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To: Öko-Institut e.V.
RoHS exemptions evaluation

Rovato, Italy, March 3rd, 2021

Please find below the input from Eural Gnutti S.p.A. on the Exemption 6(b)-II of RoHS Annex III – Lead as an alloying element in aluminium for machining purposes with a Lead content up to 0,4 % by weight

Eural Gnutti S.p.A. is an Italian manufacturer of extruded and drawn rods and bars in aluminium alloys for machining purposes containing Lead or Lead-free, among the largest ones worldwide. We already participated to the previous consultation done by your esteemed Institute, back in the year 2016.
We fully endorse European Aluminium Association, as we directly participated in the writing of their document related to the Exemption 6(b)-II. Nevertheless, we feel more appropriate to submit to your attention further data, which derives strictly from our internal know-how and experience.
We are at your full disposal for any further requirement you may have, either technical or of any other nature, we do believe that our expertise could be very helpful in such an important subject.

FOREWORD

In the years before RoHS was published, to have good machinability and high productivity, all aluminium alloys for machining purposes were either with Lead (Pb) in quantities between 1% to 2% w/w, or with Pb in combination with Bismuth (Bi). In those years Tin (Sn) was not used, it was only allowed in the alloy 2007 as an impurity (0-0,2%).
RoHS was born in 2003 limiting Pb in aluminium compounds. Many extrusion companies, in Europe and US, started to develop Lead free alloys from 1996, in order to be prepared. As initially Pb was supposed to be limited to 0,1%, all extruders tried alloys with Sn alone, or Sn in combination with Bi, as chip-breaking elements. Soon all industry found out that Sn was brittle and was creating fractures when submitted to temperatures above 160°C, so alloys with Sn or Sn+Bi could only be used in applications where temperature was not high.
RoHS was published with new Exemptions that allowed Pb max 0,4%. Using Pb alone, limited to 0,4%, could not be satisfactory as chip braking element, but Pb in combination with Bi forms an eutectic, which is an excellent chip-breaker. Therefore in those years many alloys were born with Pb max 0,4% and Bi between 0,2% and 1,5%. Moreover, the very famous alloy 2011, which originally was with Pb 0,2%-0,6% and Bi 0,2%-0,6%, has been limited by all manufacturers to Pb max 0,4% in order to comply with RoHS.
As it was clear that future would be to limit Pb to max 0,1%, Extruders started to develop new alloys removing Pb, without using Sn, and without adding further Bi. Such a difficult task ended up positively with several solutions, listed in detail in point 2.a.
European Commission published the Delegated Directive EU 2018/740 on March 1st 2018, where Exemption 6(b)-II shall expire on May 18th 2021. Since then, many industries started moving fast in updating their materials switching to Lead free aluminium alloys, with success.
From important associations and industries, many doubts have been raised on the real validity and applicability of such Delegated Directive, starting immediately to doubt that it will ever be put in place. As consequence, many industries stopped their initial work of switching to Lead free, feeling confused about the messages they were receiving from their associations. Unfortunately, these associations were right, because the D.D. 2018/740 is now on hold, and the industry feels that Pb can remain at 0,40% forever.
There is no doubt that to change material costs a lot of money, and Companies are not happy about that. Nevertheless, as we will explain later, we Extruders and Rollers are the only companies obliged to deal with pure Lead in enormous quantities into our factories. We strongly hope that the European Commission will be now as much strict as possible in denying any further delays in limiting Lead to 0,1%, in order to protect the health of all European workers, firstly the ones who must have pure Lead in their factories, but also of all workers who have to deal with Lead compounds, because Lead is toxic, and it is not needed anymore.

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QUESTIONS:

1. The applicant has requested the renewal of an exemption currently listed in RoHS Annex III (see exemption specific page accessible through the links above):

a. Do you agree with the scope of the exemption as proposed by the applicant?

An extension of exemption 6(b)-II is not necessary.

b. Please suggest an alternative wording and explain your proposal, if you do not agree with the proposed exemption wording.

The wording is right, it is just not necessary.

c. Please explain why you either support the applicant's request or object to it.

To support your views, please provide detailed technical argumentation / evidence in line with the criteria in Art. 5(1)(a) to support your statement.

We object to the applicant's request because Lead-free wrought aluminium alloys for machining purposes are globally available and Aluminium producers have developed Lead-free alternatives with properties compatible with Lead containing alloys in use for any kind of applications. Aluminium Extruders started back in 1996 to develop alloys with high machinability which could replace the Lead containing ones. Now, thanks to the big experience accumulated during decades, there are in the market all possible Lead-free alloys which could replace any kind of Lead containing alloy, for any end-use application, for all kind of families of alloys from 2000 series (Al-Cu based) to 6000 series (Al-Si-Mg series). These alloys have been tested and approved by all major industrial sectors, worldwide, in all applications, including electrical and electronic equipment, medical equipment, valves, safety parts and components, whether used in high or low temperature environments, whether in contact with fluids, lubricants, coolants, whether anodized or not. All parts passed all the requirements also in terms of respecting tight tolerances, surface roughness, superficial aspect, anodizing response, mechanical properties. The aluminium industry is immediately able to supply any quantity needed of Lead-free alloys. Roughness is even improved without Lead, as the absence of Lead avoids the eutectic with Bismuth and the alloy remains harder.
REACH Directive is taking into serious account to limit the quantity of Lead that any European Company can use and have in each factory. ECHA has also provided a detailed report on Occupational Exposure Limits in working environments where lead is present in compounds (https://echa.europa.eu/documents/10162/28403135/oel_lead_compounds_sci_rep_en.pdf/4ce397fa-433f-fa30-af4d-bb2c2f72549b). It is expected to have a final statement in the next years, where REACH will reduce the limit of Lead to a certain value that it will be impossible to produce aluminium alloys with Lead content up to 0,40% for European Extruders or Rollers. Indeed to protect the health of European workers has n.1 priority. Under this circumstance, European Companies will be obliged to respect REACH and will not be able to produce alloys with Lead max 0,4%, but companies outside Europe will, therefore if RoHS will not be limited, European Companies will suffer unfair competition from Companies extra-Europe.
We read about the assumption of Umbrella Project about the quantity of Lead used in Europe, estimated in 90 tons per year. Their assumption is largely underestimated. Eural Gnutti alone, in the year 2018, has produced alloys with Lead content in the quantity of almost 40.000 tons, therefore the Lead used to produce such quantity is about 205 tons. That means that in our factory we must have in our warehouse a minimum quantity of 20-30 tons of pure Lead, we cannot have any less in order to guarantee the regular flow of production. Such number is comparable with many Extruders and Rollers in Europe.
Lastly, several cases of saturnism have been detected especially where present large quantities of brass or steel, where Lead is present in high volume. Blood tests were made to some workers on machine shops in Lombardia area, and Lead was present in dangerous quantities.

2. Please provide information concerning possible substitutes or elimination possibilities at present or in the future so that exemption could be restricted or revoked:

a. Please detail substitution and elimination possibilities and for which part of the applications in the scope of the requested exemption they are relevant.

Here is the complete exhaustive list of all the wrought alloys which include Lead. In red all alloys which are already out of actual RoHS limit of 0,40% max and in black all alloys which are currently used. The list is extracted from the worldwide reference of alloys which is the Teal Sheet made by the American Aluminum Association (https://www.aluminum.org/sites/default/files/Teal%20Sheet.pdf).

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No. [17]	Date	By	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ag	B	Bi	Ga	Li	Pb	Sn	V	Zr		Each	Total[3]	Al Min	(kg/m³) x 10³
2005	1983	ARGENTINA	0,8	0,7	3.5-5.0	1	0.20-1.0	0,10	0,20	0,5	0,20	...	...	0,20	...	...	1.0-2.0	...	...	...	...	0,05	0,15	Rem.	2,83
2007	1979	GERMANY	0,8	0,8	3.3-4.6	0.50-1.0	0.40-1.8	0,10	0,20	0,8	0,20	...	...	0,20	...	...	0.8-1.5	0,2	...	...	...	0,10	0,30	Rem.	2,82
2011 (*)	1954	USA	0,40	0,7	5.0-6.0	...	...	...	...	0,30	...	...	...	0.20-0.6	...	...	0.20-0.6	...	...	...	...	0,05	0,15	Rem.	2,83
2011A (*)	1982	SWITZERLAND	0,4	0,5	4.5-6.0	...	...	...	...	0,30	...	...	...	0.20-0.6	...	...	0.20-0.6	...	...	...	...	0,05	0,15	Rem.	2,82
2028	2005	GERMANY	0,8	0,8	3.3-4.6	0.50-1.0	0.40-1.8	0,10	0,20	0,80	0,20	...	...	0.10-1.0	...	...	1	0.10-1.0	...	...	...	0,10	0,30	Rem.	2,83
2028A	2006	SLOVENIA	0,80	0,7	3.3-4.5	0.20-1.0	0.50-1.3	0,1	0,1	0,50	0,2	...	...	0.50-0.7	...	...	0.20-0.40	...	...	...	...	0,05	0,15	Rem.	2,8
2028B	2006	SLOVENIA	0,8	0,8	3.3.-4.6	0.50-1.0	0.40-1.8	0,10	0,10	0,80	0,20	...	...	0.50-0.7	...	...	0.20-0.40	...	...	...	...	0,05	0,15	Rem.	2,81
2030	1972	EAA	0,8	0,7	3.3-4.5	0.20-1.0	0.50-1.3	0,10	...	0,5	0,20	...	...	0,2	...	...	0.8-1.5	...	...	...	...	0,10	0,30	Rem.	2,81
6012	1979	GERMANY	0.6-1.4	0,5	0,1	0.40-1.0	0.6-1.2	0,30	...	0,30	0,20	...	...	0,7	...	...	0.40-2.0	...	...	...	...	0,05	0,15	Rem.	2,74
6018	1991	SWITZERLAND	0.50-1.2	0,7	0.15-0.40	0.30-0.8	0.6-1.2	0,1	...	0,30	0,2	...	...	0.40-0.7	...	...	0.40-1.2	...	...	...	...	0,05	0,15	Rem.	2,74
6026	2004	ITALY	0.6-1.4	0,7	0.20-0.50	0.20-1.0	0.6-1.2	0,3	...	0,30	0,20	...	...	0.50-1.5	...	...	0,40	0,05	...	...	...	0,05	0,15	Rem.	2,74
6042	2006	USA	0.50-1.2	0,70	0.20-0.6	0,40	0.7-1.2	0.04-0.35	...	0,25	0,2	...	...	0.20-0.8	...	...	0.15-0.40	...	...	...	...	0,05	0,15	Rem.	2,72
6064	2006	SLOVENIA	0.40-0.8	0,70	0.15-0.40	0,15	0.8-1.2	0.05-0.14	...	0,25	0,15	...	...	0.50-0.7	...	...	0.20-0.40	...	...	...	...	0,05	0,15	Rem.	2,72
6064A	2007	SWITZERLAND	0.40-0.8	0,70	0.15-0.40	0,15	0.8-1.2	0.04-0.14	...	0,25	0,15	...	...	0.40-0.8	...	...	0.20-0.40	...	...	...	...	0,05	0,15	Rem.	2,72
6068	2009	SWITZERLAND	0.6-1.4	0,50	0,10	0.40-1.0	0.6-1.2	0,30	0,1	0,30	0,20	...	...	0.6-1.1	0	...	0.20-0.40	...	0	...	...	0,05	0,15	Rem.	2,73
6262	1960	USA	0.40-0.8	0,70	0.15-0.40	0,15	0.8-1.2	0.04-0.14	...	0,25	0,2	...	...	0.40-0.7	...	...	0.40-0.7	...	...	...	...	0,05	0,15	Rem.	2,72

Here below the complete exhaustive list of wrought alloys for machining purposes which do not have Lead, hence Pb ≤ 0,10%.

No. [17]	Date	By	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ag	B	Bi	Ga	Li	Pb	Sn	V	Zr		Each	Total[3]	Al Min	(kg/m³) x 10³
2007A	2001	ITALY	0,8	0,8	3.3-4.6	0.20-1.0	0.40-1.8	0,10	0,20	0,8	0,20	...	...	0,20	...	...	0,05	0.8-1.5	...	...	...	0,10	0,30	Rem.	2,81
2007B	2006	SLOVENIA	0,8	0,7	3.3-4.6	0.50-1.0	0.40-1.8	0,10	0,10	0,8	0,20	...	...	0,10	...	...	0,10	0.40-1.9	...	...	...	0,05	0,15	Rem.	2,81
2012	1993	USA	0,40	0,7	4.0-5.5	...	...	...	...	0,30	...	...	...	0.20-0.7	...	...	...	0.20-0.6	...	...	...	0,05	0,15	Rem.	2,82
2028C	2006	BELGIUM	0,8	0,7	3.3-5.0	0.20-1.0	0.50-1.3	0,10	...	0,50	0,20	...	...	0.40-1.0	...	...	0,05	0.20-1.0	...	...	...	0,10	0,30	Rem.	2,82
2033	2017	ITALY	0.10-1.2	0,7	2.2-2.7	0.40-1.0	0.20-0.6	0,15	0,15	0,50	0,10	...	...	0.05-0.8	...	...	...	...	...	...	...	0,05	0,15	Rem.	2,77
2041	2006	SLOVENIA	0,40	0,7	5.0-6.0	...	...	...	...	0,30	...	...	...	0.50-0.7	...	...	0,05	0.50-0.7	...	...	...	0,05	0,15	Rem.	2,84
2044	2006	SLOVENIA	0,8	0,7	3.3-4.5	0.20-1.0	0.50-1.3	0,10	0,10	0,50	0,20	...	...	0.20-0.40	...	...	0,05	0.9-1.3	...	...	...	0,05	0,15	Rem.	2,81
2045	2006	SLOVENIA	0,8	0,8	3.3-4.6	0.50-1.0	0.40-1.8	0,10	0,10	0,8	0,20	...	...	0.20-0.40	...	...	0,05	0.9-1.3	...	...	...	0,05	0,15	Rem.	2,82
2077	2020	ITALY	0.40-1.0	0,7	4.0-5.0	0.60-1.2	0.60-1.2	0,20	0,20	0,25	0,15	0,15	...	0.20-0.90	...	0,15	...	...	...	0,15	...	0,05	0,15	Rem.	2,82
2111	1993	USA	0,40	0,7	5.0-6.0	...	...	...	...	0,30	...	...	...	0.20-0.8	...	...	...	0.10-0.50	...	...	...	0,05	0,15	Rem.	2,83
2111A	2001	ITALY	0,40	0,7	5.0-6.0	0,15	0,15	...	...	0,30	0,05	...	...	0.20-0.6	...	...	0,05	0.20-0.6	...	...	...	0,05	0,15	Rem.	2,83
2111B	2001	SWITZERLAND	0,30	0,50	4.6-6.0	0,05	0,05	...	...	...	...	...	...	0.30-0.6	...	...	...	0.30-0.7	...	...	...	0,05	0,15	Rem.	2,83
6012A	1999	ITALY	0.6-1.4	0,50	0,40	0.20-1.0	0.6-1.2	0,30	...	0,30	0,20	...	...	0,7	...	...	...	0.40-2.0	...	...	...	0,05	0,15	Rem.	2,74
6020	1995	USA	0.40-0.9	0,50	0.30-0.9	0,35	0.6-1.2	0,15	...	0,20	0,15	...	...	...	...	...	0,05	0.9-1.5	...	...	...	0,05	0,15	Rem.	2,73
6021	2000	GERMANY	0.6-1.5	0,40	0,20	0.40-1.0	0.8-1.5	0,25	...	0,20	0,10	...	...	...	...	...	...	0.6-1.5	...	...	...	0,05	0,15	Rem.	2,72
6023	2001	SWITZERLAND	0.6-1.4	0,50	0.20-0.50	0.20-0.6	0.40-0.9	...	...	...	...	...	...	0.30-0.8	...	...	...	0.6-1.2	...	...	...	0,05	0,15	Rem.	2,73
6026LF	2004	ITALY	0.6-1.4	0,7	0.20-0.50	0.20-1.0	0.6-1.2	0,30	...	0,30	0,20	...	...	0.50-1.5	...	...	0,05	0,05	...	...	...	0,05	0,15	Rem.	2,74
6028	2006	SLOVENIA	1.0-1.3	0,50	0.25-0.40	0.6-0.9	0.7-1.0	0.04-0.10	...	0,30	0,20	...	...	0.6-0.8	...	...	...	0.6-0.8	...	...	...	0,05	0,15	Rem.	2,74
6033	2002	USA	0.8-1.3	0,50	0.40-1.0	0,05	0.7-1.3	0,10	...	0.50-1.0	0,15	...	...	0.30-1.0	...	...	0,05	...	...	...	...	0,05	0,15	Rem.	2,73
6040	2002	USA	0.40-0.8	0,7	0.20-0.8	0,15	0.8-1.2	0,15	...	0,25	0,15	...	...	0.15-0.7	...	...	...	0.30-1.2	...	...	...	0,05	0,15	Rem.	2,73
6041	2006	USA	0.50-0.9	0.15-0.7	0.15-0.6	0.05-0.20	0.8-1.2	0.05-0.15	...	0,25	0,15	...	...	0.30-0.9	...	...	...	0.35-1.2	...	...	...	0,05	0,15	Rem.	2,73
6043	2006	CHINA	0.40-0.9	0,50	0.30-0.9	0,35	0.6-1.2	0,15	...	0,20	0,15	...	...	0.40-0.7	...	...	...	0.20-0.40	...	...	...	0,05	0,15	Rem.	2,72
6050	2016	USA	1.2-1.8	1.3-1.8	0.15-0.50	0.20-0.7	0.50-0.9	0.05-.025	02.0-1.0	0.25	0.10	...	...	...	...	...	...	...	...	...	...	0,05	0,15	Rem.	2.74
6065	2005	BELGIUM	0.40-0.8	0,7	0.15-0.40	0,15	0.8-1.2	0,15	...	0,25	0,10	...	...	0.50-1.5	...	...	0,05	...	...	0,15	...	0,05	0,15	Rem.	2,72
6262A	2005	BELGIUM	0.40-0.8	0,7	0.15-0.40	0,15	0.8-1.2	0.04-0.14	...	0,25	0,10	...	...	0.40-0.9	...	...	...	0.40-1.0	...	...	...	0,05	0,15	Rem.	2,72

It is evident that all actual alloys with Lead have also Bismuth in combination, in quantities between 0.2 and 1.5%.
Lead free alloys do not have Bismuth added compared to Lead containing alloys. This information needs to be clearly understood, because the statement that Bismuth has been used as a replacement of Lead is false. Bismuth is present in Lead containing alloys in the same quantity than in Lead free alloys. Therefore any consideration of the negative impact of Bismuth is meaningless, because if we would need to avoid Bismuth, we would need to avoid Lead as well. Moreover ECHA stated that on Bismuth no hazards have been classified (https://echa.europa.eu/substance-information/-/substanceinfo/100.028.343), while we have to bear in mind that Lead is very toxic (https://echa.europa.eu/substance-information/-/substanceinfo/100.028.273).

b. Please provide information on research to find Lead-free alternatives (substitution or elimination) that may cover part or all of the applications in the scope of the exemption request at present or in the future.

Please see above.

c. Please provide a roadmap of such on-going substitution/elimination efforts and research (phases that are to be carried out), detailing the current status as well as the estimated time needed for further stages.

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Many Companies have already completely switched their production into Lead-free wrought aluminium alloys. A complete replacement takes from 6 months to some years, depending on the quantity of components. As Lead-free alloys are now available worldwide, from suppliers in all Continents, the process of switching speeded up in the last years.

3. The Umbrella Project states that "*this renewal request is based on the fact that only a very low amount of Leaded aluminium is still required for some niche applications*." In the answer to the clarification questions, the Umbrella Project specifies the following exact applications where Leaded aluminium alloys are still needed (see the summary above for more details):
• Cast and machined aluminium gear boxes from handheld tools;
• Charge holders for MEMS sensor applications;
• Stand-offs and spacers to electrically connect parts, such as heat sinks, in medical equipment.
Would it be possible to narrow down the scope of the exemption to these three specific applications?

a. Please explain why you either support or object the proposal to narrow the scope of the exemption to specific applications.
There is absolutely no technical need for Lead containing wrought aluminium alloys. In Annex 1 and Annex 2, all technical information to support this statement is provided.

b. To support your views, please provide detailed technical argumentation / evidence in line with the criteria in Art. 5(1)(a) to support your statement.
Please see above.

c. If the list is not exhaustive, please specify additional applications for which this exemption is needed.
No application needs Lead containing wrought aluminium alloys.

4. According to the Umbrella Project, the 3rd criterion of Art. 5(1) applies to the renewal request because the total negative environmental, health and consumer safety impacts caused by substitution with bismuth are likely to outweigh the total environmental, health and consumer safety benefits thereof.

a. Please explain why you either support or object the proposal to narrow the scope of the exemption to specific applications.

We do not support this argument.

b. Please provide detailed information to support your statement.

As stated under question 2.a., new Bi-only alloys do not have more Bi than Lead containing alloys, so the total quantity of Bi between Lead-free alloys and non-Lead-free alloys remains the same.

5. Please provide any further information and/or data that you think is of importance to substantiate your views.

New Lead-free wrought aluminium alloys (i.e. max Lead content of 0.1%) for machining purpose have been made globally available on the market since the last consultations, opening the path towards phasing out intentional additions of Lead in Aluminium, with first cases of successful substitution in the electrical and electronic equipment sector already happening. The Aluminium industry is ready to give any support its customers need to replace the Lead containing wrought aluminium alloys.
Our experts are ready to supply any additional information that would be required.
See also Annex 1 and 2 on next pages.

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Annex 1

Functionality / Property /Performance Aspect	Performance indicator (basis for monitoring the performance and comparing between Al alloys with & without Lead)	Performance (or performance range) enabled through the use of Lead-free alloy in relevant applications	Comments - Interrelations
Corrosion resistance of manufactured articles	Lead reacts to form halides, therefore it is not suitable in applications when ions Cl-, Br-, I-, F-, At- are present	Bismuth does not react, to form halides, so it is suitable	
Surface finish of manufactured articles	Good surface finish	Lead free alloys have better surface finishing. Pb+Bi create eutectic alloy with melting point at 125°C. Without Pb, Bi melting point is 271°C, so the alloy is harder and grants better (lower) roughness on the surface.	
Longer life of manufacturing tools and less energy consumption during machining of parts		Some Lead free alloys can be machined at lower cutting speed, increasing life of manufacturing tools. Life tools is much higher using tools for steel, which are cheaper and last much more, granting the same final result.	
Cutting speeds of manufacturing tools		Using common tools for steel, we can use same speeds or even lower speeds to get the same final results. There is no need to use specific expensive tools as CVD or PVD for non-ferrous metals.	
Lubrication effect in manufactured articles		No changes	
Better chip fracturing in manufactured articles		Using common tools for steel, Lead free alloys have much better attitude in drilling and milling, as well as machining and cutting.	
Temperature resistance		Bismuth-only based alloys (e.g. 6026LF and 2033) resist +146°C compared to Pb+Bi based alloys (e.g. 2011, 6262, 6012, 6042…)	
Electrochemical potential (of additive)	Pb2+ + 2e- <---> Pb = -0,13 Pb4+ + 2e- <---> Pb2++ = 1,67	Bi3+ + 3e- <---> Bi = +0,29 Sn2+ + 2e- <---> Sn = -0,1 Sn4+ + 2e- <---> Sn2+ = +0,15	Numbers in Volt, 25°C, 101KPa, 1M
Shrinking from liquid to solid phase (of additive)	Pb shrinks of 5,94%	Bi increases of 2,97% Sn increases of 3,93%	
Durability of part		No changes	
Eutectic point of alloy	Pb only melts at 327.5°C Pb+Bi melts at 124°C Pb+Sn melts at 183°C	Bi only melts at 271,5°C Sn only melts at 231,9 °C Sn+Bi eutectic melts at 139°C	
Heat treatable strength		No changes	

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Heat treatment performance	No changes
Fatigue strength	No changes
Anodizing response	Anodizing of Lead free alloys is much better compared to Lead containing alloys, due to the absence of Lead

In all cases where there are difficulties in switching from Lead containing alloys to Lead free alloys, Eural Gnutti has made a leaflet where there are all technical indications to reach the best productivity without losses, on the contrary in most cases there have been improvements in productivity and surface finishing.
http://www.eural.com/wp-content/uploads/EURAL_tips_for_machining.pdf
Please notice that suggested tools for proper Lead free machinability are not any special PVD or CVD, but common steel tools, which are largely available in the market as standard tools.

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Annex 2

As a sample, we are giving the evidence of a comparison of a valve made in alloy 2011 (Pb max 0,4%) and alloy 2033 (Lead free), same machine, same working parameters, same tools, same lubricants.

On the next page we indicate the measured roughness on the centre large hole of both samples.

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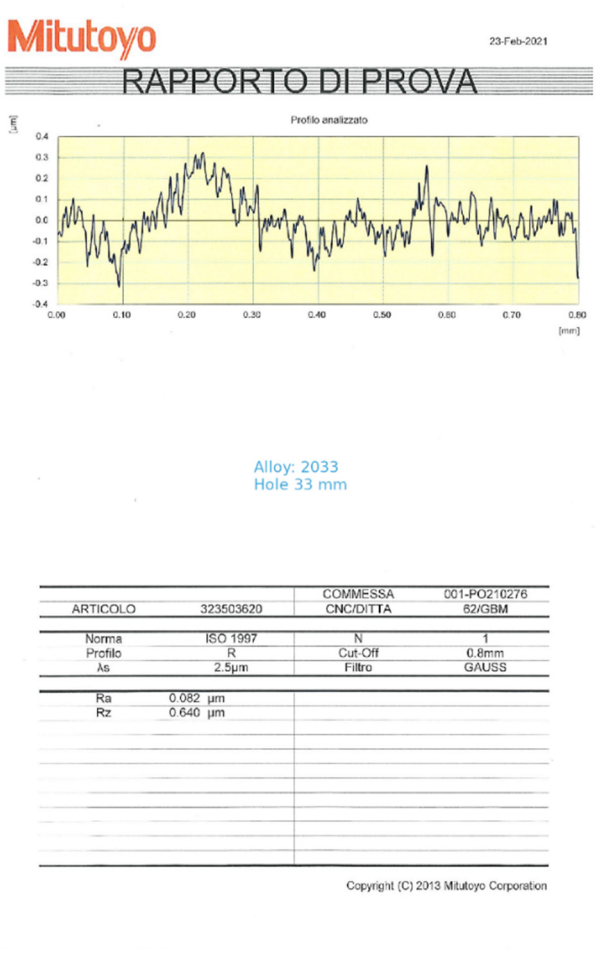
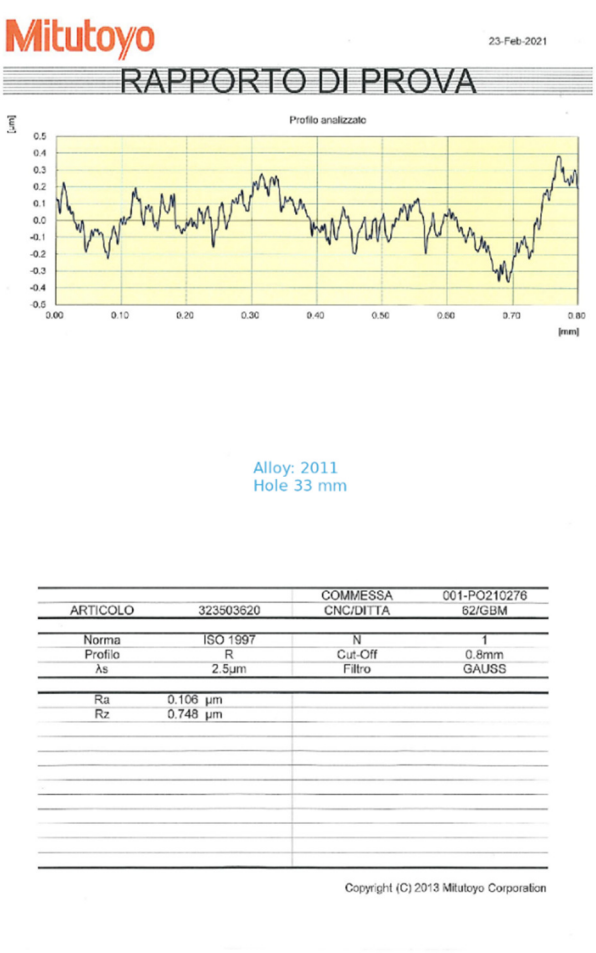


Alloy: 2033
Hole 33 mm



Alloy: 2011
Hole 33 mm

We drive your attention to Ra of 2033, which is 20% lower than 2011, and Rz of 2033 which is 15% lower than 2011.