Steel designed for hot working

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General characteristics

BeyLos® 2367 is chrome-molybdenum-vanadium alloyed steel designed for the manufacture of dies, moulds, punches and other components subjected to high working temperatures.

The best features of this steel are:

- high resistance to thermal shock and to heat cracking
- excellent mechanical characteristics in hot condition
- excellent toughness in hot condition
- resistance to temper
- excellent machinability.

BeyLos® 2367 is obtained through a special 'super clean' production process.

BeyLos® 2367 is normally supplied in the annealed condition with hardness values lower than 220 HB, thereby guaranteeing a good machinability. If subjected to suitable hardening, followed by at least two suitable tempers, BeyLos® 2367 can reach a hardness of 52 HRc without affecting the toughness.

In order to improve further the mechanical characteristics of the surface, BeyLos® 2367 can be coated with PVD or PA/CVD methods. Alternatively it can be hardened through flame hardening, induction tempering or subjected to nitriding.

This allows a hardness value of about 58 HRc to be reached. The hardness of the nitrided layer is about 900-1000 $HV_{0,2Kg}$

The high micro-purity and structural homogeneity levels give this grade good suitability to polishing and photo-engraving.

When high performances are required, is available an ESR version called EskyLos® 2367.

If required, it is possible to carry out welding operations with TIG or MMA methods on dies made of BeyLos® 2367.

Chemical analysis

BeyLos 2367		Alloying %	
C	**0,34 ÷ 0,42**	**Cr**	**4,80 ÷ 5,50**
Si	**0,30 ÷ 0,60**	**Mo**	**2,70 ÷ 3,20**
Mn	**0,20 ÷ 0,50**	**V**	**0,40 ÷ 0,70**

Table for comparison of international classification

W. Nr. 1.2367

EN ISO X38CrMoV5-3

Lucchini RS's tool steels have been researched and formulated to optimize the performance of the materials.
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

BeyLos® 2367 is suitable for the following applications:

- dies for aluminium die-casting
- dies subjected to low pressure
- chill moulds for gravity casting
- containers for die-casting presses
- dies for aluminium extrusion
- extrusion press blocks
- sleeves for extrusion presses
- injection moulds.

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Physical and mechanical properties

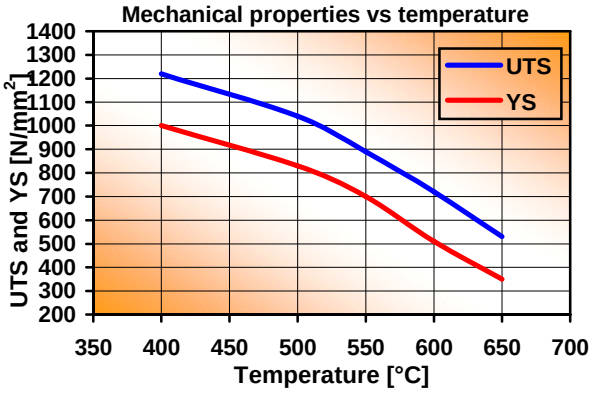
Main physical properties

BeyLos 2367	at 20°C	at 400°C	at 600°C
Modulus of elasticity [kN/mm^2]	210	175	166
Coefficient of thermal expansion from 20 °C at [10^{-6}/K]	-	12,1	12,9
Thermal conductivity [W/mK]	25,8	27,2	31,4

Main mechanical properties

BeyLos 2367	at 400°C	at 500°C	at 600°C
Ultimate Tensile strength (**UTS**) [N/mm^2]	1.240	1.060	760
Yield stress (**YS**) [N/mm^2]	1.020	850	520

These values are average values obtained on a sample which has been hardened at 1050 °C, quenched in oil and tempered at 680 °C to achieve a hardness of 44 HRc.



Heat treatments

BeyLos® 2367 is supplied in the annealed condition. If a different hardness is required or if heat treatment is needed, we suggest applying the following parameters. This information is only indicative and must be adapted depending on the different heat treatment facilities employed and on the thickness of the bar.

Soft annealing

Suggested temperature	**850 °C**
Heating	Max 50 °C/h
Soaking time	Minimum 120 min from when the temperature settles
Cooling	Slow in the furnace

Soft annealing is recommended if optimum machinability of the material is important. After soft annealing a hardness of around 220 HB is achieved.

Stress Relieving

Suggested temperature	**650 °C**
Heating	Max 100 °C/h
Soaking time	Minimum 120 min from when the temperature settles
Cooling	Slow in the furnace

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.

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First pre-heating temperature	**400 °C**
Heating	Max 150 °C/h
Soaking time	60 min for every 25 mm thickness or when (Ts-Tc) < 90 °C

Second pre-heating temperature	**600 °C**
Heating	Max 150 °C/h
Soaking time	45 min every 25 mm thickness or when (Ts-Tc) < 90 °C

Third pre-heating temperature	**800 °C**
Heating	Max 150 °C/h
Soaking time	25 min every 25 mm thickness or when (Ts-Tc) < 90 °C

Austenitising temperature	**1050°C**
Heating	> 150°C/h
Soaking time	t = (x + 39) / 2 or 30 min from when (Ts-Tc) < 15 °C
Cooling	Air, vacuum cooling, salt bath, oil

Hardening

Hardening should be carried out after the material has been pre-heated according to the following table.

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

The aim of the first pre-heat at 400 °C is to eliminate stresses caused by machining. The following pre-heating cycles at 600 °C and 800 °C are necessary to homogenise the temperature of the piece. We recommend a rate of heating of 150 °C/h.

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

Alternatively, the time can be adjusted on the basis of the difference between the internal temperature (Tc) and the Surface temperature (Ts) of the piece, measured by means of two thermocouples.

After the third pre-heat at 800 °C, the austenitising temperature should be reached as quickly as possible and maintained for 30 min from when (Ts-Tc) < 15 °C or on the basis of the following formula:

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

t = soaking time [min]

x = thickness [mm]

Tempering

It is recommended to set the temperature of the first temper at 580 °C, close to the secondary hardness.

The temperature of the second temper must be set on the basis of the required mechanical properties, and must be higher than the temperature applied for the first temper.

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

$$t' = t'' = 0{,}8\ x + 120$$

t' = t" = soaking time [min]

x = thickness [mm]

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A third temper at a temperature of 30-50 °C below the maximum temperature previously applied will function as a stress relieving cycle.

Tempers at a temperature between 400 and 550 °C are not advisable, as they reduce the material toughness. Tempers at a temperature lower than 200 °C should not be carried out.

The soaking time for the third temper are calculated by applying the following empirical formula:

$$t''' = 0{,}8\,x + 180$$

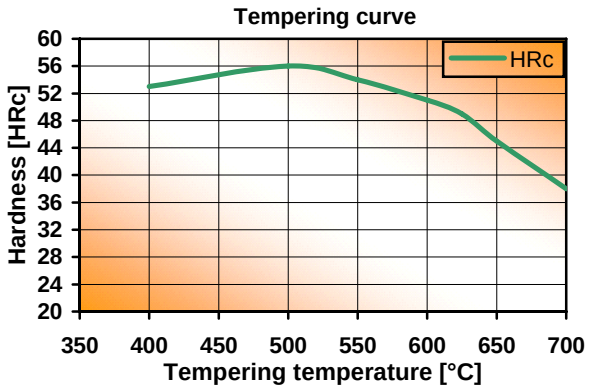
t''' = soaking time [min]

x = thickness [mm]

First tempering temperature	**580 °C**
Soaking time	t' = 0,8 x + 120
Cooling	Room temperature

Second tempering temperature	Set on the basis of the required mechanical properties, in any case higher than the temperature applied for the first temper.
Soaking time	t'' = 0,8 x + 120
Cooling	Room temperature

Third tempering temperature	30-50 °C lower than the max temperature previously applied
Soaking time	t''' = 0,8 x + 180
Cooling	Slow cooling in the furnace up to 250 °C, then at room temperature



Tempering curve of a sample which has been austenitised at 1050 °C. The diagram shows values obtained after the second temper.

Variation in dimensions during heat treatment

During the heat treatment of BeyLos® 2367 the phase transformation points are exceeded. Inevitably this causes a variation in the volume of the material. For this reason we recommend leaving enough machining allowance to compensate for the change of dimension due to heat treatment. All the corners should be rounded off.

Nitriding

The purpose of nitriding is to increase the resistance of the material to wear and abrasion. This treatment is very useful for components where high performance is necessary, as it extends the life of the material. We suggest nitriding the component in the hardened and tempered condition. The tempering temperature must be at least 50 °C higher than the nitriding temperature.

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

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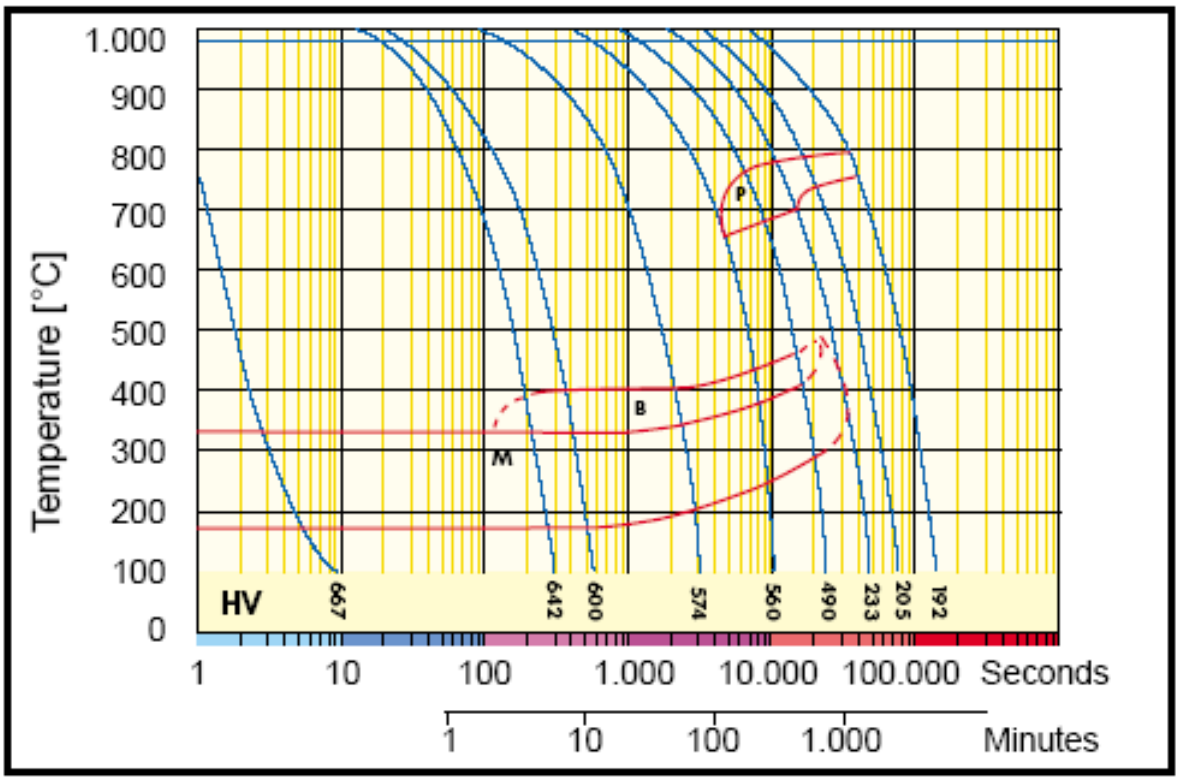
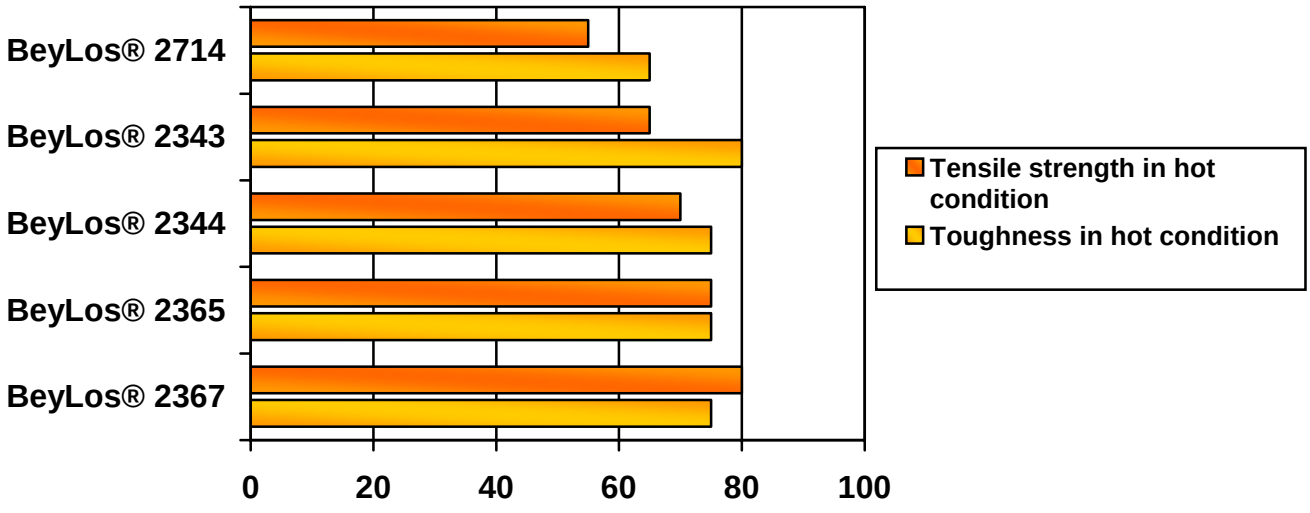
CCT Curve



Critical points

Ac1	**850°C**	**Ms**	**335°C**
Ac3	**950°C**	**Mf**	**160°C**

Comparison of properties of different hot work tool steels



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Welding

Welding of BeyLos® 2367 can give good results if the recommended procedure is followed. Being steel with high carbon equivalent content, BeyLos® 2367 is very sensitive to cracking. We recommend carrying out pre-heating and heat treatment after welding.

Condition of material	Annealed with hardness 220 HB max	
Welding technique	TIG	MMA
Pre-heating at	330÷380 °C	
Recommended heat treatment	Heating of the material at 850 °C, cooling in the furnace to 600 °C at a rate of 20 °C/h, cooling at room temperature	
Condition of material	Hardened and tempered	
Welding technique	TIG	MMA
Pre-heating at	330÷380 °C	
Recommended heat treatment	50 °C lower than the tempering temperature previously applied	

For further information, please refer to the brochure.

Electrical Discharge Machining (EDM)

BeyLos® 2367 can be machined by EDM to obtain complex shape. Afterwards it is advisable to stress relieving the material.

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