

# **ESKY<sup>®</sup> LOS 2002**

Special and Innovative  
pre-hardened steel suited  
for the most demanding plastic  
moulds also for extremely large  
sections in ESR quality

## General characteristics

EsKyLos® 2002 is a special and innovative pre-hardened steel, suitable for the manufacture of big size injection moulds.

EsKyLos® 2002 is obtained through a special 'super clean' manufacturing process and special heat treatments.

EsKyLos® 2002 is normally supplied in the pre-hardened condition with a surface hardness of 360-400 HB.

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

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

EsKyLos® 2002 represents the synthesis and the perfect balance of all the grades normally applied in this field and it is suited for a very wide range of applications in the plastics industry.

Thanks to an accurate design of the chemical alloying elements and thanks to a special heat treatment, EsKyLos® 2002 is characterized by a high degree of through hardening and it is suited in the case of very large dimensions, that need its greater toughness balanced with very high levels of hardness through to the core.

Because of the low Carbon Equivalent content, the weldability level is excellent and EsKyLos® 2002 becomes safer in case of welding repair.

Being Calcium treated, EsKyLos® 2002 has an excellent level of machinability and micro-purity. Due to its high level of micro-purity and micro-structural homogeneity, EsKyLos® 2002 is very suitable for mirror polishing and guarantees excellent suitability to photo-engraving.

EsKyLos® 2002 is the best option for the production of blocks with thicknesses up to 500 mm.

EsKyLos® 2002 offers the following advantages:

- excellent machinability;
- excellent toughness level;
- excellent suitability for photo-engraving;
- excellent suitability for polishing;
- excellent suitability for nitriding, in order to increase the wear resistance;
- excellent wear resistance;
- optimized manufacturing cycle: from steel block to mould, with no need for intermediate treatments;
- good weldability, improved with low C content.

Constant development in processing technologies of high quality plastic parts require the use of EsKyLos® 2002, thanks to its high fatigue and wear resistance, combined with its excellent homogeneity, machinability and extremely low thermal conductivity.

Thanks to its quasi-isotropic properties of ESR quality, EsKyLos® 2002 represents one of the most important tough options, for highly resistant and very large sized plastic moulds that need very high pressure strength, excellent resistance to abrasion. EsKyLos® 2002 is also safer in case of welding repair.

The increasing in the use of synthetic and abrasive materials has led manufacturers to use EsKyLos® 2002 also when suitability for polishing and graining, combined with abrasion and compression resistance, are required.

EsKyLos® 2002 is 100% ultrasonically inspected, according to the most demanding of NDT standards.

## Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	Ni [%]
 Alloying [% in weight]	min	0,20	0,20	1,40	1,20	0,55	1,00
	max	0,30	0,50	1,70	1,60	0,75	1,30

Table for comparison of international classification

W. Nr. /  
DIN designation:  $\approx$  28MnCrNiMo6-5-4

## Main applications

KeyLos<sup>®</sup> 2002 is particularly suitable for the following applications:

Plastic moulding:

- Injection molds for long run productions;
- Injection molds for reinforced plastics;
- Injection molds for plastic pieces with elaborated graining (double gloss, geometric design)
- Injection molds for plastic pieces with elevated smoothness (transparent, painted)
- Lens quality polishing: prototype and short productions
- Medium and big sized moulds for the automotive industry;
- Moulds for the food industry;
- Compression molds;
- Bolsters;

Extrusion:

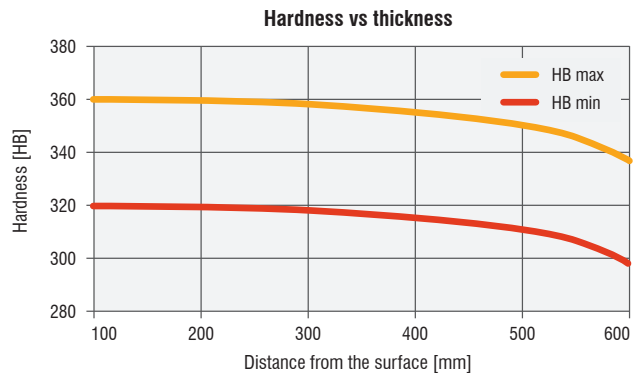
- dies and gauges for PVC extrusion;
- mechanical parts for extrusion presses.

## Physical and mechanical properties

### Main physical properties

ESKY <sup>®</sup> LOS 2002	20°C	250°C	500°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	194	176
Coefficient of thermal expansion from 20 °C at [10 <sup>-6</sup> /K]	-	12,5	14,3
Thermal conductivity [W/mK]	34,5	34,0	33,8

These values are average values obtained from the middle of the section of a 1000 mm thick bar, subjected to hardening at 900 °C, quenching and tempering at 600 °C.



### Main mechanical properties

ESKY <sup>®</sup> LOS 2002	20°C	200°C
Ultimate Tensile strength (UTS) [MPa]	1.080	920
Yield stress (YS) [MPa]	980	780
Elongation (A) [%]	17	-
Reduction of area (Z) [%]	53	-

## Heat treatments

EskyLos<sup>®</sup> 2002 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

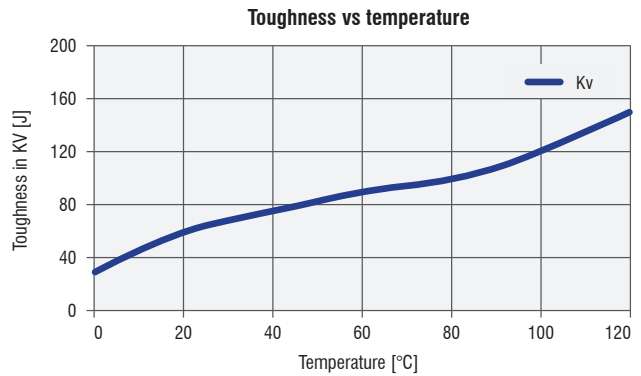
Soft annealing is useful to improve machinability. The obtained hardness is lower than 250 HB.

### 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

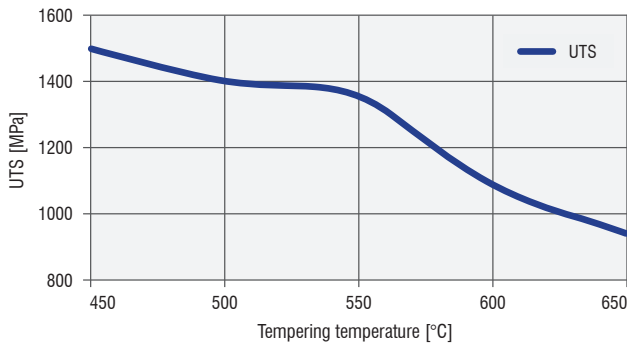
Suggested temperature	950 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

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

*Tempering*

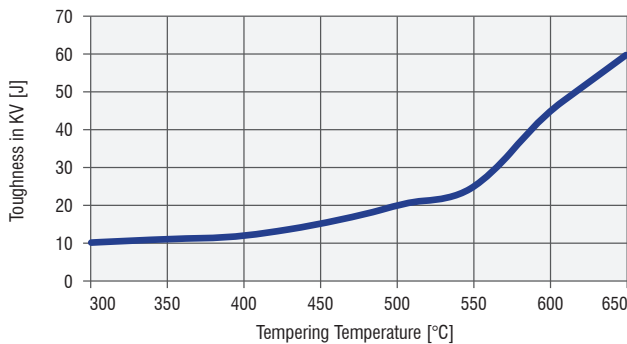
Suggested temperature	The tempering temperature to be applied to the material depends on the required mechanical properties. See following graph.
Soaking time	60 min every 25 mm thickness
Cooling	Room temperature

**Tempering curve**



Tempering curve of a sample which has been austenitised at 950 °C.

**Toughness vs tempering temperature**



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

In any case, other properties can be analysed 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*

EskyLos<sup>®</sup> 2002 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.

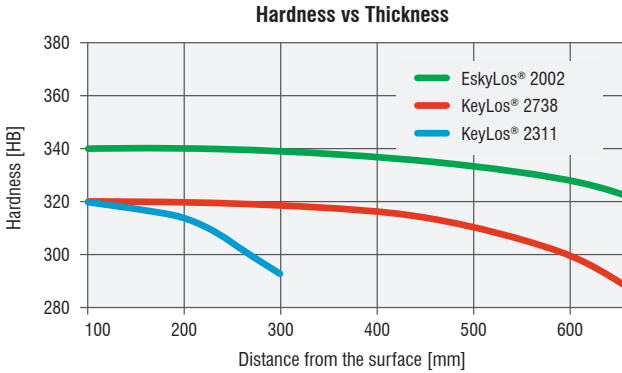
We recommend heat treating the component in the finish machined condition.

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

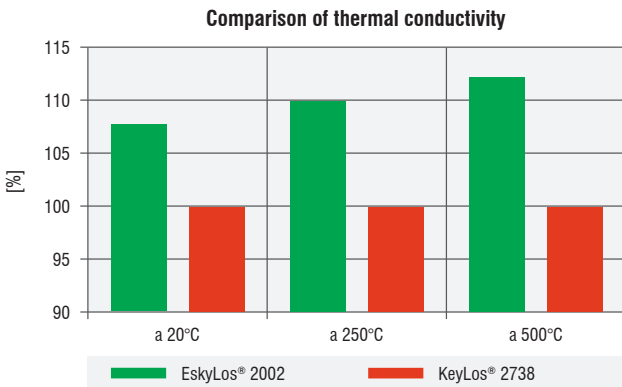
- rough machining;
- stress relieving;
- finish machining;
- nitriding.

## EsKyLos® 2002 compared to other grades

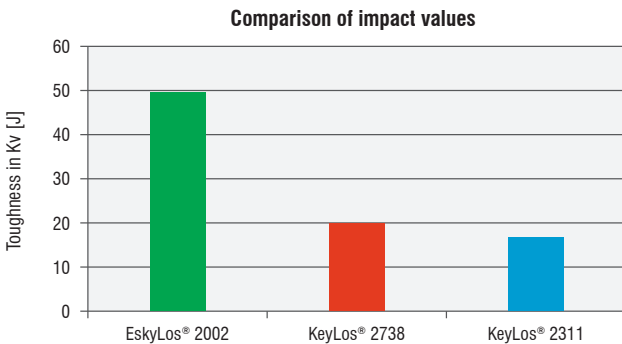
Average values of hardness variation related to thickness of blocks made of EsKyLos® 2002, KeyLos® 2738 and KeyLos® 2311.



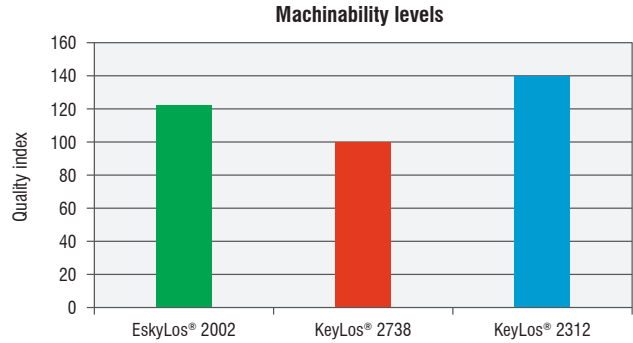
Comparison of thermal conductivity between EsKyLos® 2002 and KeyLos® 2738.



Comparison of impact values among EsKyLos® 2002, KeyLos® 2738 and KeyLos® 2311. The comparison has been made on blocks with the same hardness, at a temperature of 20 °C.

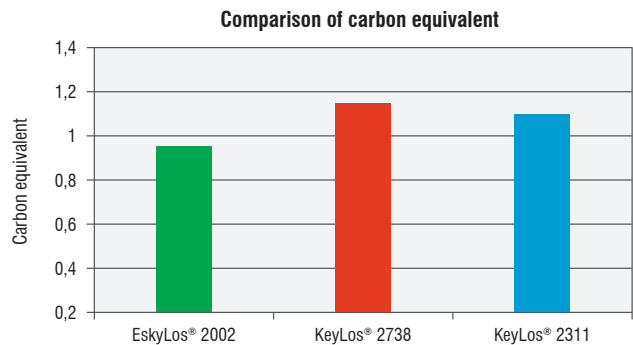


Machinability levels of EsKyLos® 2002, KeyLos® 2738 and KeyLos® 2312.

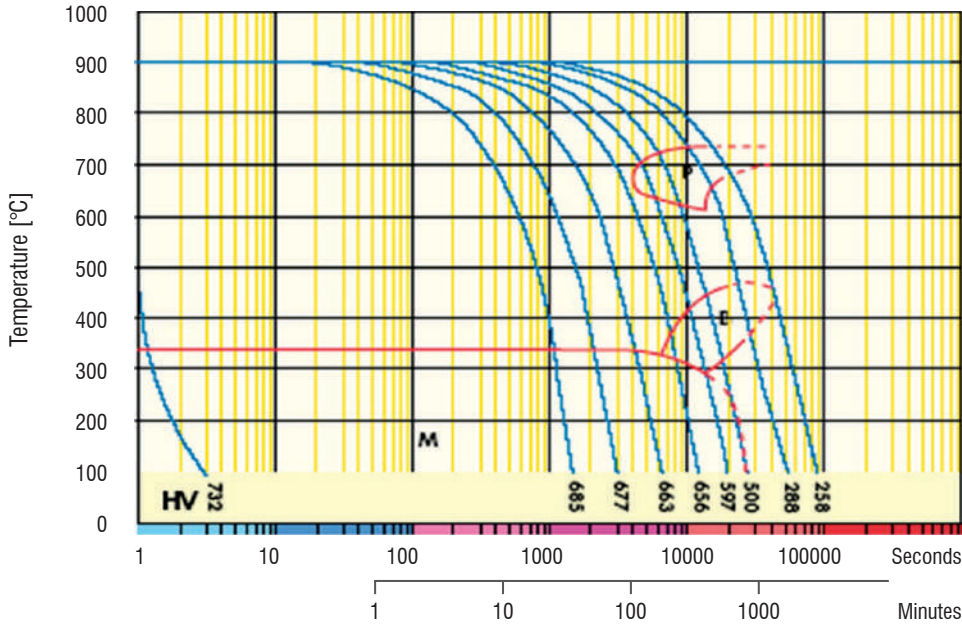


Comparison of Carbon Equivalent between EsKyLos® 2002, KeyLos® 2738 and KeyLos® 2311.

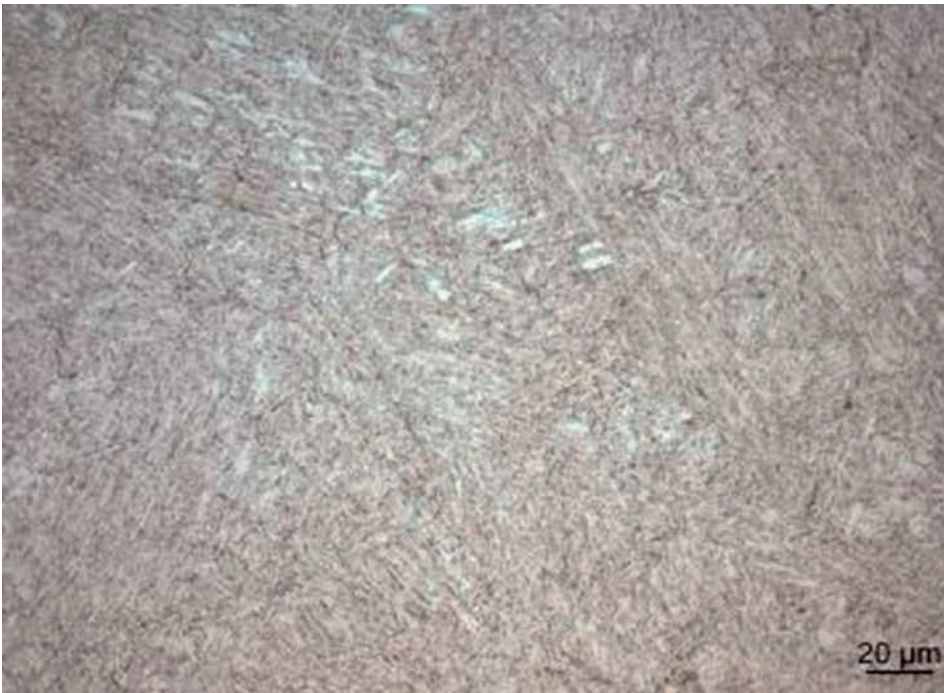
EsKyLos® 2002 has a lower carbon equivalent content than other grades normally used in this field. This implies better weldability and low risk of cracking, making welds of a finished mould easier to carry out.



### CCT Curve



### Microstructure ESKYLOS® 2002



The microstructure of EskyLos® 2002 detected about 20 mm under surface is tempered martensite.

## Quick comparison guide among the different grades

The following table shows a quick comparison among the most important characteristics of the pre-hardened grades normally applied in plastic moulding.

Lucchini RS Mould steel Family for plastics Industry																			
Special features and delivered conditions	Pre-hardened Not Corrosion Resistant Mould Steel Grades																		
	KEYLOS												ESKYLOS				BEYLOS		
	1730	1730 M	7225	ON	2312	2311	UP	2738 MSH	2738	PLUS	2738 MHH	2002	6959	2002	6959	2340	2365 M	2711	2714
HB in surface in Annealed condition	/	/	/	/	/	/	/	/	/	/	/	< 220	/	< 220	< 220	< 220	< 250	< 250	
HB in surface Pre-hardened	≤ 200	≤ 210	220-270	280-330	280-330	280-330	280-330	290-340	300-350	320-360	360-400	370-410	360-400	370-410	400-450	400-450	370-410	370-410	
Maximum thickness [mm]	300	300	500	500	600	600	800	800	1.000	800	1.200	1.200	500	500	500	500	500	700	
Hardness and Wear Resistance	1	1	1	2	2	2	2	3	2	3	3	3	3	3	4	4	3	3	
Degree of Through Hardening in the section	1	1	1	1	2	2	3	3	3	3	4	4	4	4	4	3	3	3	
Toughness	1	1	2	2	1	3	3	3	2	3	3	3	4	3	4	3	2	4	4
Machinability after Annealing	/	/	/	/	/	/	/	/	/	/	/	/	3	/	3	3	3	3	3
Machinability after Hardening	3	3	2	1	4	2	2	2	2	2	2	2	1	2	1	1	1	1	1
Etch-Grainability	1	1	1	2	0	3	3	3	3	3	3	3	2	4	4	4	4	2	2
Polishability	2	2	2	2	0	3	3	3	3	3	3	3	2	4	4	4	4	3	3
Repair by Welding	1	1	1	0	0	1	1	2	1	2	2	2	1	2	1	1	1	1	1
Thermal Conductivity	3	3	2	2	2	2	2	3	2	3	3	3	2	3	2	1	1	2	2
Corrosion Resistance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4 Excellent 3 Very Good 2 Good 1 Normal 0 Unsuitable



## The advantages of the ESR technology

The ESR (Electro-Slag-Melting) manufacturing technology offers the following advantages:

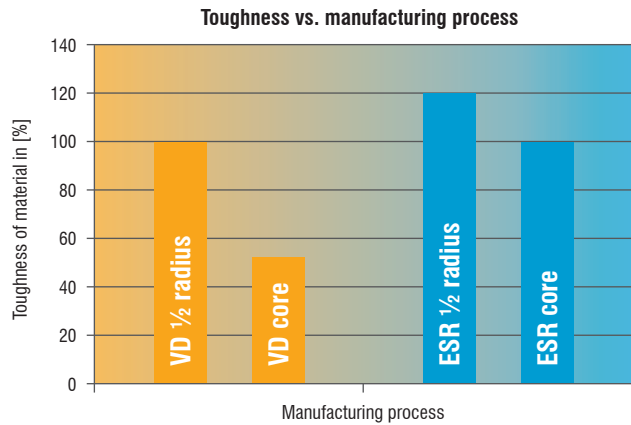
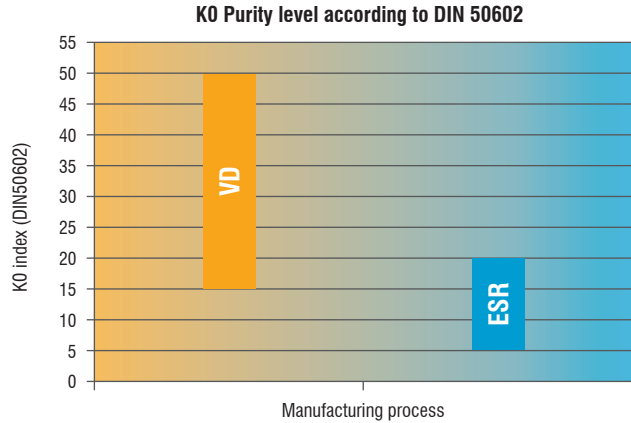
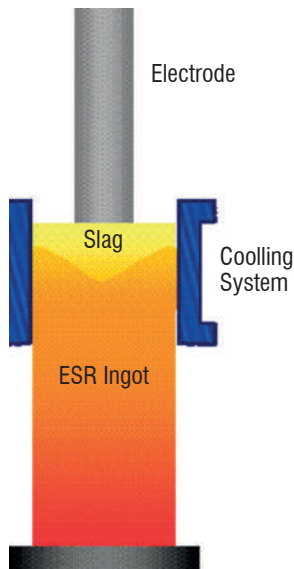
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

The ESR process is based on ingot remelting, through a traditional VD (vacuum degassing) process, using a particular copper ingot mould that contains basic slag.

The ingot is remelted in a way that the liquid metal passes through the slag, which acts as a filter and retains the inclusions.

The process of solidification inside the ingot mould is faster than in a traditional process.

The result is homogeneous and isotropic steel.



Thanks to the ESR process, EskyLos<sup>®</sup> 2002 satisfies the most difficult requirements in terms of toughness and suitability to polishing. It is suitable for the manufacture of moulds subjected to mirror polishing and to high mechanical stress.

## 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]	150 ÷ 190	(*)	190 ÷ 230	260 ÷ 320
$a_r$ 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]	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	(*)

Type of insert	Pre-finishing		
	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	(*)

Type of insert	Finishing		
	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 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 EskyLos® 2002 can give good results if that procedure is observed

Condition of material	Annealed with hardness 220 HB max	
Welding technique	TIG	MMA
Pre-heating at	330 ÷ 380 °C	

## 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)

EskyLos® 2002 can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

## Chrome Plating

KeyLos® 2002 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, EskyLos® 2002 is suitable for photo-engraving to obtain various patterns.

## Polishing

EskyLos® 2002 is particularly suitable for mirror polishing, due to the ESR process.