AN APPLICATION REPORT FROM
SPECTRO ANALYTICAL INSTRUMENTS

SMA-113/1

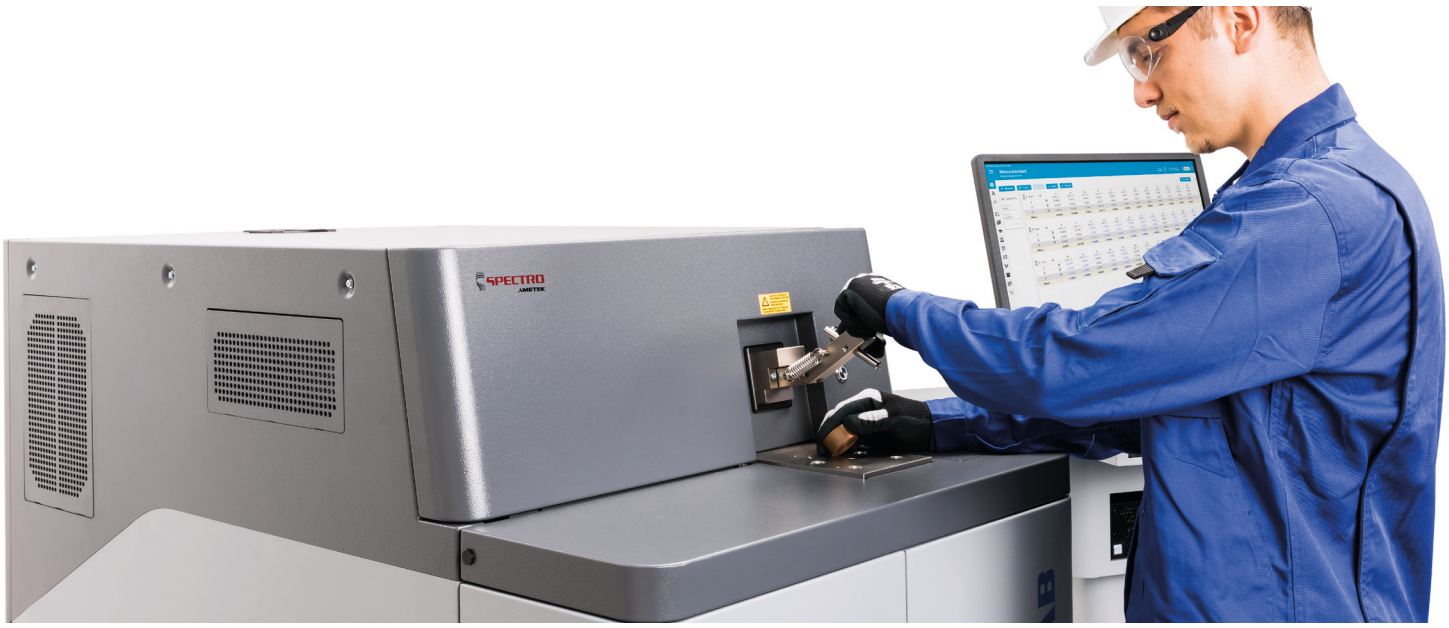
SPECTRO**LAB S** LAS02

Fusible Alloys

Introduction

Alloys with melting points below 230°C (446°F) are referred to as low-melting or fusible alloys. The most widely used fusible alloys contain high percentages of bismuth, combined with lead, tin, cadmium, indium and other metals. Bismuth has an impact on the melting point, as well as the growth and shrinkage characteristics of the alloys. Many of the bismuth-based alloys melt below the boiling point of water, and some of them melt below 65°C (ca. 150°F).

Fusible alloys are stable and can either be classified as eutectic or non-eutectic. Eutectic alloys are characterized by a single melting point (the eutectic point) for all alloy constituents, at which the solidus and the liquidus line in the phase diagram coincide and all phases of the alloy, melt and all constituent phases are in thermodynamic equilibrium. Contrary to eutectic alloys, non-eutectic alloys possess a melting temperature range, in which the melt co-exists with solid phases of other constituents (“slushy state”). The fully melted state (=all alloy constituents in liquid state) is always reached at temperatures above the liquidus line in the alloy phase digram, for non-eutectic alloy compositions, this temperature is above the eutectic (melting) point. Many of the low-melting alloys have good thermal conductivity, can be remelted and reused, and have combinations of elements that cause them to expand during solidification without contracting during cooling. These characteristics make fusible alloys versatile, allowing them to be used in a diverse amount of applications.



In the grinding of optical lenses, fusible alloys are quickly attached onto a block of lens glass that is then held in place and rotated against a grinding arm. The low-melting point allows for quick release of the lens when the grinding process is finished. No other mechanical clamping arrangement allows for the grinding of the complete lens surface opposite the clamping point. Using a fusible alloy when bending thin-walled tubing can help prevent kinks or wrinkles. Tubes are lubricated, filled with a low-melting alloy and cooled so that the alloy solidifies inside, supporting the tube's wall. Once bent, the tube is reheated to liquefy and remove the fusible alloy.

In the finishing process of turbine blades, a similar problem arises—no mechanical clamp can easily and rigidly clamp down a highly-complex curved surface such as a blade that has a non-rectangular shape and non-planar surfaces. Instead, a fusible alloy can be quickly cast around the part. Once it is solid, the entire block of encasing metal acts as a clamp, and the protruding part of the blade can be finished. After the finishing process is complete, the fusible alloy can be quickly melted and removed.

In sprinkler systems, the melting point acts as a completely passive sensor material. When a certain temperature (as in a fire) is reached, the melting alloy typically releases a spring-loaded part that helps to engage the sprinkler system. This switching action is completely passive, i.e., no active electronic circuits are needed to engage the switch.

The innovative SPECTROLAB S allows to analyze these alloys quickly and precisely.

Wood's Metal

Because of its low melting point, Wood's metal is used as a fuse for sprinkler systems or electrical fuses. It is used as a filler when bending thin-walled tubes. In laboratories it is also used for heating baths (so-called metal baths). It was also often used for joke articles. A person was given a spoon made of Wood's metal when drinking a hot beverage. When stirred, this spoon melted in the drink. Since lead and cadmium are considered hazardous substances, this prank is quite questionable.

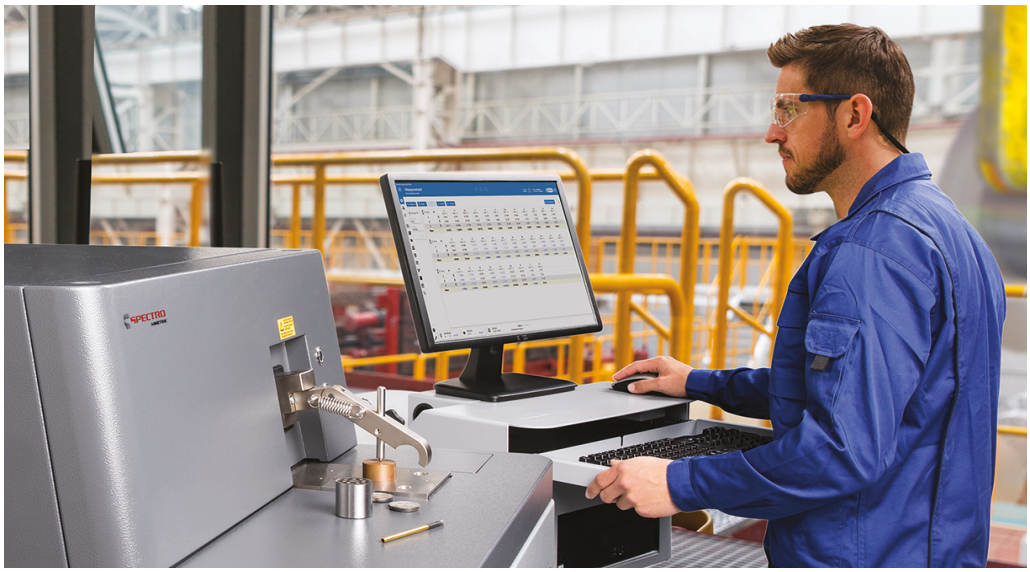
Nominal composition:

- 50% Bi
- 25% Pb
- 12.5% Cd
- 12.5% Sn

Typical Analysis using a SPECTROLAB S:

Sample Name	Melting point
Wood's Metal	70°C

Element	Bi Conc %	Pb Conc %	Sn Conc %	Cd Conc %	In Conc %	Sb Conc %	Cu Conc %	Zn Conc %
1	49.77	26.58	13.40	10.23	<0.0005	0.0117	<0.0005	<0.0005
2	50.20	26.65	13.37	9.98	<0.0005	0.0115	<0.0005	<0.0005
3	50.10	26.59	13.37	10.04	<0.0005	0.0113	<0.0005	<0.0005
Rep.	50.02	26.61	13.38	10.08	<0.0005	0.0115	<0.0005	<0.0005
SD	0.2250	0.0379	0.0173	0.1305		0.0002		



Field's Metal

Field's metal is suitable, for example, as a casting alloy. Since it wets glass in the liquid state, it can also be used as a solder for glass.

In general, it can serve as a non-toxic substitute for Wood's metal, which contains cadmium and lead and melts at about 73-77 °C. A disadvantage here is the price, which is quite high due to the high content of indium.

Nominal composition:

- 51% In
- 32.5% Bi
- 16.5% Sn

Typical Analysis using a SPECTROLAB S:

Sample Name	Melting point
Field´s Metal	62°C

Element	Bi Conc %	Pb Conc %	Sn Conc %	Cd Conc %	In Conc %	Sb Conc %	Cu Conc %	Zn Conc %
1	32.46	<0.0005	16.62	<0.0005	50.80	0.0086	0.00290	0.0057
2	32.26	<0.0005	16.57	<0.0005	51.05	0.0074	0.00300	0.0058
3	32.37	<0.0005	16.49	<0.0005	51.02	0.0107	0.00300	0.0058
Rep.	32.36	<0.0005	16.56	<0.0005	50.95	0.0089	0.00300	0.0058
SD	0.1013		0.0621		0.1347	0.0017		0.0001

Cerrolow 117

Cerrolow 117 alloy, with a melting point of 47°C, is used to clamp or fix delicate parts for machining, dental models, denture development, trial casting, as a fusible element in safety devices, as a radiopaque contrast agent in X-ray equipment, as a low-temperature solder, and for many hobby applications.

Nominal composition:

- 44.7% Bi
- 22.6% Pb
- 8.3% Sn
- 19.1% In
- 5.3% Cd

Typical Analysis using a SPECTROLAB S:

Sample Name	Melting point
Cerrolow 117	47°C

Element	Bi Conc %	Pb Conc %	Sn Conc %	Cd Conc %	In Conc %	Sb Conc %	Cu Conc %	Zn Conc %
1	44.55	22.58	8.28	5.30	19.27	0.0140	0.0026	0.0028
2	44.62	22.56	8.30	5.32	19.18	0.0113	0.0025	0.0024
3	44.69	22.54	8.27	5.33	19.15	0.0129	0.0024	0.0030
Rep.	44.62	22.56	8.29	5.32	19.20	0.0127	0.0025	0.0027
SD	0.0703	0.0217	0.0134	0.0142	0.0612	0.0014	0.0001	0.0003

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www.spectro.com

GERMANY
SPECTRO Analytical Instruments GmbH
Boschstrasse 10
D-47533 Kleve
Tel. +49.2821.892.0
spectro.sales@ametek.com

U.S.A.
SPECTRO Analytical Instruments Inc.
50 Fordham Rd
Wilmington 01887, MA
Tel. +1 800 548 5809
+1 201 642 3000
spectro-usa.sales@ametek.com

CHINA
AMETEK Commercial
Enterprise (Shanghai) CO., LTD.
Part A1, A4 2nd Floor Building No. 1 Plot Section
No. 526 Fute 3rd Road East; Pilot Free Trade Zone
200131 Shanghai
Tel. +86.400.022.7699
spectro-china.sales@ametek.com

Subsidiaries:
▶**FRANCE:** Tel. +33.1.3068.8970, spectro-france.sales@ametek.com ▶**GREAT BRITAIN:** Tel. +44.1162.462.950, spectro-uk.sales@ametek.com
▶**INDIA:** Tel. +91.22.6196.8200, sales.spectroindia@ametek.com ▶**ITALY:** Tel. +39.02.94693.1, spectro-italy.sales@ametek.com
▶**JAPAN:** Tel. +81.3.6809.2405, spectro-japan.info@ametek.co.jp ▶**SOUTH AFRICA:** Tel. +27.11.979.4241, spectro-za.sales@ametek.com

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