LucasMilhaupt®
A Handy & Harman Company
Global Brazing Solutions®

Technical Data Sheet

12-009 COMMERCIAL GRADE FINE SILVER

(99.93% Minimum Silver)

12-009 Commercial Grade Fine Silver (99.93% Min Silver Content) is widely used in numerous electrical, electronic, and industrial applications such as contacts, fuse elements, lead wires, battery plated and ruptured discs. Fine silver is generally selected for its high thermal and electrical conductivity, as well as for its good resistance to oxidation and corrosive attack. It also exhibits excellent ductility and is easily joined by welding or brazing.

NOMINAL COMPOSITION

Silver [(1)]	99.93% Min
Silver + Copper	99.95% Min
Copper	0.04-0.07%
Impurities	0.025% Max Lead
	0.005% Max Iron
	0.005% Max Cadmium
	0.005% Max Zinc
	0.002% Max Nickel
	0.002% Max Aluminum
	0.001% Max Bismuth
Other Elements (Each)	0.05% Max
Other Elements (Total)	0.10% Max

[(1)] Elements such as phosphorus, sodium and lithium are not natural impurities in this grade of silver and thus are not normally found in any appreciable quantities. However, since they may be detrimental for certain electrical contact applications, limits for these and other elements may be established. While oxygen is neither routinely specified nor determined analytically, and commercial processing includes deoxidizing steps, oxygen is known to be present at times in fine silver. When calculating the purity of silver by difference, oxygen is generally considered as silver (per American Society for Testing and Materials (ASTM) B413).

PHYSICAL PROPERTIES

Melting Point (Solidus)	1761°F (961°C)
Boiling Point	4010°F (2210°C)
Atomic Weight	107.9
Density (Troy oz/in^3)	5.53
Vapor Pressure	1.0 mm Hg at 2480°F (1360°C)
Electrical Conductivity (%IACS) [(2)] [(3)]	105 at 68°F (20°C) nominal
Electrical Resistivity (Microhm-cm) [(3)]	1.64 at 68°F (20°C) nominal
Thermal Expansion (10^{-5}/°C)	1.90 (0°C - 100°C temperature range)
Thermal Conductivity (cal/sec/cm^2/°C/cm)	1.00 at 68°F (20°C)
Heat Capacity (cal/gm°C)	0.056 at 68°F (20°C)

[(2)] IACS = International Annealed Copper Standard

[(3)] The conductivity of silver will vary according to temper and purity. Lucas Milhaupt's commercial grade fine silver has a minimum conductivity of 100% IACS in fully annealed temper. The values of conductivity and resistivity with respect to the typical values in ASTM B742 are 100% and 1.72, respectively.

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MECHANICAL PROPERTIES

WORKING FINE SILVER

Fine silver can be hot or cold worked - extruded, rolled, swaged, drawn. It can be cold-rolled or cold-drawn drastically between anneals. The heat generated in cold working may be sufficient to cause silver to partially anneal. If maximum hardening by cold work is desired, care must be taken not to work the metal so rapidly or continuously as to permit an appreciable temperature rise. Although silver is exceedingly ductile, it is also relatively weak. Its relatively low tensile strength must be taken into account in drawing and stamping. Silver requires more and lighter reductions than, for instance, brass and copper; as many as one third more dies may be required to produce a shell of comparable size. On the other hand, silver work hardens less and so more draws between anneals can be made.

ANNEALING FINE SILVER

Fine silver is annealed at relatively low temperatures. Fine silver of very high purity will anneal at quite low temperatures (below 440ºF (204ºC)). In contrast to this, the presence of a few hundredths of a percent of copper or a few thousandths of other impurities, such as iron, will raise the annealing temperature appreciably. The recommended annealing temperature for fine silver is from 440ºF (204ºC) to 800ºF (427ºC). Higher temperatures do not soften the silver materially further, but result in loss of ductility and in formation of "orange peel" surface when further working because of excessive grain growth. High temperatures also cause adjacent surfaces to stick or bond together. This sticking or diffusion bonding is more pronounced in thin sheet and fine wire, hence, the lighter the gauge the lower the annealing temperature used. Fine silver does not form a visible surface oxide file during annealing as do most metals. Therefore, pickling following annealing is unnecessary even if annealing is carried out in air. Silver will; however, dissolve oxygen with the result that the surface is affected. If silver annealed in air is thereafter annealed in hydrogen, the surface will be embrittled and blisters may form.

MACHINING FINE SILVER

Silver is a soft metal and is relatively difficult to machine; annealed silver is particularly so. The work piece is likely to bend, the tool tends to gall, and the surface tends to tear. The machining properties are greatly improved by using silver which has been cold-worked as much as possible. A lubricant, such as sulfur-free oil, should be used to prevent welding of the chips and a slightly greater than normal rake on the cutting tool is beneficial. The machining properties of cold-worked silver are about the same as those of copper.

BRAZING AND WELDING FINE SILVER

Fine silver may be brazed or soldered without difficulty. Even the temperatures reached in soft soldering are high enough to cause annealing. Where silver is used for its corrosion resistance, as in chemical equipment, welding is used so as not to introduce a second, less corrosion resistant metal. In welding, prevention of absorption of oxygen is necessary to avoid the formation of brittle joints. This can be accomplished by the use of TIG or MIG welding.

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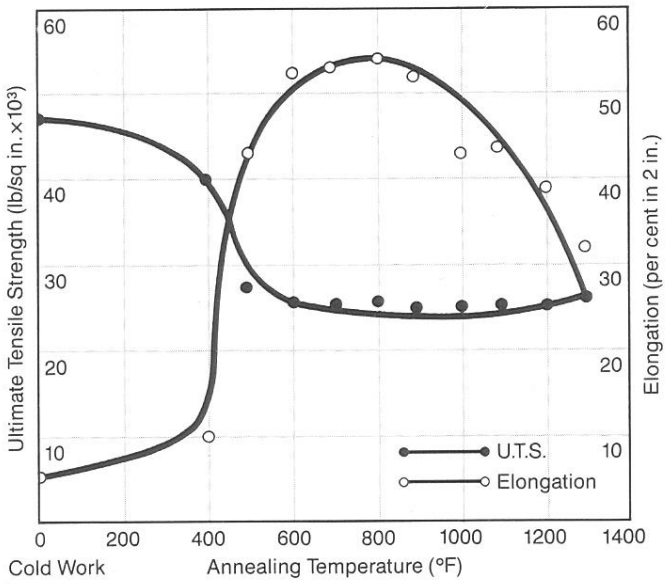
MECHANICAL PROPERTIES (CONT.)

Form	Temper	Approximate Reduction (% in area)	Tensile Strength (lbs/in^2)	Minimum Elongation (% in 2 in.)
Wire	Soft	0	24,000 - 30,000	25.0
	1/4 Hard	21.0	30,000 - 37,000	4.00
	1/2 Hard	37.0	39,000 - 46,000	4.00
	Hard	60.0	42,000 - 49,000	2.00
	Extra Hard	75.0	46,000 - 53,000	2.00
	Spring	84.0	47,000 - 54,000	1.00
	Extra Spring	90.0	48,000 - 55,000	1.00

Form	Temper	Approximate Reduction (% in area)	Tensile Strength (lbs/in2)	Minimum Elongation (% in 2 in.)
Strip	Soft	0	24,000 - 30,000	25.0
	1/4 Hard	11.0	26,000 - 33,000	18.0
	1/2 Hard	21.0	30,000 - 37,000	8.00
	Hard	37.0	37,000 - 44,000	3.00
	Extra Hard	50.0	41,000 - 47,000	2.00
	Spring	60.0	44,000 - 51,000	1.00
	Extra Spring	69.0	48,000 - 55,000	1.00

1. The effect of annealing temperature on room-temperature strength and ductility of commercial fine silver wire, 0.091 in. in diameter. [Ref. 1]



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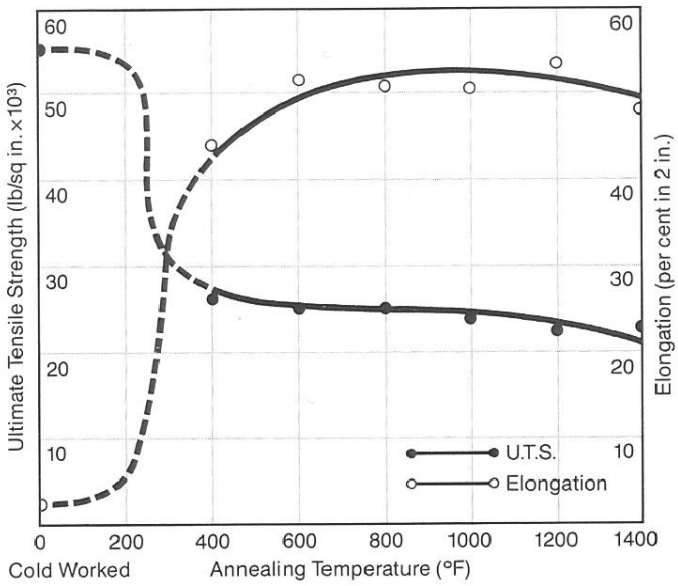
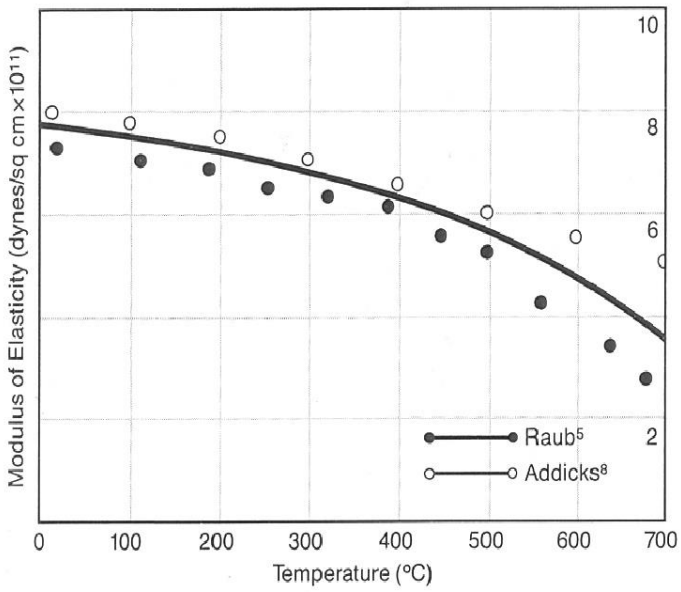
MECHANICAL PROPERTIES (CONT.)

2. The effect of annealing temperature on the room-temperature strength and ductility of commercial fine silver sheet, 0.032 in. thick. [Ref. 1]



3. The elastic modulus of silver as a function of temperature. [Ref. 1]



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AVAILABLE FORMS

Wire, strip, engineered preforms, specialty preforms per customer specification.

SPECIFICATIONS

Commercial Grade Fine Silver conforms to the following specifications:

- American Society for Testing and Materials (ASTM) B742

SELECTED REFERENCES

[1] Allison, Butts. Silver Economics Metallurgy and Use. Princeton, NJ: D. Van Nostrand Company, 1967.
[2] Lawr, Addicks. Silver in Industry. New York, NY: Rienhold Corporation, 1940.

APPLICABLE PRODUCT CODE(S)

The applicable Lucas-Milhaupt product code(s) for this technical data sheet: 12-009.

SAFETY INFORMATION

The operation and maintenance of brazing equipment or facility should conform to the provisions of American National Standard (ANSI) Z49.1, "Safety in Welding and Cutting". For more complete information refer to the Material Safety Data Sheet for Commercial Grade Fine Silver.

WARRANTY CLAUSE

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