PLASTIC MOULD

KEYLOS®UP

VALUE IN PERFORMANCE

THE CUSTOMISED SOLUTION FOR PLASTIC MOULDS

General characteristics

KEYLOS® UP is a special and innovative pre-hardened steel with improved penetration hardening, machinability and polishability, obtained through a special 'super clean' manufacturing process, which allows high level of micro-cleanness.

Lucchini RS has developed KEYLOS® UP, in order to meet all relevant quality requirements that the current state of mould making and plastics processing technologies need.

High levels of machinability and microstructural homogeneity are obtained thanks to a calcium treatment process on liquid steel and to a careful heat treatment process.

One of the main characteristics of KEYLOS® UP is the wide size range for which it is reliable, the optimal degree of homogeneity in mechanical properties and toughness in the whole section.

Nickel alloying up to 0.60% significantly increases hardness and toughness on the whole section and permit to significantly increase the mould lifetime if compared with conventional steel grades.

Delivery conditions

KEYLOS® UP is supplied in quenched and tempered condition in a wide dimensional range, from 200 mm up to 800 mm in thickness.

The surface hardness is 280 – 330 HB and the mid-thickness hardness value is guaranteed in section up to 800 mm, according to the following correlation: $(HB_{Surface,min\ required} - HB_{Core}) \leq 20HB$

Main features

- good machinability;
- good suitability for photo-engraving;
- good suitability for polishing;
- excellent suitability for nitriding, in order to increase the wear surface resistance;
- good wear resistance in the whole section of the mould;
- homogeneous hardness values and high toughness in the whole section of the mould

Main application

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

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

The content of this document is intended for information only and cannot be considered as binding in connection with the supply of material.

Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	Ni [%]
KEYLOS®UP Alloying [% in weight]	min	0,38	0,20	1,40	1,90	0,15	0,30
	max	0,48	0,50	1,70	2,30	0,30	0,60

Comparison with international classifications:
W. Nr. 1.2738 mod.
DIN: 40CrMnNiMo8.3.3

Physical and mechanical properties

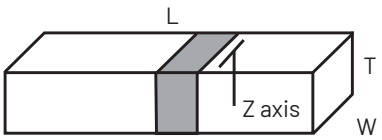
Main physical properties

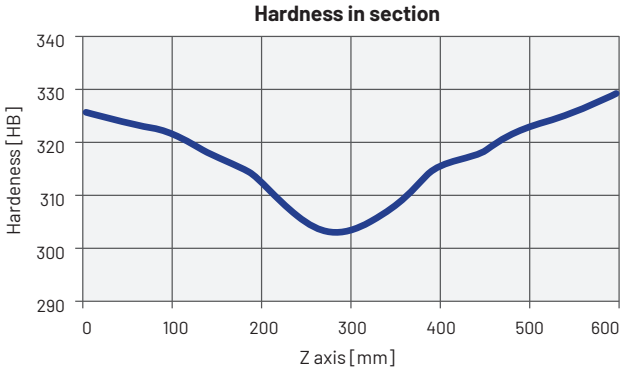
KEYLOS®UP	20°C	250°C	500°C
Young modulus E [MPa]	210	196	177
Coefficient of linear thermal expansion α [10-6/K]	-	12,7	14,3
Thermal conductivity λ [W/mK]	32,0	31,1	30,0

Main mechanical properties

KEYLOS®UP	20°C	200°C
Ultimate tensile strength UTS [MPa]	1020	900
Yield strength YS [MPa]	900	760
Elongation A [%]	17	18
Reduction in area Z [%]	53	55

Hardness profile





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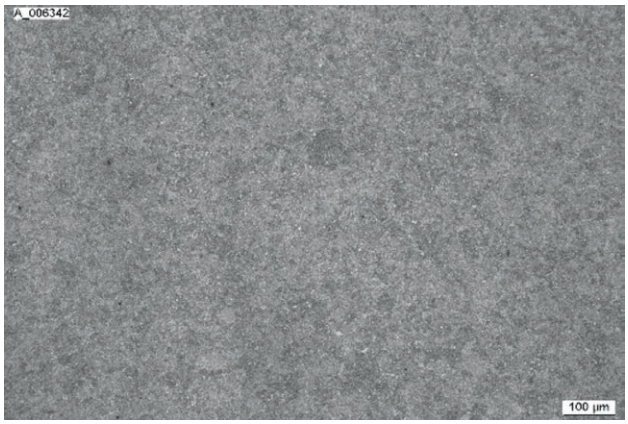
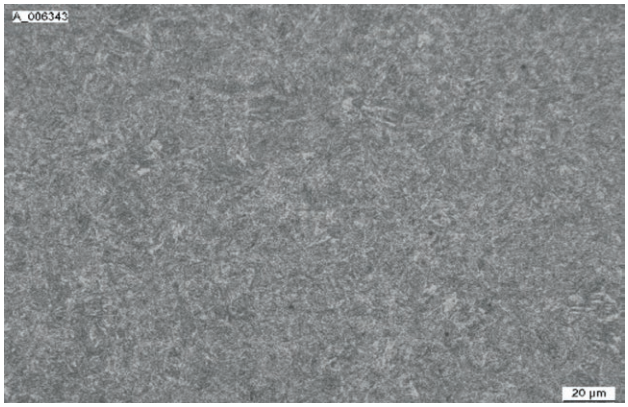
Microstructure

The main microstructure of KEYLOS® UP is tempered martensite.

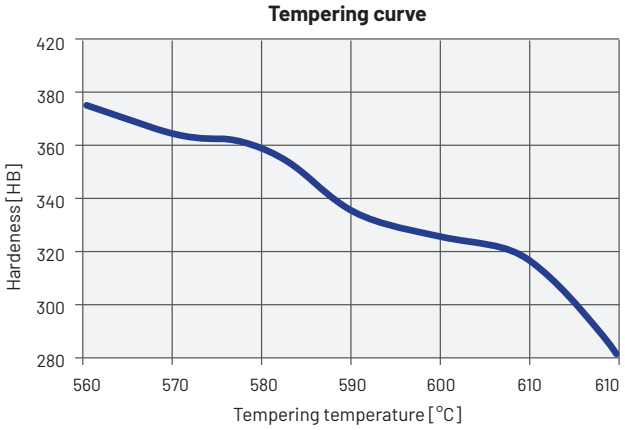


100x

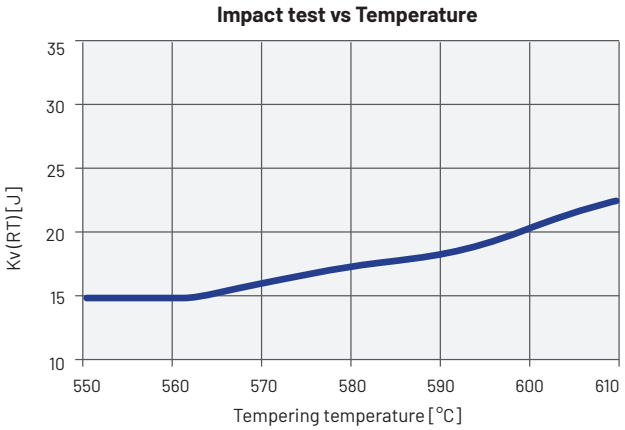


500x

Surface hardness vs tempering temperature



Toughness (Charpy V-notch test at 20°C) vs tempering temperature



Remark: the above data are representative of the typical behaviour of a 600 mm thick block made in KEYLOS® UP and are reported for information only

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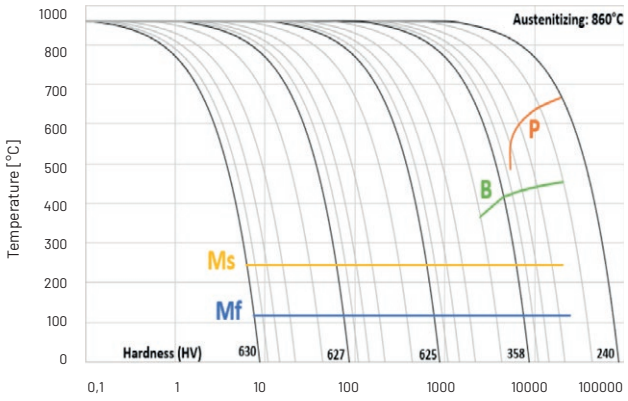
Heat treatment

KEYLOS® UP is supplied in quenched and tempered conditions with no need for additional heat treatment operations.

However, if different hardness/heat treatment procedure are required, we recommend the following parameters.

Note that the reported data are for information purpose only and must be adjusted to the heat treatment facility and the dimensions of the block therefore, before carrying out any heat treatment operation, it is strongly recommended to contact Lucchini RS for help and support.

Continuous cooling transformation curve (CCT)



Soft annealing

Suggested temperature	700 °C
Soaking time	60 min every 25 mm thickness
Cooling	Slow cooling in furnace (20°C/h)

Soft annealing is useful to improve machinability reducing hardness at 250 HB.

Stress relieving

Suggested temperature	550 °C
Soaking time	60 min every 25 mm thickness
Cooling	Slow cooling in furnace (20°C/h)

Stress relieving is recommended to reduce the tensions generated by certain manufacturing operations (e.g. machining) without affecting the hardness in the as-delivered conditions.

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.

Hardening

Suggested temperature	860 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

Tempering

Suggested temperature	Depending on the required mechanical properties
Soaking time	120 min every 25 mm thickness
Cooling	Still air

The tempering temperature should be selected form the graph "Tempering curve" reported above.

After tempering we suggest to carry out stress relieving at temperature 50 °C lower than the last tempering temperature.

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Induction hardening

KEYLOS® UP is suitable for induction hardening. We recommend cooling at room temperature and tempering after induction hardening.

Nitriding

KEYLOS® UP is suitable for ionic and gas nitriding. This treatment is very useful for moulds subjected to extremely stressful applications.

The increase of the surface hardness, following nitriding, extends the component life cycle.

Up-to-date nitriding procedures allow to minimize the dimensional variation of the piece.

In order to obtain the best results, we recommend the following manufacturing procedure:

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

Other properties can be deeper analysed against specific Customer request: please contact our Metallurgy Department.

Polishing and photo-engraving

KEYLOS® UP is the suitable material when polishing and photoengraving are needed. Thanks to its integrated manufacturing process, those material manufactured by Lucchini RS are characterized by a high degree of purity.

Polishing for graining: 3 Very Good
Suitability for medium gloss polishing: 3 Very Good
Suitability for mirror polishing: 2 Good
Suitability for engraving: 3 Very Good

Rating scale:
4 Excellent – 3 Very good – 2 Good – 1 Normal – 0 Unsuitable

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Guidance for machining

The following parameters are approximate only and must be adjusted to the specific application and machine tool.

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

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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

Welding

In order to obtain the best results, we recommend the following procedure:

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

Electrical Discharge Machining (EDM)

KEYLOS® UP can be machined by EDM to obtain complex shape. Afterwards we advise to carry out the stress relieving procedure.

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 its tool steel grades, putting eco-effectiveness into practice.

The main adopted steps are:

- to carry out an environmental assessment on processes and products, with the minimum use of virgin materials and non-renewable forms of energy;
- to move toward zero-waste manufacturing processes, considering that the ultimate destination of scrapped steel moulds becomes food for the next steel making process, that is the "waste equals food" philosophy;
- to carry out a life cycle assessment for each product and process, minimizing the environmental cost of product and service over its complete life cycles, from creation to disposal, that is the "Cradle to Cradle" philosophy

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Quick comparison guide among the different steel grades

The following table shows a quick comparison among the main characteristics of pre-hardened steel grades traditionally used in plastic moulding.

Tool Steels for plastic														
		LUCCHINI							KEYLOS					
		1730	7225	2311	2312	2738	P20	P20HH	UP	30	35	40	35 EVO	40 EVO
HB	Min	-	220	280	280	290	290	320	280	290	320	360	320	360
	Max	200	270	330	330	340	330	360	330	330	360	400	360	400
Maximum thickness [mm]		300	400	500	500	1.000	1.000	1.000	800	1.000	1.000	500	1.300	800
Wear Resistance		1	1	2	2	2	2	3	2	2	3	4	3	4
Through Hardening in the section		1	1	2	2	3	3	3	3	4	4	4	4	4
Toughness		1	2	2	2	2	2	2	2	3	3	2	3	3
Machinability		3	2	2	3	2	2	2	2	2	2	2	2	2
Polishing		1	1	2	0	2	2	2	2	3	3	3	3	3
Photo-engraving		2	2	3	0	3	3	3	3	4	4	4	4	4
Welding (reparing)		3	3	2	2	2	3	3	2	3	3	3	3	3

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

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