ESKYLOS®OPTILENS

VALUE IN ISOTROPY

MARTENSITIC STAINLESS STEEL DESIGNED FOR OPTICAL MOULD MANUFACTURING, OFFERING EXCELLENT POLISHABILITY AND GOOD CORROSION RESISTANCE

General characteristics

ESKYLOS® OptiLens is an advanced martensitic stainless steel, specifically designed to meet the demanding requirements of the optical mould market, where exceptional mirror-polishability is essential.

Produced through a special "super-clean" process followed by Electro-Slag Refining (ESR), it provides superior microstructural homogeneity, high isotropy, and outstanding surface finishing performance.

After heat treatment, ESKYLOS® OptiLens can achieve very high hardness values, offering exceptional wear and abrasion resistance, making it ideal for moulds used with abrasive polymers.

In addition, its excellent corrosion resistance also allows safe use with aggressive or corrosive polymers (PVC, recycled polymers, etc.), ensuring long-term preservation of surface quality and reliability in production.

Delivery conditions

ESKYLOS® OptiLens is supplied in annealed or quenched and tempered condition in a dimensional range up to 350 mm in thickness.

In annealed condition the surface hardness is lower than 250 HB, in quenched and tempered condition the surface hardness in 280 – 330 HB and the mid-thickness hardness value is guaranteed in section up to 350 mm, according to the following correlation: $(HB_{Surface,min\ required} - HB_{Core}) \leq 20HB$.

Main features

- Outstanding polishability;
- good hardness and wear resistance;
- good corrosion resistance;
- homogeneous mechanical properties throughout the mould
- good machinability in annealed conditions (HB < 220);
- good hardening stability and low distorsion.

Main application

- Automotive lighthing moulds;
- optical moulds;
- moulds for corrosive plastic materials (PVC, recycled polymers, etc.);
- moulds for the automotive industry;
- moulds for medical instruments;
- moulds for food industry products;
- moulds for the cosmetics industry;
- moulds for rubber pressing;
- dies and gauges for PVC extrusion.

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Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Ni [%]	V [%]
ESKYLOS® OPTILENS Alloying [% in weight]	min	0,36	0,90	0,30	13,00	Added	0,25
	max	0,40	1,20	0,60	14,00		0,35

Comparison with international classifications:
W. Nr. 1.2083 mod.
DIN EN ISO 4957: X42Cr13 mod.
AISI designation: 420 mod.

Physical and mechanical properties

Main physical properties

ESKYLOS® OPTILENS	20°C	250°C	500°C
Young modulus E [MPa]	210	198	177
Coefficient of linear thermal expansion α [10-6/K]	-	11,5	12,1
Thermal conductivity λ [W/mK]	16,5	19,8	24,1

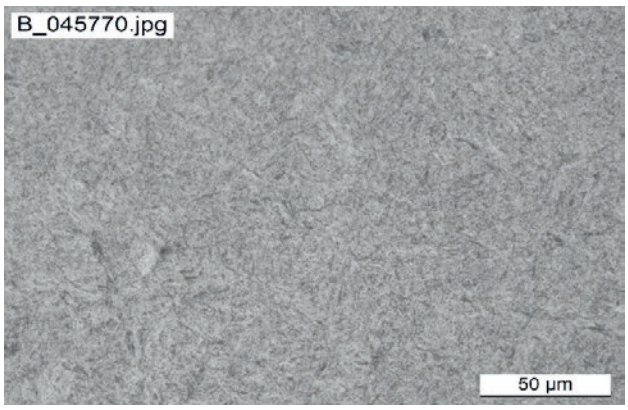
Main mechanical properties

ESKYLOS® OPTILENS	20°C	200°C
Ultimate tensile strength UTS [MPa]	1150	1050
Yield strength YS [MPa]	980	950
Reduction of area (Z) [%]	45	47

The above mentioned are average values of a sample hardened at 1030°C, quenched and tempered to achieve hardness value of 40 HRC.

Microstructure

The microstructure of ESKYLOS® OptiLens in quenched and tempered condition consists of homogeneous tempered martensite.



500x – Tempered martensite

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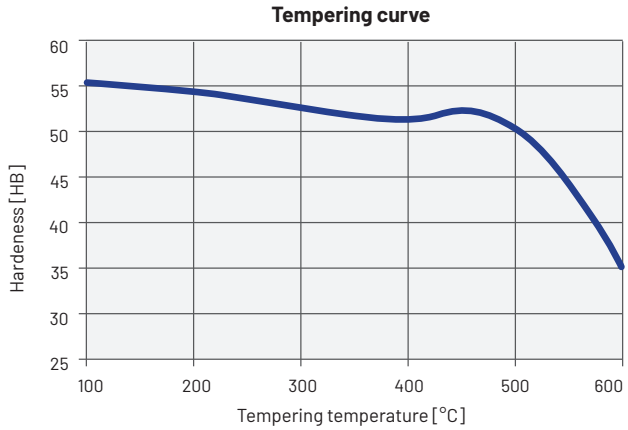
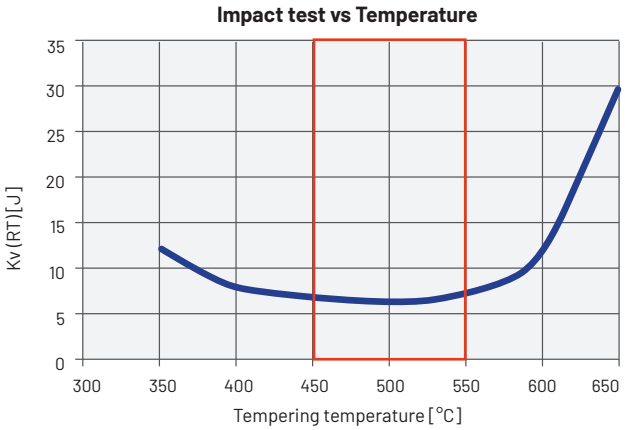
Surface hardness vs tempering temperature



Toughness (Charpy V-notch test at 20°C) vs tempering temperature



Remark: the above data are representative of the typical behaviour of a 300 mm thick block made in ESKYLOS® OptiLens and are reported for information only.

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Heat treatment

ESKYLOS® OptiLens supplied in quenched and tempered condition does not require any specific heat treatment before use. However, it is recommended to carry out a stress-relief treatment after rough machining and prior to final finishing.

If supplied in annealed condition ESKYLOS® OptiLens requires hardening and tempering before being put into service.

The recommended parameters are reported below. 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.

Stress relieving (for quenched and tempered condition)

Suggested temperature	150 - 430°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.

Hardening

Pre-heating step	700°C - 30 min every 25 mm thickness
Suggested temperature	1030°C
Soaking time	60 min every 25 mm thickness
Cooling	Vacuum cooling, oil, polymer

The pre-heating step at 700°C is recommended to reduce the stress during the heating up to austenitizing temperature.

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 form the graph "Tempering curve" reported above.

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

The suggested temperature of tempering should be outside the not recommended tempering range of 450 – 550°C, because of their possible embrittling effects (see the graph Toughness vs tempering temperature reported above).

The two optimum tempering temperatures are:
- 350°C: highest strength, high toughness;
- 600°C: moderate strength, high toughness.

If the not recommended tempering range cannot be avoided, in order to reach very high values of Hardness (around 50 HRC) on large section moulds, please consult Lucchini RS specialists.

A slightly secondary hardening effect is observed in the vicinity of 500°C after tempering, which can be attributed to the precipitation of Cr23C6 carbides heterogeneously distributed in the martensite matrix and that can lead to the loss of corrosion resistance of the steel.

After tempering we suggest to carry out stress relieving at temperature 50 °C lower than the last tempering temperature.

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

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Polishing and photo-engraving

ESKYLOS® OptiLens 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:

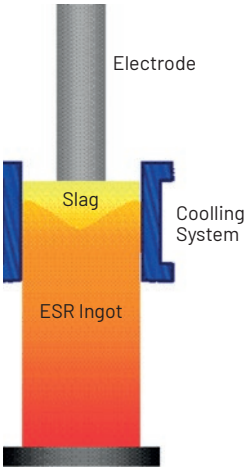
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

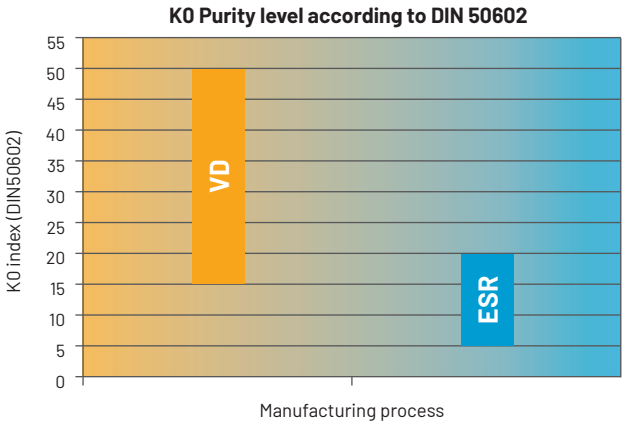
The ESR process is based on ingot remelting, through a traditional VD (vacuum degassing) process, using a particular copper ingot mould that contains basic slag.

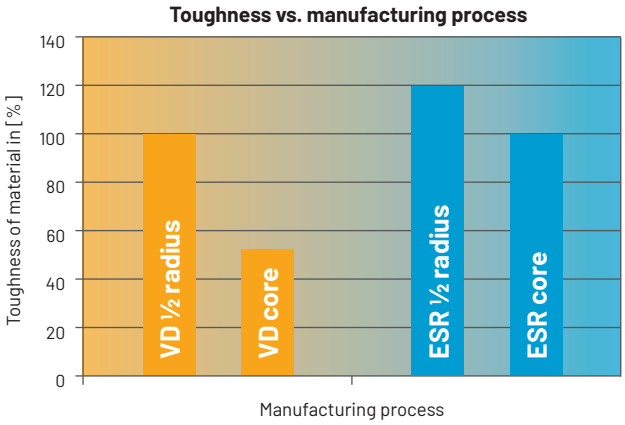
The ingot is remelted in a way that the liquid metal passes through the slag, which acts as a filter and retains the inclusions.

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® OptiLens 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.

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Guidance for machining

The following parameters are approximate only and must be adjusted to the specific application and machine tool.

Turning

	Rough machining	Finish machining		
Type of insert	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

	Rough machining		
Type of insert	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	(*)

	Pre-finishing		
Type of insert	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	(*)

	Finishing		
Type of insert	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

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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

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Welding

Welding on ESKYLOS® OptiLens is not recommended but, if it cannot be avoided, please consult Lucchini RS specialists.

The following information about welding procedure on ESKYLOS® OptiLens is only indicative.

Material condition	Annealed	Hardened and tempered
Welding technique	TIG	
Pre-heating at	250 – 300°C	
Recommended Heat treatment	Heating at 680 °C and cooling at room temperature Tempering at 10-20 °C below the temperature of the last tempering	

Electrical Discharge Machining (EDM)

ESKYLOS® OptiLens 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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