RUSAL

MAXIFLOW

6061 MAXIFLOW BILLET
PRODUCT DATA SHEET

Ultimate productivity exceeding 6061 T6 strength

Product description

Maxiflow alloys are a new range of High Speed 6000 series extrusion alloys developed by Rusal. Maxiflow alloys offer an optimum combination of extrusion speed and peak aged mechanical properties. 6061 Maxiflow alloys are heat treatable Al-Mg-Si alloys that are designed for maximum extrusion speed while still meeting the highest strength requirements such as ASTM B221 and EN 755-2 6061-T6. 6061 Maxiflow alloys have good surface finish by most surface finishing treatments, including anodizing. These characteristics are appropriate for structural end uses as well a variety of other end uses requiring higher strength levels than 6063 and 6005A alloys.

Types of 6061 Maxiflow billets

Type	Feature of each category
Type1	Type 1 was developed for structural end uses as well as numerous other products including semi complicated shapes. The alloy was developed for higher speed extrusion including solid and hollow shapes which require T6 mechanical properties and good surface finish at "as extruded" as well as "after anodizing treatment". Target Silicon content of this alloy is 0.55wt%.
Type2	Type 2 was developed for applications which require higher strength or more tolerance to process variation than Type 1. Tensile strength of this alloy can reach up to 350 MPa with good surface finish before and after anodizing. Maximum extrusion speed will however be less than Type 1. Target Silicon content of this alloy is 0.77wt%.

Recommended condition at extrusion operation

In order to produce desirable extruded products the following conditions are recommended to be carefully controlled & monitored during the extrusion operation.

Billet condition, prior to processing
Billet surface should be clean without any foreign materials, eg. sand, mud and any other substances, for minimizing the cause of surface defects on the extruded shape and for avoiding damage to the die bearing which will make the die life shorter.

Starting procedure with new die
It is recommended to heat dies to a uniform temperature in the whole die (ideally within +/-5°C). In case of lesser uniformity, extrude the first 1-2 billets with 20ºC higher preheat temperature. Then start the extrusion operation with regular preheat temperature and extrusion speed.

Preheating with Induction heater and Gas type heater

a) Induction heater
Prior to extrusion, billet should be preheated to approx. 450-480ºC for solid shapes and 460-490ºC for hollow shapes with the taper heat of 0.5ºC/cm (Front temperature should be higher than Back-end). This will allow the extrusion speed to be maximized while still maintaining a stable profile exit temperature. For heavy profiles (>12.5mm thick) with slow extrusion speeds higher preheats of 500-525ºC may be required to meet minimum exit temperature requirements.

b) Gas type heater
Under longer preheating at 400ºC or higher, a lot of β-Mg_2Si will be precipitated and have a negative influence on the mechanical properties and anodizing response. Therefore, preheating times longer than 20 mins in gas type preheater should be avoided with the best efforts.

Container temperature
The container temperature should be maintained 20-40ºC lower than the billet temperature after preheating since:

a) In case of 0-20ºC lower:
Container wall is not cool enough and billet skin would not be kept in the dead zone/into the butt discard and will tend to flow into the extruded product through the back-end as "Back-end defects".

b) In case of more than 40ºC lower:
Excessive heat loss can occur through the container wall. The press exit temperature of the profile would not increase as expected and there would be a higher risk of the press exit temperature not reaching 510ºC resulting in poor mechanical properties and slower extrusion speed.

Extrusion speed
As maximum extrusion speed is strongly influenced by the die shape and chemical composition it should be judged/controlled by the surface appearance of the extruded shape and the press exit temperature which should be maintained in the appropriate range, see below.

Press exit temperature
Press exit temperature of the profile should be measured/monitored with a thermocouple or a contactless pyrometer for ensuring mechanical properties. Press exit temperature should be kept in the range of 510ºC (min) – 540ºC (preferable), 550ºC (max) with an adequate cooling speed after press exit for achieving good mechanical properties by

aging operation. 510ºC is an acceptable minimum to ensure that all of the Mg_2Si is fully dissolved which will ensure optimum mechanical properties and uniform anodizing response assuming cooling rate after press exit is sufficient. Temperatures lower than 540°C are best for ensuring the optimum surface finish. Above 550ºC the surface will start to deteriorate and speed cracks may start to appear on sharp edges.

Quenching/Cooling after Press exit

Adequate cooling speed after press exit is essential to produce good extruded products in terms of mechanical properties, anodizing response, bending characteristics and machinability.

Minimum cooling speed of 11 ºC/sec between 500ºC and 200ºC is required to quench 6061 in order to achieve T6 properties. For sections thicker than 2 mm a water-box quench system after press-exit is necessary. However for thinner sections water mist-spray is usually sufficient for achieving this cooling speed.

Note if the distance between the press exit and the quenching tunnel is long or the extrusion speed is very slow (ie. heavy profiles) then the profile entry temperature to the quench tunnel may be < 510ºC. This could mean optimal properties are not achieved. Similarly press stoppages that occur between billet pushes can mean that the required quench rate is not achieved at the ends of the extruded profiles. Such material may need to be discarded.

Straightening

Approximately 0.5% of stretching is recommended for straightening, while over 1% of stretching might result in orange peel surface finish on the product.

Aging treatment

In order to achieve maximum mechanical properties and good anodizing response, a very fine dispersion of β" MgSi should be precipitated after the aging treatment. To achieve this the following process is recommended:

a) Natural aging (keeping as-extruded product at room temperature)

Due to the higher content of Mg and Si in 6061 alloys natural aging before artificial aging will have a negative effect on the mechanical properties. Therefore it is recommended for extruded profiles to be aged as soon as possible.

b) Artificial aging (aging Extruded profile around 170 - 200ºC for 2 - 8hrs)

In order to precipitate fine and uniform β" MgSi the as-extruded shape is artificially aged in the aging furnace. Generally lower temperatures and longer aging times achieve finer/more uniform β"- MgSi precipitation, resulting in higher mechanical properties and higher elongation values. Higher temperatures and shorter aging times have the opposite effect, as shown in the aging curves attached in the reference. In addition slower heat up time (in excess of 1 hour) will promote higher peak aged strengths.

Typical Mechanical properties for Type 1 and 2

Following table shows typical mechanical properties with Type 1 and 2 billets in peak aged condition.

Type	Tensile strength	Yield strength	Elongation	Hardness (Webster"B")
Type1	310 MPa	280 MPa	10 %	15-16 HW
Type2	340 MPa	310 MPa	10 %	15-16 HW

NOTE: (1) Hardness conversion table
Although hardness chart is made by Webster "B", hardness by other scale are shown in the table, attached in the reference.

Recommended procedure and check-points for Anodizing, Bending, Welding and Extruding Hollow Shapes

Following are some brief recommendations for Anodizing, Bending, Welding and Extruding Hollow Profile operations.

Anodizing

Anodizing treatment should be made as soon as possible after the aging treatment, preferably within 12 hrs. Prior to the anodizing treatment, the shapes should be kept clean, at ambient temperature and in a low humidity area as much as possible. In particular Acidic/ Alkaline environments should be carefully avoided.

Bending

In order to obtain good bending characteristics, the following steps are recommended.

a) The recommended timing is to bend the extruded shape within 8 hrs after extrusion, before aging.

b) If the bending has to process over 8 hrs after extrusion, the stabilization with the condition of 165ºC x 2 hrs is recommended. By this procedure, the characteristics of predicable spring back would be obtained at any time.

c) After bending, the shapes can be aged to obtain the maximum mechanical properties by normal artificial aging.

Welding

6061 extruded shapes can be joined by both Arc welding procedures, eg GMAW and GTAW, Brazing, Gas welding, Resistant spot and Seam welding.

Regarding Filler alloy, 4000 series of filler alloy is recommended for 6061 alloy.
When detailed information is needed, “The Al association welding book” is recommended.

Extrusion of Hollow shape

As defects in the weld line tend to occur relatively easily, Extruders should pay special attention to the following 2 points when they produce hollow shapes with a port hole die.

a) The welding chamber must be kept clean without any foreign material for avoiding any contamination at the welding interfaces.

b) Die design and extrusion condition must be monitored to maintain the best possible welding interface quality. For ensuring this the weld interface should be carefully inspected in the lab to confirm it is sound and fully bonded by a metallurgical bond.

REFERENCE:

1. Trend of Aging curves for Type 1 and 2
Typical aging curve for Type 1 and 2 are shown in the reference. The condition of aging treatment should be modified by the aging chart, according to mechanical properties required by the end customers.

2. Hardness conversion chart
Hardness conversion chart of Webster “B”, Rockwell “E”, Rockwell “F”, Vickers Hv is shown in the Table, attached.

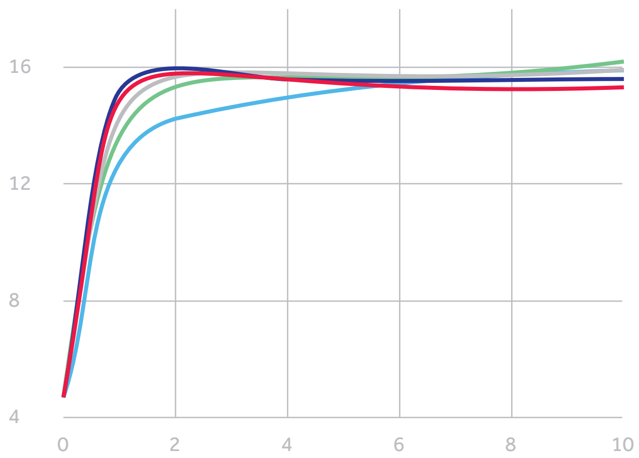
REFERENCE 1:

Mechanical Properties VS Aging condition for 6061 MF T1*

* Curves presented should be considered representative. Tensile properties were measured on 30 mm gauge length tensile specimens after separate solution heat treatment and aging. Customers should confirm actual aging response in their own process.

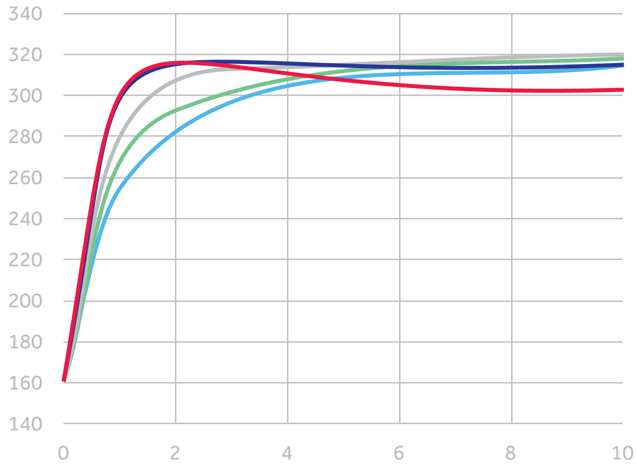
HARDNESS — WEBSTER

Hardness, HW; Holding time, hr



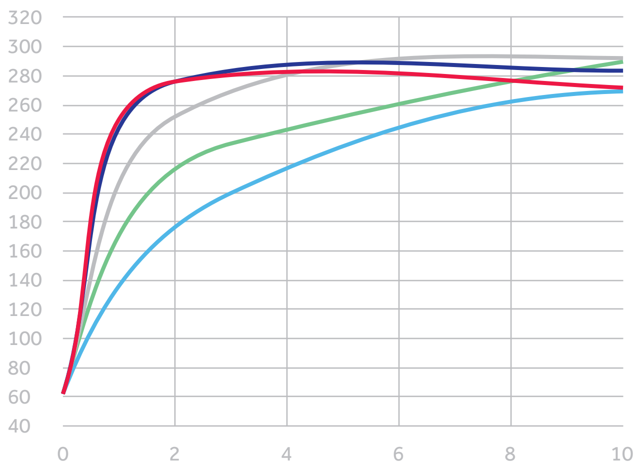
TENSILE STRENGTH

UTS, MPa; Holding time, hr



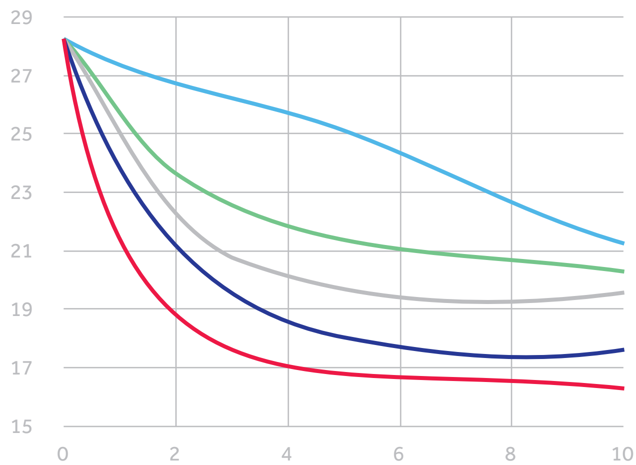
YIELD STRENGTH

YS, MPa; Holding time, hr



ELONGATION

EL, %; Holding time, hr



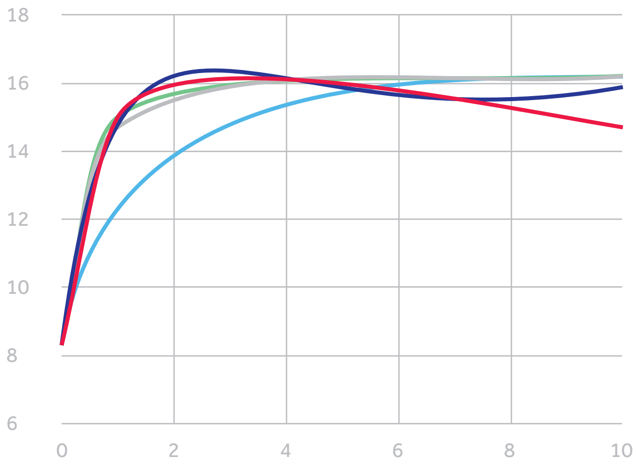
REFERENCE 1:

Mechanical Properties VS Aging condition for 6061 MF T2*

* Curves presented should be considered representative. Tensile properties were measured on 30 mm gauge length tensile specimens after separate solution heat treatment and aging. Customers should confirm actual aging response in their own process.

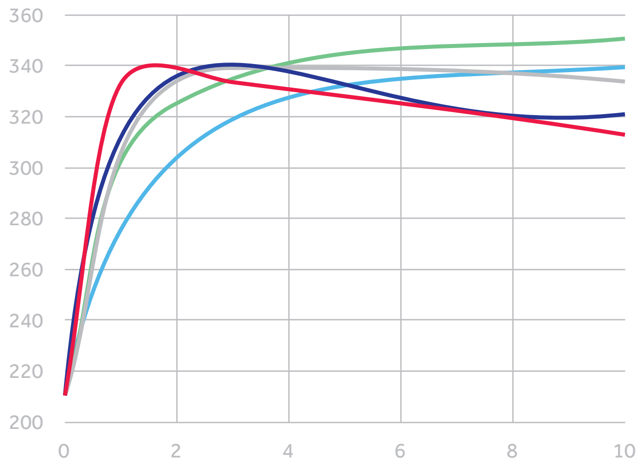
HARDNESS — WEBSTER

Hardness, HW; Holding time, hr



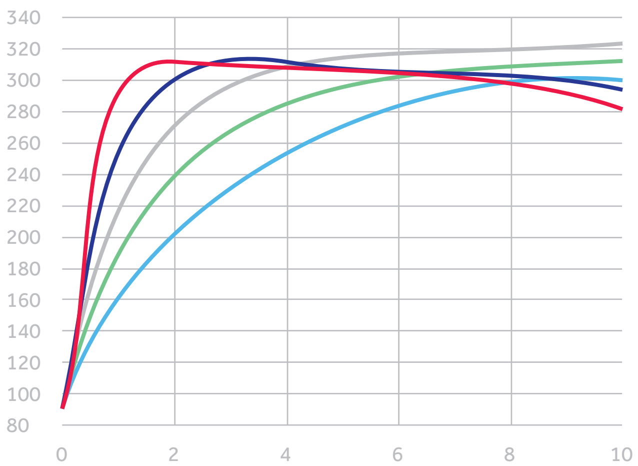
TENSILE STRENGTH

UTS, MPa; Holding time, hr



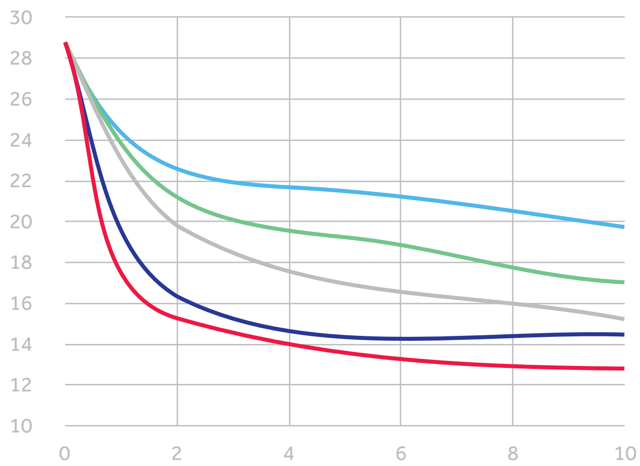
YIELD STRENGTH

YS, MPa; Holding time, hr



ELONGATION

EL, %; Holding time, hr



160 170 180 190 200

REFERENCE 2:

Hardness Conversion Table

WEBSTER HW	ROCKWELL E HRE	ROCKWELL F HRF	VICKERS HV	BRINELL HB
18	101	98.5	131	114
17	97	95	119	106
16	92.5	87.2	108	94
15	88	83	99	82
14	84	78	91	74
13	79.5	74	83	65
12	75	70	78	60
11	71	66	73	55
10	67	62.5	69	53
9	62.5	58	65	
8	58	54	61	
7	54	50	58	
6	49.5	46.5		
5	45			
4	41			

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