

About Aluminum Alloys

Aluminum is lightweight and offers moderate strength, as well as good corrosion resistance, formability, and machinability, especially when compared to steel. Aluminum typically melts at a lower temperature than steel; its capacity for conducting heat and electricity is about two-thirds that of copper.

About Temper

The temper shown indicates the processing done to achieve stabilized strength and hardness properties. A "T" temper means the material has been heat treated. An "H" temper indicates that the material is not heat treatable and may be hardened only by shaping without heat (often called strain hardening or cold working). "F" and "O" tempers are not hardened. Materials that share the same first letter and number are treated similarly.

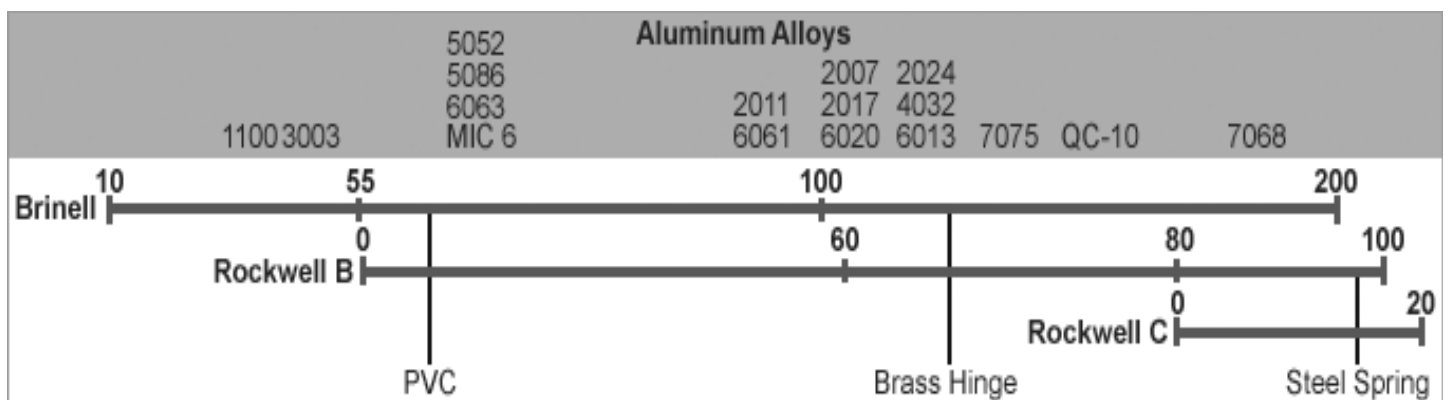
Tempers shouldn't be used to compare alloys because the tempers only indicate the processes used to achieve properties. Comparisons among alloys can be made using the hardness and yield strength figures themselves.

Aluminum Alloys: [1100](#), [2007](#), [2011](#), [2017](#), [2024](#), [3003](#), [4032](#), [5005](#), [5052](#), [5083](#), [5086](#), [5205](#), [6013](#), [6020](#), [6060](#), [6061](#), [6063](#), [7050](#), [7068](#), [7075](#), [MIC 6](#), [Porous](#), [QC-10](#).

Hardness

The hardness of a material is its resistance to another material penetrating its surface. Harder materials offer more wear resistance, but they are more brittle.

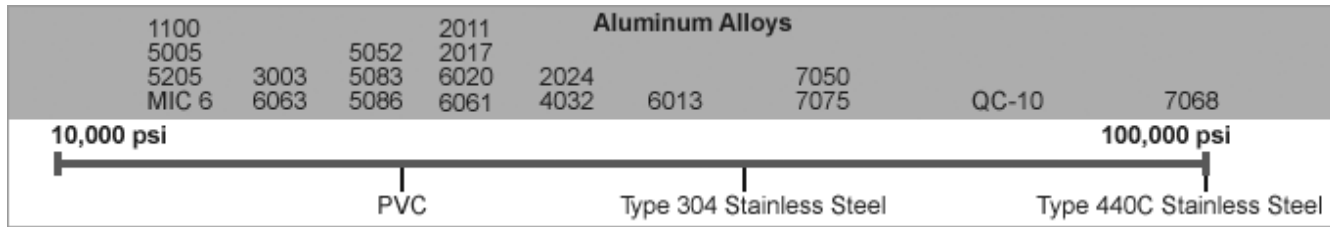
Note: Alloys 5005, 5083, 5205, 6060, 7050, and porous aluminum are not rated.



Yield Strength

Yield strength is the point at which material stretches and will not return to its original shape. At this point, the metal has changed shape permanently but does not break.

Note: Alloys 2007 and 6060 and porous aluminum are not rated.



Weldability

Good—Weldable by all commercial procedures and methods.

Fair—May require special techniques and testing to develop procedures for welding.

Note: Alloy 2007 is not rated.

Welding Type	Good	Fair	Not Recommended
TIG/MIG	1100, 3003, 5052, 6013, 6061, 6063, MIC 6	5086, 6060	2011, 2017, 2024, 4032, 5005, 5083, 5205, 6020, 7050, 7068, 7075, Porous, QC-10
Arc	1100, 3003, 5052, 5083, 5086, 6013, 6061, 6063	2017, 2024, 4032, 6020, 6060	2011, 5005, 5205, 7050, 7068, 7075, MIC 6, Porous, QC-10
Spot	1100, 3003, 5052, 5083, 5086, 6013, 6061, 6063, 7050	2017, 2024, 6060, 7068, 7075	2011, 4032, 5005, 5205, 6020, MIC 6, Porous, QC-10

Corrosion Resistance

Indicates an alloy's suitability for outdoor use and high-salt spray applications.

Note: Alloys 2007 and 6060 are not rated.

Excellent	Good	Fair	Poor
1100, 3003, 5052, 5083, 5086, QC-10	6013, 6020, 6061, 6063, Porous	4032, 5005, 5205, 7050, 7068, 7075	2011, 2017, 2024, MIC 6

Forming and Working

Also known as workability or bendability. It's the extent to which a material won't crack when bent without applying heat.

Excellent	Good	Fair	Poor
1100, 5052	3003, 5005, 5086, 5205	2011, 2024, 5083, 6060, 6061, 6063	2007, 2017, 4032, 6013, 6020, 7050, 7068, 7075, MIC 6, Porous, QC-10

Machinability

Machinable alloys can be cut, drilled, shaved, turned, reamed, tapped, threaded, or otherwise machined.

Excellent—These alloys are ideal for machining. When cut, they will not require extensive post-machining cleaning and will produce very small broken chips.

Good—These alloys will have a good to excellent finish after machining and will produce curled or easily broken chips.

Fair—Alloys have a satisfactory post-machining finish and will produce continuous chips.

Poor—Difficult to get clean part after machining.

Excellent	Good	Fair	Poor
2007, 2011, 6020, Porous, QC-10	2017, 2024, 4032, 6013, 7050, 7075, MIC 6	6060, 6061, 6063, 7068	1100, 3003, 5005, 5052, 5083, 5086, 5205

Warning! Hardness and yield strength are not guaranteed and are intended only as a basis for comparison.

About Steel

Carbon steel is an economical choice for machining and structural applications, and it can be surface hardened.

Alloy steel has greater strength and hardness than carbon steel, making it useful for high-stress applications. Heat treating can further enhance strength and hardness.

Tool steel is used to make cutting tools, and it can be heat treated for extreme hardness.

Use the charts below to identify the best steel for your application. Circles indicate that a majority of a material's shapes and sizes meet the applicable rating. Information is intended for comparison only and is not guaranteed.

- Excellent
- ◐ Good
- Poor

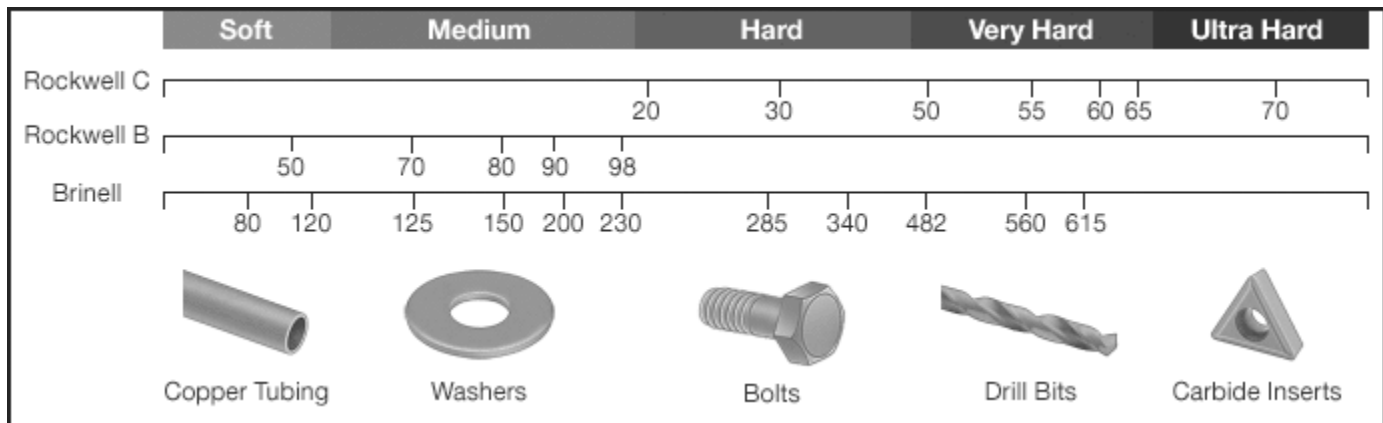
Carbon Steel								
	Min. Yield Strength, psi	Hardness (Rockwell)		Machinability	Weldability	Impact Resistance	Wear Resistance	Formability
		Unhardened	Hardened					
Gen. Purpose Low Carbon	30,000	B50	C60	◐	●	—	—	—
High Strength 1045	65,000	B86	C62	◐	◐	—	—	○
Shaft Quality 1060	50,000	—	C60	—	—	◐	◐	○
High Strength 1144	100,000	C23	—	◐	○	○	◐	○
Easy-to-Machine 1117	58,000	B75	B89	●	○	—	—	—
Very Easy-to-Machine 1215	60,000	B85	—	●	○	—	—	○
Ultra Machinable 12L14	60,000	B82	C65	●	○	○	○	○
Abrasion Resistant AR400	140,000	—	C38	◐	●	●	●	◐
Impact Resistant A516	38,000	B78	—	◐	◐	◐	—	—
Spring Steel	50,000	B88	C66	○	◐	●	●	○
Cast Iron	55,000	C20	C60	●	—	—	◐	—

Alloy Steel								
	Min. Yield Strength, psi	Hardness (Rockwell)		Machinability	Weldability	Impact Resistance	Wear Resistance	Formability
		Unhardened	Hardened					
Multipurpose 4140/4142	60,000	B90	C60	◐	◐	◐	◐	◐
Easy-to-Machine 41L40	85,000	B96	C34	●	—	◐	◐	◐
Wear Resistant 4150	48,000	B90	C63	◐	◐	—	◐	—
High Strength A514	100,000	—	C27	◐	◐	◐	○	◐
Very High Strength 300M	230,000	C23	C54	○	◐	◐	◐	◐
Impact Resistant 4340	68,500	C27	C40	◐	◐	◐	◐	—
Ultra Impact Resistant C300	110,000	C30	C55	○	◐	●	○	◐
Easy-to-Weld 4130	50,000	B85	C60	◐	●	—	—	●
Easy-to-Weld 8620	100,000	B85	C60	◐	●	◐	○	●
Bearing Quality E52100	62,000	C24	C60	○	○	◐	◐	○

Tool Steel								
	Min. Yield Strength, psi	Hardness (Rockwell)		Machinability	Weldability	Impact Resistance	Wear Resistance	Formability
		Unhardened	Hardened					
Multipurpose O1	50,000	B85	C65	◐	◐	◐	◐	●
Ultra Machinable W1	50,000	B88	C65	●	◐	◐	◐	●
Wear Resistant A2	51,000	B88	C65	◐	◐	◐	◐	○
Ultra Wear Resistant D2	50,000	B90	C62	○	○	○	●	○
High Temperature H13	52,000	B94	C53	◐	◐	●	◐	○
Shock Resistant S7	50,000	B90	C61	◐	◐	●	◐	◐
Easy-to-Machine P20	101,000	—	C26	◐	—	◐	◐	—
High Speed M2	60,000	B97	C66	○	○	○	●	○
Ultra Wear Resistant M4	60,000	B97	C65	○	—	○	●	—
Ultra-Hard Tungsten Carbide	319,000	—	C79	◐	—	◐	●	○

Hardness

As hardness increases, metals become more wear resistant but they may be less malleable. The chart below shows hardness on different scales.



Carbon Steel

General Purpose Low-Carbon Steel

One of the most widely used types of steel, low-carbon steel is weldable, machinable, and can be surface hardened by heat treating. It is suitable for a variety of applications, such as structural and power transmission components.

High-Strength 1045 Carbon Steel

This economical material is stronger than low-carbon steel. It's often used for bolts, studs, and shafts.

Shaft-Quality 1060 Carbon Steel

With a hardened surface for increased strength, this 1060 carbon steel is suitable for making shafts and components for linear bearing systems.

High-Strength Easy-to-Machine 1144 Carbon Steel

This medium-carbon steel offers high yield strength and hardness, even without further heat treating. Its composition also results in fast, reliable machining and increased tool life.

Very Easy-to-Machine 1215 Carbon Steel

For excellent machinability without lead, 1215 carbon steel can substitute for 12L14. It contains added sulfur and phosphorus to speed up machining. Use it for shaft couplings, studs, and pins.

Ultra-Machinable 12L14 Carbon Steel

When superior machinability is needed, 12L14 is the steel of choice. Lead added to the material acts as a lubricant for very fast machining and excellent surface finish.

Easy-to-Machine 1117 Carbon Steel

Extend the life of your tools and get improved surface finish with this machinable material.

Alloy Steel

Multipurpose 4140/4142 Alloy Steel

Also known as chrome-moly steel, this versatile material is used for many parts, such as gears, axles, shafts, collets, and dieholders.

Easy-to-Machine 41L40 Alloy Steel

Although its strength and wear resistance are similar to 4140/4142 alloy steel, 41L40 has added lead for fast machining.

Easy-to-Weld 4130 Alloy Steel

Its carbon content is low enough for good weldability but high enough to give this steel abrasion and impact resistance. 4130 is often used for gears, fasteners, and structural applications.

Wear-Resistant 4150 Alloy Steel

With more carbon than 4140/4142 alloy steel, 4150 resists wear from friction and abrasion. It's often used for gears, shafts, and ball screws.

High-Strength Impact-Resistant 4340 Alloy Steel

Use this material for power transmission and structural applications involving extreme impact, heat, and wear.

Very High-Strength 300M Alloy Steel

A modified version of 4340 steel, 300M is used in applications requiring high yield strength, such as torsion bars and drive shafts.

Easy-to-Weld Wear-Resistant 8620 Alloy Steel

A low carbon content makes 8620 weldable, and it contains nickel, chromium, and molybdenum for abrasion resistance.

Bearing-Quality E52100 Alloy Steel

Also known as chrome steel, E52100 is an extremely hard and wear-resistant material. It's used for parts such as bearings, bushings, and punches.

Ultra Impact-Resistant C300 Alloy Steel

Also known as maraging steel and VascoMax, C300 has excellent resistance to cracking from impact and compression. It's often used for dies and tooling applications.

Tool Steel

Multipurpose O1 Tool Steel

Commonly used for dies, punches, and gauges, O1 is a popular tool steel that resists wear and abrasion. It is an oil-hardening material.

Wear-Resistant A2 Tool Steel

Compared to O1 tool steel, A2 has better wear resistance and keeps a sharper cutting edge. It's often used for punches, broaches, and dies. This is an air-hardening tool steel.

Ultra Wear-Resistant D2 Tool Steel

A high content of carbon and chromium gives D2 excellent wear resistance, which makes it a popular choice for long-run dies and shear blades.

Ultra-Machinable W1 Tool Steel

With lower amounts of alloy elements than other tool steels, W1 offers excellent machinability. This is a water-hardening tool steel that is often used for hammers, files, taps, and reamers.

Shock-Resistant S7 Tool Steel

Capable of withstanding repeated shock and impact without fracturing, S7 is suitable for chisels, rivets, and punches.

Hardened Easy-to-Machine P20 Tool Steel

Often used for molds and die-casting dies, P20 is supplied in a hardened condition that is ready for machining. It has the wear resistance and highly polishable surface needed to fabricate long-lasting molds and dies.

Tough Wear-Resistant PM60 Tool Steel

Excellent resistance to wear, abrasion, and chipping makes this material useful for punches and stamping tools.

High-Speed M2 Tool Steel

A high molybdenum content allows this material to maintain sharp cutting edges even at elevated temperatures. It's used to fabricate high-speed cutting tools.

Ultra-Hard High-Speed M42 Tool Steel

Also known as cobalt steel, this material is capable of cutting extremely hard metals. It maintains its hardness in high-speed cutting applications that generate intense heat.

Ultra Wear-Resistant High-Speed M4 Tool Steel

Made from powdered metal, M4 has a consistent microstructure that gives it outstanding resistance to wear and abrasion. Comparable to CPM Rex M4, this material is used for punches, dies, and high-speed cutting tools.