



**KEYLOS<sup>®</sup>UP**  
| VALUE IN PERFORMANCE

## THE CUSTOMISED SOLUTION FOR PLASTIC MOULDS



**FORGING  
VALUES  
IN PERFORMANCE**

IMPROVEMENT  
COURAGE  
PEOPLE  
PASSION  
SPIRIT  
GROUP  
CUSTOMER  
SUCCESS

GROUP  
**LUCCHINI**RS

## General characteristics

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KEYLOS<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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

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KEYLOS<sup>®</sup> 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:  $(HB_{\text{Surface, min required}} - HB_{\text{Core}}) \leq 20HB$

## Main features

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- 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

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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.

## Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	Ni [%]	V [%]
<b>KEYLOS<sup>®</sup>UP</b> 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

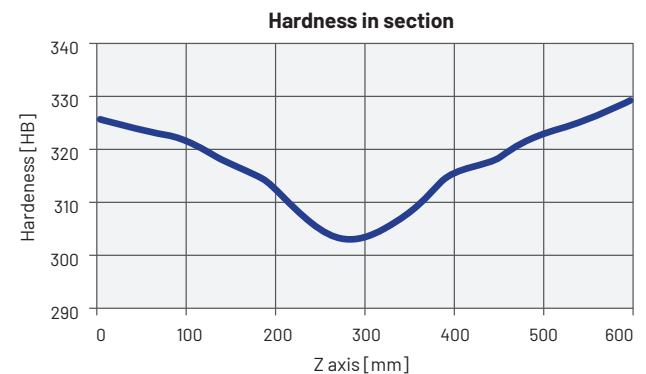
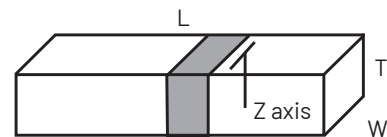
### Main physical properties

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

### Main mechanical properties

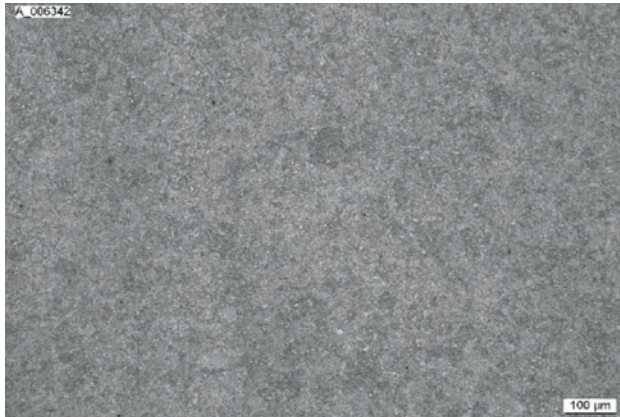
<b>KEYLOS<sup>®</sup>UP</b>	20°C	200°C
Ultimate tensile strength UTS [MPa]	1020	900
Yield strength YS [MPa]	900	760
Elongation A [%]	17	18
Reduction in area Z [%]	53	55

### Hardness profile

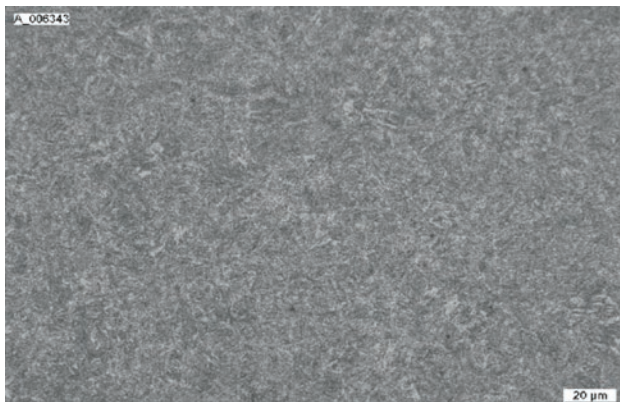


## Microstructure

The main microstructure of KEYLOS<sup>®</sup> 40 EVO is tempered martensite.



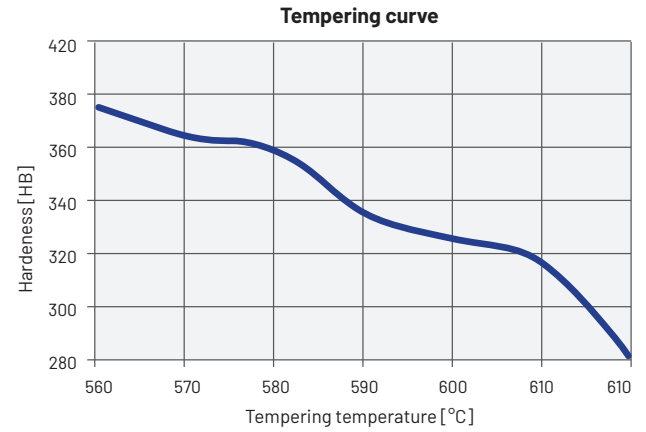
100x



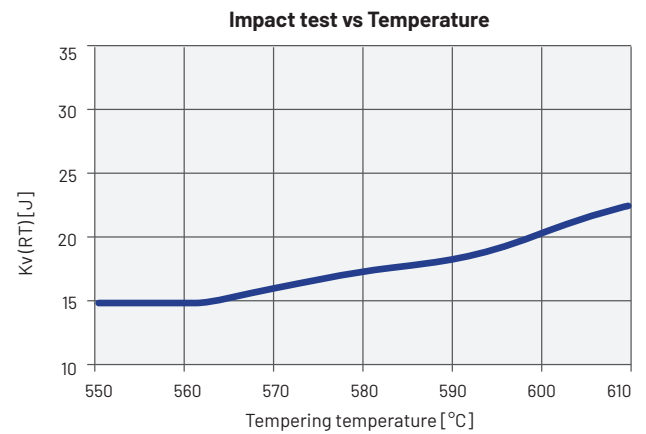
500x

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

## Surface hardness vs tempering temperature



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



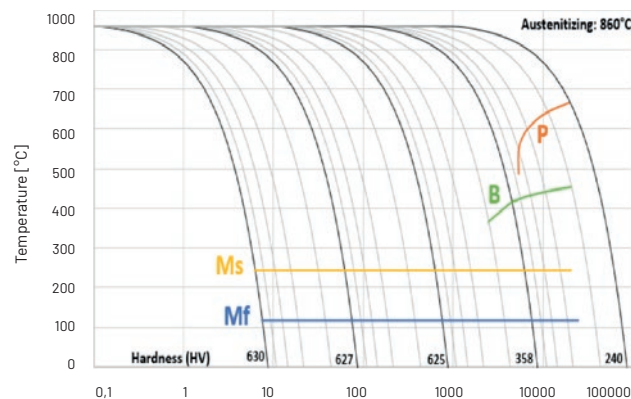
## Heat treatment

KEYLOS<sup>®</sup> 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

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

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

### Stress relieving

<b>Suggested temperature</b>	550 °C
<b>Soaking time</b>	60 min every 25 mm thickness
<b>Cooling</b>	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

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

### Tempering

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

The tempering temperature should be selected from 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.

## **Induction hardening**

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

## **Nitriding**

KEYLOS<sup>®</sup> 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**

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KEYLOS<sup>®</sup> 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**



## Guidance for machining

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

### Turning

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

### Milling

Type of insert	Rough machining		
	P25-P35 not coated	P25-P35 coated	HSS
V <sub>c</sub> cutting speed [m/min]	120 ÷ 140	160 ÷ 180	(*)
f <sub>z</sub> feed [mm]	0,15 ÷ 0,3	0,15 ÷ 0,3	(*)
a <sub>r</sub> cutting depth [mm]	2 ÷ 4	2 ÷ 4	(*)

Type of insert	Pre-finishing		
	P10-P20 not coated	P10-P20 coated	HSS
V <sub>c</sub> cutting speed [m/min]	140 ÷ 160	180 ÷ 200	(*)
f <sub>z</sub> feed [mm]	0,2 ÷ 0,3	0,2 ÷ 0,3	(*)
a <sub>r</sub> cutting depth [mm]	< 2	< 2	(*)

Type of insert	Finishing		
	P10-P20 not coated	P10-P20 coated	Cermet P15
V <sub>c</sub> cutting speed [m/min]	200 ÷ 240	250 ÷ 270	300 ÷ 340
f <sub>z</sub> feed [mm]	0,05 ÷ 0,2	0,05 ÷ 0,2	0,05 ÷ 0,2
a <sub>r</sub> 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

## 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<sup>®</sup> 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



## 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	35 EVO	40 EVO
HB	Min	-	220	280	280	290	290	320	280	290	320	320	360
	Max	250	270	330	330	340	330	360	330	330	360	360	400
Maximum thickness [mm]		300	400	500	500	1.000	1.000	1.000	800	1.000	1.000	1.300	800
Wear Resistance		1	1	2	2	2	2	3	2	2	3	3	4
Through Hardening in the section		1	1	2	2	3	3	3	3	4	4	4	4
Toughness		1	2	2	2	2	2	2	2	3	3	3	3
Machinability		3	2	2	3	2	2	2	2	2	2	2	2
Polishing		1	1	2	0	2	2	2	2	3	3	3	3
Photo-engraving		2	2	3	0	3	3	3	3	4	4	4	4
Welding (reparing)		3	3	2	2	2	3	3	2	3	3	3	3

4 Excellent 3 Very Good 2 Good 1 Normal 0 Unsuitable

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