# LUCCHINI 2083 ESR

## MARTENSITIC STAINLESS STEEL FOR SPECIAL PLASTIC MOULDS THAT NEED HIGH DEGREE OF RESISTANCE IN AGGRESSIVE ENVIRONMENTS IN ESR QUALITY

## General characteristics

LUCCHINI 2083 ESR is an advanced martensitic stainless steel, Chromium based, for plastic moulds that need resistance to wear and corrosion.

Corrosion resistance allows the surface characteristics of the mould to be maintained over time and, as consequence, the die can be stocked with no need for special precautions to be taken and with the certainty of being able to use the mould whenever needed.

The expensive and complicated operations of cleaning and setting up the die are not needed before usage. LUCCHINI 2083 ESR is suitable for the production of moulds subject to corrosive and abrasive actions due to aggressive polymers (PVC, recycled polymers, etc.) or to unfavorable atmospheric conditions (high humidity / salinity).

LUCCHINI 2083 ESR is obtained through a special 'super clean' manufacturing process, followed by the ESR (Electro-Slag- Melting) technology guaranteeing quasi-isotropic properties.

## Delivery conditions

LUCCHINI 2083 ESR 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

- 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;
- excellent polishability in hardened condition.

## Main application

- moulds for corrosive plastic materials (PVC, recycled polymers, etc.);
- moulds for the automotive industry and optical parts (head lamp components);
- moulds for medical instruments;
- moulds for food industry products;
- moulds for the cosmetics industry;
- moulds for rubber pressing;
- dies and gauges for PVC extrusion;
- mechanical parts for extrusion presses (ex. extrusion heads).



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## Chemical analysis

| | Range | C [%] | Si [%] | Mn [%] | Cr [%] |
|---|---|---|---|---|---|
| LUCCHINI 2083 ESR Alloying [% in weight] | min | 0,33 | - | 0,30 | 12,50 |
| | max | 0,43 | 1,00 | 0,60 | 13,50 |

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

## Physical and mechanical properties

### *Main physical properties*

| LUCCHINI 2083 ESR | 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 |

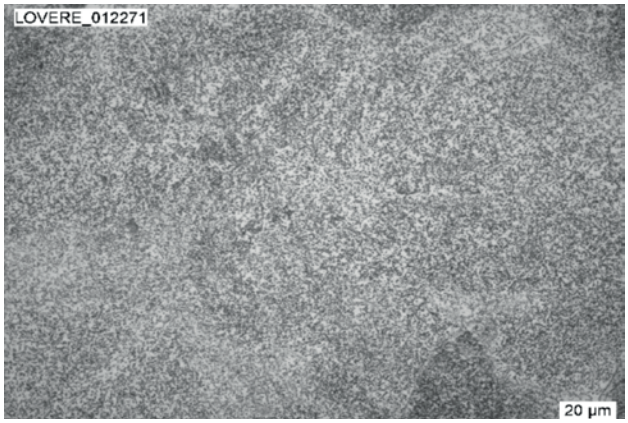
### *Main mechanical properties*

| LUCCHINI 2083 ESR | 20°C | 200°C |
|---|---|---|
| **Ultimate tensile strength UTS** [MPa] | 1150 | 1050 |
| **Yield strength YS** [MPa] | 980 | 950 |
| **Reduction of area (Z)** [%] | 45 | 47 |

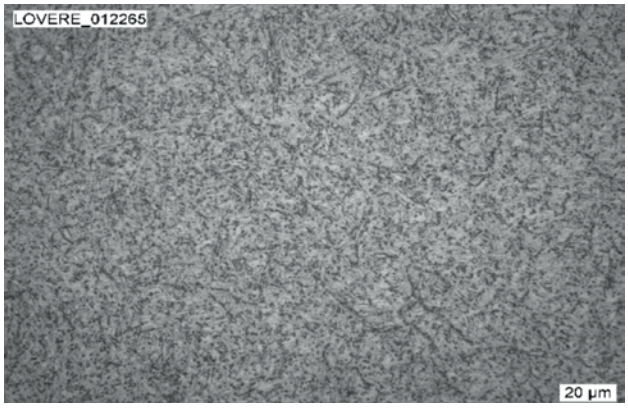
The above mentioned are average values of a sample hardened at 1030°C, quenched and tempered to achieve hardness value of 40 HRC.

### *Microstructure*

The main microstructure of LUCCHINI 2083 ESR in annealed condition is globular perlite with carbides; in quenched and tempered condition is tempered martensite.




500x – Globular perlite with carbides




500x – Tempered martensite



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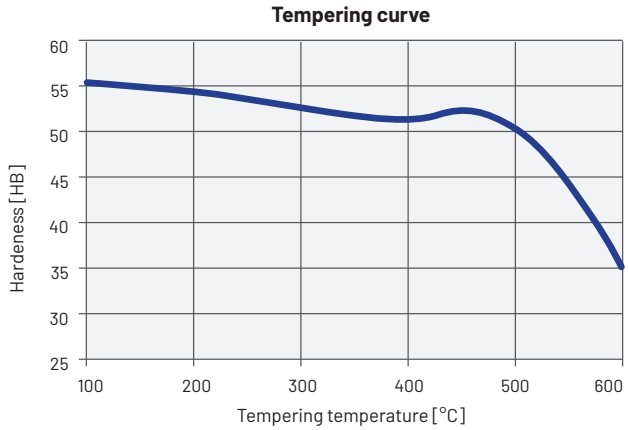
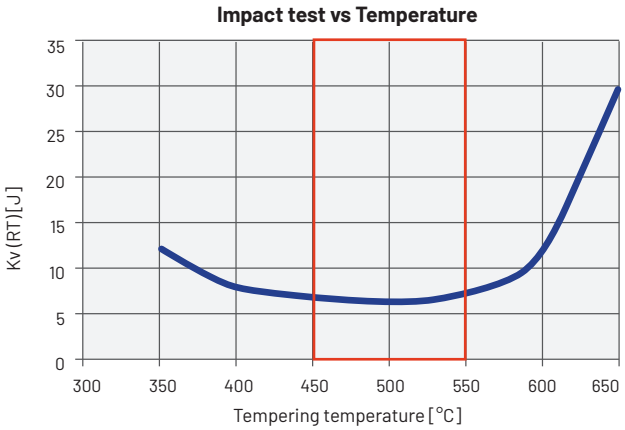
### *Surface hardness vs tempering temperature*




### *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 LUCCHINI 2083 ESR and are reported for information only.



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## Heat treatment

LUCCHINI 2083 ESR is supplied in annealed condition with a hardness value below 250 HB or in quenched and tempered conditions with no need for additional heat treatment operations.

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.

### *Soft annealing*

| | |
|---|---|
| **Suggested temperature** | 750°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** | 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.

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; the range 450 – 550°C is not recommended, because of their possible embrittling effects.

### *Hardening*

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

| | |
|---|---|
| **Suggested temperature** | 1030°C |
| **Soaking time** | 60 min every 25 mm thickness |
| **Cooling** | Vacuum cooling, oil, polymer |

### *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).



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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.

## Polishing and photo-engraving

LUCCHINI 2083 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:

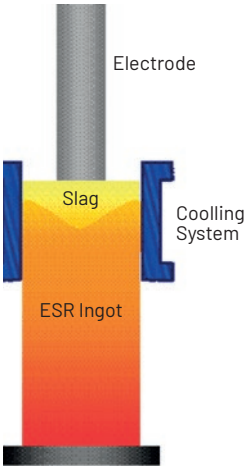
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

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.

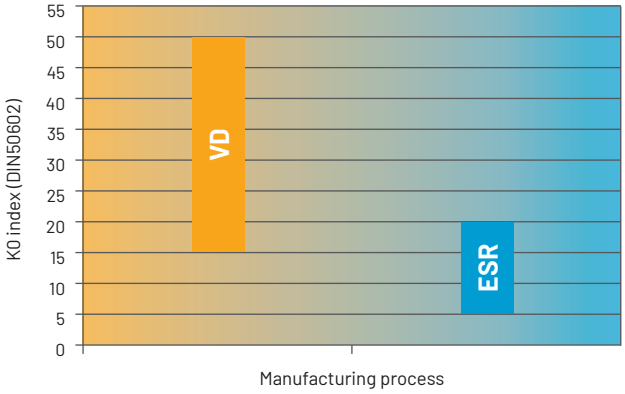
The ingot is remelted in a way that the liquid metal passes through the slag, which acts as a filter and retains the inclusions.

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

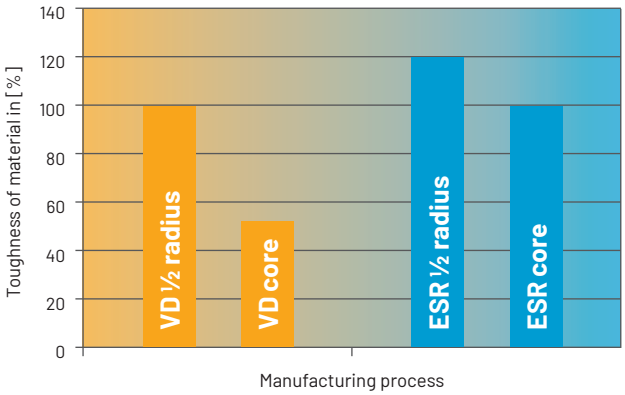
The result is homogeneous and isotropic steel.




**K0 Purity level according to DIN 50602**




**Toughness vs. manufacturing process**




Thanks to the ESR process, LUCCHINI 2083 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]<br>$V_c$: cutting speed [m/min]<br>$f_z$: feed [mm] | $f_n$: feed per turn [mm/turn]<br>$z_n$: No. of milling cutter inserts |



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## Welding

Welding on LUCCHINI 2083 ESR is not recommended but, if it cannot be avoided, please consult Lucchini RS specialists.

The following information about welding procedure on LUCCHINI 2083 ESR 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)

LUCCHINI 2083 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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