



ESKYLOS[®] 40 EVO

| VALUE IN ISOTROPY

**SPECIAL AND INNOVATIVE
PRE-HARDENED STEEL SUITED
FOR THE MOST DEMANDING
PLASTIC MOULDS ALSO FOR EXTREMELY
LARGE SECTIONS IN ESR QUALITY**

**FORGING
VALUES
IN ISOTROPY**

IMPROVEMENT
COURAGE
PEOPLE
PASSION
SPIRIT
GROUP
CUSTOMER
SUCCESS

GROUP
LUCCHINI RS

General characteristics

ESKYLOS® 40 EVO is a special and innovative pre-hardened alloyed steel, suitable for the manufacture of big size injection moulds.

ESKYLOS® 40 EVO 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® 40 EVO is characterized by a high degree of through hardening and it is suited in the case of large dimensions, that need its greater toughness balanced with very high hardness through to the core.

ESKYLOS® 40 EVO represents one of the most important tough options, for highly resistant moulds that need very high pressure strength, excellent resistance to abrasion and a shorter machining time.

The increasing in the use of synthetic and abrasive materials has led manufacturers to use ESKYLOS® 40 EVO also when suitability for polishing and graining, combined with abrasion and compression resistance, are required.

Due to its high level of micro-purity and micro-structural homogeneity, ESKYLOS® 40 EVO is very suitable for mirror polishing and guarantees excellent suitability to photo-engraving.

Because of the low Carbon Equivalent content, the weldability level is excellent and ESKYLOS® 40 EVO becomes safer in case of welding repair.

Delivery conditions

ESKYLOS® 40 EVO 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 360 – 400 HB and the mid-thickness hardness value is guaranteed in section up to 800 mm, according to the following correlation: $(HB_{\text{Surface, min required}} - HB_{\text{Core}}) \leq 20\text{HB}$

Main features

- 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;
- good weldability, improved with low C content.

Main application

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;

Extrusion:

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

Chemical analysis

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

Comparison with international classifications:

AISI: 28MnCrNiMo6.5.4.

Physical and mechanical properties

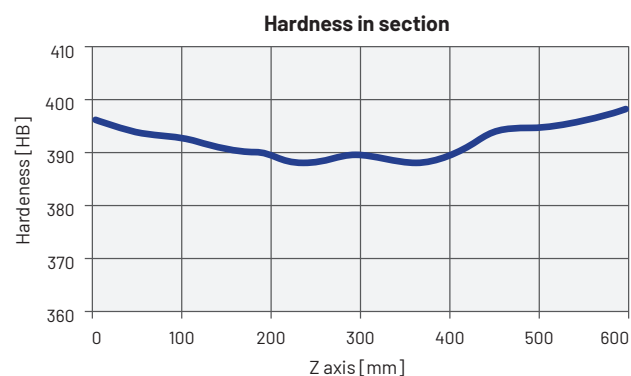
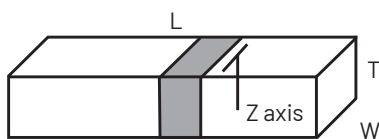
Main physical properties

ESKYLOS[®] 40 EVO	20°C	250°C	500°C
Young modulus E [MPa]	210	194	176
Coefficient of linear thermal expansion α [10 ⁻⁶ /K]	-	12,5	14,3
Thermal conductivity λ [W/mK]	34,5	34,0	33,8

Main mechanical properties

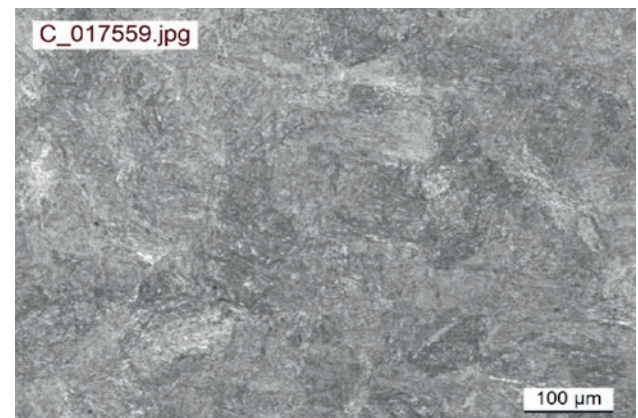
ESKYLOS[®] 40 EVO	20°C	200°C
Ultimate tensile strength UTS [MPa]	1080	920
Yield strength YS [MPa]	980	780
Elongation A [%]	17	18
Reduction in area Z [%]	53	55

Hardness profile

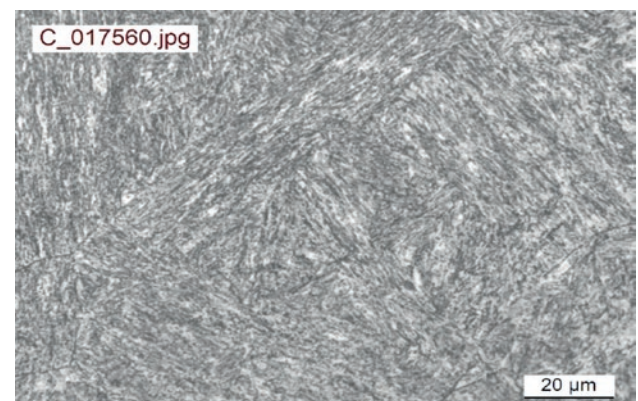


Microstructure

The main microstructure of ESKYLOS[®] 40 EVO is tempered martensite.

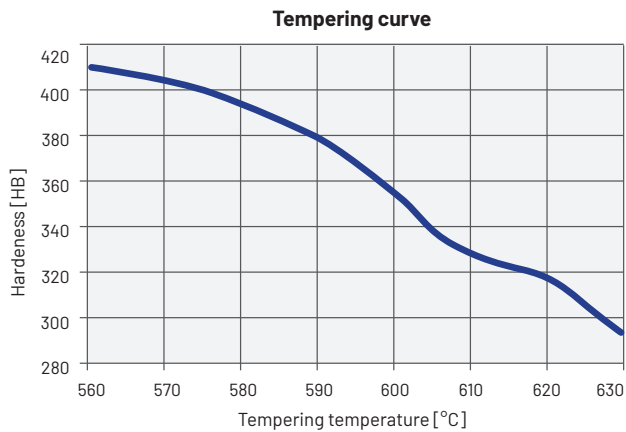


100x

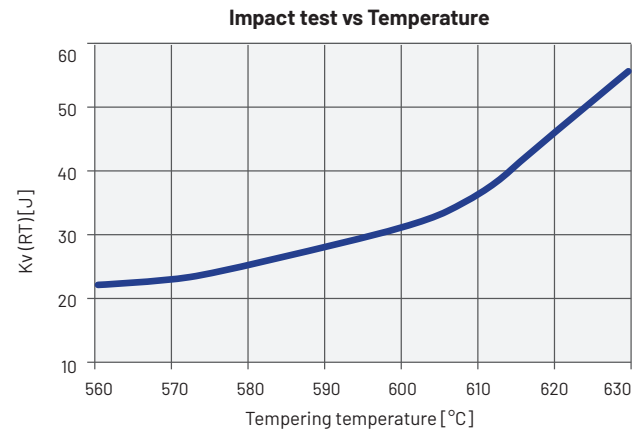


500x

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 ESKYLOS[®] 40 EVO and are reported for information only

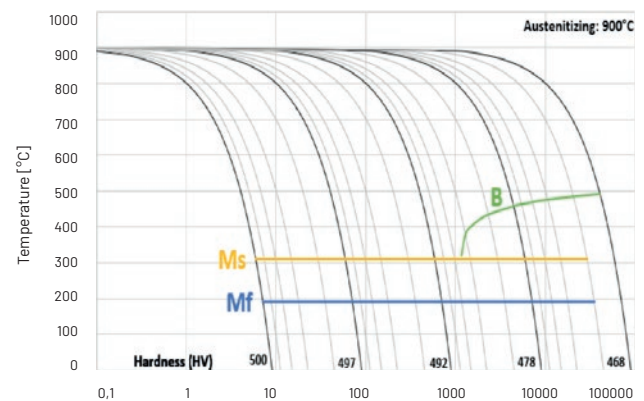
Heat treatment

ESKYLOS[®] 40 EVO 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	500 °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	900 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

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

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 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[®] 40 EVO is suitable for induction hardening. We recommend cooling at room temperature and tempering after induction hardening.

Nitriding

KEYLOS[®] 40 EVO 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.

Polishing and photo-engraving

ESKYLOS[®] 40 EVO 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: **4 Excellent**
 Suitability for medium gloss polishing: **4 Excellent**
 Suitability for mirror polishing: **4 Excellent**
 Suitability for engraving: **4 Excellent**

Rating scale:

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:

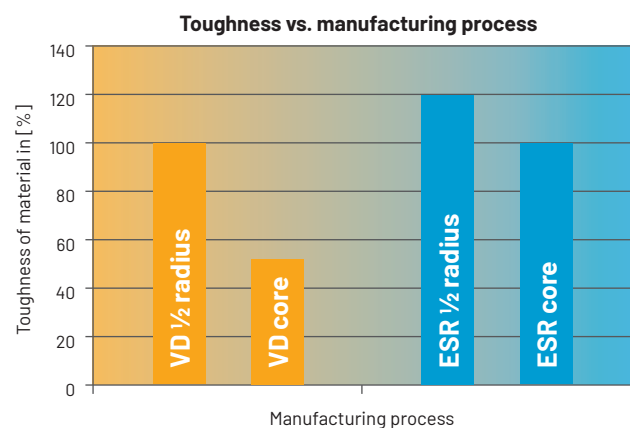
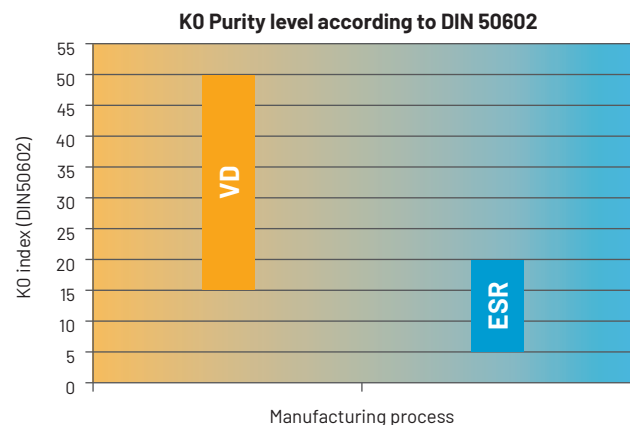
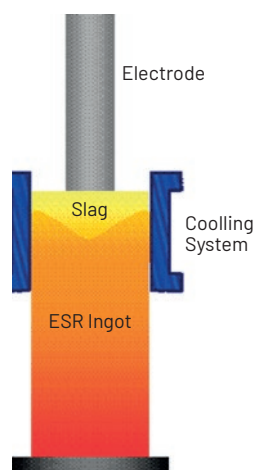
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

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[®] 40 EVO 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 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_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

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)

ESKYLOS[®] 40 EVO 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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