

ENGINEERING MATERIAL SELECTION REFERENCE

Aluminum Alloy Designations, Properties, and Applications

A Comparative Analysis Across the AA, GB, JIS, and EN Systems

Complete guide to temper designations · Property comparison of common grades
Representative application cases · Selection guidance and common misconceptions

Contents

1. 1. Introduction: Why Designation Literacy Matters
2. 2. Reading the Designation Systems
 - 1) 2.1 The AA Four-Digit System for Wrought Alloys
 - 2) 2.2 The Chinese GB System: Legacy and Current Designations
 - 3) 2.3 Japanese JIS and European EN
 - 4) 2.4 Casting Alloy Designations
3. 3. A Complete Guide to Temper Designations
 - 1) 3.1 The Five Basic Tempers
 - 2) 3.2 T Temper Subdivisions
 - 3) 3.3 Suffix Digits: Stress-Relief Indicators
 - 4) 3.4 H Temper Subdivisions
4. 4. Property Comparison of Principal Wrought Alloys
 - 1) 4.1 Core Mechanical Properties of Common Grades
 - 2) 4.2 Cross-Comparison of Six Key Properties
 - 3) 4.3 Quench Sensitivity: 7075 versus 7050
5. 5. Representative Application Cases
 - 1) 5.1 Architecture, Windows, and Curtain Walls
 - 2) 5.2 Aerospace Structures
 - 3) 5.3 New-Energy Vehicles and Battery Systems
 - 4) 5.4 Consumer Electronics and Consumer Goods
 - 5) 5.5 Marine and Offshore Engineering
 - 6) 5.6 Molds, Tooling, and Fixtures
6. 6. Material Selection Guidance
 - 1) 6.1 Fast Positioning by Performance Priority
 - 2) 6.2 A Recommended Selection Sequence
 - 3) 6.3 Common Misconceptions
7. 7. Conclusion
8. Appendix: Quick-Reference Tables

Executive Summary

The core of aluminum alloy selection can be reduced to three steps: **first establish whether the alloy is heat-treatable**, which sets the strength ceiling; **then examine weldability and corrosion resistance**, the two hard constraints that define the candidate set; **finally examine thickness and temper detail**, which determine actual performance.

The grade is only the starting point; the temper is the destination. The spread in tensile strength between 6061-O, 6061-T4, and 6061-T6 is far greater than the gap between 6061-T6 and 6082-T6. A complete material specification must state all four elements: **grade, temper, product form, and governing standard**.

Strength is broadly inversely related to corrosion resistance and weldability, because high-strength alloys depend on substantial copper and zinc additions, and these same elements increase electrochemical corrosion tendency while reducing weldability. No material is simultaneously the strongest and the easiest to weld.

1. Introduction: Why Designation Literacy Matters

On an engineering bill of materials, “6061-T6” and “7075-T651” look like a trivial difference in digits. In practice they describe two materials whose tensile strengths differ by nearly a factor of two, whose weldability ranges from “excellent” to “not recommended,” and whose cost differs by two to three times. Specifying the wrong grade can mean scrapping an entire heat of material—or, at worst, a structural component failing in service by stress-corrosion cracking.

The confusion surrounding aluminum alloy designations stems from several standards running in parallel worldwide. The four-digit system of the Aluminum Association (AA) is the most widely used international language. China’s GB standard maintains a legacy set of letter codes (LF, LY, LC, LD) alongside modern designations such as 2A12 and 5A06.

Japanese JIS prefixes the AA number with the letter A, yielding forms like A6061. European EN standards write EN AW-6061. One material therefore carries four different names across four systems, and procurement and technical communication break down easily.

This document is written for engineering material selection. It first establishes the rules for reading designations, then compares properties series by series, and finally provides actionable selection guidance together with commonly encountered misconceptions. All mechanical property values are minimum guaranteed values taken from the respective national standards. Actual purchases should always be confirmed against the supplier’s mill test certificate (MTC) or material certificate.

2. Reading the Designation Systems

2.1 The AA Four-Digit System for Wrought Alloys

The AA system is the common international language. Wrought alloy designations are always four digits: the first digit identifies the principal alloying element series, and the remaining three digits are merely a sequential identifier carrying no compositional information.

Table 1. Characteristics of the eight AA alloy series

Series	Principal alloying element	Heat-treatable	Strength level	Core characteristics
1xxx	Pure aluminum (Al ≥ 99.0%)	No	Low (40–130 MPa)	Outstanding electrical and thermal conductivity, excellent corrosion resistance, highly formable
2xxx	Copper (Cu)	Yes	High (400–500 MPa)	High strength, good elevated-temperature performance, poor corrosion resistance and weldability
3xxx	Manganese (Mn)	No	Medium-low (110–280 MPa)	Balanced formability and corrosion resistance, weldable
4xxx	Silicon (Si)	Partly	Medium (170–380 MPa)	Low melting point, excellent fluidity; mainly filler wires and brazing alloys
5xxx	Magnesium (Mg)	No	Medium-high (200–350 MPa)	Best corrosion resistance and weldability; seawater resistant
6xxx	Magnesium + silicon (Mg+Si)	Yes	Medium (200–350 MPa)	Best extrudability and anodizing response; the most balanced family
7xxx	Zinc (Zn, with Mg/Cu)	Yes	Very high (450–600 MPa)	Highest specific strength; poor corrosion resistance and weldability
8xxx	Others (Li, Fe, etc.)	Alloy dependent	Alloy dependent	Specialty properties such as low density or high stiffness

Whether a designation can be strengthened by heat treatment is determined by the first digit alone: **2xxx, 6xxx, and 7xxx are heat-treatable; 1xxx, 3xxx, and 5xxx are not** and can only be strengthened by strain hardening. This is the single most useful first dividing line in material selection.

2.2 The Chinese GB System: Legacy and Current Designations

Current designations under GB/T 3190 have moved fully to the “four digits plus element symbol” form, aligning with the AA system. Nevertheless, a great many drawings, molds, and legacy material lists still use the old letter codes beginning with L: LF for rustproof aluminum (Al-Mg and Al-Mn), LY for duralumin (Al-Cu), LC for super-duralumin (Al-Zn), LD for forging aluminum (Al-Mg-Si), and L for pure aluminum.

Table 2. Chinese GB designations cross-referenced to international systems

Chinese current	Chinese legacy	US AA	Japanese JIS	European EN	Series
1050A	L3	1050A	A1050	EN AW-1050A	1xxx
1100	L5-1	1100	A1100	EN AW-1100	1xxx
2A11	LY11	2017	A2017	EN AW-2017A	2xxx
2A12	LY12	2024	A2024	EN AW-2024	2xxx
2A14	LD10	2014	A2014	EN AW-2014	2xxx
3003	LF21	3003	A3003	EN AW-3003	3xxx
4A01	LT1	4043	A4043	EN AW-4043A	4xxx
5A02	LF2	5052	A5052	EN AW-5052	5xxx
5A06	LF6	5056	A5056	—	5xxx
5083	LF4	5083	A5083	EN AW-5083	5xxx
6061	LD30	6061	A6061	EN AW-6061	6xxx
6063	LD31	6063	A6063	EN AW-6063	6xxx
6082	—	6082	A6082	EN AW-6082	6xxx
7A04	LC4	7010 (approximate)	—	EN AW-7010	7xxx
7A09	LC9	7075	A7075	EN AW-7075	7xxx

Note: 2A12 and 2024 are chemically equivalent but not fully interchangeable; impurity control limits differ slightly, so substitution in aerospace hardware requires a formal material review. Likewise, 7A04 and 7075 both belong to the Al-Zn-Mg-Cu family but differ in their zinc-to-magnesium ratio, making them similar rather than identical.

2.3 Japanese JIS and European EN

The JIS convention is the simplest of all: prefix the AA number with the letter A and append the temper separately, as in A6061-T6, A7075-T651, or A5052-H32. Note that JIS casting alloy designations form a separate system (ADC10, ADC12, AC4C, and so on) and are not interchangeable with wrought alloy designations.

The EN system is written as EN AW-*four digits*, where AW denotes wrought aluminum. What distinguishes EN is that the temper designation is formally part of the designation itself, for example EN AW-6061-T6 or EN AW-5083-H111. EN also defines the 6xxx-specific T66 temper, which denotes a higher level of mechanical properties than T6 achieved through special process control.

2.4 Casting Alloy Designations

Casting alloy numbering follows a completely different logic from wrought alloys and must be memorized separately. China's GB uses the ZL prefix (ZL101, ZL104, ZL201, ZL302); the AA system uses three digits with an optional decimal suffix (A356, A380, A413, 206); Japanese JIS uses ADC or AC prefixes (ADC12, AC4C); and European EN uses the EN AC- prefix. Casting alloys fall into five principal families:

Table 3. The five casting alloy families, characteristics, and applications

Alloy family	Representative grades	Core characteristics	Typical applications
Al-Si	ZL101, A356	Good fluidity, low hot-tearing tendency, heat-treatable	Pump housings, engine parts, wheels
Al-Si-Mg	ZL104, A356-T6	Balanced strength and castability, T6-strengthenable	Automotive wheels, suspension arms, high-integrity housings
Al-Si-Cu	ADC12, A380, ZL108	Excellent fluidity, die-castable, good thermal conductivity	Consumer electronics enclosures, engine covers, transmission housings
Al-Cu	ZL201, ZL205	High strength, heat resistant, poor weldability	Aerospace structural parts, elevated-temperature components
Al-Mg	ZL302	Excellent corrosion resistance, weldable, non-heat-treatable	Marine parts, chemical process equipment

3. A Complete Guide to Temper Designations

A temper designation follows the alloy number, separated by a hyphen, as in 6061-T6. It directly determines the final mechanical properties of the material: **the same 6061 in the O temper and in the T6 temper can differ in tensile strength by more than a factor of three.** This is where procurement errors most commonly occur.

3.1 The Five Basic Tempers

Table 4. The five basic temper designations

Code	Name	Description
F	As fabricated	No special thermal treatment or strain-hardening control after forming; mechanical properties not specified
O	Annealed	Fully annealed; lowest strength, highest ductility; suited to deep drawing and severe bending
H	Strain hardened	Strength increased by cold work; applied to alloys that are not heat-treatable (1xxx, 3xxx, 5xxx)
W	Solution heat treated	An unstable condition during natural aging after solution treatment; an intermediate state only
T	Thermally treated	A stable condition produced by heat treatment; applied to heat-treatable alloys (2xxx, 6xxx, 7xxx)

3.2 T Temper Subdivisions: What the First Digit Means

The first digit after T (0 through 10) denotes the specific thermal treatment sequence. This is the most easily confused part of the system.

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Table 5. T temper subdivisions and their process sequences

Code	Process sequence	Characteristics and typical applications
T1	Cooled from an elevated-temperature shaping process, then naturally aged	No cold work after extrusion; low strength
T2	Cooled from elevated-temperature shaping, cold worked, then naturally aged	Balances strength and formability
T3	Solution heat treated, cold worked, then naturally aged	2024-T3, the first choice for aircraft skin; excellent toughness and fatigue performance
T4	Solution heat treated, then naturally aged	Medium strength, good formability; suited to forming followed by aging
T5	Cooled from elevated-temperature shaping, then artificially aged	6063-T5, the most common temper for extrusions
T6	Solution heat treated, then artificially aged	Peak strength; the most widely used temper (6061-T6, 7075-T6)
T7	Solution heat treated, then overaged	Slightly lower strength, greatly improved stress-corrosion resistance (7075-T73)
T8	Solution heat treated, cold worked, then artificially aged	Combines high strength with formability
T9	Solution heat treated, artificially aged, then cold worked	Highest strength, lowest ductility
T10	Cooled from elevated-temperature shaping, cold worked, then artificially aged	Strengthened condition for extruded and drawn products

3.3 Suffix Digits: Stress-Relief Indicators

The additional two digits after the T temper indicate the method used to relieve internal stress, which is critically important for thick plate and precision machined parts.

Table 6. Stress-relief suffix designations

Suffix	Meaning	Where it applies
51	Stress relieved by stretching	Thick plate, stretcher-straightened sheet (T651)
52	Stress relieved by compressing	Forgings, extrusions
511	Stress relieved by minor stretching	Only to meet dimensional tolerances
7451	Overaged and stress relieved by stretching	7050-T7451, the first choice for thick-section aerospace parts

T6 and T651 are not equivalent. Their strength levels are similar, but T651 includes an additional controlled stretching operation that markedly reduces residual internal stress, so distortion after machining is small. Precision machined parts and thick plate should preferentially be specified in T651.

3.4 H Temper Subdivisions: Strain-Hardening Indicators

The H temper format is HXY, where the first digit X denotes the method of working and the second digit Y denotes the degree of hardening.

Table 7. H temper subdivisions: working method and degree of hardening

X (method)	Meaning	Y (degree)	Meaning
H1X	Strain hardened only	X1	Quarter hard
H2X	Strain hardened and partially annealed	X2	Half hard
H3X	Strain hardened and stabilized	X4	Hard (H18 corresponds to full hard)
H4X	Strain hardened and lacquered or painted	X8	Extra hard
—	—	X9	Ultra hard

Typical examples: 5052-H32 (strain hardened and stabilized, half hard, used for marine sheet and automotive body panels) and 1100-H14 (strain hardened only, used for signage and decorative sheet).

4. Property Comparison of Principal Wrought Alloys

4.1 Core Mechanical Properties of Common Grades

The table below consolidates minimum guaranteed values for extruded products, predominantly in the T6 temper, for convenient use in grade selection and finite element input.

Table 8. Minimum guaranteed mechanical properties of common grades

Grade and temper	Tensile strength Rm (MPa)	Yield strength Rp0.2 (MPa)	Elongation A (%)	Elastic modulus E (GPa)	Density (g/cm ³)
1100-H14	110–130	35–50	20–25	69	2.71
3003-H14	150	145	8	69	2.73
5052-H32	210–260	130–200	12–15	70	2.68
5083-H112	300–330	210–240	15–18	71	2.66
6063-T5	150	110	8	68.9	2.70
6063-T6	205	170	8	68.9	2.70
6061-T6	290	240	8–12	68.9	2.70
6082-T6	310	260	8–10	69.0	2.71
2024-T4	425	275	12–20	72.0	2.78
2024-T351	470	325	18	72.0	2.78
7075-T6	560	480	7–11	71.0	2.81
7075-T7351	505	435	13	71.0	2.81
7050-T7451	525	460	11	71.7	2.83

Data note: the values above are minimum guaranteed values from the respective standards; production material is usually stronger. Elastic modulus varies little between grades (69–72 GPa), which means **switching grades is an ineffective way to increase stiffness; switching grades mainly increases strength**. This point is the most frequently misunderstood in design work.

4.2 Cross-Comparison of Six Key Properties

Beyond strength, corrosion resistance, weldability, and cost often drive the selection decision. The table below grades each alloy relatively, using 6061-T6 as the reference.

Table 9. Relative performance ratings across six key properties

Grade	Relative strength	Corrosion resistance	Weldability	Machinability	Anodizing response	Relative cost
1100	Low	Excellent	Excellent	Fair	Good	Low
5052	Medium-low	Excellent (seawater resistant)	Excellent	Fair	Excellent	Medium-low
5083	Medium-high	Excellent (best seawater resistance)	Excellent	Fair	Good	Medium
6063	Low	Good	Excellent	Good	Excellent (best appearance)	Low
6061	Medium	Good	Excellent	Good	Good	Medium
6082	Medium-high	Good	Good	Good	Good	Medium-high
2024	High	Poor (requires protection)	Poor (largely limited to friction welding)	Good	Poor	High
7075	Very high	Poor (requires protection)	Poor	Good	Poor	High
7050	Very high	Moderate (markedly improved after T7451 overaging)	Poor	Good	Poor	Very high

One rule is worth committing to memory: **strength is broadly inversely related to corrosion resistance and weldability**. High-strength alloys in the 2xxx and 7xxx families depend on substantial additions of Cu and Zn, and these same elements increase electrochemical corrosion tendency while reducing weldability. No material is simultaneously the strongest and the easiest to weld.

4.3 Quench Sensitivity: 7075 versus 7050

In thick-section aerospace selection, choosing between 7075 and 7050 is the most technically demanding judgment in this document. Both belong to the Al-Zn-Mg-Cu family, and 7075 in the T6 temper actually has higher tensile strength—but the two differ markedly in **quench sensitivity**.

7075 uses chromium as a grain-refining dispersoid. When a thick section is quenched, the cooling rate at the center is insufficient, coarse phases precipitate prematurely, and core properties degrade substantially. 7050 replaces chromium with zirconium (0.08–0.15%), which greatly reduces quench sensitivity.

Estimating on a 150 mm section: 7075-T73 loses roughly **18%** of its core yield strength, down to about 357 MPa, whereas 7050-T7451 loses only about **5%** and still reaches 446 MPa at the core—a **roughly 25% difference in core properties** between the two.

More critically, incomplete quenching at the core of 7075 not only reduces strength but simultaneously raises stress-corrosion susceptibility in that region. The conclusion is therefore unambiguous: **when section thickness exceeds approximately 75–100 mm, specify 7050 rather than 7075**. 7075 remains appropriate for thin sheet, thin-wall high-stress components, and cost-sensitive general high-strength structures.

5. Representative Application Cases

5.1 Architecture, Windows, and Curtain Walls

6063-T5 or T6 dominates this application. Its advantages are the best extrudability of any grade, excellent surface finish, the finest anodizing and coloring response, and low cost. At 205 MPa tensile strength, 6063-T6 comfortably carries curtain-wall wind loads, but it **must not be used for heavily loaded primary structure**. For long spans or high wind pressures, move up to 6061-T6 or 6082-T6.

5.2 Aerospace Structures

Table 10. Material selection by aerospace structural location

Location	Material selection	Rationale
Lower wing skin, fuselage panels	2024-T351	Best fatigue performance and toughness; resists crack growth
Upper wing skin, stringers	7075-T651 or T7351	Carries compressive load; requires maximum strength
Fuselage frames, wing ribs, heavily loaded fittings	7050-T7451	Good through-thickness hardenability; resists exfoliation corrosion
Large integral forgings	7050-T7451	Uniform core properties, low residual stress
Landing gear structural parts	7075-T7351	Overaging trades strength for stress-corrosion resistance
Avionics enclosures, hydraulic valve bodies	6061-T651	Corrosion resistant, weldable, good heat dissipation; secondary structure

5.3 New-Energy Vehicles and Battery Systems

Battery trays and energy-storage cabinet frames are predominantly 6061-T6, balancing strength, weldability, and heat dissipation. Where larger cross-sections demand higher strength, 6082-T6 is used. Liquid-cooling plates and thermal modules typically use 3003 or 6063 for their thermal conductivity and brazeability.

5.4 Consumer Electronics and Consumer Goods

Phone mid-frames and laptop enclosures are mainly 6xxx grades (6063, 6061) chosen for anodized appearance and formability, with 7xxx grades used in premium models to thin the chassis. Heat sinks commonly use 1050 or 6063 for thermal conductivity. Die-cast housings where thermal demand is high or cost is sensitive use ADC12.

5.5 Marine and Offshore Engineering

5083-H116 or H321 is the overwhelming workhorse, followed by 5052. The reason is that its seawater corrosion resistance is the best of any aluminum alloy, combined with good weldability that does not degrade corrosion resistance in the weld. **Marine environments must avoid the 2xxx and 7xxx families** unless full coating systems or sacrificial anode protection are applied.

5.6 Molds, Tooling, and Fixtures

7075-T6 or T651 is the mainstream choice for its high hardness and wear resistance. Large thick mold plates tend to favor 7050-T7451 to ensure that the plate does not distort after machining.

6. Material Selection Guidance

6.1 Fast Positioning by Performance Priority

Table 11. Grade recommendation by primary performance requirement

Primary requirement	First choice	Second choice	Avoid
High strength or specific strength	7075-T6, 7050-T7451	2024-T351, 6082-T6	1xxx, 3xxx
Corrosion resistance (including marine)	5083, 5052	6061, 6063	2024, 7075 (unprotected)
Weldability	5083, 6061, 6063	5052, 3003	2024, 7075
Extrusion formability and appearance	6063-T5 or T6	6061-T6	7xxx
Machinability	2011, 6061-T6	7075-T6	5083 (galling, built-up edge)
Anodizing and coloring	6063, 5052	6061	High-Cu and high-Zn alloys
Electrical and thermal conductivity	1050, 1070, 6063	3003, 1100	7xxx
Thick-section load-bearing parts	7050-T7451	6082-T6	7075 (above 75 mm)
Low cost	6063, 3003	1100, 6061	7050, 7075

6.2 A Recommended Selection Sequence

1. **Fix the process first, then the grade.** If the part is die cast, the candidate set collapses to the Al-Si-Cu family and 6061 is simply not available. The process defines the candidate set; the grade is chosen from within it.
2. **Fix the temper before comparing grades.** Property differences between tempers of the same grade are often larger than differences between grades in the same temper. The gap between 6061-O and 6061-T6 far exceeds the gap between 6061-T6 and 6082-T6.
3. **Identify the weakest link.** If the structure must be welded, weldability is a hard constraint and the 7xxx family is eliminated immediately. If the service environment is corrosive, corrosion resistance is a hard constraint and the 2xxx family and unprotected 7xxx are eliminated.
4. **Account for the thickness effect.** Thick sections require checking hardenability and core properties; surface test-coupon data alone is not sufficient.
5. **Specify the standard and temper completely.** Purchase orders should state all four elements—grade, full temper, product form, and governing standard—for example “6061-T651 plate, ASTM B209.” Writing only “6061 aluminum plate” is an inadequate specification.

6.3 Common Misconceptions

Misconception 1: treating T6 and T651 as equivalent

Strength is similar, but T651 includes stretcher stress relief, and the difference in distortion after machining is pronounced. Using T6 for precision parts can produce post-machining warpage.

Misconception 2: performing large-radius bending in the T6 temper

T6 has lower ductility than T4 or O, and tight-radius bends are prone to cracking. The correct practice is to form in T4 or O and then age to T6 afterward.

Misconception 3: expecting a grade change to improve stiffness

Elastic modulus across grades spans only 69–72 GPa; switching to 7075 improves stiffness by less than 3%. Stiffness should be increased by adding section or changing the structural configuration, not by changing material.

Misconception 4: assuming temper does not affect corrosion resistance

For some alloy-temper combinations, stress-corrosion and exfoliation-corrosion performance differ enormously; 7075-T6 and 7075-T73 are not in the same class for stress-corrosion resistance.

Misconception 5: applying mechanical data across thicknesses

Guaranteed properties for a given grade vary with product form, thickness, and test direction. Thick-plate data

cannot be applied directly to thin sheet.

Misconception 6: confirming temper by hardness alone

Different alloy and process combinations can produce overlapping hardness values. Hardness serves only as a supplementary check and does not replace the mill test certificate and tensile testing.

7. Conclusion

The core of aluminum alloy selection can be compressed into three statements: **first establish whether the alloy is heat-treatable, which sets the strength ceiling; then examine weldability and corrosion resistance, the two hard constraints that define the candidate set; finally examine thickness and temper detail, which determine actual performance.**

The grade is only the starting point; the temper is the destination. A complete material specification should state grade, temper, product form, and governing standard—omitting any one of the four can cause delivered material to diverge from design intent. In cross-border procurement, a cross-reference table should also be attached to prevent misreading between Chinese GB legacy codes, Japanese JIS designations, and US AA numbers.

Appendix: Quick-Reference Tables

A. Four-System Cross-Reference for Common Grades

Table 12. Cross-reference of common grades across four designation systems

Application	Chinese GB	US AA	Japanese JIS	European EN
Pure aluminum conductors	1050A	1050A	A1050	EN AW-1050A
Beverage cans, heat exchangers	3003	3003	A3003	EN AW-3003
Marine, pressure vessels	5083	5083	A5083	EN AW-5083
General sheet metal work	5A02	5052	A5052	EN AW-5052
Architectural window profiles	6063	6063	A6063	EN AW-6063
General structural components	6061	6061	A6061	EN AW-6061
European structural profiles	6082	6082	A6082	EN AW-6082
Aerospace skin	2A12	2024	A2024	EN AW-2024
Aerospace high-strength structure	7A09	7075	A7075	EN AW-7075

B. Casting Alloy Quick Reference

Table 13. Casting alloy designations by application

Application	Chinese GB	US AA	Japanese JIS
Consumer electronics enclosures, thin-wall parts	YL113	A383 / ADC12	ADC12
Engine parts, transmission housings	ZL108	A380	ADC10
Automotive wheels, suspension arms	ZL101A	A356	AC4C
High-integrity housings	ZL101A	A356-T6	AC4C-T6
Marine, chemical equipment	ZL302	518 / A535	AC7A
Aerospace elevated-temperature parts	ZL201	206	AC1B

C. Temper Designation Quick Reference

Table 14. Temper designation quick reference

Designation	Full meaning	One-line memory aid
O	Annealed	Softest, most formable
H32	Strain hardened and stabilized, half hard	Standard temper for 5xxx marine sheet
T4	Solution heat treated and naturally aged	Balanced formability and strength
T5	Cooled from shaping, then artificially aged	Standard temper for 6063 extrusions
T6	Solution heat treated and artificially aged	Peak strength, most widely used
T651	T6 plus stress relief by stretching	Choose it for thick plate and precision parts
T73	Solution heat treated and overaged	Trades strength for stress-corrosion resistance
T7451	Overaged and stress relieved by stretching	First choice for thick-section aerospace parts
H112	Slightly strain hardened from elevated-temperature working	Standard condition for 5xxx extrusions and plate