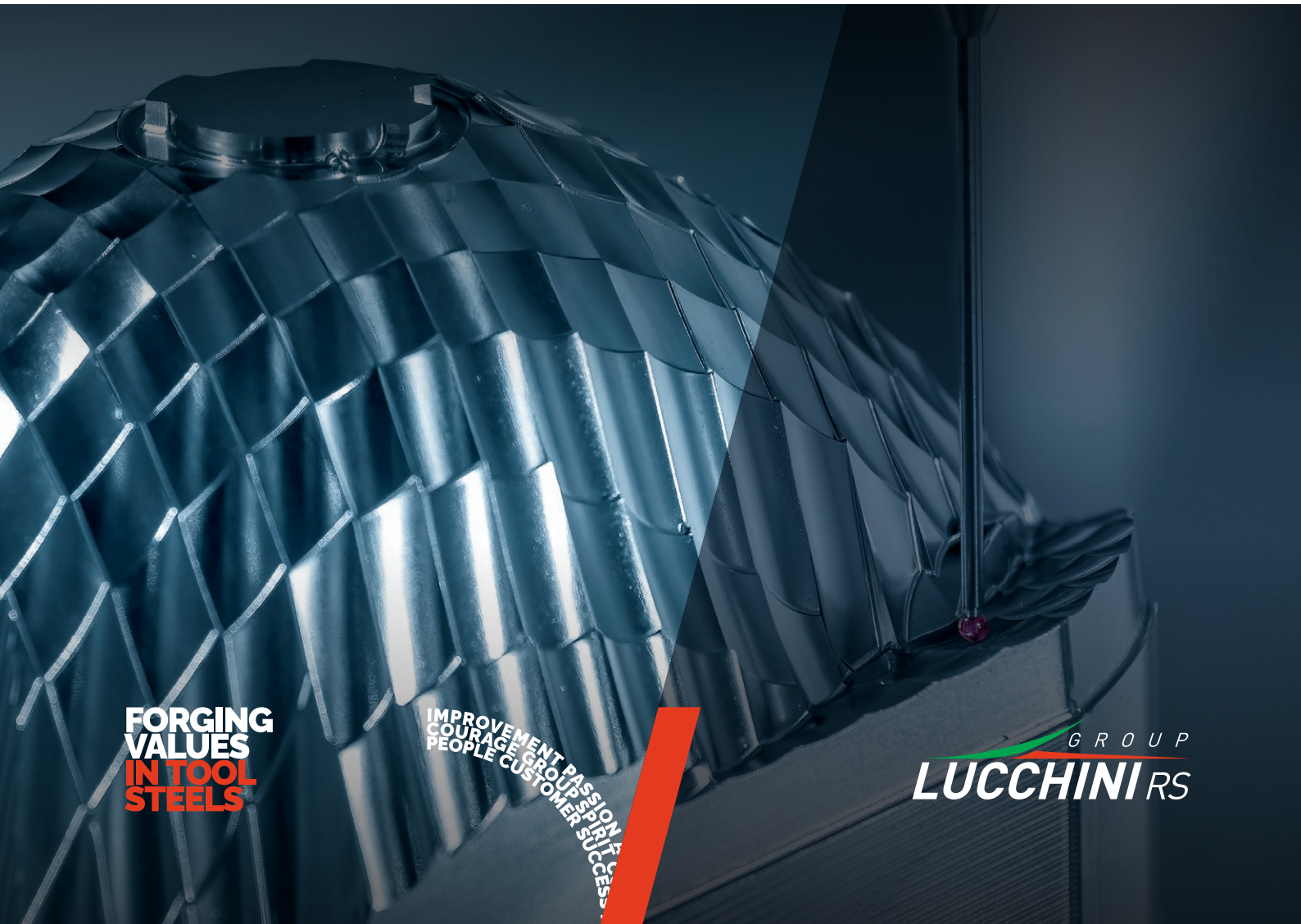
LUCCHINI 6959 ESR

SPECIAL PRE-HARDENED ESR ALLOYED STEEL FOR EXTREME STRESSED MOULDS AT LOW AND HIGH TEMPERATURES THAT NEED EXCELLENT TOUGHNESS



General characteristics

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

Thanks to its quasi-isotropic properties of ESR quality, LUCCHINI 6959 ESR 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 meantime.

Delivery conditions

LUCCHINI 6959 ESR is supplied the pre-hardened condition in a dimensional range up to 500 mm in thickness.

The surface hardness is 360 – 420 HB and the mid-thickness hardness value is guaranteed in section up to 500 mm, according to the following correlation: $(HB_{Surface,min\ required} - HB_{Core}) \leq 20HB$.

Main features

- 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.

Main application

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.

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Chemical analysis

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

Comparison with international classifications:
W. Nr. 1.6959
DIN EN ISO 4957 35NiCrMoV12.5

Physical and mechanical properties

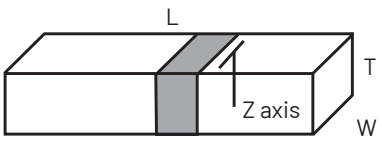
Main physical properties

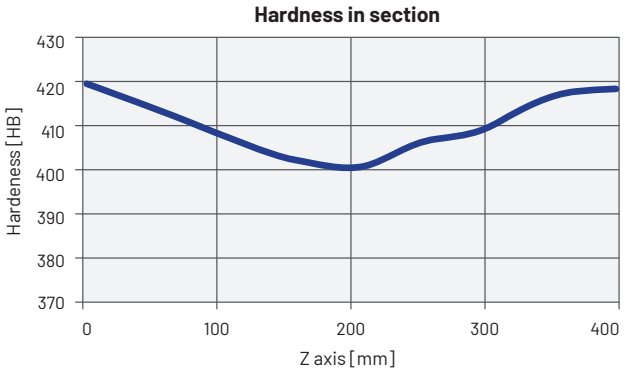
LUCCHINI 6959 ESR	20°C	250°C	500°C
Young modulus E [MPa]	210	196	177
Coefficient of linear thermal expansion α [10-6/K]	-	13,4	14,8
Thermal conductivity λ [W/mK]	24,7	24,3	23,9

Main mechanical properties

LUCCHINI 6959 ESR	20°C	200°C
Ultimate Tensile strength (UTS) [MPa]	1.460	1280
Yiels strength (YS) [MPa]	1320	1120
Elongation (A) [%]	15	16
Reduction of area (Z) [%]	48	50

Hardness profile





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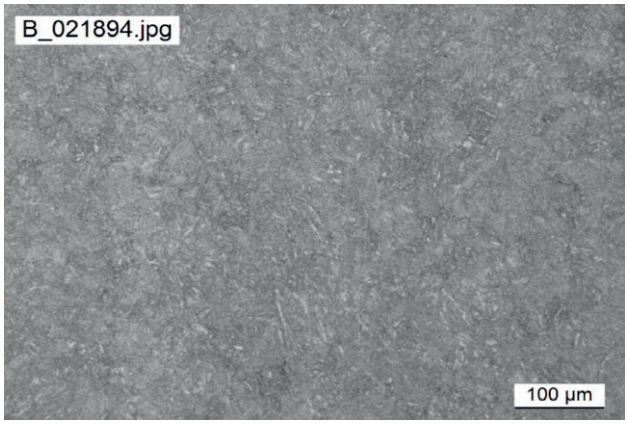
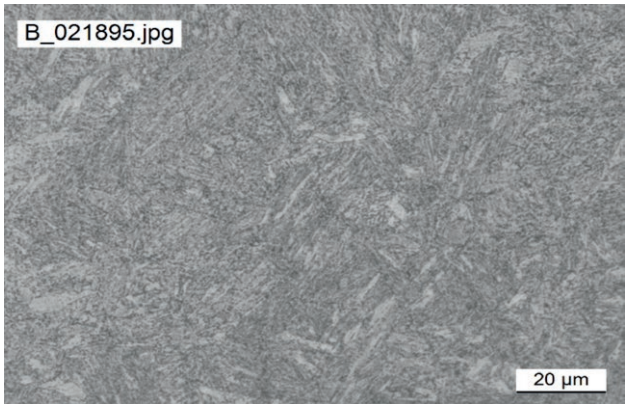
Microstructure

The main microstructure of LUCCHINI 6959 ESR is tempered martensite.

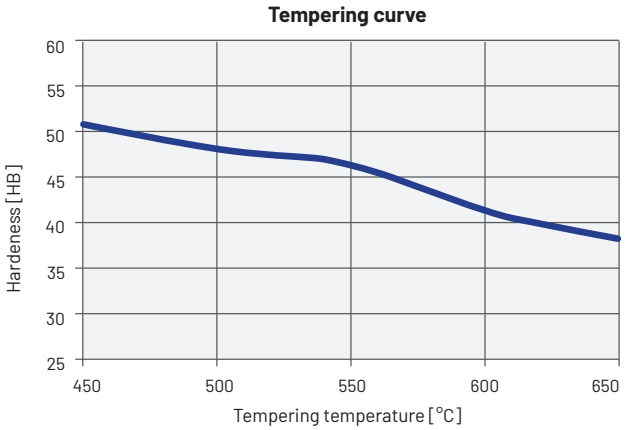


100x



500x

Surface hardness vs tempering temperature



Remark: the above data are representative of the typical behaviour of a 400 mm thick block made in LUCCHINI 6959 ESR and are reported for information only.

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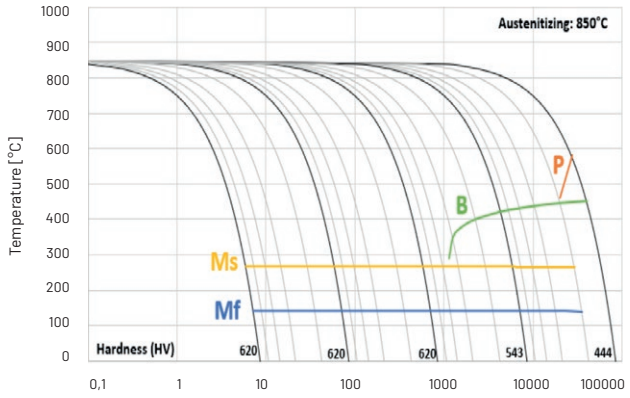
Heat treatment

LUCCHINI 6959 ESR 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	550 °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	850 °C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

Tempering

Suggested temperature	Depends on the required mechanical properties
Soaking time	120 min every 25 mm thickness
Cooling	At room temperature

The tempering temperature should be selected form 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.

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Induction hardening

LUCCHINI 6959 ESR is suitable induction hardening.

We recommend cooling at room temperature and tempering after induction hardening.

Nitriding

LUCCHINI 6959 ESR 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

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

Polishing and photo-engraving

LUCCHINI 6959 ESR 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

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The advantages of the ESR technology

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

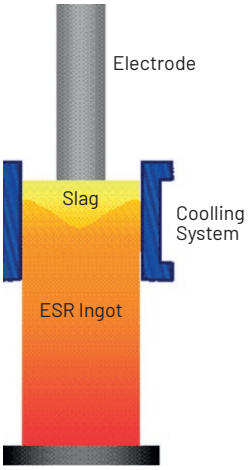
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

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.

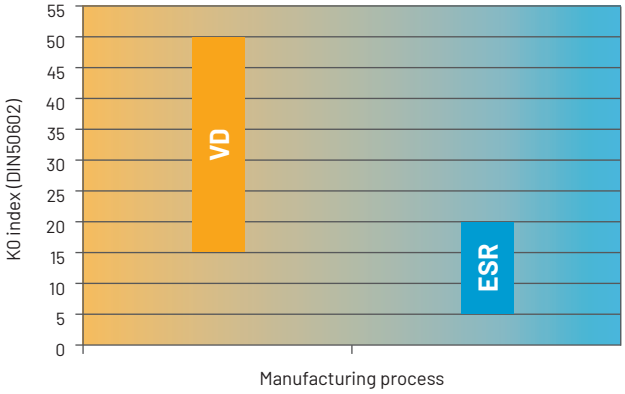
The ingot is remelted in a way that the liquid metal passes through the slag, which acts as a filter and retains the inclusions.

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

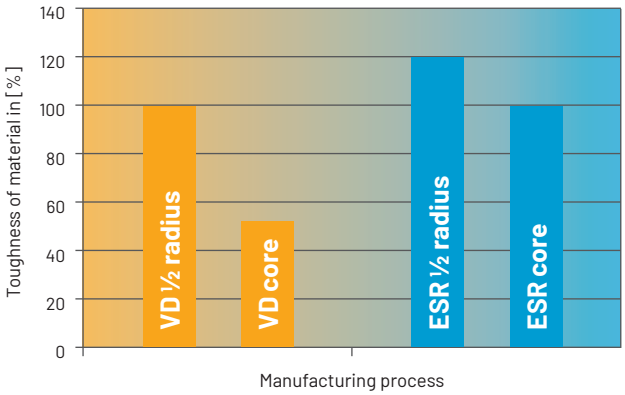
The result is homogeneous and isotropic steel.



K0 Purity level according to DIN 50602



Toughness vs. manufacturing process



Thanks to the ESR process, LUCCHINI 6959 ESR 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

Welding

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

Welding technique	TIG	MMA
Pre-heating at	250 – 300°C	
Recommended Heat treatment	Stress relieving (see heat treatment paragraph)	

Electrical Discharge Machining (EDM)

LUCCHINI 6959 ESR 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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