FORGING &
CASTING
DIVISION

GROUP
LUCCHINI RS

KEY® LOS PLUS

Special and Innovative
pre-hardened mould steel
with homogeneous hardness
in the full section, high machinability
and easy weld repair

LOOK BEYOND

General characteristics

KeyLos® PLUS is a special and innovative pre-hardened alloyed steel, suitable for the manufacture of a large amount of injection moulds.

This steel has been designed to enhance in the moulds the following characteristics:

- high degree of homogeneity of hardness and toughness in the section;
- good weldability, in case of repair;
- better machinability, reduction in cutting insert cost, shorter machining time;
- better surface quality and polishability, due to the high cleanliness and fine microstructure;
- shorter injection cycle time, due to the high thermal conductivity.

KeyLos® PLUS is obtained through a special 'super clean' manufacturing process and a special suited heat treatment process.

KeyLos® PLUS is normally supplied in the pre-hardened condition with a surface hardness range of 300-350 HB.

For the detected hardness values in standard sized products, the following correlation is usually valid and guaranteed:

$$(HB_{Surface,min\ required} - HB_{Core}) \leq 20HB$$

Thanks to the carefully designed chemical analysis and to the particular manufacturing process, KeyLos® PLUS is characterised by a high homogeneity of mechanical characteristics in the whole section and it is suitable for the production of blocks up to 800 mm thick.

Taking into consideration its low Carbon Equivalent content, KeyLos® PLUS offers good weldability levels, if compared to the other grades normally used in this field; hence, KeyLos® PLUS is also safer subjected to repairs without compromising their integrity.

Being Calcium treated, KeyLos® PLUS has an excellent level of machinability, micro-purity and micro-structural homogeneity.

KeyLos® PLUS offers the following advantages:

- excellent machinability;
- excellent hardness and toughness homogeneity levels and wear resistance;
- excellent suitability for photo-engraving;
- excellent suitability for polishing;
- excellent suitability for nitriding, in order to increase the surface wear resistance;
- internal homogeneous hardness on blocks with thickness up to 800 mm;
- good weldability, in case of repair.

Constant development in processing technologies of high quality plastic parts is requiring the use of KeyLos® PLUS, thanks to its high fatigue and wear resistance, combined with its excellent homogeneity, machinability and extremely low thermal conductivity.

KeyLos® PLUS represents one of the most important tough options, for highly resistant and large sized plastic moulds that need very high pressure strength and excellent resistance to abrasion.

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

KeyLos® PLUS is 100% ultrasonically inspected, according to the most demanding of NDT standards.

KeyLos® PLUS represents a quick way to obtain high quality plastic parts, collecting a quite long mould life and optimizing the environmental sustainability of the product, with a steel grade that guarantees the minimum use of virgin materials.

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.

KeyLos® PLUS is demonstrating good resistance to fatigue in many applications and a significantly longer mould life than conventional 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.

Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	Ni [%]
KEYLOS PLUS Alloying [% in weight]	min	0,25	0,30	1,40	1,40	0,40	0,20
	max	0,35	0,60	1,70	1,80	0,60	0,60

Table for comparision of international classification

W. Nr. /
DIN designation: **≈32MnCrMo6-6-5**

Main applications

KeyLos® PLUS is suitable for the following applications.

Plastic moulding:
- medium and big sized moulds for the automotive industry;
- moulds for the food industry;
- pressure moulds (SMC, BMC);
- bolsters.

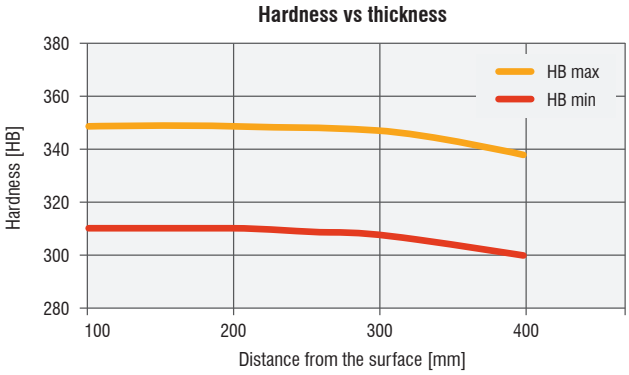
Extrusion:
- dies and gauges for PVC extrusion;
- mechanical parts for extrusion presses.

Physical and mechanical properties

Main physical properties

KEYLOS PLUS	20°C	250°C	500°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	193	175
Coefficient of thermal expansion [10^{-6}/K]	-	12,7	14,8
Thermal conductivity [W/mK]	34,8	34,3	33,9

These values are average values obtained from the middle of the section of a 600 mm thick bar, subjected to hardening at 900 °C, quenching and tempering at 600 °C.



Main mechanical properties

KEYLOS PLUS	20°C	200°C
Ultimate Tensile strength (UTS) [MPa]	1.020	910
Yield stress (YS) [MPa]	960	765

Heat treatments

KeyLos® PLUS is supplied in the pre-hardened condition. If it is necessary to obtain different hardness levels or if a heat treatment cycle is necessary, the parameters in the following table are recommended. The attached data are for information purposes only and must be varied dependent on the heat treatment facility and the thickness of the bar.

Soft annealing

Suggested temperature	700 °C
Soaking time	60 min every 25 mm thickness
Cooling	slow in the furnace at max 20 °C/h to **600 °C**, then at room temperature

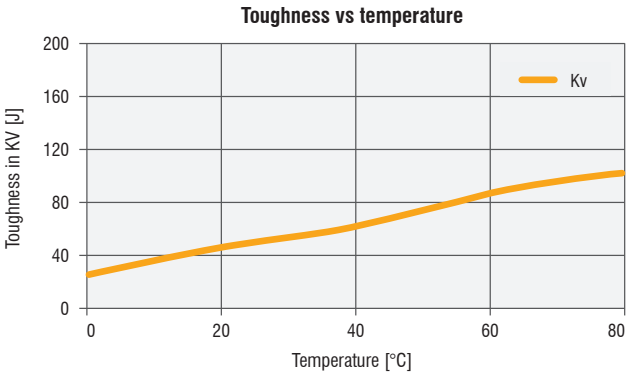
Soft annealing is useful to improve machinability. The obtained hardness is lower than 250 HB.

Stress Relieving

Suggested temperature	550 °C
Soaking time	60 min every 25 mm thickness
Cooling	slow in the furnace at max 20 °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 heatreatment.



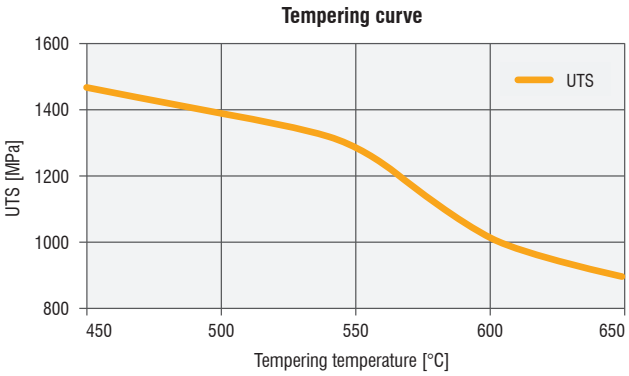
Hardening

Suggested temperature	900 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

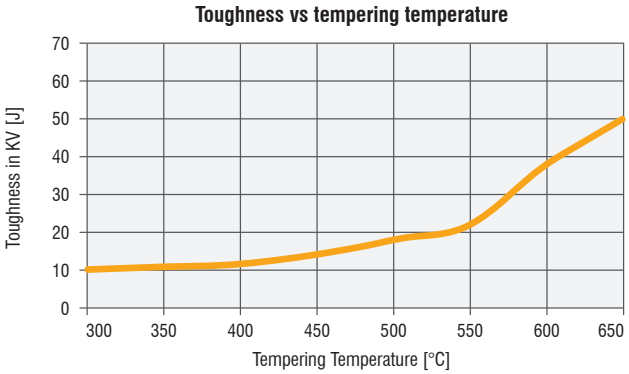
We suggest to carry out hardening on material supplied in the annealed condition and tempering immediately afterwards.

Tempering

Suggested temperature	The tempering temperature to be applied to the material depends on the required mechanical properties. See following graph.
Soaking time	60 min every 25 mm thickness
Cooling	Room temperature



Tempering curve of a sample which has been austenitised at 900 °C.



After tempering we suggest carrying out stress relieving at a temperature lower than 50 °C.

Induction hardening

On this steel it is possible to carry out induction hardening.

We recommend cooling at room temperature and tempering after heat treatment.

Nitriding

KeyLos® PLUS is suitable for ionic and gas nitriding. This treatment is very useful for moulds or dies subjected to extremely stressful applications. The increase of the surface hardness, following nitriding, lengthens the component life cycle.

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

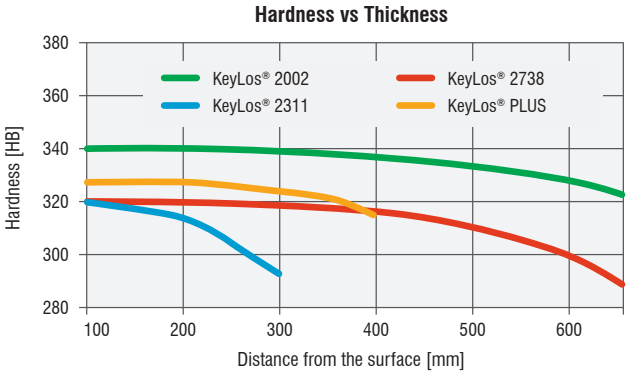
We recommend the following manufacturing cycle, in order to obtain the best results:

- rough machining;
- stress relieving;
- finish machining;
- nitriding.

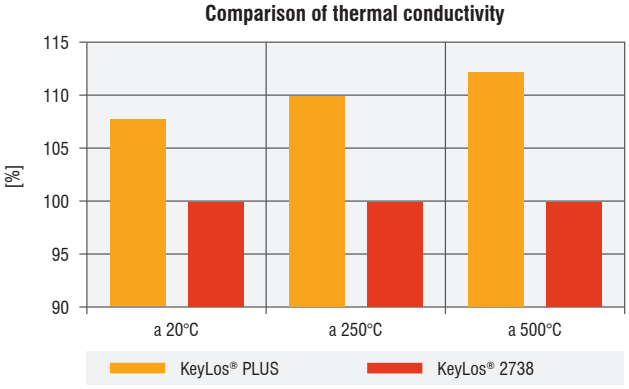
In any case, other properties can be analyzed and studied deeper by Lucchini RS on specific Customer request: please consult Lucchini RS specialists of MET Department.

KeyLos® PLUS compared to other grades

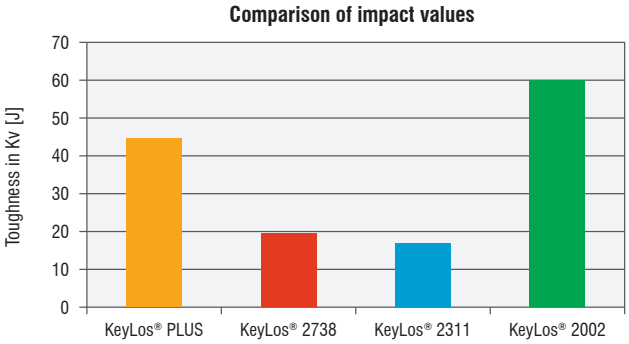
Average values of hardness variation related to thickness of blocks made of KeyLos® PLUS, KeyLos® 2002, KeyLos® 2738 and KeyLos® 2311.



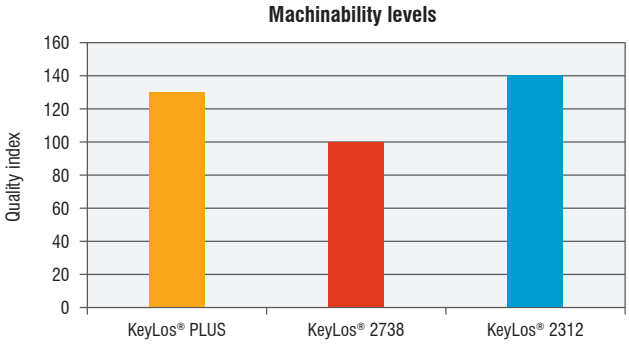
Comparison of thermal conductivity between KeyLos® PLUS and KeyLos® 2738.



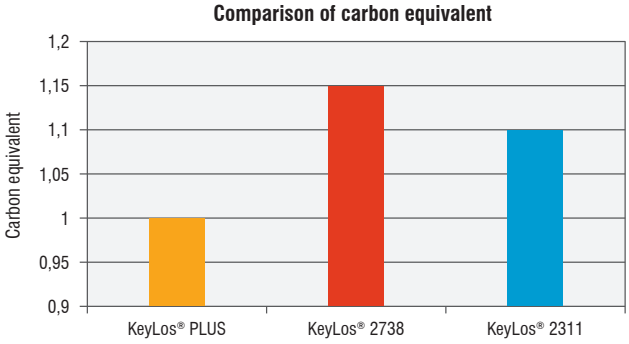
Comparison of impact values among KeyLos® PLUS, KeyLos® 2738 and KeyLos® 2311. The comparison has been made on blocks with the same hardness, at a temperature of 20 °C.



Machinability levels of KeyLos® PLUS, KeyLos® 2738 and KeyLos® 2312.



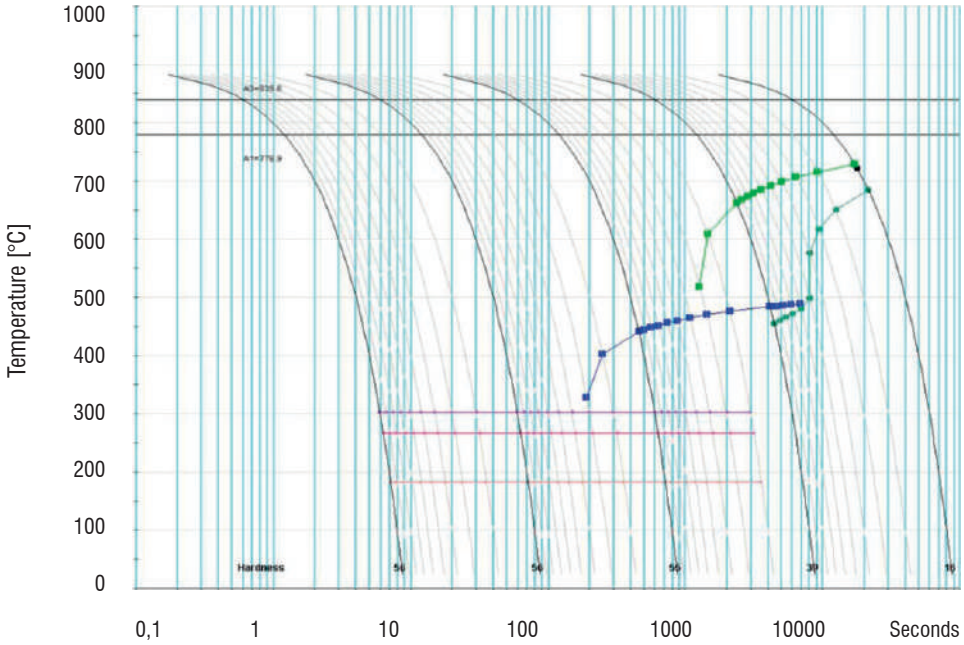
Comparison of Carbon Equivalent content between KeyLos® PLUS, KeyLos® 2738 and KeyLos® 2311.



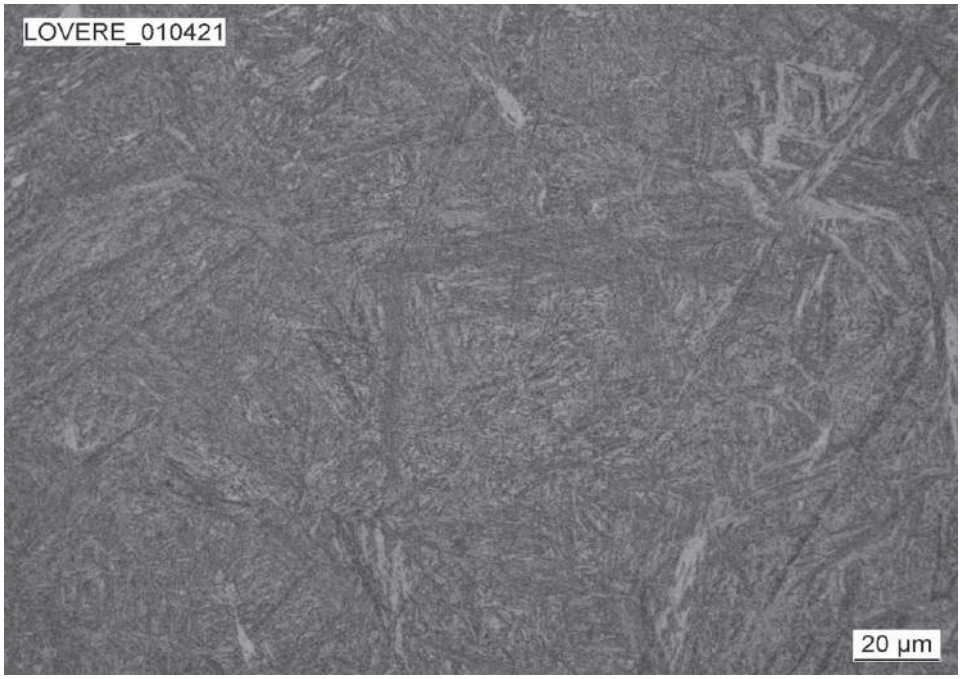
KeyLos® PLUS has a lower Carbon Equivalent content than other grades normally used in this field.

This implies better weldability and low risk of cracking, making welds of a finished mould easier to carry out.

CCT Curve



Microstructure of KEYLOS® PLUS



The microstructure of KeyLos® PLUS as delivered by Lucchini RS, detected about 20 mm under surface, consists of a fine tempered martensite.

Guidance for machining

The following parameters are indicative only and must be adapted to the particular application and to the machinery employed.

Turning

	Rough machining	Finish machining		
Type of insert	P20-P40 coated	HSS	P10-P20 coated	Cermet
V_c cutting speed [m/min]	150 ÷ 190	(*)	190 ÷ 230	260 ÷ 320
a_r cutting depth [mm]	5	(*)	< 1	< 0,5

Milling

	Rough machining		
Type of insert	P25-P35 not coated	P25-P35 coated	HSS
V_c cutting speed [m/min]	120 ÷ 140	160 ÷ 180	(*)
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]	140 ÷ 160	180 ÷ 200	(*)
f_z feed [mm]	0,2 ÷ 0,3	0,2 ÷ 0,3	(*)
a_r cutting depth [mm]	< 2	< 2	(*)

	Finishing		
Type of insert	P10-P20 not coated	P10-P20 coated	Cermet P15
V_c cutting speed [m/min]	200 ÷ 240	250 ÷ 270	300 ÷ 340
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]	130 ÷ 160	(*)	90 ÷ 120
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 comparison between hardness and ultimate tensile strength values.

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

Welding

Welding of KeyLos® PLUS can give good results if the following procedure is observed:

Welding technique	TIG	MMA
Pre-heating at	250÷300 °C	
Recommended heat treatment	Stress relieving (see heat treatment paragraph)	

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.

Electrical Discharge Machining (EDM)

KeyLos® PLUS can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

Chrome Plating

KeyLos® PLUS 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 embrittlement, it is advisable to carry out heat treatment at 200°C for about 4 hours.

Photo-engraving

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

Polishing

KeyLos® PLUS is particularly suitable for polishing.