

KEY[®] LOS UP

Special and Innovative
pre-hardened steel
with improved penetration
hardening and machinability

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.

KeyLos® UP is the new steel grade coming from the long experience of Lucchini RS in the production of plastic moulds steel grades.

It is particularly suitable for sophisticated punches and dies in the dimension range up to 800 mm. thick.

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.

One of the main characteristics of this steel grade is the large size range for which it is reliable, the optimal degree of homogeneity in mechanical properties and toughness in the whole section.

Adding up to 0.60% Nickel by alloying significantly increases hardness and toughness on the section, up to 800 mm thick, KeyLos® UP is the best option when the Customer is looking for:

- toughness and mechanical characteristics in the whole section of the mould;
- machinability and polishability;
- micro-purity.

KeyLos® UP is normally supplied in the pre-hardened condition to give a surface hardness between 280 and 330 HB.

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

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

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.

In summary, KeyLos® UP offers the following advantages:

- excellent machinability;
- excellent suitability for photo-engraving;
- excellent 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;
- internal homogeneous hardness and toughness on blocks with thickness up to 800 mm;
- optimised manufacturing cycle: from steel block to mould, with no need for intermediate treatments;
- also welding, in case of extreme repairing only, is possible.

KeyLos® UP is 100% ultrasonically inspected, according to the most restrictive NDT standards.

KeyLos® UP 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® UP 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 [%]
 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

Table for comparison of international classification.

W. Nr. /
 DIN designation: \approx 40CrMnNiMo8.3.3

Lucchini RS's tool steels have been researched and formulated in order to optimize the material performances.

Main applications

The brand name identifies the Lucchini RS product and the number evokes the Werkstoff classification or other means of reflecting the characteristics of use.

KeyLos® UP in the pre-hardened condition is suitable for the following applications:

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.

Physical and mechanical properties

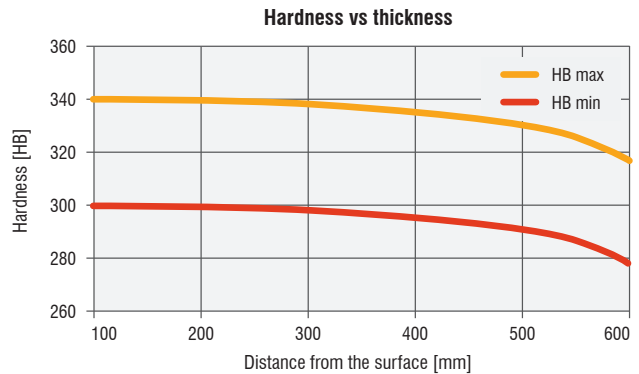
Main physical properties

KEY[®]LOS UP	20°C	250°C	500°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	196	177
Coefficient of thermal expansion [10 ⁻⁶ /K]	-	12,7	14,3
Thermal conductivity [W/mK]	32,0	31,1	30,0

Main mechanical properties

KEY[®]LOS UP	20°C	200°C
Ultimate Tensile strength (UTS) [MPa]	1.020	900
Yield stress (YS) [MPa]	900	760
Elongation (A) [%]	17	-
Reduction of area (Z) [%]	53	-

These values are average values obtained from the middle of the section of a 900 mm thick bar, subjected to hardening at 850°C, quenching and tempering at 600°C.



Heat treatments

KeyLos[®] UP 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.

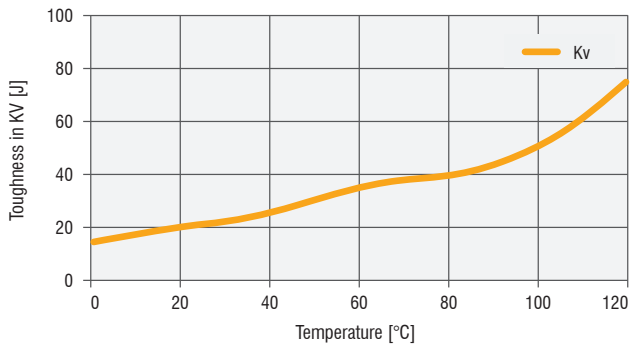
Stress Relieving

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.

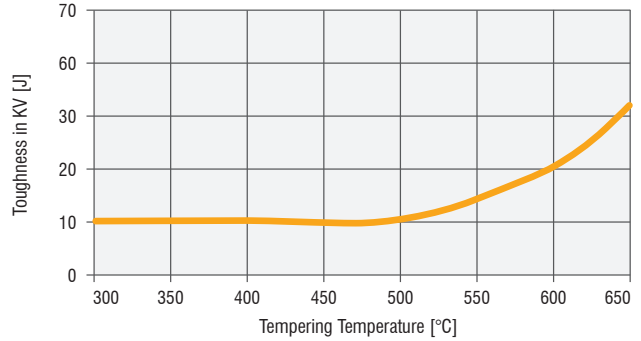
Stress relieving is recommended where it is necessary to eliminate residual stresses induced by mechanical working or by a preceding heat treatment.

Toughness vs temperature



Tempering curve of a sample which has been austenitised at 850 °C

Toughness vs tempering temperature



Hardening

Suggested temperature	850 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

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

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

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

Nitriding

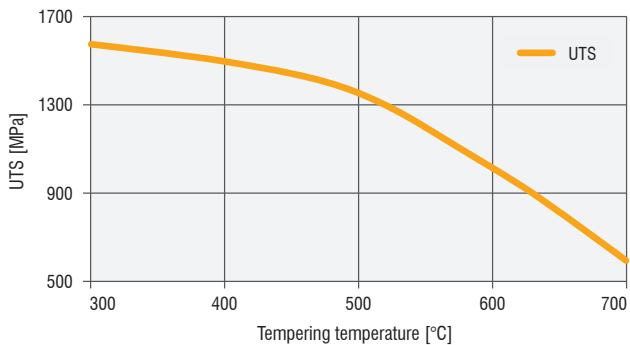
KeyLos[®] UP is suitable for ionic and gas nitriding. This treatment is very useful for moulds or dies subjected to extremely stressful applications.

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.

Tempering curve

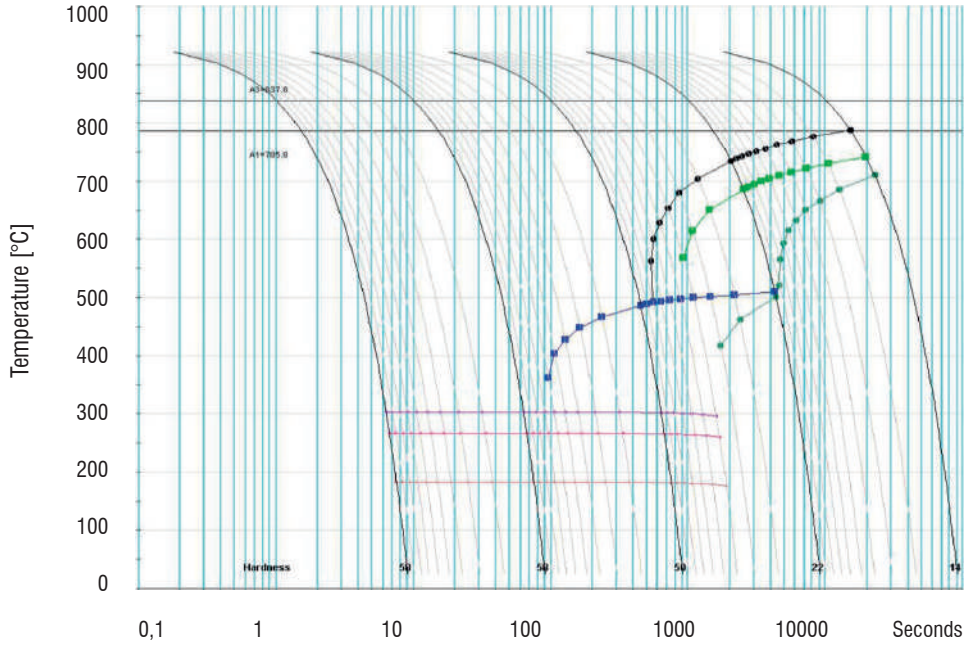


We recommend the following manufacturing cycle, in order to obtain the best results:

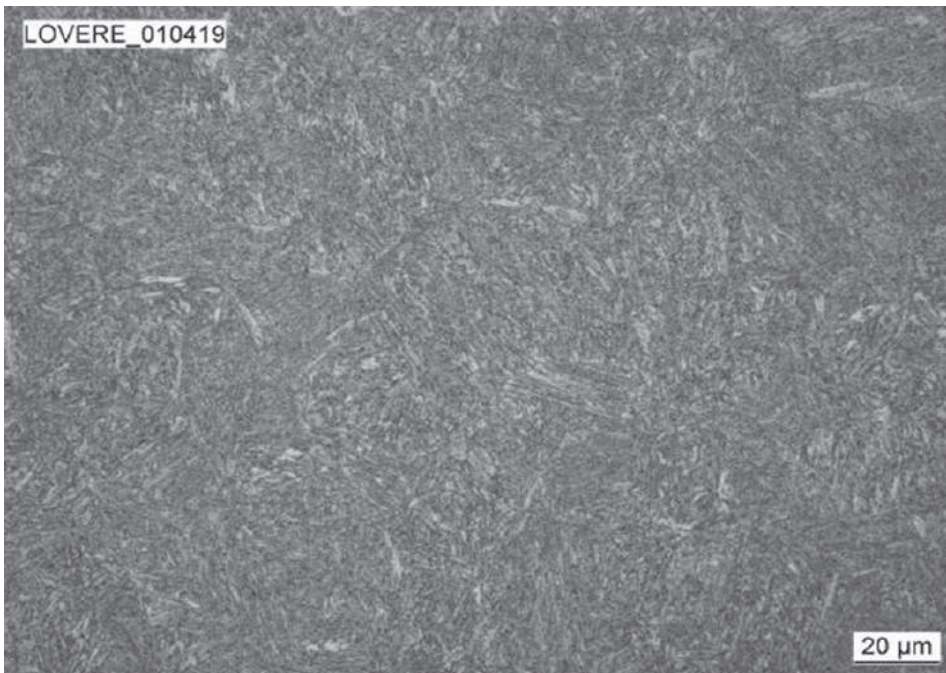
- rough machining;
- stress relieving;
- finish machining;
- nitriding.

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.

CCT Curve



Microstructure of KEYLOS[®] UP



The microstructure of KeyLos[®] UP detected about 20 mm under surface is 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

Type of insert	Rough machining		Finish machining	
	P20-P40 coated	HSS	P10-P20 coated	Cermet
V _c cutting speed [m/min]	120 ÷ 160	(*)	160 ÷ 220	220 ÷ 270
a _r cutting depth [mm]	5	(*)	< 1	< 0,5

Milling

Type of insert	Rough machining		
	P25-P35 not coated	P25-P35 coated	HSS
V _c cutting speed [m/min]	80 ÷ 100	120 ÷ 150	(*)
f _z feed [mm]	0,15 ÷ 0,3	0,15 ÷ 0,3	(*)
a _r cutting depth [mm]	2 ÷ 4	2 ÷ 4	(*)

Type of insert	Pre-finishing		
	P10-P20 not coated	P10-P20 coated	HSS
V _c cutting speed [m/min]	100 ÷ 125	145 ÷ 175	(*)
f _z feed [mm]	0,2 ÷ 0,3	0,2 ÷ 0,3	(*)
a _r cutting depth [mm]	< 2	< 2	(*)

Type of insert	Finishing		
	P10-P20 not coated	P10-P20 coated	Cermet P15
V _c cutting speed [m/min]	170 ÷ 210	220 ÷ 240	270 ÷ 310
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]	90 ÷ 120	(*)	50 ÷ 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 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® UP 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 destiny 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® UP can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

Chrome Plating

KeyLos® UP 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

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

Polishing

KeyLos® UP is particularly suitable for polishing.