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## Alloy 6061

Alloy 6061 is one of the most widely used alloys in the 6000 series. This standard structural alloy, one of the most versatile of the heat-treatable alloys, is popular for medium to high strength requirements and has good toughness characteristics. Hydro produces 6061 for use in standard and custom, solid and hollow shapes, rod and bar products, and seamless and structural pipe and tube.

Alloy 6061 has excellent corrosion resistance to atmospheric conditions and good corrosion resistance to seawater. This alloy also offers good finishing characteristics and responds well to anodizing; however, where cosmetic appearance is critical, consider the use of alloy 6063. The most common anodizing methods include clear, clear and color dye, and hardcoat.

Alloy 6061 is easily welded and joined by various commercial methods. (Caution: direct contact by dissimilar metals can cause galvanic corrosion.) Since 6061 is a heat-treatable alloy, strength in its -T6 condition can be reduced in the weld region. Selection of an appropriate filler alloy will depend on the desired weld characteristics. Consult the Safety Data Sheet (SDS) for proper safety and handling precautions when using alloy 6061.

For screw machine applications, alloy 6061 has adequate machinability characteristics in the heat-treated -T6/-T6511 condition. Chips from machining (particularly turning and drilling) can be difficult to break in the -T6/-T6511 temper condition. Chip breakers are recommended, and special machining techniques (i.e. peck drilling) can improve chip formation. For machining applications, alloy 6061 is available in many rod, bar and hex sizes. Refer to Hydro ACC-U-LINE™ machine grade product brochures for more details. Alloy 6061 conforms to standard industry specifications.

For minor bending applications, special forming tempers are available (dependent upon bend radius and degree of bend). When more severe bends are required, a softer temper condition such as -T1/-T4 or even -O (anneal) may be necessary to prevent cracking. After artificial aging (precipitation heat-treating), 6061-T1/-T4 is capable of developing -T6 properties. Hydro offers 6061 alloy with a wide selection of standard and special tempers.

### Typical applications for 6061 alloy:

- Transportation components
- Recreation products
- Machinery and equipment
- Consumer durables

## 6061 Temper Designations and Definitions

Standard Tempers	Standard Temper Definitions*
F	As fabricated. There is no special control over thermal conditions and there are no mechanical property limits.
O	Annealed. Applies to products that are annealed to obtain the lowest strength temper.
T1	Cooled from an elevated temperature shaping process and naturally aged. (See Note A.)
T4, T4510, T4511	Solution heat-treated and naturally aged. (See Notes B & C.)
T51	Cooled from an elevated temperature shaping process and artificially aged. (See Note A.)
T6, T6511	Solution heat-treated and artificially aged. (See Notes B & C.)

Special Tempers	Special Temper Definitions**
T4S6	For 6061 extrusions requiring maximum formability in the unaged condition and subsequently aged to -T6. May not meet -T4 minimum mechanical properties, but will meet -T6 minimum when properly aged. Test reports state -T6 properties to demonstrate heat-treat capabilities, but extrusions are supplied unaged. (See Note D.)
T6S2, T6S15	For 6061 extrusions requiring good formability; meets standard 6061-T6 minimum properties (See Note B.)
T51S10	For 6061 extrusions requiring improved forming characteristics not obtainable with -T6S2 and -T6S15 tempers. Lower minimum properties of 35.0 ksi tensile and 30.0 ksi yield guaranteed to enhance formability. Meets standard 6061-T51 mechanical properties (See Note B.)
T6H, T6511H	Hydro's "H" temper is offered for special applications requiring improved machinability and higher minimum mechanical properties than standard -T6 or -T6511. Minimum properties of 42 ksi tensile, 38 ksi yield, and 10% elongation are guaranteed. "H" temper is available for rod, bar, and certain profiles with a principle thickness of .500" or greater. (See Notes B & C.)
T6G, T6511G	Hydro's "G" temper is available for applications requiring a uniform grain structure to enhance anodized appearance for rod and bar sizes with a thickness of 2.00" or greater. A minimal peripheral grain band may still be present, but is greatly reduced compared to standard -T6, -T6511. Minimum mechanical properties are same as "H" tempers. (See Notes B & C.)
T6X, T6511X	Hydro's "X" temper is available for special applications requiring a uniform recrystallized grain structure in extrusions less than 2.75" thickness to enhance anodizing appearance. Other benefits may include improved machinability and the same minimum mechanical properties as standard 6061-T6, -T6511. (See Notes B & C.)

\* For further details of definitions, see Aluminum Association's Aluminum Standards and Data manual and Tempers for Aluminum and Aluminum Alloy Products.

\*\* Hydro Special Temper Designations are unregistered tempers for reference only, not recognized by the Aluminum Association, and are provided for customer use to identify unique processing, material or end use application characteristics.

Note A: Applies to products that are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical properties.

Note B: Applies to products that are not cold worked after solution heat-treatment, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical properties.

Note C: Tempers -T4511 and -T6511 apply to products that are stress-relieved by stretching.

Note D: The specified special temper will not conform to Military, Federal, ASTM, ASME and AMS specifications.



# Alloy 6061

## Chemical Composition

Melting Temperature Range: 1080-1206 °F

Density: 0.098 lb./in.<sup>3</sup>

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others	
									Each	Total
6061	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	0.25	0.15	0.05	0.15

Chemical composition in weight percent maximum unless shown as a range or minimum.

Aluminum = Remainder

Average Coefficient of Thermal Expansion (68° to 212°F) =  $13.1 \times 10^{-6}$  (in./in.°F)

## 6061 Extruded Mechanical and Physical Property Limits<sup>1</sup>

Standard Tempers	Wall Thickness <sup>2</sup> (min.)		Tensile Strength ksi (MPa)		Elongation <sup>3</sup> % (min.)	Typical Thermal Conductivity, @77°F, BTU-in./ft. <sup>2</sup> hr.°F (W/m-K@25°C)	Typical Electrical Conductivity, @68°F, % IACS
	inches	mm	Ultimate (min.)	Yield - 0.2% offset (min.)			
O	All	All	22.0 (150) max.	16.0 (110) max.	16	1250 (180)	47
T1	up thru 0.625	up thru 16.00	26.0 (180)	14.0 (95)	16	—	40
T4, T4511	All	All	26.0 (180)	16.0 (110)	16	1070 (155)	42
T51	up thru 0.625	up thru 16.00	35.0 (240)	30.0 (205)	8	—	42
T6, T6511	up thru 0.249	up thru 6.30	38.0 (260)	35.0 (240)	8	1160 (167)	43
	0.250 & above	>6.30	38.0 (260)	35.0 (240)	10	1160 (167)	43
Hydro Special Tempers*							
T6S2, T6S15	up thru 0.249	up thru 6.30	38.0 (260)	35.0 (240)	8	—	—
	0.250 & above	>6.30	38.0 (260)	35.0 (240)	10	—	—
T51S10	up to 0.169	up thru 4.30	35.0 (240)	30.0 (205)	8	—	—
	0.170 & above	>4.30	35.0 (240)	30.0 (205)	12	—	—
T6H, T6511H	1.000 & above	25.0 & above	42.0 (290)	38.0 (260)	10	—	—
T6G, T6511G	3.000 & above	76.2 & above	42.0 (290)	38.0 (260)	10	—	—
T6X, T6511X	.250 thru 2.750	6.30 - 69.85	38.0 (260)	35.0 (240)	10	—	—

1. Minimum property levels unless shown as a range or indicated as a maximum (max.)

2. The thickness of the cross section from which the tension test specimen is taken determines the applicable mechanical properties.

3. For materials of such dimensions that a standard test specimen cannot be taken, or for shapes thinner than .062", the test for elongation is not required. Elongation percent is minimum in 2" or 4 times specimen diameter.

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## Comparative Characteristics of Related Alloys/Tempers<sup>1</sup>

Alloy	Temper	Formability				Machinability				General Corrosion Resistance				Weldability				Brazeability				Anodizing Response			
		D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A
6061	-O																								
	-T1, -T4, -T4S6, -T4511																								
	-T6, -T6511 -T6X, -T6511X																								
6061	-T6H, -T6G, -T6511H, -T6511G																								
	-T6S2, -T6S15																								
	-T51S10																								
6042	-T5, -T5511																								
6063	T6, -T6511																								
	-T5, -T52																								
6262	-T6, T6511																								

1. Rating: A = Excellent B = Good C = Fair D = Poor

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