FORGING & CASTING DIVISION

LUCCHINI RS GROUP

BEYLOS 2340®

The new approach
in the world of Hot Work Tools and
highly resistant plastic moulds

LOOK BEYOND

General characteristics

BeyLos® 2340 is a high alloyed Chromium-Molybdenum-Vanadium Hot Work Tool steel characterised by a low Silicon content and by other special micro-alloying elements.

BeyLos® 2340 has been expressly designed for tools that have to work in a wide temperature range without compromising toughness.

BeyLos® 2340 is suited for production of complex tools that need:

- increasing in toughness;
- elevated grade of micro purity;
- low segregation level.

BeyLos® 2340 is the result of years of research in the Metallurgical Department of Lucchini RS on the field of Hot Work Tool steels.

BeyLos® 2340 is an innovative steel grade able to support the most severe thermal stresses, without significant reduction in mechanical properties due to high temperature.

The strong points of this innovative steel grade are:

- high resistance to thermal shock and to heat cracking;
- good mechanical characteristics in hot and cold condition;
- excellent mechanical properties in the ductile-brittle transitional phases;
- excellent toughness in hot and cold conditions;
- high resistance to tempering;
- excellent machinability in annealed conditions.

BeyLos® 2340 is the ideal choice in hot applications where it is necessary to maintain unaltered the mechanical properties of the material in all the phases of the process, including the most critical moments on start-up.

BeyLos® 2340 is normally supplied in sections up to 500 mm in thickness, in annealed condition with hardness below 220 HB, to guarantee optimum machinability.

With suitable hardening followed by at least two appropriate tempers, BeyLos® 2340 can even reach a hardness up to 50 HRC, without penalising toughness.

Constant development in hot processing technologies require the use of BeyLos® 2340, thanks to its high resistance to thermal fatigue and to high temperature wear.

BeyLos® 2340 represents also one of the most important tough options, for highly resistant plastic moulds that need very high pressure strength, excellent resistance to abrasion, also in combination with different surface coatings, and improved toughness in the mean time.

The increasing in the use of synthetic and abrasive materials has led manufacturers to use BeyLos® 2340 also when suitability for polishing and graining, combined with abrasion and compression resistance, are required.

BeyLos® 2340 is 100% ultrasonically inspected, according to the most demanding of NDT standards, and it represents a innovative way to obtain high quality moulds, collecting a very long mould life and optimizing the environmental sustainability of the product, thanks to a strong reduction of non-renewable forms of energy.

It is difficult to predict the improvement that a innovative material will provide over the traditional one: it's only the feedback from service and the cooperation with Customers that can validate the longer mould life of the proposed materials.

BeyLos® 2340 is demonstrating impressive resistance to fatigue in many applications and a significantly longer mould life than conventional Hot Work Tool steel grades.

Continuous improvement of materials technology is managed in safety and in accordance with eco-consistency and sustainability criteria, because Lucchini RS believes that Safety and Environment are the main priorities in all the phases of the manufacturing process.

BeyLos® 2340 is also designed with the aim to guarantee the minimum use of virgin materials, moving toward the use of scrap categories difficult to be recycled, that can became food for the steel making production of BeyLos® 2340 grade.

Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	V [%]
BEYLOS® 2340 Alloying [% in weight]	min	0,32	0,10	0,30	4,80	1,20	0,30
	max	0,40	0,30	0,50	5,50	1,50	0,50

Main applications

BeyLos® 2340 lends itself to the following applications:

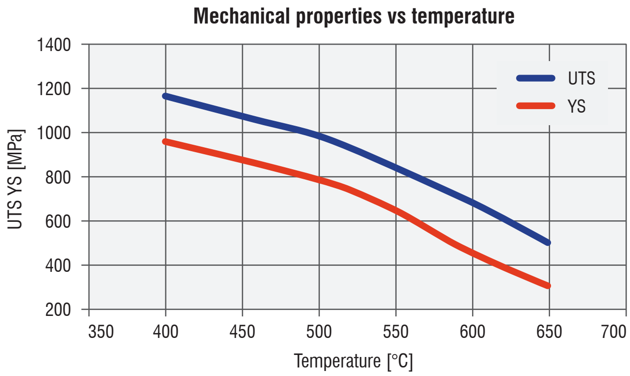
- dies for aluminium stamping;
- low pressure dies;
- moulds for gravity casting;
- containers for presses;
- matrices for aluminium extrusion;
- heels for extrusion presses;
- jackets for extrusion presses;
- injection moulds;
- special plastic moulds for the automotive industry and optical parts (head lamp components);
- dies and gauges for PVC extrusion.

Physical and mechanical properties

Main physical properties

BEYLOS® 2340	20°C	400°C	600°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	186	167
Coefficient of thermal expansion [10^{-6}/K]	-	12,0	12,8
Thermal conductivity [W/mK]	24,7	27,8	29,5

The data are average values taken from a test piece hardened at 980° C, quenched and with a final temper to give a hardness of 44 HRc.



Main mechanical properties

BEYLOS® 2340	400°C	500°C	600°C
Ultimate tensile strength (UTS) [MPa]	1.170	970	660
Yield stress (YS) [MPa]	920	760	485

Heat treatments

BeyLos® 2340 is supplied in the annealed condition.
If a different hardness is required or if heat treatment is needed, we suggest applying the following parameters.
This information is only indicative and must be adapted depending on the different heat treatment facilities employed and on the thickness of the bar.

Soft annealing

Recommended temperature	850°C
Heating	Max 50°C/h
Soaking time	Minimum 120 min from when the temperature settles
Cooling	Slow in the furnace at max 25 °C/h to **600°C**, then at room temperature

Soft annealing is recommended where it is necessary to improve the machinability of the tool. After annealing a hardness of max 220 HB is achieved.

Stress Relieving

Recommended temperature	650°C or 50°C lower than the tempering temperature previously applied
Heating	Max 100 °C/h
Soaking time	Minimum 120 min from when the temperature settles
Cooling	Slow in the furnace at max 25 °C/h to **200°C**, then at room temperature.

If the suggested temperature is lower than the tempering temperature, the stress relieving temperature will be 50° C lower than the tempering temperature previously applied.

Stress relieving is recommended where it is necessary to eliminate residual stresses induced by mechanical working or by a preceding heat treatment.

First pre-heating temperature	400 °C
Heating	Max 150 °C/h
Soaking time	25 min every 25 mm thickness or when (Ts-Tc) < 90 °C

Second pre-heating temperature	600 °C
Heating	Max 150 °C/h
Soaking time	20 min every 25 mm thickness or when (Ts-Tc) < 90 °C

Third pre-heating temperature	800 °C
Heating	Max 150 °C/h
Soaking time	20 min every 25 mm thickness or when (Ts-Tc) < 90 °C

Austenitising temperature	980°C
Heating	> 150°C/h
Soaking time	t = (x + 39) / 2 or 30 min from when (Ts-Tc) < 15 °C
Cooling	air, vacuum cooling, salt bath, polymer in H2O
Hardness after quenching	54 ÷ 55 HRc

Hardening

Hardening should be carried out after the material has been pre-heated according to the following table.

We suggest to carry out hardening on material supplied in the annealed condition and tempering immediately afterwards.

The first preheat at 400°C is advisable to eliminate the accumulated stresses caused by machining. The successive preheats at 600°C and 800°C are necessary to homogenise the temperature of the piece. rate of heating is 150 °C/h for hour max.

The soaking time is calculated from the thickness of the piece and will vary with the temperature, as indicated in the table.

Alternatively, the times can be calculated from the difference between the temperature in the core (Tc) and surface (Ts) of the piece, measured by means of two thermocouples.

After the third preheat at 800°C, it is recommended to achieve the austenitising temperature as quickly as possible, and to maintain that temperature for 30 minutes from when the condition (Ts-Tc) < 15 °C or by applying the following empirical formula:

$t = (x + 39)/2$
t = soaking time [min]
x = thickness [mm]

Tempering

It is recommended to set the temperature of the first temper in proximity with the secondary hardness at 580 °C. The temperature of the second temper will be chosen having regard to the mechanical properties to achieve and in any case must be higher than the temperature of the first temper.

The soaking time for the first and second tempers are calculated by applying the following empirical formula:

$t' = t'' = 0.8\,x + 120$
where:
$t' = t''$ = soaking time [min]
x = thickness [mm]

A third temper can be useful as a stress relieve at a temperature that is 30-50 °C below the maximum temperature previously imposed. Tempers between 400°C and 550°C are not advisable because they reduce the toughness of the material.

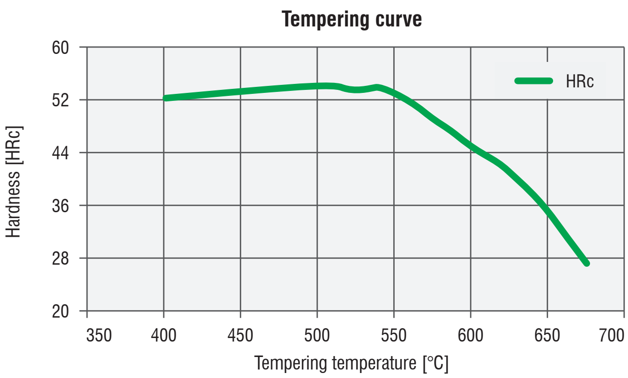
Tempers below 200 °C are not recommended.
The soaking time of the third temper are calculated from the following empirical formula:

$t''' = 0.8\,x + 120$
where:
t''' = soaking time [min]
x = thickness [mm]

First tempering temperature	550 - 580 °C
Soaking time	$t' = 0,8\,x + 120$
Cooling	Room temperature

Second tempering temperature	580 °C
Soaking time	$t' = 0,8\,x + 120$
Cooling	Room temperature

Third tempering temperature	30-50 °C lower than the max temperature previously applied
Soaking time	$t''' = 0,8\,x + 180$
Cooling	Slow cooling in the furnace up to 250°C, then at room temperature



Tempering curve of a sample which has been austenitised at 980 °C. The diagram shows values obtained after the second temper.

Variation in dimensions during heat treatment

During the heat treatment of BeyLos®2340 the phase transformation points are exceeded. Inevitably this causes a variation in the volume of the material. For this reason we recommend leaving enough machining allowance to compensate for the change of dimension due to heat treatment. All the corners should be rounded off.

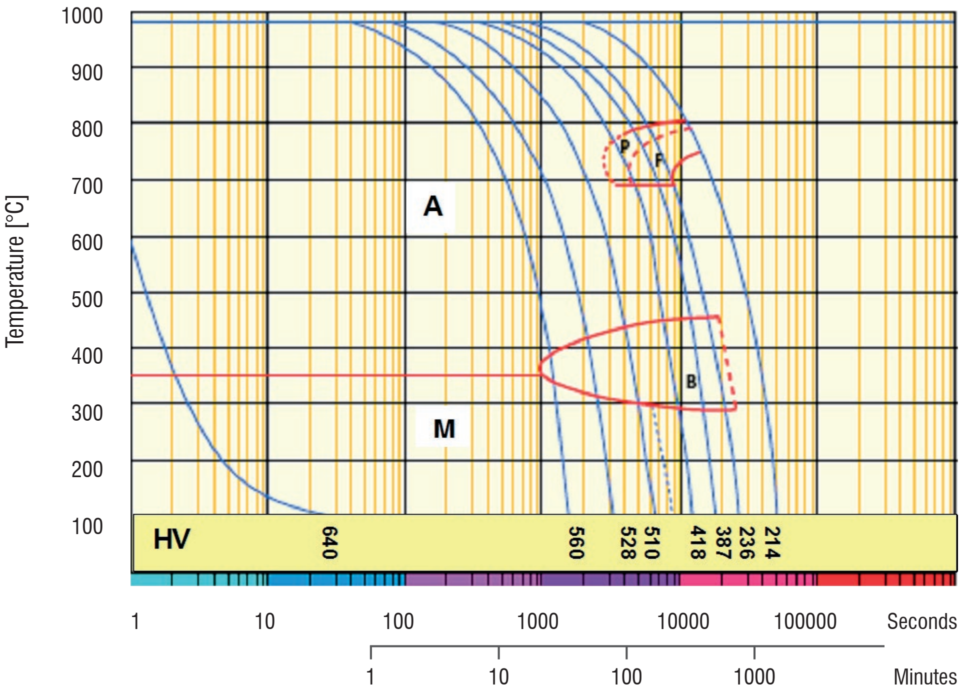
Nitriding

The purpose of nitriding is to increase the resistance of the material to wear and abrasion. This treatment is very useful for components where high performance is necessary, as it extends the life of the material. We suggest nitriding the component in the hardened and tempered condition. The tempering temperature must be at least 50 °C higher than the nitriding temperature.

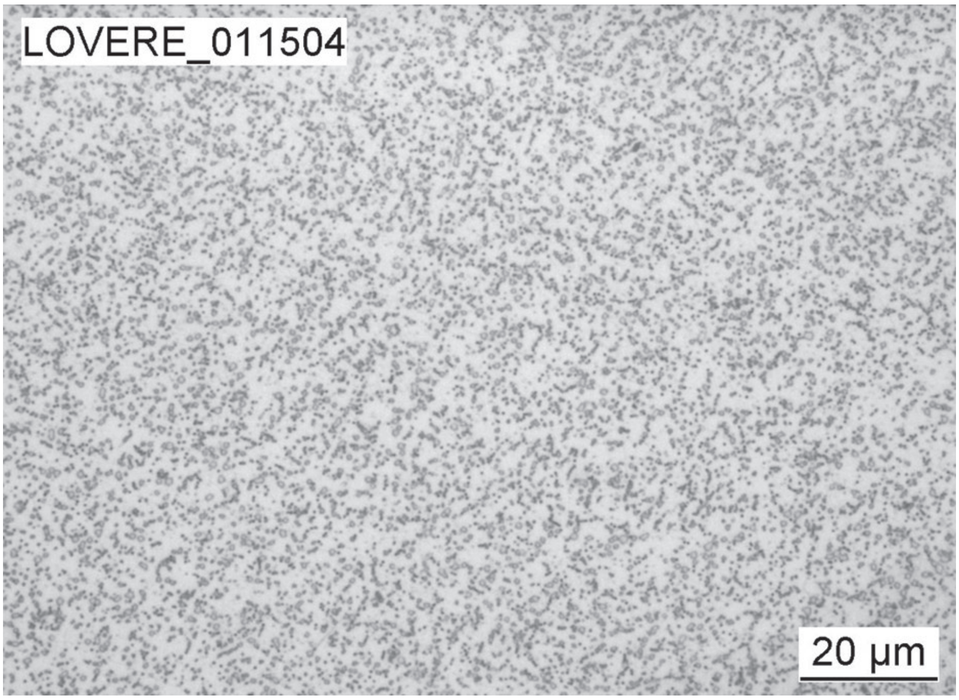
Modern nitriding processes allow the original dimensions of the component to be maintained. We recommend heat treating the component in the finish machined condition.

In any case, other properties can be analyzed and studied deeper by Lucchini RS on specific Customer request: please consult Lucchini RS specialists of MET Department.

CCT Curve

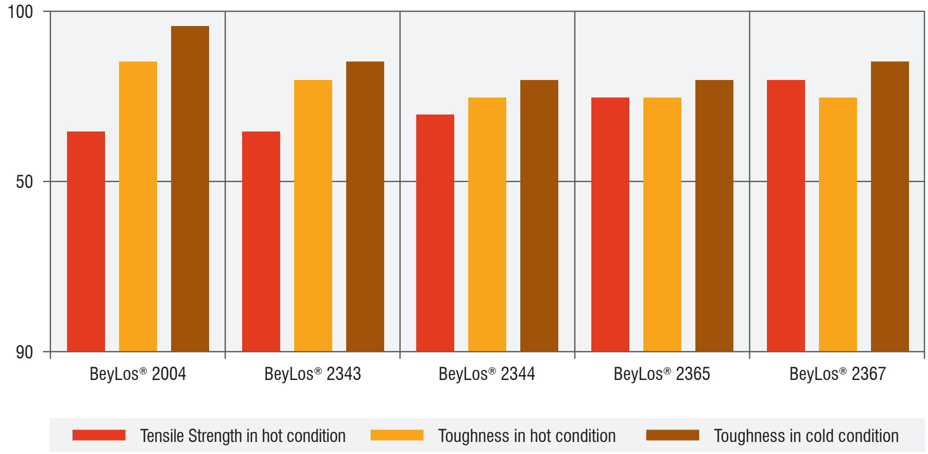


Annealed microstructure of BeyLos® 2340



The annealed microstructure of the as received steel consists essentially of a ferritic matrix with a homogeneous distribution of spheroidized carbides, when examined at 500X, after being polished and etched with 4% Nital.

Comparison of properties of different hot work tool steel



Quick comparison guide among the different Hot Work Tool Steel Grades

The following table shows a quick comparison among the most important characteristics of the Hot Work tool Steel grades produced by Lucchini RS.

Special features and delivered conditions	Lucchini RS Hot Work tool Steel Family														
	Annealed Not Corrosion Resistant														
	KEYLOS	BEYLOS								ESKYLOS					
	6959	2329	2711	2714	2340	2343	2344	2365M	2367	6959	2340	2343	2344	2365M	2367
HB in surface In Annealed condition	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220
HB in surface Hardened after machining	370 - 410	370 - 410	370 - 410	370 - 410	400 - 450	400 - 450	400 - 450	400 - 450	400 - 450	370 - 410	400 - 450	400 - 450	400 - 450	400 - 450	400 - 450
Maximum thickness [mm]	500	600	500	700	500	500	500	500	500	500	500	500	500	500	500
Hardness and Wear Resistance	3	3	3	3	4	4	4	4	4	3	4	4	4	4	4
Degree of Through Hardening in the section	4	2	3	3	3	3	3	3	3	4	3	3	3	3	3
Toughness	4	1	4	4	3	3	2	2	2	4	3	3	2	2	2
Machinability after Annealing	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Machinability after Hardening	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Etch-Grainability	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4
Polishability	2	2	2	2	2	2	2	2	2	4	4	3	3	4	3
Repair by Welding	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Thermal Conductivity	2	2	2	2	1	1	1	1	1	2	1	1	1	1	1
Corrosion Resistance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4 Excellent **3 Very Good** **2 Good** **1 Normal** **0 Unsuitable**

The information and the data presented here are typical or average values and are not a guarantee of maximum or minimum values.

Applications specifically suggested for materials described herein and in the quick comparison guide among the different grades are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.

Guidance for machining

The following parameters are indicative only and must be adapted to the particular application and to the machinery employed. The data refer to material in the annealed condition. Hardness 220 HB max.

Turning

	Rough machining	Finish machining		
Type of insert	P20-P40 coated	HSS	P10-P20 coated	Cermet
V_c cutting speed [m/min]	170 ÷ 220	(*)	200 ÷ 250	240 ÷ 300
a_r cutting depth [mm]	1 ÷ 5	(*)	< 1	< 0,5

Milling

	Rough machining		
Type of insert	P25-P35 not coated	P25-P35 coated	HSS
V_c cutting speed [m/min]	160 ÷ 240	180 ÷ 280	(*)
f_z feed [mm]	0,15 ÷ 0,3	0,15 ÷ 0,3	(*)
a_r cutting depth [mm]	2 ÷ 4	2 ÷ 4	(*)

	Pre-finishing		
Type of insert	P10-P20 not coated	P10-P20 coated	HSS
V_c cutting speed [m/min]	180 ÷ 260	200 ÷ 280	(*)
f_z feed [mm]	0,2 ÷ 0,3	0,2 ÷ 0,3	(*)
a_r cutting depth [mm]	1 ÷ 2	1 ÷ 2	(*)

	Finishing		
Type of insert	P10-P20 not coated	P10-P20 coated	Cermet P15
V_c cutting speed [m/min]	200 ÷ 280	220 ÷ 300	240 ÷ 330
f_z feed [mm]	0,05 ÷ 0,2	0,05 ÷ 0,2	0,05 ÷ 0,2
a_r cutting depth [mm]	0,5 ÷ 1	0,5 ÷ 1	0,3 ÷ 0,5

(*) not advisable

Drilling

Type of insert	tip with interchangeable inserts	HSS	brazed tip
V_c cutting speed [m/min]	190 ÷ 220	(*)	60 ÷ 80
f_z feed per turn [mm/turn]	0,05 ÷ 0,15	(*)	0,15 ÷ 0,25

(*) not advisable

General formulae

Type of machining	Drilling	Milling
n: number of turns of mandrel	$V_c * 1000 / \pi * D_c$	$V_c * 1000 / \pi * D_c$
V_f: feed speed [m/min]	$V_f = f_z * n$	$V_f = f_z * n * z_n$
f_z feed per turn [mm/turn]	-	$f_n = V_f / n$
Note	D_c: Milling cutter or tip diameter [mm] V_c: cutting speed [m/min] f_z: feed [mm]	f_n: feed per turn [mm/turn] z_n: No. of milling cutter inserts

Approximate equivalent values between hardness and ultimate tensile strength.

HB	530	520	512	495	480	471	458	445	430	415	405	390	375
HRc	54	53	52	51,1	50,2	49,1	48,2	47	45,9	44,5	43,6	41,8	40,5
MPa	1.900	1.850	1.800	1.750	1.700	1.650	1.600	1.550	1.500	1.450	1.400	1.350	1.300

HB	360	350	330	320	305	294	284	265	252	238	225	209	195
HRc	38,8	37,6	35,5	34,2	32,4	31	29	27	--	--	--	--	--
MPa	1.250	1.200	1.150	1.100	1.050	1.000	950	900	850	800	750	700	650

The information and the data presented here are typical or average values and are not a guarantee of maximum or minimum values.

Applications specifically suggested for materials described herein and in the quick comparison guide among the different grades are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.

Welding

Welding of BeyLos® 2340 can give good results if the recommended procedure is followed. Being steel with high Carbon Equivalent content, BeyLos® 2340 is very sensitive to cracking. We recommend carrying out pre-heating and heat treatment after welding.

Condition of material	Annealed with hardness 220 HB max	
Welding technique	TIG	MMA
Pre-heating at	330÷380 °C	
Recommended heat treatment	Heating of the material at 850 °C, cooling in the furnace to 600 °C at a rate of 20 °C/h, cooling at room temperature	
Condition of material	Hardened and tempered	
Welding technique	TIG	MMA
Pre-heating at	330÷380 °C	
Recommended heat treatment	650 °C or 50 °C lower than the tempering temperature previously applied	

Electrical Discharge Machining (EDM)

BeyLos® 2340 can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

Chrome Plating

BeyLos® 2340 can be Chrome plated in order to enhance the mechanical characteristics on the surface.

Within 4 hours of Chrome plating, in order to prevent Hydrogen embitterment it is advisable to carry out heat treatment at 200°C for about 4 hours.Photo-engraving.

Photo-engraving

Thanks to modern production processes and to the low Sulphur content, BeyLos® 2340 is suitable for photo-engraving to obtain various patterns.

Polishing

BeyLos® 2340 is particularly suitable for polishing.

If a mirror finished die is required, we recommend using the ESR version of this steel, known as EskyLos® 2340.

Process and materials selection for product recyclability

According to the potential of steel recycling, Lucchini RS is adopting a strategy for environmental excellence in designing and manufacturing of its tool steel grades, putting eco-effectiveness into practice.

The main adopted steps are:

- conducting an environmental assessment on processes and products, with the minimum use of virgin materials and non-renewable forms of energy;
- moving toward zero-waste manufacturing processes, considering that the ultimate destinity of a scrapped steel mould becomes food for the next steel making process, that is the “waste equals food” philosophy;
- conducting a life cycle assessment for-each product and process, minimizing the environmental cost of product and service over its entire life cycles, from creation to disposal, that is the ”Cradle to Cradle” philosophy.

FORGING & CASTING DIVISION

LUCCHINI RS GROUP

Lucchini RS S.p.a.
Via Giorgio Paglia, 45
24065 Lovere (BG) - Italy
Phone +39 035 963566
info@LucchiniRS.com

Lucchini Industries S.r.l.
Via Oberdan, 6/A
25128 Brescia - Italy
Phone +39 035 963566
info@LucchiniRS.com

Lucchini Mamé Forge S.p.a.
Via delle Cave, 1
25040 Cividate Camuno (BS) - Italy
Phone +39 0364 347711
info@LucchiniRS.com

Lucchini Tool Steel S.r.l.
Via dei Piazzoli, 1
24040 Suisio (BG) - Italy
Phone +39 035 4936611
info@LucchiniToolSteel.com