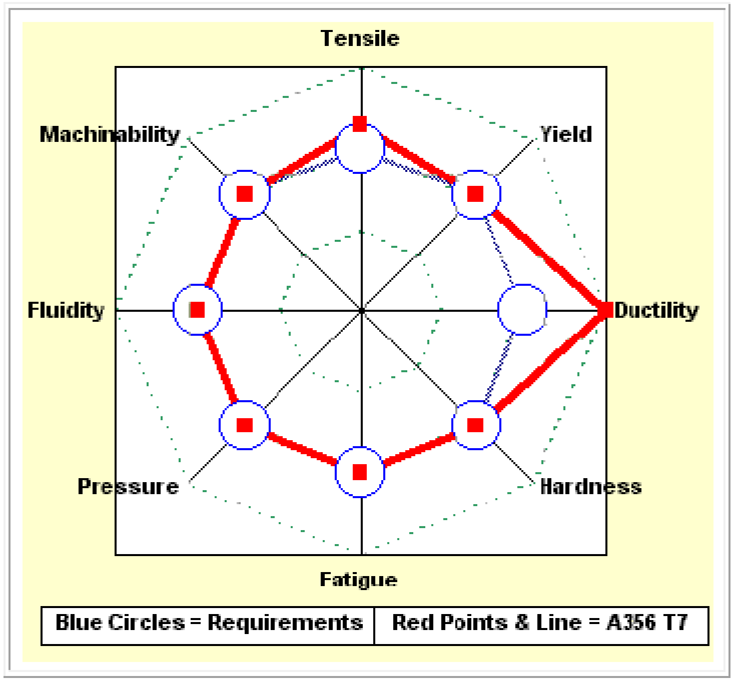
Aluminum Alloy A356 T6



- Alloy A356 is a 7Si-0.3 Mg alloy with 0.2 Fe (max) and 0.10 Zn (max). The T6 heat treatment is a solution-anneal heat treat followed by a 320F aging.
- Alloy A356 has greater elongation, higher strength and considerably higher ductility than Alloy 356.
    - A356 has improved mechanical properties because of lower iron content, compared to 356.
- Typical applications are airframe castings, machine parts, truck chassis parts, aircraft and missile components, and structural parts requiring high strength

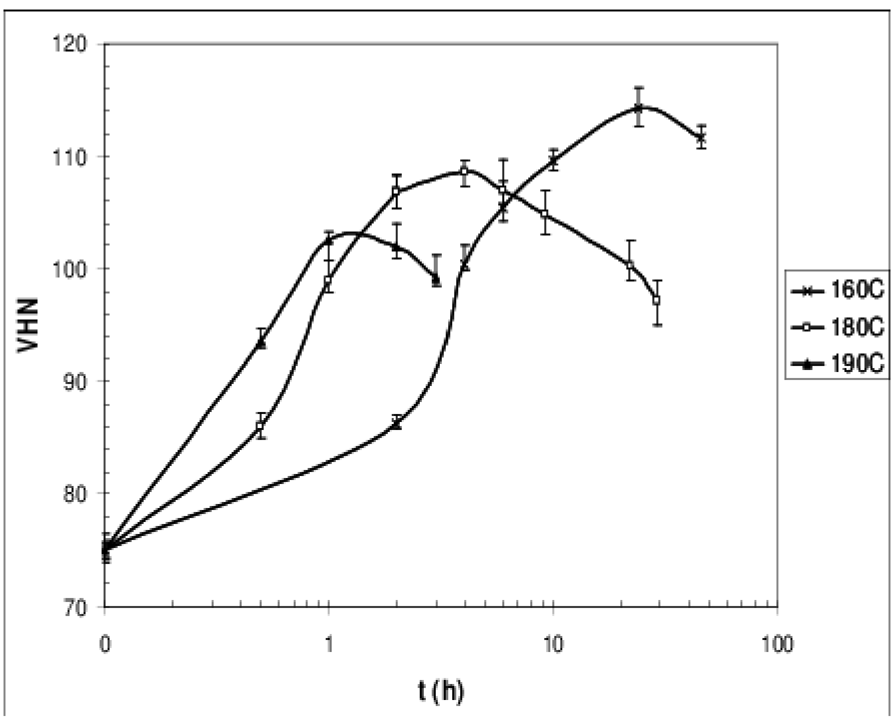
A356-T6 is the alloy used by over 95% of contemporary Aluminum wheels. It is used because it is a good balance of many expectations mandated by the material. Starting at the top and going clockwise:

1. Tensile strength is the measurable used to describe when the material will rupture under excessive load, such as a tire blow out.
2. Yield strength is the measurable at which the material begins to take a new permanent shape, such as when a wheel and tire hits an abrupt pot hole with underinflation.
3. Ductility is the measure of the material's ability to stretch prior to rupturing. The opposite of ductile is brittle.
4. Hardness is a measure of the material's ability to maintain its original shape under significant loads. A repeatable hardness check is a quality assurance check for the metal and aging process.
5. Fatigue strength is a measure of how many cycles a material will sustain prior to a crack initiating and subsequently growing.
6. Pressure in this usage is the measure of pressure necessary to get the molten material to fill the mold. The less the pressure the easier to cast.
7. Fluidity is the measure of the material to flow like water instead of oil or ketchup. The more fluid the material in the molten state, the easier to cast.

8. Machineability is the ability to remove excess material from the casting to get the wheel to its final form of a wheel. A 20lb wheel can start with a 40lb casting, so the machineability is necessary to remove material quickly and precisely.

To optimize the properties outlined in items 1 thru 4 per the above, a heat treat sequence must be followed with some variation allowed. The ingot material is melted and at about 1050 degrees F, fluidity is fine for casting. The material is pumped into the mold and let to solidify. The mold opens up and the casting is removed and is either air or watered cooled for handling. The casting is staged in a furnace and heated to 1000 degrees F for 2 hours to bring the alloying elements, namely silicon and magnesium into solid solution. The castings are quenched in hot water to keep the alloying elements suspended. The castings are then at least artificially aged to refine the grain structure that increases items 1 thru 4 and makes the material machinable. The casting is machined, typically in a couple of lathe operations and a subsequent milling operation. Wheels are fully painted and then a paint cure operation adds to the artificial aging process. If the wheel paint bubbles or incurs slight handling damage, the wheel can be repaired, painted and cured again changing the metallurgy. Two repair process are typically accepted prior to the wheel being melted and the process starting over.

Adding artificial aging of this alloy can be beneficial or detrimental depending on the level of aging at which one starts and the temperature of the material. Referring to the chart, one can see the different conditions.



A356-T6 material is solution heat treated at 1000 degrees F for 6 hours then quenched and subsequently artificially aged at three different reference temperatures. The goal is to get near the maximum Vickers Hardness (VHN) without going over the top. The following explain the sensitivity of the hardening process relative to time at temperature.

1. At 320 degrees F, it can take five hours initiate the hardening and about 50 hours to get to the maximum hardness.
2. At 350 degrees F, the hardening process starts in one hour and is maximum in about 5 hours.
3. At 375 degrees F, the hardening process starts and is at maximum within an hour.
4. These hardness curves are known shorten in time and the temperature is increased.

One of the substantive concerns of the NewArc™ wheel straightening process is to minimize the time at elevated temperature to minimize the artificial hardening process. Experience has demonstrated that when the material is at 400 degrees F, it will yield locally while under high load. The procedure allows heating to 400 degrees F for two minutes, prior to cooling. 400 degrees F for 2 minutes is predicated on the fact that, at 375 degrees F, it takes two hours to overage (soften the material). No literature has been found that depicts the hardness relationship at 400 degrees F. To error on the conservative side, temperature is restricted to 400 degrees F and the time at 400 degrees F to two minutes.

Aside from the artificial aging process the A356-T6 material has been found to be near optimal for making Aluminum wheels. Whereas the vast majority of contemporary wheels are made of A356-T6. Most of the remainder of wheels are made of 6061-T6, which has a similar age hardening relationship so the same 400 degrees F for two minutes can be used. The remaining material not very popular is ALSi11 which is a not heat treat alloy that does not mandate heat to straighten as it is more malleable to begin with.