Introduction to Aluminum Alloys and Tempers
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CHAPTER 3

Understanding Wrought and Cast Aluminum Alloys Designations

THE WROUGHT ALLOY DESIGNATION SYSTEM consists of four numerical digits, sometimes preceded by a capital letter as indicated in Chapter 2. The first digit indicates the principal alloying elements, as described in this chapter in the section "Principal Alloying Elements" and Table 1; the second digit is the variation of that alloy; and the last two digits represent the specific alloy designation.

The Wrought Alloy Series

How the System is Applied

The First Digit. Assignment of the first digit of the designation of a new alloy is fairly straightforward; few judgment decisions are needed unless there are equal amounts of two or more alloys. In the latter case, specific guidance has been provided by the developers of the alloy designation system that the choice of alloy series assigned shall be in the order of copper (Cu), manganese (Mn), silicon (Si), magnesium (Mg), magnesium silicide (Mg_2Si), and zinc (Zn). Thus, if a new alloy has equal amounts of manganese and zinc, it will be assigned to the 3*xxx* series. In such cases, the 6*xxx* series requires the most judgment because alloys that have more silicon than magnesium, but significant quantities of both, are likely to be placed in the 6*xxx* series rather than the 4*xxx* series in establishing properties and characteristics due to the predominance of the magnesium and silicon combination. Thus, for example, alloys such as 6005, 6066, and 6351, all have significantly more silicon than magnesium or other elements, but find themselves in the Mg_2Si series.

The Second Digit. Assignment of the second digit of the alloy designation is related to the variations in a specific alloy, in many cases, tightening of controls on one or more impurities to achieve specific properties. If the second digit is 0, it generally indicates that the aluminum making up the bulk of the alloy is commercially pure aluminum having naturally occurring impurity levels. When the second digit is an integer 1 to 9, it indicates that some special control has been placed on the impurity levels of that variation, or that the range for one of the major alloy elements has been shaded one way or the other to achieve certain performance. However, the sequence has no significance in the composition variation; the digits are assigned sequentially as the situations occur, and the sequence indicates chronology more than level of control.

An example of the application of these principles is the alloy set 7075, 7175, 7275, 7375, and 7475. The original alloy was 7075 with commercial quality aluminum; when added fracture toughness was needed, controls on various impurities, notably iron and silicon led to the other variations, of which 7175 and 7475 remain active alloys known for their superior toughness.

The Third and Fourth Digits. As noted earlier, the last two digits in the 1*xxx* series indicate the purity level in terms of the first two digits after the 99.*XX*% purity of the aluminum used in preparing that composition. Thus, for example, the designation 1060 indicates 99.60% minimum aluminum in that composition. In the remaining 2*xxx* to 8*xxx* series, the last two digits have no special significance. They serve only to identify the specific individual alloys and mean nothing in terms of the sequence in which the alloys were developed or registered. Historically, for the older alloys, those digits came from the earlier designations (e.g., 2024 was 24S before 1950). More recently, it has been the tradition that developers of new alloys ask for specific designations, sometimes based on proximity of application to other alloys of the same series or because they judge them easy to remember or such. Alloy 2020, now inactive, is an example of the latter. If the developer asks for a specific number when filing for registration, the Aluminum Association Product Standards Committee, which oversees the system, is likely to agree to the request if no confusion would result. However, if no designation is requested, the committee would likely take the lowest used number in the sequence 1 to 99.

The alloy designation system also calls for the use of capital letters in front of the four-digit numerical:

- *Experimental alloys—X:* Early in the development of aluminum alloys, when such development has moved beyond single-company in-house trials, and the alloys are ready for customer trials and/or perhaps multicompany production but are still not sufficiently well understood or documented to become standard alloys, the alloys may be registered, but an X is added to the designation. A historical example was the use of X2020, when the first of the lithium-bearing alloys was put forth in the 1960s. That designation was employed for about ten years before the further use of the alloy was deemed inappropriate and its application was discontinued. Another example is X7050, from which the X was removed once the broad application of the alloy was considered appropriate and the properties and standards were well defined.

- *Variations—A, B, etc.:* Under certain situations when minor variations in alloy compositions are introduced, such variation sometimes is noted with the addition of a capital letter behind the original four-number designation, rather than a change in the second digit. The only current example of the application of this procedure in commercial practice is 6005A—a modification of alloy 6005. In general, the practice is to reflect such variations with the second digit as noted earlier in this chapter.

Principal Alloying Elements

As indicated in Chapter 2 and in the previous discussion, the most obvious characteristic of the alloy series defined by the designation is the major alloying element or elements, as recapped in Table 1. This breakdown leads to the ability to recognize a variety of things about the alloys themselves because each of these elements carries certain characteristics with it into the aluminum system as defined in subsequent paragraphs. Remembering these associations will add immeasurably to understanding the behavior and proper treatments to be given the alloys.

Understanding Wrought Alloy Strengthening Mechanisms

The first major piece of information conveyed by understanding the alloy designation system is the manner in which the alloy can be most effectively strengthened.

For example, pure aluminum (1*xxx*) and alloys containing principally manganese (3*xxx*) or magnesium (5*xxx*) with only minor amounts of other elements must be strengthened primarily by strain hardening because they

Table 1 Main alloying elements in the wrought aluminum alloy designation system

Alloy	Main alloying element
1*xxx*	Mostly pure aluminum; no major alloying additions
2*xxx*	Copper
3*xxx*	Manganese
4*xxx*	Silicon
5*xxx*	Magnesium
6*xxx*	Magnesium and silicon
7*xxx*	Zinc
8*xxx*	Other elements (e.g., iron and silicon)
9*xxx*	Unassigned

do not respond to solution heat treatment. Pure aluminum has no appreciable amounts of any elements that can go into solution to provide solution strengthening or precipitation hardening. And elements such as magnesium, silicon, and manganese, while they are soluble to some degree in aluminum and provide modest solution strengthening, do not provide for an appreciable amount of the more significant precipitation hardening. Thus, for pure aluminum and the 3*xxx* and 5*xxx* alloys, cold rolling, stretching, or drawing, or some combination of these, are the principal means of strengthening.

On the other hand, elements such as copper (2*xxx* series), zinc (7*xxx* series), and magnesium in combination with silicon as Mg_2Si (6*xxx* series) do go into solution to an appreciable degree and provide the opportunity for appreciable precipitation hardening. Thus, solution heat treatment (a high temperature holding to permit the elements to go into solution), followed by a sufficiently rapid quench to keep the elements in solution, and then either natural aging (i.e., at room temperature) or artificial aging (holding in a furnace at a moderately elevated temperature) for precipitation hardening are most often used. The result is that alloy series containing copper (2*xxx*), magnesium plus silicon (6*xxx*), or zinc (7*xxx*) are the higher-strength series.

The 4*xxx* series is somewhat unique in that silicon alone does not provide much heat treating advantage, so most alloys in this series are considered non-heat-treatable. However, in some 4*xxx* alloys the silicon is present with sufficient amounts of other elements such as magnesium that heat treatment is effective; alloy 4032 is an example. The situation is similar for the 8*xxx* series; some alloys such as 8017 and 8040 with only small amounts of alloying element are non-heat-treatable, while those such as 8090, with a significant amount of copper are.

Understanding Wrought Alloy Advantages and Limitations

In addition to being indicative of specific strengthening mechanisms, the major alloying elements also indicate several things about basic behavioral or performance characteristics of the alloys. It is helpful to a secondary fabricator, heat treater, or user of the various alloys to be knowledgeable about these as well. The following example characteristics may be noted.

1*xxx*, Pure Aluminum. The compositions in this group have relatively low strength, even when strain hardened; however, they have extremely high ductility and formability and so may be readily worked or formed. The 1*xxx* series aluminums also have exceptionally high electrical conductivity and resistance to all types of corrosive environments and may be readily joined by a number of commercial processes.

2*xxx*, Copper. As the principal alloying element in this series, copper provides relatively high strength because it provides solution strengthening and the ability to precipitation harden. Many commercial aluminum alloys contain copper as the principal alloying constituent in concentrations from 1 to 10%. Because these alloys naturally age at room temperature, it is advantageous to do any required working or forming of the metal soon after quenching from solution heat treatment. If a delay is needed, it may be desirable to cool them until the mechanical work can be performed.

In the fully hardened (age-hardened) condition, the ductility of 2*xxx* alloys is generally lower than for some other alloys (except in special variations that are discussed later), and their resistance to atmospheric corrosion is not as good as that of pure aluminum or most non-heat-treatable alloys.

Unless given special treatments, 2*xxx* alloys in the T3 and T4 conditions may be susceptible to stress-corrosion cracking (SCC) when stressed in the short-transverse direction (i.e., normal to the principal plane of grain flow). Precipitation hardening improves resistance to SCC but reduces ductility and toughness.

Most aluminum-copper alloys are not readily welded by commercial processes, but a few alloys such as 2219 and 2195 have been developed especially for applications requiring welding.

3*xxx*, Manganese. Manganese provides only modest strength increase even when strain hardened but relatively high formability and ductility, and very high resistance to corrosion in almost all environments. Alloys of the 3*xxx* series are readily weldable and are among the best for brazing and soldering applications.

Commercial aluminum-manganese alloys contain up to 1.2% manganese, but it is appropriate to note that manganese is commonly employed as a supplementary alloying constituent in alloys of the other series to enhance strength.

4*xxx*, Silicon. There are two types of silicon-bearing aluminum alloys: those with silicon alone, which are not very strong but provide excellent flow and finishing characteristics, and those that also include copper and/or magnesium as well as silicon and so gain strength by solution heat treatment and aging.

The 4*xxx* alloys are not highly resistant to atmospheric corrosion and tend to "gray" with time in humid environments. Interestingly, this characteristic is used to advantage with finishing techniques such as anodizing to obtain a variety of rich gray shades.

Because silicon adds to their "flow" characteristics during working, some 4*xxx* alloys (e.g., 4032) are used for complex or finely detailed forgings such as pistons. The 4*xxx* alloys are readily welded and, in fact, include some of the mostly widely used weld filler alloys, another result of their high fluidity.

5*xxx*, Magnesium. Magnesium additions to aluminum provide among the highest strength non-heat-treatable alloys. These alloys also are exceptionally tough, absorbing lots of energy during fracture, and so can be used in critical applications where superior toughness is vital. Alloys of the 5*xxx* series are readily welded by commercial procedures.

Generally, the 5*xxx* alloys also have excellent resistance to atmospheric and seawater corrosion to the point that they may be used in severe marine environments (as described in more detail in Chapter 6). However, alloys with more than 3% Mg are not recommended for service in which significant exposure to high temperature may be encountered because some sensitization to SCC may develop. For these types of applications, alloys such as 5052, 5454, and 5754 containing less magnesium are recommended.

6*xxx*, Magnesium Plus Silicon. With both magnesium and silicon present, aluminum forms a quasi-binary section with the Mg_2Si phase of the magnesium-silicon system, which in turn provides excellent precipitation-hardening capability. This results in modestly higher strengths than possible with non-heat-treatable alloys, combined with generally excellent corrosion resistance.

Alloys of the 6*xxx* type are among the easiest of aluminum alloys to extrude, and are thus widely used for complex (e.g., multihollow or finned) shapes produced in this manner. In addition, they are readily joined by almost all commercial processes.

As with the 2*xxx* series, some natural aging begins immediately after solution heat treatment, so forming operations should be scheduled soon after the material is quenched.

7*xxx*, Zinc. Zinc-bearing aluminum alloys, especially when combined with copper and magnesium, provide the highest strengths of any commercial series.

As a group, these alloys possess relatively poorer atmospheric corrosion resistance compared with other aluminum alloys and, except for the special versions described later, are less tough and more susceptible to stress-corrosion cracking under short-transverse stressing. Special treatments have been developed to deal with these characteristics and are especially important when the alloys would be subjected to high short-transverse stresses in service (as described in the following paragraphs).

As with the 2*xxx* and 6*xxx* series, 7*xxx* alloys naturally age following heat treatment, so scheduling of any intended forming operations is essential.

Other Characteristics Related to Principal Alloying Element

As noted earlier, knowledge of the alloy designation system also provides some information about the properties and characteristics of the alloys. Two notable examples are density and modulus of elasticity:

- *Density:* The density of each aluminum alloy is influenced by the density of each of the individual alloying elements, most especially by the major alloying element indicated by the first number of the designation. The degree of influence is directly related to the percentage of the alloying element present. For example, alloys with magnesium and lithium present are lighter than pure aluminum, while alloys with copper, iron, and zinc are heavier. Those alloys with mostly silicon or silicon combined with magnesium have densities about the same as pure aluminum. In Section 2 of *Aluminum Standards and Data*, Tables I and II provide both typical density values and procedures for calculating densities. Practical estimates of the density of an alloy also may be made by summing the percentages of each element present multiplied by the respective density of that element (representative values given in Table 2).

- *Modulus of Elasticity:* As in the case of density, the moduli of elasticity of aluminum alloys, with a few exceptions, are influenced by the modulus of elasticity of the alloying elements in direct relation to the amount present. Thus, by summing the percentages of each element present multiplied by the respective modulus, the modulus of the alloy may be estimated. There are two important exceptions—magnesium and lithium; both of these relatively low-modulus elements have the effect of increasing the modulus of aluminum: magnesium by a small amount and lithium by a large amount. Table 3 provides the moduli of the major alloying elements for use in estimating the moduli of alloys in which they are used. It must be emphasized that calculations made on this basis are to be considered to be rough estimates, not suitable for

Table 2 Densities of aluminum and aluminum alloying elements

	Density	
Alloying element	g/cm^3	$lb/in.^3$
Aluminum	2.699	0.0971
Silver	10.49	0.379
Gold	19.32	0.698
Beryllium	1.82	0.066
Bismuth	9.80	0.354
Cadmium	8.65	0.313
Cobalt	8.9	0.32
Chromium	7.19	0.260
Copper	8.96	0.324
Iron	7.87	0.284
Lithium	0.53	0.019
Magnesium	1.74	0.0628
Manganese	7.43	0.268
Molybdenum	13.55	0.490
Nickel	8.90	0.322
Lead	11.34	0.410
Silicon	2.33	0.084
Tin	7.30	0.264
Titanium	4.54	0.164
Zinc	7.13	0.258
Zirconium	6.5	0.23

design purposes. For design purposes, there is no substitute for precise measurements of modulus in accordance with ASTM Method E 111.

Understanding Wrought Alloy Variations

Most wrought alloys start at the mill as cast ingot or billet. The ingot or billet is hot worked into semifabricated wrought products by such processes as hot rolling and extrusion, some of which are further finished by cold rolling or drawing. Wrought alloys are available in a variety of product forms, including sheet, plate, tube, pipe, structural shapes, extrusions, rod, bar, wire, rivets, forging, forging stock, foil, and fin stock. These processes and products are described further in Chapter 6.

As stated earlier, the second digit of an alloy designation defines variations of the original alloy composition. Several examples may help to illustrate this point.

Example 1. Alloys 2124, 2224, and 2324 are variations, actually higher-purity variations, of alloy 2024. The original alloy has been and continues to be useful for transportation applications, but research metallurgists noted that controlling impurity elements such as iron and silicon enhanced the toughness of the alloy, providing variations especially useful for critical aerospace applications where high fracture toughness is vital. This procedure was adopted first to make 2124, a plate

Table 3 Elastic moduli of aluminum and aluminum alloying elements

Alloying element	Elastic modulus, GPa	Elastic modulus, 10^6 psi
Aluminum	69	10.0
Silver	71	11.0
Gold	78	12.0
Beryllium	255	37.0
Bismuth	32	4.6
Cadmium	55	8.0
Cobalt	21	30.0
Chromium	248	36.0
Copper	128	16.0
Iron	208	28.5
Lithium	0.7(b)	0.1(b)
Magnesium	44(a)	6.5(a)
Manganese	159	23.0
Molybdenum	325	50.0
Nickel	207	30.0
Lead	261	2.6
Silicon	110	16.0
Tin	44	6.0
Titanium	120	16.8
Zinc	69(c)	10(c)
Zirconium	49.3	11.0

(a) Effect of magnesium is equivalent to approximately 75 GPa/11.0 × 10^6psi. (b) Effect of lithium is equivalent to approximately 207 GPa/30.0 × 10^6psi. (c) The modulus of elasticity of zinc is not well defined; these values are lower-limit estimates.

alloy with all the advantages of 2024 but substantially higher elongation and toughness, especially in the short transverse direction. The process was adopted subsequently to create 2324, an alloy for extrusions with similar attributes. Some special processing also may be required for such alloys.

Example 2. Alloys 7175 and 7475 are modifications of alloy 7075. Both 7175 and 7475 alloys have the same major alloying elements as 7075 but, as in the case of the 2*xxx* alloys, scientists learned that control of the impurities and the relationship of the levels of certain minor elements added to the fracture toughness of alloys, making them especially useful for critical aerospace applications. Alloy 7175 has found most of its application in forgings, while 7475 is most often used in applications requiring sheet and plate. Designations 7275 and 7375 were assigned earlier but then discarded and are no longer in commercial use.

Links to Earlier Alloy Designations

For reference purposes, it is useful to note that prior to the development of the current Aluminum Association Alloy Designation System, another alloy designation system had been in place. Occasionally, a specification or a component turns up where the older designation still is evident, and it is useful to be able to bridge the gap.

The old system for wrought alloy designations consisted of a one or two digit number followed by a capital S. A capital letter in front of the alloy number was used to illustrate a variation of a basic composition. Because it lacked sufficient rigor, flexibility, and consistency, this system was abandoned in the 1950s and replaced by the current system.

When the four-digit system was installed, the letters were dropped, and the two surviving numbers became a part of the new system. For example, alloy 17S became alloy 2017, and similarly, alloy 24S became alloy 2024, as illustrated in Table 4, which provides a reference conversion showing both the current and original designations.

Unified Numbering System (UNS) Alloy Designation System for Wrought Alloys

The UNS alloy designation system, while not used in most domestic or international commerce, is sometimes cited for information purposes in domestic or international standards, including ASTM material specifications.

For both wrought and cast aluminum alloys, the UNS designation is based directly on the Aluminum Association alloy designation system. For wrought alloys, the UNS number is the Aluminum Association designation preceded by "A9." Thus, for example, alloy 2024 becomes A92024 in the UNS system; 7075 is A97075.

The Aluminum Association is the maintainer of the UNS designation system for aluminum alloys.

Table 4 Comparison of previous and current aluminum alloy designation systems

Old designation	Current designation
1S	1100
3S	3003
4S	3004
14S	2014
17S	2017
A17S	2117
24S	2024
25S	2025
26S	2026
32S	4032
50S	5050
B51S	6151
52S	5052
56S	5056
61S	6061
63S	6063
75S	7075
76S	7076

The Cast Alloy Series

The cast alloy designation series has a more complex and confusing history than the wrought alloy series, and so, in addition to describing the current alloy designations, some explanation will be given to the several variations of designations still rather widely applied to cast aluminum alloys. This is made more important because the most recent changes in the cast alloy designation system have occurred much more recently than those in the wrought alloy series, so there is a much higher probability that there are many parts in service and specified in drawings identified with earlier designations. There may be many individuals still unaware of the most recent changes.

In the material that follows, the current system is discussed first, followed by a look back at earlier designations systems.

How the Current Aluminum Cast Alloy Designation System is Applied

The cast alloy designation has four numbers, with a decimal point between the third and fourth numbers and a letter preceding the numbers to indicate variations. The first three numbers indicate the alloy, and the fourth indicates the product form.

The first digit identifies the family, based on the series listed in Table 5. For example, a 3*xx.x* designation represents the group of aluminum-silicon alloys that contain magnesium or copper. As with wrought alloy designations, when there are two major elements in equal percentage in

Table 5 Aluminum casting alloys

Series	Alloying element(s)
1*xx.x*	Unalloyed compositions
2*xx.x*	Copper
3*xx.x*	Silicon plus copper and/or magnesium
4*xx.x*	Silicon
5*xx.x*	Magnesium
6*xx.x*	Not used
7*xx.x*	Zinc
8*xx.x*	Tin
9*xx.x*	Other elements

the alloy, the alloy is designated in accordance with the sequence: copper, silicon plus copper and/or magnesium, silicon, magnesium, or zinc.

The second and third digits identify a specific alloy of the family. For all except the 1*xx.x* series, there is no special significance to those numbers; they neither indicate a sequence of any type nor represent any characteristic of the alloy. In some, though not all, instances, the numbers may refer back to an earlier designation system. In the 1*xx.x* series, the last two digits represent the percentage of aluminum present in terms of the two digits to the right of the decimal point in that percentage; for example, 160.0 represents a casting of 99.60% minimum aluminum, relatively high purity.

The final digit following the decimal indicates the product form−casting or ingot. If the designation applies to a finished casting, a zero always is used (*xxx*.0); if it applies to the ingot from which the casting was or will be produced, a 1 or 2 is used (*xxx*.1 or *xxx*.2). In the latter case, the *xxx*.1 designation is the most common and refers to the common commercial composition. The *xxx*.2 designation usually is limited to those cases where a narrower composition range of one or more of the elements—all within the composition limits for the *xxx*.1 version—is used to achieve special properties.

As an example, alloy 356.0 represents a finished casting of the silicon plus copper and/or magnesium series. The designation 356.1 normally would represent the ingot from which the 356.0 casting was made.

Prefix letters such as A or B indicate variations in the composition of casting alloys, but overall similarity. Continuing the example above, alloy A356.0 indicates a variation of 356.0 alloy, but with tighter controls on iron and other impurities. The ingot from which the A356.0 was made may be designated A356.1 or 356.2, both indicating the tighter control at the ingot stage.

Understanding Cast Alloy Strengthening Mechanisms

As with wrought alloys, we can note several major characteristics of casting alloys by their alloy class, the first digit of the designation. Response to heat treatment is one important characteristic:

- *1xx.0:* Unalloyed; non-heat-treatable
- *2xx.0:* Copper; heat treatable
- *3xx.0:* Silicon plus copper and/or magnesium; heat treatable
- *4xx.0:* Silicon; heat treatable
- *5xx.0:* Magnesium; non-heat-treatable
- *6xx.0:* Unused series
- *7xx.0:* Zinc; heat treatable
- *8xx.0:* Tin; heat treatable
- *9xx.0:* Other elements; limited use

Despite these descriptive categorizations, it is appropriate to note that while casting alloys of the 3*xx*.0 and 4*xx*.0 groupings are listed as heat treatable, it is not customary in the die-casting industry to use separate solution heat treatment for these alloys. Some strength advantage is gained by the rapid cooling from the casting process, but even this is not usually a closely controlled procedure. On the other hand, sand and permanent mold castings foundries typically take advantage of solution heat treating capabilities.

The reader also will note that there is no discussion of strain hardening as a strengthening mechanism for cast alloys. This is simply because the vast majority of castings are produced to near-finished dimensions, and neither the shapes nor the dimensional controls lend themselves to stretching or compression cold work.

Understanding Cast Alloy Advantages and Limitations

Based upon the effects of the primary alloying elements, some generalizations may be made about several characteristics of the major classes of aluminum casting alloys. Among the most important such characteristics are those related to castability and to end-product properties and characteristics, as illustrated in Table 6, with ratings from 1 (highest or best) to 5 (lowest or worst). Such ratings are generalizations, and some individual alloys in the groups may exhibit somewhat different behavior.

Table 6 Characteristic ratings for cast aluminum alloys

Class	Fluidity	Cracking	Tightness	Corrosion	Finishing	Joining
1*xx*.0				1	1	1
2*xx*.0	3	4	3	4	1–3	2–4
3*xx*.0	1–2	1–2	1–2	2–3	3–4	1–3
4*xx*.0	1	1	1	2–3	4–5	1
5*xx*.0	5	4	4–5	3	1–2	3
7*xx*.0	3	4	4	4	1–2	4
8*xx*.0	4	5	5	5	3	5

Examples of the Use of Variations in Cast Alloy Designations

In the cast alloy designations more so than in the wrought series, letter prefixes are used to indicate variations. As noted earlier, an excellent example is illustrated by A356.0 as a variation of 356.0. Both are readily castable into complex shapes, but 356.0, because of the relatively greater impurity levels tolerated by its specifications (e.g., 0.6% Fe max), may be more variable in quality, including reduced ductility and toughness. A356.0 is a variation of 356.0 where iron and other impurities are controlled to lower levels (e.g., 0.20% Fe max) with the result that appreciably higher strength, ductility, and toughness are reliably provided.

Another example is A357.0 as a low-impurity variation of 357.0, for which the situation is quite parallel.

Alloys for Different Casting Processes

There are a variety of processes that can be employed to produce aluminum cast parts, as described in Chapter 5. While many of the alloys can be produced from a wide variety of these processes, commercial die castings are generally limited to a relatively small number of compositions, namely, 360.0, A360.0, 380.0, A380.0, 383.0, 384.0, A384.0, B390.0, 413.0, C443.0, and 518.0.

Other Characteristics Related to Composition

As with wrought alloys, both density and elastic modulus are directly related to composition, and the same procedures and rules apply. Reference is thus made to an earlier section in this chapter, "Other Characteristics Related to Principal Alloying Element," and to Tables 2 and 3 for the procedures on how to estimate these properties from the compositions.

Evolution of the Aluminum Cast Alloy Designation System

For reference purposes, when links to earlier alloy designation systems are required, it is useful to note that there have been two gradual transitions in casting alloy designations. Originally, casting alloys were specified by a rather randomly applied two- or three-digit designation, without consistent relationships to major alloying elements.

Around 1950, with the increased wrought alloy standardization, there began the tendency to standardize casting alloys with three digits, often with the aforementioned letter prefixes, but there were still few specific rules or guidelines guiding alloy designation uniformity.

When the current system was adopted in about 1980, the change was both to reform the series designations to make it more reliable and consistent with regard to alloying constituents and to add the fourth digit, which included the precursor casting ingot from which the castings are made. Therefore, at that time, castings designated as 356 castings became 356.0, and A356 castings became A356.0; the ingot from which they were made became 356.1, A356.1, or 356.2, respectively. For some other alloys placed in the wrong series initially, the change was more drastic: alloy 108 became 208.0, alloy 43 became 443.0 (or B443.0), and B214 became 512.0.

A summary of some of the major changes over this period is shown in Table 7. Included in this table are both the current and former designations used within the industry, as well as the former designations followed by federal, ASTM, and SAE specifications.

Regrettably, unlike the case with wrought alloys, the current cast alloy designations are not so widely accepted throughout the world, and in fact, they are not universally accepted even in the United States. While the American Foundrymen's Society (AFS) and the Non-Ferrous Founders' Society (NFFS) accept and use the Aluminum Association/ANSI cast alloy designation system, even the 1996 publications of the Die Casting Development Council still report cast alloy designations without the decimal point and the fourth digit and, more surprisingly, refer to the alloy designations used before the alloy series were rationalized by major alloying element.

UNS Alloy Designation System for Cast Alloys

As noted earlier, the UNS alloy designation system for cast aluminum alloys, as for wrought aluminum alloys, is based directly on the Aluminum Association alloy designation system. For cast alloys, the Aluminum Association alloy designation is preceded by "A" followed by a "0" (zero) if there is no letter preceding the alloy designation, or by 1, 2, 3, and so on, representing the letter of the alphabet used. No period is used, as in the Aluminum Association casting alloy designation. So, for example, 356.0 becomes A03560, A356.0 becomes A13560, and B518.0 becomes A25180.

Table 7 Cross reference chart of aluminum casting alloy designations

AA/ANSI	Former	UNS	Federal	Old ASTM	Old SAE
201.0	. . .	A02010	. . .	CQ51A	382
204.0	. . .	A02040	. . .	. . .	. . .
208.0	108	A02080	108	CS43A	. . .
213.0	C113	A02130	C113	CS74A	33
222.0	122	A02220	122	CG100A	34
242.0	142	A02420	142	CN42A	39
295.0	195	A02950	195	C4A	38
296.0	B295	A02960	B295	. . .	380
308.0	A108	A03080	A108	. . .	. . .
319.0	319, Allcast	A03190	319	SC64D	326
328.0	Red X-8	A03280	Red X-8	SC82A	327
332.0	F332.0	A03320	F132	SC103A	332
333.0	333	A03330	333	SC94A	331
336.0	A332.0	A03360	A132	SN122A	321
354.0	354	A03540	. . .	. . .	. . .
355.0	355	A03550	355	SC51A	322
C355.0	C355	A33550	C355	SC51B	335
356.0	356	A03560	356	SG70A	323
A356.0	A356	A13560	A356	SG70B	336
357.0	357	A03570	357	. . .	. . .
A357.0	A357	A13570	. . .	. . .	. . .
359.0	359	A03590	. . .	. . .	. . .
360.0	360	A03600	360	SG100B	. . .
A360	A360	A13600	A360	SG100A	309
380.0	380	A03800	380	SC84B	308
A380	A380	A13800	A380	SC84A	306
383.0	383	A03830	383	SC102	383
384.0	384	A0384	384	SC114A	303
B390.0	390	A23900	390	SC174B	. . .
413.0	13	A04130	13	S12B	. . .
A413.0	A13	A14130	A13	S12A	305
443.0	43	A04430	. . .	S5B	35
B443.0	43	A24430	43	S5A	. . .
C443.0	43	A34430	43	S5C	304
A444.0	. . .	A14440	. . .	. . .	. . .
512.0	B514.0	A05120	B214	GS42A	. . .
513.0	A514.0	A05130	A214	GZ42A	
514.0	214	A05140	214	G4A	320
518.0	218	A05180	218	G8A	. . .
520.0	220	A05200	220	G10A	324
535.0	Almag 35	A05350	Almag 35	GM70B	. . .
705.0	603, Ternalloy 5	A07050	Ternalloy 5	ZG32A	311
707.0	607, Ternalloy 7	A07070	Ternalloy 7	ZG42A	312
710.0	A712.0	A07100	A612	ZG61B	313
711.0	C721.0	A07110	. . .	ZC60A	314
712.0	D712.0	A07120	40E	ZG61A	310
713.0	613, Tenzaloy	A07130	Tenzaloy	ZC81A	315
771.0	Precedent 71A	A07710	Precedent 71A	. . .	. . .
850.0	750	A08500	750	. . .	. . .
851.0	A850.0	A08510	A750	. . .	. . .
852.0	B850.0	A08520	B750	. . .	. . .