FORGING &
CASTING
DIVISION

GROUP
LUCCHINI RS

BEYLOS 2329®

Special alloyed steel designed
for dies, moulds, punches subjected
to high working temperature

LOOK BEYOND

General characteristics

BeyLos® 2329 is a special 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
- good mechanical characteristics in hot condition
- optimal mechanical characteristics in cold condition
- good toughness in hot condition.

BeyLos® 2329 is obtained through a special 'super clean' manufacturing process, which allows a high level of micro-purity to be achieved.

BeyLos® 2329 is normally supplied in round sections up to 600 mm in diameter, in the annealed condition with hardness values lower than 220 HB, thereby guaranteeing a good machinability.

If subjected to suitable heat treatment, BeyLos® 2329 can reach a hardness of 48 HRc without affecting the toughness.

In order to improve further the mechanical characteristics of the surface, BeyLos® 2329 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 52 HRc to be reached. The hardness of the nitrided layer is about 900-1000 HV.

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

If required, it is possible to carry out welding operations with TIG or MMA methods on dies made of BeyLos® 2329.

BeyLos® 2329 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 became food for the steel making production of BeyLos® 2329 grade.

Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Ni [%]	Cr [%]	Mo [%]	V [%]
BEYLOS 2329 Alloying [% in weight]	min	0,44	0,60	0,70	0,50	1,70	0,25	0,15
	max	0,54	0,90	1,00	0,80	2,10	0,45	0,25

Table for comparison of international classification

W. Nr.	**1.2329**
DIN	**46CrSiMoV7**

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

BeyLos® 2329 is suitable for the following applications:

- dies subjected to low pressure
- containers for die-casting presses
- extrusion press blocks
- sleeves for extrusion presses.

Physical and mechanical properties

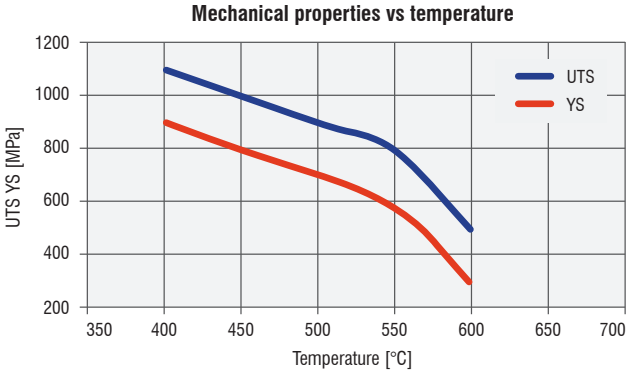
Main physical properties

BEYLOS 2329	20°C	400°C	600°C
Modulus of elasticity [GPa] (1GPa=1000 MPa)	210	186	179
Coefficient of thermal expansion [10^{-6}/K]	-	13,2	14,5
Thermal conductivity [W/mK]	27,0	29,1	32,4

Main mechanical properties

BEYLOS 2329	400°C	500°C	600°C
Ultimate tensile strength (UTS) [MPa]	1.080	900	440
Yield stress (YS) [MPa]	850	680	270

These are average values obtained on a sample which has been hardened at 870° C, quenched and tempered at 560°C to achieve a hardness of 44 HRc.



Heat treatments

BeyLos® 2329 is supplied in the annealed or in the pre-hardened condition, depending on the application.
We suggest applying the following parameters if a different hardness is required or if heat treatment is needed.
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	700°C
Heating	Maximum 50°C/h
Soaking time	60 min every 25 mm thickness
Cooling	In the furnace at less than 20° C/hr to **500° C**, then at room temperature

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	Maximum 100°C/h
Soaking time	60 min every 50 mm thickness
Cooling	Slow in the furnace at max 25 °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

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

First pre-heating temperature	550°C
Soaking time	60 min every 25 mm thickness

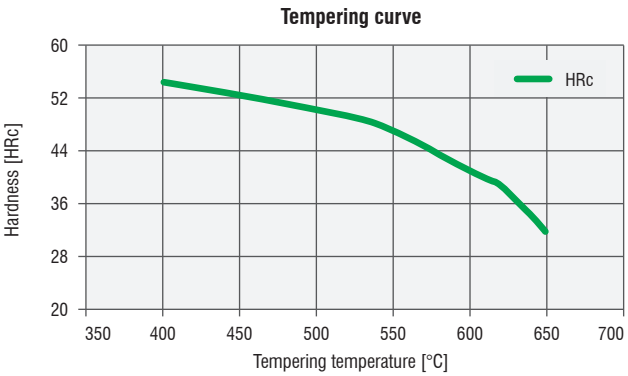
Austenitising temperature	870°C
Soaking time	60 min every 25 mm thickness
Cooling	Air or vacuum cooling, salt bath or polymer in H2O

We suggest to carry out the hardening on material supplied in the annealed condition and to temper the material immediately afterwards. The suggested rate of heating is less than or equal to 30 °C.

Tempering

The tempering temperature to be applied to the material depends on the required mechanical properties. A second temper at a temperature of 30-50° C below the maximum temperature previously applied will function as a stress relieving cycle.

Suggested temperature	Depending on the required mechanical properties. See tempering curve
Heating	Less than or equal 30 ° C/h
Soaking time	60 min every 25 mm thickness
Cooling	At room temperature



Tempering curve of a sample which has been austenitised at 870 °C and quenched.

Variation in dimensions during heat treatment

During the heat treatment of BeyLos® 2329 the phase transformation points are exceeded. Inevitably this causes a variation in the volume of the material. For this reason we recommend leaving enough 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.

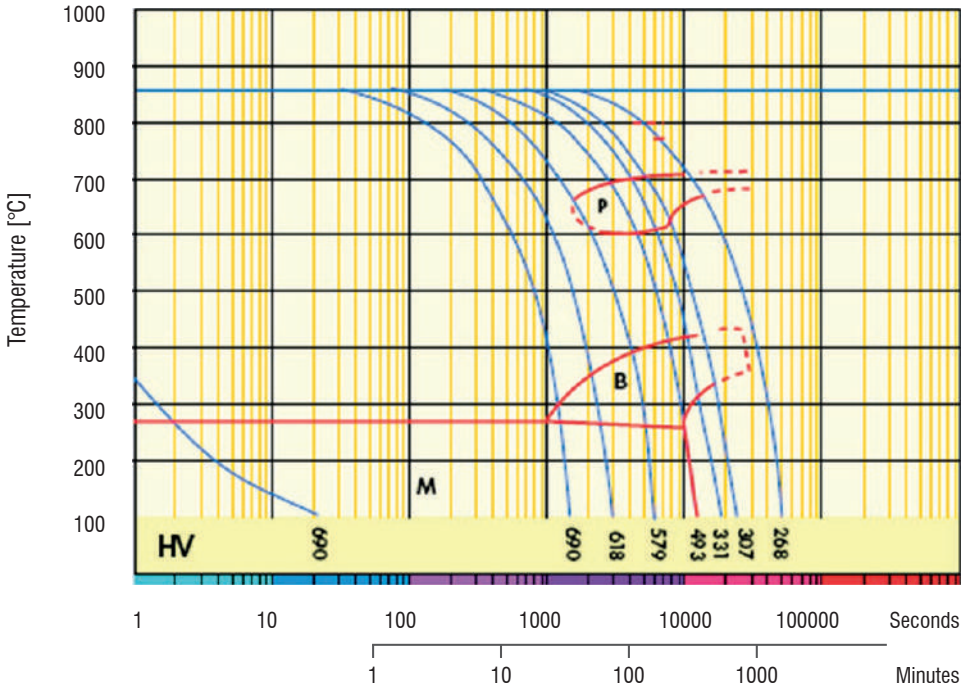
The tempering temperature must be at least 50°C higher than the nitriding temperature.

Modern nitriding processes allow the original dimensions of the component to be maintained.

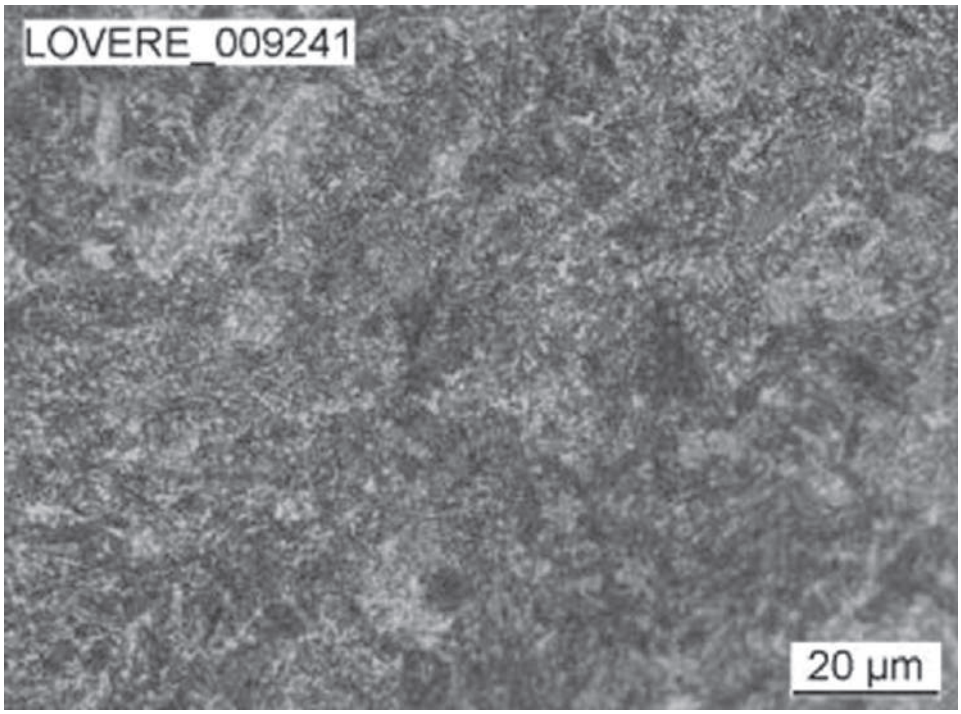
We recommend heat treating the component in the finish machined condition.

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.

CCT Curve



Microstructure of Beylos® 2329



Microstructure of a pre-hardened BeyLos® 2329 of tempered martensite.

Quick comparison guide among the different Hot Work Tool Steel Grades

The following table shows a quick comparison among the most important characteristics of the Hot Work tool Steel grades produced by Lucchini RS.

Lucchini RS Hot Work tool Steel Family															
Special features and delivered conditions	Annealed Not Corrosion Resistant														
	KEYLOS	BEYLOS								ESKYLOS					
	6959	2329	2711	2714	2340	2343	2344	2365M	2367	6959	2340	2343	2344	2365M	2367
HB in surface In Annealed condition	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220	<220
HB in surface Hardened after machining	370 - 410	370 - 410	370 - 410	370 - 410	400 - 450	400 - 450	400 - 450	400 - 450	400 - 450	370 - 410	400 - 450	400 - 450	400 - 450	400 - 450	400 - 450
Maximum thickness [mm]	500	600	500	700	500	500	500	500	500	500	500	500	500	500	500
Hardness and Wear Resistance	3	3	3	3	4	4	4	4	4	3	4	4	4	4	4
Degree of Through Hardening in the section	4	2	3	3	3	3	3	3	3	4	3	3	3	3	3
Toughness	4	1	4	4	3	3	2	2	2	4	3	3	2	2	2
Machinability after Annealing	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Machinability after Hardening	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
Etch-Grainability	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4
Polishability	2	2	2	2	2	2	2	2	2	4	4	3	3	4	3
Repair by Welding	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Thermal Conductivity	2	2	2	2	1	1	1	1	1	2	1	1	1	1	1
Corrosion Resistance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4 Excellent 3 Very Good 2 Good 1 Normal 0 Unsuitable

The information and the data presented here are typical or average values and are not a guarantee of maximum or minimum values.

Applications specifically suggested for materials described herein and in the quick comparison guide among the different grades are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.

Guidance for machining

The following parameters are indicative only and must be adapted to the particular application and to the machinery employed. The data refer to material in the annealed condition. Hardness 220 HB max.

Turning

	Rough machining	Finish machining		
Type of insert	P20-P40 coated	HSS	P10-P20 coated	Cermet
V_c cutting speed [m/min]	170 ÷ 220	(*)	200 ÷ 250	240 ÷ 300
a_r cutting depth [mm]	1 ÷ 5	(*)	< 1	< 0,5

Milling

	Rough machining		
Type of insert	P25-P35 not coated	P25-P35 coated	HSS
V_c cutting speed [m/min]	140 ÷ 200	180 ÷ 260	(*)
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]	160 ÷ 240	240 ÷ 280	(*)
f_z feed [mm]	0,2 ÷ 0,3	0,2 ÷ 0,3	(*)
a_r cutting depth [mm]	1 ÷ 2	1 ÷ 2	(*)

	Finishing		
Type of insert	P10-P20 not coated	P10-P20 coated	Cermet P15
V_c cutting speed [m/min]	200 ÷ 260	240 ÷ 300	240 ÷ 330
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
V_c cutting speed [m/min]	190 ÷ 220	(*)	60 ÷ 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 BeyLos® 2329 can give good results if the recommended procedure is followed. Being steel with high carbon equivalent content, BeyLos® 2329 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	250÷300 °C	
Recommended heat treatment	Heating of the material at 700 °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	250÷300 °C	
Recommended heat treatment	550 °C or 50 °C lower than the tempering temperature previously applied	

Electrical Discharge Machining (EDM)

BeyLos® 2329 can be machined by EDM to obtain complex shape.

Afterwards it is advisable to stress relieving the material.

Chrome Plating

BeyLos® 2329 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 embitterment 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, BeyLos® 2329 is suitable for photo-engraving to obtain various patterns.

Polishing

BeyLos® 2329 is particularly suitable for polishing.

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 destinity 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.