



**ESKYLOS<sup>®</sup> 2343**

**| VALUE IN ISOTROPY**

**SPECIAL ESR VERSION ACCORDING  
TO SEP 1614.96 AND VDG M82-1993  
SPECIFICATIONS FOR LIGHT ALLOYS  
DIE CASTING APPLICATIONS**



**FORGING  
VALUES  
IN ISOTROPY**

IMPROVEMENT  
COURAGE  
PEOPLE  
PASSION  
SPIRIT  
GROUP  
CUSTOMER  
SUCCESS

GROUP  
**LUCCHINI** RS

## General characteristics

ESKYLOS® 2343 is a special version of the high alloyed Chromium–Molybdenum–Vanadium Hot Work Tool steels family, specifically designed by Lucchini RS for high pressure Light Alloys (Al-Mg) die casting dies.

The optimized chemical analysis ( $P < 0.0015\%$ ,  $S < 0.003\%$  and low secondary elements content), together with the Electro Slag Re-melting process, followed by special forging and specifically designed heat treatment procedures, allows ESKYLOS® 2343 to fully meet the requirements of the European specifications SEP 1614.96 concerning the annealed microstructure and banding segregation and VDG M82-1993 concerning the Impact capability testing.

Annealed steel capability indicators are tested and certified according to Lucchini RS' internal technical instruction I.T.MET U003.

Compared with conventional Hot Work Tool steel grades, ESKYLOS® 2343 is showing an excellent resistance to thermal fatigue, a very good wear resistance at high temperature and a significantly longer mould life.

## Delivery conditions

ESKYLOS® 2343 is supplied in annealed condition and for each single block Lucchini RS guarantees an high level of material quality, based on the control of key quality indicators of annealed steel capability summarized by the Table 1 "Annealed steel capability".

		Sampling location
<b>Micro-cleanliness</b>	According to NADCA #207	
<b>Microstructure</b>	According to SEP 1614	
<b>Banding segregation</b>		
<b>Impact test</b>	According to VDG M83 $K_{vw} \geq 250 \text{ J}$	<p>Corner</p>
<b>Grain size</b>	$G \geq 5$	

Samples taken from a corner of the block and heat treated separately for  $45 \pm 1 \text{ HRC}$

**Tab. 1:** annealed steel capability

## Main features

- excellent isotropy;
- high resistance to thermal shock: heat checks and hot cracks resistance;
- excellent toughness in hot and cold conditions;
- high tempering resistance;

## Main application

- Dies, inserts and sliders for high pressure Aluminium/Magnesium die castings;
- Moulds for low pressure Aluminium die castings;
- Moulds for Aluminium gravity die castings;
- Plastic injection moulds with optical mirror polishing.

## Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	V [%]	S [%]	P [%]
<b>ESKYLOS<sup>®</sup> 2343</b> Alloying [% in weight]	min	0,35	0,80	0,30	5,00	1,20	0,30	-	-
	max	0,40	1,10	0,50	5,50	1,50	0,50	0,003	0,015

Comparison with international classifications:

**W. Nr.** 1.2343

**DIN EN ISO4957 X38CrMoV5-1**

**AISI:** H11

**NADCA GRADE D**

Heat analysis obtained during the pouring of the steel: in accordance with NADCA #207, as show in the table.

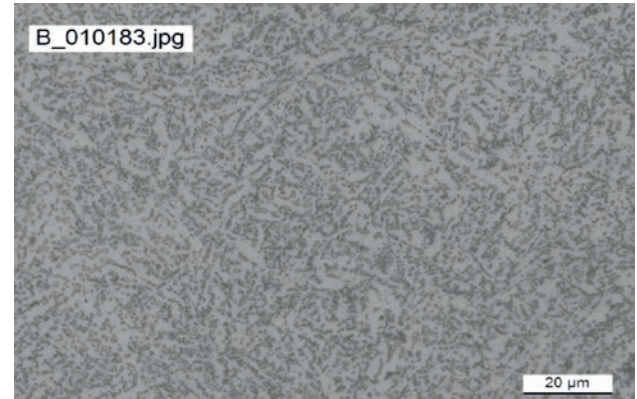
Product analysis: in order to consider the possible deviations due to the analytical reproducibility and the heterogeneity of the steel, the range of the chemical composition applicable to product analysis is usually wider than the one applicable to the heat analysis for C and Cr values.

This point is regulated by the Table 6 of DIN 17 350.

## Physical and mechanical properties

### Main physical properties

ESKYLOS <sup>®</sup> 2343	20°C	400°C	600°C
Young modulus E [MPa]	210	183	168
Coefficient of linear thermal expansion $\alpha$ [10 <sup>-6</sup> /K]	-	11,8	12,4
Thermal conductivity $\lambda$ [W/mK]	24,4	27,1	28,5



500x

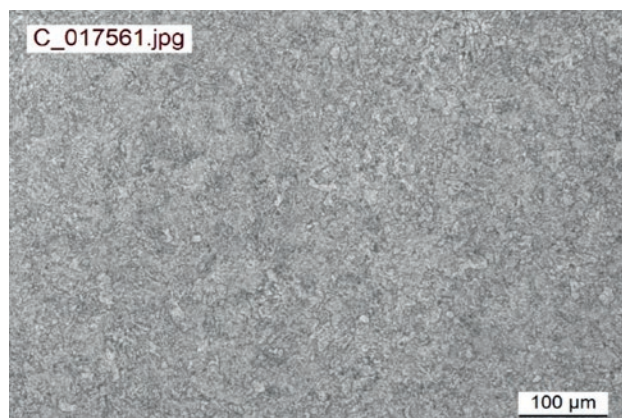
### Main mechanical properties

ESKYLOS <sup>®</sup> 2343	400°C	500°C	600°C
Ultimate tensile strength UTS [MPa]	1150	950	670
Yield strength YS [MPa]	900	750	470

The above mentioned are average values of a sample hardened at 980 °C, quenched and tempered to achieve hardness value of 44 HRC.

### Microstructure

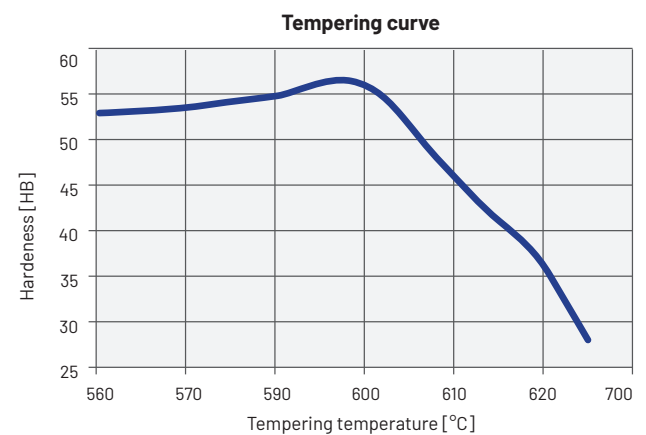
The main microstructure of ESKYLOS<sup>®</sup> 40 EVO is tempered martensite.



100x

### Surface hardness vs tempering temperature

Tempering curve of a sample austenitized at 980°C. The diagram shows values obtained after the second tempering; the first tempering is performed at 550°C.

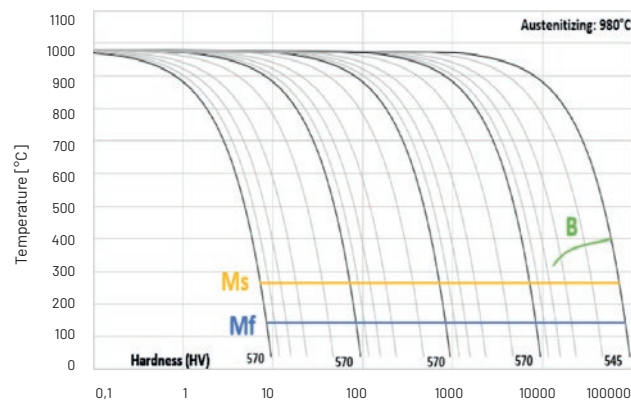




## Heat treatment

ESKYLOS® 2343 is supplied in annealed condition with a hardness value below 220 HB. Heat treatment shall be carried out using the parameters recommended and given below.

### Continuous cooling transformation curve (CCT)



### Soft annealing

Heating	max 50°C/h
Suggested temperature	850 °C
Soaking time	120 min from the temperature's settlement
Cooling	Slow cooling in furnace (20°C/h)

Soft annealing is useful to improve machinability reducing hardness at 220 HB.

### Stress relieving

Heating	max 100°C/h
Suggested temperature	Annealed condition: 650°C QT condition: 50°C lower than the last tempering
Soaking time	120 min from the temperature's settlement
Cooling	Slow cooling in furnace (20°C/h)

We strongly recommend to perform the stress relieving:

- After rough machining in order to minimize distortions and avoid quenching cracks by hardening treatment;
- After the finish machining, before the very first sampling, to avoid possible damages to cavity surface and sub-surface caused by not optimized hard milling.

### Hardening

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

Hardening should be carried out after the material pre-heating according to the following table.

Heating	Max 150°C/h
First pre-heating temperature	400°C
Soaking time	25 min / 25 mm in thickness or ( $T_{SURFACE} - T_{CORE}$ ) < 90°C

Heating	Max 150°C/h
Second pre-heating temperature	600°C
Soaking time	20 min / 25 mm in thickness or ( $T_{SURFACE} - T_{CORE}$ ) < 90°C

Heating	Max 150°C/h
Third pre-heating temperature	800°C
Soaking time	20 min / 25 mm in thickness or ( $T_{SURFACE} - T_{CORE}$ ) < 90°C

The aim of the first pre-heat at 400 °C is to eliminate stresses caused by machining: if stress relieving is performed earlier, this step could be avoided.

The following pre-heating cycles at 600 °C and 800 °C are necessary to homogenize the temperature of the piece. We recommend an heating rate of 150 °C/h max.

The time of the different stages of pre-heating is calculated on the basis of the thickness of the piece and the temperature, as described in the above attached table.

Alternatively, the time can be adjusted on the basis of the difference between the internal temperature ( $T_{CORE}$ ) and the Surface temperature ( $T_{SURFACE}$ ) of the piece, measured by two thermocouples.

After the third pre-heating at 800°C, the austenitizing temperature should be reached as quickly as possible and maintained for 30 min from when ( $T_{SURFACE} - T_{CORE}$ ) < 15 °C or on the basis of the following formula:

$$t = (x + 39) / 2$$

t = soaking time [min]  
x = thickness [mm]

<b>Heating</b>	Max 150°C/h
<b>Austenitizing</b>	Annealed condition: 650°C QT condition: 50°C lower than the last tempering
<b>temperature</b>	980°C
<b>Soaking time</b>	$t = (x+39)/2$ or 30 min from ( $T_{SURFACE} - T_{CORE}$ ) < 15°C
<b>Cooling</b>	Air, vacuum cooling, salt bath, polymer

## Tempering

It is recommended to set the temperature of the first tempering at 550°C, close to the secondary peak hardness.

The temperature of the second tempering must be set according to the required mechanical properties and must be higher than the temperature of the first tempering.

The soaking time for the first and the second tempering are calculated by the following empirical formula:

$$t' = t'' = 0,8 x + 120$$

t' = t'' = soaking time [min]  
x = thickness [mm]

A third tempering at 30-50 °C less than the maximum temperature previously used will work as a stress relieving process.

Tempering at a temperature between 400 and 550 °C is not advisable, as it may reduce the material toughness. Tempering at a temperature lower than 200 °C should not be carried out.

The soaking time for the third tempering is calculated by the following empirical formula:

$$t''' = 0,8 x + 120$$

t''' = soaking time [min]  
x = thickness [mm]

<b>First tempering temperature</b>	550°C
<b>Soaking time</b>	$t' = 0,8 x + 120$
<b>Cooling</b>	Still air

<b>Second tempering temperature</b>	Based on mechanical properties required
<b>Soaking time</b>	$t'' = 0,8 x + 120$
<b>Cooling</b>	Still air

<b>Third tempering temperature</b>	30-50 °C less than the maximum temperature previously used
<b>Soaking time</b>	$t''' = 0,8 x + 180$
<b>Cooling</b>	Still air

## **Chrome plating**

ESKYLOS® 2343 can be Chrome plated in order to enhance the mechanical characteristics on the surface.

In order to prevent Hydrogen embitterment, within 4 hours of Chrome plating it is advisable to carry out heat treatment at 200 °C for about 4 hours.

## **Nitriding**

ESKYLOS® 2343 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.

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

## **Polishing and photo-engraving**

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ESKYLOS® 2343 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:

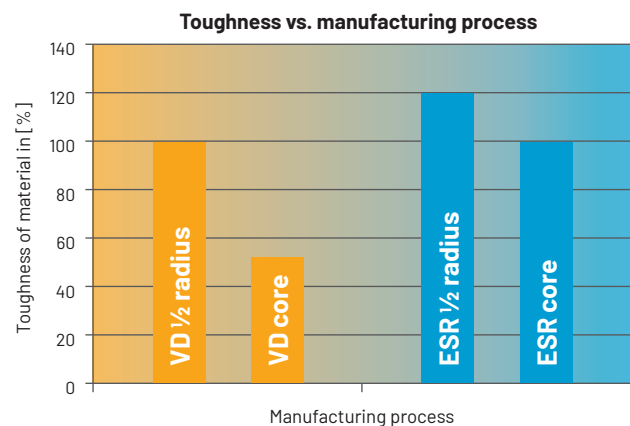
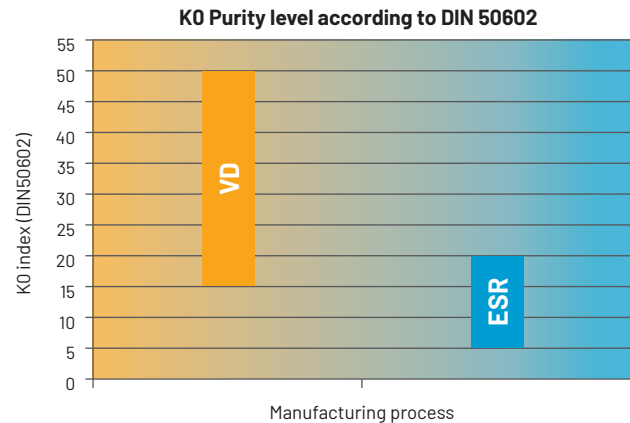
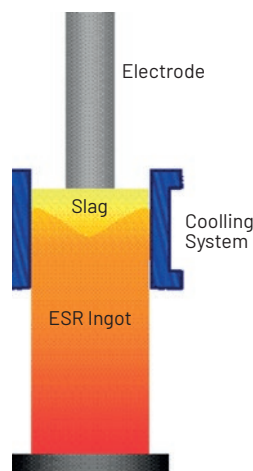
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

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® 2343 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

Welding ESKYLOS<sup>®</sup> 2343 can give good results if it is carried out using the recommended procedure.

As steel with high Carbon Equivalent content, ESKYLOS<sup>®</sup> 2343 is very sensitive to cracking.

We recommend to carry out pre-heating and heat treatment after welding.

In order to obtain the best results, we recommend the following procedure:

<b>Material condition</b>	Annealed	
<b>Welding technique</b>	TIG	MMA
<b>Pre-heating at</b>	330 – 380°C	
<b>Recommended Heat treatment</b>	Heating at 850 °C, cooling in furnace up to 600°C at a rate of 20 °C/h, afterward cooling at room temperature	
<b>Material condition</b>	Hardened and tempered	
<b>Welding technique</b>	TIG	MMA
<b>Pre-heating at</b>	330 – 380°C	
<b>Recommended Heat treatment</b>	650°C or 50°C lower than the tempering temperature previously used	

## Electrical Discharge Machining (EDM)

ESKYLOS<sup>®</sup> 2343 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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