BEHR
IRON & METAL
RECYCLING SINCE 1906

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Behr Iron & Metal has established itself within the Babbitt industry by following the same core principles and beliefs that have been the industry standard for nearly 100 years. In 1923, William Cohen of National Lead Company wrote about Babbitt and related affairs in an issue of Industrial and Engineering Chemistry. He spoke briefly on the progression of Babbitt through the years, from Isaac Babbitt's original Babbitt alloy to today's collection of alloys. At the time of the issue, it was becoming more evident that long-established ideas in the Babbitt industry were, in fact, based on a lack of full knowledge. As the true differences and advantages of different grades of Babbitt were becoming readily available to both suppliers and customers, Babbitt dealers began digging deeper for sales tactics to impress their customers. Using pseudo-scientific jargon, dealers were rambling on about unique methods and alternative, yet infinitesimal, residuals which made their Babbitt superior to the competitor's. It was in response to these growing numbers of false claims that Cohen stated:

> "It is now well established that such methods are both unwise and unnecessary, since the best alloys can be made by the use of good practice in the art based on skilful experience and well-known metallurgical principles."

By combining finely tuned processes, a wealth of knowledge stemming from experience and a strong quality control program through ISO 9001 and 14001 certification, Behr Iron & Metal recycles and supplies Babbitt alloys to meet each customer's individual needs. Through the use of three melting furnaces, Behr Iron & Metal is capable of simultaneously recycling scrap Babbitt and producing high quality tin- and lead-based alloys without any threat of contamination.

BABBITT RECYCLING

Babbitt scrap is created as soon as Babbitt begins to melt. Molten metal must be kept free of all impurities and a Babbitt dross will surely be formed when cleaning the surface. As Babbitt is cast onto a bearing, an overspill will likely occur. While machining the babbit-lined bearing back to its specifications, Babbitt turnings will be produced. When repairing a Babbitt lining, the old Babbitt must be melted out before the Babbitting process can begin again. Regardless of form (whether it be dross, spills, clean turnings, contaminated turnings or pigs) Behr Iron & Metal has a processing method specific to your Babbitt scrap.

Upon being received by Behr Iron & Metal, each lot of Babbitt scrap is given a unique identification number to track it throughout processing. A processing route is then chosen, based on the condition of the Babbitt scrap, to produce the purest end result possible. As a state-of-the-art scrap processing facility, Behr Iron & Metal manages a variety of equipment to remove impurities from Babbitt scrap and process it for re-use:

- Magnetic separator- Removes steel from Babbitt turnings
- Rotary dryer - Burns cutting oils and melts Babbitt turnings into sow molds
- Burn chamber - Sweats Babbitt out of steel bearings
- Crucible furnace - Low-volume, high-temperature furnace melts Babbitt out of low-recovery drosses
- Melting Kettle - Melts each lot of clean Babbitt scrap to be poured into pigs and analyzed

The use of technologically advanced spectrometers, both on-site and through third party testing, allow for the chemical composition of every lot of Babbitt scrap to be analyzed. Any lots containing both a chemical composition and visual appearance similar to a specific grade of Babbitt are re-alloyed to meet the required specifications of the customer.

BABBITT PRODUCTION

Behr Iron & Metal maintains both the expertise and capability to produce all standard grades of Babbitt or solder as well as any alternative grades a customer should request. Three charts of the more common grades can be seen in the appendix below. Through the use of three melting furnaces (as previously mentioned) and complete certification upon shipment, all Babbitt is guaranteed to be without contamination of any kind and within the pre-determined specifications. The variety of forms in which the metal is available makes it suitable to all needs. All grades of Babbitt are available in both 22”x4”x3” ingots and 11”x2”x1¼” notchbars. The more popular Grade 2 and Grade 7 are also both available in 25lb. wire spools, ideal for puddling and metal spraying.

We at Behr Iron & Metal take pride in ensuring our products meet the required specifications 100% of the time. To receive a quote on Babbitt products or to learn more about the Babbitt process at Behr Iron & Metal and how our recycling program can benefit you, please call 815-987-2680 to speak with us.

BABBITT ALLOYS

HISTORY, CHARACTERISTICS & APPLICATION

Since its introduction as an anti-friction alloy by Isaac Babbitt in 1834, Babbitt has withstood the test of time as a tried and true bearing liner. Today, the term Babbitt covers a collection of "white metal" alloys consisting generally of a tin or lead base accompanied by antimony and copper. From one Babbitt alloy to the next, slight variations in chemical composition allow for consistent results throughout a wide range of working conditions. Babbitt is most desirable for its heterogeneous structure providing bearings with the advantages of both hard and soft surfaces. As a producer and recycler of Babbitt alloys, Behr Iron & Metal uses finely tuned practices along with a comprehensive quality control program to work towards each customer's personal needs.

HISTORY OF BABBITT

As a skilled goldsmith in Taunton, Massachusetts, Isaac Babbitt began experimenting with alloys around 1824. It was then that Babbitt became the first US producer of table utensils made of Britannia (an alloy similar to Pewter). In 1930, he started a business for this specialized trade known as the Taunton Britannia Manufacturing Company. Shortly thereafter, the company dissipated and, along with his partners, Babbitt was forced to hand over control to two men who had worked their way up through the company ranks. Charles E. Barton and Henry Good Reed resurrected the business and, with a few fresh ideas, gave it what was needed to survive the test of time. The company, which originated with Isaac Babbitt, is still in existence today as Reed and Barton, the world renowned fine tableware marketer.

After turning over control of Taunton Britannia Manufacturing Company, Babbitt began working for Alger's Foundry and Ordinance Works in South Boston. It was here that he left his mark on the industrial world. In 1834, Babbitt cast the first ever brass cannon in the US. Five years later, Babbitt produced an alloy used to reduce friction in steam engines. The alloy, which would later become known as Babbitt, originally consisted of:

4 Parts Copper
8 Parts Antimony
24 Parts Banca Tin

The practical nature of Babbitt's invention was rewarded by the U.S. Congress with a $20,000 grant to allow production of the alloy for use in Naval applications. Since 1839, the term Babbitt has grown to cover a number of similar alloys, all providing the same general characteristics of Isaac Babbitt's first friction reducing metal.

CHARACTERISTICS OF BABBITT

Isaac Babbitt's first anti-friction alloy in 1839 consisted of 24 parts tin, 8 parts antimony and 4 parts copper. Today, Babbitt alloys cover a wide range of compositions anywhere from 90% tin base to 90% lead base. A variety of accepted compositions within this range are provided by the following sources and can be seen in the appendix:

ASTM B-23	(American Society of Testing Materials)
QQ-T-390A	(U.S. Government Specifications)
SAE J460	(Society of Automotive Engineers)

As seen in the ASTM, QQ-T-390A and SAE charts, each alloy consists of a slightly different makeup providing for a wide range of benefits, whether it be a greater load bearing capacity, greater allowable surface speed of the shaft or the ability to withstand higher temperatures. While all Babbitt alloys have differing compositions, each one provides a similar heterogeneous mixture of intertwined hard crystals and soft matrices exhibiting characteristics similar to those of Babbitt's original bearing liner. This structure allows for hard copper and antimony crystals to be uniformly embedded within a softer tin or lead base. A well worn Babbitt lining will then effectively have the strength to maintain its load bearing capacity while providing a surface soft enough to conform to irregularities and aid in preserving the bearing's oil film. As the Babbitt wears, the soft base will recess and embed any foreign substances to avoid scoring, conform to deformations in the shaft to maintain sufficient equilibrium and expose the hard crystals to maintain strength. Lastly, a grooved surface will begin to take shape within the softer base. Although not noticeable, the grooves absorb lubricating oil helping to maintain the oil film required for the bearing to run efficiently. As this oil film breaks down with time, the Babbitt lining will provide enough lubrication to allow for a controlled failure and subsequent replacement of the Babbitt lining; a far more economical choice than replacement of the bearing as a whole. It is interesting to consider that although the independent elements in their homogenous form may provide the strength or softness desired, unless alloyed to one of a few specific chemical compositions, the compound will not interlace uniformly and therefore will not provide a sufficient bearing surface.

In industry today, tin-based Babbitt alloys are, physically, far superior to lead-based Babbitt alloys. Tin-based Babbitt can withstand surface speeds of 1,000 to 2,400 ft/min and loads of 100-2,000 lbs/sq. in., easily surpassing the lead-based Babbitt limits of 100-1,000 ft/min and 100-500 lbs/sq. in. Tin-based Babbitt alloys are also structurally stronger as they exhibit greater tensile strength and elongation than lead-based Babbitt. These numbers are laid out in Tables 1 and 2 for two of Behr Iron & Metal most commonly requested products, Grade 2 and Grade 7 Babbitt. Additionally, although not clearly compared in the tables below, at 100 ºC (212 ºF), lead-based Alloy #7 shows a hardness of 10.5 HB while the hardness of tin-based Alloy #2 is 22 HB.

Table 1: Mechanical Properties of Chill Cast Tin-Base Babbitt Alloy 2

Tin Babbitt Alloy 2 (89 Sn – 7.5 Sb – 3.5 Cu)
ASTM B23, Grade 2
SAE, No. 12
Government QQ-M-161, Grade 2
Navy 46M2, Grade 2

Temperature		Tensile Strength		Elongation	Reduction
ºC	ºF	MPa	Ksi	% (a)	In Area, %
20	68 (b)	77	11.2	18	25
49	120	63	9.2	24	27
100	212 (c)	45	6.5	23	28
149	300	28	4.0	32	38
175	345	20	2.9	38	44

(a) Gage length equals 4 √area. (b) Compressive yield strength, 0.125% set, 42 MPa (6.1 ksi); compressive strength, 25% set, 103 MPa (14.9 ksi). (c) Compressive yield strength, 0.125% set, 21 MPa (3.0 ksi); compressive yield strength, 25% set, 60 MPa (8.7 ksi).

Table 2: Mechanical Properties of Chill Cast Lead-Base Babbitt Alloy 7

Lead Babbitt Alloy 7 (75 Pb – 15 Sb – 10 Sn)
ASTM B23, Grade 7
SAE J460, No. 14

Temperature		Tensile Strength		Elongation	Hardness,
ºC	ºF	MPa	ksi	%	HB
25	77	72	10.5	4	22
100	212	38	5.5	25	10.5
150	302	21	3.0	52	8

Even with the significant advantage tin-based Babbitt holds over lead-based Babbitt, there is no lack of demand for lead-based Babbitt today. Not every application requires the full capabilities of tin-based Babbitt and, in those cases, lead-based Babbitt may suffice. Needing only 10% tin to obtain maximum strength at room temperature, lead-based Babbitt is a much more economical choice when work is being done at a slower speed and/or with a less heavy load.

CASTING OF BABBITT

The true value of a bearing's Babbitt lining lies deeper than just the cost of having Babbitt cast into that bearing. Just as any other profitable function, if a piece of equipment does not live up to its expectations, money is lost. As far as a Babbitt lining is concerned, the two factors which determine value are effectiveness and lifespan. Assuming that the Babbitt used meets the required chemistry, the most crucial part to increasing the lifespan, and therefore value, of a Babbitt lining is ensuring it is properly cast and maintains a strong bond to the bearing. The bond strength can be maximized by ensuring a number of steps are taken before casting.

- **Prepare the bearing surface**

  By giving the bearing a phonographic (grooved) or otherwise rough finish, the potential bond strength will be greatly increased in a way similar to duct tape showing greater adhesion to a rough, versus a smooth, surface. As grooves are created in the bearing, the surface area is effectively increased allowing for a greater number of bond points.

- **Clean the bearing surface**

  Exposure to cutting oils, grease, dirt and even oils from our own skin decreases the potential bond strength of the bearing. A thorough cleaning of the bearing in any variety of caustic or acidic baths should efficiently remove all oil and grease.

- **Tin the bearing**

  Tinning provides a fine layer, generally of pure tin, between the bearing metal and the Babbitt which adheres to both metals and provides a stronger bond. In large operations, bearings can be submerged in a tin tank, best maintained at around 600ºF. It is important to keep the surface of the tin tank clean in order for the clean bearing to remain free of contaminates. After submerging the bearing in the tin tank, a thin, silvery layer should result. At this point the bearing is ready to accept the Babbitt lining through one of multiple casting techniques.

Depending on the bearing type, various methods of casting Babbitt can be used. A decision must be made between hand (static) casting, centrifugal casting, spray casting and puddling based on the situation at hand as well as the advantages and disadvantages of each casting method.

- **Hand casting (static casting)**

  This method is typically called upon for Babbitting thrust shoes or abnormally shaped bearings, but may also be used for journal bearings where any of the alternative methods are not feasible. The term "static casting" is simply derived from the process of pouring Babbitt directly onto a stationary bearing. In order for the Babbitt to form an acceptable bond, a mold must be created which will fill all voids in the bearing and hold the molten metal in place as it cools. This mold should be made to hold a generous amount of Babbitt. Excess Babbitt is needed as it will decrease in volume as it cools. In the case of a journal bearing, a shaft should also be used as a barrier for the Babbitt. At this point, the bearing is ready for tinning. While in the tinning tank, it is important to allow enough time for the bearing to become thoroughly heated. This allows for a more consistent cooling pattern and a stronger bond. If a shaft is being used, heat it as well until it reaches a temperature well above that of the bearing to ensure the Babbitt cools first at the bearing. When the bearing has reached a temperature near that of the tinning tank and the shaft has been heated to a sufficient temperature, immediately begin pouring. If at all possible, use a ladle large enough so that multiple pours are not necessary. If pouring ceases, so that the ladle may be refilled, separation will occur greatly diminishing the overall strength of the Babbitt layer. Also, avoid pouring the entire ladle directly onto a single point on the bearing surface. This will cause the point to become overheated resulting in unnecessary stress to the bearing and an inconsistent cooling pattern in the Babbitt. Overall, hand casting is an effective Babbitting method in the instances where centrifugal or spray casting are not practical. When applied correctly, the Babbitt layer will have both an acceptable bond strength and consistency.

- **Centrifugal casting**

Providing the best bond strength and among the most consistent layers (along with spray casting), centrifugal casting is the preferred casting method for cylindrical bearings of manageable size. In this method, centrifugal force is used to express the Babbitt outward against the bearing surface. Similar to hand casting, all voids must first be filled before the bearing can be tinned. After tinning, the bearing is placed perpendicular to any variety of vertical spinning surfaces. A second surface, with a hole to allow for pouring, is placed over the opposite end of the bearing to hold the Babbitt in place. The bearing must be perfectly centered on the machine to assure it remains equilibrated throughout the process. The slightest loss of equilibrium will cause an asymmetrical Babbitt layer. By placing a heated pipe through the pour hole and a funnel at the other end of the pipe, Babbitt can be poured at a consistent rate into the bearing. After pouring, use water to cool the outside of the bearing shell. Allow the Babbitt to solidify before stopping the rotation.

Through centrifugal casting, separation will tend to occur as the force will affect all elements of the alloy differently. In tin-based Babbitt, for instance, copper has more mass than tin or antimony and will tend to expel further outward embedding itself deep into the Babbitt layer. Segregation can be easily eliminated by reducing the rotational speed (RPM) of the bearing, however doing so will also weaken the bond. To minimize segregation while still providing sufficient force, the rotational speed must vary, depending on the bearing size, to reach a set tangential velocity (m/s^2). Tangential velocity refers to the effect that radius has on a rotating object. In an instance where two people are standing on the same rotating disc, but at different distances from the center, the person further from the center will be traveling faster than the person nearer the center. Due to the increased velocity, the person further from the center will also be experiencing a greater centrifugal force. Therefore, for bearings of larger diameter, less revolutions per minute (RPMs) are required to maintain the same centrifugal force.

- **Spraying**

  An excellent method for repairing an outer diameter is metal spraying. With the exception of typically lesser bond strength compared with centrifugal casting, spraying provides a high-quality Babbitt surface. Depending on the specific style of spraying used, the technicalities and characteristics will vary slightly, but overall the process allows for the most control and eliminates voids as well as any other casting method. Two of the more popular spray methods, arc spraying and flame spraying, are quite similar in practice. Both consist of a gun through which wire is fed, melted and sprayed. In an arc sprayer, two wires are simultaneously fed through the gun and melted by an electrical load. Compressed air then forces the molten metal away from the wires and onto the bearing surface. Similarly, in a flame sprayer, wire is fed into the gun, heated by an oxygen/gas-fed flame and sprayed by compressed air. Arc sprayers tend to provide a more efficient and consistent spray when compared to flame sprayers, however they do not allow for the portability that makes flame sprayers attractive. A major downfall of metal spraying, in general, is that it can create a fairly substantial health hazard. Large amounts of smoke, atomized metal and tin oxide, which result from the process, require the use of a filter mask and sufficient ventilation. Metal spraying techniques should only be practiced under well-ventilated conditions by thoroughly knowledgeable persons.

- **Puddling**

  As a method to provide quick, small scale repairs to an existing Babbitt surface, puddling is a less intensive Babbitting method. It is not a practical method for large scale repairs as it does not yield the strength nor uniformity of a completely re-cast Babbitt lining, however it is an efficient method for repairing surface scars. Due to its low melting temperature, Babbitt can easily be melted directly into a well-prepped void and machined back to the original specifications.

ASTM B-23 Chemical Compositions

Grade	1	2	3	11	7	8	13	15
Tin	90.0-92.0	88.0-90.0	83.0-85.0	86.0-89.0	9.3-10.7	4.5-5.5	5.5-6.5	0.8-1.2
Antimony	4.0-5.0	7.0-8.0	7.5-8.5	6.0-7.5	14.0-16.0	14.0-16.0	9.5-10.5	14.5-17.5
Lead	< 0.35	< 0.35	< 0.35	< 0.50	remainder	remainder	remainder	remainder
Copper	4.0-5.0	3.0-4.0	7.5-8.5	5.0-6.5	< 0.50	< 0.50	< 0.50	< 0.60
Iron (% Max)	0.08	0.08	0.08	0.08	0.10	0.10	0.10	0.10
Arsenic	< 0.10	< 0.10	< 0.10	< 0.10	0.30-0.60	0.30-0.60	0.25	0.8-1.4
Bismuth (% Max)	0.08	0.08	0.08	0.08	0.10	0.10	0.10	0.10
Zinc (% Max)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Aluminum (% Max)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Cadmium (% Max)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Named Elements	> 99.80	> 99.80	> 99.80	> 99.80	n/a	n/a	n/a	n/a

QQ-T-390A Chemical Compositions

Alloy #	1	2	3	4	5	6	7	10	11	13
Tin (%)	90.0-92.0	88.0-90.0	83.0-85.0	80.5-82.5	61.0-63.0	4.5-5.5	9.3-10.7	0.75-1.25	9.0-11.0	4.0-6.0
Antimony (%)	4.0-5.0	7.0-8.0	7.5-8.5	12.0-14.0	9.5-10.5	14.0-16.0	14.0-16.0	14.5-17.5	11.5-13.5	8.0-10.0
Lead (%)	0.35[1]	0.35[1]	0.35[1]	0.25	24.0-26.0	79.0-81.0	74.0-76.0	78.0-83.0	74.0-79.0	83.0-88.0
Copper (%)	4.0-5.0	3.0-4.0	7.5-8.5	5.0-6.0	2.5-3.5	.50[1]	.50[1]	.60[1]	0.40-0.60	.50[1]
Iron (% Max)	0.08	0.08	0.08	0.08	0.08	0.10	0.10	0.10	0.10	0.10
Arsenic (% Max)	0.10	0.10	0.10	0.10	0.15	0.20	0.60	(3)	0.20	0.20
Zinc (% Max)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Aluminum (% Max)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bismuth (% Max)	0.08	0.08	0.08	-	-	-	-	-	-	-
Others (% Max)	0.10	0.10	0.10	0.10	0.30	0.50	0.50	0.50	0.50	0.75

1- Maximum
2- A narrower range of Antimony within the limits stated may be specified, but the spread shall not be less than 1.00 percent.
3- 0.80-1.40

SAE J460 Chemical Compositions

Number	11	12	13	14	15	16
Tin	< 86.0	< 88.0	5.0-7.0	9.2-10.7	0.9-1.3	3.5-4.7
Antimony	6.0-7.5	7.0-8.0	9.0-11.0	14.0-16.0	14.0-15.5	3.0-4.0
Lead	< 0.50	< 0.50	remainder	remainder	remainder	remainder
Copper	5.0-6.5	3.0-4.0	< 0.50	< 0.50	< 0.50	< 0.10
Iron (% Max)	0.08	0.08				
Arsenic	< 0.10	< 0.10	< 0.25	< 0.6	0.8-1.2	< 0.05
Bismuth (% Max)	0.08	0.08	0.10	0.10	0.10	0.10
Zinc (% Max)	0.005	0.005	0.005	0.005	0.005	0.005
Aluminum (% Max)	0.005	0.005	0.005	0.005	0.005	0.005
Cadmium (% Max)			0.05	0.05	0.02	0.005
Others (% Max)	0.20	0.20	0.20	0.20	0.20	0.40

Lead Alloy Chemical Compositions

Number	6/2 Bullet Lead	8/2 Bullet Lead	1:20 Cowboy Lead	Antimonial (Hard) Lead
Tin	2.0 – 2.5	2.0 – 2.5	5.0 – 5.5	< 0.50
Antimony	6.0 – 6.5	8.0 – 8.5	< 0.50	CUSTOM
Lead	remainder	remainder	remainder	remainder
Copper	< 0.10	< 0.10	< 0.10	< 0.50
Iron (% Max)	0.08	0.08		
Arsenic	< 0.10	< 0.10	< 0.10	< 0.10
Bismuth (% Max)	0.08	0.08	0.08	0.08
Zinc (% Max)	0.005	0.005	0.005	0.005
Aluminum (% Max)	0.005	0.005	0.005	0.005
Cadmium (% Max)			0.05	0.05
Others (% Max)	0.20	0.20	0.20	0.20