addition to that, ALFE can be mass-produced at a reasonable cost.

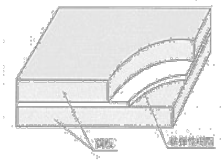
Conventional damping material

Rubber, wood, plastics



- Low strength
- Weak heat resistance
- Weak damping control

Sandwich steel plate (Composite plate)



- Low strength
- Weak heat resistance

Other alloy materials

- Thicker and heavier
- Rust easily
- Expensive,

cannot be mass-produced

Advantage of ALFE

Vibration absorption capability

Promising anelastic material with high yield point

Potential electromagnetic material

Superb damping capacity: 7- 15 times as carbon steel for structure

Heat-resistance: Damping capability won't change up to 300℃

Strength: Same as the other steel materials

Workability：Same as the other steel materials (in sheets and rods)

Welding: Suitable for laser-welding

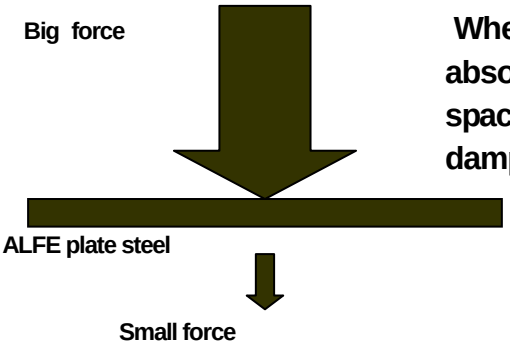
Relative density: Lighter than iron（7.0）

Hardness: High (can be improved to high tensile strength steel)

Durability: Excellent corrosion resistance and heat-resistant capabilities

3. Main features of ALFE

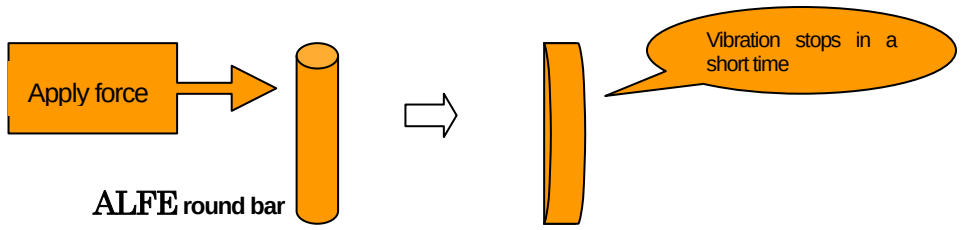
○"ALFE absorbs force."



When a force is applied to the ALFE plate steel, the force is absorbed by the plate steel itself. This feature is best suited for spacers and mounts for precision devices and machines requiring damping capacity.

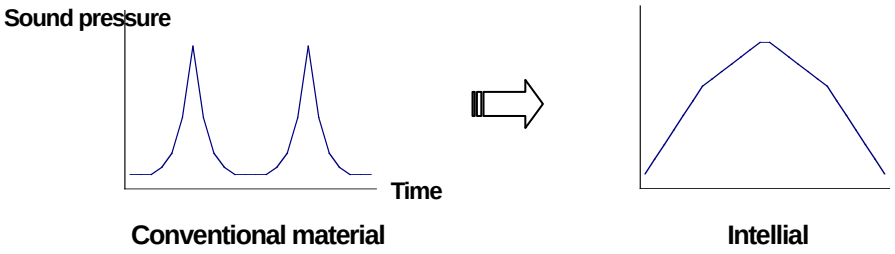
○”ALFE　stops vibration in a short time.”

When apply force to the ALFE round bar, the vibration stops in a short time.
ALFE is ideal for boring bar and tool steel.



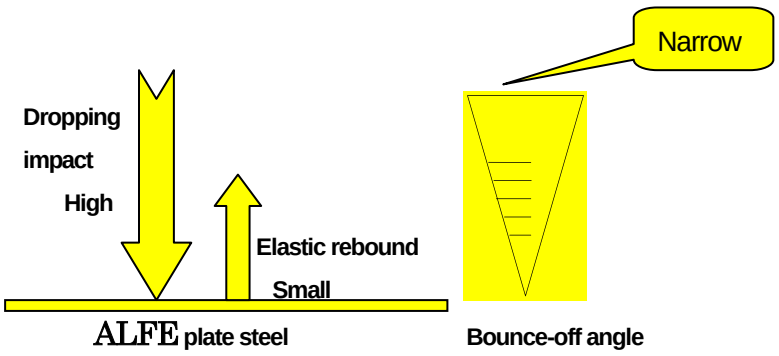
○”ALFE softens sound quality.”

ALFE softens sound quality.　Therefore, it is applicable to materials for audio speakers, musical instruments, and mufflers for motorcycles.



○”ALFE minimize rebound and bounce-off angle.”

When a ball is dropped on ALFE steel, the elastic rebound is small and the bounce-off angle is narrow.　This feature is perfect for the materials of golf ball.



Ⅱ Damping capacity of ALFE

1. Damping capacity

Sound pressure becomes weaker as the time lapses. Compared with other materials, ALFE (Fe-Al alloy) decreases sound pressure in shorter time.

A. Sound pressure and Time

An iron ball was dropped on each material to understand. the relationship between sound pressure and time. The test result shows ALFE's high damping capacity.

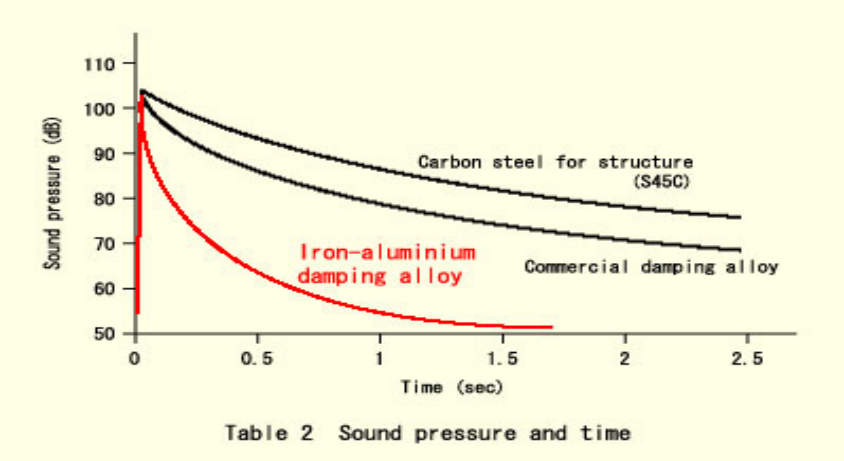
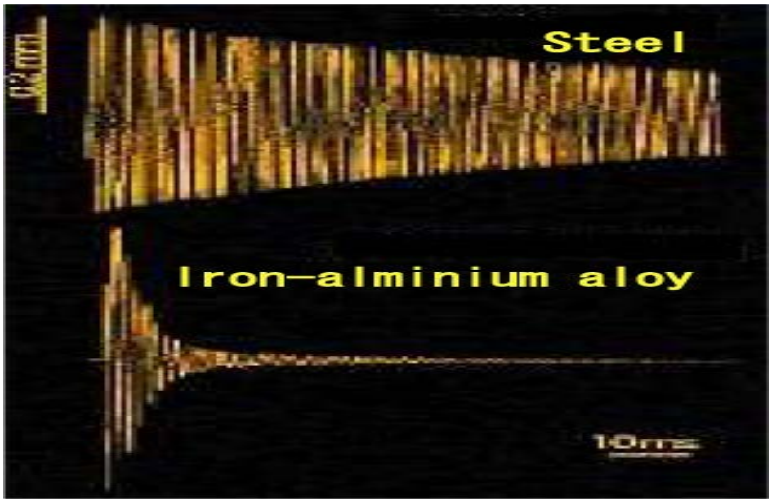


Table 2 Sound pressure and time

B. Sound resonance

The horizontal axis represents vibration, and the vertical axis represents time. ALFE has an outstanding damping capacity in comparison with the standard steel.

(Table3: Comparative vibration test)



2． Damping characteristics

ALFE's damping capacity is in particular effective at low frequency band and low strain.

A. Frequency and damping capacity

ALFE's damping capacity is high at low frequency band.

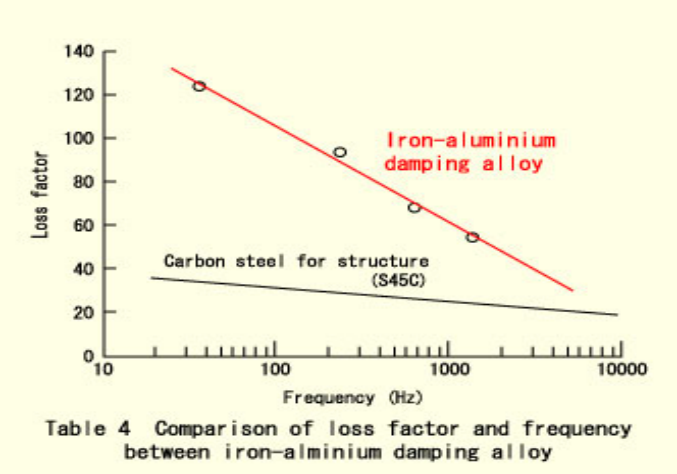


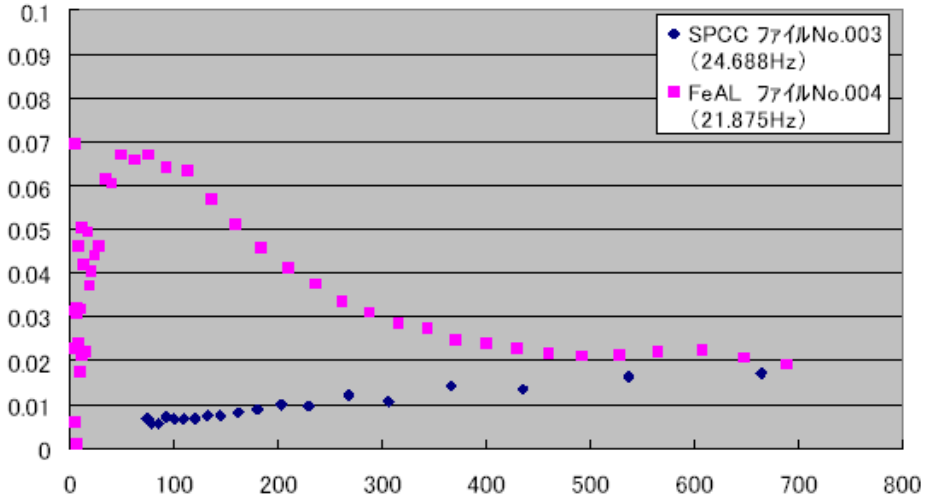
Table 4 Comparison of loss factor and frequency between iron-alminium damping alloy

B. Strain and damping capacity

ALFE's damping capacity is high at low strain. It is effective unless deformation occurs

(Table 6: Strain and damping capacity)

ALFE's damping capacity is high at low strain. It is effective unless deformation occurs.



Relation between loss coefficient and strain (The vertical axis and the horizontal axis represent loss coefficient and strain, effectively. 10-6)

3． Temperature characteristics

ALFE maintains its high damping capacity even at a high temperature range. The damping quality is retained unless the temperature exceeds300℃.

A. Temperature and damping capacity

ALFE's damping quality is maintained unless the temperature exceeds 300℃.
The test data shows its damping capacity up to 300℃.

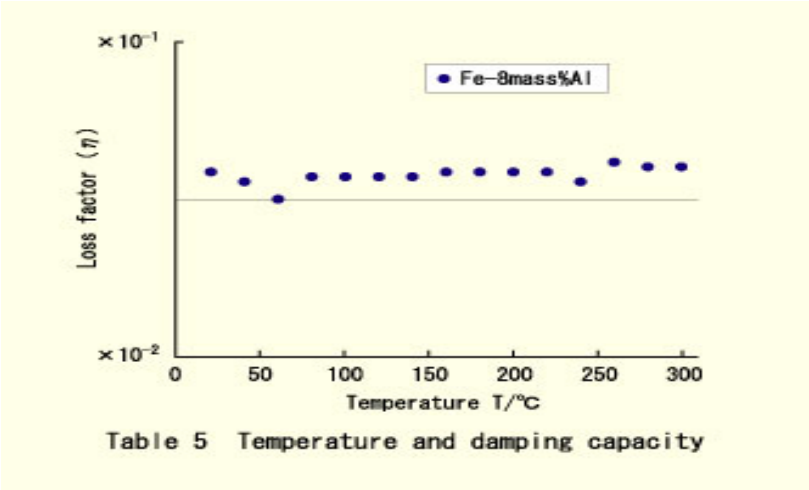


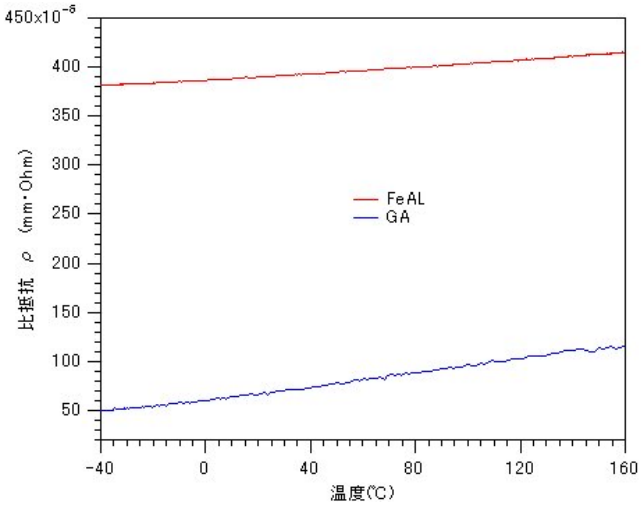
Table 5 Temperature and damping capacity

Ⅲ Electromagnetic and heat-retention capacity of ALFE

1. Electric resistance

ALFE's electric resistance is 7 times as that of normal steel, and approximately 4 times as that of molten galvanized steel plate (please refer to the figure below).
The percentage of change in the electric resistance due to temperature change is notably small.
(Table 7 : Temperature and electric resistance)

Specific resistance



Temperature

2. Coefficient of thermal diffusivity

ALFE keeps heat. **Coefficient of thermal diffusivity is <u>0.05067cm²/s.</u>**
(Measured by laser flash method [Measured temperature: 22.4℃, thickness of sample:0.9663mm])
(Reference value Ti:0.06505cm²/s, SK:0.1161cm²/s, SUS304:0.03808cm²/s)

3. ALFE's Magnetic characteristics

Features:

○Moderately high magnetic permeability & saturated magnetic flux density

○Very small coersivity

○Exceptionally high electrical resistance & magnetic restriction ○Lower iron loss

(Comparison with other materials)

	Maximum magnetic permeability μm	Coercivity A/m	Saturated magnetic flux density T	Resistance μΩ cm	Magnetic restriction $\Lambda(10^{-6})$
ALFE Fe-8% AL	5,500	23	1.3	80	50-
Steel (S10C)	1,380	Several hundreds	2.2	16	5
Directional electromagnetic steel Fe-3%Si	-70,000	10	2.0	50	-
Electromagnetic stainles Fe-18Cr	4,000	80	1.2	60	-
Permalloy Fe-79Ni-4%Mo	200,000	4	0.8	55	-

4. Application of electromagnetic and heat-retention capacity

The result of the heating test with IH cooker showed satisfactory energy saving effect which is higher than normal steel by approximately 25% as well as excellent heat-retention capacity.

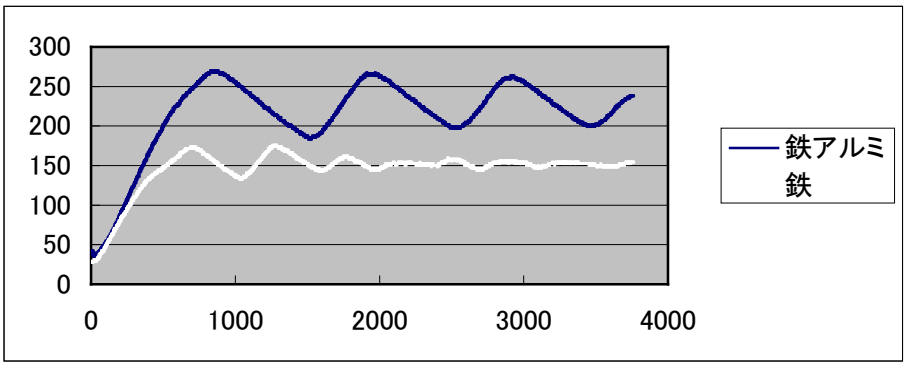
○Heating test with IH cooker

- Comparative heating test I: Set a IH cooker manufactured by company M at 200℃ and heated the sample. Measured the temperature controlled by the thermostat.

- Comparative heating test II: Set a IH cooker manufactured by company M at 140℃ and heated the sample.The power was automatically cut-off at the temperature peak. Measured the temperature change.

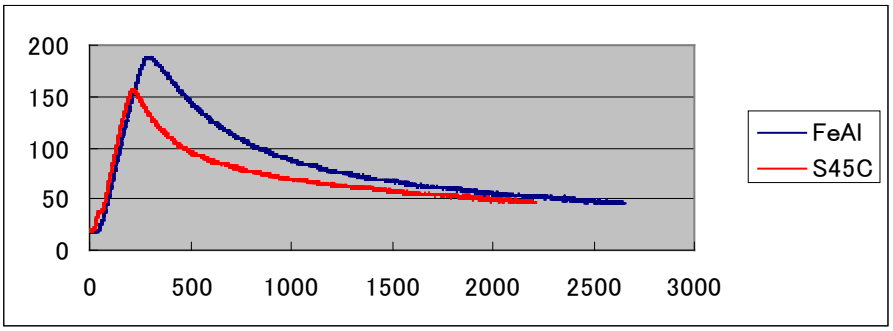
- Sample :Normal steel S45C 4.5㎜x215㎜x250㎜
  ALFE (Fe- AL) 4.5㎜x215㎜x250㎜

(Table 8: Comparative heating test with IH cooker I) ※Above:FeAL, Below:Fe



Vertical axis presents temperature (℃), and horizontal axis present time(sec).

(Table 9: Comparative heating test with IH cooker II)



Vertical axis presents temperature (℃), and horizontal axis present time(sec).
Maximum temperature :Intellial(189℃), normal steel (154℃)
Cooling time (Maximum temperature-50℃):Intellial(1,857sec), normal steel(1,540sec)

Ⅳ Features as a heat-resistant material

1. Heat-resustant capacity

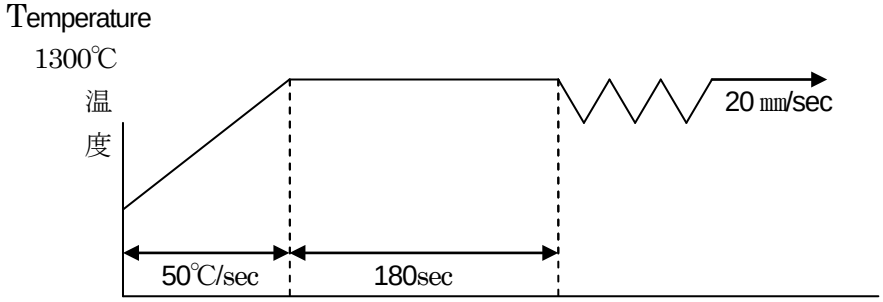
ALFE's upper temperature limit is approximately 300℃ as damping material, however, it can withstand up to approximately 800℃ when it is used as construction material. As an alternative material of heat-resistant stainless steel, ALFE is also ideal because it forms less scale in high temperature with small. Besides, it brings out its quality in low temperature as well.

(Table 10: Specification of heating test)

○Test condition

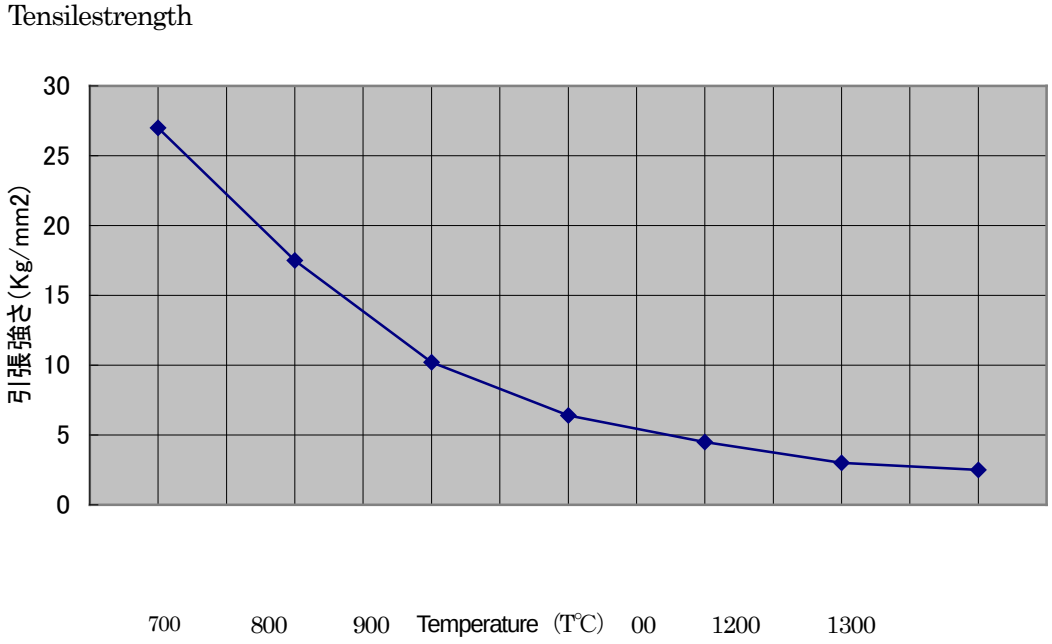
Warm-up speed: 50℃/sec, tensile speed:20 ㎜/sec

○Pattern of temperature rising



○ Test result

(Table 11: Relation between the changes in tensile strength and heating)



Ⅴ Properties of ALFE

1. Chemical composition

ALFE is the iron-aluminum alloy that contains 8mass% of aluminum.

(Table 12: Chemical compositions)

C	Si	Mn	P	S	Cr	Ni	Al
0.01%<	0.20%<	0.20%<	0.03%<	0.005%<	0.2%<	0.2%<	7.5-8.5%

2. Properties

(Table 13: Properties of ALFE)

	Properties	Characteristics
Specific gravity	6.85	(Reference value) Iron: 7.85 Lighter than iron by approx. 13%
Specific heat	0.143cal/g℃	
Thermal diffusivity	0.0603c ㎡/S	(Reference value) Titanium: 0.06505 SUS304: 0.03808 Less thermal conductivity and emanation
Heat conductivity	0.059cal/cm s ℃	
Coefficient of thermal expansion	$\alpha = 11.0 \times 10^{-6}$ (50-300℃)	
Electrical resistance	380×10^{-6}(-40℃) - 420×10^{-6}mm.ohm (160℃)	High electrical resistance and low rate of change due to temperature variation
Magnetivity	Ferro-magnetic	

3. Strength of Intellial

(1) Temperature and strength

ALFE's strength is almost as high as standard steel's strength.

(Table 14: Mechanical strength of ALFE)

		-30℃ (Low temperature)	26℃ (Ordinary temperature)	160℃ (High temperature)
Tensile strength	Strength (MPa)	491-500	525-545	433-488
	Elongation (%)	37.2-46.5	13.4-18.8	42.5-43.0
Vickers hardness		165	168	163
*Impact test	Impact value (J/cm ㎡)	4.9-8.5	17.2-24.8	30.0-37.9

*Charpy impact test result: JIS No.3 specimen (U-notch)

(2) Coefficient of Friction

ALFE has enough frictional strength. Its coefficient of friction is equivalent to that of SUS304.

(Table 15: Comparison of coefficient of friction)

	ALFE	SUS304	S45 Annealed material	graphite cast iron of Ferrite	Flake graphite cast iron
Coefficient of Friction	0.62	0.60	0.50	0.20	0.15

(3) Fatigue strength

ALFE doesn't brake with stress amplitude of 10kg/m ㎡ with 10^7 times (one million times)

Ⅵ Workability of ALFE

1. Workability

ALFE is suitable for general metalworking including tubulizing, bending, and stamping. Higher temperature is ideal for quality stamping.

(Table 16: Workability of ALFE)

Category	Evaluation	Note
Machining	◎	
Bending	○	◎for 0.3mm or less thick iron sheet
Bending at a 90-degree angle	△	
Stamping	○	◎when the temperature is raised.

2. Welding

As ALFE keeps heat, TIG-welding and spot-welding require skilled work. Laser-welding is suitable for ALFE.

3. Thermal resistance

Damping capacity is effective unless the temperature exceeds approx.300℃.

4. Corrosion resistance

SST test (35℃, 5%NaCl spraying, 250℃) and JASO test (SST→drying→damping [3C/day], 60℃) showed favorable results in terms of the ALFE's corrosion resistance capacity.

5. Other properties

(Table 17: Properties of ALFE)

Category	Evaluation	Note
Welding	○	Laser-welding
Castability	○	
Thermal resistance	◎	Damping capacity is effective unless the temperature exceeds approx. 300℃.
Corrosion resistance	○	◎ with oxide film. Without oxide film, it is equivalent to that of SUS430.
Plating	◎	
Coating	◎	

Ⅶ Available shapes and sizes of ALFE

1． Size＆shapes

Sizes or shapes others than the below may be available by consultation.

(Table 18: Specification of Intellial)

Shape	Thickness / Diameter	Size	Note
Rod or Wire	0.3φ - 30φ	Coil or Bar	
SHEET	0.2mm or more	Width: up to 300mm	
Foil	40 μ or more	Width: up to 150mm	

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