



ALCOA

ALLOY 6013 SHEET

Maximum Strength 6XXX Series Sheet

SUPPLYING THE WORLD'S BEST

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ALCOA TECHNICAL FACT SHEET

INTRODUCTION

Alcoa alloy 6013 is a weldable high strength 6XXX series alloy that exhibits 7XXX strength levels in the T6 temper. Compared to 6061-T6, alloy 6013 provides higher strength (25%) and improved toughness and fatigue properties with equivalent corrosion resistance.

Alloy 6013's attractive combination of mechanical properties, corrosion resistance, weldability and formability makes it ideal for structural and automotive body sheet applications. In particular it has been identified for welded, stamped or roll formed bumper reinforcement assembly applications and stamped sheet wheels. Like 7021 and 7029/7129, 6013 will respond to artificial aging treatments to achieve T6 strength levels. At this strength level, alloy 6013 may be used in many sheet applications in the same thickness as the steel previously employed allowing maximum weight savings without sacrificing strength.

CHEMICAL COMPOSITION LIMITS (WT. %)

| Alloy | Si | Fe | Cu | Mn | Mg | Cr | Zn | Ti | V | Zr | Ga | Others Each | Others Total | Aluminum |
|-------|----------|------|-----------|---------|---------|-----------|---------|------|------|-----------|------|-------------|--------------|-----------|
| 6013 | 0.60-1.0 | 0.5 | 0.6-1.1 | 0.2-0.8 | 0.8-1.2 | 0.1 | 0.25 | 0.1 | — | — | — | 0.05 | 0.15 | Remainder |
| 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 | Remainder |
| 7021 | 0.25 | 0.4 | 0.25 | 0.1 | 1.2-1.8 | 0.05 | 5.0-6.0 | 0.1 | — | 0.08-0.18 | — | 0.05 | 0.15 | Remainder |
| 7029 | 0.1 | 0.12 | 0.5-0.9 | 0.03 | 1.3-2.0 | — | 4.2-5.2 | 0.05 | 0.05 | — | — | 0.03 | 0.10 | Remainder |
| 7129 | 0.15 | 0.3 | 0.5-0.9 | 0.1 | 1.3-2.0 | 0.1 | 4.2-5.2 | 0.05 | 0.05 | — | 0.03 | 0.05 | 0.15 | Remainder |

MECHANICAL PROPERTIES

| Alloy and Temper | | Ultimate Tensile Strength | | Yield Strength | | Elongation % in 2 inches |
|------------------|---------|---------------------------|-----|----------------|-----|--------------------------|
| | | MPa | KSI | MPa | KSI | |
| 6013-T4 | Minimum | 275 | 40 | 145 | 21 | 20 |
| | Typical | 325 | 47 | 185 | 27 | 24 |
| 7021-0 | Minimum | 165 | 25 | 125 | 18 | 12 |
| | Typical | 195 | 28 | 145 | 22 | 17 |
| 6061-T6 | Minimum | 295 | 42 | 245 | 35 | 10 |
| | Typical | 315 | 45 | 280 | 40 | 12 |
| 6013-T6 | Minimum | 360 | 52 | 320 | 46 | 8 |
| | Typical | 405 | 59 | 370 | 54 | 9 |
| 7021-T61, -T62 | Minimum | 380 | 55 | 345 | 50 | 8 |
| | Typical | 430 | 62 | 365 | 53 | 13 |
| 7029/7129/T61 | Minimum | 380 | 55 | 340 | 49 | 10 |
| | Typical | 420 | 61 | 380 | 55 | 15 |

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FORMING

Field forming trials of 6013-T4 have demonstrated forming performance equivalent to 7021-O. 6013 can be formed in the W temper condition, if formed within four hours after solution heat treatment. Limited bumper face bar trials have shown that the overall forming characteristics of 6013 are better in the W versus T4 temper condition.

Alloy 6013 is ideally suited for rolled formed applications because of its excellent bending performance in the full hard T6 temper condition. This feature is unique to 6013 alloy compared to alloy 6061 and other high strength 7XXX bumper structural alloys like 7021 and 7029/7129.

6013-T4 exhibits better bend capability and lower springback characteristics than high strength steel (120 ksi and higher). Successful roll formed bumper trials conducted with alloy 6013-T4 on tooling designed for high strength steels (120 ksi or higher) have demonstrated its capability to attain high sweep numbers (50 - 60).

TYPICAL BEND PERFORMANCE DATA

| Alloy/Temper | Min. 90° | |
|--------------------|-------------|------------|
| | Bend Radius | Springback |
| | (R/t) | (Deg) |
| 6013-T4 | 1.00 | 5° |
| 6013-T6 | 1.50 | 7° |
| 7021-O | 2.00 | 4° |
| 7029/7129-W | 1.00 | 1.5° |

FORMING: RELATIVE RANKING OF ALLOY (A)

| Alloy and Temper | Overall Ranking | Stretchability (B) | Limiting Strain (C) | Bending (D) |
|------------------|-----------------|--------------------|---------------------|-------------|
| 6013-T4 | 3 | 3 | 2 | 2 |
| 6013-T6 | 5 | 5 | 5 | 5 |
| 7021-O | 3 | 3 | 3 | 3 |
| 7029-W | 1 | 1 | 1 | 1 |
| 7129-W | 2 | 1 | 1 | 2 |

A comparison of the relative ranking of current bumper/reinforcement alloys.

- A. This ranking is for this group of alloys. One is best.
- B. Stretchability is measured by limiting dome height 102 mm (four-inch) hemispherical punch test.
- C. Limiting strain data determined by 102 mm (four-inch) hemispherical punch test.
- D. Minimum bend radii for -W temper alloys is limited by the severity of orange peel and not fracturing. The -W temper can be bent to 1/2t radius without fracture. This is not true for -O and -T4. Identical ranking indicates comparable performance in this test.

JOINING

6013 sheet is weldable using gas metal arc, gas tungsten arc, resistance spot, and seam welding processes. It is not susceptible to hot cracking during welding as are some of the 7XXX series alloys. However, since 6013 contains approximately 1% copper, it should not be welded with 5XXX series filler materials as is common practice with other 6XXX series alloys, due to the likelihood of weld cracking. Filler materials in 4XXX series, such as 4043, 4047, or 4643 are recommended for this reason.

Typical as-welded yield and ultimate tensile strengths of 6013-T6 welded with 4043 filler are 34ksi and 40ksi, respectively, which represents an improvement over 6061-T6 of approximately 17%. If higher strengths are required it is recommended that components be welded in the T4 or T6 temper and post weld aged at 400° F for one hour. Typical yield and ultimate tensile strengths for weldments given this treatment are 41ksi and 42ksi, respectively. Where the highest joint strengths are required 6013 should be welded in the -O, -T4, or -T6 tempers, and re-solution heat treated, quenched and aged after welding. Yield strengths of 47ksi and ultimate tensile strengths of 55ksi may be obtained using this post weld heat treatment. While distortion of the component is a possibility during the quenching operation, it can often be controlled to within acceptable limits by additions of glycol to the quench medium.

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ARTIFICIAL AGING PRACTICES

1 hour @ 400° F or 4 hours @ 375° F. Both practices denote metal temperatures.

CORROSION

Alloy 6013-T6 is resistant to exfoliation corrosion by all current tests and is virtually immune to stress corrosion cracking (SCC).

When exposed to severe environments such as a seacoast environment, 6013-T6 products may exhibit some intergranular (IG) corrosion. This shallow IG attack is similar to that which occasionally appears in other 6XXX-T6 series alloys in similar environments. The type of IG attack which occurs in 6013 is not expected to have a detrimental effect on the strength of products any greater than that resulting from pitting corrosion and does not lead to exfoliation and SCC.

Like all aluminum alloys in a corrosive environment, alloy 6013, when coupled with dissimilar metals such as steel, is subject to galvanic corrosion. Proper protection must be taken to ensure that damaging corrosion does not occur. Protection can be accomplished by treatment of the steel. Additional protection can be obtained through the use of adhesives and sealants. Thorough testing of the finished assembly is necessary to determine if the protection used is adequate. (Ref: SAE Paper 760166, "Corrosion Performance of Painted Aluminum and Steel Body Sheet," by King and Englehart.)

FINISHING

The 6XXX series alloys are among the best with regard to finishing characteristics. Mechanical finishes such as scratch-brushing, buffing, grinding, polishing, and others are readily applicable to these alloys and provide highly satisfactory results.

CONCLUSIONS

Alloy 6013 is a new weldable aluminum alloy specifically developed for high strength applications. The alloy is generally used for, but not limited to, welded, stamped or roll formed bumpers and other structural applications. Its strength is similar to the bumper alloys 7021 and 7029/7129 but does not exhibit embrittlement due to welding as the 7XXX series alloys. 6013 in the T6 temper has a yield strength comparable to many HSLA steels and with proper design a 60% weight savings can be achieved. Finishing systems and repair are similar to steel in all aspects including time.

The properties described in this technical fact sheet represent the best current information on alloy 6013. Periodic updates will be provided when additional data becomes available. The end user is expected to evaluate and test the alloy, temper, and finishing method for each specific application. Alcoa's warranty is limited to that published on the reverse side of its sales order acknowledgment form.