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MILITARY STANDARDIZATION HANDBOOK

ALUMINUM AND ALUMINUM ALLOYS

MISC

DEPARTMENT OF DEFENSE
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Aluminum and Aluminum Alloys
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1. This standardization handbook was developed by the Department of Defense in accordance with established procedure.

2. This publication was approved on 15 December 1966 for printing and inclusion in the military standardization handbook series.

3. This document provides basic and fundamental information on aluminum and aluminum alloys for the guidance of engineers and designers of military materiel. The handbook is not intended to be referenced in purchase specifications *except for informational purposes, nor shall it supersede any specification requirements.*

4. Every effort has been made to reflect the latest information on aluminum and aluminum alloys. It is the intent to review this handbook periodically to insure its completeness and currency. Users of this document are encouraged to report any errors discovered and any recommendations for changes or inclusions to the Commanding Officer, U. S. Army Materials Research Agency, Watertown, Mass., 02172. Attn: AMXMR-TMS.

Preface

This is one of a group of handbooks covering metallic and nonmetallic materials used in the design and construction of military equipment.

The purpose of this handbook is to provide, in condensed form, technical information and data of direct usefulness to design engineers. The data, especially selected from a very large number of industrial and government publications, have been checked for suitability for use in design. Wherever practicable the various types, classes, and grades of materials are identified with applicable government specifications. The corresponding technical society specifications and commercial designations are shown for information.

The numerical values for properties listed in this handbook, which duplicate specification requirements, are in agreement with the values in issues of the specifications in effect at the date of this handbook. Because of revisions or amendments to specifications taking place after publication, the values may, in some instances, differ from those shown in current specifications. In connection with procurement, it should be understood that the governing requirements are those of the specifications of the issue listed in the contract.

Wherever specifications are referred to in this handbook, the basic designation only is shown, omitting any revision or amendment symbols. This is done for purposes of simplification and to avoid the necessity for making numerous changes in the handbook whenever specifications are revised or amended.

Current issues of specifications should be determined by consulting the latest issue of the "Department of Defense Index of Specifications and Standards."

The material in the text is based on the literature listed in the bibliography. It is subdivided into four sections:

- Section I - Aluminum in Engineering Design
- Section II - Standardization Documents
- Section III - Typical Properties of Aluminum and Aluminum Alloys
- Section IV - Specification Requirements.

Comments on this handbook are invited. They should be addressed to Commanding Officer, U. S. Army Materials Research Agency, Watertown, Mass. 02172. Attn: AMXMR-TMS.

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Aluminum in Engineering Design

GENERAL

1. **Characteristics.** Aluminum alloys are used in engineering design chiefly for their light weight, high strength-to-weight ratio, corrosion resistance, and relatively low cost. They are also utilized for their high electrical and thermal conductivities, ease of fabrication, and ready availability. (Aluminum is the most widely distributed of the elements, except for oxygen, nitrogen, and silicon.)

Aluminum alloys weigh about 0.1 pound per cubic inch. This is about one-third the weight of iron at 0.28 pound and copper at 0.32, is slightly heavier than magnesium at 0.066, and somewhat lighter than titanium at 0.163.

In its commercially pure state, aluminum is a relatively weak metal, having a tensile strength of approximately 13,000 psi. However, with the addition of small amounts of such alloying elements as manganese, silicon, copper, magnesium, or zinc, and with the proper heat treatment and/or cold working, the tensile strength of aluminum can be made to approach 100,000 psi. Figure 1 shows some typical mechanical property values required by current Government specifications.

Corrosion resistance of aluminum may be attributed to its self-healing nature, in which a thin, invisible skin of aluminum oxide forms when the metal is exposed to the atmosphere. Pure aluminum will form a continuous protective oxide film – i.e., corrode uniformly – while high-strength alloyed aluminum will sometimes become pitted as a result of localized galvanic corrosion at sites of alloying-constituent concentration.

As a conductor of electricity, aluminum competes favorably with copper. Although the conductivity of the electric-conductor grade of aluminum is only 62 percent that of the International Annealed Copper Standard (IACS), on a pound-for-pound basis the power loss for aluminum is less that half that of copper – an advantage where weight and cost are the governing factors rather than space requirements.

As a heat conductor, aluminum ranks high among the metals. It is especially useful in heat exchangers and in other applications requiring rapid dissipation.

As a reflector of radiant energy, aluminum is excellent throughout the entire range of wavelengths, from the ultraviolet end of the spectrum through the visible and infrared bands to the electromagnetic wave frequencies of radio and radar. As an example, its reflectivity in the visible range is over 80 percent.

Aluminum is easily fabricated – one of its most important assets. It can be cast by any method known to the foundryman; it can be rolled to any thickness, stamped, hammered, forged, or extruded. Aluminum is readily turned, milled, bored, or machined at the maximum speeds of

Property	Cast	Wrought
Tensile Strength, min. psi	42,000	80,000
Yield Strength, min. psi	22,000	72,000
Endurance Limit, min. psi	13,500	24,000
Elongation, percent	6	varies markedly
Modulus of Elasticity	9.9 million to 11.4 million (usually taken as 10.3 million)	

FIGURE 1. Typical Mechanical Property Values

which most machines are capable, and is adaptable to automatic screw machine processing. Aluminum can be joined by almost any method – riveting; gas, arc, or resistance welding; brazing; and adhesive bonding.

Finally, aluminum can be coated with a wide variety of surface finishes for decorative as well as protective purposes. In addition to the more common chemical, electrochemical, and paint finishes, vitreous enamels – specially developed for aluminum – can be applied.

2. Economic Considerations. The cost of aluminum is relative, and should not be determined by the price of the base metal alone. Advantages in the processing of aluminum can materially contribute to the reduction of the cost of the end item. Therefore, the overall cost should be judged in relation to the finished product.

Many aluminum alloys have wide property ranges as a result of tempers attainable through treatment, both thermal and mechanical. With these wide ranges, much overlapping of properties exists among the various alloys thus making available a large number of compositions from which to choose. This increased selection provides for a greater latitude in the choice of fabricating techniques, and permits the selection of the most economical method.

In the fabrication of aluminum products, the economies effected may be more than enough to overcome other cost disparities. The ease with which the metal can be machined, finished, polished, and assembled permits a reduction of the time, material, labor, and equipment required for the product. Coupled with these assets are the advantages of light weight, which often can be of considerable importance in the cost of handling, shipping, storage, or assembly of the end item.

CLASSES OF ALUMINUM AND ALUMINUM ALLOY

3. Types Available. Aluminum is available in various compositions, including "pure" metal, alloys for casting, and alloys for the manufacture of wrought products. (Alloys for casting are normally different from those used for rolling, forging, and other working.) All types are produced in a wide variety of industrial shapes and forms.

4. "Pure" Aluminum. Pure aluminum is available both as a high-purity metal and as a commercially pure metal. Both have relatively low strength, and thus have limited utility in engineering design, except for applications where good electrical conductivity, ease of fabrication, or high resistance to corrosion are important. Pure aluminum is not heat treatable. However, its mechanical properties may be varied by strain hardening (cold work). Pure aluminum exhibits poor casting qualities; it is employed chiefly in wrought form. Commercially pure aluminum is available as foil, sheet and plate, wire, bar, rod, tube, and as extrusions and forgings.

5. Casting Alloys. The aluminum alloys specified for casting purposes contain one or more alloying elements, the maximum of any one element not exceeding 12 percent. Some alloys are designed for use in the as-cast condition; others are designed to be heat treated to improve their mechanical properties and dimensional stability. High strength, together with good ductility, can be obtained by selection of suitable composition and heat treatment.

Aluminum casting alloys are usually identified by arbitrarily selected, commercial designations of two- and three-digit numbers. These designations are sometimes preceded by a letter to indicate that the original alloy of the same number has been modified. (See table I.)

6. Wrought Alloys. Most aluminum alloys used for wrought products contain less than 7 percent of alloying elements. By the regulation of the amount and type of elements added, the properties of the aluminum can be enhanced and its working characteristics improved. Special compositions have been developed for particular fabrication processes such as forging and extrusion.

As with casting alloys, wrought alloys are produced in both heat-treatable and non-heat-treatable types. The mechanical properties of the non-heat-treatable type may be varied by strain-hardening, or by strain-hardening followed by partial annealing. The mechanical properties of the heat-treatable types may be improved by quenching from a suitable temperature and then aging. With the heat-treatable alloys, especially desirable properties may be obtained by a combination of heat treatment and strain hardening.

ALUMINUM ASSOCIATION DESIGNATIONS FOR ALLOY GROUPS		① AA No
Aluminum - 99.00% minimum and greater		1xxx
	Major Alloying Element	
Aluminum Alloys grouped by major Alloying Elements	Copper	2xxx
	Manganese	3xxx
	Silicon	4xxx
	Magnesium	5xxx
	Magnesium and Silicon	6xxx
	Zinc	7xxx
	Other Elements	8xxx
Unused Series		9xxx

① Only compositions conforming to those listed in the chemical composition of Table III or are registered with The Aluminum Association should bear the prefix "AA".

FIGURE 2. Wrought Aluminum and Aluminum Alloy Designations

The principal wrought forms of aluminum alloys are plate and sheet, foil, extruded shapes, tube, bar, rod, wire and forgings. (See table II.)

Wrought aluminum alloys are designated by four-digit numbers assigned by the Aluminum Association. The first digit indicates the alloy group; the second digit indicates modifications of the original alloy (or impurity limits); the last two digits identify the aluminum alloy or indicate the aluminum purity. The system of designating alloy groups is shown in figure 2. Experimental alloys are also designated in accordance with this system, but their numbers are prefixed by the letter X. This prefix is dropped when the alloy becomes standard. Chemical composition limits of wrought aluminum alloys are given in table III. Tables IV and V provide a cross reference between designations under Government and industrial standards.

PROPERTIES OF ALUMINUM

7. **Physical Properties.** The ranges of the physical properties of aluminum are shown in figure 3. Those properties which may assume importance in considering particular applications are indicated in tables VI and VII.

8. **Mechanical Properties.** The wide range of mechanical properties of aluminum alloys depends upon composition, heat treatment, cold working, and other factors. Some properties may also vary appreciably in identical compositions according to the type of product or processing history. It is, therefore, essential to define the form of material in addition to the alloy.

Aluminum alloys are restricted in use to only moderately elevated temperatures because of their relatively low melting point; 900°F (482°C) to 1200°F (649°C). Some aluminum alloys begin to soften and weaken appreciably at temperatures as low as 200°F (93°C); others maintain strength fairly well at temperatures up to 400°F (204°C). (See tables VIII, IX and X.)

The strength, hardness, and modulus of elasticity of aluminum alloys decrease with rising temperatures. Elongation increases with rising temperatures (until just below the melting point when it drops to zero). Some alloys have been developed especially for high-temperature service. These include alloys 2018, 2218, and 4032 in QQ-A-367 for forgings, alloy 142 in QQ-A-601 for sand castings, and classes 3, 9, and 10 in QQ-A-596 for permanent-mold castings.

PHYSICAL PROPERTIES				
Property	Range		Notes	
	Cast Alloys	Wrought Alloys		
Specific Gravity	2.57 to 2.95	2.70 to 2.82	About 1/3 that of steel.	
Weight (pounds per cubic inch)	0.093 to 0.107	0.095 to 0.102	Approximately 173 pounds per cubic foot.	
Electrical Conductivity (International Annealed Copper Standard)	21% to 47%	30% to 60%	About 59% for 99.9% aluminum	Values for electrical and thermal conductivity depend upon the composition and condition of the alloys. Both are increased by annealing, and decreased by adding alloying elements to pure (99.0%) aluminum. Both are also decreased by heat treatment, cold work, and aging.
Thermal Conductivity (cgs units at 77 deg. F.)	0.21 to 0.40	0.29 to 0.56	About 0.53 for 99.0% aluminum	
Thermal Expansion (average coefficient between the range of 68 deg. and 212 deg. F.)	11.0 to 14.0	10.8 to 13.2	Roughly double that of ordinary steels and cast irons; substantially greater than copper-alloy materials. Alloying elements other than silicon have little effect on the expansion of aluminum. Considerable amounts of silicon (12%) appreciably decrease the dimensional changes induced by varying temperatures. Where a low coefficient of thermal expansion is desirable, as in engine pistons, an aluminum alloy containing a relatively high percentage of silicon may be specified.	
Reflectivity	–	–	Greater than any other metal. Suitably treated, aluminum sheet of high purity may yield a reflectivity for light greater than 80%. Used for shields, reflectors, and wave guides in radio and radar equipment.	

FIGURE 3. Physical Property Ranges

Creep and stress-rupture data, which are of interest when considering aluminum for some applications at elevated temperatures, are contained in References 16, 17, 44, and 46 of the Bibliography. From the design curves, which show stress versus time for total deformation in percent for various temperatures, minimum creep rates may be compared.

The mechanical properties of aluminum tend to improve as the temperature is lowered. Tests at temperatures down to -320°F (-196°C) show that with a decrease in temperature, there is a corresponding increase in strength and elongation. There is also an increase in modulus of elasticity (table XI) and in fatigue strength (table XII), and no evidence of low-temperature embrittlement.

Values for the various properties of aluminum alloys are given in Section II (typical values) and Section III (specification requirements). Unless otherwise stated, the tensile and compressive yield strengths correspond to 0.2 percent offset; elongation refers to gage length of 2 inches; Brinell hardness number is for a 500-kg load with a 10-mm ball; and endurance limit is based on 500 million cycles of completely reversed stress, using the R.R. Moore type of machine and specimen.

The following values generally apply to aluminum alloys:

Modulus of elasticity (tension and compression), psi . . . . 10.3×10^6

Modulus of rigidity, psi . . . . 3.9×10^6

Poisson's ratio 0.33

Torsional yield strength, percent of tensile yield strength 55

Ultimate torsional strength, percent of ultimate tensile strength 65

The mechanical properties of wrought alloys (table XIII) may be affected appreciably by the form, thickness, and direction of fabrication. Normally, tensile properties of commercial wrought materials are based on test data obtained on 1/2-inch diameter test specimens cut from production materials. Small sizes, such as wire, bar, and rod, as well as tube, are usually tested full size, The types of test specimens acceptable under Government specifications are illustrated in Fed. Test Method Std. No. 151.

The tensile properties of cast alloys (tables XIV, XV, and XVI), as ordinarily reported, are obtained from tests on 1/2-inch diameter test specimens separately cast under standard conditions of solidification. These specimens serve as controls of the metal quality, but their properties do not necessarily represent those of commercial castings. (The properties may be higher or lower depending on the factors that influence the rate of solidification in the mold.) Likewise, the properties of test specimens cut from a single casting may vary widely, depending on their location within the casting. Usually, the average strength of several test specimens taken from various locations in the casting – so that thick, thin, and intermediate sections are represented – will be at least 75 percent of the strength of the separately cast bars.

TEMPER DESIGNATION SYSTEM

9. **Temper Designations**. The following temper designations indicate mechanical or thermal treatment of the alloy. The temper designation shall follow the four-digit alloy designation and shall be separated from it by a dash, i.e., 2024-T4. Basic temper designations consist of letters. Subdivisions of the basic tempers, where required, are indicated by one or more digits following the letter. These designate specific sequences of basic treatments, but only operations recognized as significantly influencing the characteristics of the product are indicated. Should some other variation of the same sequence of basic operations be applied to the same alloy, resulting in different characteristics, then additional digits are added to the designation.

The basic temper designations and subdivisions are as follows:

-F As Fabricated. Applies to products which acquire some temper from shaping processes not having special control over the amount of strain-hardening or thermal treatment. For wrought products, there are no mechanical property limits.

-O Annealed, recrystallized (wrought products only). Applies to the softest temper of wrought products.

-H Strain-Hardened (Wrought Products Only). Applies to products which have their strength increased by strain-hardening with or without supplementary thermal treatments to produce partial softening. The -H is always followed by two or more digits. The first digit indicates the specific combination of basic operations as follows:

-H1 Strain-Hardened Only. Applies to products which are strain-hardened to obtain the desired mechanical properties without supplementary thermal treatment. The number following the designation indicates the degree of strain-hardening.

-H2 Strain-Hardened and then Partially Annealed. Applies to products which are strain-hardened more than the desired final amount and then reduced in strength to the desired level by partial annealing. For alloys that age-soften at room temperature, the -H2 tempers have approximately the same ultimate strength as the corresponding -H3 tempers. For other alloys, the -H2 tempers have approximately the same ultimate strength as the corresponding -H1 tempers and slightly higher elongations. The number following this designation indicates the degree of strain-hardening remaining after the product has been partially annealed.

-H3 Strain-Hardened and then Stabilized. Applies to products which are strain-hardened and then stabilized by low temperature heating to slightly lower their strength and increase ductility. The designation applies only to the magnesium-containing alloys which, unless stabilized, gradually age-soften at room temperature. The number following this designation indicates the degree of strain-hardening remaining after the product has been strain-hardened a specific amount and then stabilized.

The digit following the designations -H1, -H2, and -H3 indicates the final degree of strain-hardening. The hardest commercially practical temper is designated by the numeral 8 (full hard). Tempers between -0 (annealed) and 8 (full hard) are designated by numerals 1 through 7. Materials having an ultimate strength about midway between that of the -0 temper and that of and 8 temper is designated by the numeral 4 (half hard); between -0 and 4 by the numeral 2 (quarter hard); between 4 and 8 by the numeral 6 (three-quarter hard); etc. Numeral 9 designates extra hard tempers.

The third digit, when used, indicates that the degree of control of temper or the mechanical properties are different from, but within the range of, those for the two-digit -H temper designation to which it is added. Numerals 1 through 9 may be arbitrarily assigned and registered with The Aluminum Association for an alloy and product to indicate a specific degree of control of temper or specific mechanical property limits. Zero has been assigned to indicate degrees of control of temper, or mechanical property limits negotiated between the manufacturer and purchaser which are not used widely enough to justify registration with The Aluminum Association.

The following three-digit -H temper designations have been assigned for wrought products in all alloys:

-H111 Applies to products which are strain-hardened less than the amount required for a controlled H11 temper.

-H112 Applies to products which acquire some temper from shaping processes not having special control over the amount of strain-hardening or thermal treatment, but for which there are mechanical property limits or mechanical property testing is required.

-H311 Applies to products which are strain-hardened less than the amount required for a controlled H31 temper.

The following three-digit -H temper designations have been assigned for:

a. Patterned or Embossed Sheet	b. Fabricated From
-H114	-0 temper
-H134, -H234, -H334	-H12, -H22, -H32 temper, respect.
-H154, -H254, -H354	-H14, -H24, -H34 temper, respect.
-H174, -H274, -H374	-H16, -H26, -H36 temper, respect.
-H194, -H294, -H394	-H18, -H28, -H38 temper, respect.
-H195, -H395	-H19, -H39 temper, respect.

-W Solution Heat-Treated. An unstable temper applicable only to alloys which spontaneously age at a room temperature after solution heat-treatment. This designation is specific only when the period of natural aging is indicated; for example, -W 1/2 hour.

-T Thermally Treated to Produce Stable Tempers Other than -F, -O, or -H. Applies to products which are thermally treated, with or without supplementary strain-hardening to produce stable tempers. The -T is always followed by one or more digits. Numerals 2 through 10 have been assigned to indicate specific sequences of basic treatment, as follows:

-T2 Annealed (Cast Products Only). Designates a type of annealing treatment used to improve ductility and increase dimensional stability of castings.

-T3 Solution Heat-treated and then Cold Worked. This designation applies to products which are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in applicable specifications.

-T4 Solution Heat-treated and Naturally Aged to a Substantially Stable Condition. Applies to products which are not cold worked after solution heat-treatment, but in which the effect of cold work in flattening or straightening may be recognized in applicable specifications.

-T5 Artificially Aged Only. Applies to products which are artificially aged after an elevated-temperature rapid-cool fabrication process, such as casting or extrusion, to improve mechanical properties and/or dimensional stability.

-T6 Solution Heat-Treated and then Artificially Aged. Applies to products which are not cold worked after solution heat treatment, but in which the effect of cold work in flattening or straightening may be recognized in applicable specifications.

-T7 Solution Heat-Treated and then Stabilized. Applies to products which are stabilized to carry them beyond the point of maximum hardness, providing control of growth and/or residual stress.

-T8 Solution Heat-Treated, Cold Worked, and then Artificially Aged. Applies to products which are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in applicable specifications.

-T9 Solution Heat-Treated, Artificially Aged, and then Cold Worked. Applies to products which are cold worked to improve strength.

-T10 Artificially Aged and then Cold Worked. Applies to products which are artificially aged after an elevated-temperature rapid-cool fabrication process, such as casting or extrusion, and then cold worked to improve strength.

A period of natural aging at room temperature may occur between or after the operations listed for tempers -T3 through -T10. Control of this period is exercised when it is metallurgically important.

Additional digits may be added to designations -T2 through -T10 to indicate a variation in treatment which significantly alters the characteristics of the product. These may be arbitrarily assigned and registered with The Aluminum Association for an alloy and product to indicate a specific treatment or specific mechanical property limits.

The following additional digits have been assigned for wrought products in all alloys:

-TX51 Stress-Relieved by Stretching. Applies to products which are stress-relieved by stretching the following amounts after solution heat-treatment:

Plate — 1½ to 3% permanent set

Rod, Bar and Shapes — 1 to 3% permanent set

Applies directly to plate and rolled or cold-finished rod and bar. These products receive no further straightening after stretching. Applies to extruded rod, bar and shapes when designated as follows:

-TX510 Applies to extruded rod, bar and shapes which receive no further straightening after stretching.

-TX511 Applies to extruded rod, bar and shapes which receive minor straightening after stretching to comply with standard tolerances.

-TX52 Stress-Relieved by Compressing. Applies to products which are stress-relieved by compressing after solution heat-treatment.

-TX53 Stress-Relieved by Thermal Treatment.

The following two-digit -T temper designations have been assigned for wrought products in all alloys:

-T42 Applies to products solution heat-treated by the user which attain mechanical properties different from those of the -T4 temper.*

-T62 Applies to products solution heat-treated and artificially aged by the user which attain mechanical properties different from those of the -T6 temper.*

*Exceptions not conforming to these definitions are 4032-T62, 6101-T62, 6061-T62, 6063-T42 and 6463-T42. The tempers are developed for special applications and are not normally considered for military applications.

HEAT TREATMENT

10. Effects of Heat Treatment. The heat treatment processes, commonly used to improve the properties of aluminum alloys, are: solution heat treatment, precipitation hardening (age hardening), and annealing.

Solution heat treatment is used to redistribute the alloying constituents that segregate from the aluminum during cooling from the molten state. It consists of heating the alloy to a temperature at which the soluble constituents will form a homogeneous mass by solid diffusion, holding the mass at that temperature until diffusion takes place, then quenching the alloy rapidly to retain the homogeneous condition.

In the quenched condition, heat-treated alloys are supersaturated solid solutions that are comparatively soft and workable, and unstable, depending on composition. At room temperature, the alloying constituents of some alloys (W temper) tend to precipitate from the solution spontaneously, causing the metal to harden in about four days. This is called natural aging. It can be retarded or even arrested to facilitate fabrication by holding the alloy at sub-zero temperatures until ready for forming. Other alloys age more slowly at room temperature, and take years to reach maximum strength and hardness. These alloys can be aged artificially to stabilize them and improve their properties by heating them to moderately elevated temperatures for specified lengths of time.

A small amount of cold working after solution heat treatment produces a substantial increase in yield strength, some increase in tensile strength, and some loss of ductility. The effect on the properties developed will vary with different compositions.

Annealing is used to effect recrystallization, essentially complete precipitation, or to remove internal stresses. (Annealing for obliterating the hardening effects of cold working, will also remove the effects of heat treatment.) For most alloys, annealing consists of heating to about 650°F (343°C) at a controlled rate. The rate is dependent upon such factors as thickness, type of anneal desired, and method employed. Cooling rate is not important, but drastic quenching is not recommended because of the strains produced.

11. Effects of Quenching. Quenching is the sudden chilling of the metal in oil or water. Quenching increases the strength and corrosion resistance of the alloy. The structure and the distribution of the alloying constituents that existed at the temperature just prior to cooling are "frozen" into the metal by quenching. The properties of the alloy are governed by the composition and characteristics of the alloy, the thickness of cross section, and the rate at which the metal is cooled. The rate is controlled by proper choice of both type and temperature of cooling medium.

Rapid quenching, as in cold water, will provide maximum corrosion resistance, and is used for items produced from sheet, tube, extrusions, and small forgings, and is preferred to a less drastic quench which would increase the mechanical properties. The slower quench, which is done in hot or boiling water, is used for heavy sections and large forgings; it tends to minimize distortion and cracking which result from uneven cooling. (The corrosion resistance of forging alloys is not affected by the temperature of the quench water; also the corrosion resistance of thicker sections is generally less critical than that of thinner ones.)

FORMABILITY

12. Factors Affecting Formability. Aluminum alloys can be formed hot or cold by common fabricating processes. In general, pure aluminum is more easily worked than the alloys, and annealed tempers are more easily worked than the hard tempers. Also, the naturally aged tempers afford better formability than the artificially aged tempers. For example, the 99-percent metal (alloy 1100, QQ-A-250/1) in the annealed temper, "-O", has the best forming characteristics; alloy 7075 (QQ-A-250/12) in the full heat-treated temper, "-T6", is the most difficult to form because of its hardness.

In the process of forming, the metal hardens and strengthens by reason of the working effect. In cold drawing, the changes in tensile strength and other properties can become quite large, depending upon the amount of work and on the alloy composition used. In bending, which is another form of cold working, the bend radius and the thickness of the metal are also factors that must be considered. (Refer to table XVII which gives the permissible bend radii for 90-degree bends in terms of sheet thickness.)

Most forming of aluminum is done cold. The temper chosen usually permits the completion of the fabrication without the necessity of any intermediate annealing. In some difficult drawing operations, however, intermediate annealing may be required between successive draws.

Hot forming of aluminum is usually done at temperatures of 300°F (149°C) to 400°F (204°C). At these temperatures the metal is readily worked, and its strength is not reduced appreciably, provided the heating periods are no more than 15 to 30 minutes. In general, a combination of the shortest possible time with the lowest temperature which will give the desired results in forming is the best.

Forming is also done in the as-quenched condition on those alloys that age spontaneously at room temperature after solution heat treatment ("-W" temper). In these instances the quenched metal is refrigerated to retard hardening until forming is complete.

The selection of the proper temper is important when specifying aluminum for forming operations. When non-heat-treatable alloys are to be formed, the temper chosen should be just sufficiently soft to permit the required bend radius or draw depth. In more difficult forming operations material in the annealed temper "-O" should be used; for less severe forming requirements, material in one of the harder tempers, such as "-H14", may be handled satisfactorily.

When heat-treatable alloys are to be used for forming, the shape should govern the selection of the alloy and its temper. Maximum formability of the heat-treatable alloys is attained in the annealed temper. However, limited formability can be effected in the fully heat-treated temper, provided the bend radii are large enough.

A clue to the formability of an alloy may be found in the percent of elongation, and in the difference between the yield strength and the ultimate tensile strength. As a rule, the higher the elongation value or the wider the range between the yield and tensile strengths, the better the forming characteristics.

MACHINABILITY

13. Factors Affecting Machinability. Machinability is the ease with which a material can be finished by cutting. Good machinability is characterized by a fast cutting speed, small chip size, smoothness of surface produced, and good tool life. Some aluminum alloys are excellent for machining; others are more troublesome. The troublesome ones are soft and "gummy", producing chips that are long and stringy, and the cutting rates are slow. The harder alloys and the harder tempers afford better machinability. The machinability of forging alloys are rated in table XVIII.

In general, alloys containing copper, zinc, or magnesium as the principal added constituents are the most readily machined. Other compositions (such as alloy 2011, QQ-A-225/3), containing bismuth and lead, are also unusually machinable, being specially designed for high-speed screw-machine work. Compositions containing more than 10 percent silicon are ordinarily the most difficult to machine. (Even alloys containing 5 percent silicon do not machine to a bright, lustrous finish, but exhibit a gray surface.)

Wrought alloys that have been heat treated have fair to good machining characteristics. These are easier to machine to a good finish in the full-hard temper than when annealed. Wrought alloys that are not heat treated, regardless of temper, tend to be gummy. Also, wrought compositions that contain copper as the principal alloying element are more easily machined than those that have been hardened mainly by magnesium silicide.

JOINING

14. Joining Methods. Aluminum and its alloys may be joined by a number of processes. The choice of method depends on the design, the material to be joined, the strength requirements, and the service conditions to be encountered. The methods available include riveting, welding, brazing, soldering, and adhesive bonding.

15. Riveting. Riveting is a commonly used method of joining aluminum. When done properly, riveting can produce extremely dependable and consistently uniform joints without affecting the strength or other characteristics of the metal. However, it is more time consuming and creates bulkier joints than those made by other methods. Also, riveting requires care in the formation of the rivet holes, in the selection of the size and length of rivets, and in the choice of the rivet alloy and temper.

The selection of the size of rivet is not governed by hard-and-fast rules. However, the diameter and the length of the rivet should be such that the sheet is not damaged during driving, and the joint does not fail in service. In general, the diameter should not be less than the thickness of the thickest part through which the rivet is driven nor greater than three times the thinnest outside part. The length (which should be determined by experimentation) should be sufficient to fill the rivet hole after driving.

The holes should be large enough to accept the rivet without forcing but not so large that the rivet will be bent or upset eccentrically, or that the sheets will bulge or separate. Also, the holes should be small enough so that the rivets will fill them without excessive cold working. The spacing of the holes should be such that the sheets are not weakened by the holes, and that the sheet does not buckle. According to general recommendations, the spacing (center-to-center) should be not less than three times the hole diameter nor more than 24 times the thickness of the sheet.

Holes for riveting may be formed by punching, by drilling, or by subpunching and reaming. Drilling is preferred to punching because it does not produce rough edges which might cause cracks to propagate radially from the hole. However, subpunching or subdrilling, followed by reaming is preferred to either because reaming produces a smooth edge, permits exact aligning of holes, and forestalls uneven loading on the rivets.

The choice of rivet alloy is influenced by several considerations, including corrosion problems, property requirements, and fabricating costs. From a strength standpoint, it is generally advantageous to use a rivet alloy having the same properties as the material into which it is driven. However, from a fabrication standpoint, it is often necessary to have a somewhat softer rivet to permit driving. A list of combinations of the structural metals and rivet alloys that have proved satisfactory is shown in figure 4.

Most aluminum alloy rivets are driven cold in the as-received temper, others are heat treated

Structural Metal		Alloy	Rivet Metal Temper	
Alloy	Temper		Before Driving	After Driving
1100	Any	1100	H14	F
2014	T6	2017 2024 2117 7277	T4 T4 T4 T4	T31 T31 T3 T41
3003	0 H12*	1100 6053	H14 T61	F T61
5052	H12*	6053	T61	T61
6053	T4	6053 6061 7277	T61 T6 T4	T61 T6 T41
6061	T4 or T6	6053 6061 7277	T61 T6 T4	T61 T6 T41

*Or harder.

Note: Rivet alloys 1100, 2017, 2024, 2117, and 5056 are specified in QQ-A-430; 3003, 6053, and 6061 in MIL-R-1150; and 7277 in MIL-R-12221. These meet the majority of riveting needs. Alloys 6053 and 6061 are recommended for clad sheet because of their high resistance to corrosion and their similarities in solution potential to the cladding material of the sheet.

FIGURE 4. Suggested Combinations of Rivet Alloy and Structural Metal

Rivet Condition Before Driving			Shear Strength* Developed, ksi
Rivet Alloy	Rivet Temper	Condition When Inserted	
1100	H14	As received	11
2017	T4	Immediately after quenching	34
2024	T4	Immediately after quenching	42
2117	T4	As received	33
6053	T61	As received	23
6061	T6	As received	30
7277	T4	Hot (850° to 975°F)	38
*Cone-point heads. (Slightly higher for heads requiring more pressure.)			

FIGURE 5. Rivet Condition at Driving

just before being driven, while rivets of alloy 7277 are driven hot. Figure 5 indicates the condition of the various rivet alloys at insertion, and the shear strengths developed after driving.

16. **Welding.** The welding of aluminum is common practice in industry because it is fast, easy, and relatively inexpensive. It is especially useful in making leakproof joints in thick or thin metal, and can be employed with either wrought or cast aluminum, or a combination of both.

The nominal strengths of welds in some specified aluminum alloys are given in tables XIX, XX, and XXI. If greater strengths are required, and if increased weight and bulk are not objectionable, a mechanical joint should be substituted for welding.

Not all compositions of aluminum alloy are suitable for welding, and not all methods of welding can be used with them. The suitability for welding and the relative weldability of some aluminum alloys are given in table XXII.

The welding of aluminum consists of fusing the molten parent metal together (with or without the use of filler metal), or of upsetting by pressure (with or without heat generated by the electrical resistance of the metal).

A wide variety of welding methods are employed in the welding of aluminum. These include torch (gas), metal-arc, carbon-arc, tungsten-arc, atomic-hydrogen, and electric-resistance welding. The equipment used is the same, except that it must be modified in some instances to permit slight changes in welding practices.

The corrosion-resistant oxide film that protects aluminum, deters the "wetting" action required for coalescence of the metals during welding. To effect a successful weld, this tough coating must be removed (and prevented from reforming) either mechanically, chemically, or electrically. Mechanical removal consists of abrading with a sander, stainless-steel wool, or some such means. Such a method is fast, but it is a manual operation, and should be reserved for comparatively small amounts of work. Chemical removal is accomplished with fluxes that dissolve and float the oxides away. It is the most practical means of penetrating the glass-like oxide coating, and is well suited to the production of larger amounts of work. Its drawbacks include the danger of leaving voids or blow holes as a result of entrapment of slag, and the need for cleaning operations to remove any remaining corrosive flux. Electrical removal, used in some forms of arc welding, consists of the application of a reverse polarity (work negative) of welding current which loosens the oxide by electron emission. The reforming of oxides is prevented during welding and cooling of the weld by the cover of flux or by the use of inert gases to blanket the weld area.

The good thermal conductivity of aluminum allows the heat of welding to spread rapidly from the weld zone; this can result in a loss in strength in work-hardened or heat-treated alloys through annealing. It can also cause buckling or total collapse of the parent metal if the metal is not supported properly during welding. The good electrical conductivity necessitates the use of higher currents in resistance welding.

The low melting point of aluminum, in the range of 900°F (482°C) to 1216°F (658°C), increases the need for care in preventing the melting away of the metal parts that are to be welded. Since aluminum gives no visual indication of having attained welding temperature (that is, it does not become red, as does steel), the temperature has to be measured by the physical condition of the aluminum instead of its appearance.

In welding applications where a considerable amount of general heating can be tolerated and where an easily finished bead is desired, gas welding is preferred. However, where minimum general heating, absence of flux, and very good properties are requirements, one of the types of inert-gas-shielded arc-welding method should be selected.

Gas welding is commonly done with oxyhydrogen or oxyacetylene mixtures. The oxyacetylene flame is used most widely because of its availability for welding other metals. Butt, lap, and fillet welds are made in thickness of metal from 0.040 up to 1 inch.

Metal-arc welding is especially suitable for heavy material. Welds in plate 2½ inches thick are made satisfactorily by this method. Unsound joints are likely to appear in metal-arc-welded material which is less than 5/64 inch thick. Weld soundness and smoothness of the surface are not as good as other arc-welding methods. The latter factors, and the necessity to use a welding flux, have been responsible for the decrease in popularity of this process.

Carbon-arc welding is an alternative method for joining material about 1/16 to 1/2 inch thick. The carbon arc affords a more concentrated heat source than a gas torch flame. Hence, it permits faster welding with less distortion. Soundness of welds is excellent and is comparable to that of good gas welding.

Tungsten-arc welding has two distinct advantages over other forms of fusion welding; no flux is needed, and welds can be made with almost equal facility in the flat, vertical, or overhead positions. The advantages are the result of the ability to concentrate the heat, and the blanketing of the area with inert gas (argon or helium). The process can be used for either manual or automatic welding on metals 0.05 inch thick or thicker.

Resistance welding is especially useful for joining high-strength aluminum alloy sheet with practically no loss of strength. It includes three main types of processes; spot welding, seam or line welding, and butt or flash welding. The type adopted for assembly operations depends mainly on the form of material to be joined. Spot welding is widely used to replace riveting; it joins sheet structures at intervals as required. Seam welding is merely spot welding with the spots spaced so closely that they overlap to produce a gas-tight joint. Flash welding, sometimes classified as a resistance welding process, differs from spot welding in that it is used only for butt joints; the metal is heated for welding by establishing an arc between the ends of the two pieces to be joined.

17. **Brazing.** Brazing differs from welding, in that filler metal is melted and flowed into the joint with little or no melting of the parent metal. (The brazing alloy melts at about 100°F (38°C) below that of the parent metal.) As a result, brazing is ideally suited to the joining of thinner material. It is also lower in cost than welding, has neater appearance, requires little finishing, and is suited to mass production methods. In addition, the corrosion resistance of brazed aluminum joints compares favorably, in general, to welded joints in the same alloy because, unlike solder, the filler metal is an aluminum alloy.

The strength of a brazed joint is equivalent to that of the metal in the annealed condition. However, in some instances where an age-hardening alloy is used, the mechanical properties of the metal can be enhanced by treatment. For example, alloy 6061 (61S), when quenched from the brazing operation and then artificially aged, will exhibit a tensile strength of approximately 45,000 psi, a yield strength of 40,000 psi, and an elongation in two inches of 9 percent.

Brazeable alloys are available in plate, sheet, tube, rod, bar, wire, and shapes. They are generally confined to alloys 1100, 3003, and 6061.

18. **Soldering.** Aluminum can be joined to aluminum and to other solderable metals by means

of a soldering iron or torch, and an alloy of approximately 60 percent tin and 40 percent zinc. (Solders for aluminum are specified in MIL-S-12204.) This method of joining is satisfactory for such applications as indoor electrical joints; it is not recommended for joining structural members or for use in moist or corrosive atmospheres because of the low mechanical properties of the solder and the difference in electrical potential between the solder and the aluminum.

The soldering of aluminum is similar to other forms of soldering, but it is somewhat more difficult to perform because of the high thermal conductivity of the aluminum and the presence of a tough oxide film. The thermal conductivity increases the problem of maintaining sufficient heat at the working area to melt the solder. (Aluminum solder melts at 550°F (288°C) to 700°F (371°C) as compared with 375°F (190°C) to 400°F (204°C) for most other solders.) Thus only small parts (20 square inches or less) which can be preheated, are suitable for soldering with an iron; larger parts require the use of a torch to concentrate sufficient heat.

The tough oxide film may be removed by dissolving it with a flux or by abrading it with a soldering iron or other mechanical means. In each instance, the working area must be kept covered with fluid flux or molten solder to exclude oxygen from the surface and to prevent the formation of a new oxide coating. However, after the surfaces are tinned, they may be joined in the usual manner.

19. **Adhesive Bonding.** Adhesive bonding of aluminum, either metal-to-metal or metal-to-nonmetal, may be effected with thermosetting or thermoplastic resins, or with one of the elastomeric compounds. These adhesives can provide tensile strengths up to 7000 psi and shear strengths of approximately 5000 psi, depending on the type of adhesive used and the conditions under which it is used. Their peel strengths vary from 10 to 65 pounds per linear inch. (The peel strength of solder is about 60 pounds per inch.) The reliability of the joint will depend upon several factors, including the type of joint, thickness of adherents, cleanliness of surfaces, method and care in fabrication, and the service conditions. For further information on adhesive bonding, refer to MIL-HDBK-691(MR), "ADHESIVES".

CORROSION RESISTANCE

20. **Factors Affecting Corrosion Resistance.** Aluminum and its alloys are inherently corrosion resistant as a result of the oxide film that forms on the surface upon exposure to oxygen. This coating prevents further oxidation of the aluminum beneath the surface. In many instances, this film is sufficient. However, in some environments, supplementary protection is required.

The degree of inherent corrosion resistance of the aluminum alloy depends on the composition and on the thermal history of the metal. Compositions containing magnesium, silicon, or magnesium silicide (relatively close to aluminum in the electromotive series) exhibit the greatest resistance to corrosive attack. On the other hand, alloys containing copper have relatively poor corrosion resistance. (Copper behaves cathodicly with respect to aluminum – in a galvanic couple, the anode corrodes.) The relative corrosion resistance of aluminum casting alloys is given in table XXIII.

The potential differences between aluminum and its alloying elements become important when the alloy has not been properly heat treated; that is, when there has been a lag between the solution heat treating and quenching. This lag permits excessive precipitation of the alloying elements to the grain boundaries. As a result, the alloy is subject to intergranular corrosion through galvanic action.

21. **Protective Finishes.** Supplementary protection of aluminum can be accomplished by cladding, chemical treatment, electrolytic oxide finishing, electroplating, and application of organic or inorganic coatings. (These processes are covered briefly in the following paragraphs.) For additional information on protective finishes, the reader should consult MIL-HDBK-132, Military Handbook Protective Finishes. This publication includes finishes for aluminum and aluminum alloys.

Cladding is probably the most effective means of corrosion protection for aluminum. The process consists of applying layers (approximately 2 to 15 percent of the total thickness) of pure aluminum or a corrosion-resistant aluminum alloy to the surface of the ingot, and hot working the ingot to cause the cladding metal to weld to the core. In subsequent hot working and fabricating, the cladding becomes alloyed with the core and is reduced in thickness proportionately.

The cladding serves as a protective coating for the core metal; it also affords protection by electrolytic action because the cladding is anodic to the base metal and, hence, corrodes sacrificially. (This protection remains even when the metal is sheared or scratched so that the core metal is exposed.) Clad sheet and plate are specified in QQ-A-250/3, QQ-A-250/5, and QQ-A-250/13, QQ-A-250/15, and QQ-A-250/18.

Some chemical treatments result in the formation of oxide films; others etch the metal and lower the corrosion resistance by removing the oxide film. Chemical finishes, though widely used, are not as satisfactory as those produced by electrolytic means. They are, however, well suited as bases for paint because they are slightly porous. Requirements for chemical finishes are specified in MIL-C-5541A.

Electrolytic oxide finishing is perhaps the most widely used method for protecting aluminum. It consists of treating the metal in an electrolyte capable of giving off oxygen, using the metal as an anode. The film thus formed is an aluminum oxide which is thin, hard, inert, and minutely porous. It can be used as is, painted, or dyed.

The electroplating process is similar to that used on other metals. Preparation of the surface however, requires greater care to ensure proper adhesion. The surface must be buffed to remove any scratches and defects; it must be cleaned thoroughly to remove all grease, dirt, or other foreign matter; and it must be given a coating of pure zinc (by immersion in a zincate solution) as a base for the plating metal. After plating, the surface is buffed and finished like other metals.

Organic and inorganic coatings range from paints and lacquers to vitreous enamels. Although paint for decorative purposes may be applied to the metal after removal of surface contaminants, paint used for protective purposes requires more elaborate surface preparation. Usually, an etching type cleaner such as one containing phosphoric acid is used to remove surface contaminants and deposit a thin phosphate film. Then a prime coat such as zinc chromate, with good corrosion-inhibiting properties, good adhesion, and good flexibility is applied. This is followed by the paint, varnish, or lacquer.

Vitreous enamels are essentially lead borosilicates, which are complex glasses. These are applied as frit and fired at about 920°F (493°C). The resulting glaze is hard and heat resistant.

SELECTING ALUMINUM ALLOY

22. Choice of Alloys. With few exceptions, aluminum alloys are designed either for casting or for use in wrought products, but not for both. Some general purpose alloys are available, but on the whole, compositions are formulated to satisfy specific requirements. The more widely used and readily available compositions are covered by Government specifications; most are adaptable to a variety of applications.

In the selection of aluminum, as in the selection of any material used in engineering design, many factors must be taken into account to obtain maximum value and optimum performance. Among these factors are the service conditions to be satisfied, the number of items to be produced, and the relative costs of suitable fabricating processes. These factors dictate the mechanical and physical properties required and the methods of fabrication to be used; and these in turn dictate the requirements for composition, thermal and mechanical treatment, and finishing.

Within certain limits, the selection of a specific composition for a particular use may be much simplified. Having determined the requirements for mechanical or physical properties, determine which alloys will satisfactorily meet the requirements. From these, select all those alloys that are suitable for use with the proposed method and alternate methods of fabrication. Then weigh the costs of the various methods of production.

23. Casting Alloys. The choice of an alloy for casting is governed to a great extent by the type of mold to be employed. The type of mold (sand, permanent, or die) to be used is determined by such factors as intricacy of design, size, cross section, tolerance, surface finish, and number of castings to be produced.

Sand molds are particularly suited to large castings, wide tolerances, and small runs. They are not suitable for the production of thin (less than 3/16 inch) sections or smooth finishes.

Permanent molds, which are generally of cast iron, yield castings with better surface finishes and closer tolerances than those from sand molds, but the minimum thicknesses which can be produced are about the same. Permanent molds are also better suited to larger runs because they do not require the pattern equipment or molding operations needed in sand casting.

Dies are especially suited to long-run production. Although they are relatively expensive, their initial cost can be justified by the savings in machining and finishing costs, and in high production rate. Other advantages include ability to produce thinner cross sections, closer tolerances, smoother surfaces, and intricate designs.

Alloys for use with the various types of molds are listed in table XXIV, together with their characteristics and their recommended uses. In all casting processes, alloys with a high silicon content are useful in the production of parts with thin walls and intricate design.

24. **Wrought Alloys.** The choice of an alloy for a wrought product is influenced almost as much by the proposed method of fabrication, as by the design requirements for the part to be fabricated. Although a variety of compositions and tempers will generally produce the desired mechanical and physical properties, the number of compositions and tempers amenable to the various fabrication techniques in some instances is limited. On the other hand, the fabrication technique that will provide the greatest economy is governed to some extent by the quantity to be produced. It is therefore necessary in the selection of an appropriate alloy to compare the costs of the various methods, taking into account all the processes and tooling that must be employed for each method, such as forming, joining, hardening, and finishing, and such items as designing and manufacturing an extrusion die.

Aluminum can be formed by any of the conventional methods, but is especially suited to extrusion, drawing, and forging. The principal characteristics and uses of wrought aluminum alloys that are covered by Government specifications are summarized in table XXV.

When choosing an aluminum alloy for any wrought product, keep in mind that for corresponding tempers, the ease of fabricating decreases as the strength increases; also, that as the strength increases, the price increases. Hence, economy will indicate the use of alloys with lower strength when their properties are adequate for the intended service conditions. Also, to ensure that the finished part will have the maximum strength and stiffness, the material should be chosen in the hardest temper that will withstand the necessary fabricating operations.

Aluminum extrusions have numerous applications, and are especially useful for producing shapes for architectural assemblies. This method of fabrication makes possible the economical manufacture of more efficient shapes that can withstand relatively higher stresses. It is cheaper than roll-forming, but it cannot produce as thin sections. In addition, the dies used are not expensive, but their design requires care to ensure uniform metal flow from both thick and thin sections. Finally, extruded shapes are ready for use after little more than heat treating and straightening.

Alloys for extrusion are specially designed for the intended use. Alloy 7075-T6 is often used when high strength is desired. Alloy 2014-T6 may also be used, but it is not as strong as the 7075. Alloy 2024-T6 is useful for thinner sections, while alloy 6061 has good forming qualities, resistance to corrosion, and high yield strength. Alloy 6063, either in the as-extruded (-T42) or the artificially aged (-T5) temper, provides adequate strength for some purposes and does not discolor when given an anodic oxide finish. When high resistance to corrosion is required. extruded shapes of alloy 1100 and 3003 are often used.

Drawing is much the same as that for other metals. It is a more expensive operation than extrusion, but it yields products with much closer tolerances. In drawing aluminum, tool radii are important for proper results; a thickness of 4 to 8 times that of the metal thickness is usually satisfactory. Too small a radius may cause tensile fracture; too large a radius may result in wrinkling. Alloys of the non-heat-treatable variety, such as 1100, 3003, 5050, and 5052, are commonly used because they can be deformed to a greater extent before they rupture.

Forgings are used where higher strength is required, or where the forging process is especially adapted for manufacturing the part. Aluminum may be either press forged or drop forged, using special forging stock produced in the form of an extruded bar or shape. Press forging, though slower than drop forging, affords greater flexibility in design, higher accuracy, and lower die cost. Aluminum alloy for forgings is specified in QQ-A-367.

Section II

Standardization Documents

25. **General.** Both the Government and non-government technical societies issue standardization documents dealing with aluminum and aluminum alloy materials and processes. This section covers the current specifications and standards prepared by the Government, the American Society for Testing and Materials (ASTM), and the Aerospace Materials Specifications (AMS) issued by the Society of Automotive Engineers (SAE).

26. **Government Documents.** Following is a list of Government documents dealing with aluminum and aluminum alloy materials processes and items.

MILITARY SPECIFICATIONS

Specification No.	Title	Date
MIL-A-148D #1#	Aluminum Foil	February 1964
JAN-M-454 #1#	Magnesium-Aluminum Alloy, Powdered	February 1952
MIL-A-512A	Aluminum, Powdered, Flaked, Grained and Atomized	22 May 1961
MIL-R-1150A #1#	Rivets, Solid (Aluminum Alloy), and Aluminum Alloy Rivet Wire and Rod	June 1952
MIL-P-1747C INT AMD 2 #GL#	Pan, Baking and Roasting, Aluminum with Cover for Range, Field	March 1962
MIL -A-2877B INT AMD 1 #SH#	Aluminum and Aluminum Alloy Tape, Gray	May 1962
MIL-C-3554	Candler, Egg (Aluminum) 110 Volts AC-DC	August 1951
MIL-D-4303A	Drum Aluminum, 55-Gallon	January 1953
MIL-A-4864A	Aluminum Wool	February 1960
MIL-C-5410B #3#	Cleaning Compound, Aluminum Surface, Non-Flame-Sustaining	September 1965
MIL-R-5674C	Rivet, Aluminum and Aluminum Alloy	January 1966
MIL-H-6088D	Heat Treatment of Aluminum Alloys	March 1965
MIL-W-6858C #INT AMD 1#	Welding, Resistance, Aluminum, Magnesium, Non-Hardening Steels or Alloys, Nickel Alloys, Heat-Resisting Alloys, and Titanium Alloys, Spot and Seam	October 1964
MIL-T-6869B #2#	Impregnants for Aluminum Alloy and Magnesium Alloy Castings	January 1963
MIL-P-6888B	Polish, Metal, Aluminum, Aircraft, (ASG)	March 1963
MIL-W-7072B	Wire, 600-Volt, Aluminum Aircraft, General Specification for (ASG)	September 1962

Specification No.	Title	Date
MIL-T-7081D #1#	Tube, Aluminum Alloy, Seamless, Round 6061, Aircraft Hydraulic Quality	February 1966
MIL-C-7438C #2#	Core Material, Aluminum, for Sandwich Construction	March 1961
MIL-S-7811	Sandwich Construction, Aluminum Alloy Faces, Aluminum Foil Honeycomb Core	August 1952
MIL-R-7885B	Rivets, Blind, Structural, Pull-Stem, and Chemically Expanded	June 1963
MIL-I-8474B	Inspection of Aluminum Alloy Parts, Anodizing Process For	May 1965
MIL-W-8604 #1#	Welding of Aluminum Alloys, Process For	October 1959
MIL-A-8625B	Anodic Coatings, for Aluminum and Aluminum Alloys	June 1965
MIL-A-882A #1#	Aluminum Alloy Plate and Sheet, 2020 (ASG)	February 1964
MIL-A-8920A	Aluminum Alloy Plate and Sheet, 2219 (ASG)	May 1963
MIL-A-8923	Aluminum Alloy Sheet, Alclad 7079 (ASG)	December 1962
MIL-T-10086D	Tanks Liquid Storage, Metal, Vertical Bolted (Steel and Aluminum)	
MIL-S-10133B #1#	Seat, Outlet-Valve, Aluminum-Base-Alloy Die Casting for Outlet Valve-C15	August 1957
MIL-T-10794D #1#	Tubes, Aluminum-Alloy, Extruded Pipeline Sect With Grooved Nipple Welded on Each End	August 1965
MIL-C-11080	Coating, Corrosion-Resistant (For Aluminum Gas Mask Canisters)	April 1951
MIL-A-11267B	Aluminum Sheet, X8280 (For Recoil Mechanism Cup Rings)	June 1963
MIL-B-11353B #1#	Bridge, Floating, Aluminum, Foot Type, Packaging of	September 1958
MIL-S-12204B #1#	Solder, Aluminum Alloy	December 1957
MIL-R-12216B	Reflector, Light, Aluminum and Shield Telescoping Lamp, Aluminum	June 1960
MIL-R-12221B	Rivet, Solid Aluminum Alloy, Grade 7277, Tempered	April 1962
MIL-A-12545B	Aluminum Alloy Impacts	June 1966
MIL-A-12608	Aluminum Chips for Hydrogen Generation (Aluminum Charge ML-389/UM)	April 1953
MIL-B-13141	Boat, Skiff Type, Outboard Motor or Oar Propelled Aluminum, 18 Ft., Design 6002, With Ice Runners	December 1953
MIL-B-13157A	Bridge, Fixed Panel, Single Lane, Aluminum	May 1965
MIL-I-13857	Impregnation of Metal Castings (including Al)	December 1954
MIL-P-14462	Protractor, Fan, Range Deflection Aluminum, Graduated In Mils and Meters	March 1961
MIL-T-15089B	Tubing, Aluminum Alloy, Round, Seamless (For Rocket Motors)	April 1959
MIL-E-16053K AMEND 1	Electrodes, Welding, Bare, Aluminum Alloys	June 1964

Specification No.	Title	Date
MIL-L-17067B	Ladder, Berth, Adjustable (Aluminum) MS&S (Passenger Ships)	September 1952
MIL-F-17132B	Floor Plate, Aluminum Alloy (6061) Rolled	February 1961
MIL-S-17917 #1#	Sandwich Construction, Aluminum Alloy Facings Balsa Wood Core	August 1956
MIL-M-17999B	Metal, Expanded, Aluminum	October 1965
MIL-B-19942	Box, Food Handling, Aluminum	June 1957
MIL-B-20148A	Brazing Alloys Aluminum, and Aluminum Alloy Sheets and Plates, Aluminum Brazing Alloy Clad	August 1955
MIL-A-21180C #1#	Aluminum Alloy Castings - High Strength	February 1965
MIL-T-21494A	Tube, Aluminum Alloy 5086, Round Seamless (Extruded or Drawn)	April 1961
MIL-A-22152 AMEND 1	Aluminum Alloy Sand Castings, Heat Treatment Processes For	November 1959
MIL-W-22248	Weldments, Aluminum and Aluminum Alloy	November 1959
MIL-B-22342A	Brows, Aluminum, Beam and Truss	August 1965
MIL-A-22771B	Aluminum Alloy Forgings, Heat Treated	February 1966
MIL-C-23217A	Coating, Aluminum, Vacuum Deposited (ASG)	September 1963
MIL-C-23396	Chair, Stacking, Aluminum Frame, Upholstered	June 1962
MIL-B-23362 CHANGE 1	Brazing of Aluminum and Aluminum Alloys	February 1964
MIL-S-24149/5	Studs, Aluminum Alloy, for Stored Energy (Capacitor Discharge) Arc Welding	June 1965
MIL-S-24149/2	Studs, Aluminum Alloy for Direct Energy Arc Welding and Arc Shields (Ferrules)	June 1965
MIL-A-25994	Aluminum Alloy Angles, Channels, I and Z Beams, Extruded or Rolled, Structural Shapes	June 1959
MIL-P-25995	Pipe, Aluminum Alloy, Drawn or Extruded	June 1959
MIL-C-26094	Can, Hermetic Sealing, Aluminum, Two-Piece	November 1965
MIL-S-36079	Sterilizer, Surgical Instrument Boiling Type, Electrically and Fuel Heated, Aluminum	June 1961
MIL-B-36195A	Bowl, Gauze Pad, Aluminum, Nesting	November 1964
MIL-S-36315	Splint, Hand, Mason-Allen, Aluminum	October 1964
MIL-C-36465	Cot, Folding, Hospital, Aluminum	January 1966
MIL-T-40057A	Table, Wrapping, Plywood, Aluminum Top	November 1964
MIL-P-40130B	Paddle, Parachute Packing, Aluminum	December 1965
MIL-A-40147 #1#	Aluminum Coating (Hot Dip) For Ferrous Parts	March 1963
MIL-P-40618A	Pan, Pie, Aluminum, Disposable	November 1965
MIL-T-43124	Trucks, Hand, Platform, 4 wheel, Caster Steer Magnesium or Aluminum	December 1962

Specification No.	Title	Date
MIL-B-43341	Breadbox, Delivery, Aluminum	June 1965
MIL-W-45205 #1#	Welding, Inert-Gas, Metal Arc, Aluminum Alloys Readily Weldable for Structures Excluding Armor	May 1962
MIL-W-45206 #1#	Welding, Aluminum Alloy Armor	November 1960
MIL-W-45210A	Welding, Resistance, Spot, Weldable Aluminum Alloys	January 1965
MIL-W-45211A	Welding, Stud, Aluminum	November 1964
MIL-A-45225B	Aluminum Alloy Armor - Forged	December 1965
MIL-R-45774 #1#	Radiographic Inspection, Soundness Requirements for Fusion Welds in Aluminum and Magnesium Missile Components	October 1963
MIL-A-46027C AMEND 1	Aluminum Alloy Armor Plate; Weldable 5083 and 5456	June 1966
MIL-A-46063B AMEND 2	Aluminum Alloy Armor Plate, Heat Treatable, Weldable	August 1966
MIL-A-46083 AMEND 1	Aluminum Alloy Armor, Extruded Weldable	June 1966
MIL-A-46104	Aluminum Alloy Bar, Rod, Shapes and Tube, Extruded, 6070	October 1965
MIL-C-52084 #1#	Curb Assemblies, Bridge, Floating, Aluminum, Light-Tactical	March 1962
MIL-A-52174A #1#	Aluminum Alloy Duct Sheet	November 1963
MIL-A-52242	Aluminum Alloy Extruded Rod, Bar and Shapes, 7001	August 1962
MIL-C-52269	Clamp, Hinge, Bridge, Steel, Treadway Bridge, Floating, Foot, Aluminum	February 1963
MIL-L-54002	Ladders, Aluminum, Three-Way Combination, Step, Straight, Extension	July 1962

FEDERAL SPECIFICATIONS

Specification No.	Title	Date
L-T-80A	Tape, Pressure Sensitive Adhesive, Aluminum Backed	September 1965
L-T-775	Tray, Service, Aluminum and Plastic	May 1956
QQ-A-200B	Aluminum Alloy Bar, Rod, Shapes and Tube, Extruded, General Specification For Parts 1 - 13	August 1964
QQ-A-200/1A	3003	December 1963
QQ-A-200/2B	2014	August 1964
QQ-A-200/3B	2024	August 1964
QQ-A-200/4A	5083	December 1963
QQ-A-200/5A	5086	December 1963

Specification No.	Title	Date
QQ-A-200/6B	5454	June 1964
QQ-A-200/7B	5456	June 1964
QQ-A-200/8B	6061	August 1964
QQ-A-200/9A	6063	December 1963
QQ-A-200/10B	6066	August 1964
QQ-A-200/11B	7075	August 1964
QQ-A-200/12B	7079	August 1964
QQ-A-200/13	7178	August 1964
QQ-A-225B	Aluminum Alloy Bar, Rod, Wire or Special Shapes Rolled, Drawn, or Cold Finished, General Specification For Parts 1 - 9	August 1964
QQ-A-225/1B	1100	August 1964
QQ-A-225/2B	3003	August 1964
QQ-A-225/3B	2011	August 1964
QQ-A-225/4B	2014	August 1964
QQ-A-225/5B	2017	August 1964
QQ-A-225/6B	2024	August 1964
QQ-A-225/7A	5052	December 1963
QQ-A-225/8B #1#	6061	December 1964
QQ-A-225/9B	7075	August 1964
QQ-A-250C	A1 Alloy Plate and Sheet General Specification For Parts 1 - 18	September 1964
QQ-A-250/1C	1100	September 1964
QQ-A-250/2B	3003	December 1963
QQ-A-250/3C	ALCLAD 2014	September 1964
QQ-A-250/4C	2024	September 1964
QQ-A-250/5D	ALCLAD 2024	April 1965
QQ-A-250/6D	5083	September 1964
QQ-A-250/7C	5086	May 1964
QQ-A-250/8C	5052	September 1964
QQ-A-250/9D	5456	September 1964
QQ-A-250/10B	5454	December 1963
QQ-A-250/11C	6061	September 1964
QQ-A-250/12C	7075	September 1964
QQ-A-250/13C	ALCLAD 7075	September 1964
QQ-A-250/14C	7178	
QQ-A-250/15C	ALCLAD 7178	September 1964
QQ-A-250/16C	2020	April 1964

Specification No.	Title	Date
QQ-A-250/17C	7079	September 1964
QQ-A-250/18C	ALCLAD One Side 7075	September 1964
QQ-A-367G	Aluminum Alloy Forgings	June 1966
QQ-A-371E	Aluminum Alloy Ingot (For Remelting)	August 1965
QQ-A-430 #1#	Aluminum Alloy Rod and Wire, for Rivets and Cold Heading	April 1962
QQ-A-00435	Aluminum Alloy Sheet, Painted (For Exterior Use)	May 1964
QQ-A-591D	Aluminum Alloy Die Castings	January 1963
QQ-A-596D	Aluminum Alloy Permanent and Semi-permanent Mold Castings	May 1966
QQ-A-601C #2# INT AMD 3 #SH#	Aluminum Alloy Sand Castings	October 1965
QQ-A-00640	Aluminum Foil (Insulation Reflective Building)	October 1964
QQ-A-825	Bus Bar, Copper Aluminum or Aluminum Alloy	May 1965
QQ-B-655B	Brazing Alloys, Aluminum and Magnesium, Filler Metal	September 1959
QQ-N-286A #1#	Nickel-Copper - Aluminum Alloy, *K-Monel	August 1956
QQ-R-566A	Rods, Welding, Aluminum and Aluminum Alloys	March 1964
RR-K-00190	Kettles, Steam-Jacketed (Aluminum)	December 1957
RR-P-54	Pan, Aluminum	January 1965
RR-P-0090	Pan, Pie (Aluminum Foil)	August 1964
RR-B-500	Boiler, Kettle and Pot (Aluminum)	January 1965
TT-P-320	Pigment, Aluminum, Powder and Paste, for Paint	August 1961
WW-C-540A	Conduit, Metal, Rigid, (Electrical Aluminum)	November 1960
WW-P-402A	Pipe, Corrugated (Aluminum Alloy)	December 1964
WW-P-471A	Pipe Fittings, Bushings, Locknuts and Plugs, Brass or Bronze, Iron or Steel, and Aluminum (Screwed) 125-150 pounds	March 1964
WW-T-700C	Tube, Aluminum Alloy, Drawn, Seamless, General Specification For Parts 1 - 6	August 1964
WW-T-700/1C	Tube 1100	August 1964
WW-T-700/2C	Tube 3003	August 1964
WW-T-700/3C	Tube 2024	August 1964
WW-T-700/4C	Tube 5052	August 1964
WW-T-700/5C	Tube 5086	August 1962
WW-T-700/6C	Tube 6061, 6062	August 1962
WW-T-816 AMEND 2	Tubing, Flexible, Aluminum Alloy (Number Was Formerly RR-T-791) Supersedes ANT 13	January 1961

MILITARY STANDARDS

Standard No.	Title	Date
MS-9095	Nipple, Tube, AMS 4120 Boss A1	April 1960
MS-9096A	Elbow, Tube, AMS 4135 Boss 90 A1	May 1962
MS-9097A	Elbow, Tube, AMS 4135 Boss 45 A1	May 1962
MS-9098A	Tee, Tube - AMS 4135, Boss A1	May 1962
MS-9099	Nut-Hex, Boss Connection, Aluminum	
MS-9199	Nut, Tube Coupling - Aluminum, AMS 4121 ASG	March 1962
MS-9200	Nut-Plain, Hex, Boss Connection, Aluminum ASG	
MS-16206	Bolt, Machine, Hexagon Head, Regular Semi-Finished, Aluminum Alloy, UNC-2A, Non-Magnetic	May 1957
MS-16593A	Rivet Solid, 78 Degree, Flat Head, Aluminum	2 February 1956
MS-17354	Nut Plain, Hex, Boss Connection, Aluminum #MIL-S-8879 Thread#	March 1962
MS-20426D	Rivet, Solid, Countersunk 100 Deg., Precision Head Aluminum and Aluminum Alloy	July 1964
MS-20470B	Rivet, Solid-Universal Head, Aluminum and Aluminum Alloy	September 1960
MS-25191B	Wire, Electric, 600-Volt, Aluminum, Aircraft #ASG#	October 1962
MS-27088A	Nipple, Brazed, Aluminum Alloy	2 July 1963
MS-27957	Hinge, Butt Narrow and Broad, Template; Hardware, Builders, Commercial, Aluminum	February 1961
MS-27959	Hinge, Butt- Narrow and Broad, Without Holes, Hardware, Builders, Commercial, Aluminum	February 1961
MS-35202B	Screw, Machine, Flat Countersunk Head, Cross-Recessed, Aluminum Alloy Anodize Finish Nc2A-UNC-2 A	May 1965
MS-35516	Corrosion Resistant Coating Chemically Treated Aluminum	March 1956
MS-35965	Dish, Moisture Determination, Aluminum	September 1959
MS-36163	Rack, Test Tube, Laboratory Folding, Aluminum	December 1960
MIL-STD-437A	X-Ray Standard for Bare Aluminum Alloy Electrode Welds	December 1958
MIL-STD-645A	Dip Brazing of Aluminum Alloys	December 1965
MIL-STD-649	Aluminum and Magnesium Products Preparation For Shipment and Storage	July 1963

QUALIFIED PRODUCTS LISTS

Number	Title	Date
QPL-6888-14	Polish, Metal, Aluminum Aircraft	October 1963
QPL-6939-4	Flux, Aluminum and Aluminum Alloy Gas Welding	February 1960

Number	Title	Date
QPL-14276-7	Paint, Heat Resisting Silicone, Aluminum	March 1963
QPL-15599-44	Electrode, Welding, Covered, Aluminum and Aluminum Alloy	March 1965
QPL-27347-1	Cloth, Coated Glass, Aluminum Face Silicone Rubber Back	June 1960

OTHER STANDARDIZATION DOCUMENTS

Number	Title	Date
AN 123020 thru 123150	Gasket, Aluminum-Asbestos, Annular (Reactivated for Design)	
AND 10106 Rev 3	Tubing-Standard Sizes for Aluminum Alloy Round (5250)	April 1948
AND 10107 Rev 3	Tubing - Standard Sizes for Aluminum Alloy (24ST) Round	October 1942
AND 10125	Aluminum Wire-Standard Alloys, Tempers and Sizes of Round and Hexagon (For Welding Rod and General Use)	October 1945
AND 10126 Rev 1	Aluminum Wire-Standard Conditions and Sizes for Sheet, Strip	February 1943
AND 10130 Rev 1	Aluminum Rod and Bar - Standard Alloys Tempers and Sizes of Round and Hexagon	July 1943
AND 10131	Aluminum Bar - Standard Alloys, Temper and Sizes of Square	October 1942
AND 10132	Aluminum Bar - Standard Alloy and Temper (24st) and Sizes of Rectangular	October 1942
USAF Spec X-40911 (1) Change 2 1 Aug 1958	Rivets, Blind, Aluminum Alloy (Reinstated) For Requirements of Type B, Class 1 Rivets Only	July 1948
AIA-NAS 1516 - 1522	Pin, Swage Locking, Aluminum Alloy 100 Deg. Head (AN509) Tension Pull Type, Close Tol.	October 1963
AIA-NAS NAS 1525 - 1532	Pin, Swage Locking, Aluminum Alloy Protruding Head, Tension, Pull Type, Close Tol.	
AIA-NAS 1535 - 1542	Pin, Swage Locking, Aluminum Alloy 100 Deg. Head (MS20426), Tension, Pull Type Close Tol.	
AIA-NAS 1546 - 1552	Pin, Swage Locking, Aluminum Alloy, 100 Deg., Head (AN509), Tension, Stump Type, Close Tol.	October 1963
AIA-NAS 1556-1562	Pin, Swage Locking, Al Alloy Protruding Head Tension, Stump Type, Close Tol.	October 1963

Number	Title	Date
Fed. Std. 184	Identification Marking of Aluminum Magnesium and Titanium	August 1959
Fed. Std. 245B	Tolerances for Aluminum Alloy and Magnesium Alloy Wrought Products	December 1963

CANCELLED AND SUPERSEDED STANDARDIZATION DOCUMENTS

The following listed standardization documents have been cancelled or superseded since the compilation that appeared in the previous issue of this handbook.

Number	Title
QQ-A-411	Aluminum Alloy Bars, Rods, and Wire; Rolled Drawn or Cold Finished, 1100. Superseded by Federal Specification QQ-A-225/1a, December 16, 1963.
MIL-A-799	Aluminum High Purity, Wrought. Cancelled without replacement, 15 October 1965.
MIL-A-8097	Aluminum Alloy Forgings, 76S for Aircraft Applications.
MIL-A-8705	Aluminum Alloy, Bare and Alclad 2024 (24S), Artificial Aging of.
MIL-A-8825	Aluminum Bars and Shapes, Extruded 7079. See QQ-A-200/12b.
MIL-A-8877	Aluminum Alloy Sheet and Plate 7079. See QQ-A-250/17c.
MIL-A.8902	Aluminum Alloy Plate and Sheet Alclad One Side 7075. See QQ-A-250/18c.
MIL-A-9180	Aluminum Alloy Plate and Sheet 7178. See QQ-A-250/14c.
MIL-A-9183	Aluminum Plate and Sheet Clad 7178. See QQ-A-250/15c.
MIL-A-9186	Aluminum Alloy Bars, Rods and Shapes Extruded, 7178. See QQ-A-200/13.
MIL-A-17358	Aluminum Alloy Plate and Sheets, 5083 (X-183). See QQ-A-250/6d.
MIL-A-19842	Aluminum Alloy Plates and Sheets, 5456. See QQ-A-250/9.
MIL-A-20695	Aluminum Products, Preparation for Storage and Shipment of. See MIL-STD-649.
MIL-A-21170	Aluminum Alloy Bar, Rod, and Structural Shaped Sections Rolled or Extruded, 5456. See QQ-A-200/7b.
MIL-T-21494A	Tube, Aluminum Alloy 5086, Round, Seamless (Extruded or Drawn). See WW-T-700/5.
MIL-A-21579	Aluminum Alloy Bars, Rods and Structural Shapes, Rolled or Extruded 5086. See QQ-A-200/5a.
MIL-A-25493	Aluminum Alloy Bars, Rods, and Shapes, Extruded, 6066. See QQ-A-200/10b.
MIL-STD-192A	Alloy and Temper Designation System for Wrought-Aluminum. See ASA - H-35.1 - 1962.

27. **Society of Automotive Engineers Specifications.** Following is a list of Aerospace Materials Specifications Dealing with Aluminum and Aluminum Alloys.

AMS Number	Title
4000C	Sheet and Plate - 99.7 Aluminum (Annealed)
4001C	Sheet and Plate - 99.0 Aluminum

AMS Number	Title
4003C	Sheet and Plate - 99.0 Aluminum
4006C	Sheet and Plate - 1.25 Manganese
4008C	Sheet and Plate - 1.25Mn
4010	Foil - 1.2 Manganese
4012A	Sheet - Laminated, Edge Bonded
4013A	Sheet - Laminated, Surface Bonded
4014	Plate - 4.5Cu, 0.8Si, 0.80Mn, 0.5Mg
4015E	Sheet and Plate - 2.5Mg, 0.25Cr
4016E	Sheet and Plate - 2.5Mg, 0.25Cr
4017E	Sheet and Plate - 2.5Mg, 0.25Cr
4018A	Sheet and Plate - 3.5Mg, 0.25Cr
4019	Sheet and Plate - 3.5Mg, 0.25Cr
4020	Plate, Alclad - 1.0Mg, 0.6Si, 0.25Cu, 0.25Cr
4021B	Sheet and Plate, Alclad - 1Mg, 0.6Si, 0.25Cu, 0.25Cr
4022C	Sheet and Plate, Alclad - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr
4023C	Sheet and Plate, Alclad - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr
4024A	Sheet and Plate - 4.3Zn, 3.3Mg, 0.60Cu, 0.20Mn, 0.17Cr
4025D	Sheet and Plate - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr
4026D	Sheet and Plate - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr
4027E	Sheet and Plate - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr
4028B	Sheet and Plate - 4.5Cu, 0.85Si, 0.80Mn, 0.50Mg
4029B	Sheet and Plate - 4.5Cu, 0.85Si, 0.80Mn, 0.50Mg
4031A	Sheet and Plate - 6.3Cu, 0.30Mn, 0.18Zr, 0.10V, 0.06Ti
4033A	Plate - 4.5Cu, 1.5Mg, 0.6Mn, Stress Relief Stretched
4034A	Plate, Alclad - 4.5Cu, 1.5Mg, 0.6Mn, Stress-Relief Stretched
4035E	Sheet and Plate - 4.5Cu, 1.5Mg, 0.6Mn
4036A	Sheet and Plate, Alclad One Side - 4.5Cu, 1.5Mg, 0.60Mn
4037F	Sheet and Plate - 4.5Cu, 1.5Mg, 0.6Mn
4038A	Plate - 5.6Zn, 2.5Mg, 1.6Cu, 0.30Cr, Stress-Relief Stretched
4039A	Plate - 5.6Zn, 2.5Mg, 1.6Cu, 0.30Cr, Stress-Relief Stretched
4040F	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.6Mn
4041G	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.6Mn
4042F	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width 48 in. and under
4043	Plate - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr, Stress-Relief Stretched
4044C	Sheet and Plate - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4045C	Sheet and Plate - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4046A	Sheet and Plate, Alclad One Side - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4047B	Sheet & Pl. Alclad, Roll Tapered - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4048D	Sheet and Plate, Alclad - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4049D	Sheet and Plate, Alclad - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4051B	Sheet and Plate, Alclad - 6.8Zn, 2.75Mg, 2.0Cu, 0.30Cr
4052A	Sheet and Plate, Alclad - 6.8Zn, 2.7Mg, 2Cu, 0.3Cr
4053	Plate - 1.0Mg, 0.60Si, 0.25Cu, 0.25Cr, Stress-Relief Stretched
4054A	Sheet, Clad One Side - 0.60Mg, 0.35Si, 0.30Cu
4055A	Sheet, Clad Two Sides - 0.60Mg, 0.35Si, 0.30Cu
4056B	Sheet and Plate - 4.5Mg, 0.65Mn, 0.15Cr
4057B	Sheet and Plate - 4.5Mg, 0.65Mn, 0.15Cr
4058B	Sheet and Plate - 4.5Mg, 0.65Mn, 0.15Cr
4059C	Sheet and Plate - 4.5Mg, 0.65Mn, 0.15Cr

AMS Number	Title
4060	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 48-60 in., Incl.
4061	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 60 in.
4062D	Tubing, Seamless, Round, Drawn - 99.0 Aluminum
4065C	Tubing, Seamless, Drawn - 1.25Mn
4067C	Tubing, Seamless, Round, Drawn - 1.25Mn
4069	Tubing, Seamless, Drawn-Close Tolerance, 2.5Mg, 0.25Cr
4070F	Tubing, Seamless, Drawn, Round - 2.5Mg, 0.25Cr
4071F	Tubing, Hydr., Seamless, Drawn, Round - 2.5Mg, 0.25Cr
4072	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width 30 in. and Under
4073	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 30 to 48 in., Incl.
4074	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 48 to 60 in., Incl.
4075	Sheet and Plate, Alclad - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 60 Inches
4079	Tubing, Seamless, Drawn - Close Tolerance, 1Mg, 0.6Si, 0.25Cu, 0.25Cr
4080G	Tubing, Seamless, Drawn - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4081A	Tubing, Hydr., Seamless, Drawn - 1.0Mg, 0.6Si, 0.25Cu, 0.25Cr
4082F	Tubing, Seamless, Drawn - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4083D	Tubing, Hydr., Seamless, Drawn - 1.0Mg, 0.6Si, 0.25Cu, 0.25Cr
4086F	Tubing, Hydr., Seamless, Drawn - 4.5Cu, 1.5Mg, 0.6Mn
4087C	Tubing, Seamless, Drawn - 4.5Cu, 1.5Mg, 0.60Mn
4088E	Tubing, Seamless, Drawn - 4.5Cu, 1.5Mg, 0.6Mn
4091A	Tubing, Hydraulic
4092A	Tubing Seamless, Drawn
4093A	Tubing, Hydraulic
4097	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width 48 in. and Under
4098	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 48 to 60 in., Incl.
4099	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 60 Inches
4102B	Bars and Rods, Rolled or Cold Finished - 99.0 Aluminum
4103	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width 30 in. and Under
4104	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 30 to 48 in., Incl.
4105	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 48 to 60 in., Incl.
4106	Sheet and Plate - 4.5Cu, 1.5Mg, 0.60Mn, Width Over 60 Inches
4110A	Bars and Rods, Rolled or Cold Finished - 4.0Cu, 0.70Mn, 0.50Mg, Stress-Relief Stretched
4112	Bars, Rods, and Wire, Rolled, Drawn, or Cold Finished - 4.5Cu, 1.5Mg, 0.60Mn
4114C	Bars, Rolled, Drawn, or Cold Finished - 2.5Mg, 0.25Cr
4115A	Bars, Rolled, Drawn, or Cold Finished - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4116B	Bars, Rolled, Drawn, or Cold Finished - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4117B	Bars, Rolled, Drawn, or Cold Finished - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4118D	Bars, Rods, and Wire, Rolled, Drawn, or Cold Finished - 4.0Cu, 0.7Mn, 0.50Mg
4119C	Bars and Rods, Rolled or Cold Finished - 4.5Cu, 1.5Mg, 0.60Mn, Stress-Relief Stretched
4120F	Bars, Rods, Wire, Rolled - 4.5Cu, 1.5Mg, 0.60Mn
4121C	Bars, Rods, Wire, Rolled - 4.5Cu, 0.90Si, 0.80Mn, 0.50Mg
4122D	Bars, Rods, Wire, Rolled, Drawn, or Cold Finished - 5.6Zn, 2.5Mg, 1.6Cu, 0.30Cr
4123C	Bars and Rods, Rolled or Cold Finished - 5.6Zn, 2.5Mg, 1.6Cu, 0.30Cr, Stress-Relief Stretched
4125E	Forgings - 1Si, 0.6Mg, 0.25Cr
4127C	Forgings - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4130G	Forgings - 4.5Cu, 0.85Si, 0.80Mn
4132A	Forgings - 2.3Cu, 1.6Mg, 1.1Fe, 1.1Ni, 0.07Ti
4134A	Forgings - 4.4Cu, 0.8Si, 0.8Mn, 0.4Mg
4135J	Forgings - 4.5Cu, 0.9Si, 0.8Mn, 0.5Mg

AMS Number	Title
4136	Forgings - 4.3Zn, 3.3Mg, 0.6Cu, 0.2Mn, 0.2Cr, Sol. and Precip. Ht. Treated, Low Residual Stresses
4137A	Forgings - 7.5Zn, 1.6Mg, 0.7Cu, 0.55Mn
4138	Forgings - 4.3Zn, 3.3Mg, 0.6Cu, 0.2Mn, 0.2Cr
4139F	Forgings - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4140D	Forgings - 4.0Cu, 2.0Ni, 0.7Mg
4141	Forgings - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4142B	Forgings - 4Cu, 2Ni, 1.5Mg, 0.7Si
4143	Forgings - 6.3Cu, 0.3Mn, 0.2Zr, 0.1Ti, 0.1V, Solution and Precip. Heat Treated
4144	Hand Forgings and Rings - 6.3Cu, 0.3Mn, 0.2Zr, 0.1V, 0.1Ti, Stress-Relief Compressed
4145E	Forgings - 12.2Si, 1.1Mg, 0.9Cu, 0.9Ni
4146A	Forgings - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4150D	Extrusions - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4152G	Extrusions - 4.5Cu, 1.5Mg, 0.60Mn
4153C	Extrusions - 4.5Cu, 0.85Si, 0.80Mn, 0.50Mg
4154F	Extrusions - 5.6Zn, 2.5Mg, 1.6Cu, 0.3Cr
4155B	Extrusions
4156D	Extrusions - 0.65Mg, 0.40Si
4158A	Extrusions - 6.8Zn, 2.75Mg, 2.0Cu, 0.3Cr
4160A	Extrusions - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4161A	Extrusions - 1.0Mg, 0.60Si, 0.30Cu, 0.20Cr
4164C	Extrusions - 4.4Cu, 1.5Mg, 0.60Mn, Stress-Relief Stretched, Unstraightened
4165C	Extrusions - 4.4Cu, 1.5Mg, 0.60Mn, Stress-Relief Stretched and Straightened
4168A	Extrusions - 5.6Zn, 2.5Mg, 1.6Cu, 0.3Cr, Stress-Relief Stretched, Unstraightened
4169B	Extrusions - 5.6Zn, 2.5Mg, 1.6Cu, 0.3Cr, Stress-Relief Stretched and Straightened
4170	Extrusions, Impact - 5.6Zn, 2.5Mg, 1.6Cu, 0.25Cr
4171A	Extrusions - 4.3Zn, 3.3Mg, 0.6Cu, 0.2Mn, 0.17Cr
4180B	Wire, Spray-Aluminum, 99.0 Min
4182A	Wire - 5Mg, 0.12Mn, 0.12Cr
4184B	Wire, Brazing - 10Si, 4Cu
4185A	Wire, Brazing - 12Si
4190A	Rod and Wire, Welding - 5Si
4191A	Rod and Wire, Welding - 6.3Cu, 0.3Mn, 0.18Zr, 0.15Ti, 0.10V
4210F	Castings, Sand - 5Si, 1.2Cu, 1.5Mg
4212E	Castings, Sand - 5Si, 1.2Cu, 0.5Mg
4214D	Castings, Sand - 5Si, 1.2Cu, 0.5Mg
4215B	Castings, Premium Grade - 5Si, 1.2Cu, 0.5Mg
4217D	Castings, Sand - 7Si, 0.3Mg
4218B	Castings, Premium Grade - 7Si, 0.3Mg
4219	Castings, High Strength, Premium Quality - 7.0Si, 0.60Mg
4220D	Castings, Sand - 4Cu, 2Ni, 1.5Mg, 0.2Cr, Sol Tr. & Overaged
4222D	Castings, Sand - 4Cu, 2Ni, 1.5Mg, Sol. Tr. & Overaged
4224	Castings, Sand - 4Cu, 2Ni, 2Mg, 0.3Cr, 0.3Mn, 0.1Ti, 0.1V, Stabilized
4227A	Castings, Sand - 8Cu, 6Mg, 0.5Mn, 0.5Ni
4230C	Castings, Sand - 4.5Cu, Sol. Treated
4231C	Castings, Sand - 4.5Cu, Sol. & Precip, Treated
4238A	Castings, Sand - 6.8Mg, 0.2Ti, 0.2Mn, As Cast
4239	Castings, Sand - 6.8Mg, 0.2Ti, 0.2Mn, Stabilized
4240C	Castings, Sand - 10Mg, Solution Treated

Number	Title
4260A	Castings, Investment - 7Si, 0.3Mg, Sol. & Precip. Treated
4261	Castings, Investment - 7.0Si, 0.3Mg, Precipitation Heat Treated
4275B	Castings, Permanent Mold - 6Sn, 1Cu, 1Ni, Stress Relieved
4280E	Castings, Permanent Mold - 5Si, 1.2Cu, 0.5Mg, Sol. Tr. & Overaged
4281C	Castings, Permanent Mold - 5Si, 1.2Cu, 0.5Mg, Sol. & Precip. Treated
4282E	Castings, Permanent Mold - 4.5Cu, 2.5Si, Sol. & Precip. Treated
4283D	Castings, Permanent Mold - 4.5Cu, 2.5Si, Solution Treated
4284D	Castings, Permanent Mold - 7Si, 0.3Mg, Sol. & Precip. Treated
4285	Castings, Centrifugal - 7Si, 0.3Mg, Sol. & Precip. Treated
4286A	Castings, Permanent Mold - 7Si, 0.3Mg
4290F	Castings, Die - 9.5Si, 0.5Mg, As Cast
4291B	Castings, Die - (5Si or 8.5Si) 3.5Cu, As Cast
2201G	Tolerances - Aluminum & Alum. Alloy Bar, Rod, Wire & Forging Stock - Rolled or Drawn
2202F	Tolerances - Aluminum and Magnesium Alloy Sheet and Plate
2203F	Tolerances - Aluminum Alloy Drawn Tubing
2204C	Tolerances - Aluminum Rolled or Extruded Standard Structural Shapes
2205J	Tolerances - Aluminum and Magnesium Alloy Extrusions
2355	Tensile Testing of Wrought Alum. & Magnesium Prods., Except Forgings
2420	Plating - Aluminum for Solderability (Zincate Process)
2450C	Sprayed Metal Finish - Aluminum
2468A	Hard Coating Treatment - Aluminum Alloys
2469B	Hard Coating Treatment - Process and Performance Requirements of Aluminum Alloys
2470F	Anodic Treatment - Aluminum Base Alloys (Chromic Acid Process)
2471B	Anodic Treatment - Aluminum Base Alloys, Sulfuric Acid Process, Undyed Coating
2472A	Anodic Treatment - Aluminum Base Alloys, Dyed Coating (Sulfuric Acid Process)
2473B	Chemical Treatment - Aluminum Base Alloys (General Purpose Coating)
2474A	Chemical Treatment - Aluminum Base Alloys (Low Electrical Resistance Coating)
2672B	Brazing - Aluminum
2673	Brazing - Aluminum Molten Flux (Dip)
3412A	Flux - Brazing, Aluminum
3414A	Flux - Welding, Aluminum
3415	Flux - Aluminum Dip Brazing, 1030F Fusion Point
3416	Flux - Aluminum Dip Brazing, 1090F Fusion Point

28. **American Society for Testing and Materials Specifications.** Following is a list of ASTM Specifications.

Number	Title
B26-65	Sand Castings, Aluminum Alloy
B85-60	Die Castings, Aluminum Alloy
B108-65	Permanent Mold Castings, Aluminum Alloy
B209-65	Sheet and Plate, Aluminum Alloy
B210-65	Drawn Seamless Tubes, Aluminum Alloy
B211-65	Bars, Rods, and Wire, Aluminum Alloy
B221-65	Extruded Bars, Rods, Shapes and Tubes, Aluminum Alloy
B234-65	Drawn Seamless Tubes for Condensers and Heat Exchangers - Aluminum Alloy

AMS Number	Title
B241-65	Seamless Pipe Aluminum Alloy
B307-64	Drawn Seamless Coiled Tubes for Special Purpose Applications, Aluminum Alloy
B313-65	Round Welded Tubes, Aluminum Alloy
B345-65	Seamless Pipe for Gas and Oil Transmission and Distribution Piping Systems, Aluminum Alloy
B361-64	Welding Fittings, Factory Made Wrought, Aluminum and Aluminum Alloy
B404-65T	Seamless Condenser and Heat Exchanger Tubes with Integral Fins, Aluminum Alloy
B429-65T	Extruded Structural Pipe and Tube, Aluminum Alloy

Aluminum Wrought Products for Electrical Purposes

B230-60	Wire for Electrical Purposes, Aluminum, EC-H19
B231-64	Concentric-Lay-Stranded Aluminum Conductors
B232-64T	Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced (ACSR)
B233-64	Rods for Electrical Purposes, Rolled Aluminum
B236-64	Bars for Electrical Purposes (Bus Bars), Aluminum
B245-63	Steel Core Wire for Aluminum Conductors, Standard Weight Zinc-Coated (Galvanized), Steel-Reinforced (ACSR)
B258-65	Standard Nominal Diameters and Cross-Sectional Areas of Awg Sizes of Solid Round Wires Used as Electrical Conductors
B261-63	Steel Core Wire (With Coatings Heavier Than Standard Weight) for Aluminum Conductors, Zinc-Coated (Galvanized), Steel-Reinforced (ACSR)
B262-61	Wire for Electrical Purposes, Aluminum, EC-H16 or -H26
B314-60	Wire for Communication Cable, Aluminum
B317-64	Bar, Rod, Pipe, and Structural Shapes for Electrical Purposes (Bus Conductors), Aluminum-Alloy Extruded
B323-61	Wire for Electrical Purposes, Aluminum, EC-H14 or -H24
B324-60	Wire for Electrical Purposes, Rectangular and Square Aluminum
B341-63T	Steel Core Wire for Aluminum Conductors, Aluminum-Coated (Aluminized), Steel-Reinforced (ACSR)
B373-65	Aluminum Foil for Capacitors
B396-63T	Wire for Electrical Purposes, 5005-H19 Aluminum-Alloy
B397-63T	Concentric-Lay-Stranded Conductors, 5005-H19 Aluminum-Alloy
B398-63T	Wire for Electrical Purposes, 6201-T81 Aluminum-Alloy
B399-63T	Concentric-Lay-Stranded Conductors, 6201-T81 Aluminum-Alloy
B400-63T	Concentric-Lay-Stranded Aluminum EC Grade Conductors, Hard-Drawn Compact Round
B401-63T	Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced (ACSR) Compact Round
B415-64T	Steel Wire, Hard-Drawn Aluminum-Clad
B416-64T	Concentric-Lay-Stranded Steel Conductors, Aluminum-Clad

Section III

Typical Properties and Characteristics

The properties cited in this Section are average for various forms, sizes, and methods of manufacture, and may not exactly describe any one particular product.

The abbreviations used in this section and in Section III are defined as follows:

Al	-	Aluminum
BHN	-	Brinell Hardness Number
Cr	-	Chromium
Cu	-	Copper
D	-	Die cast
EL	-	Permanent extension in gage length measured after rupture and stated as a percent of the original gage length
End	-	Endurance
Fe	-	Iron
Ksi	-	Thousand pounds per square inch
Mg	-	Magnesium
Mn	-	Manganese
Ni	-	Nickel
PM	-	Permanent-mold cast
S	-	Sand cast
Si	-	Silicon
Sn	-	Tin
SS	-	Shear strength
Ti	-	Titanium
TS	-	Tensile strength
YS	-	Yield strength (0.2% offset)
Zn	-	Zinc

TABLE 1. CASTING ALLOYS - CROSS REFERENCE

		SAND CASTINGS			PERMANENT AND SEMI-PERMANENT MOLD CASTINGS			DIE CASTINGS			
Commercial Designation	SAE	QQ-A-601d	ASTM B-26-65	AMS	QQ-A-596d	ASTM B108-65	AMS	QQ-A-591d	ASTM B-85-60	AMS	MIL-A-21180C
13								13	S12B		
A13	305							A13	S12A		
40E	310	40E	ZG61A								
43	35, 304	43	S5A		43			43	SC5		
108		108	CS43A								
A108					A108						
113	33	113	CS72A		113						
122	34	122	CG100A		122						
A132	321				A132	SN122A					
B132	328										
E132	334										
F132	332				F132	SC103A					
142	39	142	CN42A	4220, 4221	142	CN42A					
152	300										
195	38	195	C4A	4230, 4231							
B195	380				B195		4282, 4288				
214	320	214									
A214					A214	CZ428					
B214		B214									
218								218			
220	324	220	G10A	4240							
319	326, 329	Allcast	SC64D		319	SC64D					
333					333	SC94A					
354											354
355	322	355	SC51A	4210, 4212, 4214		SC51A	4281, 4282				
C355	335				C355	SC51B					C355
356	323	356	SG70A	4217		SG70A	4260, 4261 4284, 4285 4286				
A356	336				A356	SG70B					A356
357		357			357						357
360								360	SG100B	4290	359
A360	309							A360			
380	308							380	SC84B	4291	
A380	306							A380	SC84A		
384	303										
A612	313	A612	ZG61A								
C612	314										
750		750			750		4275				
A750		A750			A750						
B750		B750			B750						
Almag 35		Almag 35	GM70B								
Precedent 71A		Precedent 71A									
Red X-8	327	Red X-8	SC82A								
T-1		T-1									
Tenzaloy	315	Tenzaloy	ZC81A		Tenzaloy (613)	ZC81B					
Ternalloy 5	311	Ternalloy 5	ZG32A		Ternalloy 5 (603)	ZG32A					
Ternalloy 7	312	Ternalloy 7	ZG42A		Ternalloy 7 (607)	ZG42A					
SC114A								SC114A	SC114A		

TABLE II. CHEMICAL COMPOSITION LIMITS OF CAST ALUMINUM ALLOYS

Alloy Number	Copper	Iron	Silicon	Magnesium	Manganese	Nickel	Zinc	Titanium	Chromium	Tin	Other Elements Each	Other Elements Total	Remainder
13	0.6	2.0	11.0-13.0	0.10	0.35	0.50	0.50	-	-	0.15	-	0.25	
A13	0.6	1.3	11.0-13.0	0.10	0.35	0.50	0.50	-	-	0.15	-	0.25	
40E	0.25	0.50	0.30	0.50-0.65	0.10	-	5.0-7.0	0.15-0.25	0.40-0.60	-	0.05	0.20	
43 (1)	0.15	0.80	4.5-6.0	0.05	0.35	-	0.35	0.25	-	-	0.05	0.15	
108	3.5-4.5	1.2	2.5-3.5	0.10	0.50	0.35	1.0	0.25	-	-	-	0.50	
A108	4.0-5.0	1.0	5.0-6.0	0.10	0.50	-	1.0	0.25	-	-	-	0.50	
113	6.0-8.0	1.4	1.0-4.0	0.10	0.60	0.35	2.5	0.25	-	-	-	0.50	
SC114A	3.0-4.5	1.3	10.5-12.0	0.10	0.50	0.50	1.0	-	-	0.35	-	0.50	
122	9.2-10.8	1.5	2.0	0.15-0.35	0.50	0.50	0.8	0.25	-	-	-	0.35	
A132	0.50-1.5	1.3	11.0-13.0	0.70-1.3	0.35	2.0-3.0	0.35	0.25	-	-	0.05	-	
F132	2.0-4.0	1.2	8.5-10.5	0.50-1.5	0.50	0.50	1.0	0.25	-	-	-	0.50	
142	3.5-4.5	1.0	0.70	1.2-1.8	0.35	1.7-2.3	0.35	0.25	0.25	-	0.05	0.15	
195	4.0-5.0	1.0	1.5	0.03	0.35	-	0.35	0.25	-	-	0.05	0.15	
B195	4.0-5.0	1.2	2.0-3.0	0.05	0.35	0.35	0.50	0.25	-	-	-	0.35	
214	0.15	0.50	0.35	3.5-4.5	0.35	-	0.15	0.25	-	-	0.05	0.15	
A214	0.10	0.40	0.30	3.5-4.5	0.30	-	1.4-2.2	0.20	-	-	0.05	0.15	
B214	0.35	0.60(2)	1.4-2.2	3.5-4.5	0.80(2)	-	0.35	0.25	0.25	-	0.05	0.15	
218	0.25	1.8	0.35	7.5-8.5	0.35	0.15	0.15	-	-	0.15	-	0.25	
220	0.25	0.30	0.25	9.5-10.6	0.15	-	0.15	0.25	-	-	0.05	0.15	
319	3.0-4.5	1.20	5.5-7.0	0.50	0.80	0.50	1.0	0.25	-	-	-	0.50	
333	3.0-4.0	1.0	8.0-10.0	0.05-0.50	0.50	0.50	1.0	0.25	-	-	-	0.50	
355	1.0-1.5	0.80(3)	4.5-5.5	0.40-0.60	0.50(3)	-	0.35	0.25	0.25	-	0.05	0.15	
C355	1.0-1.5	0.20	4.5-5.5	0.40-0.60	0.10	-	0.10	0.20	-	-	0.05	0.15	
356	0.25	0.60	6.5-7.5	0.20-0.40	0.35	-	0.35	0.25	-	-	0.05	0.15	
A356	0.20	0.20	6.5-7.5	0.20-0.40	0.10	-	0.10	0.20	-	-	0.05	0.15	
357	0.05	0.15	6.5-7.5	0.45-0.60	0.03	-	0.05	0.20	-	-	0.05	0.15	
360	0.60	2.0	9.0-10.0	0.40-0.60	0.35	0.50	0.50	-	-	0.15	-	0.25	
A360	0.60	1.3	9.0-10.0	0.40-0.60	0.35	0.50	0.50	-	-	0.15	-	0.25	
380	3.0-4.0	1.3	7.5-9.5	0.10	0.50	3.0	0.50	-	-	0.35	-	0.50	
A380	3.0-4.0	2.0	7.5-9.5	0.10	0.50	3.0	0.50	-	-	0.35	-	0.50	
A612	0.35-0.65	0.50	0.15	0.60-0.80	0.05	-	6.0-7.0	0.25	-	-	0.05	0.15	
750	0.70-1.30	0.70	0.70	-	0.10	0.70-1.30	-	0.20	-	5.5-7.0	-	0.30	
A750	0.70-1.30	0.70	2.0-3.0	-	0.10	0.30-0.70	-	0.20	-	5.5-7.0	-	0.30	
B750	1.7-2.3	0.70	0.40	0.60-0.90	0.10	0.90-1.50	-	0.20	-	5.5-7.0	-	0.30	
Almag 35	0.10	0.25(4)	0.20(4)	6.2-7.5	0.10-0.25	-	-	0.10-0.25	-	-	0.05	0.15	
Allcast	3.3-4.3	1.0	5.5-7.0	0.10	0.50	0.35	1.0	0.25	-	-	-	0.50	
Precedent 71A	0.10	0.15	0.15	0.75-0.92	0.10	0.05	6.5-7.5	0.08-0.20	0.06-0.20	0.03	0.03	0.10	
Red X-8	1.0-2.0	1.0	7.0-8.6	0.20-0.60	0.20-0.60	0.25	1.5	0.25	0.35	-	-	0.50	
TI	1.5-2.5	0.80	0.25	0.50-1.10	0.30	-	0.50-1.25	0.10-0.25	0.15-0.30	1.25-2.50	-	-	
Tenzaloy	0.40-1.0	1.3	0.25	0.20-0.50	0.60	0.15	7.0-8.0	0.25	0.35	-	0.10	0.25	
Ternalloy 5	0.20	0.80	0.20	1.4-1.8	0.40-0.60	-	2.7-3.3	0.25	0.20-0.40	-	0.05	0.15	
Ternalloy 7	0.20	0.80	0.20	1.8-2.40	0.40-0.60	-	4.0-4.5	0.25	0.20-0.40	-	0.05	-	

(1) Values given are taken from QQ-A-596 and QQ-A-601. QQ-A-591 differs in that it requires; 0.60 Copper, 2.0 Iron, 0.10 Magnesium, 0.50 Nickel, 0.50 Zinc, NO Titanium and 0.15 Tin.

(2) If Copper plus Iron exceeds 0.50 percent, a Manganese content of at least 0.35 percent is desirable.

(3) If the Iron content exceeds 0.45 percent, it is desirable to have the Manganese content equal to one-half the Iron.

(4) Iron plus Silicon not to exceed 0.40 percent.

TABLE III. CHEMICAL COMPOSITION LIMITS OF WROUGHT ALUMINUM ALLOYS

Designation	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Others (3) Each	Others (3) Total	Aluminum(4) Min.
EC(6)	-	-	-	-	-	-	-	-	-	-	-	99.45
1100	1.0 Si + Fe		0.20	0.05	-	-	-	0.10	-	0.05(18)	0.15	99.00
1130(7)	0.7 Si + Fe		0.20	-	-	-	-	-	-	0.05	-	99.30
1230(8)	0.7 Si + Fe		0.10	0.05	-	-	-	0.10	-	0.05	-	99.30
1235	0.65 Si + Fe		0.05	-	-	-	-	-	-	0.05	-	99.35
1145(9)	0.55 Si + Fe		0.05	0.05	-	-	-	-	-	0.03	-	99.45
1345	0.30	0.40	0.10	-	-	-	-	-	-	0.05	-	99.45
1060	0.25	0.35	0.05	0.03	0.03	-	-	0.05	0.03	0.03(18)	-	99.60
1175(10)	0.15 Si + Fe		0.10	-	-	-	-	-	-	0.02	-	99.75
2011	0.40	0.7	5.0-6.0	-	-	-	-	0.30	-	0.05(11)	0.15	Remainder
2014	0.50-1.2	1.0	3.9-5.0	0.40-1.2	0.20-0.8	0.10	-	0.25	0.15	0.05(18)	0.15	Remainder
2017	0.8	1.0	3.5-4.5	0.40-1.0	0.20-0.8	0.10	-	0.25	-	0.05	0.15	Remainder
2117	0.8	1.0	2.2-3.0	0.20	0.20-0.50	0.10	-	0.25	-	0.05	0.15	Remainder
2018	0.9	1.0	3.5-4.5	0.20	0.45-0.9	0.10	1.7-2.3	0.25	-	0.05	0.15	Remainder
2218	0.9	1.0	3.5-4.5	0.20	1.2-1.8	0.10	1.7-2.3	0.25	-	0.05	0.15	Remainder
2618	0.25	0.9-1.3	1.9-2.7	-	1.3-1.8	-	0.9-1.2	-	0.04-0.10	0.05	0.15	Remainder
2219	0.20	0.30	5.8-6.8	0.20-0.40	0.02	-	-	0.10	0.02-0.10	0.05(20)	0.15	Remainder
2024	0.50	0.50	3.8-4.9	0.30-0.9	1.2-1.8	0.10	-	0.25	-	0.05	0.15	Remainder
2025	0.50-1.2	1.0	3.9-5.0	0.40-1.2	0.05	0.10	-	0.25	0.15	0.05	0.15	Remainder
3003	0.6	0.7	0.20	1.0-1.5	-	-	-	0.10	-	0.05(18)	0.15	Remainder
3004	0.30	0.7	0.25	1.0-1.5	0.8-1.3	-	-	0.25	-	0.05(18)	0.15	Remainder
4032	11.0-13.5	1.0	0.50-1.3	-	0.8-1.3	0.10	0.50-1.3	0.25	-	0.05	0.15	Remainder
4043	4.5-6.0	0.8	0.30	0.05	0.05	-	-	0.10	0.20	0.05(18)	0.15	Remainddr
4343(12)	6.8-8.2	0.8	0.25	0.10	-	-	-	0.20	-	0.05	0.15	Remainder
5005	0.40	0.7	0.20	0.20	0.50-1.1	0.10	-	0.25	-	0.05	0.15	Remainder
5050	0.40	0.7	0.20	0.10	1.0-1.8	0.10	-	0.25	-	0.05(18)	0.15	Remainder
5052	0.45 Si + Fe		0.10	0.10	2.2-2.8	0.15-0.35	-	0.10	-	0.05(18)	0.15	Remainder
5252	0.08	0.10	0.10	0.10	2.2-2.8	-	-	-	-	0.03	0.10	Remainder
5652	0.40 Si + Fe		0.04	0.01	2.2-2.8	0.15-0.35	-	0.10	-	0.05(18)	0.15	Remainder
5154	0.45 Si + Fe		0.10	0.10	3.1-3.9	0.15-0.35	-	0.20	0.20	0.05(18)	0.15	Remainder
5254	0.45 Si + Fe		0.05	0.01	3.1-3.9	0.15-0.35	-	0.20	0.05	0.05(18)	0.15	Remainder
5454	0.40 Si + Fe		0.10	0.50-1.0	2.4-3.0	0.05-0.20	-	0.25	0.20	0.05	0.15	Remainder
5155	0.30	0.7	0.25	0.20-0.6	3.5-5.0	0.05-0.25	-	0.25	0.15	0.05	0.15	Remainder
5056	0.30	0.40	0.10	0.05-0.20	4.5-5.6	0.05-0.20	-	0.10	-	0.05(18)	0.15	Remainder
5356	0.50 Si + Fe		0.10	0.05-0.20	4.5-5.5	0.05-0.20	-	0.10	0.06-0.20	0.05(18)	0.15	Remainder
5456	0.40 Si + Fe		0.10	0.50-1.0	4.7-5.5	0.05-0.20	-	0.25	0.20	0.05	0.15	Remainder
5257	0.08	0.10	0.10	0.03	0.20-0.6	-	-	0.03	-	0.02	0.05	Remainder
5457	0.08	0.10	0.20	0.15-0.45	0.8-1.2	-	-	-	-	0.03	0.10	Remainder
5557	0.10	0.12	0.15	0.10-0.40	0.40-0.8	-	-	-	-	0.03	0.10	Remainder
5657	0.08	0.10	0.10	0.03	0.6-1.0	-	-	0.03	-	0.02	0.05	Remainder
5083	0.40	0.40	0.10	0.30-1.0	4.0-4.9	0.05-0.25	-	0.25	0.15	0.05	0.15	Remainder
5086	0.40	0.50	0.10	0.20-0.7	3.5-4.5	0.05-0.25	-	0.25	0.15	0.05	0.15	Remainder
6101(13)	0.30-0.7	0.50	0.10	0.03	0.35-0.8	0.03	-	0.10	-	0.03(19)	0.10	Remainder
6201	0.50-0.9	0.50	0.10	0.03	0.6-0.9	0.03	-	0.10	-	0.03(19)	0.10	Remainder
6003(14)	0.35-1.0	0.6	0.10	0.8	0.8-1.5	0.35	-	0.20	0.10	0.05	0.15	Remainder

TABLE III (Continued). CHEMICAL COMPOSITION LIMITS OF WROUGHT ALUMINUM ALLOYS

Designation	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Others (3) Each	Others (3) Total	Aluminum (4) Min.
6011	0.6-1.2	1.0	0.40-0.9	0.8	0.6-1.2	0.30	0.20	1.5	0.20	0.05	0.15	Remainder
6151	0.6-1.2	1.0	0.35	0.20	0.45-0.8	0.15-0.35	-	0.25	0.15	0.05	0.15	Remainder
6951	0.20-0.50	0.8	0.15-0.40	0.10	0.40-0.08	-	-	0.20	-	0.05	0.15	Remainder
6053	(17)	0.35	0.10	-	1.1-1.4	0.15-0.35	-	0.10	-	0.05	0.15	Remainder
6253(15)	(17)	0.50	0.10	-	1.0-1.5	0.15-0.35	-	1.6-2.4	-	0.05	0.15	Remainder
6061	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.15-0.35	-	0.25	0.15	0.05	0.15	Remainder
6262	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.14	-	0.25	0.15	0.05(5)	0.15	Remainder
6063	0.20-0.6	0.35	0.10	0.10	0.45-0.9	0.10	-	0.10	0.10	0.05	0.15	Remainder
6463	0.20-0.6	0.15	0.20	0.05	0.45-0.9	-	-	-	-	0.05	0.15	Remainder
6066	0.9-1.8	0.50	0.7-1.2	0.6-1.1	0.8-1.4	0.40	-	0.25	0.20	0.05	0.15	Remainder
7001	0.35	0.40	1.6-2.6	0.20	2.6-3.4	0.18-0.40	-	6.8-8.0	0.20	0.05	0.15	Remainder
7039	0.30	0.40	0.10	0.10-0.40	2.3-3.3	0.15-0.25	-	3.5-4.5	0.10	0.05	0.15	Remainder
7072(16)	0.7 Si + Fe		0.10	0.10	0.10	-	-	0.8-1.3	-	0.05	0.15	Remainder
7075	0.50	0.7	1.2-2.0	0.30	2.1-2.9	0.18-0.40	-	5.1-6.1	0.20	0.05	0.15	Remainder
7076	0.40	0.6	0.30-1.0	0.30-0.8	1.2-2.0	-	-	7.0-8.0	0.20	0.05	0.15	Remainder
7277	0.50	0.7	0.8-1.7	-	1.7-2.3	0.18-0.35	-	3.7-4.3	0.10	0.05	0.15	Remainder
7178	0.50	0.7	1.6-2.4	0.30	2.4-3.1	0.18-0.40	-	6.3-7.3	0.20	0.05	0.15	Remainder
7079	0.30	0.40	0.40-0.8	0.10-0.30	2.9-3.7	0.10-0.25	-	3.8-4.8	0.10	0.05	0.15	Remainder
Al Zn Mg. MIL-A-45225B	0.30	0.40	0.10	0.10-0.70	2.0-3.8	0.25	-	3.5-5.0	0.10	0.05	0.15	Remainder + 0.20 Zirconium

NOTES:

(1) Composition in percent maximum unless shown as a range.

(2) For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis is rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

(3) Analysis is regularly made only for the elements for which specific limits are shown, except for unalloyed aluminum. If, however, the presence of other elements is suspected, or indicated in the course of routine analysis, further analysis is made to determine that these other elements are not in excess of the amount specified.

(4) The aluminum content for unalloyed aluminum not made by a refining process is the difference between 100.000 percent and the sum of all other metallic elements present in amounts of 0.010 percent or more each, expressed to the second decimal.

(5) Also contains 0.40-0.7 percent each of lead and bismuth.

(6) Electric conductor.

(7) Reflector sheet.

(8) Cladding on alclad 2024.

(9) Foil.

(10) Cladding on clad 1100 and clad 3003 reflector sheet.

(11) Also contains 0.20-0.6 percent each of lead and bismuth.

(12) Brazing alloy

(13) Bus conductor

(14) Cladding on alclad 2014.

(15) Cladding on alclad 5056.

(16) Cladding on alclad 2219, 3003, 3004, 5050, 5155, 6061, 7075, 7178 and 7079.

(17) Silicon 45 to 65 percent of magnesium content.

(18) Beryllium 0.0008 maximum for welding electrode and filler wire only.

(19) Boron, 0.06 percent maximum.

(20) Vanadium 0.05-0.15; zirconium 0.10-0.25.

TABLE IV. WROUGHT ALLOYS - CROSS REFERENCE (ALLOY TO FORM)

Commercial Alloy Designation	Plate Sheet	Bar, Rod Shapes and Tube Extruded	Bar, Rod, Wire or Special Shapes Rolled, Drawn or Cold Finished	Drawn Seamless Tube	Forgings	Impact Extrusions	Rivet Heading Wire
1100(1)	QQ-A-250/1		QQ-A-225/1	WW-T-700/1		MIL-A-12545	QQ-A-430
2011			QQ-A-225/3				
2014		QQ-A-200/2	QQ-A-225/4		QQ-A-367	MIL-A-12545	
Alclad 2014	QQ-A-250/3						
2017			QQ-A-225/5		QQ-A-367		QQ-A-430
2018					QQ-A-367		
2020	QQ-A-250/16						
2024	QQ-A-250/4	QQ-A-200/3	QQ-A-225/6	WW-T-700/3			QQ-A-430
Alclad 2024	QQ-A-250/5						
2025					QQ-A-367		
2117							QQ-A-430
2218					QQ-A-367		
2219					QQ-A-367		
2618					QQ-A-367		
3003	QQ-A-250/2	QQ-A-200/1	QQ-A-225/2	WW-T-700/2			QQ-A-430
4032					QQ-A-367		
5052	QQ-A-250/8		QQ-A-225/7	WW-T-700/4			QQ-A-430
5056							QQ-A-430
5083	QQ-A-250/6	QQ-A-200/4			QQ-A-367		
5086	QQ-A-250/7	QQ-A-200/5		WW-T-700/5			
5454	QQ-A-250/10	QQ-A-200/6					
5456	QQ-A-250/9	QQ-A-200/7					
6011						MIL-A-12545	
6053							QQ-A-430
6061	QQ-A-250/11	QQ-A-200/8	QQ-A-225/8	WW-T-700/6	QQ-A-367		QQ-A-430
6063		QQ-A-200/9					
6066		QQ-A-200/10			QQ-A-367		
6151					QQ-A-367	MIL-A-12545	
7075	QQ-A-250/12	QQ-A-200/11	QQ-A-225/9		QQ-A-367	MIL-A-12545	QQ-A-430
Alclad 7075	QQ-A-250/13						
Alclad one side 7075	QQ-A-250/18						
7076					QQ-A-367		
7079	QQ-A-250/17	QQ-A-200/12			QQ-A-367		
7178	QQ-A-250/14						
Alclad 7178	QQ-A-250/15						
7277							MIL-R-12221
X8280	MIL-A-11267						

NOTE:

(1) MIL-A-148 – Aluminum Foil

TABLE V. WROUGHT ALLOYS - CROSS REFERENCE (ALLOY TO SPECIFICATION)

Alloy	Government	ASTM	SAE	AMS
1060		B209, B211, B221, B245, B210, B234	AA1060	4000B
1100	QQ-A-225/1 QQ-A-250/1 QQ-A-430 QQ-A-00435 WW-T-700/1 MIL-A-148 MIL-A-12545 MIL-R-5674	B211 B209 B316 B209 B234, B210 - - B316	AA1100 AA1100 AA1100 AA1100 AA1100 - - AA1100	4102, 4180 4001, 4003 7220 4001, 4003 4062 - - -
2011	QQ-A-225/3	B211	AA2011	-
2014	QQ-A-200/2 QQ-A-225/4 QQ-A-367 MIL-A-12545 MIL-T-15089 MIL-A-22771 MIL-A-25994	B221 B211 B247 - B221 B247 B221	AA2014 AA2014 AA2014 - AA2014 AA2014 AA2014	4153 4121 4134, 4135 - - - 4028, 4029, 4014
Alclad 2014	QQ-A-250/3	B209	AA2014	-
2017	QQ-A-225/5 QQ-A-430	B211 B316	AA2017 AA2017	4110, 4118 -
2018	QQ-A-367	B247	AA2018	4146
2020	QQ-A-250/16 MIL-A-8882	- -	AA2020 -	- -
2024	QQ-A-200/3 QQ-A-225/6 QQ-A-250/4 QQ-A-430 WW-T-700/3 MIL-R-5674 MIL-R-7885 MIL-T-15089	B221 B211 B209 B316 B210, B234 B316 B316 B234, B221	AA2024 AA2024 AA2024 AA2024 AA2024 AA2024 AA2024 AA2024	4152, 4164, 4165 4112, 4119, 4120 4033, 4035, 4037 - 4086, 4087, 4088, 4097, 4098, 4099, 4103, 4104, 4105, 4106 - - -
Alclad 2029	QQ-A-250/5 MIL-S-7811	B209 -	AA2024 -	4034, 4036, 4040, 4041, 4042, 4060, 4061, 4072, 4073, 4074, 4075 -
2025	QQ-A-367	B247	-	4130
2117	QQ-A-430 MIL-R-5674	B316 B316	AA2117 AA2117	- -
2218	QQ-A-367	B247	AA2218	4142
2219	MIL-A-8920	B209	AA2219	4031
2618	QQ-A-367	-	-	4132
3003	QQ-A-200/1 QQ-A-225/2 QQ-A-250/2 QQ-A-430 QQ-A-00434 WW-T-700/2 MIL-R-1150 MIL-M-17999 MIL-P-25995	B221 B211 B209 - - B210, B234 316 - B241, B345	AA3003 AA3003 AA3003 - - AA3003 AA3003 - AA3003	- - 4006, 4008 - - 4065, 4067 - - -
3004	WW-P-402	-	AA3004	-
4032	QQ-A-36	B247	AA4032	4145
5052	QQ-A-225/7 QQ-A-250/8 QQ-A-430 QQ-A-00435 WW-T-700/4 MIL-M-17999	B211 B209 B316 - B210, B234, B307 -	AA5052 AA5052 AA5052 AA5052 AA5052 AA5052	4114 4015, 4016, 4017 - - 4069, 4070, 4071 -

TABLE V (Continued). WROUGHT ALLOYS - CROSS REFERENCE (ALLOY TO SPECIFICATION)

Alloy	Government	ASTM	SAE	AMS
5056	QQ-A-430 MIL-R-5674C	B316 B316	- -	4182 -
5083	QQ-A-200/4 QQ-A-250/6 MIL-A-45225 MIL-A-46027 MIL-A-46083	B221, 345 B209 - - -	AA5083 AA5083 AA5083 AA5083 AA5083	- 4056, 4057, 4058, 4059 - - -
5086	QQ-A-200/5 QQ-A-250/7 WW-T-700/5 MIL-A-21579	B221 B209 B210 -	AA5086 AA5086 AA5086 AA5086	- - - -
5154	MIL-P-25995	B241, B234	AA5154	-
5254	MIL-P-25993	B241	-	-
5454	QQ-A-200/6 QQ-A-250/10 MIL-P-25995	B221 B209 B241	AA5454 AA5454 AA5454	- - -
5456	QQ-A-250/9 MIL-A-25994 MIL-A-25995 MIL-A-45225 MIL-A-46027 MIL-A-46083	B209 - B241, B345 B209 - -	AA5456 AA5456 AA5456 AA5456 AA5456 AA5456	- - - - - -
6053	WW-P-402 QQ-A-430 MIL-P-1150	- B316 B316	 - -	- - -
6061	QQ-A-200/8 QQ-A-225/8 QQ-A-250/11 QQ-A-367 WW-P-402 QQ-A-430 WW-T-700/6 MIL-R-1150 MIL-T-7081 MIL-T-10794 MIL-A-12545 MIL-F-17132 MIL-M-17999 MIL-A-22771 MIL-A-25994 MIL-A-25995	B221 B211 B209 B247 - B316 B210, B234 B316 B345 B345 - B209 - B247 B221 B241, B345	AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061 AA6061	4150, 4160, 4161 4115, 4116, 4117 4025, 4026, 4027, 4053 4127, 4146 - - 4079, 4080, 4081, 4082, 4083 - - - - - - - - -
6063	QQ-A-200/9 MIL-P-25995	B221 B241, B345	AA6063 AA6063	4156 -
6066	QQ-A-200/10 QQ-A-367 MIL-A-25994	- - -	- - -	- - -
6070	MIL-A-12545 MIL-A-46104	- -	- -	- -
6151	QQ-A-367 MIL-A-12545	B247 -	AA6151 AA6151	4125 -
7001	MIL-A-52242	-	-	-
7075	QQ-A-200/11 QQ-A-225/9 QQ-A-250/12 QQ-A-367 QQ-A-430 MIL-A-18545 MIL-A-22771	B221 B211 B209 B247 B316 - B247	AA7075 AA7075 AA7075 AA7075 AA7075 AA7075 AA7075	4154, 4168, 4169, 4170 4122, 4123 4038 4139, 4141, 4044, 4045 - 4170 -
Alclad 7075	QQ-A-250/13 MIL-S-7811	B209 -	AA7075 AA7075	4039, 4047, 4048, 4049 -
Alclad 7075 One Side	QQ-A-250/18	B204	-	4046

TABLE V (Continued). WROUGHT ALLOYS - CROSS REFERENCE (ALLOY TO SPECIFICATION)

Alloy	Government	ASTM	SAE	AMS
7076	QQ-A-367	-	-	4137
7079	QQ-A-200/12 QQ-A-250/17 QQ-A-367 MIL-A-22771	B221 B209 - -	AA7079 AA7079 AA7079 AA7079	4171 4024 4138, 4136 -
Alclad 7079	MIL-A-8923	B209	AA7079	-
7178	QQ-A-200/13 QQ-A-350/14	B221 B209	AA7178 AA7178	4158 -
Alclad 7178	QQ-A-250/15	B209	-	4051, 4052
7277	MIL-R-12221	B316	AA7277	-
X8280	MIL-A-11267	-	-	-
Al, Zn, Mg	MIL-A-45225 MIL-A-46063 MIL-A-46083	- - -	- - -	- - -

TABLE VI. TYPICAL PHYSICAL PROPERTIES OF ALUMINUM ALLOYS

Alloy			Density, lb per cu in.	Thermal Conductivity,		Electrical Resistivity		Coef. Linear Therm. Expan. 10^{-6} in./in. (5)	Melting Point, °F	
Type	Designation	Temper		CGS (1)	Eng. (2)	% IACS (3)	µΩcm (4)		Solidus	Liquidus
Sand Cast (QQ-A-601)	43	-F	0.097	0.34	990	37	4.660	12.3	1065	1170
	356		0.097					11.9	1035	1135
		-T51		0.40	1160	43	4.010			
		-T6		0.36	1045	39	4.421			
		-T7		0.37	1070	40	4.310			
	195	-T4	0.102	0.33	960	35	4.926	12.7	970	1190
	214		0.096	0.33	960	35	4.926	13.4	1110	1185
	142		0.102					12.6	990	1175
		-T21		0.40	1160	44	3.9			
		-T571		0.32	930	34	5.1			
	122		0.107					12.4	965	1155
		-T61		0.31	900	33	5.225			
	108		0.101					12.4	970	1160
		-F		0.29	840	31	5.562			
	113		0.106					12.3	965	1160
		-F		0.29	840	30	5.747			
	355		0.098					12.4	1015	1170
		-T51		0.40	1160	43	4.010			
		-T6		0.34	990	36	4.789			
	220		0.093					13.7	840	1120
		-T4		0.21	610	21	8.210			
	40E		0.100					13.7	1105	1195
		-T5		0.33	960	35	4.926			
	Allcast		0.101					11.9	960	1120
		-F		0.26	750	27	6.4			
	Red X-8		0.096					11.9	960	1135
		-F		0.24	695	26	6.6			
	Tenzaloy		0.100							
	A612		0.102					13.1	1105	1195
		-F		0.33	960	35	4.9			
	Ternalloy 5								1030	1175
	Ternalloy 7		0.100						1020	1170
	Almag 35		0.095					13.0	1020	1165
		-F				23	7.5			
	B214		0.096					12.7	1090	1170
		-F		0.35	1015	38	4.5			

TABLE VI (Continued). TYPICAL PHYSICAL PROPERTIES OF ALUMINUM ALLOYS

Alloy			Density, lb per cu in.	Thermal Conductivity,		Electrical Resistivity		Coef. Linear Therm. Expan. 10^{-6} in./in. (5)	Melting Point, °F	
Type	Designation	Temper		CGS (1)	Eng. (2)	% IACS (3)	μΩcm (4)		Solidus	Liquidus
Permanent Mold Cast (QQ-A-596)	113		0.106					12.3	965	1160
		-F		0.29	840	30	5.747			
	122		0.107					12.4	965	1155
		-F		0.32	930	34	5.071			
	142		0.102					12.6	990	1175
		-T571		0.32	930	34	5.071			
		-T61		0.31	900	33	5.224			
	B195		0.101					12.4	970	1170
		-T4		0.31	900	33	5.224			
		-T6		0.31	900	33	5.224			
	A108		0.101						970	1135
		-F		0.34	990	37	4.660	11.9		
	355		0.098					12.4	1015	1150
		-T51		0.40	1160	43	4.010			
		-T6		0.34	990	36	4.789			
	43		0.097					12.3	1065	1170
		-F		0.34	990	37	4.660			
	356		0.097					11.9	1035	1135
		-T6		0.36	1045	39	4.421			
		-T7		0.37	1070	40	4.310			
			0.098					11.0	1000	1050
		-T551		0.28	810	29	5.945			
	319		0.101					11.9	960	1120
		-F		0.26	750	27	6.386			
	Tenzaloy 613								1100	1185
	Ternalloy 5 603								1105	1180
	Ternalloy 7 607								1085	1165
	750		0.104					13.0	435	1200
		-T5		0.44	1275	47	3.668			
MIL-A-10935			0.095			23	7.496	13.0	1020	1165
Die Cast (QQ-A-591)	13		0.096	0.29	841	31	5.561	11.5	1065	1080
	A13		0.096							
	43		0.096	0.34	990	37	4.660	12.3	1065	1170
	218		0.093	0.23	670	24	7.184	13.3	995	1150
	B214		0.096	0.35	1015	38	4.537	12.7		
	A380		0.098	0.24	695	25	6.896	11.7	1000	1100
	380		0.098	0.23	670	23	7.496	11.6	1000	1100
	360		0.095	0.27	785	28	6.158	11.6	1035	1105
	A360		0.095	0.29	841	30	5.747	11.8	1035	1105
	384		0.098	0.23	670	23	7.496	11.3	960	1080
Wrought	1060	-O	0.098	0.56	1625	62	2.8	13.1	1195	1215
		-H18		0.53	1540	61	2.8			
	1100		0.098					13.1	1190	1215
		-O		0.53	1540	59	2.9			
		-H18		0.52	1510	57	3.0			
	2011		0.102					12.7	995	1190
		-T3		0.34	990	36	4.8			
	2014		0.101					12.8	950	1180
		-O		0.46	1340	50	3.4			
		-T4		0.29	840	30	5.7			
		-T6		0.37	1070	40	4.3			
	2017		0.099					13.2	950	1200
		-O		0.41	1190	45	3.8			
		-T4		0.29	840	30	5.7			

TABLE VI (Continued). TYPICAL PHYSICAL PROPERTIES OF ALUMINUM ALLOYS

Alloy			Density, lb per cu in.	Thermal Conductivity,		Electrical Resistivity		Coef. Linear Therm. Expan. 10^{-6} in./in. (5)	Melting Point, °F	
Type	Designation	Temper		CGS (1)	Eng. (2)	% IACS (3)	μΩcm (4)		Solidus	Liquidus
Wrought (Cont.)	2018		0.101					12.4	948	1180
		-T61		0.37	1070	40	4.3			
	2024		0.100					12.9	935	1180
		-O		0.45	1310	50	3.4			
		-T4		0.29	840	30	5.7			
	2025		0.101					12.6	970	1185
		-T6		0.37	1070	40	4.3			
	2117		0.099					13.2	950	1200
		-T4		0.37	1070	40	4.3			
	2218		0.102					12.4	940	1175
		-T72		0.37	1070	40	4.3			
	2219		0.103					12.4	1010	1190
		-O		0.41	1190	44	4.3			
		-T31,T37		0.27	780	28	3.4			
		-T62,T81,T87		0.30	870	30	5.1			
	3003		0.099					12.9	1190	1210
		-O		0.46	1340	50	3.4			
		-H12		0.39	1130	42	4.1			
		-H18		0.37	1070	40	4.3			
	3004	All	0.098	0.39	1130	42	4.1	13.3	1165	1205
	4032		0.097					10.8	990	1160
		-T6		0.33	960	35	4.9			
	4043	-O	0.097	0.39	1130	42	4.1	-	1065	1170
	5005	All	0.098	0.48	1390	52	3.3	13.2	1170	1205
	5050	All	0.097	0.46	1340	50	3.4	13.2	1160	1205
	5052		0.097					13.2	1100	1200
		All		0.33	960	35	4.9			
	5056		0.095					13.4	1055	1180
		-O		0.28	810	29	5.9			
		-H38		0.26	750	27	6.4			
	5083	-O	0.096	0.28	810	29	5.9	13.2	1060	1180
	5086	All	0.096	0.30	870	31	5.5	13.2	1084	1184
	5154	All	0.096	0.30	870	32	5.3	13.3	1100	1190
	5252	All	0.097	0.33	960	35	4.9	13.2	1100	1200
	5254	All	0.096	0.30	870	32	5.3	13.3	1100	1190
	5357	All	0.098	0.40	1160	43	3.9	13.2	1165	1210
	5454		0.097					13.1	1115	1195
		-O		0.32	930	34	5.1			
		-H38		0.32	930	34	5.1			
	5456	-O	0.096	0.28	810	29	5.9	13.3	1060	1180
	5557	All	0.098	0.45	1310	49	3.5	13.1	1180	1215
	5657	All	0.098	0.33	960	35	4.9	13.1	1180	1215
	6053		0.097					12.8	1070	1205
		-T6		0.37	1070	40	4.3			
	6061		0.098					13.1	1080	1200
		-O		0.41	1190	45	3.8			
		-T4		0.37	1070	40	4.3			

TABLE VI (Continued). TYPICAL PHYSICAL PROPERTIES OF ALUMINUM ALLOYS

Alloy			Density, lb per cu.in.	Thermal Conductivity,		Electrical Resistivity		Coef. Linear Therm. Expan. 10^{-6} in./in. (5)	Melting Point, °F	
Type	Designation	Temper		CGS (1)	Eng. (2)	% IACS (3)	μΩcm (4)		Solidus	Liquidus
	6063		0.098					13.0	1140	1205
		-T6		0.48	1390	53	3.3			
		-T42		0.46	1340	50	3.4			
	6066		0.098					12.9	1050	1200
		-O		0.37	1070	40	4.3			
		-T6		0.35	1010	37	4.7			
	6101		0.098					13.0	1140	1205
		-T6		0.52	1510	57	3.0			
		-T61		0.53	1540	59	2.9			
		-T62		0.52	1510	58	3.0			
		-T64		0.54	1570	60	2.9			
	6151		0.098					13.0	1140	1205
		-O		0.49	1420	54	3.2			
		-T4		0.39	1130	42	4.1			
		-T6		0.41	1190	45	3.8			
	6262	-T9	0.098	0.41	1190	44	3.9	13.0	1100	1205
	7001	-T6	0.102	0.29	840	31	5.5	13.0	890	1160
	7072	-O	0.098	0.53	1540	59	2.9	13.1	1195	1215
	7075		0.101					13.1	890	1180
		-T6		0.29	840	30	5.7			
	7178	-T6	0.102	0.30	870	31	5.6	13.0	890	1165
	7079		0.099					13.1	900	1180
		-T6		0.29	840	31	5.5			

NOTES:

(1) CGS - cal/cm/cm^2/°C/sec at 77°F

(2) English units - btu/in./ft^2/°F/hour at 77°F

(3) IACS - International Annealed Copper Standard - equal volume

(4) uocm - microhm - centimeter at 68°F

(5) Average Change in length per °F from 68°F to 212°F

TABLE VII. EFFECT OF TEMPERATURE ON THERMAL COEFFICIENT OF LINEAR EXPANSION

Alloy		Average Coefficient, 10^{-6} in./in./°F			
		Temperature Range, °F			
Type	Designation	-58 to +68	68 to 212	68 to 392	68 to 572
Sand Cast (QQ-A-601)	43	11.4	12.3	12.9	13.4
	356	11.0	11.9	12.5	12.9
	195	11.7	12.7	13.2	13.8
	214	12.3	13.4	13.9	14.5
	142	11.6	12.6	13.1	13.6
	122	11.5	12.4	12.9	13.4
	108	11.5	12.4	13.0	13.4
	113	11.3	12.3	12.9	13.3
	355	11.5	12.4	13.0	13.7
	220	12.6	13.7	14.2	14.8
	40E		13.7		
	Allcast	11.0	11.9	12.4	12.7
	Red X-8		11.9		
	A612	12.1	13.1	13.6	14.2
	Ternalloy 7		13.3		14.4
	Almag 35	12.0	13.0	14.2	14.8
	B214	11.8	12.7	13.3	13.8
Permanent Mold Cast (QQ-A-596)	113	11.3	12.3	12.9	13.3
	122	11.5	12.4	12.9	13.4
	142	11.6	12.6	13.1	13.6
	B195	11.4	12.4	13.0	13.4
	A108	11.1	11.9	12.5	12.9
	355	11.5	12.4	13.0	13.7
	43	11.4	12.3	12.9	13.4
	356	11.0	11.9	12.5	12.9
	A132	10.3	11.0	11.5	12.0
	319	11.0	11.9	12.4	12.7
	750	12.0	13.0	13.5	
Die Cast (QQ-A-591)	13	10.7	11.5	12.0	12.6
	43	11.4	12.3	12.9	13.4
	218	12.4	13.3	14.0	14.3
	B214	11.8	12.7	13.3	13.8
	A380	10.8	11.7	12.2	12.6
	380	10.7	11.6	12.1	12.5
	360	10.8	11.6	12.2	12.7
	A360	10.9	11.8	12.4	12.8
	384	10.5	11.3	11.8	12.3
Wrought	1100	12.2	13.1	13.7	14.2
	2011	11.9	12.8	13.4	13.9
	2014	12.0	12.3	13.1	13.6
	2017	12.1	12.7	13.3	13.9
	2018	11.7	12.4	12.9	13.4
	2024	11.9	12.6	13.2	13.7
	2025	12.1	12.6	13.1	13.6
	2117	12.1	13.0	13.6	14.0
	2218	11.7	12.4	13.0	13.5
	3003	12.0	12.9	13.5	13.9
	4032	10.3	10.8	11.3	11.7
	5052	12.3	13.2	13.8	14.3
	5056	12.5	13.4	14.0	14.5
	6053	12.1	12.8	13.4	14.0
	6061	12.1	13.0	13.5	14.1
	6063	12.1	13.0	13.6	14.2
	6151	12.1	12.8	13.4	13.9
	7075	12.1	12.9	13.5	14.4

TABLE VIII. TYPICAL EFFECT OF TEMPERATURE ON ULTIMATE TENSILE STRENGTH

Alloy			Percent of Ultimate Strength at 75°F									
Type	Designation	Temper	-320F	-110F	-20F	+75F	+212F	+300F	+400F	+500F	+600F	+700F
Sand Cast (QQ-A-601)	356	-T51	126	108	104	100	92	83	48	30	16	8
		-T6					90	70	36	23	12	6
	195	-T4					95	86	46	28	12	8
		-T6					94	78	42	25	11	7
	214	-F					94	88	72	52	36	20
	142	-T21						85	67	44	28	
		-T571					100	94	81	41	25	16
	122	-T61					90	80	55	37	18	11
	355	-T51	118	105	101		100	86	50	34	21	12
		-T6					100	94	49	27	17	10
		-T7	116	106	103		97	55	34	20	12	8
		-T71					97	86	49	27	17	10
Permanent Mold Cast (QQ-A-596)	122	-T551					92	81	68	49	24	14
	142	-T571					99	92	70	33	20	12
	B195	-T6					88	72	42	18	9	6
	355	-T51					93	77	50	32	20	12
		-T6					95	76	30	17	10	7
		-T71					92	80	53	26	17	10
	356	-T6					79	55	32	20	10	7
		-T7	133	107	103		84	66	38	22	12	8
	A132	-T551					97	86	72	50	28	14
Die Cast (QQ-A-591)	13						86	74	56	30	16	10
	43						85	67	48	27	15	11
	218						89	71	47	29	19	11
	360						94	74	47	26	15	10
	A360						93	74	46	24	14	9
	380						94	71	50	27	15	8
	A380						94	70	49	26	13	8
	384						98	81	55	30	15	10
Wrought	1100	-O	189	115	104		77	65	46	31	19	16
		-H18	144	109	104		92	75	25	17	10	8
	3003	-O	206	122	107		81	69	53	38	25	19
		-H14	164	109	103		95	82	64	34	18	14
		-H18	143	110	104		90	79	48	26	14	10
	5052	-O	158	106	101		100	86	64	43	27	18
		-H34	144	106	101		100	82	60	32	20	13
		-H38	141	105	101		98	81	55	29	18	12
	5083	-O	141	105	101		100	68	52	36	25	14

TABLE VIII (Continued). TYPICAL EFFECT OF TEMPERATURE ON ULTIMATE TENSILE STRENGTH

Alloy			Percent of Ultimate Strength at 75°F									
Type	Designation	Temper	-320F	-110F	-20F	+75F	+212F	+300F	+400F	+500F	+600F	+700F
Wrought (Cont.)	2011	-T3					85	51	29	12	6	4
	2014	-T6	120	104	103		89	57	23	13	9	6
	2017	-T4	128	104	103		90	64	36	19	10	7
	2018	-T61	118	104	103		92	74	31	16	9	7
	2024	-T3					94	79	41	17	11	8
		-T4	127	106	104		94	66	40	18	12	8
		-T81					94	79	41	17	11	8
		-T86					93	73	27	16	11	7
	2117	-T4					84	70	37	17	10	7
	2218	-T61					95	70	37	17	9	7
	4032	-T6	119	105	102		91	67	24	14	9	6
	6053	-T6					86	68	35	15	11	8
	6061	-T6	133	110	105		93	76	42	17	10	7
	6063	-T42	153	120	108		100	95	41	20	14	11
		-T5	138	108	105		89	74	33	17	11	9
		-T6	135	109	103		89	60	26	13	9	7
	6151	-T6	125	107	104		88	56	25	14	10	8
	7075	-T6	123	105	103		80	30	17	13	10	8
	7079	-T6					86	44	20	14	10	6

TABLE IX. TYPICAL EFFECT OF TEMPERATURE ON YIELD STRENGTH

Alloy			Percent of Yield Strength at 75°F									
Type	Designation	Temper	-320F	-110F	-20F	+75F	+212F	+300F	+400F	+500F	+600F	+700F
Sand Cast (QQ-A-601)	356	-T51	108	102	100	100	98	84	48	25	12	8
		-T6					96	79	37	21	12	8
	195	-T4					95	86	46	28	12	8
		-T6					96	83	37	25	12	6
	214	-F					100	100	100	67	33	17
	142	-T21						83	61	28	17	
		-T571					100	93	70	27	13	10
	122	-T61					95	88	42	23	12	6
	355	-T51	122	109	104		96	83	43	22	13	9
		-T6					100	100	38	20	12	8
		-T7	107	100	100		93	81	26	14	8	6
		-T71					96	90	45	17	10	7
Permanent Mold Cast (QQ-A-596)	122	-T551					93	78	57	34	15	7
	142	-T571					99	97	65	24	12	9
	B195	-T6					88	87	42	15	10	6
	355	-T51					100	83	42	21	12	8
		-T6					100	93	35	19	11	7
		-T71					94	84	42	16	10	6
	356	-T6					93	63	31	18	11	7
		-T7	119	107	103		96	71	35	19	12	8
	A132	-T551					89	78	54	36	14	11
Die Cast (QQ-A-591)	13						95	90	71	43	21	12
	43						100	94	75	38	22	16
	218						92	78	56	33	17	9
	360						100	96	56	30	18	12
	A360						100	96	54	27	17	10
	380						100	92	67	33	17	10
	A380						100	91	65	30	17	11
	384						100	96	72	36	16	10
Wrought	1100	-O	123	107	103		100	90	70	40	30	20
		-H18					82	64	18	9	7	4
	3003	-O	145	116	105		92	83	75	58	42	33
		-H14	120	104	101		90	76	43	19	12	10
		-H18	122	107	103		78	59	33	15	9	7

TABLE IX (Continued). TYPICAL EFFECT OF TEMPERATURE ON YIELD STRENGTH

Alloy			Percent of Yield Strength at 75°F									
Type	Designation	Temper	-320F	-110F	-20F	+75F	+212F	+300F	+400F	+500F	+600F	+700F
Wrought (Cont.)	5052	-O	121	100	100		100	100	85	62	38	23
		-H34	118	103	100		97	87	48	26	16	10
		-H38	116	101	100		100	78	40	22	14	8
	5083	-O					100	82	77	50	34	20
	2011	-T3					79	44	26	9	5	4
	2014	-T6	113	103	102		93	58	22	12	8	6
	2017	-T4	132	104	101		92	75	42	24	12	9
	2018	-T61	110	103	101		94	87	28	14	6	5
	2024	-T3	133	106	101		96	92	44	18	12	8
		-T4					96	77	43	19	13	8
		-T81					95	78	34	14	9	6
		-T86					94	73	23	13	9	6
	2117	-T4					88	71	50	23	15	8
	2218	-T61					95	80	36	14	7	6
	4032	-T6	103	100	100		96	72	20	12	6	4
	6053	-T6					88	75	38	12	8	6
	6061	-T6	116	105	103		95	78	38	12	6	5
	6063	-T42	126	119	110		108	115	50	26	19	16
		-T5	116	105	104		95	86	31	17	12	10
		-T6	116	106	102		90	64	21	11	8	6
	6151	-T6	115	106	104		91	58	22	13	10	8
	7075	-T6	124	105	102		85	29	16	12	9	6
	7079	-T6					88	44	19	12	9	6

TABLE X. TYPICAL EFFECT OF TEMPERATURE ON ELONGATION

Alloy			Percent Elongation									
Type	Designation	Temper	-320F	-110F	-20F	+75F	+212F	+300F	+400F	+500F	+600F	+700F
Sand Cast (QQ-A-601)	356	-T51										
		-T6				3.5	4	5	15	30	60	75
	195	-T4				8.5		9	20	25	80	
		-T6				5	5	5	15	25	75	100
	214	-F				9	9	7	9	12	17	35
	142	-T21				1	1	1	3	8	20	
		-T571				0.5	0.5	0.5	1	8	20	40
	122	-T61				0.5	0.5	1	2	6	14	30
	355	-T51	1.2	1.5	1.5	1.5	2	3	8	16	36	50
		-T6				3	2	1.5	8	16	36	50
		-T7										
		-T71				1.5	2	3	8	16	36	50
Permanent Mold Cast (QQ-A-596)	122	-T551				0.5	0.5	0.5	1	3	10	25
	142	-T571				1	1	1	2	15	35	60
	B195	-T6				5	5	5	15	25	75	100
	355	-T51				2	3	4	19	33	38	60
		-T6				4	5	10	20	40	50	60
		-T71				3	4	8	20	40	50	60
	356	-T6				5	6	10	30	55	70	80
		-T7				6	10	20	40	55	70	80
	A132	-T551				0.5	1	1	2	5	10	45
Die Cast (QQ-A-591)	13					2.5	5	8	15	30	35	40
	43					9	9	10	25	30	35	35
	218					8	8	25	40	45	45	45
	360					3	2	4	8	20	35	40
	A360					5	3	5	14	30	45	45
	380					3	4	5	8	20	30	35
	A380					4	5	10	15	30	45	45
	384					1	1	2	6	25	45	45
Wrought	1100	-O				45	45	55	65	75	80	85
		-H18				15	15	20	65	75	80	85
	3003	-O	49	45	44	43	40	47	60	65	70	70
		-H14	32	18	16	16	16	16	20	60	70	70
		-H18				10	10	11	18	60	70	70

TABLE X (Continued). TYPICAL EFFECT OF TEMPERATURE ON ELONGATION

Alloy			Percent Elongation									
Type	Designation	Temper	-320F	-110F	-20F	+75F	+212F	+300F	+400F	+500F	+600F	+700F
Wrought (Cont.)	5052	-O				30	35	45	65	80	100	120
		-H32	30	21	18	14	16	25	40	80	100	120
		-H38				8	9	20	40	80	100	120
	5083	-O				25	35	45	60	70	95	120
	2011	-T3				15	16	25	35	45	90	125
	2014	-T6				13	14	15	35	45	65	70
	2017	-T4				22	18	16	28	45	95	100
	2018	-T61				12	12	12	25	40	60	100
	2024	-T3				17	16	11	23	55	75	100
		-T4				19	19	17	27	55	75	100
		-T81				7	8	11	23	55	75	100
		-T86				5	6	11	28	55	75	100
	2117	-T4				27	16	20	35	55	80	110
	2218	-T61				13	14	17	30	70	85	100
	4032	-T6				9	9	9	30	50	70	90
	6053	-T6				13	13	13	25	70	80	90
	6061	-T6	25	20	19	17	18	20	28	60	85	90
	6063	-T42				33	18	20	40	75	80	105
		-T5				22	18	20	40	75	80	105
		-T6				18	15	20	40	75	80	105
	6151	-T6				17	19	22	40	50	50	50
	7075	-T6				11	15	30	60	65	80	65
	7079	-T6				13	18	37	60	100	175	175

TABLE XI. TYPICAL MODULII OF ELASTICITY (TENSILE) AT 75° F

Designation		Modulus 10^6 psi
Type	Alloy	
Sand Cast (QQ-A-601)	43	10.3
	356	10.5
	195	10.0
	214	10.3
	142	10.3
	122	10.7
	355	10.2
	220	9.5
	40E	10.3
	Allcast	10.7
	A612	9.7
	Ternalloy 5	10.3
	Ternalloy 7	10.3
Permanent Mold Cast (QQ-A-596)	All	10.3
Die Cast (QQ-A-591)	All	10.3
Wrought	1100	10.0
	2011	10.2
	2014	10.6
	Alclad 2014	10.5
Wrought	2017	10.5
	2018	10.8
	2024	10.6
	Alclad 2024	10.6
	2025	10.4
	2117	10.3
	2218	10.8
	3003	10.0
	4032	10.3
	5052	10.2
	5056	10.3
	5083	10.3
	6053	10.0
	6061	10.0
	6063	10.0
	6066	10.0
	6151	10.2
	7075	10.4
	7079	10.4

NOTE :
(1) For temperatures other than 75° F refer to the following table:

MULTIPLIERS FOR
OTHER TEMPERATURES

Temperature °F	Percent of Modulus at 75°F
-320	112
-112	107
-18	102
+75	100
+212	98
+300	95
+400	90
+500	80

TABLE XII. TYPICAL FATIGUE STRENGTHS – WROUGHT PRODUCTS

Designation		Repeated Flexure Fatigue Strength[1], ksi				
		Million Cycles to Failure				
Alloy	Temper	0.1	1.0	10	100	500
1100	-O		6.5	5.5	5	5
	-H16	14	11.5	10	9	8
3003	-O	10.5	9	8	7.5	7
	-H14	17	12	10	9	9
	-H18	19	14	11.5	10.5	10
5052	-O	23.5	19.5	17.5	16.5	16
	-H34	26	20.5	19	18	18
	-H38	29.5	24	22.5	21	20
2011	-T3	35	26.5	22.5	19.5	18
2014	-T6	39	30	24	19	18
2017	-T4	42	34	27	22	20
2018	-T61	42	29	23	19.5	17
2024	-T4	43	31	24	21	20
4032	-T6	37	30	23.5	18	16
6061	-T6	31	23	17	14.5	13.5
6063	-T42	19.5	16	13.5	11	9.5
	-T5	20.5	15.5	12	10.5	9.5
	-T6	23.5	16.5	13.5	11	9.5
6151	-T6	30	22	17	13	12
7075	-T6	40	29	24	22	22

Designation		Fatigue Strength[1], ksi			
Alloy	Temper	75°F	300°F	400°F	500°F
3003	-H18	10	7.5	5	3.5
2014	-T6	18	12	8	5
2024	-T4	20	14	9	6
5052	-H36	18.5	12.5	9.5	6
6061	-T6	16	11	7.5	4.5
7075	-T6	22	12	8.5	7

NOTE:

(1) Reversed Flexural Stress (R.R. Moore Rotating Beam Test)

TABLE XIII. TYPICAL MECHANICAL PROPERTIES OF WROUGHT ALLOYS

Alloy	Temper	Ult. TS ksi	Ten. YS ksi	Ult. EL % 1/16-in. thick	Ult. EL % 1/2-in. dia.	Hard-ness BHN	Shear Str ksi	Fatigue End. Limit ksi
1100	-O	13	5	35	45	23	9	5
	-H12	16	15	12	25	28	10	6
	-H14	18	17	9	20	32	11	7
	-H16	21	20	6	17	38	12	9
	-H18	24	22	5	15	44	13	9
2011	-T3	55	43	-	15	95	32	18
	-T8	59	45	-	12	100	35	18
2014	-O	27	14	-	18	45	18	13
	-T4, -T451	62	42	-	20	105	38	20
	-T6, -T651	70	60	-	13	135	42	18
Clad 2014	-O	25	10	21	-	-	18	-
	-T3	63	40	20	-	-	37	-
	-T4, -T451	61	37	22	-	-	37	-
	-T6, -T651	68	60	10	-	-	41	-
2017	-O	26	10	-	22	45	18	13
	-T4, -T451	62	40	-	22	105	38	18
2018	-T61	61	46	-	12	120	39	17
2020	-O	35	-	10	-	-	-	-
	-T6	75	70	2	-	-	-	-
	-T651	67	59	6	-	-	-	-
	-F	No Requirements						
2024	-O	27	11	20	22	47	18	13
	-T3	70	50	18	-	120	41	20
	-T4, -T351	68	47	20	19	120	41	20
	-T36	72	57	13	-	130	42	18
Clad 2024	-O	26	11	20	-	-	18	-
	-T3	65	45	18	-	-	40	-
	-T4, -T351	64	42	19	-	-	40	-
	-T36	67	53	11	-	-	41	-
	-T81, -T851	65	60	6	-	-	40	-
	-T86	70	66	6	-	-	42	-
2025	-T6	58	37	-	19	110	35	18
2117	-T4	43	24	-	27	70	28	14
2218	-T72	48	37	-	11	95	30	-
2219	-T6	58	38	8	-	-	-	-

TABLE XIII (Continued). TYPICAL MECHANICAL PROPERTIES OF WROUGHT ALLOYS

Alloy	Temper	Ult. TS ksi	Ten. YS ksi	Ult. EL % 1/16-in. thick	Ult. EL % 1/2-in. dia.	Hard-ness BHN	Shear Str ksi	Fatigue End. Limit ksi
2616	-T61	58	48	4	-	-	-	-
3003	-O	16	6	30	40	28	11	7
	-H12	19	18	10	20	35	12	8
	-H14	22	21	8	16	40	14	9
	-H16	26	25	5	14	47	15	10
	-H18	29	27	4	10	55	16	10
4032	-T6	55	46	-	9	120	38	16
5052	-O	28	13	25	30	47	18	16
	-H32	33	28	12	18	60	20	17
	-H34	38	31	10	14	68	21	18
	-H36	40	35	8	10	73	23	19
	-H38	42	37	7	8	77	24	20
5056	-O	42	22	-	35	65	26	20
	-H18	63	59	-	10	105	34	22
	-H38	60	50	-	15	100	32	22
5083	-O	42	21	22	-	-	25	-
	-H113	46	33	16	-	-	-	23
5086	-O	35	14	14	-	-	-	-
	-H111	36	21	12	-	-	-	-
5454	-O	41	19	14	-	-	-	-
	-H111	42	26	12	-	-	-	-
	-H112	41	19	12	-	-	-	-
5456	-O	45	23	24	-	-	-	-
	-H112	45	24	22	-	-	-	-
	-H311	47	33	18	-	-	-	-
6011	-F	35	32	-	3	70	-	-
	-T6	50	42	-	7	95	-	-
6053	-O	16	8	-	35	26	11	8
	-T6	37	32	-	13	80	23	13
6061	-O	18	8	25	30	30	12	9
6063	-O	13	7	-	-	25	10	8
	-T4	25	13	22	-	-	-	-
	-T5	27	21	12	-	60	17	10
	-T6	35	31	12	-	73	22	10
	-T42	22	13	20	-	42	14	9
	-T83	37	35	9	-	82	22	-
	-T831	30	27	10	-	70	18	-
	-T832	42	39	12	-	95	27	-

TABLE XIII (Continued). TYPICAL MECHANICAL PROPERTIES OF WROUGHT ALLOYS

Alloy	Temper	Ult. TS ksi	Ten. YS ksi	Ult. EL % 1/16-in. thick	Ult. EL % 1/2-in. dia.	Hard-ness BHN	Shear Str ksi	Fatigue End. Limit ksi
6066	-O	22	12	-	18	43	14	-
	-T4, -T451	52	30	-	18	90	30	-
	-T6, -T651	57	52	-	12	120	34	16
6151	-T6	48	43	-	17	100	32	11
7075	-O	40[1]	24[1]	-	10	-	-	-
	-T6, -T6510, -T6511	78	70	7	-	-	-	-
		81	73	-	7	-	-	-
Alclad 7075	-O	36[1]	20[1]	10	-	-	-	-
		40[1]	-	-	10	-	-	-
	-T6	72	62	8	-	-	-	-
		77	66	-	6	-	-	-
	-T651	77	66	-	6	-	-	-
	-F	No Requirements						
Alclad one side 7075	-O	22[1]	21[1]	10	-	-	-	-
		40[1]	-	-	10	-	-	-
	-T6	74	64	8	-	-	-	-
		77	66	-	6	-	-	-
	-T651	77	66	-	6	-	-	-
	-F	No Requirements						
7076	-T61	70	60	-	-	-	-	-
7079	-T6, -T651	78	68	-	14	145	45	23
7178	-O	40[1]	21[1]	10	-	-	-	-
		40[1]	-	-	10	-	-	-
	-T6	84	73	8	-	-	-	-
		84	73	-	6	-	-	-
	-T651	84	73	-	6	-	-	-
	-F	No Requirements						
Alclad 7178	-O	36[1]	20[1]	10	-	-	-	-
		40[1]	-	-	10	-	-	-
	-T6	78	68	8	-	-	-	-
		84	73	-	6	-	-	-
	-T651	84	73	-	6	-	-	-
	-F	No Requirements						
7277	-T4	60	-	-	-	-	35	-
X8280	-H12	18	15	4	-	-	-	-

NOTE : (1) Specification maximum requirement

TABLE XIV. TYPICAL MECHANICAL PROPERTIES OF SAND CAST ALLOYS

QQ-A-601 Alloy	QQ-A-601 Temper	Ult. TS ksi	Ten. YS ksi	Ult. El. %	Hardness BHN	Comp. YS ksi	Shear Str ksi	Fatigue End. Limit ksi
43	-F	19	8	8	40	9	14	8
356	-T4 -T51 -T6	25(1) 25 33	16 20 24	3(1) 2 3.5	65 60 70	 21 25	 20 26	 8 8.5
195	-T4 -T6 -T62 -T7	32 36 41 29(1)	16 24 32 19	8.5 5 2 3(1)	60 75 90 70	17 25 34	26 30 33	7 7.5 8
214	-F	25	12	9	50	12	20	7
142	-T21 -T571	27 32	18 30	1 0.5	70 85	18 34	21 26	8 11
122	-T2 -T61	27 41	20 40	1 (2)	80 115	 43	 32	 8.5
108	-F -T55	21 21(1)	14	2.5	55 75	15	17	11
113	-F	24	15	1.5	70	16	20	9
355	-T51 -T6 -T7 -T71	28 35 38 35	23 25 36 29	1.5 3 0.5 1.5	65 80 85 75	24 26 38 30	22 28 28 26	8 9 10 10
220	-T4	48	26	16	75	27	34	8
40E	-T5	35	26	5	75	14	28	9
Allcast	-F -T6	27 36	18 24	2 2	70 80	19 25	22 29	10 11
Red X-8	-F -T6	30 39	21 30	1.5 1.5	60 85			
T1	-T5	30(1)	22	4(1)	65			
Tenzaloy	-T5	34	25	4.5	75			
A612	-T5	35	25	5	75	25	26	8
Ternalloy 5	-T5	30(1)	19	5(1)	65			
Ternalloy 7	-T5	37	27	1.5	85			
Almag 35	-F -T4	40 35(1)	21 18(1)	13 9(1)	70			10
B214	-F	20	13	2	50	14	17	8.5

NOTES:

(1) Specification minimum requirement

(2) Less than 0.5 percent

TABLE XV. TYPICAL MECHANICAL PROPERTIES OF PERMANENT AND SEMI-PERMANENT MOLD CASTING ALLOYS

QQ-A-596		Ult. TS ksi	Ten. YS ksi	Ult. EL %	Hard-ness BHN	Comp. YS ksi	Shear Str ksi	Fatigue End Limit ksi
Class	Temper							
113	-F	28	19	2	70	20	22	9.5
122	-T551 -T65	37 48	35 36	0.5 0.5	115 140	40 36	30 36	8.5 9
142	-T571 -T61	40 47	34 42	1 0.5	105 110	34 44	30 35	10.5 9.5
B195	-T4 -T6 -T7	37 40 39	19 26 20	9 5 4.5	75 90 80	20 26 20	30 32 30	9.5 10 9
A108	-F	28	16	2	70	17	22	13
355	-T51 -T6 -T62 -T71	30 42 45 36	24 27 40 31	2 4 1.5 3	75 90 105 85	24 27 40 31	24 34 36 27	 10 10 10
43	-F	23	9	10	45	9	16	8
356	-T6 -T7	38 32	27 24	5 6	80 70	27 24	30 25	13 11
A132	-T551 -T65	36 47	28 43	0.5 0.5	105 125	28 43	28 36	13.5
319	-F -T6	34 40	19 27	2.5 3	85 95	19	24	10
Tenzaloy (613)	-T5	33	22	4				
Ternalloy 5 (603)	-T5	37	21	10	70			
Ternalloy 7 (607)	-T5 -T7	47 53	29 43	4 3	95 95			
750	-T5	23	10	12	45	11	15	9
A214	-F	22		2.5				
333	-F -T5 -T6 -T7	28 30 35 31		- - - -				
357	-T6	45		3.0				
A750	-T5	18		6.0				
B750	-T5	27		3.0				
F132	-T5	31		-				
C355	-T61	40		3.0				
A356	-T61	37		5.0				

TABLE XVI. TYPICAL MECHANICAL PROPERTIES OF DIE CASTING ALLOYS

QQ-A-591 Alloy No.	Tensile Strength ksi	Yield strength at 0.2% offset ksi	Elongation in 2 inches %	Shear Str ksi	Fatigue End. Limit ksi
13	43	21	2.5	25	19
A13	42	19	3.5	25	19
43	33	14	9.0	19	17
218	45	27	8.0	29	20
A360	46	24	3.5	26	18
360	44	25	2.5	28	20
A380	47	23	3.5	27	20
380	46	23	2.5	28	20
SC114A	48	24	2.5	-	-

TABLE XVII. APPROXIMATE RADII FOR 90-DEGREE COLD BEND OF WROUGHT ALLOYS

Designation		Radius Required (in terms of sheet thickness, t)							
Alloy	Temper	t=1/64	t=1/32	t=1/16	t=1/8	t=3/16	t=1/4	t=3/8	t=1/2
1100	-O	0	0	0	0	0	0	0	1 - 2
	-H14	0	0	0	0	0 - 1	0 - 1	0 - 1	2 - 3
	-H18	0 - 1	0.5 - 1.5	1 - 2	1.5 - 3	2 - 4	2 - 4	3 - 5	3 - 6
3003	-O	0	0	0	0	0	0	0	1 - 2
	-H14	0	0	0	0 - 1	0 - 1	1 - 1.5	1 - 2.5	1.5 - 3
	-H18	0.5 - 1.5	1 - 2	1.5 - 3	2 - 4	3 - 5	4 - 6	4 - 7	5 - 8
5052	-O	0	0	0	0	0 - 1	0 - 1	0.5 - 1.5	1 - 2
	-H34	0	0	0 - 1	0.5 - 1.5	1 - 2	1.5 - 3	2 - 3	2.5 - 3.5
	-H38	0.5 - 1.5	1 - 2	1.5 - 3	2 - 4	3 - 5	4 - 6	4 - 7	5 - 8
5083	-O	-	-	0 - 0.5	0 - 1	0 - 1	0.5 - 1.5	1.5 - 2	1.5 - 2.5
2014 Clad	-O	0	0	0	0	0 - 1	0 - 1	1.5 - 3	3 - 5
	-T3	1 - 2	1.5 - 3	2 - 4	3 - 5	4 - 6	4 - 6	5 - 7	5.5 - 8
	-T4	1 - 2	1.5 - 3	2 - 4	3 - 5	4 - 6	4 - 6	5 - 7	5.5 - 8
	-T6	2 - 4	3 - 5	3 - 5	4 - 6	5 - 7	6 - 10	7 - 10	8 - 11
2024	-O	0	0	0	0	0 - 1	0 - 1	1.5 - 3	3 - 5
	-T3	1.5 - 3	2 - 4	3 - 5	4 - 6	4 - 6	5 - 7	6 - 8	6 - 9
	-T4	1.5 - 3	2 - 4	3 - 5	4 - 6	4 - 6	5 - 7	6 - 8	6 - 9
	-T81	3.5 - 5	4.5 - 6	5 - 7	6.5 - 8	7 - 9	8 - 10	9 - 11	9 - 12
5456	-O	-	-	-	0 - 1	0.5 - 1	0.5 - 1	0.5 - 1.5	0.5 - 2
	-H321	-	-	-	2 - 3	2 - 3	3 - 4	3 - 4	3 - 4
6061	-O	0	0	0	0	0 - 1	0 - 1	0.5 - 2	1 - 2.5
	-T4	0 - 1	0 - 1	0.5 - 1.5	1 - 2	1.5 - 3	2 - 4	2.5 - 4	3 - 5
	-T6	0 - 1	0.5 - 1.5	1 - 2	1.5 - 3	2 - 4	3 - 4	3.5 - 5.5	4 - 6
7075	-O	0	0	0 - 1	0.5 - 1.5	1 - 2	1.5 - 3	2.5 - 4	3 - 5
	-T6	2 - 4	3 - 5	4 - 6	5 - 7	5 - 7	6 - 10	7 - 11	7 - 12

TABLE XVIII. FORGING ALLOYS - RELATIVE RATING BY CHARACTERISTICS

Alloy	Strength	Cold Workability	Corrosion Resist.	Machinability	Electric Conductance	Hardness	Forgability
1100	4 - 3	1 - 3	1	4 - 3	2	4 - 3	1
2011	2	3 - 4	3 - 4	1	3	2	-
2014	1	3 - 4	3 - 4	2	3	1 - 2	3
2014-Clad	1	3 - 4	1	2	3	-	-
2017	1	3	3 - 4	2	4	2	-
2018	1	-	3	2	3	2	3
2024	1	3 - 4	3 - 4	2	4	1	-
2024-Clad	1	4	1	2	4	-	-
2117	3	2	3	3	-	-	-
2218	2	-	3	2	3	2	4
3003	4 - 3	1 - 3	1	4 - 3	3	4 - 3	1
4032	2	-	3	3	4	2	3
5052	3	1 - 3	1	4 - 3	4	3 - 2	-
5056	2	1 - 3	1 - 3	4 - 3	4	-	-
5083	2	3	1	4 - 3	4	2	-
5456	2	3	1 - 2	4 - 3	4	2	-
6061	3 - 2	3 - 4	1	3	3	3 - 2	-
6063	3 - 2	2 - 3	1	3	2	3 - 2	-
6151	2	-	2	3	3	2	1
7075	1	4	3	2	4	1	4
7075-Clad	1	4	1	2	4	-	-
7079	1	4	3	2	4	1	3

NOTES:

(1) — Relative ratings are in decreasing order of merit.

(2) — First number in numbered pairs is rating for softest temper; second number is for hardest.

TABLE XIX. TYPICAL TENSILE STRENGTHS OF GAS-WELDED JOINTS

Alloy			Thickness, inch	Tensile Strength ksi
Type	Designation	Temper		
Sand Cast (QQ-A-601)	43	-F	0.500	12
	214	-F	0.500	12
Wrought	1100	-H14	0.249	11
	3003	-H14	0.249	14
	5052	-H34	0.249	27

TABLE XX. TYPICAL TENSILE STRENGTHS OF BUTT WELDED JOINTS

Designation			Tensile Strength Across Weld, ksi	
Base Metal		Filler Metal Alloy	As Welded	After Heat Treatment and Aging
Alloy	Temper			
1100		1100	13.5	-
3003		1100	16	-
5052		5052	28	-
2014	-T6	4043	34	51
6061	-T6	4043	27	43
6063	-T5, T6	4043	20	-

NOTE :

(1) Using Argon - shielded tungsten arc or Argon - shielded consumable electrode.

TABLE XXI. TYPICAL SHEAR STRENGTHS OF SPOT WELDS

Combination		Shear Strength (minimum), pounds per spot									
Alloy	Temper	Thinnest Sheet in Joint, inch									
		0.016	0.020	0.025	0.032	0.040	0.051	0.064	0.081	0.102	0.125
1100	-H14) to -H18)	40	55	70	110	150	205	280	420	520	590
3003 3003 5052	-H12) or -H18) to -O)	70	100	145	210	300	410	565	775	950	1000
5052 6061	-H32) or -H38) to -T4) or -T6)	98	132	175	235	310	442	625	865	1200	1625
2024 Clad 2024 7075 Clad 7075	-T3) to) -T3) or -T6) or) -T6)	108	140	185	260	345	480	690	1050	1535	2120

TABLE XXII. WELDABILITY RATINGS FOR CAST AND WROUGHT PRODUCTS

Government Designation		Relative Suitability for Welding, Brazing, and Soldering						
			Arc Weld					
Spec.	Alloy	Gas Weld	with flux	with inert gas	Resist-ance Weld	Pres-sure Weld	Solder-ing	Braz-ing
QQ-A-601 (Sand-cast)	43	A	A	A	A	D	D	C
	356	B	B	B	B	D	D	C
	195	C	C	C	C	D	D	D
	214	C	C	C	C	D	D	D
	142	C	C	C	C	D	D	D
	122	C	C	C	C	D	D	D
	108	B	B	B	B	D	D	D
	113	C	C	C	C	D	C	D
	355	B	B	B	B	D	D	C
	220	D	D	D	D	D	D	D
	Allcast	B	B	B	B	D	D	D
	A612	C	C	C	C	D	C	A
	B214	C	B	B	C	D	D	D
Spec.	Class							
QQ-A-596 (Perma-nent and semi-per-manent Mold Cast)	1	C	C	C	C	D	C	D
	2	C	C	C	C	D	D	D
	3	C	C	C	C	D	D	D
	4	C	C	C	C	D	D	D
	5	B	B	B	B	D	D	D
	6	B	B	B	B	D	D	C
	7	A	A	A	A	D	D	C
	8	B	B	B	B	D	D	C
	9	B	B	B	B	D	D	D
	15	D	D	D	B	D	D	D
Spec.	Alloy							
(Wrought) (See table V for cor-responding spec. nos)	1100	A	A	A	B	A	A	A
	2011	D	D	D	D	D	D	D
	2014	D	B	B	B	D	D	D
	2014-Clad	D	B	B	A	C	D	D
	2017	D	B	B	B	D	D	D
	2018	D	B	B	B	D	D	D
	2024	D	B	B	B	C	D	D
	2024-Clad	D	B	B	A	C	D	D
	3003	A	A	A	A-B	A	A	A
	4032	D	B	B	C	C	D	D
	5052	A	A	A	A-B	A-B	C	C
	6061	A	A	A	A	C	B	A
	6151	A	A	A	A	C	B	B
	7075	D	D	D	B	D	D	D

NOTES:

(1) - Ratings are defined as follows:
- A - Generally weldable by all commercial procedures and methods.
- B - Weldable by special technique.
- C - Weldability limited because of crack sensitivity or loss of properties.
- D - No common methods have been developed.

TABLE XXIII. CASTING ALLOYS – RELATIVE RATING BY CHARACTERISTICS

Designation			Foundry Characteristics				
Sand QQ-A-601 Alloy	P&SP Mold QQ-A-596 Class	Die QQ-A-591 Alloy	Pattern Shrinkage Allowance (2)	Resistance to Hot Cracking (3)	Pressure Tightness	Fluidity (4)	Solidification Shrinkage Tendancy (5)
43		43	5/32	1	1	1	1
	7		-	1	1	1	2
356			5/32	1	1	1	1
	8		-	1	1	2	1
195			5/32	4	4	3	3
214			5/32	4	5	5	5
142			5/32	4	3	3	4
	3		-	4	4	3	4
122			5/32	3	3	3	3
	2		-	4	4	3	4
108			-	2	2	2	2
113			5/32	3	3	2	3
	1		-	3	3	2	3
355			5/32	1	1	1	1
	6		-	1	1	2	2
220			1/10	2	5	4	5
40E			3/16	5	3	4	4
Allcast			5/32	2	2	2	2
319			5/32	2	2	2	2
	11		-	2	2	2	3
Red X-8			5/32	1	1	1	1
T1			-	-	-	3	-
Tenzaloy			3/16	5	3	4	4
	12		-	5	4	4	5
A612			3/16	5	3	4	4
Ternalloy 5			3/16	5	3	4	4
	13		-	5	4	4	5
Ternalloy 7			3/16	5	3	4	4
	14		-	5	4	4	5
Almag 35	MIL-A-10935		-	3	5	5	5
B214		B214	-	3	4	3	4
	4		-	4	3	3	3
	5		-	1	2	2	3
	9		-	1	2	1	3
	10		-	1	2	1	3
	15		-	-	4	4	-
		13	-	1	2	1	-
		A13	-	1	2	1	-
		43	-	2	3	3	-
		A380	-	2	2	2	-
		380	-	2	2	2	-
		360	-	1	1	1	-
		A360	-	1	1	1	-
		218	-	5	5	5	-
		SC114A	-	2	2	1	-

Notes:

(1) Rating: 1 through 5 are relative ratings with 1 indicating the highest and 5 the lowest in each type of casting.

(2) Not applicable to permanent mold and die castings. Allowances are for average sand castings. Shrinkage requirements will vary with intricacy of design and dimensions.

(3) Ability of alloy to withstand contraction stresses while cooling through hot-short or brittle temperature range.

(4) Ability of liquid alloy to flow readily in mold and fill thin sections.

(5) Decrease in volume accompanying freezing of alloy and measure of amount of compensating feed metal required in form of risers.

(6) Based on alloy resistance in 5% salt spray test (ASTM B117).

(7) Composite rating based on ease of cutting, chip characteristics, quality of finishing, and tool life. Ratings, in the case of heat treatable alloys, based on T6 temper. Other tempers, particularly the annealed temper, may have lower rating.

(8) Composite rating based on ease and speed of polishing and quality of finish provided by typical polishing procedure.

(9) Ability of casting to take and hold an electroplate applied by present standard methods.

(10) Rated on lightness of color, brightness, and uniformity of clear anodized coating applied in sulfuric acid electrolyte.

(11) Rated on combined resistance of coating and base alloy to corrosion.

(12) Rating based on tensile and yield strengths at temperature up to 500 F, after prolonged heating at testing temperatures.

(13) Based on ability of material to be fusion welded with filler rod of same alloy.

(14) Refers to suitability of alloy to withstand brazing temperatures without excessive distortion or melting.

(15) Not recommended for service at temperatures exceeding 200 F.

(16) Stress relief anneal at 250 F or less.

TABLE XXIII (Continued). CASTING ALLOYS – RELATIVE RATING BY CHARACTERISTICS

Designation			Other Characteristics									
Sand QQ-A-601 Alloy	P&SP Mold QQ-A-596 Class	Die QQ-A-591 Alloy	Normally Heat Treated	Resistance to Corrosion (6)	Machin-ing (7)	Polish-ing (8)	Electro-plating (9)	Anodize Appearance (10)	Chemical Oxide Coating Protection (11)	Strength at Elevated Temperatures (12)	Welding Suitability (13)	Brazing Suitability (14)
43		43	no	3	5	5	2	5	2	4	1	limited
	7		no	3	5	4	2	4	2	4	1	limited
356			yes	2	4	5	2	4	2	3	2	no
	8		yes	2	3	3	1	4	2	3	2	no
195			yes	3	2	2	1	2	3	3	3	no
214			no	1	1	1	5	1	1	2	4	no
142			yes	4	2	2	1	3	4	1	4	no
	3		yes	4	2	2	1	2	3	1	4	no
122			yes	4	1	2	1	3	4	1	4	no
	2		yes	5	1	2	1	3	4	1	4	no
108			no	4	3	3	2	3	3	3	2	no
113			no	5	2	2	2	3	4	3	3	no
	1		no	6	2	2	2	3	4	3	4	no
355			yes	3	3	3	1	4	2	2	2	no
	6		yes	3	3	3	2	4	2	2	2	no
220			yes	1	1	1	4	1	1	(15)	5	no
40E			aged only	2	1	1	2	2	3	5	4	yes
Allcast			yes	3	3	4	2	4	3	3	2	no
319			yes	3	3	4	2	4	3	3	2	no
	11		yes	3	3	3	2	4	3	3	2	no
Red X-8			yes	3	4	5	2	4	2	2	2	no
T1			aged only	-	1	-	-	-	-	-	-	-
Tenzaloy			aged only	2	1	1	2	2	3	5	4	yes
	12		aged only	2	1	1	2	1	2	5	4	yes
A612			aged only	2	1	1	2	2	3	5	4	yes
Ternalloy 5			aged only	2	1	1	3	2	2	5	4	yes
	13		aged only	2	1	1	3	1	2	5	4	yes
Ternalloy 7			yes	2	1	1	3	2	2	5	4	yes
	14		yes	2	1	1	3	1	2	5	4	yes
Almag 35	MIL-A-10935		(16)	1	1	1	5	1	1	3	4	no
B214		B214	no	1	2	2	4	2	1	3	4	no
	4		yes	4	3	2	1	3	2	2	4	no
	5		no	4	3	3	2	4	3	3	2	no
	9		yes	3	4	5	4	5	2	2	2	no
	10		yes	3	4	5	3	5	2	2	2	no
	15		aged only	3	1	-	-	-	-	-	4	-
		13	no	3	3	5	3	5	3	3	no	no
		A13	no	3	4	5	3	5	3	3	no	ro
		43	no	2	5	4	2	4	3	5	no	no
		A380	no	5	3	3	1	3	5	2	no	no
		380	no	5	3	3	1	3	5	2	no	no
		360	no	3	3	3	1	3	3	2	no	no
		A360	no	3	3	3	1	3	3	2	no	no
		218	no	1	1	1	5	1	1	4	no	no
		SG114A	no	5	3	3	2	4	4	2	no	no

TABLE XXIV. TYPICAL APPLICATIONS FOR CASTING ALLOYS

Type of Casting	General Purpose	Pressure Tight	Corrosion Resistance	High Temp. Strength	Architectural and Decorative	Special Purpose
Sand (QQ-A-601)(1)	43, 195, 108, 40E Allcast T1, 356 355, Red X-8 Tenzaloy A612 Ternalloy 5, Ternalloy 7, Precedent 71A	43, 356 195, 113, 355, Precedent 71A	43, 356, 214, 355, 220, Almag 35, B214	142, 122, 355,	43, 356, 214, 40E Tenzaloy, A612, Ternalloy 5, Almag 35, B214	142-pistons 122-pistons 750-bearings A750-bearings B750-bearings
Permanent & Semi-Permanent Mold (QQ-A-596)(2)	1, 4, 5, 6, 7, 8, 11, 12, 13, 14, 16, 17, 18	5, 6, 7, 8, 9, 10, 11, 13, 14	7, 8, 12, 13, 14, 18 Almag 35 MIL-A-10935	2, 3, 6, 9 10	12, 13, 14, Almag 35 MIL-A-10935	2-pistons 3-pistons 9-pistons 10-pistons 15-bearings 19-bearings 20-bearings
Die (QQ-A-591)(1)	13, A13, 43, 380, A380	360, A360 384	13, A13, 43, B214 218, 360 A360	A380, 380, A360, 360 384	13, A13, B214, 218	

NOTES:

(1) Alloy designation

(2) Class designation

TABLE XXV. PRINCIPAL CHARACTERISTICS AND USES OF WROUGHT ALUMINUM ALLOYS

Alloy	Outstanding Characteristics	Recommended Use
	Non-heat-treatable Alloys	
1100	Very good formability, weldability, and resistance to corrosion. Relatively low strength but high ductility.	General purpose material for drawing and stamping, and for a miscellany of parts where high strength is not required.
3003	Good formability and weldability, very good resistance to corrosion. Appreciably higher strength than 1100.	General purpose material for drawing and stamping. Miscellaneous parts where higher strength is needed than that provided by 1100.
5052	Moderate mechanical properties, stronger and harder than 1100 and 3003. Fairly good formability. Readily weldable. Excellent resistance to corrosion by salt water.	General purpose alloy where fairly high strength is required. For marine and outside applications, fuel and hydraulic lines, and tanks.
	Heat-treatable Alloys	
2011	Excellent free-machining qualities. Fairly high mechanical properties.	Stock for screw-machine products. Bolts, nuts, screws, and a great diversity of parts made on automatic screw machines.
2014	High mechanical properties including yield and tensile strength, fatigue, and hardness. Fair formability and forging qualities. Readily machinable.	Most commonly used alloy where high strength is required. General structural applications, heavy duty forgings, and strong fittings.
Clad 2014	A sheet product which combines the high mechanical properties of 2014 with the good corrosion resistance of 6053.	For structures requiring high unit strength together with good resistance to various corrosive environments.
2017	A bar, rod, and wire alloy having relatively high strength, and good machining qualities.	Screw-machine products, fittings, and structural applications where relatively high strength is required. Now largely superseded by newer alloys
2018 2218	Both retain strength well at elevated temperatures.	Forged pistons and cylinder head for internal-combustion engines. Suitable for various types of high temperature services. Forged cylinder heads and pistons.
2024	A high strength alloy with mechanical properties intermediate between 2014 and 6061.	General purpose material for various structural applications where good strength is required. Fittings and screw-machine products.

TABLE XXV (Continued). PRINCIPAL CHARACTERISTICS AND USES OF WROUGHT ALUMINUM ALLOYS

Alloy	Outstanding Characteristics	Recommended Use
	Heat-treatable Alloys	
Clad 2024	A sheet product which combines the mechanical properties of 2024 with the corrosion resistance of 1230 aluminum alloy.	For structural applications requiring good strength together with resistance to corrosion.
2025	Fairly high mechanical properties. Good forging qualities.	Specialty forging alloy. Applications mostly confined to propellers for superchargers and engines.
4032	Retains strength well at elevated temperatures	Forged pistons for internal-combustion engines.
6151	Fairly good mechanical properties. Excellent forging qualities. Good resistance to corrosion.	General purpose material for ordinary forgings. Small press forgings and intricate pieces that are difficult to forge in the harder alloys.
6061	Good mechanical properties. Superior brazing and welding qualities. Good forging characteristics, workability, and resistance to corrosion.	General structural purposes. Marine and outside work. Transportation equipment. Many small forged parts. Various extrusion applications.
7075	Affords maximum strength and endurance limit. Not readily formed. Poorest forging qualities.	Structual applications requiring maximum yield and tensile strength. Section thickness limited to 3 inches.
Clad 7075	A sheet product which combines the mechanical properties of 7075 with improved corrosion resistance.	Structural applications where the highest strength together with maximum corrosion resistance is necessary.

Section IV
Specification Requirements

This section contains tabulations of the chemical composition and mechanical property requirements for wrought aluminum alloys used by the Government. The data are arranged according to the numerical commercial designations of the alloys.

Each tabulation of chemical composition shows the maximum allowable percentage of the alloying element, or if a range is indicated, the minimum and the maximum allowable percentages of the element. The mechanical property tabulation, when given, indicates the minimum values that can be expected unless otherwise noted.

In the tables, reference is made to explanatory footnotes (numerals in parentheses). Since these footnotes are repeated in many of the tables, they are omitted from the tabulations and are included in the following listing.

(1) Analysis shall regularly be made only for the elements listed. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine conformance with the limits specified for other elements.

(2) Not required for wire of less than 0.125 inch diameter.

(3) For rounds (rod) maximum diameter is 8.000 inches; for square, rectangular, hexagonal, or octagonal bar maximum thickness is 4.000 inches, and maximum cross-sectional area is 36 inches.

(4) Direction of specimen:
- P - Parallel to forging flow lines
- NP - Not parallel to forging flow lines
- L - Longitudinal
- LT - Long Transverse
- ST - Short Transverse

(5) Maximum heat treat section thickness.

(6) Test coupon.

(7) Identification classification number.

(8) Applicable to flat sheet only.

(9) Applicable to plate and coiled sheet and to flat sheet heat treated by the user.

(10) Applicable to plate heat treated by user.

(11) These properties are those of the core alloy since the tests are made on a round specimen machined from the plate.

(12) For bar, maximum cross-sectional area is 50 square inches.

(13) Applicable to plate and coiled sheet only.

(14) Applicable to flat sheet and plate only.

(15) Applicable to sheet and plate heat treated by user.

(16) Not required for material ½ inch or less in width.

(17) For rounds (rods) maximum diameter is 6.500 inches - see note (3) for other requirements.

(18) Cutout specimen.

(19) Tensile and yield strength test requirements may be waived for material in any direction in which the dimension is less than 2 inches because of the difficulty to obtain a tension test specimen suitable for routine control.

(20) For cross sectional areas greater than 144 square inches, or thickness greater than 4 inches at the time of heat treatment, the properties shall be as specified in the contract or purchase order.

(21) Non-heat treatable alloys.

(22) For cross-sectional areas greater than 72 square inches, or thicknesses greater than 6 inches at the time of heat treatment, the properties shall be as specified in the contract or purchase order.

1100

CHEMICAL COMPOSITION - percent											
Specification	Cu	Si & Fe	Mg	Zn	Mn	Ti	Cr	Sn	Ni	Al	Other (1)
All[a] - see below	0.20	1.0 max	-	0.10	0.05	-	-	-	-	99.0 min	0.05 each 0.15 total

(a) - Aluminum foil (Spec. MIL-A-148) shall contain less than 0.01 percent each of arsenic, cadmium or lead.

MECHANICAL PROPERTIES - minimum

Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	Mullen Bursting Strength - psi min	max
MIL-A-148 Foil	Annealed	0.0008					8	23
		0.0010					11	31
		0.0015					22	55
		0.0020					40	90
		0.0030					75	150
		0.0040					110	220
		0.0050					140	280
QQ-A-250/1 Plate and Sheet	-O	0.006-0.019		11	-	15		
		0.020-0.031		11	-	20		
		0.032-0.050		11	-	25		
		0.051-0.249		11	3.5	30		
		0.250-3.000		11	3.5	28		
	-H12 and -H22	0.017-0.019		14	-	3		
		0.020-0.031		14	-	4		
		0.032-0.050		14	-	6		
		0.051-0.113		14	11	8		
		0.114-0.499		14	11	9		
		0.500-2.000		14	11	12		
	-H14 and -H24	0.009-0.012		16	-	1		
		0.013-0.019		16	-	2		
		0.020-0.031		16	-	3		
		0.032-0.050		16	-	4		
		0.051-0.113		16	14	5		
		0.114-0.499		16	14	6		
		0.500-1.000		16	14	10		
	-H16 and -H26	0.006-0.019		19		1		
		0.020-0.031		19		2		
		0.032-0.050		19		3		
		0.051-0.162		19		4		

1100 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont).							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	Mullen Bursting Strength - psi min max
QQ-A-250/1 Plate and Sheet (Cont.)	-H18 and -H28	0.006-0.019		22		1	
		0.020-0.031		22		2	
		0.032-0.050		22		3	
		0.051-0.128		22		4	
	-H112	0.250-0.499		13		9	
		0.500-2.000		12		14	
		2.001-3.000		11.5		20	
	-F	2.250-6.000	- No requirement -				
QQ-A-225/1 Bar, Rod, and Wire, Rolled, Drawn, or Cold Finished	-O	All		15.5 max		25(2)	
	-H12	Up to 0.374		14		-	
	-H14	Up to 0.374		16		-	
	-H16	Up to 0.374		19		-	
	-H18	Up to 0.374		22		-	
	-F	0.375 and over	- No requirement -				
	-H12	All		11		-	
WW-T-700/1 Tube, Seamless, Round, Square, Rectangular, and Other Shapes	-O	All		15.5 max			
	-H12	All		14			
	-H14	All		16			
	-H16	All		19			
	-H18	All		22			
	-F	-	- No requirement -				
MIL-A-12545 Impact Extrusion	-F	-		-	-	-	
QQ-A-430 Rod and Wire for Rivets and Cold Heading		-diameter-					
	-O	0.501 and over		15.5 max	-	-	
	-H14	0.501 and over		16	-	-	

2011 Free-machining

CHEMICAL COMPOSITION - percent													
Specification	Cu	Si	Fe	Mg	Zn	Mn	Cr	Sn	Ni	Bi	Pb	Al	Other(1)
QQ-A-225/3	5.0-6.0	0.40	0.7	-	0.30	-	-	-	-	0.20-0.6	0.20-0.6	Balance	0.05 each 0.15 total

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-225/3 Bar, Rod, and Wire	-T3	0.125 to 1.500	-	45	38	10
		1.501 to 2.000	-	43	34	12
		2.001 to 3.000	-	42	30	14
	-T8	0.125 to 3.250	-	52	40	10

2014

CHEMICAL COMPOSITION - percent									
Specification	Cu	Si	Fe	Mg	Zn	Mn	Ti	Cr	Al	Other[(1)]
All-see below	3.9-5.0	0.50-1.2	1.0	0.20-0.8	0.25	0.40-1.2	0.15	0.10	Balance	0.05 each 0.15 total

MECHANICAL PROPERTIES - minimum

Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN
QQ-A-200/2 Bar, Rod, Shapes, and Tube, Extruded	-O	All	All	30 max	18 max	12	
	-T4, -T4510, -T4511	All	All	50	35	12	
	-T42	All	All	50	29	12	
	-T6, -T6510, -T6511	Up to 0.499	All	60	53	7	
		0.500-0.749	All	64	58	7	
		0.750 & over	Up thru 25	68	60	7	
		0.750 & over	Over 25 thru 32	68	58	6	
	-T62	Up to 0.749	All	60	53	7	
		0.750 & over	Up thru 25	60	53	7	
		0.750 & over	Over 25 thru 32	60	53	6	
QQ-A-225/4 Bar, Rod, Wire and Special Shapes; Rolled, Drawn, or Cold Finished	-O	Up to 8.000	-	35 max	-	12(3)	
	-T4	Up to 8.000(3)	-	55	32	16	
	-T451	0.500-8.000(3)	-	55	32	16	
	-T6	Up to 8.000(3)	-	65	55	8	
	-T651	0.500-8.000(3)	-	65	55	8	
		(5)		(4)	(19)-(4)	(6)	
QQ-A-367 Die Forgings, Heat Treated	-T4	4 max		55(P)	30(P)	16	100
	-T6	4 max		65(P)	55(P)	10	125
	-T6	4 max		64(NP)	56(P)	3	125
	-T6(I)(7)	6	Up to 16. Lengths up to 3 X the width	65(L) 63(LT) 60(ST)	55(L) 55(LT) 55(ST)	10 6 3	
	-T6(II)(7)	6	Up to 16. Lengths up to 3X the width	65(L) 63(LT) 60(ST)	55(L) 55(LT) 55(ST)	10 4 2	
	-T6(III)(7)	6	Over 16 to 36. Lengths up to 3 X the width	65(L) 63(LT) 60(ST)	53(L) 53(LT) 53(ST)	9 5 2	
	-T6(IV)(7)	6	Over 16 to 36. Lengths up to 3X the width	65(L) 63(LT) 60(ST)	53(L) 53(LT) 53(ST)	9 3 2	

2014 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont).							
Designation Specification	Temper	Thickness inch (5)	Area Sq. in.	Tensile Str ksi (4)	Yield Str ksi (19) - (4)	EL % (6)	BHN
QQ-A-367 Die Forgings, Heat Treated (Cont.)	-T6(V)(7)	6	Over 36 to 144 Lengths up to 3X the width	62(L) 59(LT) 56(ST)	53(L) 52(LT) 52(ST)	7 3 1	
	-T6(VI)(7)	6	Over 36 to 144 Lengths up to 3X the width	62(L) 59(LT) 56(ST)	53(L) 52(LT) 52(ST)	7 2.5 1	
	-T6(VII)(7)	6	Over 144	60(L) 58(LT) 55(ST)	52(L) 50(LT) 50(ST)	5 2 1	
MIL-A-12545 Impact Extrusions	-F	-	-	-	-	-	-
	-O	-	-	30 max	-	-	-
	-T4	-	-	55	32	10	100
	-T6	-	-	65	55	6	125

2014 Alclad

CHEMICAL COMPOSITION - percent									
Specification	Cu	Si	Fe	Mg	Zn	Mn	Ti	Cr	Other[a] (1)
QQ-A-250/3 Core 2014	3.9-5.0	0.5-1.2	1.0 max	0.20-0.8	0.25 max	0.40-1.2	0.15 max	0.10 max	0.05 each, 0.15 total
Cladding 6003	0.10 max	0.35-1.0	0.6 max	0.8-1.5	0.20 max	0.8 max	0.10 max	0.35 max	0.05 each, 0.15 total

a - Remainder Al

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-250/3 Plate and Sheet	-O	0.020-0.499 (11)	-	30 max	14 max	16
		0.500-1.000 (11)	-	-	-	10
	-T3(8)	0.020-0.039	-	55	35	14
		0.040-0.249	-	57	36	15
	-T4(9)	0.020-0.039	-	55	32	14
		0.040-0.249	-	57	34	15
		0.250-0.499 (11)	-	57	36	15
		0.500-1.000 (11)	-	58	36	15
	-T451	0.250-0.499 (11)	-	57	36	15
		0.500-1.000 (11)	-	58	36	15
	-T42(10)	0.250-0.499 (11)	-	57	34	15
		0.500-1.000 (11)	-	58	34	15
	-T6	0.020-0.039	-	63	55	7
		0.040-0.499	-	64	57	8
		0.500-1.000 (11)	-	67	59	6
		1.001-1.500 (11)	-	67	59	4
		1.501-2.000 (11)	-	65	59	3
		2.001-3.000 (11)	-	63	57	2
	-T651	0.250-0.499	-	64	57	8
		0.500-1.000 (11)	-	67	59	6
		1.001-1.500 (11)	-	67	59	4
		1.501-2.000 (11)	-	65	59	3
		2.001-3.000 (11)	-	63	57	2
	-F	All	- No requirements -			

2017

CHEMICAL COMPOSITION - percent									
Specification	Cu	Mg	Mn	Si	Fe	Zn	Cr	Other[1]	Al
All - see below	3.5-4.5	0.20-0.8	0.40-1.0	0.8	1.0	0.25	0.10	0.05 each, 0.15 total	Balance

MECHANICAL PROPERTIES - minimum									
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	Shear Str ksi	BHN
QQ-A-225/5 Bar, Rod, and Wire (Rolled or Drawn)	-O	Up to 8.000	-	35 max	-	16		
	-T4	Up to 8.000[12]	-	55	32	12		
	-T451	Up to 8.000[12]	-	55	32	12		
QQ-A-367 Forgings, Heat Treated	-T4	4 max[5]		55(P)[4]	30[19]	16[6]		100
QQ-A-430 Rod and Wire for Rivets and Cold Heading		- diameter -						
	-O	0.501 and over	-	35 max	-	-		
	-H13	Up thru 0.500	-	30	-	-		
	-T4	0.063-0.615		55	32[19]	16	33	

2018

CHEMICAL COMPOSITION - percent										
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ni	Other[1]	Al
QQ-A-367	3.5-4.5	0.9	1.0	0.20	0.45-0.9	0.25	0.10	1.7-2.3	0.05 each, 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi[19]	EL %	BHN
QQ-A-367 Forgings, Heat Treated	-T61	4 max[5]	-	55(P)[4]	40(P)[4]	10[6]	100

2020

CHEMICAL COMPOSITION - percent										
Specification	Li	Cd	Mn	Cu	Fe	Si	Mg	Zn	Ti	Other[1]	Al
QQ-A-250/16	0.9-1.7	0.10-0.35	0.30-0.8	4.0-5.0	0.40	0.40	0.03	0.25	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-250/16 Plate and Sheet	-O	0.040-2.000	-	35 max	-	10
	-T6	0.040-0.249	-	76	70	4
		0.250-0.499	-	76	70	3
		0.500-1.000	-	75	70	2
		1.001-2.000	-	75	70	1.5
	-T651	0.250-0.499	-	64	57	8
		0.500-1.000	-	67	59	6
		1.001-1.500	-	67	59	4
		1.501-2.000	-	65	59	3
		2.001-3.000	-	63	57	2
	-F	All	-	- No requirements -		

2024

	CHEMICAL COMPOSITION - percent								
Specification	Cu	Mg	Mn	Fe	Si	Zn	Cr	Other[1]	Al
All - see below	3.8-4.9	1.2-1.8	0.30-0.9	0.50	0.50	0.25	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum

Designation Specification	Designation Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL % (16)
QQ-A-250/4 Plate and Sheet	-O	0.010-0.499	All	32 max	14 max	12
		0.500-1.750	All	32 max	-	-
	-T3(8)	0.008-0.009	All	63	42	10
		0.010-0.020	All	64	42	12
		0.021-0.249	All	64	42	15
	-T4(13)	0.010-0.020	All	62	40	12
		0.021-0.249	All	62	40	15
		0.250-0.499	All	64	40	12
		0.500-1.000	All	62	40	8
		1.001-1.500	All	60	40	7
		1.501-2.000	All	60	40	6
		2.001-3.000	All	56	40	4
			- width -			
	-T36(14)	0.020-0.062	30 & under	69	52	8
		0.063-0.499	30 & under	69	52	9
		0.500	30 & under	69	52	10
		0.020-0.062	over 30 thru 48	69	52	8
		0.063-0.249	over 30 thru 48	69	52	9
		0.250-0.500	over 30 thru 48	69	52	10
		0.020-0.062	over 48 thru 60	67	50	8
		0.063-0.249	over 48 thru 60	68	51	9
		0.250-0.500	over 48 thru 60	67	50	10
		0.063-0.249	over 60	67	50	8
		0.250-0.499	over 60	66	49	9
		0.500	over 60	66	49	10
	-T42(15)	0.010-0.020	All	62	38	12
		0.021-0.249	All	62	38	15
		0.250-0.499	All	64	38	12
		0.500-1.000	All	62	38	8
		1.001-1.500	All	60	38	7
		1.501-2.000	All	60	38	6
		2.001-3.000	All	56	38	4
	-T351	0.250-0.499	All	64	40	12
		0.500-1.000	All	62	40	8
		1.001-1.500	All	60	40	7
		1.501-2.000	All	60	40	6
		2.001-3.000	All	56	40	4
	-T6(15)	0.012-0.499	All	64	50	5
		0.500 & over	All	63	50	5
	-T81(14)	0.010-0.499	All	67	58	5
		0.500-1.000	All	66	58	5
			- width -			
	-T86(14)	0.020-0.062	30 & under	72	66	3
		0.063-0.249	30 & under	72	68	4
		0.250-0.500	30 & under	72	67	4
		0.020-0.062	over 30 thru 48	72	66	3
		0.063-0.249	over 30 thru 48	72	67	4
		0.250-0.500	over 30 thru 48	71	66	4
		0.020-0.062	over 48 thru 60	70	62	3
		0.063-0.249	over 48 thru 60	71	67	4
		0.250-0.500	over 48 thru 60	70	65	4
		0.063-0.249	over 60	71	66	4
		0.250-0.500	over 60	70	64	4
	-T851	0.250-0.499	All	67	58	5
		0.500-1.000	All	66	58	5
	-F	All	All	- No requirements -		

2024 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont.)						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-200/3 Bar, Rod, Shapes, and Tube, Extruded	-O	All	All	35 max	10max	12
	-T4, -T3510, -T3511	Up to 0.249 incl	All	57	42	12(10 for tube)
		0.250-0.749	All	60	44	12(10 for tube)
		0.750-1.499	All	65	46	10
		1.500 & over	Up thru 25	70	52 (48 for tube)	10
		1.500 & over	Over 25 thru 32	68	48(46 for tube)	8
	-T42	Up to 0.749	All	57	38	12
		0.750-1.499	All	57	38	10
		1.500 & over	Up thru 25	57	38	10
		1.500 & over	Over 25 thru 32	57	38	8
	-T81, -T8510, -T8511	0.050-0.249	All	64	56	4
		0.250-1.499	All	66	58	5
		1.500 & over	Up thru 32	66	58	5
QQ-A-225/6 Bar, Rod, and Wire, Rolled, Drawn, or Cold Finished	-O	Up to 8.000 incl	-	35 max	-	(2) 16
	-T351	0.500 to 6.500(17)	-	62	40	10
	-T4	Up to 6.500(17)	-	62	40	10
	-T6	Up to 6.500(17)	-	62	50	5
	-T851	0.500 to 6.500(17)	-	66	58	5
WW-T-700/3 Tube, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless	-O	- wall thickness - All	-	32 max	15 max	-
	-T3	0.018-0.024	-	64	42	-
		0.025-0.049	-	64	42	10(18)
		0.050-0.259	-	64	42	10(18)
		0.260-0.500	-	64	42	12(18)
	-T4	0.018-0.024	-	64	40	-
		0.025-0.049	-	64	40	10(18)
		0.050-0.259	-	64	40	10(18)
		0.250-0.500	-	64	40	12(18)
QQ-A-430 Rod and Wire; For Rivets and Cold Heading	-O	- diameter - 0.501 & over	-	35 max	-	-
	-H13	Up thru 0.500	-	32	-	-

2024 Alclad

CHEMICAL COMPOSITION - percent									
Specification	Cu	Mg	Mn	Fe	Si	Cr	Zn	Others(1)	Al
QQ-A-250/5 Core 2024	3.8-4.9	1.2-1.8	0.30-0.9	0.5	0.50	0.10	0.25	0.05 each 0.15 total	Balance
Cladding 1230	0.10	-	0.05	Fe&Si	0.7	-	0.10	0.05 each	99.3 min

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch width	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-250/5 Plate and Sheet	-O	0.008-0.009	All	30 max	14 max	10
		0.010-0.062	All	30 max	14 max	12
		0.063-0.499	All	32 max	14 max	12
		0.500-1.750	All	32 max		12
	-T3(8)	0.008-0.009	All	58	39	10
		0.010-0.020	All	59	39	12
		0.021-0.062	All	59	39	15
		0.063-0.249	All	62	40	15

2024 Alclad (Cont.)

MECHANICAL PROPERTIES - minimum (Cont.)

Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-250/5 Plate and Sheet (Cont)	-T4(13)	0.010-0.020	All	58	37	12
		0.021-0.062	All	58	37	15
		0.063-0.128	All	61	38	15
		0.250-0.499	All	62	40	12
		0.500-1.000(11)	All	62	40	8
		1.001-1.500(11)	All	60	40	7
		1.501-2.000(11)	All	60	40	6
		2.001-3.000(11)	All	56	40	4
	-T36(14)	0.020-0.062	48 and under	62	48	8
		0.063-0.499	48 and under	66	50	9
		0.500(11)	48 and under	69	52	10
		0.020-0.062	over 48 thru 60	61	47	8
		0.063-0.499	over 48 thru 60	65	49	9
		0.500(11)	over 48 thru 60	67	50	10
		0.063-0.499	over 60	64	48	9
		0.500(11)	over 60	66	49	10
	-T42(15)	0.008-0.009	All	55	34	10
		0.010-0.020	All	56	34	12
		0.021-0.062	All	56	34	15
		0.063-0.249	All	59	36	15
		0.250-0.499	All	62	38	12
		0.500-1.000(11)	All	62	38	8
		1.001-1.500(11)	All	60	38	7
		1.501-2.000(11)	All	60	38	6
		2.001-3.000(11)	All	56	38	4
	-T351	0.250-0.499	All	62	40	12
		0.500-1.000(11)	All	62	40	8
		1.001-1.500(11)	All	60	40	7
		1.501-2.000(11)	All	60	40	6
		2.001-3.000(11)	All	56	40	4
	-T6(15)	0.010-0.062	All	60	47	5
		0.063-0.499	All	62	49	5
	-T81(14)	0.010-0.062	All	62	54	5
		0.063-0.499	All	65	56	5
		0.500-1.000(11)	All	66	58	5
	-T86(14)	0.020-0.062	30 and under	66	62	3
		0.063-0.249	30 and under	70	66	4
		0.250-0.499	30 and under	70	65	4
		0.500(11)	30 and under	72	67	4
		0.020-0.062	over 30 thru 48	66	62	3
		0.063-0.249	over 30 thru 48	70	65	4
		0.250-0.499	over 30 thru 48	69	64	4
		0.500(11)	over 30 thru 48	71	66	4
		0.020-0.062	over 48 thru 60	64	58	3
		0.063-0.249	over 48 thru 60	69	65	4
		0.250-0.499	over 48 thru 60	68	63	4
		0.500(11)	over 48 thru 60	70	65	4
		0.063-0.249	over 60	69	64	4
		0.250-0.499	over 60	68	62	4
		0.500(11)	over 60	70	64	4
	-T851	0.250-0.499	All	65	56	5
		0.500-1.000(11)	All	66	58	5
	-F	All	All	- No requirements -		

2025

CHEMICAL COMPOSITION - percent										
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Other [1]	Al
QQ-A-367	3.9-5.0	0.50-1.2	1.0	0.40-1.2	0.05	0.25	0.10	0.15	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str[19] ksi	EL %
QQ-A-367 Forgings, Heat Treated	-T6	4[5]	-	55(P)[4]	33(P)[4]	16[6]

2117

CHEMICAL COMPOSITION - percent								
Specification	Cu	Mn	Mg	Si	Fe	Cr	Zn	Others[1]	Al
QQ-A-430	2.2-3.0	0.20	0.20-0.50	0.8	1.0	0.10	0.25	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Diameter	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	Shear Str ksi
QQ-A-430 Rod and Wire; for Rivets and Cold Heading	-O	0.501 and over	-	25 max	-	-	-
	-H15	Up thru 0.500	-	28	-	-	-
	-T4	0.063-0.615	-	38	18	18	26

2218

CHEMICAL COMPOSITION - percent											
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Ni	Other[1]	Al
QQ-A-367	3.5-4.5	0.9	1.0	0.20	1.2-1.8	0.25	0.10	-	1.7-2.3	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str[19] ksi	EL %	BHN
QQ-A-367 Forgings, Heat Treated	-T61	4[5]	-	55(P)[4]	40(P)[4]	10[6]	100

2219

CHEMICAL COMPOSITION - percent											
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Ni	Other(1)a	Al
QQ-A-367	5.8-6.8	0.20	0.30	0.20-0.40	0.02	0.10	-	0.02-0.10	-	0.05 each 0.15 total	Balance

a - Vanadium 0.05-0.15 and Zirconium 0.10-0.25

MECHANICAL PROPERTIES - minimum

Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str(4,19) ksi	Yield Str(4,19) ksi	EL %
QQ-A-367 Forgings, Heat Treated	-T6	4(5)	-	58(P)	38(P)	8(6)
	-T6	4(5)	-	58(NP)	38(NP)	8(6)
	-T6	4(5,20)	-	58(L) 55(LT) 53(ST)	40(L) 37(LT) 35(ST)	6 4 2
	-T852	4(5,20)	-	61(L) 58(LT) 56(ST)	43(L) 40(LT) 38(ST)	6 4 2
	-T87	4(5,20)	-	65(L) 62(LT) 58(ST)	47(L) 44(LT) 40(ST)	6 4 2

2618

CHEMICAL COMPOSITION - percent											
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Ni	Other(1)	Al
QQ-A-367	1.9-2.7	0.25	0.9-1.3	-	1.3-1.8	-	-	0.04-0.10	0.9-1.2	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum

Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str(4,19) ksi	Yield Str(4,19) ksi	EL %	BHN
QQ-A-367 Forgings, Heat Treated	-T61	4(5)		58(P)	48(P)	6(6)	115
	-T61	4(5)		55(NP)	45(NP)	4(6)	
	-T61 (Class I)	4(5,20)	16 and under	58(L) 55(LT) 52(ST)	48(L) 45(LT) 42(ST)	7 5 4	
	-T61 (Class II)	4(5,20)	Over 16 to 36	57(L) 55(LT) 52(ST)	47(L) 45(LT) 42(ST)	7 5 4	
	-T61 (Class III)	4(5,20)	Over 36 to 144	56(L) 53(LT) 51(ST)	46(L) 40(LT) 39(ST)	7 4 4	

3003

CHEMICAL COMPOSITION - percent							
Specification	Mn	Fe	Si	Cu	Zn	Other [1]	Al
All - see below	1.0-1.5	0.7	0.6	0.20	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
						(16)
QQ-A-250/2 Plate and Sheet	-O	0.006-0.007	-	14	-	14
		0.008-0.012	-	14	-	18
		0.013-0.031	-	14	-	20
		0.032-0.050	-	14	-	23
		0.051-0.249	-	14	-	25
		0.250-3.000	-	14	-	23
	-H12 or -H22	0.017-0.019	-	17	-	3
		0.020-0.031	-	17	-	4
		0.032-0.050	-	17	-	5
		0.051-0.113	-	17	-	6
		0.114-0.161	-	17	-	7
		0.162-0.249	-	17	-	8
		0.250-0.499	-	17	-	9
		0.500-2.000	-	17	-	10
	-H14 or -H24	0.009-0.012	-	20	-	1
		0.013-0.019	-	20	-	2
		0.020-0.031	-	20	-	3
		0.032-0.050	-	20	-	4
		0.051-0.113	-	20	-	5
		0.114-0.161	-	20	-	6
		0.162-0.249	-	20	-	7
		0.250-0.499	-	20	-	8
		0.500-1.000	-	20	-	10
	-H16 or -H26	0.006-0.019	-	24	-	1
		0.020-0.031	-	24	-	2
		0.032-0.050	-	24	-	3
		0.051-0.162	-	24	-	4
	-H18 or -H28	0.006-0.019	-	27	-	1
		0.020-0.031	-	27	-	2
		0.032-0.050	-	27	-	3
		0.051-0.128	-	27	-	4
	-H112	0.250-0.499	-	17	-	8
		0.500-2.000	-	15	-	12
		2.001-3.000	-	14	-	18
	-F	0.250-6.000	-	- No requirements -		
QQ-A-200/1 Bar, Rod, Shapes, and Tube Extruded	-O	All	-	19 max	-	25
	-H112	All	-	14	-	-
	-F	All	-	- No requirements -		
		- diameter -				
QQ-A-225/2	-O	All sizes	-	15 max	-	25
	-H12	Up to 0.374	-	14	-	-
	-H14	Up to 0.374	-	16	-	-
	-H16	Up to 0.374	-	19	-	-
	-H18	Up to 0.374	-	22	-	-
	-H112	All sizes	-	11	-	-

3003 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont.)						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
		- wall thickness -				
WW-T-700/2 Tube, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless	-O	All	-	19 max	-	-
	-H12	All	-	17	-	-
	-H14	All	-	20	-	-
	-H16	All	-	24	-	-
	-H18	All	-	27	-	-
	-F	-	-	- No requirements -		
		- diameter -				
QQ-A-430 Rod and Wire; for Rivets and Cold Heading	-O	0.501 and over	-	19 max		
	-H14	Up thru 0.500	-	20		

4032

CHEMICAL COMPOSITION - percent											
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Ni	Other[1]	Al
QQ-A-367	0.50-1.3	11.0-13.5	1.0	-	0.8-1.3	0.25	0.10	-	0.50-1.3	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str[19] ksi	EL %	BHN
QQ-A-367 Forgings, Heat Treated	-T6	4[5]	-	52(P)[4]	42(P)[4]	5[6]	115

5052

CHEMICAL COMPOSITION - percent								
Specification	Mg	Fe & Si	Cr	Cu	Mn	Zn	Others	Al
All-see below	2.2-2.8	0.45	0.15-0.35	0.10	0.10	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
						(16)
QQ-A-250/8 Plate and Sheet	-O	0.006-0.007	-	25	-	--
		0.008-0.019	-	25	-	15
		0.020-0.031	-	25	-	18
		0.032-0.249	-	25	-	20
		0.250-3.000	-	25	-	18
	-H32 or -H22	0.017-0.019	-	31	-	4
		0.020-0.050	-	31	-	5
		0.051-0.113	-	31	-	7
		0.114-0.249	-	31	-	9
		0.250-0.499	-	31	-	11
		0.500-2.000	-	31	-	12
	-H34 or -H24	0.009-0.019	-	34	-	3
		0.020-0.050	-	34	-	4
		0.051-0.113	-	34	-	6
		0.114-0.249	-	34	-	7
		0.250-1.000	-	34	-	10
	-H36 or -H26	0.006-0.007	-	37	-	--
		0.008-0.031	-	37	-	3
		0.032-0.162	-	37	-	4

5052 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont.)						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-250/8 Plate and Sheet (Cont)	-H38 or -H28	0.006-0.007	-	39	-	--
		0.008-0.031	-	39	-	3
		0.032-0.128	-	39	-	4
	-H112	0.250-0.499	-	28	-	7
		0.500-2.000	-	25	-	12
		2.001-3.000	-	25	-	16
	-F	0.250-6.000	-	- No requirements -		
QQ-A-225/7 Bar, Rod, and Wire; Rolled, Drawn, or Cold Finished		- diameter -				(2)
	-O	All sizes	-	32 max	-	25
	-H32	Up to 0.374	-	31	-	--
	-H34	Up to 0.374	-	34	-	--
	-H36	Up to 0.374	-	37	-	--
	-H38	Up to 0.374	-	39	-	--
WW-T-700/4 Tube, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless		- wall thickness -				
	-O	All	-	35 max	-	-
	-H32	All	-	31	-	-
	-H34	All	-	34	-	-
	-H36	All	-	37	-	-
	-H38	All	-	39	-	-
	-F	All	-	- No requirements -		
QQ-A-430 Rod and Wire; For Rivets and Cold Heading		- diameter -				
	-O	0.501 and over	-	32 max	-	
	-H32	Up thru 0.500	-	31	-	

5056

CHEMICAL COMPOSITION - percent										
Specification	Mg	Mn	Cr	Cu	Si	Fe	Zn	Ti	Others[1]	Al
QQ-A-430	4.5-5.6	0.05-0.20	0.05-0.20	0.10	0.30	0.40	0.10	-	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-430 Rod and Wire; For Rivets and Cold Heading		- diameter -				
	-O	0.501 and over	-	46 max		
	-H32	Up thru 0.500	-	44		

5083

CHEMICAL COMPOSITION - percent											
Specification	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Ni	Other[1]	Al
QQ-A-250/6 and QQ-A-200/4	0.40	0.40	0.10	0.30-1.0	4.0-4.9	0.05-0.25	0.25	0.15	-	0.05 each 0.15 total	Balance
QQ-A-367	0.40	0.40	0.10	0.30-1.0	4.0-4.9	-	0.25	-	-	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL % (16)
QQ-A-250/6 Plate and Sheet	-O	0.051-1.500	-	40	18	16
		1.501-3.000	-	39	17	16
	-H32	0.051-0.125	-	45	34	8
		0.126-0.249	-	45	34	10
	-H34	0.051-0.125	-	50	39	6
		0.126-0.249	-	50	39	8
	-H113	0.188-2.000	-	44	31	12
QQ-A-200/4 Bar, Rod, Shapes; and Tube, Extruded	-O	Up thru 5.000	Up thru 32	39	16	14
	-H111	Up thru 5.000	Up thru 32	40	24	12
QQ-A-367 Forgings, Heat Treated				(4-19)	(4-19)	
	-H111	5(5)	-	42(P)	22(P)	16(6)
	-H112	5(5)	-	40(P)	18(P)	16(6)
	-H111	4(5)(21)	-	42(NP)	22(NP)	14(6)
	-H112	4(5)(21)	-	40(NP)	18(NP)	16(6)
	-H111		-	42(L)	22(L)	16
			-	39(LT)	20(LT)	14
	-H112		-	40(L)	18(L)	16
			-	39(LT)	16(LT)	14

5086

CHEMICAL COMPOSITION - percent										
Specification	Si	Fe	Cu	Mn	Mg	Cr	Ti	Zn	Others[1]	Al
All - see below	0.40	0.50	0.10	0.7	3.5-4.5	0.05-0.25	0.15	0.25	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL % (16)
QQ-A-250/7 Plate and Sheet	-O	0.020-0.050	-	35	14	15
		0.051-0.249	-	35	14	18
		0.250-2.000	-	35	14	14
	-H32	0.020-0.050	-	40	28	6
		0.051-0.249	-	40	28	8
		0.250-2.000	-	40	28	12
	-H34	0.020-0.050	-	44	34	5
		0.051-0.249	-	44	34	6
		0.250-2.000	-	44	34	10
	-H36	0.020-0.050	-	47	38	4
		0.051-0.162	-	47	38	6
	-H112	0.188-0.499	-	36	18	8
		0.500-1.000	-	35	16	10
		1.001-2.000	-	35	14	14
		2.001-3.000	-	34	14	14

5086 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont.)						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-200/5 Bar, Rods, Shapes, and Tube Extruded	-O	Up thru 5.000	Up thru 32	35 max	14	14
	-H111	Up thru 5.000	Up thru 32	36	21	12
WW-T-700/5 Tube, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless		-wall thickness-				
	-O	All sizes	-	35	14	14
	-H32	0.010-0.050	-	40	28	6
		0.051-0.450	-	40	28	8
	-H34	0.010-0.050	-	44	34	5
		0.051-0.450	-	44	34	6
	-H36	0.010-0.050	-	47	38	4
		0.051-0.450	-	47	38	5
	-F	- No requirements -				

5454

CHEMICAL COMPOSITION - percent									
Specification	Mg	Cr	Mn	Ti	Cu	Zn	Fe & Si	Other(1)	Al
All - see below	2.4-3.0	0.05-0.20	0.50-1.0	0.20	0.10	0.25	0.50	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
						(16)
QQ-A-250/10 Plate and Sheet	-O	0.020-0.031	-	31	12	12
		0.032-0.050	-	31	12	14
		0.051-0.113	-	31	12	16
		0.114-3.000	-	31	12	18
	-H32	0.020-0.050	-	36	26	5
		0.051-0.249	-	36	26	8
		0.250-2.000	-	36	26	12
	-H34	0.020-0.050	-	39	29	4
		0.051-0.161	-	39	29	6
		0.162-0.249	-	39	29	7
		0.250-1.000	-	39	29	10
	-H112	0.250-0.499	-	32	18	8
		0.500-2.000	31	12	11	11
		2.001-3.000	-	31	12	15
QQ-A-200/6 Bar, Rod, Shapes, and Tube, Extruded	-O	Up thru 5.000	Up thru 32	41	19	14
	-H111	Up thru 5.000	Up thru 32	42	26	12
	-H112	Up thru 5.000	Up thru 32	41	19	12

5456

CHEMICAL COMPOSITION - percent									
Specification	Mg	Cr	Mn	Ti	Cu	Zn	Fe & Si	Others[1]	Al
All - see below	4.7-5.5	0.05-0.20	0.50-1.0	0.20	0.10	0.25	0.40	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
						(16)
QQ-A-250/9 Plate and Sheet	-O	0.051-1.500	-	42	19	16
		1.501-3.000	-	41	18	16
		3.001-5.000	-	40	17	14
		5.001-7.000	-	39	16	14
		7.001-8.000	-	38	15	12
	-H24	0.051-0.249	-	51	39	9
	-H112	0.250-1.500	-	42	19	12
		1.501-3.000	-	41	18	12
	-H321	0.051-0.624	-	46	33	12
		0.625-1.250	-	46	33	12
		1.251-1.500	-	44	31	12
		1.501-3.000	-	41	29	12
	-H323	0.051-0.125	-	48	36	6
		0.126-0.249	-	48	36	8
	-H343	0.051-0.125	-	53	41	6
		0.126-0.249	-	53	41	8
QQ-A-200/7 Bar, Rod, Shapes, and Tube, Extruded	-O	Up thru 5.000	Up thru 32	31	12	14
	-H111	Up thru 5.000	Up thru 32	33	19	12
	-H112	Up thru 5.000	Up thru 32	31	12	12

6011

CHEMICAL COMPOSITION - percent										
Specification	Cu	Mg	Si	Mn	Zn	Fe	Ti	Cr	Ni	Others[1]	Al
MIL-A-12545	0.40-0.9	0.6-1.2	0.6-1.2	0.8	1.5	1.0	0.20	0.30	0.20	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN
MIL-A-12545	-F	-	-	35	32	3	70
Impact Extrusions	-T6	-	-	50	42	7	95

6053

CHEMICAL COMPOSITION - percent									
Specification	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others[1]	Al
QQ-A-430	-a-	0.35	0.10	-	1.1-1.4	0.15-0.35	0.10	-	0.05 each 0.15 total	Balance

a - 45 to 65 percent of magnesium content.

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	Shear Str ksi
		- diameter -					
QQ-A-430 Rod and Wire; For Rivets and Cold Heading	-O	0.501 and over	-	19 max	-	-	-
	-H13	Up thru 0.500	-	19	-	-	-
	-T61	0.063-0.615	-	30	20	14	20

6061

CHEMICAL COMPOSITION - percent										
Specification	Mg	Si	Cr	Fe	Cu	Ti	Mn	Zn	Others [1]	Al
All - see below	0.8-1.2	0.40-0.8	0.15-0.35	0.7	0.15-0.40	0.15	0.15	0.25	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum								
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi (19)	Yield Str ksi	EL %	BHN	Shear Str ksi
						(16)		
QQ-A-250/11 Plate and Sheet	-O	0.010-0.020	-	22 max	12 max	14		
		0.021-0.128	-	22 max	12 max	16		
		0.129-0.499	-	22 max	12 max	18'		
		0.500-1.000	-	22 max	--	18		
		1.001-3.000	-	22 max	--	16		
	-T4	0.010-0.020	-	30	16	14		
		0.021-0.249	-	30	16	16		
		0.250-1.000	-	30	16	18		
		1.001-3.000	-	30	16	16		
	-T451	0.250-1.000	-	30	16	18		
		1.001-3.000	-	30	16	16		
	-T6	0.010-0.020	-	42	35	8		
		0.021-0.499	-	42	35	10		
		0.500-1.000	-	42	35	9		
		1.001-2.000	-	42	35	8		
		2.001-3.000	-	42	35	6		
		3.001-4.000	-	42	35	6		
		4.001-5.000	-	40	35	6		
	-T651	0.250-0.499	-	42	35	10		
		0.500-1.000	-	42	35	9		
		1.001-2.000	-	42	35	8		
		2.001-3.000	-	42	35	6		
		3.001-4.000	-	42	35	6		
		4.001-5.000	-	40	35	6		
	-F	0.250-6.000	- No requirements -					
QQ-A-200/8 Bar, Rod, Shapes, and Tube, Extruded	-O	-	-	22 max	16 max	16		
	-T4, -T4510, -T4511	-	-	26	16	16		
	-T6, -T6510, -T6511	-	-	38	35	10		
		(12)			(2)			
QQ-A-225/8 Bar, Rod, Wire and Special Shapes; Rolled, Drawn or Cold Finished	-O	Up to 8.000	-	22 max	--	18		
	-T4	Up to 8.000	-	30	16	18		
	-T451	0.500 to 8.000	-	30	16	18		
	-T6	Up to 8.000	-	42	35	10		
	-T651	0.500 to 8.000	-	42	35	10		
		-wall thickness-				(18)		
WW-T-700/6 Tube, Round, Square, Rectangular, and Other Shapes, Drawn, Seamless	-O	All sizes	-	22 max	14 max	15		
	-T4	0.025 to 0.049	-	30	16	14		
		0.050 to 0.259	-	30	16	16		
		0.260 to 0.500	-	30	16	18		
	-T6	0.025 to 0.049	-	42	35	8		
		0.050 to 0.259	-	42	35	10		
		0.260 to 0.500	-	42	35	12		

6061 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont.)								
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN	Shear Str ksi
QQ-A-367 Forgings, Heat Treated	-T6	4(5)	-	(4) 38(P)	(4) 35(P)	10(6)	80	
	-T6	4(5)	-	38(NP)	35(NP)	5(6)	80	
	-T6	Up to 4	Up to 144	38(L) 38(LT) 37(ST)	35(L) 35(LT) 33(ST)	10 8 5		
		Over 4 to 8	Up to 256	37(L) 37(LT) 35(ST)	34(L) 34(LT) 32(ST)	8 6 4		
QQ-A-430 Rod and Wire; For Rivets and Cold Heading	-O	- diameter - 0.501 and over	-	22 max	-	-		
	-H13	Up thru 0.500	-	22	-	-		
	-T6	0.063-0.615	-	42	35	10		25

6063

CHEMICAL COMPOSITION - percent										
Specification	Mg	Si	Fe	Cu	Ti	Mn	Zn	Cr	Others(1)	Al
QQ-A-200/9	0.45-0.9	0.20-0.6	0.35	0.10	0.10	0.10	0.10	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-200/9 Bar, Rod, Shapes, and Tube, Extruded	-O	All	-	19 max	-	18
	-T4	Up thru 0.500	-	19	10	14
		0.501-1.000	-	18	9	14
	-T42	Up thru 0.500	-	17	9	12
		0.501-1.000	-	16	8	12
	-T5	Up thru 0.500	-	22	16	8
		0.501-1.000	-	21	15	8
	-T6	Up ~~thru~~ 0.124	-	30	25	8
		0.125-1.000	-	30	26	10

6066

CHEMICAL COMPOSITION - percent										
Specification	Mg	Si	Cu	Mn	Cr	Fe	Zn	Ti	Others	Al
All - see below	0.8-1.4	0.9-1.8	0.7-1.2	0.6-1.1	0.40	0.50	0.25	0.20	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN
QQ-A-200/10 Bar, Rod, Shapes, and Tube Extruded	-O	-	-	29 max	18 max	16	
	-T4, -T4510, -T4511	-	-	40	25	14	
	-T42	-	-	40	24	14	
	-T6, -T6510, -T6511	-	-	50	45	8	
	-T62	-	-	50	42	8	
QQ-A-367 Forgings, Heat Treated	-T6	4(5)	-	50(P)(4)	45(P)(4)	12(6)	100

6151

CHEMICAL COMPOSITION - percent										
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Others	Al
All - see below	0.35	0.6-1.2	1.0	0.20	0.45-0.8	0.25	0.15-0.35	0.15	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN
QQ-A-367 Forgings, Heat Treated	-T6	(5) 4	-	(4) 44(P)	(4) 37(P)	(6) 14	90
	-T6	4	-	44(NP)	37(NP)	6	90
MIL-A-12545 Impact Extrusions	-T6	-	-	44	37	10	90

7075

CHEMICAL COMPOSITION - percent										
Specification	Zn	Mg	Cu	Cr	Mn	Fe	Si	Ti	Others (1)	Al
All - see below	5.1-6.1	2.1-2.9	1.2-2.0	0.18-0.40	0.30	0.7	0.50	0.20	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum								
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN	Shear Str ksi
QQ-A-250/12 Plate and Sheet	-O	0.015-0.499	-	40 max	21 max	(16) 10		
		0.500-2.000	-	40 max	-	10		
	-T6	0.015-0.039	-	76	65	7		
		0.040-0.499	-	77	66	8		
		0.500-1.000	-	77	66	6		
		1.001-2.000	-	77	66	4		
		2.001-2.500	-	73	62	3		
		2.501-3.000	-	70	60	3		
		3.001-3.500	-	70	57	3		
		3.501-4.000	-	67	53	2		
	-T651	0.250-0.499	-	77	66	8		
		0.500-1.000	-	77	66	6		
		1.001-2.000	-	77	66	4		
		2.001-2.500	-	73	62	3		
		2.501-3.000	-	70	60	3		
		3.001-3.500	-	70	57	3		
		3.501-4.000	-	67	53	2		
	-F	All		- No requirements -				
QQ-A-200/11 Bar, Rod, Shapes, and Tube, Extruded	-O	All sizes	-	40 max	24 max	10		
	-T6, -T6510, -T6511	Up to 0.249	-	78	70	7		
		0.250 to 0.499	-	81	73	7		
		0.500 to 2.999	-	81	72	7		
		3.000 to 4.499	-					
		Up to 20 sq. in.	-	81	71	7		
		Over 20 to 32 sq. in.	-	78	70	6		
		4.500 to 5.000	-					
		Up to 32 sq. in.	-	78	68	6		
QQ-A-225/9 Bar, Rod, Wire, and Special Shapes; Rolled Drawn, or Cold Finished	-O	Up to 8.000	-	40 max	(2) -	(2) 10		
	-T6	Up to 4.000	-	77	66	7		
	-T651	0.500 to 4.000	-	77	66	7		
QQ-A-367 Forgings, Heat Treated	-T6	(5) 3	-	(19, 4) 75(P)	(19, 4) 65(P)	10(6)	135	
	-T6	3	-	71(NP)	62(NP)	3(7)	135	
	-T6 (Class I)	3	Up to 16 Lengths up to 3 times the width	75(L) 75(LT) 72(ST)	64(L) 63(LT) 63(ST)	9 4 2		
	-T6 (Class II)	3	Up to 16 Lengths over 3 times the width	75(L) 73(LT) 70(ST)	63(L) 61(LT) 61(ST)	9 4 2		
	-T6 (Class III)	3	Over 16 to 36 Lengths over 3 times the width	73(L) 71(LT) 68(ST)	61(L) 60(LT) 60(ST)	7 3 2		
	-T6 (Class IV)	3	Over 16 to 36 Lengths over 3 times the width	73(L) 71(LT) 68(ST)	60(L) 59(LT) 59(ST)	7 3 2		

7075 (Cont.)

MECHANICAL PROPERTIES - minimum (Cont).								
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN	Shear Str ksi
QQ-A-367 Forgings, Heat Treated (Cont)	-T6 (Class V)	3	Over 36 to 144 Lengths up to 3 times the width	71(L) 69(LT) 66(ST)	60(L) 58(LT) 58(ST)	4 2 1		
	-T6 (Class VI)	3	Over 36 to 144 Lengths up to 3 times the width	71(L) 69(LT) 66(ST)	59(L) 57(LT) 57(ST)	4 2 1		
	-T6 (Class VII)	3	Over 144 to 256	70(L) 67(LT) 64(ST)	58(L) 56(LT) 56(ST)	4 2 1		
MIL-A-12545 Impact Extrusions	-F	-	-	-	-	-		
	-O	-	-	40 max	-	-		
	-T6	-	-	75	65	5	135	
QQ-A-430 Rod and Wire; For Rivets and Cold Heading	-O	-diameter- 0.501 and over	-	40 max				
	-H13	Up thru 0.500	-	36				
	-T6	0.063-0.615	-	77	66	7		42

7075 Alclad

CHEMICAL COMPOSITION - percent										
Specification	Zn	Mg	Cu	Cr	Mn	Fe	Si	Ti	Others[1]	Al
QQ-A-250/13 Core (7075)	5.1-6.1	2.1-2.9	1.2-2.0	0.18-0.40	0.30	0.7	0.50	0.20	0.05 each 0.15 total	Balance
Cladding (7072)	0.8-1.3	0.10	0.10	-	0.10	Fe & Si/0.7		-	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL[16] %
QQ-A-250/13 Plate and Sheet	-O	0.008-0.014	-	36 max	20 max	9
		0.015-0.062	-	36 max	20 max	10
		0.063-0.087	-	38 max	20 max	10
		0.188-0.499	-	39 max	21 max	10
		0.500-1.000	-	40 max[11]	-	10
	-T6	0.008-0.011	-	68	58	5
		0.012-0.039	-	70	60	7
		0.040-0.062	-	72	62	8
		0.063-0.187	-	73	63	8
		0.188-0.499	-	75	64	8
		0.500-1.000	-	77[11]	66[11]	6
		1.001-2.000	-	77[11]	66[11]	4
		2.001-2.500	-	73[11]	62[11]	3
		2.501-3.000	-	70[11]	60[11]	3
		3.001-3.500	-	70[11]	57[11]	3
		3.501-4.000	-	67[11]	53[11]	2
	-T651	0.250-0.499	-	75	64	8
		0.500-1.000	-	77[11]	66[11]	6
		1.001-2.000	-	77[11]	66[11]	4
		2.001-2.500	-	73[11]	62[11]	3
		2.501-3.000	-	70[11]	60[11]	3
		3.001-3.500	-	70[11]	57[11]	3
		3.501-4.000	-	67[11]	53[11]	2
	-F	0.250-6.000	-	- No requirements -		

7075 Alclad one side

CHEMICAL COMPOSITION - percent										
Specification	Zn	Mg	Cu	Cr	Mn	Fe	Si	Ti	Others[1]	Al
QQ-A-250/18 Core (7075)	5.1-6.1	2.1-2.9	1.2-2.0	0.18-0.40	0.30	0.7	0.50	0.20	0.05 each 0.15 total	Balance
Cladding (7072)	0.8-1.3	0.10	0.10		0.10	Fe & Si/0.7		-	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
QQ-A-250/18 Plate and Sheet	-O	0.015-0.062	-	38 max	21 max	10
		0.063-0.187	-	39 max	21 max	10
		0.188-0.499	-	39 max	21 max	10
		0.500-1.000	-	40 max	-	10
	-T6	0.015-0.039	-	73	62	7
		0.040-0.062	-	74	64	8
		0.063-0.187	-	75	64	8
		0.188-0.499	-	76	65	8
		0.500-1.000	-	77(11)	66(11)	6
		1.001-2.000	-	77(11)	66(11)	4
	-T651	0.250-0.499	-	76	65	8
		0.500-1.000	-	77(11)	66(11)	6
		1.001-2.000	-	77(11)	66(11)	4
	-F	All	-	- No requirements -		

7076

CHEMICAL COMPOSITION - percent										
Specification	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti	Ni	Others[1]	Al
QQ-A-367	0.30-1.0	0.40	0.6	0.30-0.8	1.2-2.0	7.0-8.0	-	0.20	-	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum							
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str[4] ksi	Yield Str[4] ksi	EL[6] %	BHN
QQ-A-367 Forgings, Heat Treated	-T61	4[5]	-	70(P)	60(P)	14	140
			-	67(NP)	58(NP)	3	140

7079

CHEMICAL COMPOSITION - percent										
Specification	Zn	Mg	Cu	Cr	Mn	Fe	Si	Ti	Others(1)	Al
All - see below	3.8-4.8	2.9-3.7	0.40-0.8	0.10-0.25	0.10-0.30	0.40	0.30	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum

Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %	BHN
		(Long traverse mechanical properties)				(16)	
QQ-A-250/17 Plate	-T6	0.040-0.249	-	72	62	8	
	-T6 and -T651	0.250-1.000	-	73	63	8	
		1.001-1.500	-	73	63	8	
		1.501-2.000	-	73	63	7	
		2.001-2.500	-	73	63	6	
		2.501-3.000	-	71	62	6	
		3.001-4.000	-	70	60	5	
		4.001-4.500	-	68	58	5	
		4.501-5.000	-	68	58	5	
		5.001-5.500	-	67	57	4	
		5.501-6.000	-	66	56	4	
	-F	0.250-6.000	-	- No requirements -			
		(Mechanical capabilities properties)					
	-T6 and -T651	3.001-4.000	-	70	60	6	
			-	65	56	2	
		4.001-4.500	-	68	58	6	
			-	63	54	2	
		4.501-5.000	-	68	58	5	
			-	63	54	2	
		5.001-5.500	-	67	57	4	
			-	62	53	2	
		5.501-6.000	-	66	56	4	
			-	61	52	2	
QQ-A-250/12 Plate and Sheet	-O	All	All	42 max	24 max	10	
	-T6	Up thru 0.249	Up thru 20	75	67	7	
	-T6510	0.250-0.499	Up thru 20	77	68	7	
	-T6511	0.500-1.499	Up thru 20	78	70	7	
		1.500-2.999	Up thru 20	79	70	7	
		3.000-4.499	Up thru 20	79	70	7	
			Over 20 thru 32	77	70	7	
			Over 32 thru 50	76	68	7	
		4.500-5.000	Up thru 38	78	68	6	
			Over 38 thru 60	76	68	6	
		5.001-5.999	Up thru 38	78	68	6	
			Over 38 thru 60	76	68	6	
		6.000-6.999	Up thru 50	76	66	6	
			Over 50 thru 60	74	64	4	
QQ-A-367 Forgings, Heat Treated	-T6	6(5)		(22, 4) 72(P)	(19, 4) 62(P)	10(6)	135
	-T6	6(5) Up to 6	Up to 72(22)	70(NP) 71(L) 69(LT) 65(ST)	60(NP) 62(L) 58(LT) 54(ST)	3(6) 9 6 4	135

7178

CHEMICAL COMPOSITION - percent										
Specification	Zn	Mg	Cu	Cr	Mn	Fe	Si	Ti	Others(1)	Al
QQ-A-250/14	6.3-7.3	2.4-3.1	1.6-2.4	0.18-0.40	0.30	0.7	0.50	0.20	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Designation Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
						(16)
QQ-A-250/14 Plate and Sheet	-O	0.015-0.499	-	40 max	21 max	10
		0.500	-	40 max	--	10
	-T6	0.015-0.044	-	83	72	7
		0.045-0.499	-	84	73	8
		0.500-1.000	-	84	73	6
		1.001-1.500	-	84	73	4
		1.501-2.000	-	80	70	3
	-T651	0.250-0.499	-	84	73	8
		0.500-1.000	-	84	73	6
		1.001-1.500	-	84	73	4
		1.501-2.000	-	80	70	3
	-F	All	-	- No requirements -		

7178 Alclad

CHEMICAL COMPOSITION - percent										
Specification	Zn	Mg	Cu	Cr	Mn	Fe	Si	Ti	Others(1)	Al
QQ-A-250/15 Core (7178)	6.3-7.3	2.4-3.1	1.6-2.4	0.18-0.40	0.30	0.7	0.50	0.20	0.05 each 0.15 total	Balance
Cladding (7072)	0.8-1.3	0.10	0.10	-	0.10	Fe & Si/0.7		-	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Designation Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
						(16)
QQ-A-250/15	-O	0.015-0.499	-	36 max	20 max	10
		0.500(11)	-	40 max	--	10
	-T6	0.015-0.044	-	76	66	7
		0.045-0.499	-	78	68	8
		0.500-1.000(11)	-	84	73	6
		1.001-1.500(11)	-	84	73	4
		1.501-2.000(11)	-	80	70	3
	-T651	0.250-0.499	-	78	68	8
		0.500-1.000(11)	-	84	73	6
		1.001-1.500(11)	-	84	73	4
		1.501-2.000(11)	-	80	70	3
	-F	All	-	- No requirements -		

7277

CHEMICAL COMPOSITION - percent										
Specification	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Others[1]	Al
MIL-R-12221	0.50	0.7	0.8-1.7	-	1.7-2.3	0.18-0.35	-	3.7-4.3	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
MIL-R-12221 Rivet, Solid, Tempered	-	-	-	-	-	-

X8280

CHEMICAL COMPOSITION - percent									
Specification	Sn	Cu	Ni	Si	Fe	Mn	Ti	Others[1]	Al
MIL-A-11267	5.5-7.0	0.7-1.3	0.20-0.7	1.0-2.0	0.7	0.10	0.10	0.05 each 0.15 total	Balance

MECHANICAL PROPERTIES - minimum						
Designation Specification	Temper	Thickness inch	Area Sq. in.	Tensile Str ksi	Yield Str ksi	EL %
MIL-A-11267 Sheet (For Recoil Mechanism Cup Rings)	-H12	-	-	18	15	4

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