



EURAL
GNUTTI S.p.A.

Aluminum Bars

Dear Customer,

Since 1968 EURAL Gnutti S.p.A. has manufactured semi finished products in aluminum and occupied a position of worldwide leadership in bars and rods. The production facilities include the foundry located in Pontevico, Brescia (Italy) and the extrusion plant in Rovato, Brescia (Italy). With a workforce of over 400 employees and built on an area covering 4,305,000 sq.ft., Eural possesses the latest state-of-the-art casting and extrusion equipment.

The passion for aluminum has pushed the Gnutti family to always achieve excellence for its products, to constantly invest in research and development and in the latest technologies so our customers receive the maximum for their applications.

The choice of the most suitable alloy is a crucial step that determines the success of a product. For this reason, EURAL has released this catalogue that gives for each alloy a detailed technical data sheet with all the parameters needed.

International standards leave the manufacturers too wide a margin of variability for creating each alloy. In practice this means that, for each alloy, it is possible to face significant differences in mechanical properties, with not always acceptable results on your final products. EURAL has generated a code that is more stringent than the international regulations and restricts further the oscillations within the same alloy, constantly guaranteeing homogeneous products to always achieve the best mechanical properties.

Eural Gnutti S.p.A. is since 2008 IATF 16949 (Automotive) and, since 2016, AS/EN/JISQ 9100 (Aerospace) certified that guarantees extremely high-quality systems. A modern and automatic system for ultrasonic tests certifies the absolute integrity of each and every billet produced in the foundry, according to class "A" of SAE AMS-STD-2154 regulations. At EURAL each production process is subject to quality controls which go beyond standard requirements.

EURAL firmly believes that dialogue with the customers, through technical and commercial staff, is fundamental to support the choice of the most suitable aluminum alloy, by offering to all customers availability and experience made along over 50 years of business in machining.

Fifty years after its foundation, EURAL Gnutti S.p.A. is the largest producer in the World of cold-finished/drawn bars. EURAL bases its success on this specific product and on developing free-cutting aluminum alloys for machine-shops. EURAL offers services to all its customers that makes the difference on all the competitors:

- Trade missions in more than 50 countries
- Assistance on choosing the proper alloy for each machining need
- Technicians supporting end-user customers worldwide to find out the best machining parameters and reach the best ever performance using EURAL bars
- Technical advice on managing every single step of the process, from planning to production.

EURAL - RESEARCH & DEVELOPMENT

EURAL Gnutti S.p.A. dedicates a significant and ever increasing investment in the development of new solutions for the industry.

New alloys 2033, 2077 & 6026^{LF} LEAD FREE are the results of years of studies by the Research & Development department. International regulations ruling metal business (RoHS, ELV, and REACH) are moving to a drastic limitation of lead (Pb) content in aluminum alloys and in other metals for machining as it is considered highly dangerous to human health and toxic for the environment.

These new solutions, compliant to the most restrictive limitations, do not affect machinability of EURAL bars guaranteeing productivity and quality without compromises.



EURAL, aware of the importance of the World where we are living, proudly support the use of recycled aluminum to protect the environment, to reduce the energy consumption needed to produce semis from primary aluminum and, therefore, significantly reduce CO2 emissions thanks to the high level of recycled material in its LEAD FREE alloys.

2033^{by EURAL} LEAD FREE

According to:
EU directives RoHS II, ELV, REACH

Applications

2033 LEAD FREE by EURAL is an alloy with multiple potential applications; it gives excellent machinability thanks to very thin chip forming, high mechanical properties, better anodizing and weldability attitude if compared to alloys such as 2011, 2007, 2030.

2033 LEAD FREE by EURAL is strongly recommended as an alloy to replace 2011, 2007, 2030 in view of the incoming restrictions on lead content (RoHS, ELV, REACH).

High Machinability

2033 LEAD FREE by EURAL has been developed specifically for being machined on high-speed automatic lathes thanks to its excellent chip forming performance.



Production range

2033 LEAD FREE by EURAL is available both as drawn and extruded condition. Drawn round bars Ø .197" - 3.15" Tempers T3, T351 and T8. Extruded round bars Ø 1.181" - 10" Tempers T6

Available also in square, flat and hexagonal bars. A wide range of drawn bars is also available in h9 tolerance.



FREE-MACHINING Aluminum alloy

Green choice

For many years RoHS II regulations permit, with an exception, a maximum lead content in aluminum alloys up to 0.4% by weight. Such limit is under discussion for a further reduction.

REACH recently included lead in the SVHC list as highly toxic element for human health.

2033 LEAD FREE by EURAL is ready in anticipation of any possible future scenario being free of lead.



Alloy with high recycled aluminum content.

No tin

Today there are several 2000 series alloys containing tin (Sn) which is well known to cause weakness in machined parts when submitted to high stress or high temperatures ($\geq 320^{\circ}\text{F}$).

Tin, due to its brittle nature, has the dangerous tendency to suddenly break without significant previous deformation (strain).

2033 LEAD FREE by EURAL does not contain tin.



Alternative to:

2033 LEAD FREE by EURAL is the best alternative to several alloys such as 2007, 2030, 2011, 2028A, 2041, 2044, 7020.

2033 LEAD FREE by EURAL is the best replacement of brass, due to its excellent machinability and high mechanical properties. Moreover, due to future drastic reduction of lead (Pb) content in any metals for machining and, having a specific gravity of 1/3 compared to brass, it results extremely convenient costwise.

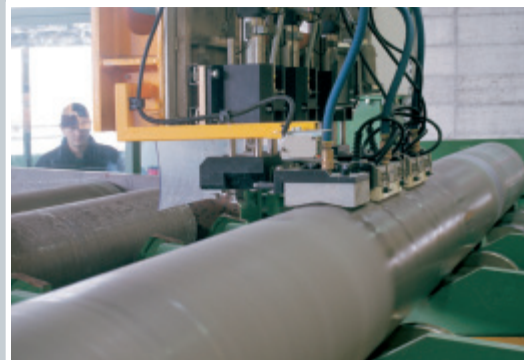
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GNUTTI S.p.A.

2033 LEAD FREE by EURAL is the result of long and accurate work by EURAL Research & Development Department in order to make available an aluminum alloy with high machinability and having better features than others available in the market today.

Ultrasonic tested billets

All semi-finished products in **2033 LEAD FREE by EURAL** are made by Class A ultrasonic tested billets (SAE AMS STD 2154).



RoHS & REACH and other metals

The imminent restrictions about maximum lead content allowed will affect all products obtained by mechanical processing, including steel and brass. These metal, without the lead which was a guarantee of good or acceptable machinability, will not be allowed anymore. For all these cases, the only option in terms of machinability is aluminum and the best choice available today is **2033 LEAD FREE by EURAL**.

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PRODUCTION PROGRAM

Unit: in.	●	■	■	■
Drawn	0.197 - 3.15	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	1.181 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)
Ready to imminent restrictions on lead content
because LEAD FREE

PRESENTATION

This alloy has been developed by EURAL and it is one of the best for high speed automatic lathes. It gives the following advantages:

- Easy machining
- Outstanding chip forming performance (thin chip)
- Longer tool life
- High mechanical properties
- Better anodizing and weldability attitude compared to alloys 2011, 2007, 2030.

This alloy does not contain neither lead (Pb) nor tin (Sn) and therefore it is the best option for the production of parts complying current, incoming possible and confirmed restrictions of lead (RoHS, ELV, REACH).

Main applications: automotive industry, electric and electronic industry, precision machining, forging, screws, bolts, nuts, threaded parts of thin thickness.

Properties	T3/T6	T8
Machinability	■	■
Protective anodizing	■	■
Decorative anodizing	■	■
Hard anodizing	■	■
Resistance to atmospheric corrosion	■	■
Resistance to marine corrosion	■	■
MIG-TIG weldability	■	■
Resistance weldability	■	■
Brazing weldability	■	■
Plastic formability when cold	■	■
Plastic formability when hot	■	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	0.10 - 1.20
Fe	≤ 0.70
Cu	2.20 - 2.70
Mn	0.40 - 1.00
Mg	0.20 - 0.60
Cr	≤ 0.15
Ni	≤ 0.15
Zn	≤ 0.50
Ti	≤ 0.10
Bi	0.05 - 0.80

Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties			
Density	lb	0.1001	
	in ³		
Modulus of elasticity	ksi	10,152	
Coefficient of thermal expansion	x10 ⁻⁶	12.7	
	°F		
Thermal conductivity at 68°F	Btu	T3: 86.7	
	ft h °F	T8: 99.4	
Typical electrical resistivity at 68°F	Ω mm ²	T3: 0.046	
	m	T8: 0.046	

Minimum mechanical properties						
	Temper	Diam. in	UTS		YTS	
			ksi	ksi	A%	Typical
Drawn	T3	≤ 1.2	53.7	34.8	7	95
	T3	1.2 < D ≤ 3.15	49.3	31.9	7	95
	T351	≤ 3.15	53.7	34.8	5	95
	T8	≤ 3.15	53.7	34.8	8	95
Extruded	T6	≤ 3.15	53.7	36.3	8	95
	T6	3.15 < D ≤ 10	49.3	31.9	8	95



Colour code
EU red

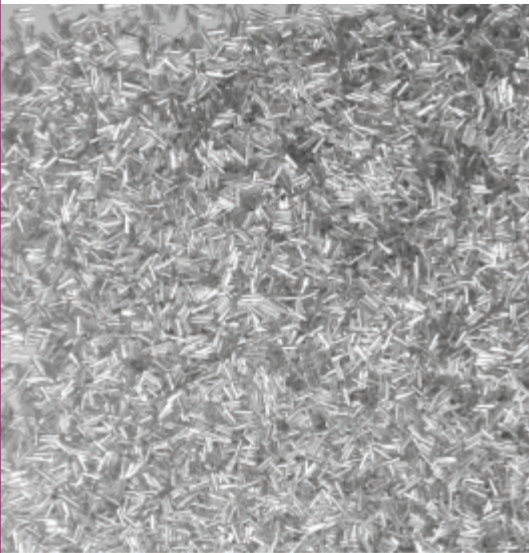


Colour code
USA brown

PRODUCTION PROGRAM

Unit: in.	●	■	■	◆
Drawn	0.197 - 3.15	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	1.181 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU (ELV) - 2011/65/EU (RoHS II)



PRESENTATION

This alloy is the most often selected for high speed automatic lathes.

It offers the following advantages:

- easy machining with any equipment;
- cutting stress lower than most of other alloys;
- longer life of cutting tools;
- cutting area always clean due to very thin chip;
- high mechanical properties;
- possibility to anodize finished parts in several colours *.

Due to imminent restrictions on lead content in metals for machining, 2011 alloy will no longer be suitable for the production of RoHS, REACH and ELV-compliant components.

EURAL recommends the free-cutting alloy 2033 LEAD FREE as the only option complying with current directives and ready for any possible future scenarios.

Main applications: screws, bolts, nuts, threaded parts.

* To get an optimal surface finishing of anodized pieces, we suggest use suitable lubricants during machining.

Properties	T3/T6	T8
Machinability	■	■
Protective anodizing	■	■
Decorative anodizing	■	■
Hard anodizing	■	■
Resistance to atmospheric corrosion	■	■
Resistance to marine corrosion	■	■
MIG-TIG weldability	■	■
Resistance weldability	■	■
Brazing weldability	■	■
Plastic formability when cold	■	■
Plastic formability when hot	■	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	≤ 0.40
Fe	≤ 0.70
Cu	5.00 - 6.00
Mn	
Mg	
Cr	
Ni	
Zn	≤ 0.30
Ti	
Pb	0.20 - 0.40
Bi	0.20 - 0.60
Others	Each 0.05 Total 0.15
Al	Remainder

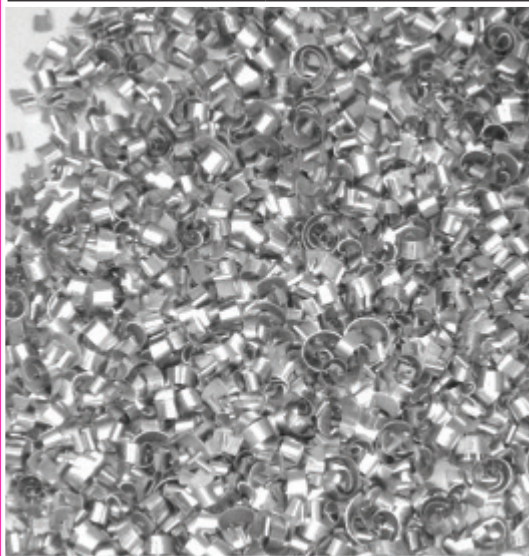
Physical properties		
Density	lb in ³	0.1022
Modulus of elasticity	ksi	10.152
Coefficient of thermal expansion	x10 ⁻⁶ °F	12.7
Thermal conductivity at 68°F	Btu ft h °F	T3: 86.7 T8: 98.8
Typical electrical resistivity at 68°F	Ω mm ² m	T3: 0.043 T8: 0.038

Minimum mechanical properties					
Temper	Diam. in	UTS ksi	YTS ksi	A% Typical	HBW
Drawn	T3	≤ 1.5	46.4	39.2	10 90
	T3	1.5 < D ≤ 2	43.5	36.3	10 90
	T3	2 < D ≤ 3.15	40.6	30.5	10 90
	T8	≤ 3.15	53.7	39.2	8 115
Extruded	T6	≤ 3	45.0	33.4	8 110
	T6	3 < D ≤ 8	42.8	28.3	6 110



PRODUCTION PROGRAM

Unit: in.	●	■	■	●
Drawn	0.551 - 3.15	0.787 - 2.559	Thick. 0.472 - 2.165	-
Extruded	1.181 - 10	1.181 - 6.5	Thick. 1.181 - 5	-



PRESENTATION

Alloy 2007 and 2030 have high mechanical properties and excellent machinability. However, both have a particularly high lead content, which makes them unsuitable for the production of components that comply with the European RoHS and ELV directives. For such applications, and due to the high toxicity of lead demonstrated by the ECHA (REACH regulation), EURAL suggests the use of 2033 LEAD FREE, which has the same mechanical characteristics and excellent machinability (very thin chip formation).

Main applications: screws, bolts, nuts, threaded parts.

Properties	T3/T4
Machinability	■
Protective anodizing	■
Decorative anodizing	■
Hard anodizing	■
Resistance to atmospheric corrosion	■
Resistance to marine corrosion	■
MIG-TIG weldability	■
Resistance weldability	■
Brazing weldability	■
Plastic formability when cold	■
Plastic formability when hot	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	≤ 0.80
Fe	≤ 0.80
Cu	3.30 - 4.60
Mn	0.50 - 1.00
Mg	0.40 - 1.80
Cr	≤ 0.10
Ni	≤ 0.20
Zn	≤ 0.80
Ti	≤ 0.20
Pb	0.80 - 1.00
Bi	≤ 0.20
Sn	≤ 0.20
Others	Each 0.10 Total 0.30
Al	Remainder

Physical properties		
Density	lb in ³	0.103
Modulus of elasticity	ksi	10.298
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.1
Thermal conductivity at 68°F	Btu ft h °F	80.4
Typical electrical resistivity at 68°F	Ω mm ² m	0.057

Minimum mechanical properties						
	Temper	Diam. in	UTS ksi	YTS ksi	HBW A%	Typical
Drawn	T3	≤ 1.2	53.7	34.8	7	95
	T3	1.2 < D ≤ 3.15	49.3	31.9	6	95
	T351	≤ 3.15	53.7	34.8	5	95
Extruded	T4, T4510, T4511	≤ 3.15	53.7	36.3	8	95
	T4, T4510, T4511	3.15 < D ≤ 8	49.3	31.9	8	95
	T4, T4510, T4511	8 < D ≤ 10	47.9	30.5	7	95

2077 by EURAL LEAD FREE

According to:
EU directives RoHS II, ELV, REACH

Applications

2077 LEAD FREE by EURAL is a free-cutting aluminum alloy with the best machinability within the hard alloys and with extremely high mechanical properties. It has been developed by Eural Gnutti and can overperform alloys as 2017, 2017A, 2014, 2014A, 2024, 7020 and 7022 and can compete with 7075 alloy.

Its excellent machinability, a guarantee of high yield/productivity, has no comparison within the hard aluminum alloys.

High Machinability

2077 LEAD FREE by EURAL has been specifically developed to be machined on high speed automatic lathes thanks to its thin chip formation.



Production range

2077 LEAD FREE by EURAL is available both as drawn and extruded condition.

Drawn round bars Ø 0.394-3.15"

Temper T6

Extruded round bars Ø 1.181 – 10"mm

Temper T6 and T4

Available also in square, rectangular and hexagonal bars.

A wide range of drawn bars are also available in h9 tolerance.



FREE CUTTING Aluminum alloy

Green choice

For many years RoHS II regulations permit, with an exception, a maximum lead content in aluminum alloys up to 0.4% by weight. Such limit is under discussion for a further reduction.

REACH recently included lead in SVHC list as highly toxic element for human health.

2077 LEAD FREE by EURAL is ready in anticipation of any possible future scenario because it is free of lead.



Alloy with high recycled aluminum content.

No tin

Today there are several 2000 series alloys with contain tin (Sn) which is well known to cause weakness and cracking of machined parts when submitted to stress or high temperatures (> 320°F).

Tin, due to its brittle nature, has the dangerous tendency to break without significant previous deformation (strain).

2077 LEAD FREE by EURAL does not contain tin.



Alternative alloy to:

2077 LEAD FREE by EURAL is the best alternative option to many hard alloys such as 2017, 2017A, 2014, 2014A, 2024, 7020, 7022 and 7075.

Furthermore, thanks to a very high yield strength (YTS), it can be an option to replace, depending on the final application, certain stainless steel (AISI 303/4/4L/316/L), cast iron (GH 350/500) and brass (CW608N R360).

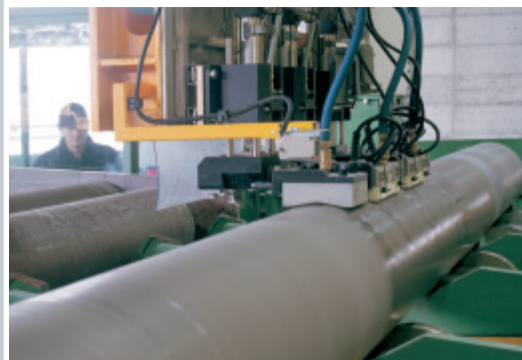
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2077 LEAD FREE by EURAL is member of free-cutting alloys, lead free, developed by the Eural Research & Development department and born thanks to the never-ending vision of the Gnutti family. It's an alloy which was missing until today, an alloy that mixes very high mechanical properties and excellent machinability.

Ultrasonic tested billets

All semi-finished products in **2077 LEAD FREE by EURAL** are made by Class A ultrasonic tested billets (SAE AMS-STD-2154).



RoHS & REACH and other metals

The imminent restrictions about the maximum lead content allowed will affect all products obtained by mechanical processing, including steel, cast iron and brass. These metals, without the lead which was a guarantee of good or acceptable machinability, will not be allowed anymore. For all these cases, the only option in terms of machinability is aluminum and the best choice available today is **2077 LEAD FREE by EURAL**.

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PRODUCTION PROGRAM

Unit: in.	●	■	■	■
Drawn	0.394 - 3	To be defined	To be defined	To be defined
Extruded	1.181 - 10	1.181 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)
Ready to imminent restrictions on lead content
because LEAD FREE



PRESENTATION

This alloy has very high mechanical properties, high fatigue strength, good forging attitude and excellent machinability on high-speed lathes.

Eural alloy 2077 is the first and only hard alloy with superior characteristics to 2024, which guarantees a chip formation comparable to 2011 and 2033, thus very high productivity, tighter tolerances, better surface roughness and longer tool life.

Eural 2077 is the best alternative to alloys 2017, 2017A, 2014, 2014A, 2024, 7020, 7022, 7075.

Due to its high mechanical properties and excellent machinability, it can replace certain types of steel and cast iron.

Main applications: valves, bolts and nuts, threaded bars, structural and high resistance components.

Properties	T6	T4
Machinability	Excellent	Excellent
Protective anodizing	Good	Good
Decorative anodizing	Good	Good
Hard anodizing	Good	Good
Resistance to atmospheric corrosion	Good	Good
Resistance to marine corrosion	Good	Good
MIG-TIG weldability	Good	Good
Resistance weldability	Good	Good
Brazing weldability	Good	Good
Plastic formability when cold	Good	Good
Plastic formability when hot	Good	Good

Legend

Excellent	Good	Acceptable	Not recommended
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Samples of finished products made of Eural bars



Chemical composition	
Si	0.40 - 1.00
Fe	≤ 0.70
Cu	4.00 - 5.00
Mn	0.60 - 1.20
Mg	0.60 - 1.20
Cr	≤ 0.20
Ni	≤ 0.20
Zn	≤ 0.25
Ti	≤ 0.15
Ag, Li, Zr	Each ≤ 0.15
Bi	0.20 - 0.90
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.1015
Modulus of elasticity	ksi	11,168
Coefficient of thermal expansion	x10 ⁻⁶ °F	12.7
Thermal conductivity at 68°F	Btu ft h °F	T6: 86.7 T4: 98.2
Typical electrical resistivity at 68°F	Ω mm ² m	T6: 0.045 T4: 0.052

Minimum mechanical properties					
Temper	Diam. in	UTS ksi	YTS ksi	HBW A%	Typical
Drawn	T6/T651	≤ 3.15	69.6 58.0	5	130
	T4/T4511	≤ 3	58.0 39.2	10	105
	T4/T4511	3 < D ≤ 6	56.6 37.7	9	105
Extruded	T4/T4511	6 < D ≤ 8	53.7 34.8	8	105
	T4/T4511	8 < D ≤ 10	52.2 31.9	7	105
	T6/T6511	≤ 6	66.0 55.1	5	130
	T6/T6511	6 < D ≤ 8	60.9 40.6	8	120
	T6/T6511	8 < D ≤ 10	58.0 39.2	8	110

*HBW only for indicative purposes

2017A_{by EURAL}



Colour code
EU green

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PRODUCTION PROGRAM

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)

Unit: in.	●	■	■	◆
Drawn	0.551 - 3.15	0.787 - 2.559	Thick. 0.472 - 2.165	-
Extruded	1.181 - 10	1.181 - 6.5	Thick. 1.181 - 5	-

PRESENTATION

This alloy has high mechanical properties and excellent resistance to fatigue. During machining, it creates quite long chips, therefore it is not well suited for automatic lathes. It can be replaced by 2033 or 2077 LEAD FREE, having higher mechanical properties, both guarantying a much better machinability and higher productivity.

Main applications: screws and bolts, high structural resistance components for aviation and defense.



Properties	T3/T4			
Machinability	■			
Protective anodizing	■			
Decorative anodizing	■			
Hard anodizing	■			
Resistance to atmospheric corrosion	■			
Resistance to marine corrosion	■			
MIG-TIG weldability	■			
Resistance weldability	■			
Brazing weldability	■			
Plastic formability when cold	■			
Plastic formability when hot	■			

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	0.20 - 0.80
Fe	≤ 0.70
Cu	3.50 - 4.50
Mn	0.40 - 1.00
Mg	0.40 - 1.00
Cr	≤ 0.10
Ni	
Zn	≤ 0.25
Zr+Ti	≤ 0.25
Pb	
Bi	
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.1008
Modulus of elasticity	ksi	10,878
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.1
Thermal conductivity at 68°F	Btu ft h °F	77.0
Typical electrical resistivity at 68°F	Ω mm ² m	0.051

Minimum mechanical properties						
	Temper	Diam. in	UTS ksi	YTS ksi	HBW A%	Typical
Drawn	T3	≤ 3.15	58.0	36.3	10	105
	T351	≤ 3.15	58.0	36.3	8	105
Extruded	T4, T4510, T4511	≤ 3	58.0	39.2	10	105
	T4, T4510, T4511	3 < D ≤ 6	56.6	37.7	9	105
	T4, T4510, T4511	6 < D ≤ 8	53.7	34.8	8	105
	T4, T4510, T4511	8 < D ≤ 10	360	220	7	105

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PRODUCTION PROGRAM

Unit: in.	●	■	■	●
Drawn	0.787 - 3.15	-	-	-
Extruded	1.181 - 10	1.969 - 6.496	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)



PRESENTATION

This alloy has high mechanical properties and excellent resistance to fatigue. During machining, it creates quite long chips, therefore it is not well suited for automatic lathes. For a much better machinability and higher mechanical properties, EURAL suggests to use alloy 2077 LEAD FREE.

Main applications: screws and bolts, high structural resistance components for aviation and defense.

Properties	T3			
Machinability	■			
Protective anodizing	■			
Decorative anodizing	■			
Hard anodizing	■			
Resistance to atmospheric corrosion	■			
Resistance to marine corrosion	■			
MIG-TIG weldability	■			
Resistance weldability	■			
Brazing weldability	■			
Plastic formability when cold	■			
Plastic formability when hot	■			

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	≤ 0.50
Fe	≤ 0.50
Cu	3.80 - 4.90
Mn	0.30 - 0.90
Mg	1.20 - 1.80
Cr	≤ 0.10
Ni	
Zn	≤ 0.25
Ti	≤ 0.15
Pb	
Bi	
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.1008
Modulus of elasticity	ksi	10,153
Coefficient of thermal expansion	x10 ⁻⁶ °F	12.8
Thermal conductivity at 68°F	Btu ft h °F	68.9
Typical electrical resistivity at 68°F	Ω mm ² m	0.057

Minimum mechanical properties					
Temper	Diam. in	UTS ksi	YTS ksi	HBW A%	Typical
T3	0.394 < D ≤ 3.15	61.6	42.1	9	120
T351	≤ 3.15	61.6	45	8	120
T6	≤ 3.15	61.6	45.7	5	125
T651	≤ 3.15	61.6	45.7	4	125
T8	≤ 3.15	66.0	58.0	4	130
T851	≤ 3.15	66.0	58.0	3	130
T3, T3510, T3511	≤ 2	65.3	45.0	8	120
T3, T3510, T3511	2 < D ≤ 4	63.8	43.5	8	120
T3, T3510, T3511	4 < D ≤ 8	60.9	40.6	8	120
T3, T3510, T3511	8 < D ≤ 10	58.0	39.2	8	120
T8, T8510, T8511	≤ 6	66.0	55.1	5	130

6026^{LF} by EURAL

LEAD FREE

According to
EU directives RoHS II, ELV, REACH



FREE CUTTING Aluminum alloy

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GNUTTI S.p.A.

Application fields

6026^{LF} LEAD FREE by EURAL is extremely versatile due to its medium-high mechanical properties, good attitude to anodizing, good weldability, good attitude to forging and good corrosion resistance.

6026^{LF} LEAD FREE by EURAL is suitable for components used in several industries such as automotive, electric and electronics, valves, oleo-hydraulic, pneumatics, furniture & lighting.

Green choice

For many years RoHS II regulations permit, with an exception, a maximum lead content in aluminum alloys up to 0.4% by weight. Such limit is under discussion for a further reduction. REACH recently included lead in SVHC list as highly toxic element for human health.

6026^{LF} LEAD FREE by EURAL is ready in anticipation to any possible future changes because it is free of lead.



Alloy with high recycled aluminum content.

Birth of 6026^{LF}

6026^{LF} LEAD FREE by EURAL is an innovative alloy designed and developed by Eural Gnutti S.p.A. R&D laboratories in order to meet the strictest requirements in critical automotive applications such as brake systems.

Today 6026^{LF} LEAD FREE by EURAL is approved for several different business applications.

High machinability

6026^{LF} LEAD FREE by EURAL is particularly suitable for being machined on high speed automatic lathes thanks to its thin chip formation.



No tin

In many 6000 series alloys lead (Pb) has been replaced by tin (Sn) which, as it has been proved, can cause weakness and cracking of the machined parts when submitted to stress and high temperature (>320°F).

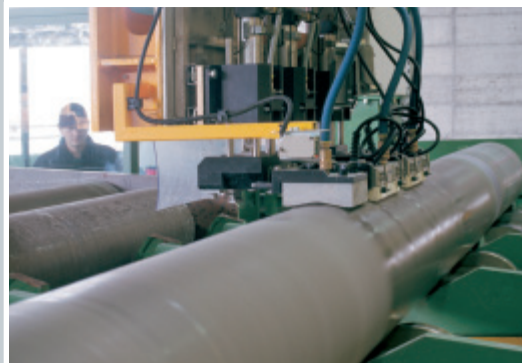
Tin, due to its brittle nature, has the dangerous tendency to break without significant previous deformation (strain).

6026^{LF} LEAD FREE by EURAL does not contain tin.



Ultrasonic tested billets

All semi-finished products in 6026^{LF} LEAD FREE by EURAL are made of 100% ultrasonic tested billets according to SAE AMS-STD-2154 class A.



Production program

6026^{LF} LEAD FREE by EURAL is available in drawn or extruded conditions.

Drawn round bars Ø 0.236 – 3.15"

Temper T6, T8 and T9.

Extruded round bars Ø 1.181 – 10"

Temper T6.

Square, rectangular, hexagonal bars are available.

A wide range of drawn bars are also available in h9 tolerance.

Alternative to:

6026^{LF} LEAD FREE by EURAL is the best alternative to several aluminum alloys such as 6012, 6012A, 6020, 6021, 6023, 6028, 6033, 6040, 6041, 6042, 6061, 6065, 6082, 6262, 6064A, 6262A, 6351, and 7020.

6026^{LF} LEAD FREE by EURAL is an excellent replacement of brass due to its excellent machinability, good attitude to forging, and medium-high mechanical properties. Moreover, since 6026^{LF} has a specific gravity of 1/3 compared to brass, it results extremely convenient costwise.

Compatibility in drawings

Original alloy 6026 was born in 2002 and has been registered by Eural to the Aluminum Association and to EN standards with a lead content of Pb ≤ 0.4% (0 - 0.4%).

Therefore, 6026^{LF} LEAD FREE by EURAL does not need any variations in drawings where 6026 is already indicated.

Lead (Pb) and tin (Sn) can be present as traces within the limits of 0.05%, as any other chemical element, as prescribed by international regulations.

www.eural.com



PRODUCTION PROGRAM

Unit: in.	●	■	■	■
Drawn	0.236 - 3.15	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	1.969 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)
Ready to imminent restrictions on lead content
because LEAD FREE



PRESENTATION

Alloy 6026^{LF} LEAD FREE is the best option for machinability since recent limitations by RoHS (2018/740/EU) and REACH on lead content allowance (Pb ≤ 0.1%). It is particularly suitable for being machined on high-speed automatic lathes. 6026^{LF} LEAD FREE offers:

- Excellent chip forming performance
- Good attitude to anodizing, big thickness also
- Good corrosion resistance
- Excellent surface finishing (low roughness)
- Good for forging

It is definitely a better solution than aluminum + Tin (Sn) alloys because free from any limitations on possible application (final parts subjected to high stress, low or high temperatures). It can replace 6012, 6012A, 6020, 6021, 6023, 6028, 6033, 6040, 6041, 6042, 6061, 6065, 6082, 6262, 6064A, 6262A, 6351, 7020 alloys.

Main applications: automotive industry, electric and electronic industry, hot forging, screws, bolts, nuts, threaded parts, furniture & lighting.

Properties	T6	T8/T9
Machinability	Excellent	Good
Protective anodizing	Good	Acceptable
Decorative anodizing	Acceptable	Not recommended
Hard anodizing	Excellent	Good
Resistance to atmospheric corrosion	Good	Acceptable
Resistance to marine corrosion	Acceptable	Not recommended
MIG-TIG weldability	Good	Acceptable
Resistance weldability	Good	Acceptable
Brazing weldability	Acceptable	Not recommended
Plastic formability when cold	Acceptable	Not recommended
Plastic formability when hot	Good	Acceptable

Legend

Excellent	Good	Acceptable	Not recommended
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Samples of finished products made of Eural bars



Chemical composition	
Si	0.60 - 1.40
Fe	≤ 0.70
Cu	0.20 - 0.50
Mn	0.20 - 1.00
Mg	0.60 - 1.20
Cr	≤ 0.30
Ni	≤ 0.30
Zn	≤ 0.30
Ti	≤ 0.20
Sn	≤ 0.05
Pb	≤ 0.05* (traces)
Bi	0.50 - 1.50
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.0983
Modulus of elasticity	ksi	10,950
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.0
Thermal conductivity at 68°F	Btu ft h °F	98.8
Typical electrical resistivity at 68°F	Ω mm ² m	0.039

Minimum mechanical properties					
	Temper	Diam. in	UTS ksi	YTS ksi	HBW A% Typical
Drawn	T6	≤ 3.15	54.0	44.0	8 95
	T8	≤ 3.15	50.0	46.0	4 95
	T9	≤ 3.15	52.0	48.0	4 95
Extruded	T6	≤ 5.5	54.0	44.0	8 95
	T6	5.5 < D ≤ 8	49.0	36.0	8 90
	T6	8 < D ≤ 10	44.0	29.0	8 90

6064A by EURAL

Colour code
EU yellow

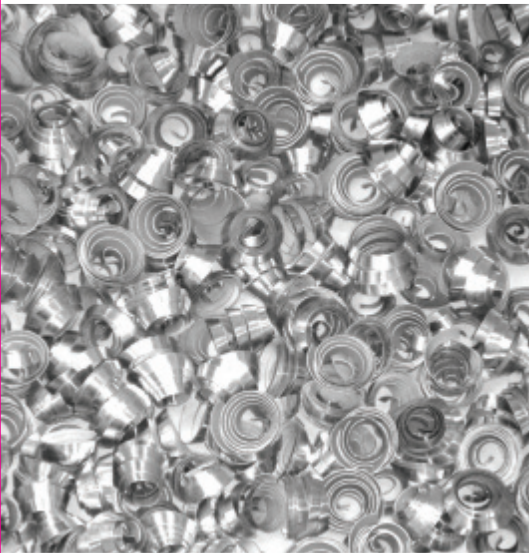
Colour code
USA orange



PRODUCTION PROGRAM

Unit: in.	●	■	■	◆
Drawn	0.236 - 3.15	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	2 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)



PRESENTATION

This alloy has good machinability and high properties. Moreover it has resistance to corrosion and suitability to hard, protective and decorative anodizing. Its original chemical composition oblige to have lead (Pb) content within this range 0.2-0.4%. Once the imminent restrictions by REACH & RoHS on lead content in metals for machining will be in force, alloy 6064A will not be conform anymore. Eural strongly suggest as alternative option, compliant to current and to any possible future restrictions on lead (Pb) 6026^{LF} LEAD FREE.

Main applications: particulars for braking systems for automotive, structural components for civil constructions, railroad and heavy street vehicles.

Properties	T6	T8/T9
Machinability	■	■
Protective anodizing	■	■
Decorative anodizing	■	■
Hard anodizing	■	■
Resistance to atmospheric corrosion	■	■
Resistance to marine corrosion	■	■
MIG-TIG weldability	■	■
Resistance weldability	■	■
Brazing weldability	■	■
Plastic formability when cold	■	■
Plastic formability when hot	■	■

Legend

■ Excellent ■ Good ■ Acceptable ■ Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	0.40 - 0.80
Fe	≤ 0.70
Cu	0.15 - 0.40
Mn	≤ 0.15
Mg	0.80 - 1.20
Cr	0.04 - 0.14
Ni	
Zn	≤ 0.25
Ti	≤ 0.15
Pb	0.20 - 0.40
Bi	0.40 - 0.80
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties	
Density	lb in ³ 0.0983
Modulus of elasticity	ksi 10,008
Coefficient of thermal expansion	x10 ⁻⁶ °F 13.0
Thermal conductivity at 68°F	Btu ft h °F 98.8
Typical electrical resistivity at 68°F	Ω mm ² m 0.039

Minimum mechanical properties					
	Temper	Diam. in	UTS		HBW
			ksi	ksi	A% Typical
Drawn	T6	≤ 3.15	45	37.7	8 95
	T8	≤ 3.15	50.0	45.7	4 95
	T9	≤ 3.15	52.2	47.1	4 95
Extruded	T6, T6510, T6511	≤ 5.5	45.0	37.7	8 95
	T6, T6510, T6511	5.5 < D ≤ 10	37.7	34.8	8 90

www.eural.com



PRODUCTION PROGRAM

Unit: in.	●	■	■	●
Drawn	0.236 - 3.15	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	2 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)



PRESENTATION

This is an ecologic alloy, it does not have lead, it has good machinability and high mechanical characteristics. Moreover, it has a good resistance to corrosion and suitability to hard, protective and decorative anodizing. It is an alternative to 6012, 6262, 6020, 6023 alloys.

Main applications: machining on high-speed automatic lathes, particulars for automotive applications, automatic transmission shafts, valves and clutches, hydraulic parts.

NOTE: it is particularly suitable for the realization of parts not subject to extreme heat solicitations (max 160°F) and therefore it is appropriate for automotive parts as automatic transmission shafts. For applications at higher temperatures, we suggest to use 6026^{LF} LEAD FREE by EURAL.

Properties	T6	T8/T9
Machinability	■	■
Protective anodizing	■	■
Decorative anodizing	■	■
Hard anodizing	■	■
Resistance to atmospheric corrosion	■	■
Resistance to marine corrosion	■	■
MIG-TIG weldability	■	■
Resistance weldability	■	■
Brazing weldability	■	■
Plastic formability when cold	■	■
Plastic formability when hot	■	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	0.40 - 0.80
Fe	≤ 0.70
Cu	0.15 - 0.40
Mn	≤ 0.15
Mg	0.80 - 1.20
Cr	0.04 - 0.14
Ni	
Zn	≤ 0.25
Ti	≤ 0.10
Bi	0.40 - 0.90
Sn	0.40 - 1.00
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.0983
Modulus of elasticity	ksi	10,008
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.0
Thermal conductivity at 68°F	Btu ft h °F	98.8
Typical electrical resistivity at 68°F	Ω mm ² m	0.038

Minimum mechanical properties						
	Temper	Diam. in	UTS		YTS	
			ksi	ksi	A%	HBW
Drawn	T6	≤ 3.15	42.1	34.8	10	-
	T8	≤ 2	50.0	45.7	4	-
	T9	≤ 2	52.2	47.9	4	-
Extruded	T6	≤ 8	37.7	34.8	10	75

6082 by EURAL



Colour code
EU turquoise

EURAL

GNUTTI S.p.A.

PRODUCTION PROGRAM

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)

Unit: in.	●	■	■	◆
Drawn	0.236 - 3	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	1.181 - 6.5	Thick. 1.181 - 5	-



PRESENTATION

This alloy has medium mechanical properties, but high resistance to corrosion and excellent attitude to weldability, hot forging and anodizing.

Main applications: highly stressed structural parts for ground and nautical means of transport, anti-iksict lateral bars, door frame, space frame and sub frame for cars, hydraulic systems, stairs and scaffoldings, platforms, screws and rivets, particulars for nuclear plants, food industry.

Properties	T6
Machinability	■
Protective anodizing	■
Decorative anodizing	■
Hard anodizing	■
Resistance to atmospheric corrosion	■
Resistance to marine corrosion	■
MIG-TIG weldability	■
Resistance weldability	■
Brazing weldability	■
Plastic formability when cold	■
Plastic formability when hot	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	0.70 - 1.30
Fe	≤ 0.50
Cu	≤ 0.10
Mn	0.40 - 1.00
Mg	0.60 - 1.20
Cr	≤ 0.25
Ni	
Zn	≤ 0.20
Ti	≤ 0.10
Pb	
Bi	
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.0979
Modulus of elasticity	ksi	10,008
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.3
Thermal conductivity at 68°F	Btu ft h °F	95.9
Typical electrical resistivity at 20°F	Ω mm ² m	0.037

Minimum mechanical properties					
Temper	Diam. in	UTS ksi	YTS ksi	HBW A%	Typical
Drawn	T6	≤ 3.15	45.0 37.0	10	95
	T6	≤ 6	45.0 37.7	8	95
Extruded	T6	6 < D ≤ 8	40.6 34.8	6	95
	T6	8 < D ≤ 10	39.2 29.0	6	95

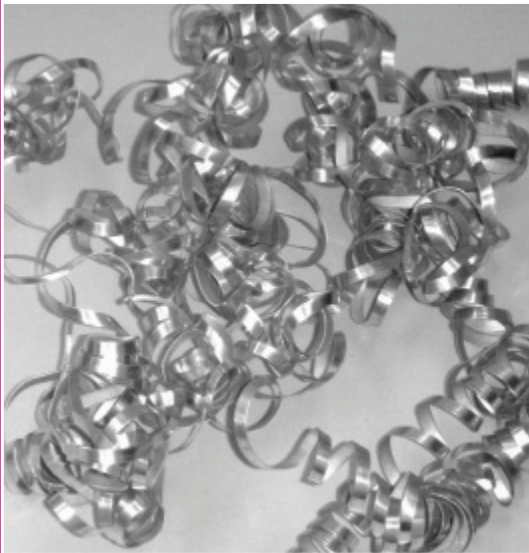
www.eural.com



PRODUCTION PROGRAM

Unit: in.	●	■	■	●
Drawn	0.236 - 3.15	0.394 - 2.559	Thick. 0.472 - 2.165	0.394 - 2.5
Extruded	1.181 - 10	2 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)



PRESENTATION

This alloy has medium mechanical properties, but high resistance to corrosion and excellent attitude to weldability, hot forging and anodizing.

Main applications: highly stressed structural parts for ground and nautical means of transport, anti-iksict lateral bars, door frame, space frame and sub frame for cars, hydraulic systems, stairs and scaffoldings, platforms, screws and rivets, particulars for nuclear plants, food industry.

Properties	T6
Machinability	■
Protective anodizing	■
Decorative anodizing	■
Hard anodizing	■
Resistance to atmospheric corrosion	■
Resistance to marine corrosion	■
MIG-TIG weldability	■
Resistance weldability	■
Brazing weldability	■
Plastic formability when cold	■
Plastic formability when hot	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	0.40 - 0.80
Fe	≤ 0.70
Cu	0.15 - 0.40
Mn	≤ 0.15
Mg	0.80 - 1.20
Cr	0.04 - 0.35
Ni	
Zn	≤ 0.25
Ti	≤ 0.15
Pb	
Bi	
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.0979
Modulus of elasticity	ksi	10,008
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.1
Thermal conductivity at 68°F	Btu ft h °F	99.4
Typical electrical resistivity at 68°F	Ω mm ² m	0.037

Minimum mechanical properties					
Temper	Diam. in	UTS ksi	YTS ksi	HBW A%	Typical
Drawn T6	≤ 3.15	42.1	34.8	10	95
Extruded T6	≤ 8	37.7	34.8	8	95

7075 by EURAL



Colour code
EU violet



Colour code
USA black

EURAL

GNUTTI S.p.A.

PRODUCTION PROGRAM

Unit: in.	●	■	■	◆
Drawn	0.75 - 3	-	-	-
Extruded	1.181 - 10	2 - 6.5	Thick. 1.181 - 5	-

According to EU directives:
2000/53/EU - 2011/65/EU (RoHS II)



PRESENTATION

This alloy has extremely high mechanical properties and high resistance to fatigue. Moreover, it has good resistance to corrosion and attitude to hard, protective and decorative anodizing.

Main applications: high resistance structural parts for mechanical industry, aviation, defense, motorbike and automotive.

Properties	T6
Machinability	■
Protective anodizing	■
Decorative anodizing	■
Hard anodizing	■
Resistance to atmospheric corrosion	■
Resistance to marine corrosion	■
MIG-TIG weldability	■
Resistance weldability	■
Brazing weldability	■
Plastic formability when cold	■
Plastic formability when hot	■

Legend

■	■	■	■
Excellent	Good	Acceptable	Not recommended

Samples of finished products made of Eural bars



Chemical composition	
Si	≤ 0.40
Fe	≤ 0.50
Cu	1.20 - 2.00
Mn	≤ 0.30
Mg	2.10 - 2.90
Cr	0.18 - 0.28
Ni	
Zn	5.10 - 6.10
Ti	≤ 0.20
Pb	
Bi	
Others	Each 0.05 Total 0.15
Al	Remainder

Physical properties		
Density	lb in ³	0.1012
Modulus of elasticity	ksi	10,443
Coefficient of thermal expansion	x10 ⁻⁶ °F	13.1
Thermal conductivity at 68°F	W mk	74.7
Typical electrical resistivity at 68°F	Ω mm ² m	0.052

Minimum mechanical properties						
	Temper	Diam. in	UTS ksi	YTS ksi	A% Typical	HBW
Drawn	T6	≤ 3.15	78.3	70.3	7	150
	T651	≤ 3.15	78.3	70.3	5	150
	T73	≤ 3.15	66.0	55.8	10	135
	T7351	≤ 3.15	66.0	55.8	8	135
Extruded	T6, T6510, T6511	≤ 4	81.2	72.5	7	150
	T6, T6510, T6511	4 < D ≤ 6	79.8	63.8	5	150
	T6, T6510, T6511	6 < D ≤ 8	63.8	58.0	5	150
	T73, T73510, T73511	≤ 3	68.9	58.7	7	135
	T73, T73510, T73511	3 < D ≤ 4	68.2	56.6	6	135
	T73, T73510, T73511	4 < D ≤ 6	63.8	52.2	6	135

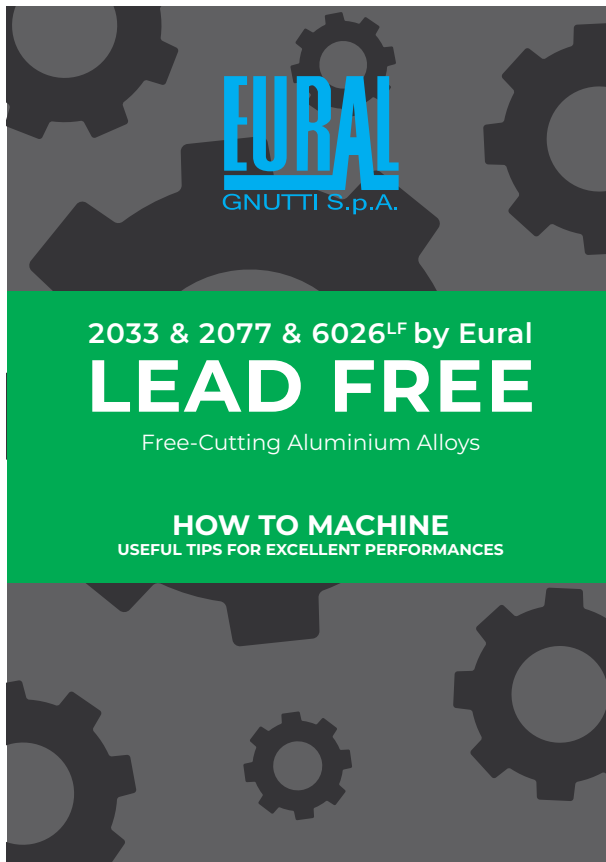
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2033 & 2077 & 6026^{LF} LEAD FREE by Eural

“How to machine”

In “How to Machine” catalog:

- What is FREE-CUTTING and how such solutions can play a crucial role for any successful project
- How to achieve small chips and reduce cycle times
- Chip-breaking elements, lubricants and coolants, turning, drilling and milling inserts
- How chip formation changes by switching to different machining inserts with 2033, 2077 & 6026^{LF} alloys
- Possible machining parameters by choosing free-cutting **LEAD FREE** aluminum alloys by Eural



DOWNLOAD
www.eural.com

EURAL has been a leading producer of aluminum bars since 1968 and one of the keys to its great success is being close to all customers, understanding their requirements and meeting their expectations. After 50 years of industry knowledge EURAL can now also create new solutions to support and improve the production of our customers.

EURAL's technicians travel worldwide wherever support is needed to understand, cooperate and to share the benefits of using Eural products.

For these reasons, we have produced a technical guide:
“How To Machine - Useful tips for excellent performances”.

In this guide you will find tips on how to approach the machining of free-cutting LEAD FREE solutions from EURAL. It's full of all our experience into this business.

EURAL supplies aluminum with technology.



Alloys with high recycled
aluminum content.



Billets extraction in foundry



Automatic ultrasonic control system for the entire length of the billet according to class "A" of SAE AMS-STD-2154 regulation



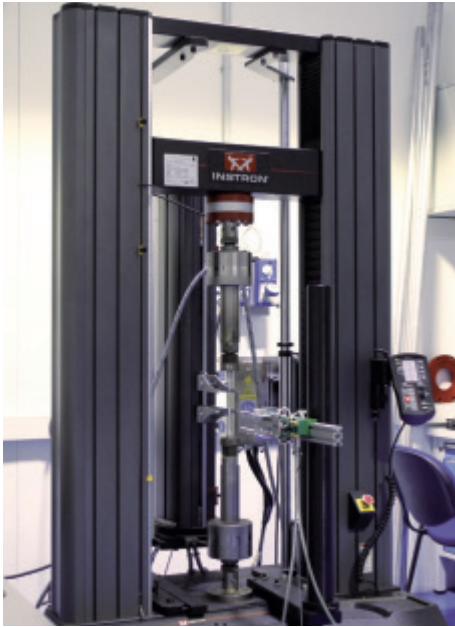
Particular of bars warehouse



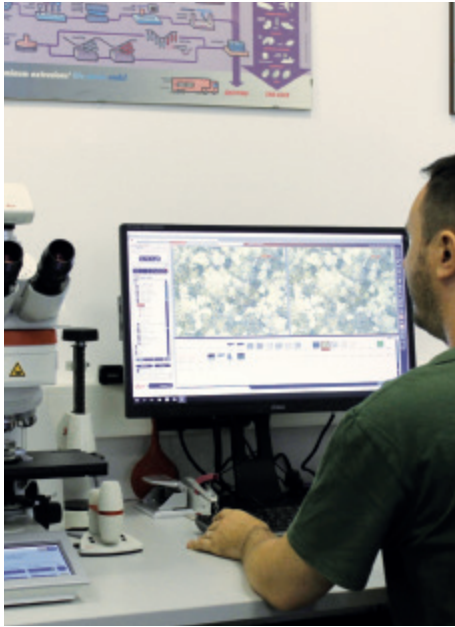
5500-T Indirect extrusion press



Imprint of Eural logo, alloy code and batch number on all extruded bars



R&D Department



Quality Department



Quality Department



Eural Gnutti extrusion plant in Rovato (Brescia), Italy



Eural Gnutti foundry plant in Pontevico (Brescia), Italy

ALLOY	AA	EN	EN (CS)	ASTM	BS	BS(OLD)	DIN	WNR	JIS	JIS(OLD)	NF	NF(OLD)	SFS
	Intl.	Intl.	Intl.	USA	GB	GB	DE	DE	JP	JP	FR	FR	FI
2033	2033	2033	Al Cu ₂ 5BiMnMg										
2011	2011	2011	Al Cu ₆ BiPb	2011	2011	FC1	AlCuBiPb	3.1655	A2011		2011	A-U5PbBi	
2030	2030	2030	Al Cu ₄ PbMg	\			~AlCuMgPb				2030	A-U4Pb	
2007	2007	2007	Al Cu ₄ PbMgMn	\			AlCuMgPb	3.1645				~ A-U4Pb	
2077	2077	2077	Al Cu ₄ 5MnMgBi										
2017A	2017A	2017A	Al Cu ₄ MgSi(A)	~2017	2017A		AlCuMg1	3.1325	~A2017	A3x2	2017A	A-U4G	
2024	2024	2024	Al Cu ₄ Mg1	2024	2024	2L97	AlCuMg2	3.1355	A2024	A3x4	2024	A-U4G1	
6026 ^{LF}	6026	6026	Al MgSiBi	6026									
6064A	6064A	6064A	Al Mg1SiBi	\									
6061	6061	6061	Al Mg1SiCu	6061	6061	H20	AlMg1SiCu	3.3211	A6061	A2x4	6061	A-GSUC	
6082	6082	6082	Al Si1MgMn		6082	H30	AlMgSi1	3.2315			6082	A-GSM0.7	2593
6262	6262	6262	Al Mg1SiPb	6262									
6262A	6262A	6262A	Al Mg1SiSn	\									
7075	7075	7075	Al Zn5,5MgCu	7075	7075	2L95	AlZnMgCu1,5	3.4365	A7075	A34x6	7075	A-Z5GU	

ALLOY	SNCH	SS	UNI	UNI(OLD)	UNS	NS	UNE	ASV	ALUSUISSE	CSA(OLD)	GOST(OLD)
	CH	SE	IT	IT							
2011	AlCu ₆ BiPb	4355	9002/5	6362	A92011		L-3192		2500	CB60	
2030	AlCu ₄ MgPb				A92030						
2007	AlCu ₄ MgPb	4335	9002/8				L-3121		2118		
2017A			9002/2	3579	~A92017		L-3120		2100	CM41	D1/V65
2024	AlCu ₄ Mg1,5		9002/4	3583	A92024		L-3140		2150	CG42	D16
6026											
6064A											
6061			9006/2	6170	A96061		L-3420	2079	6061	GS11N	AD33/AV
6082	AlMgSi1Mn	4212	~9006/4	3571		17305	L-3451	2005	6112	SG11R	AD35
6262											
6262A											
7075	AlZn6MgCu1,5		9007/2	3735	A97075		L-3710	2082	7215	ZG62	B95(V95)



Line marking

in.	●	■	◆
0.20	0.038	-	-
0.24	0.055	-	-
0.28	0.075	-	-
0.32	0.097	-	-
0.36	0.123	-	-
0.40	0.152	0.194	0.168
0.44	0.184	0.235	0.203
0.48	0.219	0.279	0.242
0.52	0.257	0.328	0.284
0.56	0.299	0.380	0.329
0.60	0.343	0.436	0.378
0.64	0.390	0.496	0.430
0.68	0.440	0.560	0.485
0.72	0.493	0.628	0.544
0.76	0.550	0.700	0.606
0.80	0.609	0.776	0.672
0.84	0.672	0.855	0.741
0.88	0.737	0.939	0.813
0.92	0.806	1.026	0.888
0.96	0.877	1.117	0.967
1.00	0.952	1.212	1.050
1.04	1.030	1.311	1.135
1.08	1.110	1.414	1.224
1.12	1.194	1.520	1.317
1.16	1.281	1.631	1.412
1.20	1.371	1.745	1.511
1.24	1.464	1.864	1.614
1.28	1.560	1.986	1.720
1.32	1.659	2.112	1.829
1.36	1.761	2.242	1.941
1.40	1.866	2.376	2.057
1.44	1.974	2.513	2.176
1.48	2.085	2.655	2.299
1.52	2.199	2.800	2.425
1.56	2.317	2.950	2.554
1.60	2.437	3.103	2.687
1.64	2.560	3.260	2.823
1.68	2.687	3.421	2.962
1.72	2.816	3.586	3.105
1.76	2.949	3.754	3.251

in.	●	■	◆
1.80	3.084	3.927	3.401
1.84	3.223	4.103	3.553
1.88	3.364	4.284	3.710
1.92	3.509	4.468	3.869
1.96	3.657	4.656	4.032
2.00	3.808	4.848	4.198
2.04	3.961	5.044	4.368
2.08	4.118	5.244	4.541
2.12	4.278	5.447	4.717
2.16	4.441	5.655	4.897
2.20	4.607	5.866	5.080
2.24	4.776	6.081	5.266
2.28	4.948	6.300	5.456
2.32	5.123	6.523	5.649
2.36	5.302	6.750	5.846
2.40	5.483	6.981	6.046
2.44	5.667	7.216	6.249
2.48	5.854	7.454	6.455
2.52	6.045	7.697	6.665
2.56	6.238	7.943	-
2.60	6.435	8.193	-
2.64	6.634	8.447	-
2.68	6.837	8.705	-
2.72	7.042	8.967	-
2.76	7.251	9.233	-
2.80	7.463	9.502	-
2.84	7.678	9.776	-
2.88	7.895	10.053	-
2.92	8.116	10.334	-
2.96	8.340	10.619	-
3.00	8.567	10.908	-
3.04	8.797	11.201	-
3.08	9.030	11.498	-
3.12	9.266	11.798	-
3.16	9.505	12.103	-
3.20	9.747	12.411	-
3.24	9.992	12.723	-
3.28	10.241	13.039	-
3.32	10.492	13.359	-
3.36	10.746	13.683	-

in.	●	■	◆
3.40	11.004	14.011	-
3.44	11.264	14.342	-
3.48	11.528	14.678	-
3.52	11.794	15.017	-
3.56	12.064	15.360	-
3.60	12.336	15.708	-
3.64	12.612	16.059	-
3.68	12.891	16.413	-
3.72	13.173	16.772	-
3.76	13.457	17.135	-
3.80	13.745	17.501	-
3.84	14.036	17.872	-
3.88	14.330	18.246	-
3.92	14.627	18.624	-
3.96	14.927	19.006	-
4.00	15.230	19.392	-
4.20	16.791	21.380	-
4.40	18.428	23.464	-
4.60	20.142	25.646	-
4.80	21.931	27.924	-
5.00	23.797	30.300	-
5.20	25.739	32.772	-
5.40	27.757	35.342	-
5.60	29.851	38.008	-
5.80	32.021	40.772	-
6.00	34.268	43.632	-
6.20	36.590	46.589	-
6.40	38.989	49.644	-
6.60	41.464	52.795	-
6.80	44.015	56.043	-
7.00	46.642	-	-
7.20	49.346	-	-
7.60	54.981	-	-
8.00	60.921	-	-
8.40	67.165	-	-
8.80	73.714	-	-
9.20	80.567	-	-
9.60	87.726	-	-
10.00	95.188	-	-

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