

KEY[®]LOS 6959

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

General characteristics

KeyLos[®] 6959 is a special Chromium-Nickel-Molybdenum and Vanadium alloyed pre-hardened 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.

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

KeyLos[®] 6959 is supplied in the pre-hardened condition in two hardness ranges:

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

KeyLos[®] 6959 with hardness between 300 and 360 HB is suitable for applications where the toughness of the material is of priority importance, whereas KeyLos[®] 6959 with hardness between 360 and 420 HB is recommended for applications where the mechanical stress and wear resistance are required.

Upon request, KeyLos[®] 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, KeyLos[®] 6959 in pre-machined conditions can be used also for moulds that require high levels of hardness up to 50 HRC after hardening.

KeyLos[®] 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;
- excellent wear resistance;
- internal homogeneous hardness in blocks with thickness up to 500 mm;
- quite good weldability.

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

KeyLos[®] 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 KeyLos[®] 6959 grade.

Chemical analysis

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

KeyLos[®] 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

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

Main mechanical properties

| KEY [®] LOS 6959 | 20°C | 200°C |
|--|-------|-------|
| 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

KeyLos[®] 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 |

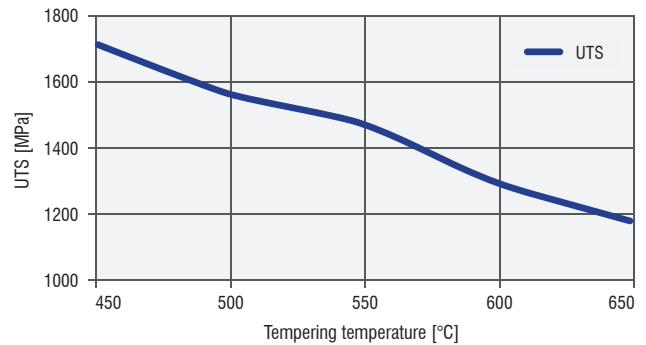
We suggest to carry out hardening on material supplied in the annealed condition and tempering immediately afterwards.

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 |

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.

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

KeyLos® 6959 is suitable for ionic and gas nitriding.

This treatment is very useful for moulds or dies subjected to extremely stressful applications.

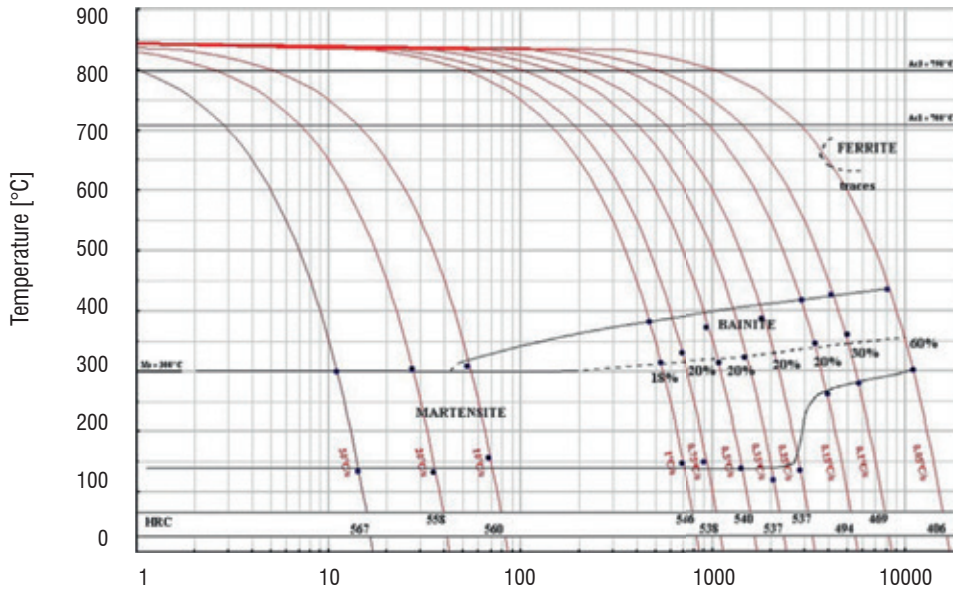
The increase of the surface hardness, following nitriding, lengthens the component life cycle.

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

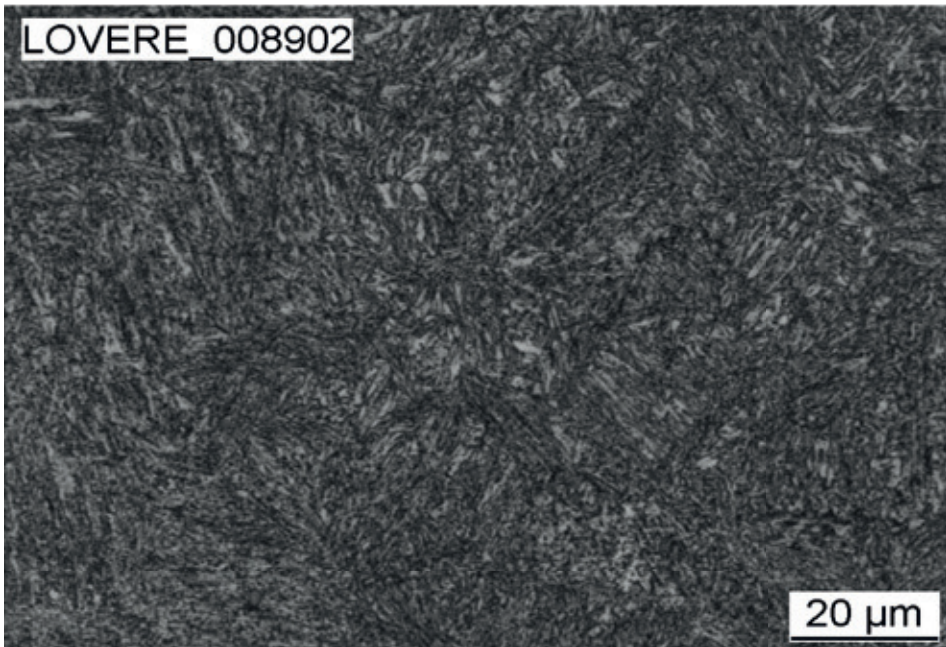
We recommend the following manufacturing cycle, in order to obtain the best results:

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

CCT Curve



Microstructure of KeyLos® 6959



The microstructure of KeyLos® 6959 detected about 20 mm under surface is tempered martensite.

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 KeyLos® 6959 can give good results if that 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)

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

Afterwards it is advisable to stress relieving the material.

Chrome Plating

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

Polishing

KeyLos® 6959 is particularly suitable for polishing.

If a mirror finished die is required we recommend to use the ESR (Electro Slag Remelting) version of this steel, known as EskyLos® 6959.



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