

# **KEY<sup>®</sup> LOS 2311**

Pioneer pre-hardened  
mould steel with improved  
machinability and polishability

## General characteristics

KeyLos<sup>®</sup> 2311 is the pioneer of the mould alloyed steel grades, designed for the manufacture of small and medium sized moulds, up to 600 mm thick.

KeyLos<sup>®</sup> 2311 represents the ideal option for the mould making and plastics processing technology, who is looking for:

- good toughness and mechanical proprieties;
- machinability and polishability;
- micro-cleanliness.

This steel is obtained through a special 'super clean' manufacturing process, which allows a high level of micro-purity.

KeyLos<sup>®</sup> 2311 is normally supplied in the pre-hardened condition with 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 level of machinability and micro-structural homogeneity are obtained thanks to a Calcium treatment process on the liquid steel and to a careful heat treatment process.

KeyLos<sup>®</sup> 2311 is the best classic option for the production of blocks with low and medium thickness, up to 600 mm, that need a high degree of homogeneity of hardness, mechanical properties and toughness in the whole section of the mould.

In summary, KeyLos<sup>®</sup> 2311 offers the following advantages:

- good machinability;
- excellent suitability for photo-engraving;
- excellent suitability for polishing;
- excellent suitability for nitriding, in order to increase the surface wear resistance;
- good wear resistance in the whole section of the mould;
- optimized manufacturing cycle: from steel block to mould, with no need for intermediate treatments.

Also welding, in case of extreme repairing only, is possible.

KeyLos<sup>®</sup> 2311 is 100% ultrasonically inspected, according to the most demanding of NDT standards.

KeyLos<sup>®</sup> 2311 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 become food for the steel making production of KeyLos<sup>®</sup> 2311 grade.

## Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]
<b>KEY<sup>®</sup>LOS 2311</b>	min	0,35	0,20	1,30	1,80	0,15
Alloying [% in weight]	max	0,45	0,40	1,60	2,10	0,30

Table for comparison of international classification

**W. Nr.**                    **1.2311**  
**DIN EN ISO 4957**    **40CrMnMo7**

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

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

## Main applications

KeyLos<sup>®</sup> 2311 in the pre-hardened condition is suitable for the following applications:

Plastic moulding:

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

Extrusion:

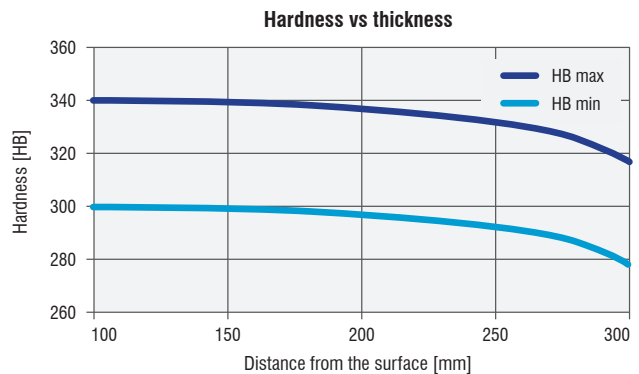
- dies and gauges for PVC extrusion;
- mechanical parts for extrusion presses.

## Physical and mechanical properties

### Main physical properties

<b>KEY<sup>®</sup>LOS 2311</b>	20°C	250°C	500°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	196	177
Coefficient of thermal expansion [10 <sup>-6</sup> /K]	-	12,6	14,4
Thermal conductivity [W/mK]	34,0	33,4	33,0

These values are average values obtained from the middle of the section of a 400 mm thick bar, subjected to hardening at 860 °C, quenching and tempering at 600 °C.



### Main mechanical properties

<b>KEY<sup>®</sup>LOS 2311</b>	20°C	200°C
Ultimate tensile strength (UTS) [MPa]	1.000	890
Yield stress (YS) [MPa]	880	750

## Heat treatments

KeyLos® 2311 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 <b>600 °C</b> , then at room temperature

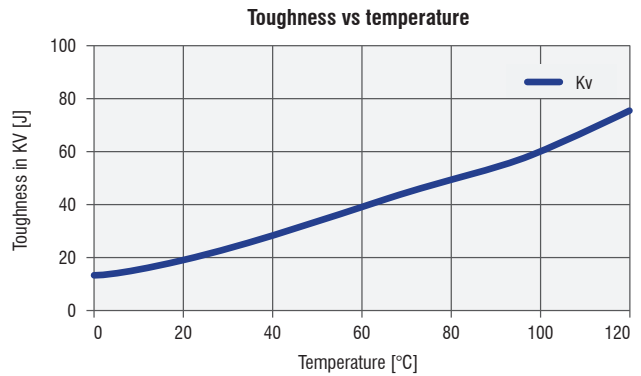
Soft annealing is useful to improve machinability. The obtained hardness is lower than 250 HB.

### 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 <b>200 °C</b> , 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.



### Hardening

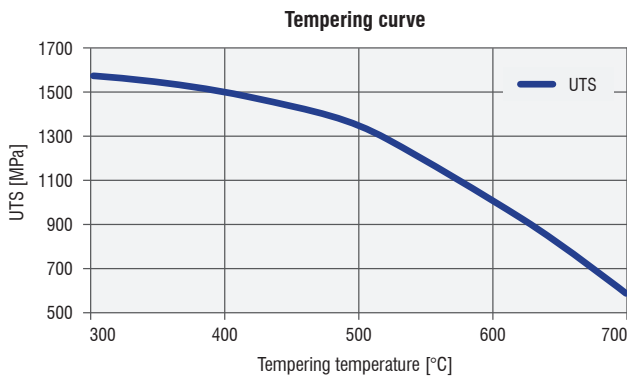
Suggested temperature	860 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

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

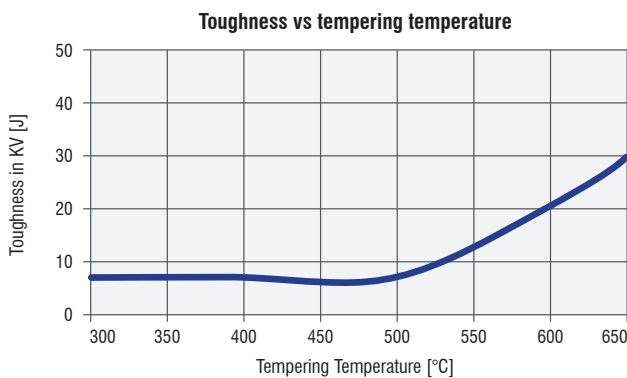
*Tempering*

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 repeated two times are recommended, in order to reduce the amount of retained austenite.



Tempering curve of a sample which has been austenitised at 860 °C.



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

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.

*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<sup>®</sup> 2311 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.

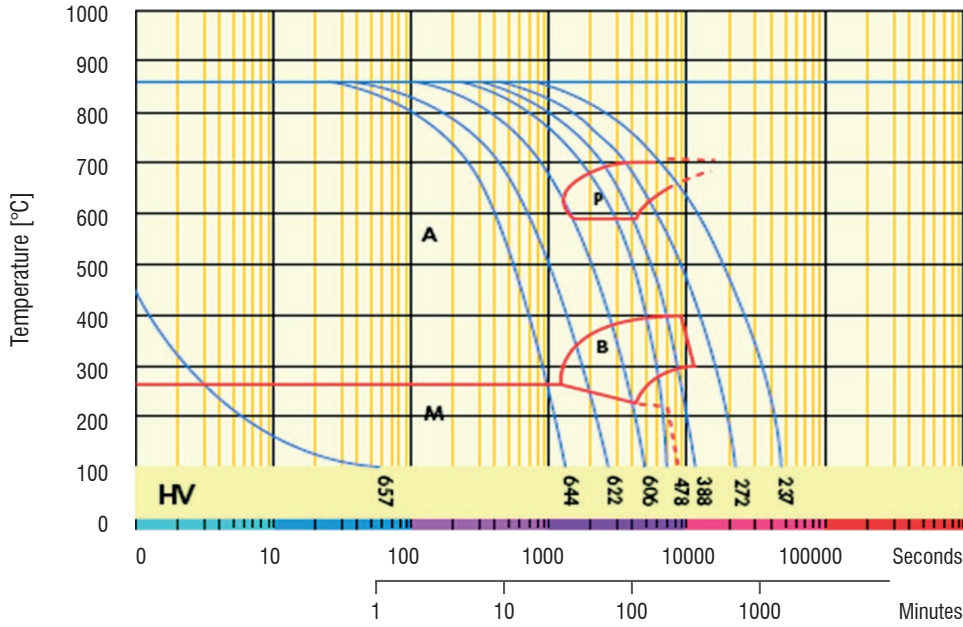
Modern nitriding processes allow the original dimensions of the component to be maintained.

We recommend heat treating the component in the finish machined condition.

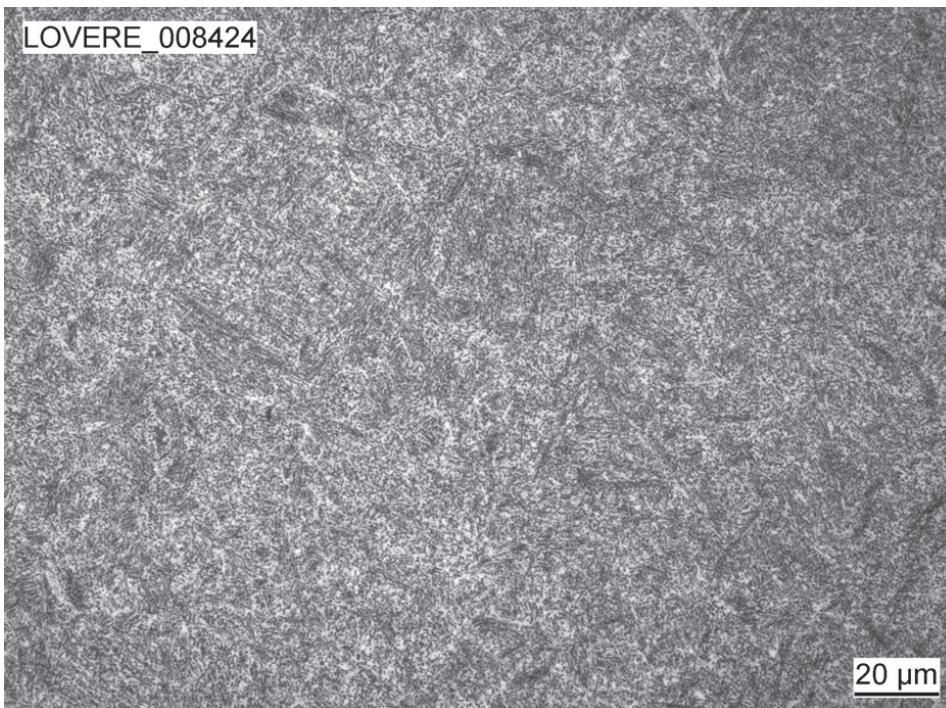
We recommend the following manufacturing cycle, in order to obtain the best results:

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

### CCT Curve



### Microstructure of KEYLOS® 2311



The microstructure of KeyLos® 2311 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 <sub>c</sub> cutting speed [m/min]	140 ÷ 180	(*)	180 ÷ 220	240 ÷ 300
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]	100 ÷ 120	145 ÷ 175	(*)
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]	120 ÷ 140	160 ÷ 190	(*)
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]	190 ÷ 230	240 ÷ 260	280 ÷ 320
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]	110 ÷ 140	(*)	70 ÷ 100
$f_z$ 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



## Welding

Welding of KeyLos® 2311 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® 2311 can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

## Chrome Plating

KeyLos® 2311 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® 2311 is suitable for photo-engraving to obtain various patterns.

## Polishing

KeyLos® 2311 is particularly suitable for polishing.

**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