

ESKY[®] LOS 6959

Special pre-hardened ESR
alloyed steel for extreme stressed
moulds at low and high temperatures
that need excellent toughness

General characteristics

EsKyLos® 6959 is a Chromium-Nickel-Molybdenum and Vanadium special pre-hardened alloyed steel, suitable for the production of medium and big sized plastic moulds, up to 500 mm, highly stressed, that need extreme toughness characteristics combined with high hardness through the section.

EsKyLos® 6959 is obtained through a special 'super clean' manufacturing process, which allows an excellent level of micro-purity to be achieved.

EsKyLos® 6959 is supplied in the pre-hardened condition in two hardness ranges:

- hardness between 300 and 360 HB
- hardness between 360 and 420 HB

EsKyLos® 6959 with hardness between 300 and 360 HB is suitable for applications where the toughness of the material is the first aim.

EsKyLos® 6959 with hardness between 360 and 420 HB is recommended for applications where high levels of mechanical stresses and wear resistance are required.

Upon request, EsKyLos® 6959 can be supplied in the annealed condition with hardness lower than 250 HB. Thanks to its excellent dimensional stability, extremely low distortion, high hardenability, EsKyLos® 6959 in pre-machined conditions can be used also for moulds that require high levels of hardness up to 50 HRC after suited heat treatment.

EsKyLos® 6959 offers the following advantages:

- good machinability;
- excellent suitability for photo-engraving;
- excellent suitability for polishing;
- excellent suitability for nitriding, in order to increase the wear resistance in surface;
- excellent wear resistance in the whole section of the mould;
- internal homogeneous hardness and toughness in blocks with thickness up to 500 mm;
- quite good weldability, in case of repair by welding.

EsKyLos® 6959 is 100% ultrasonically inspected, according to the most demanding of NDT standards.

Constant development in hot processing technologies require the use of EsKyLos® 6959, thanks to its high resistance to thermal fatigue and high temperature wear.

Thanks to its quasi-isotropic properties of ESR quality, EsKyLos® 6959 represents also one of the most important tough options, for highly resistant plastic moulds that need very high pressure strength, excellent resistance to abrasion, also in combination with different surface coatings, and improved toughness in the mean time.

The increasing in the use of synthetic and abrasive materials has led manufacturers to use EsKyLos® 6959 also when suitability for polishing and graining, combined with abrasion and compression resistance, are required. EsKyLos® 6959 represents an innovative way to obtain high quality tools, collecting a very long mould life and optimizing the environmental sustainability of the product, with a suited steel grade design, that guarantees the minimum use of virgin materials.

It is difficult to predict the improvement that an 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.

EsKyLos® 6959 is demonstrating impressive resistance to fatigue in many applications and a significantly longer mould life than conventional Hot Work Tool 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.

EsKyLos® 6959 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 EsKyLos® 6959 grade.

Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Ni [%]	Cr [%]	Mo [%]	V [%]
ESKY[®] LOS 6959 Alloying [% in weight]	min	0,30	0,15	0,40	3,00	0,80	0,35	0,05
	max	0,40	0,55	0,90	4,00	1,70	0,90	0,25

Table for comparison of international classification

W. Nr. 1.6959
DIN EN ISO 4957 35NiCrMoV12-5

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

EskyLos[®] 6959 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 for plastic pressure pouring.

Extrusion:

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

Physical and mechanical properties

Main physical properties

ESKY[®] LOS 6959	20°C	250°C	500°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	196	177
Coefficient of thermal expansion from 20 °C at [10 ⁻⁶ /K]	-	13,4	14,8
Thermal conductivity [W/mK]	24,7	24,3	23,9

Main mechanical properties

ESKY[®] LOS 6959	20°C	200°C
Ultimate Tensile strength (UTS) [MPa]	1.460	1.280
Yield stress (YS) [MPa]	1.320	1.120

These values are average values obtained from the middle of the section of a 500 mm thick bar, subjected to hardening by Lucchini RS.

Heat treatments

EskyLos[®] 6959 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.

Hardening

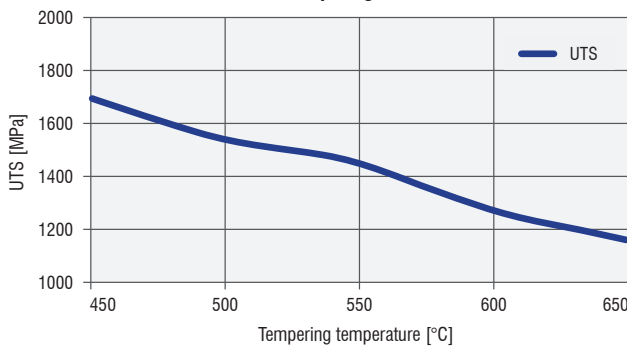
Suggested temperature	850 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

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 850 °C.

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 recommend cooling at room temperature and tempering after heat treatment.

Nitriding

EskyLos[®] 6959 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.

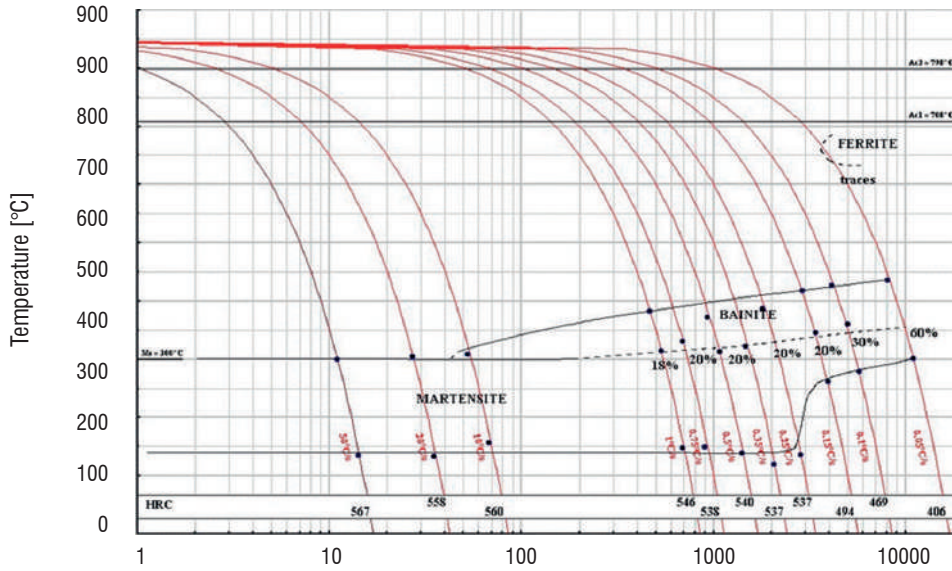
Modern nitriding processes allow the original dimensions of the component to be maintained. We recommend heat treating the component in the finish machined condition.

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

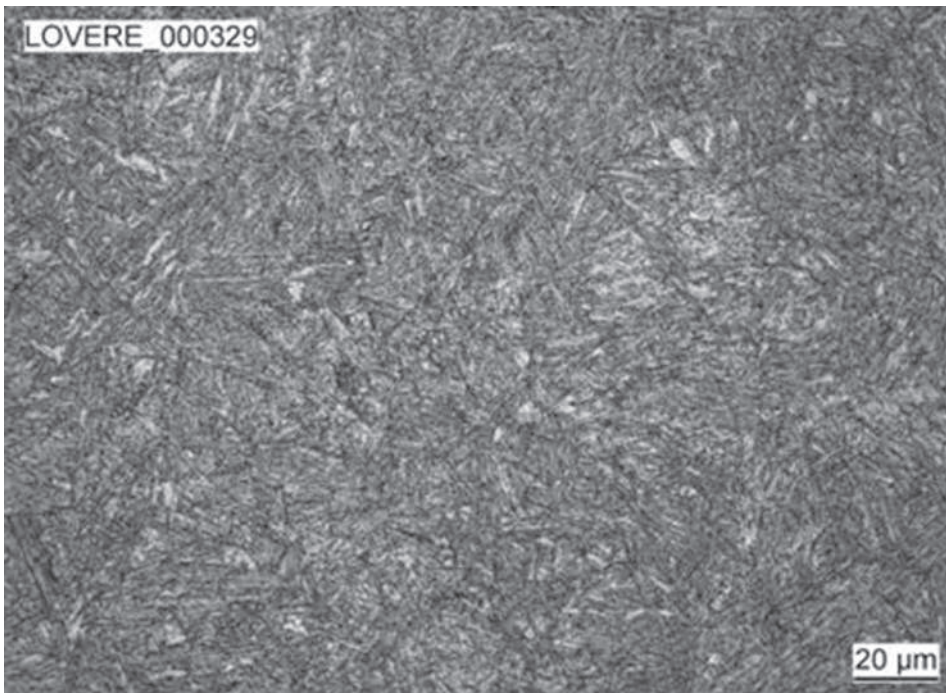
- rough machining;
- stress relieving;
- finish machining;
- nitriding.

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 ESKYLOS® 6959



The microstructure of EskyLos® 6959 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	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	500	700
Hardness and Wear Resistance	1	1	1	2	2	2	2	3	2	3	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	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

Quick comparison guide among the different Hot Work Tools grades

The following table shows a quick comparison among the most important characteristics of the pre-hardened or annealed grades normally applied for Hot Work tools.

Lucchini RS Hot Work tool Steel Family															
Special features and delivered conditions	Annealed Not Corrosion Resistant														
	KEYLOS	BEYLOS								ESKYLOS					
	6959	2329	2711	2714	2340	2343	2344	2365M	2367	6959	2340	2343	2344	2365M	2367
HB in surface In Annealed condition	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220
HB in surface Hardened after machining	370 410	370 410	370 410	370 410	400 450	400 450	400 450	400 450	400 450	370 410	400 450	400 450	400 450	400 450	400 450
Maximum thickness [mm]	500	600	500	700	500	500	500	500	500	500	500	500	500	500	500
Hardness and Wear Resistance	3	3	3	3	4	4	4	4	4	3	4	4	4	4	4
Degree of Through Hardening in the section	4	2	3	3	3	3	3	3	3	4	3	3	3	3	3
Toughness	4	1	4	4	3	3	2	2	2	4	3	3	2	2	2
Machinability after Annealing	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Machinability after Hardening	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Etch-Grainability	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4
Polishability	2	2	2	2	2	2	2	2	2	4	4	3	3	4	3
Repair by Welding	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Thermal Conductivity	2	2	2	2	1	1	1	1	1	2	1	1	1	1	1
Corrosion Resistance	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 information and the data presented here are typical or average values and are not a guarantee of maximum or minimum values.

Applications specifically suggested for materials described herein and in the quick comparison guide among the different grades are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.

The advantages of the ESR technology

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

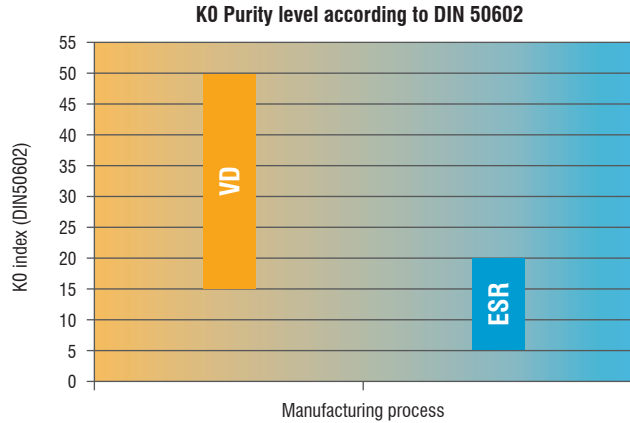
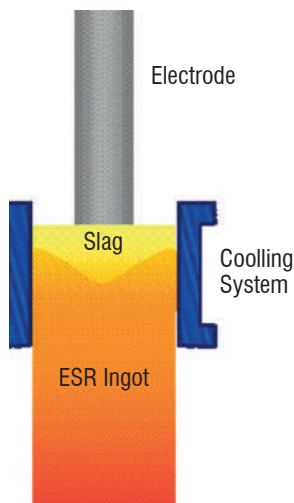
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

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® 6959 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]	90 ÷ 140	(*)	120 ÷ 180	180 ÷ 240
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]	50 ÷ 80	100 ÷ 140	(*)
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]	80 ÷ 110	100 ÷ 140	(*)
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]	120 ÷ 180	170 ÷ 210	230 ÷ 300
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]	60 ÷ 100	(*)	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 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® 6959 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)

EskyLos® 6959 can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

Chrome Plating

EskyLos® 6959 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® 6959 is suitable for photo-engraving to obtain various patterns.

Polishing

EskyLos® 6959 is particularly suitable for mirror polishing, due to the ESR Electro Slag Remelting process.