Programa Oficial de Posgrado en
INGENIERIA MECÁNICA y de MATERIALES

MASTER EN SISTEMAS MECÁNICOS

ANEXOS

RETROFIT DE UNA MAQUINA DE ENSAYOS DE RODADURA A DOS FLANCOS PARA ENGRANAJES SINFÍN CORONA

Autor

Marcos Pueo Arteta

Director

Jorge Santolaria Mazo

Departamento de Ingeniería de Diseño y Fabricación

Escuela de Ingeniería y Arquitectura

Diciembre de 2011 - Curso 2010 / 2011

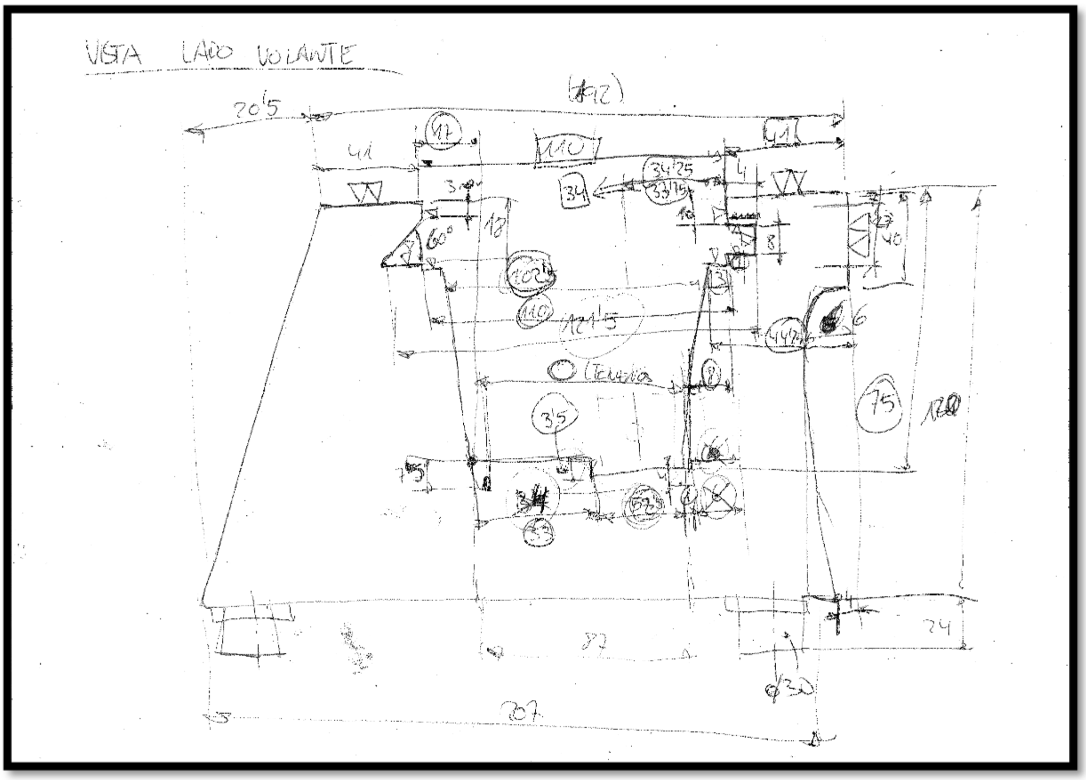
INDICE ANEXOS

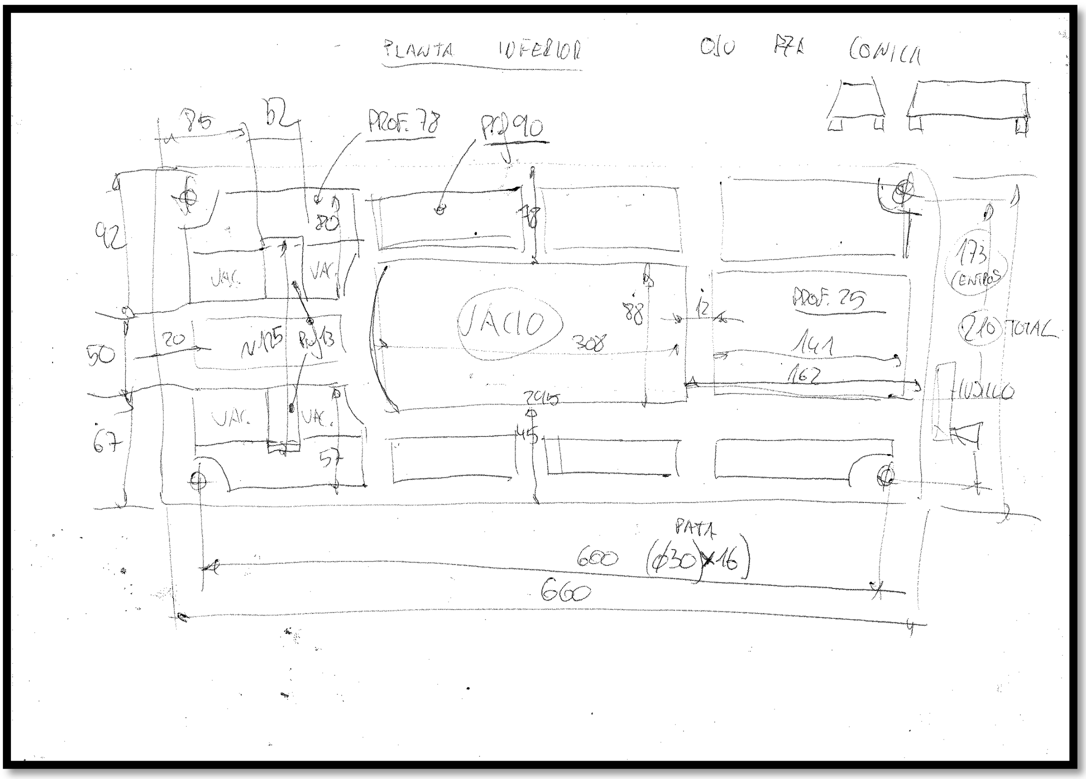
ANEXO I: CROQUIS

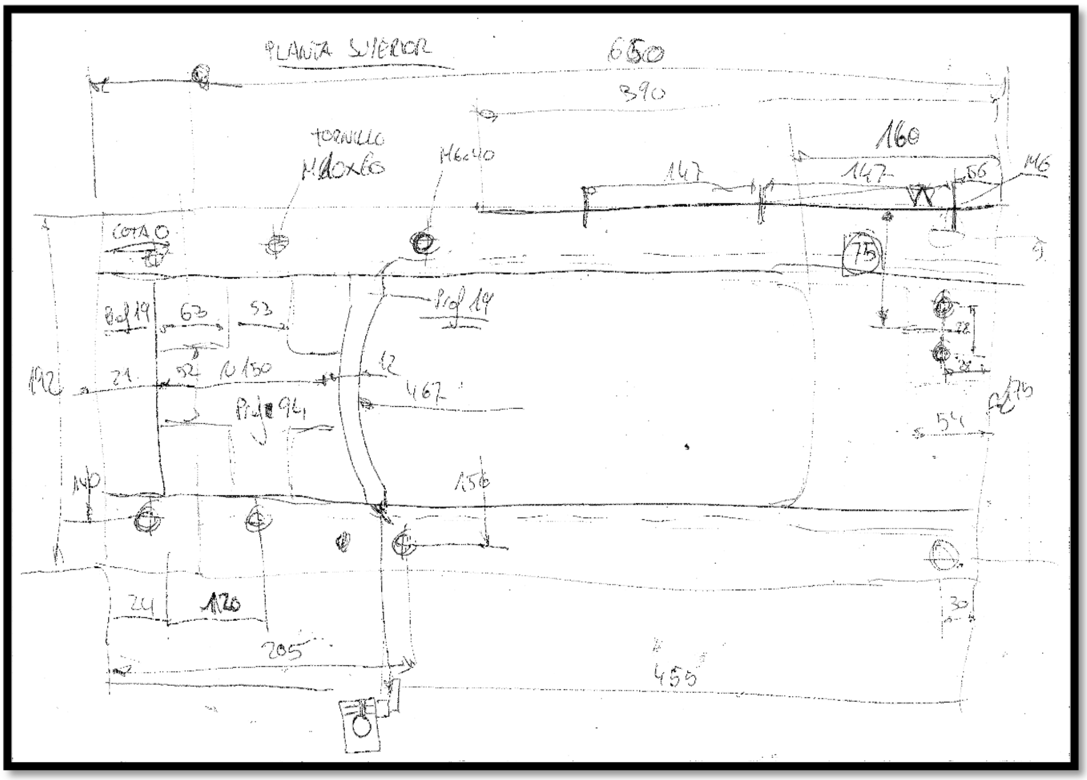
En este anexo se incluyen todos los croquis a mano alzada y anotaciones que se han realizado durante la primera parte del proyecto para su posterior utilización en la parte del modelado CAD.

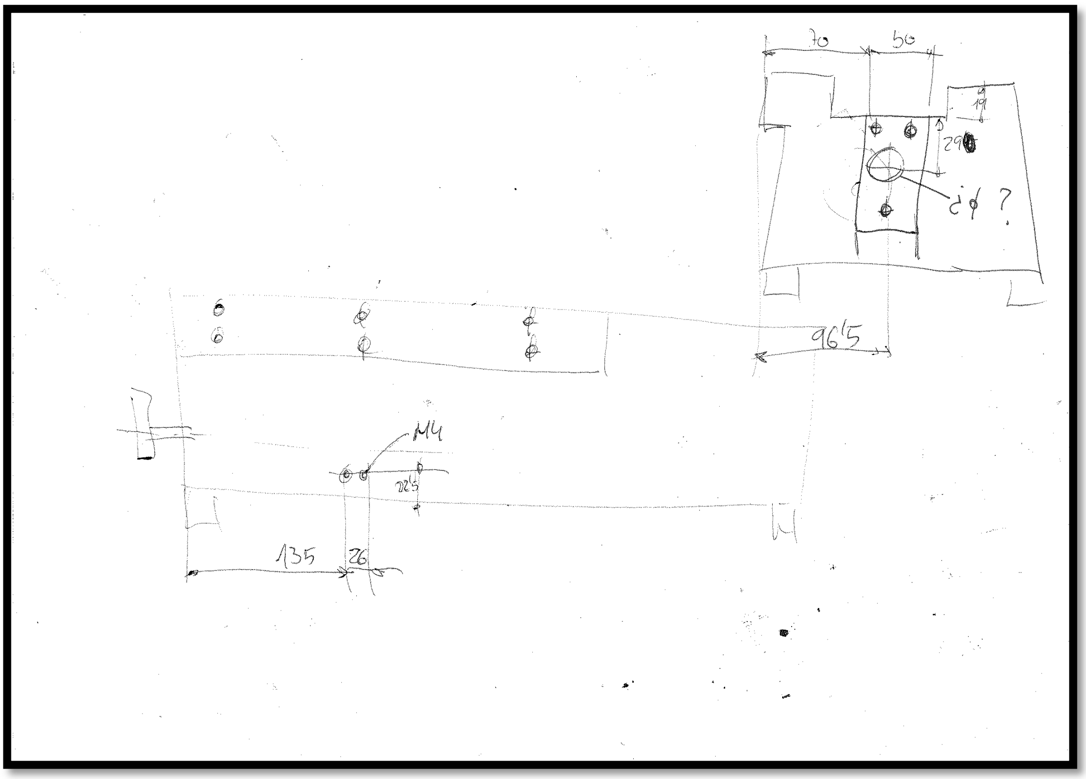
Los croquis que podemos encontrar son los siguientes:

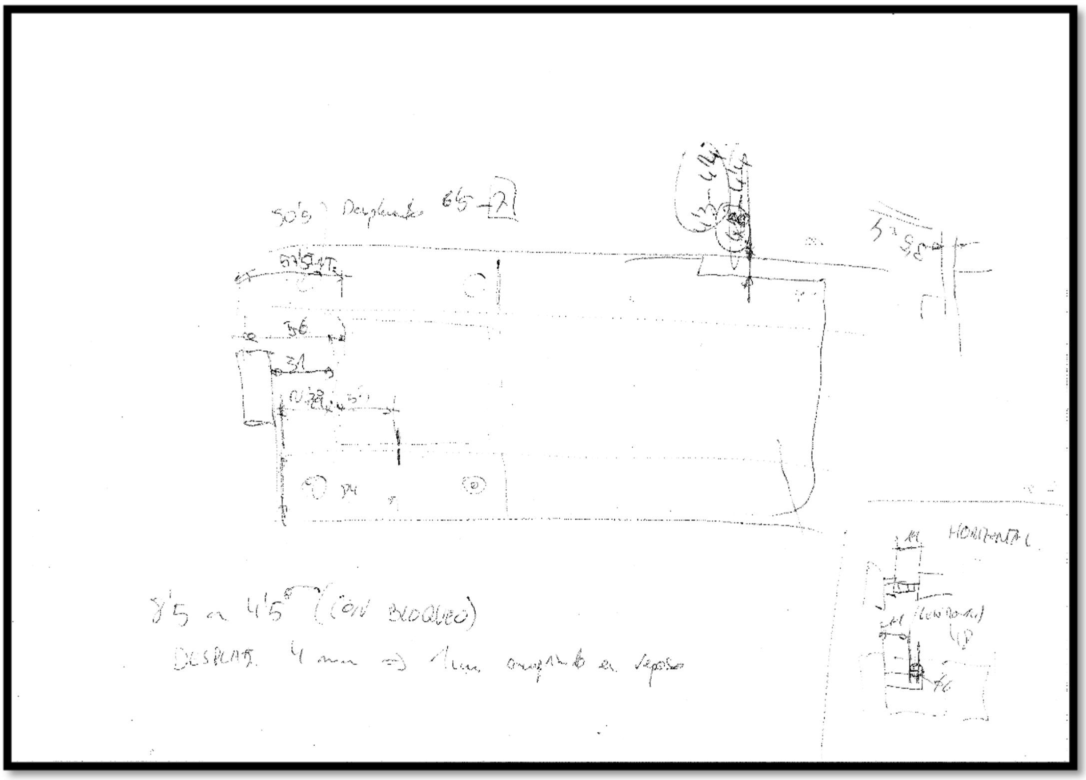
Croquis 1 *Bancada*



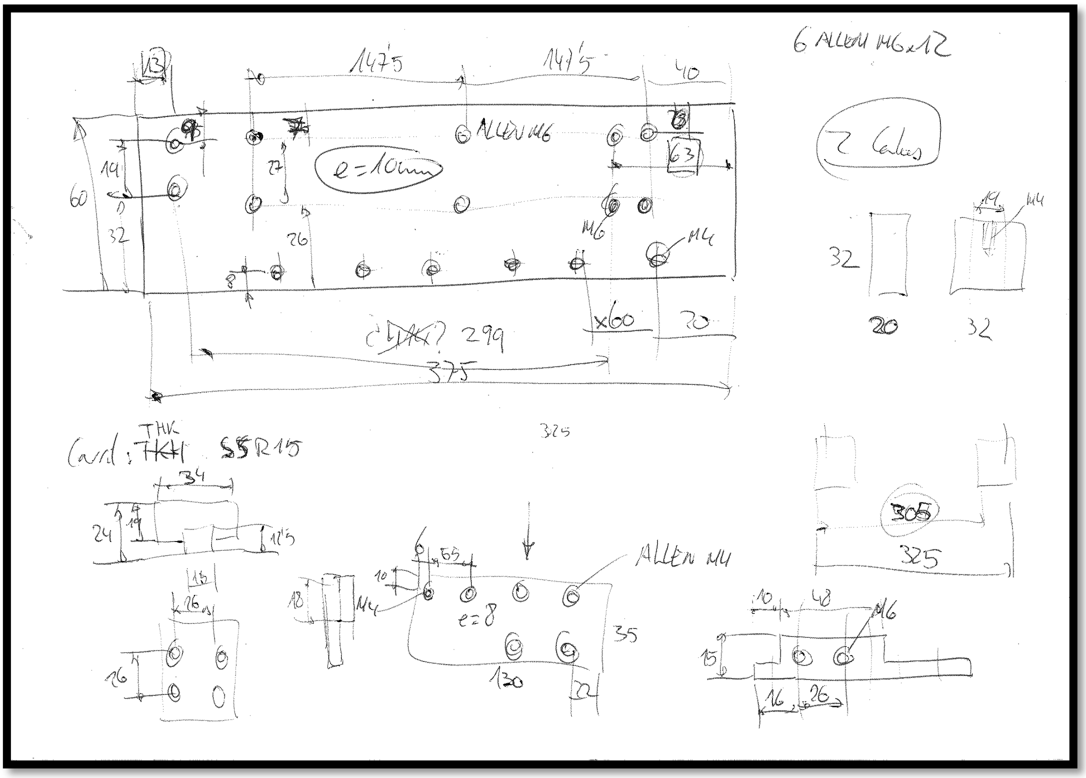



PLANTA SUPERIOR
650
390
TORNILLO
M10x60
M6x40
160
147
147
56
M6
COTA 0
75
Prof 19
63
53
22
192
21
52
R150
12
467
Prof 94
54
140
156
24
120
30
205
455

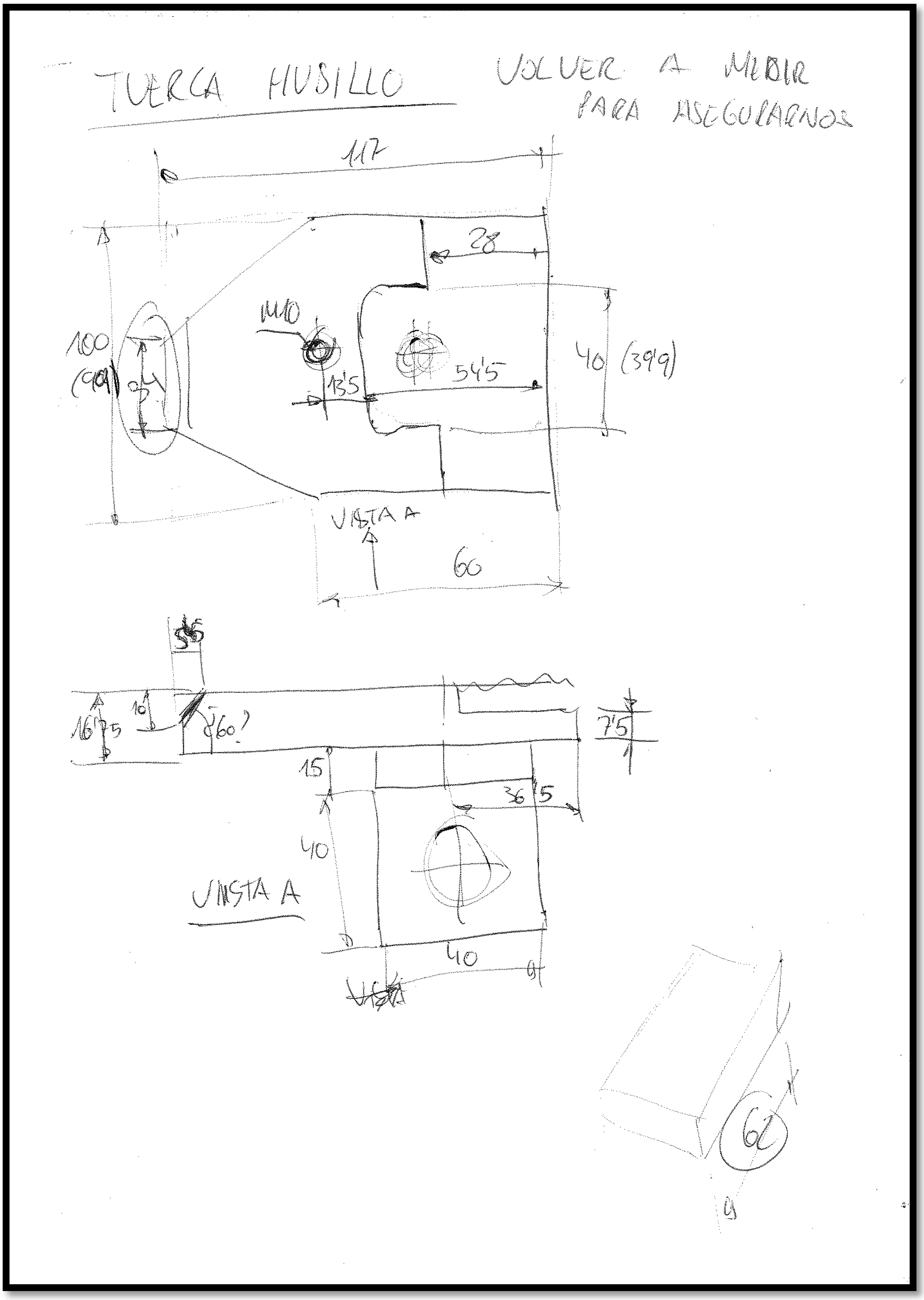

70
50
19
29
¿φ ?
96'5
M4
22'5
135
26

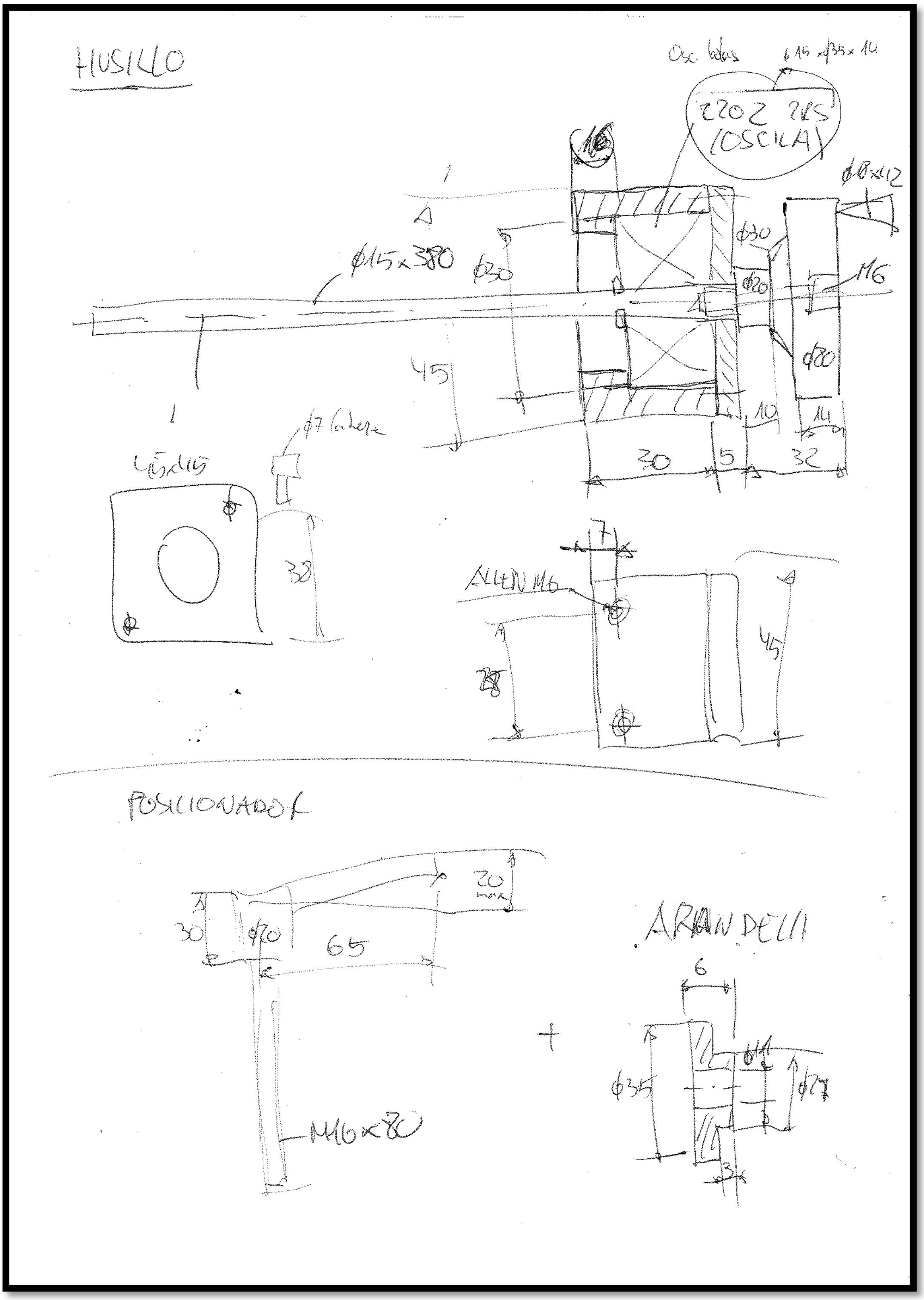


Croquis 2 *Sistema encoder lineal*

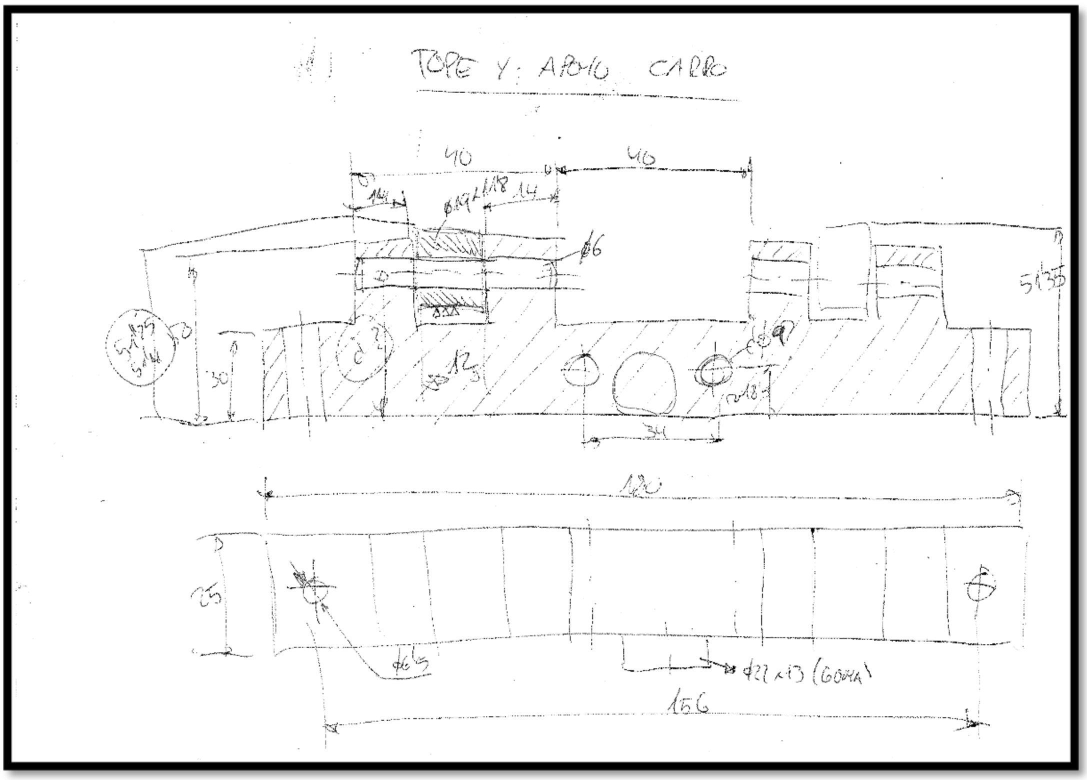


Croquis 3 *Sistema de posicionamiento carro porta-sinfín*

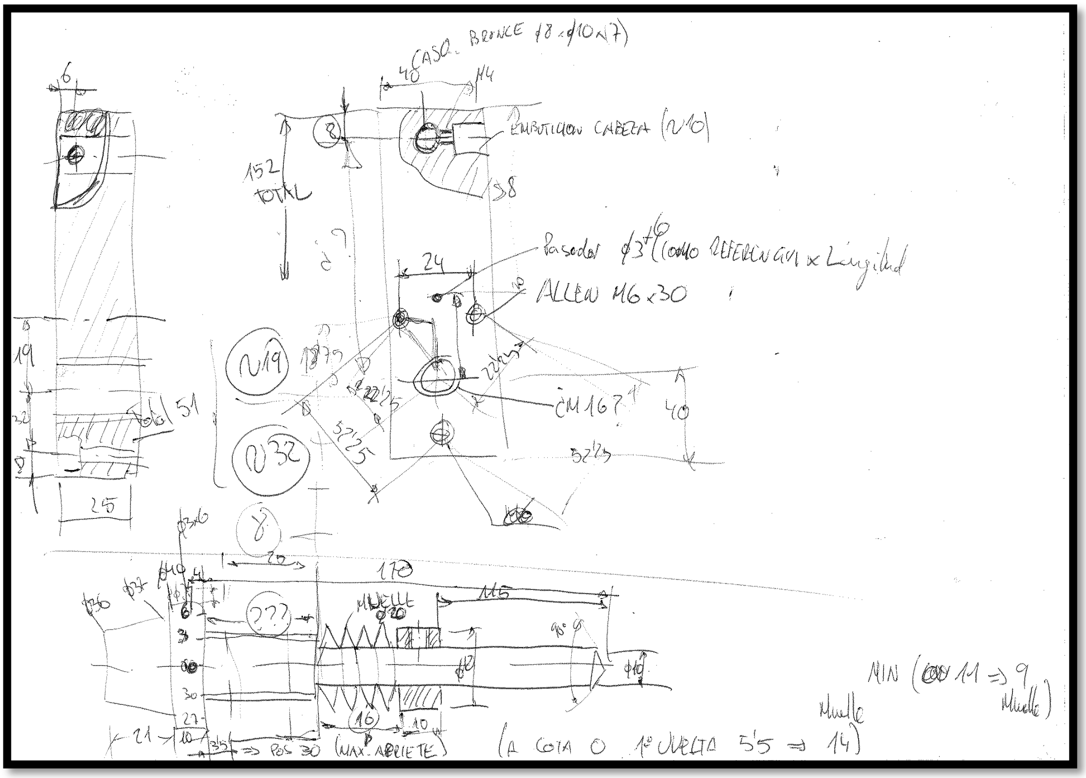



HUSILLO
2202 2RS
(OSCILA)
ϕ15x380
ϕ30
M6
ϕ20
ϕ80
45
30
5
32
10
14
38
ALLEN M6
45
POSICIONADOR
20
ϕ20
65
30
M16x80
6
ϕ35

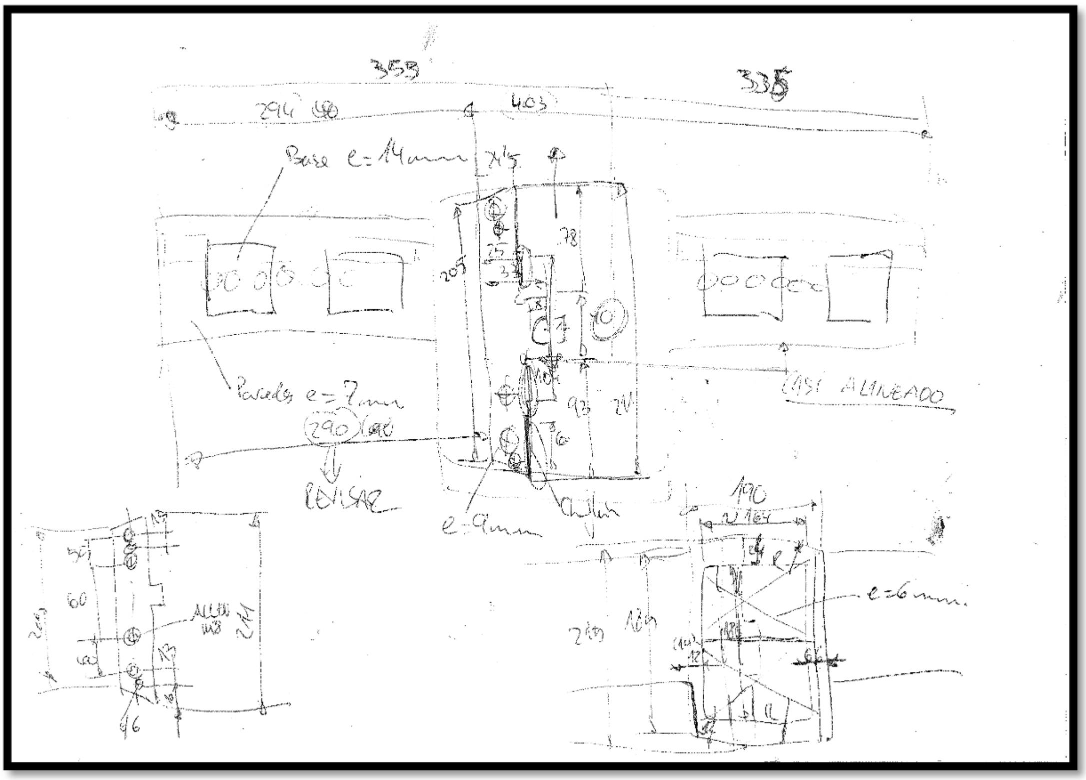
Croquis 4 *Tope mecánico carro porta-sinfín*

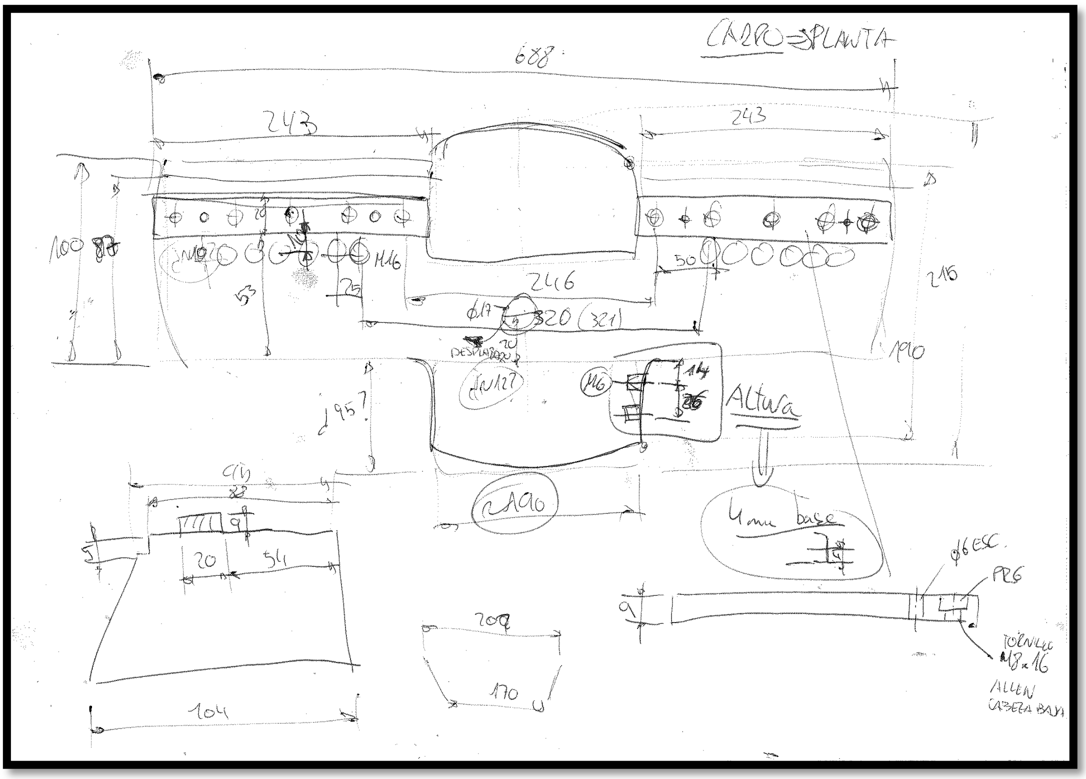


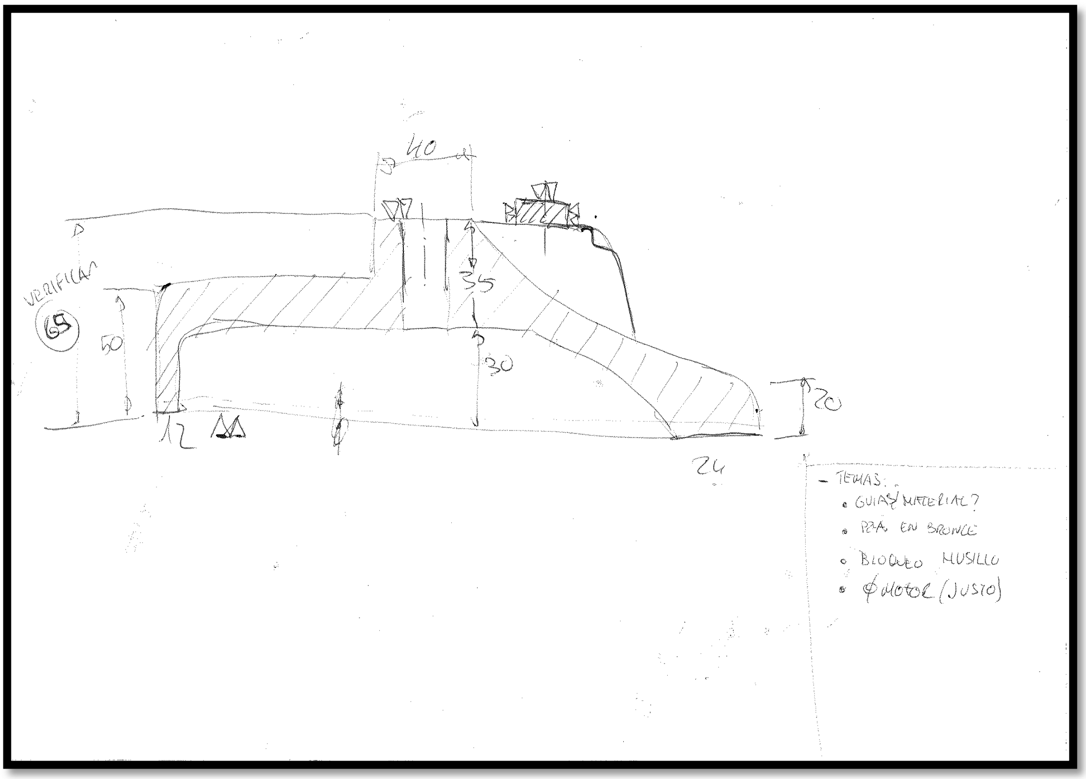
Croquis 5 *Sistema regulación presión muelle columna*



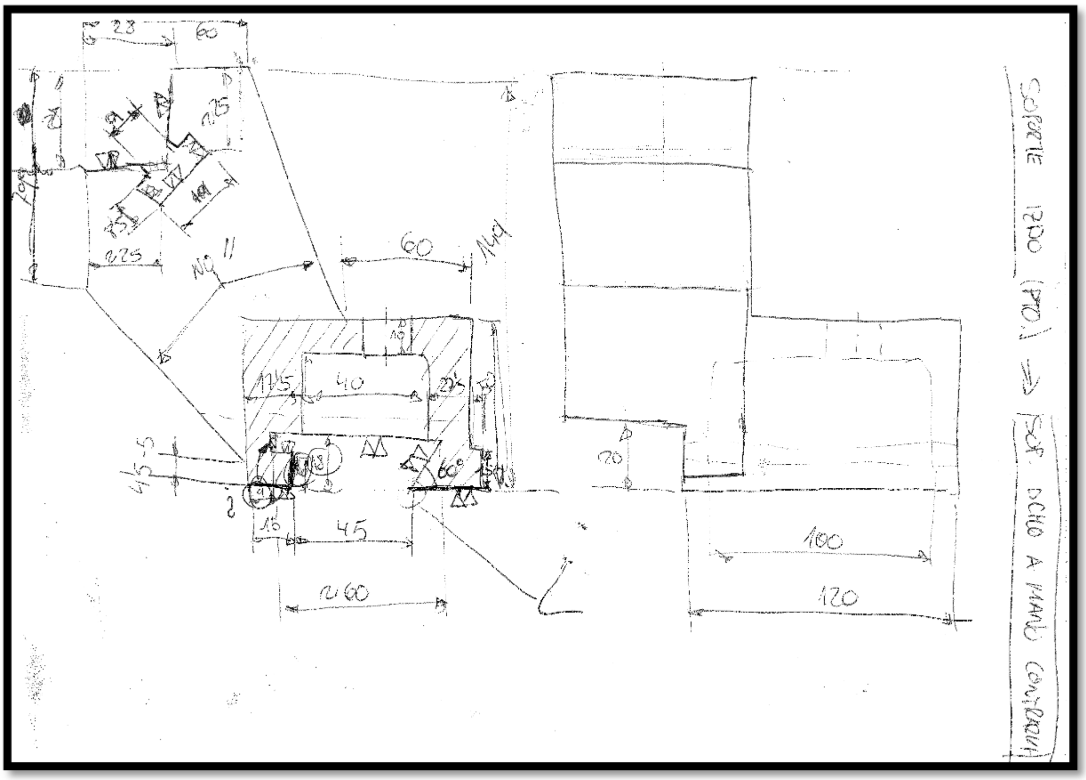
Croquis 6 *Base carro porta-sinfín*

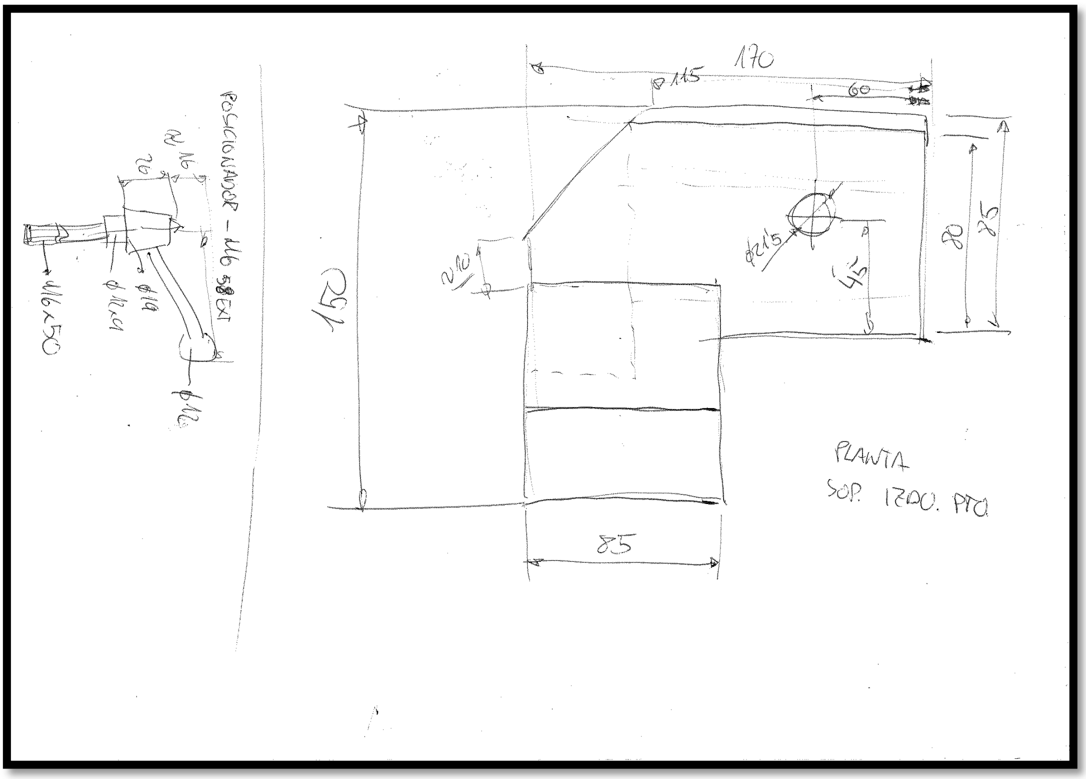




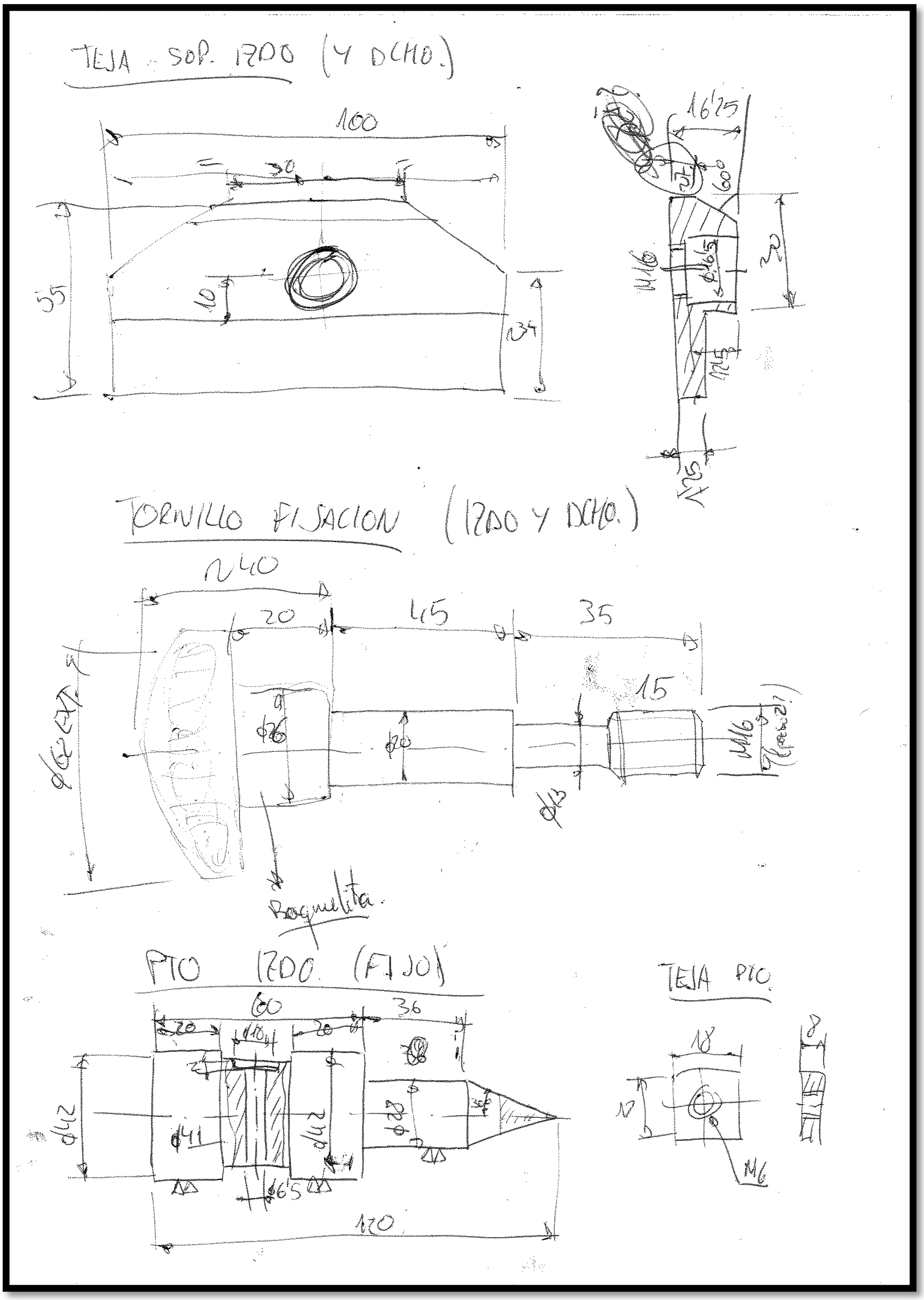

40
35
30
VERIFICAR
65
50
12
20
24
– TEMAS:
• GUIAS/MATERIAL?
• PZA. EN BRONCE
• BLOQUEO HUSILLO
• ϕ MOTOR (JUSTO)

Croquis 7 *Porta puntos*

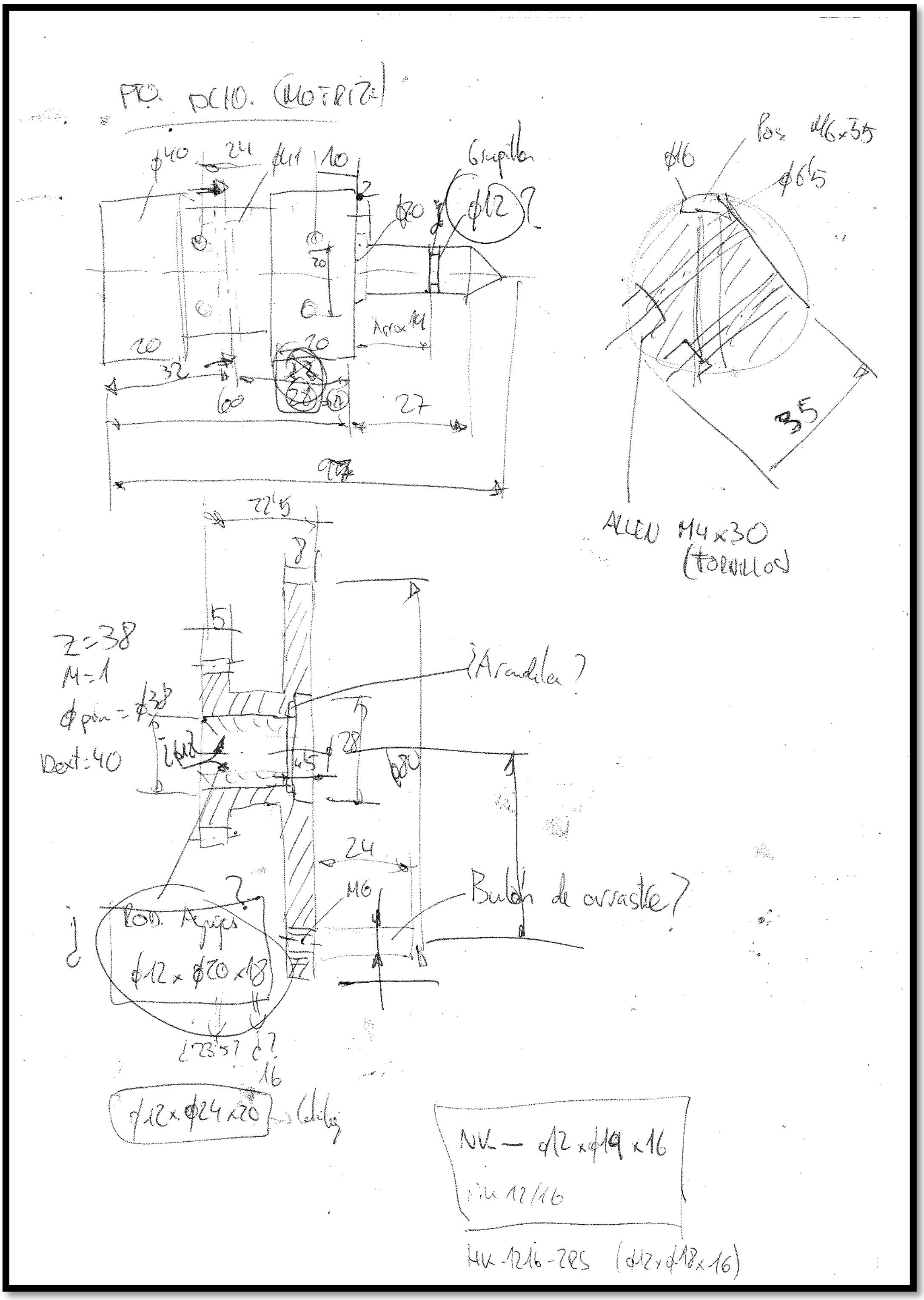




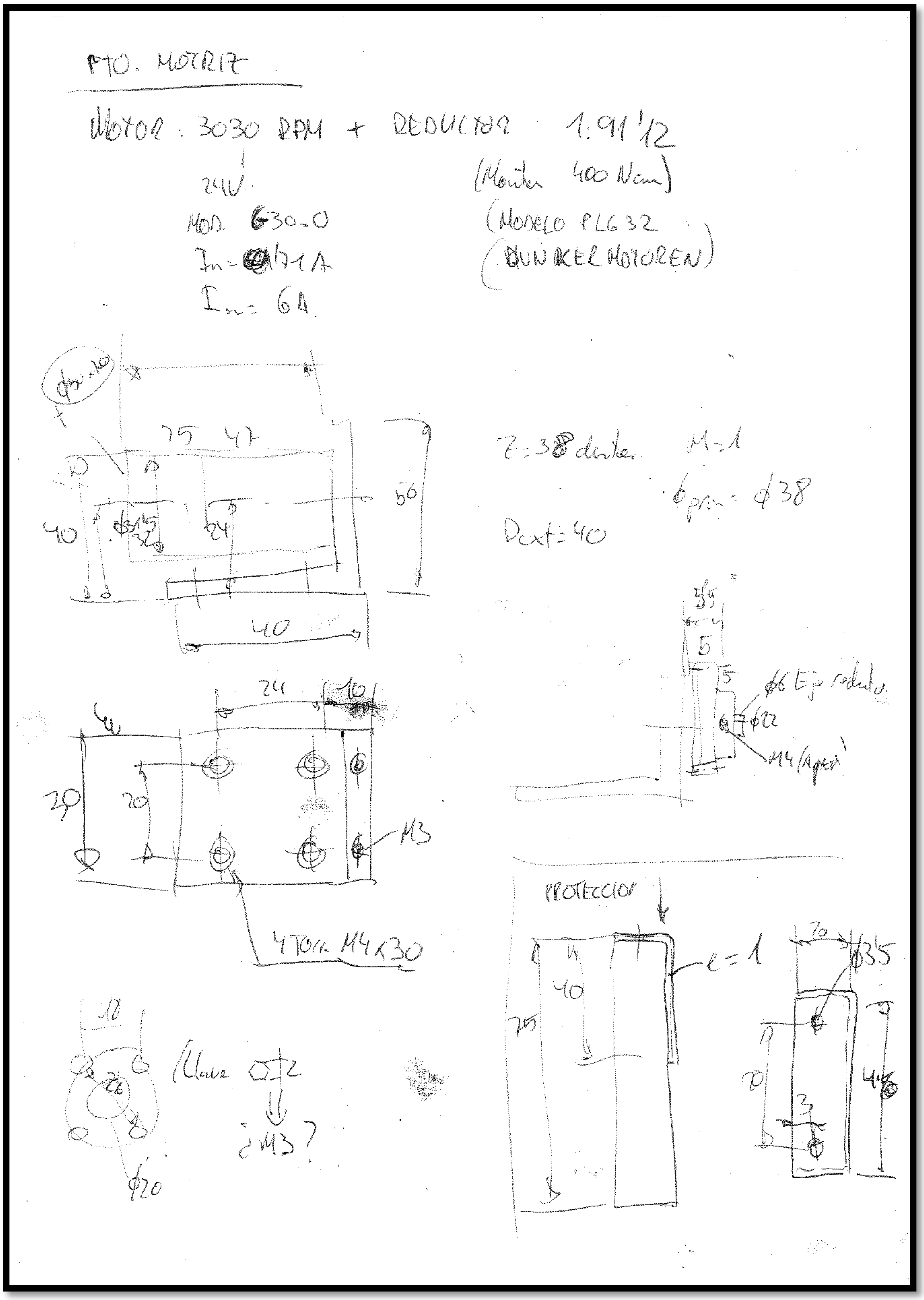
Croquis 8 <u>*Punto fijo y maneta posicionadora*</u>



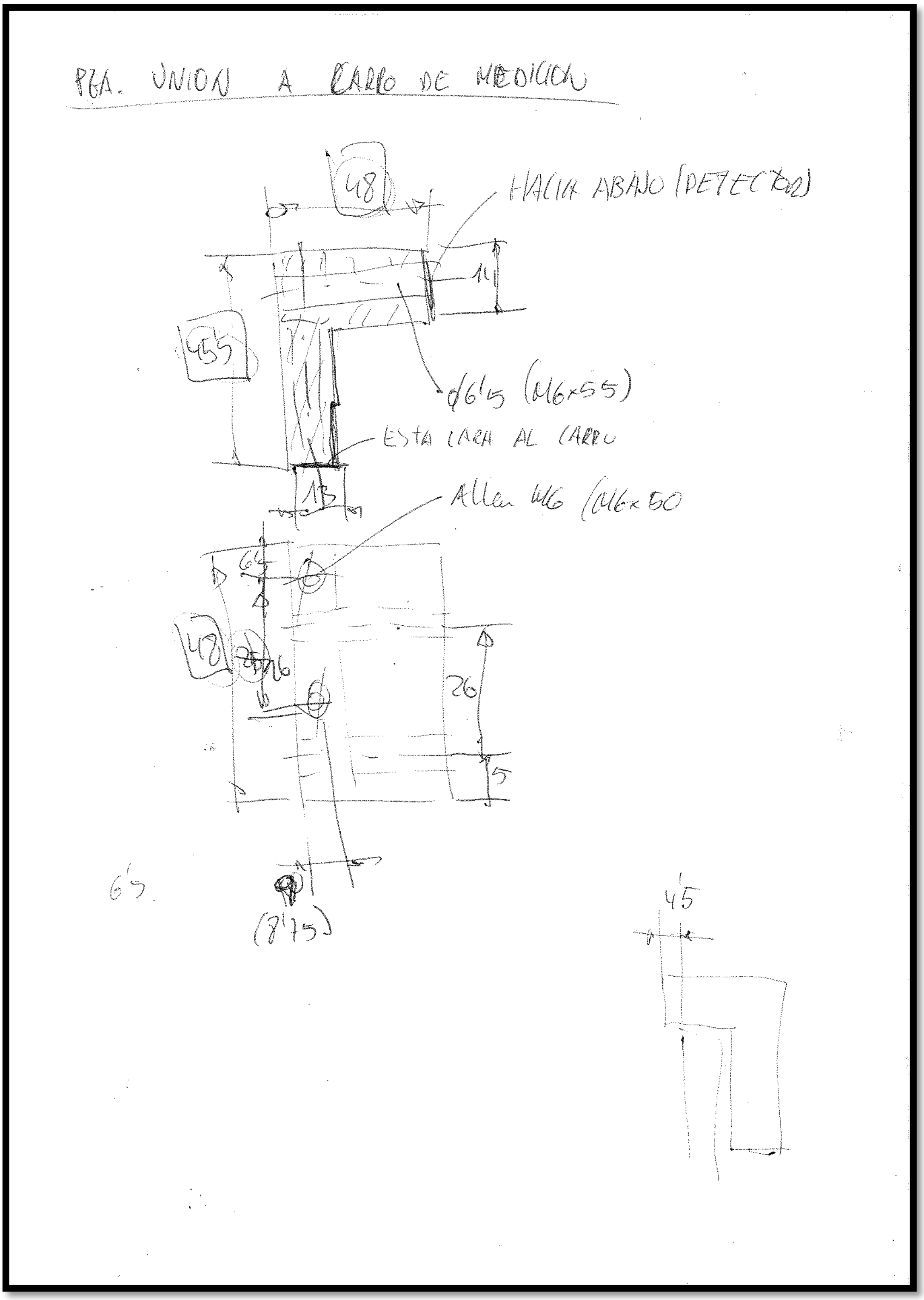
Croquis 9 *Punto motriz*



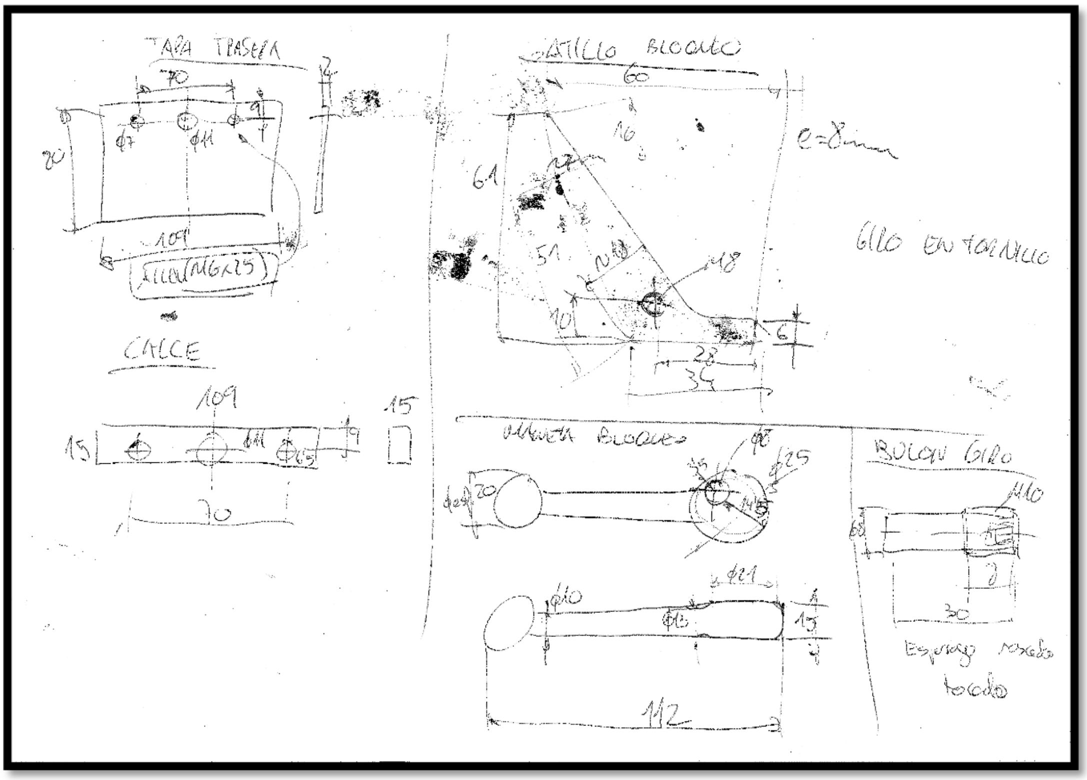
Croquis 10 *Soporte y protección punto motriz*



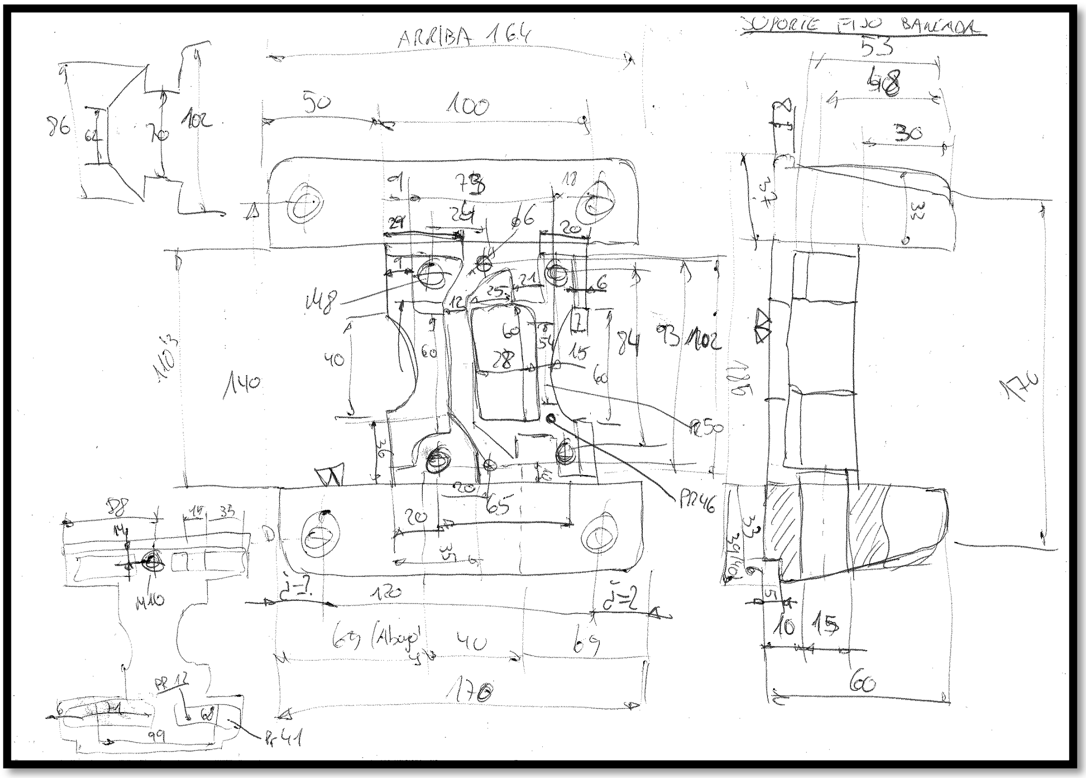
Croquis 11 *Pieza unión a encoder lineal*

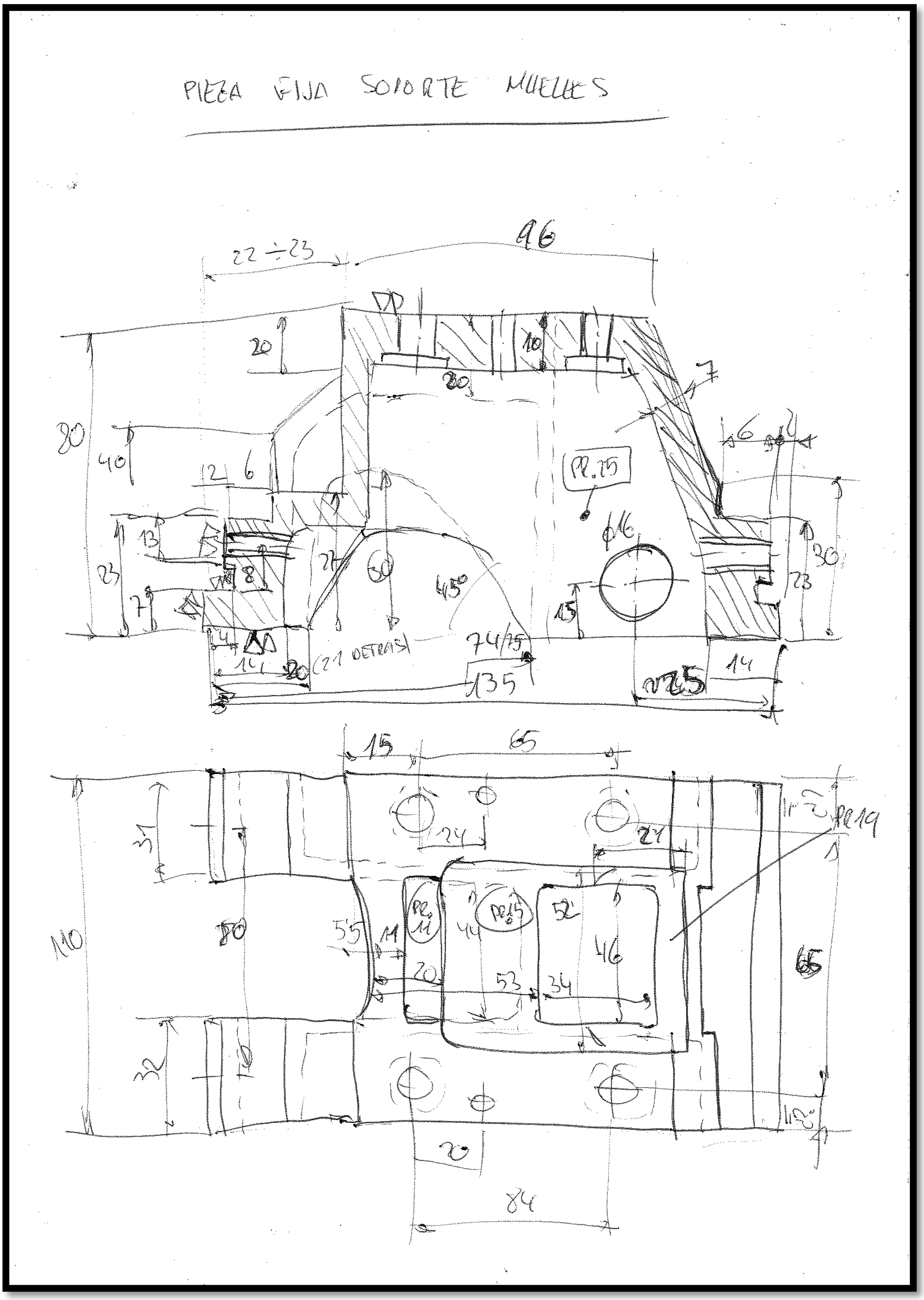


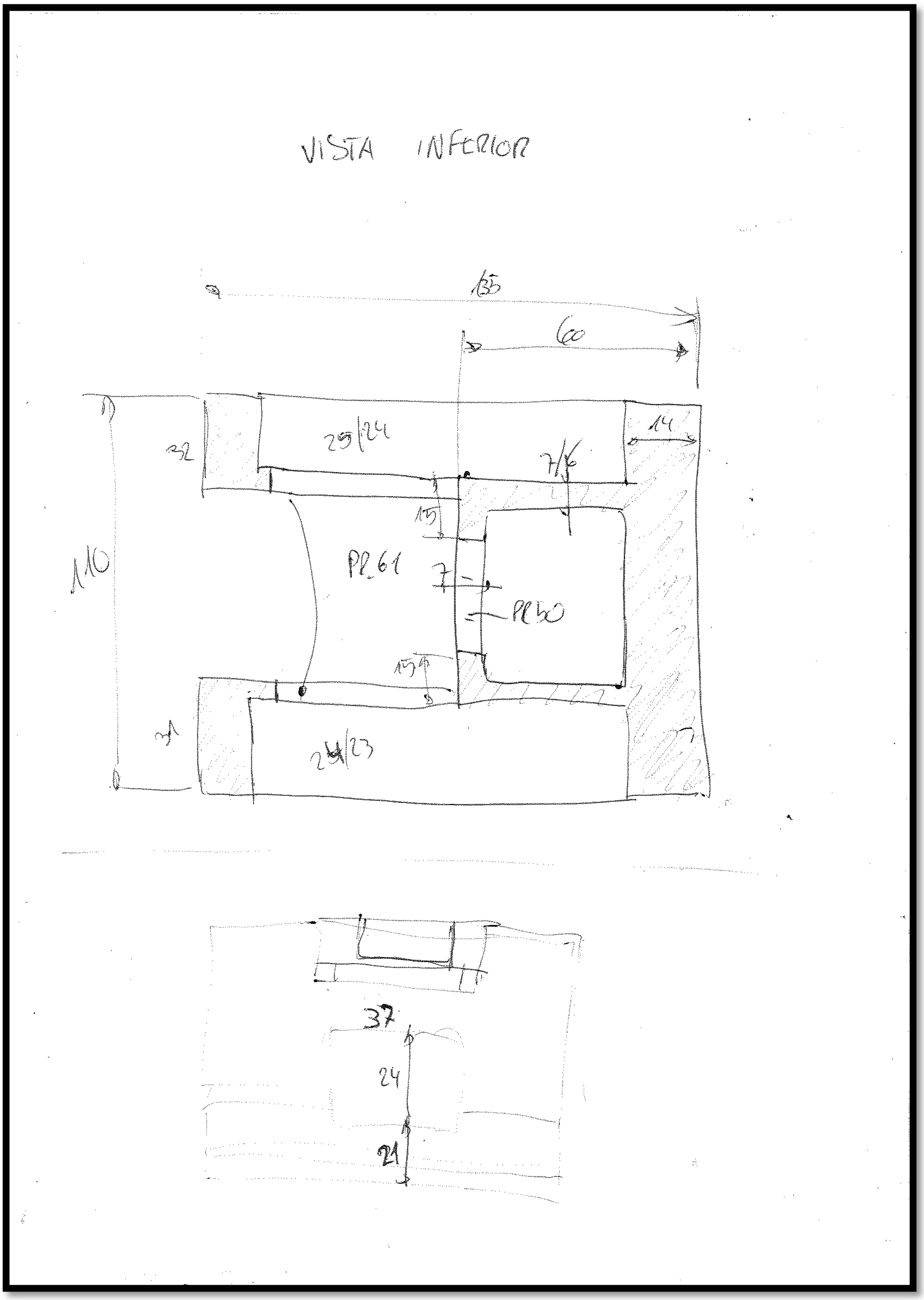
Croquis 12 *Maneta y leva bloqueo columna*



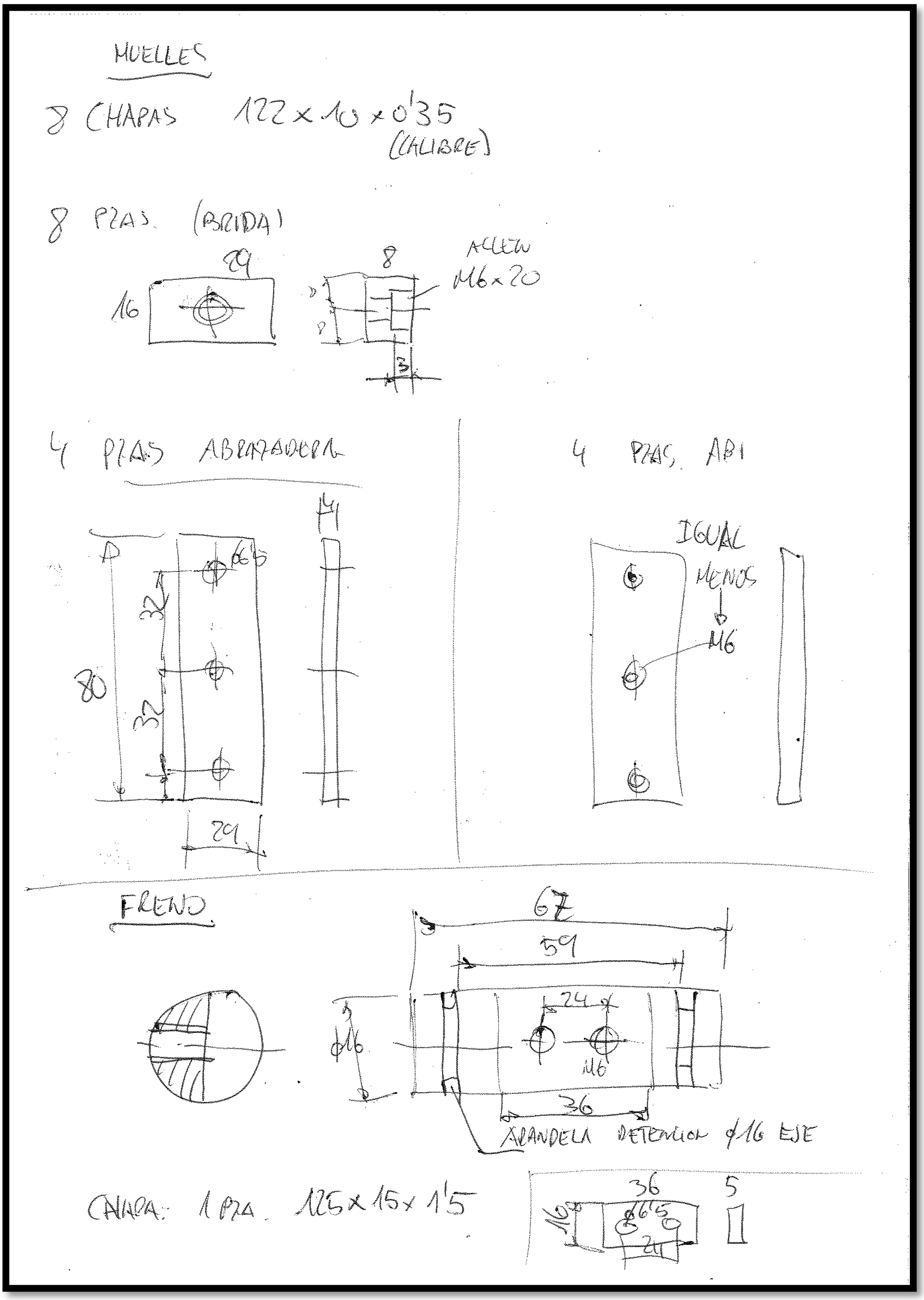
Croquis 13 *Base columna unión a bancada*



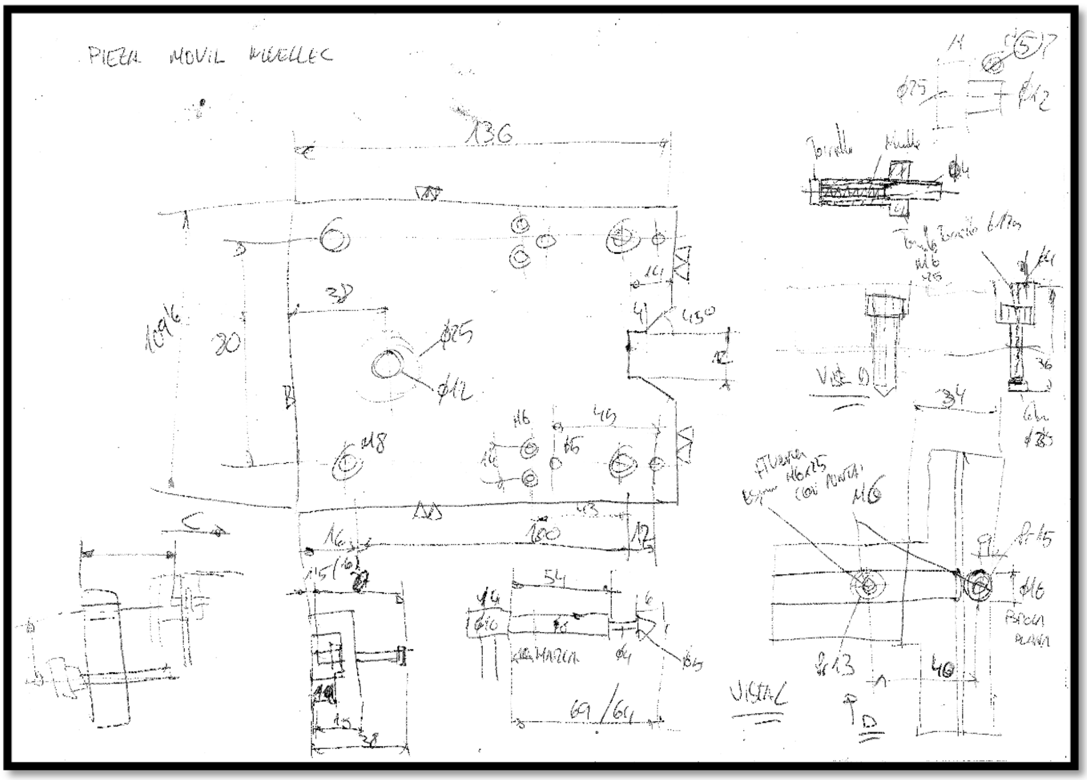

PIEZA FIJA SOPORTE MUELLES
96
22 ÷ 23
20
10
7
80
40
12
6
M6
Ø16
45°
74/75
135
(21 DETRÁS)
15
65
24
27
37
110
80
55
11
20
44
53
34
52
46
65
32
20
84

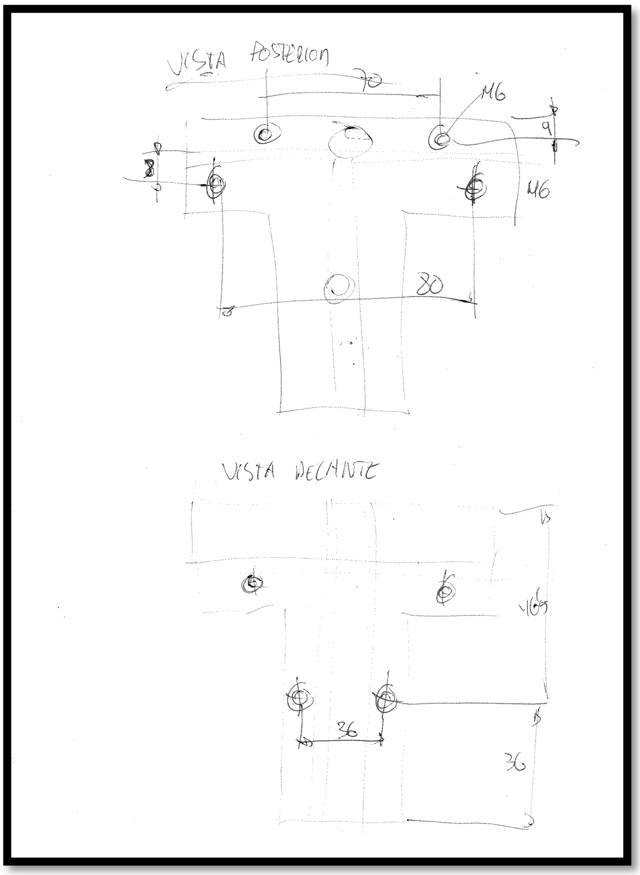

VISTA INFERIOR
135
60
14
32
25/24
7/6
15
PR 61
7
PR 50
110
15/14
31
24/23
37
24
21

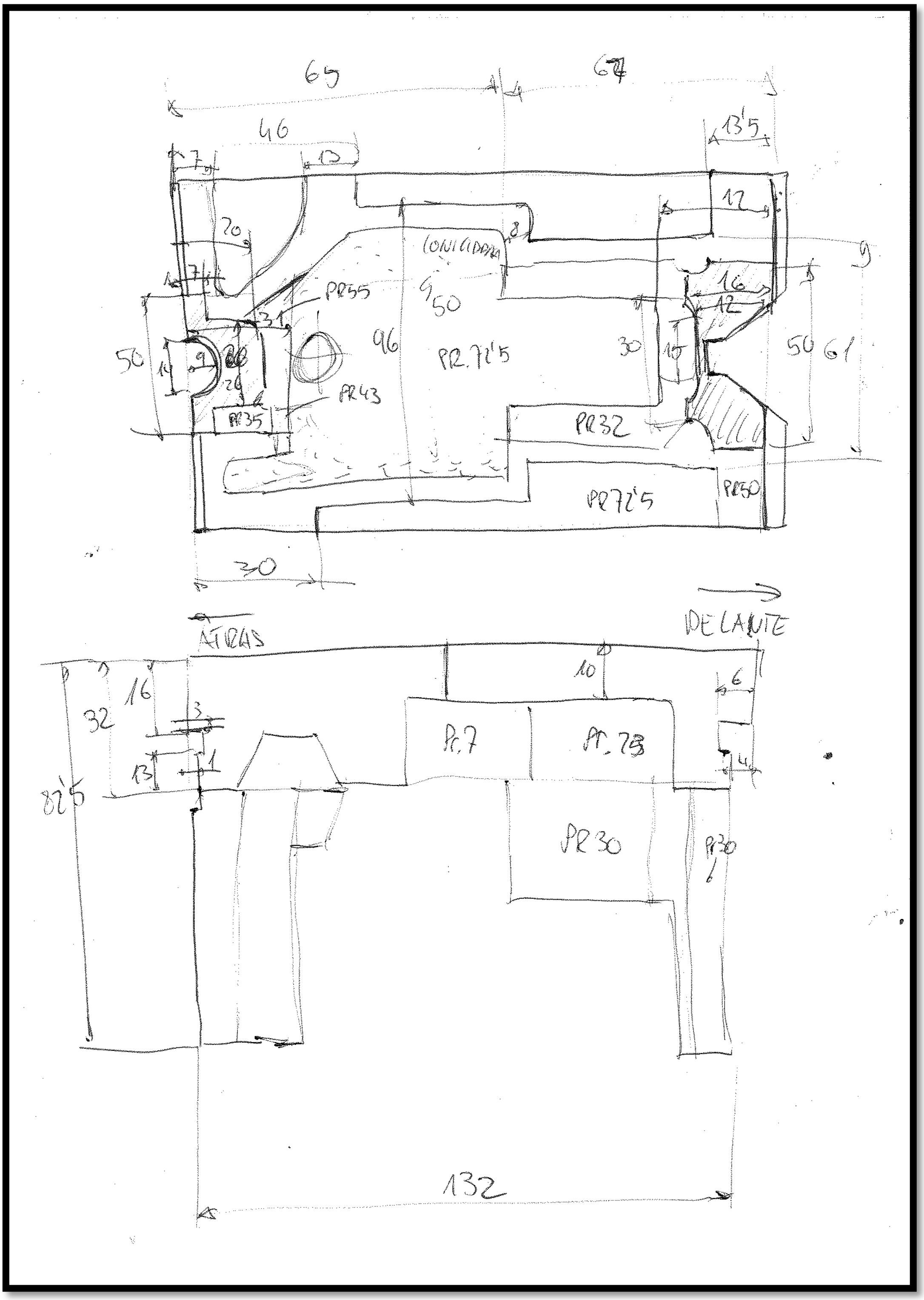
Croquis 14 <u>*Sistema elástico columna*</u>



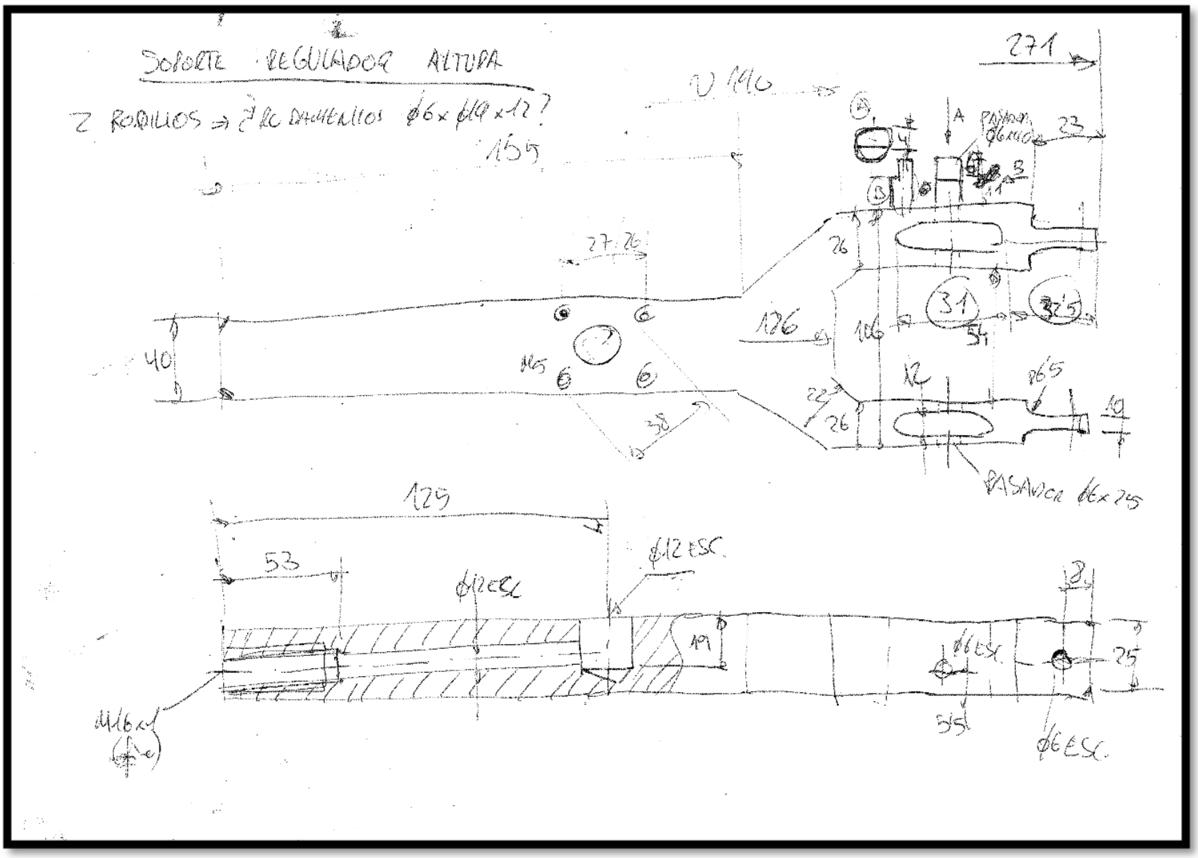
Croquis 15 *Base sistema elástico*

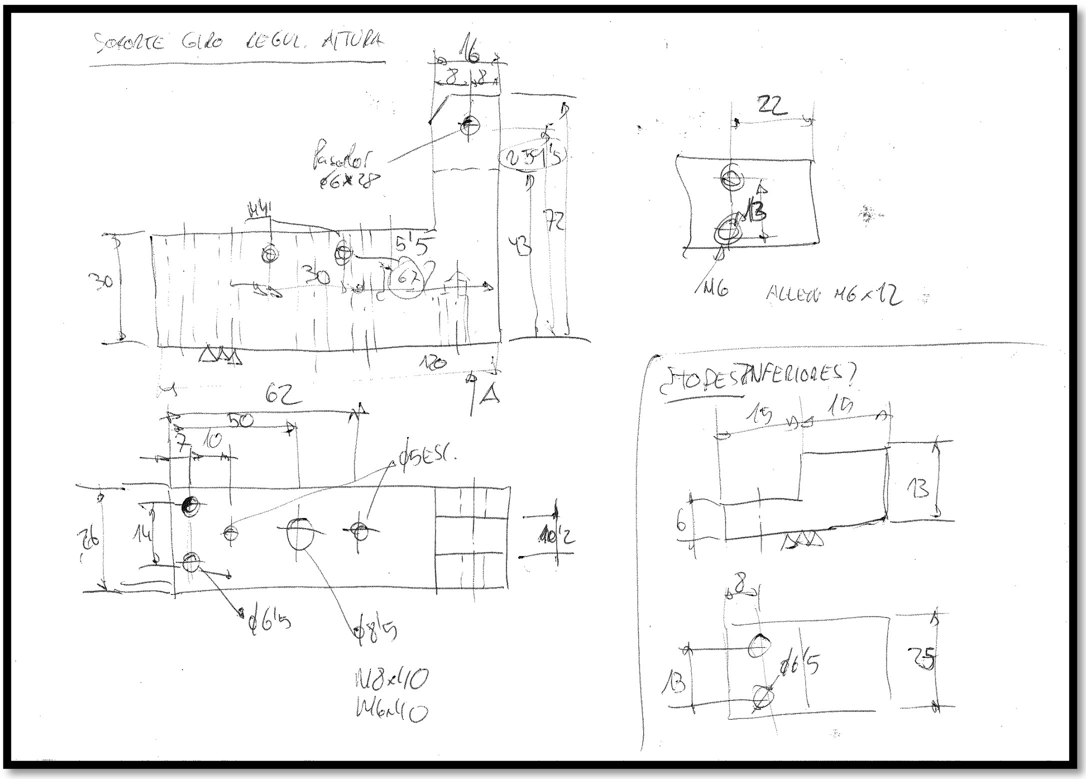




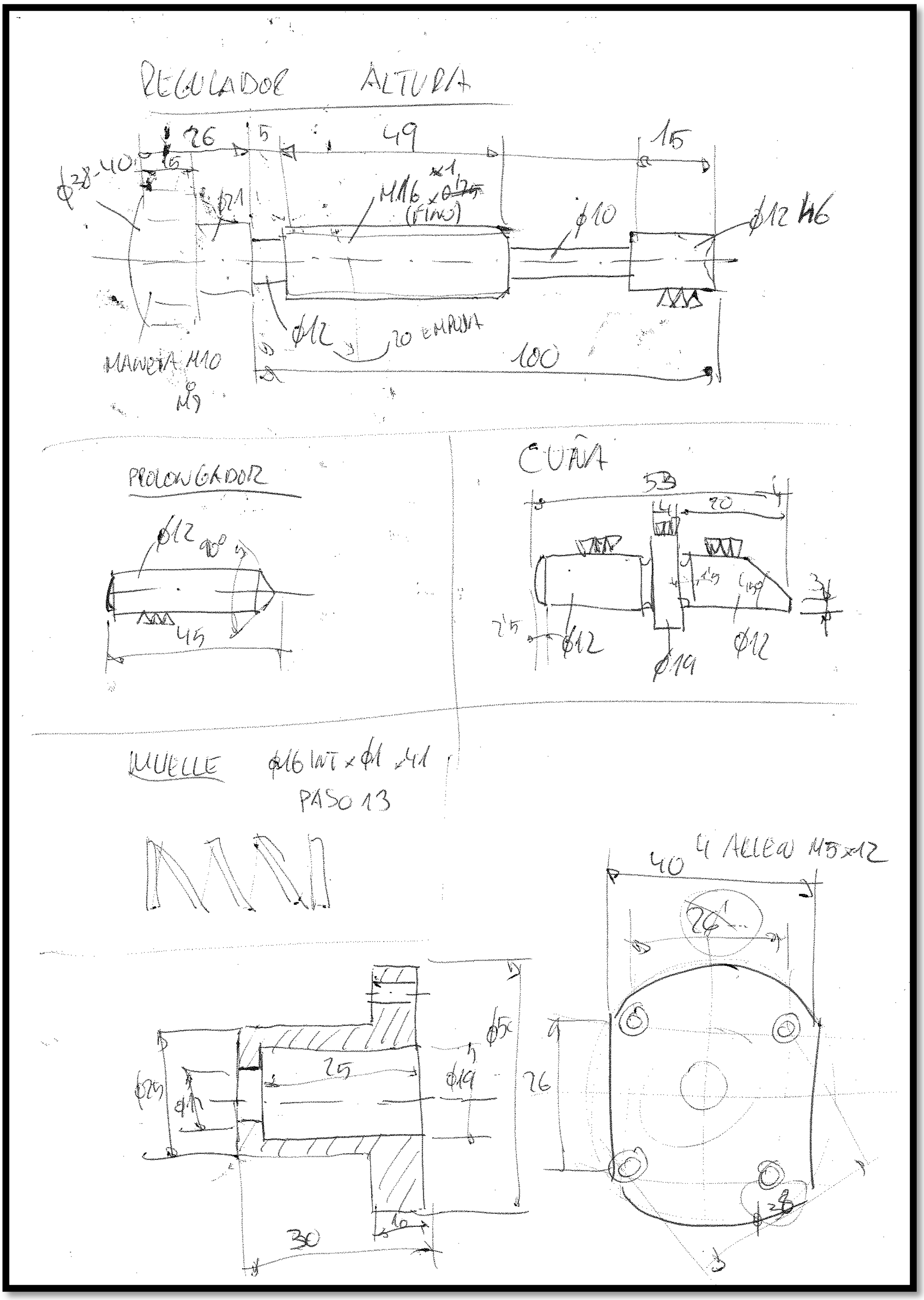

ATRAS
DELANTE
PR55
PR43
PR35
PR.72'5
PR32
PR72'5
PR50
LONGITUDINAL
PR.7
PR.78
PR30
132

Croquis 16 ***Soporte regulación altura corona***

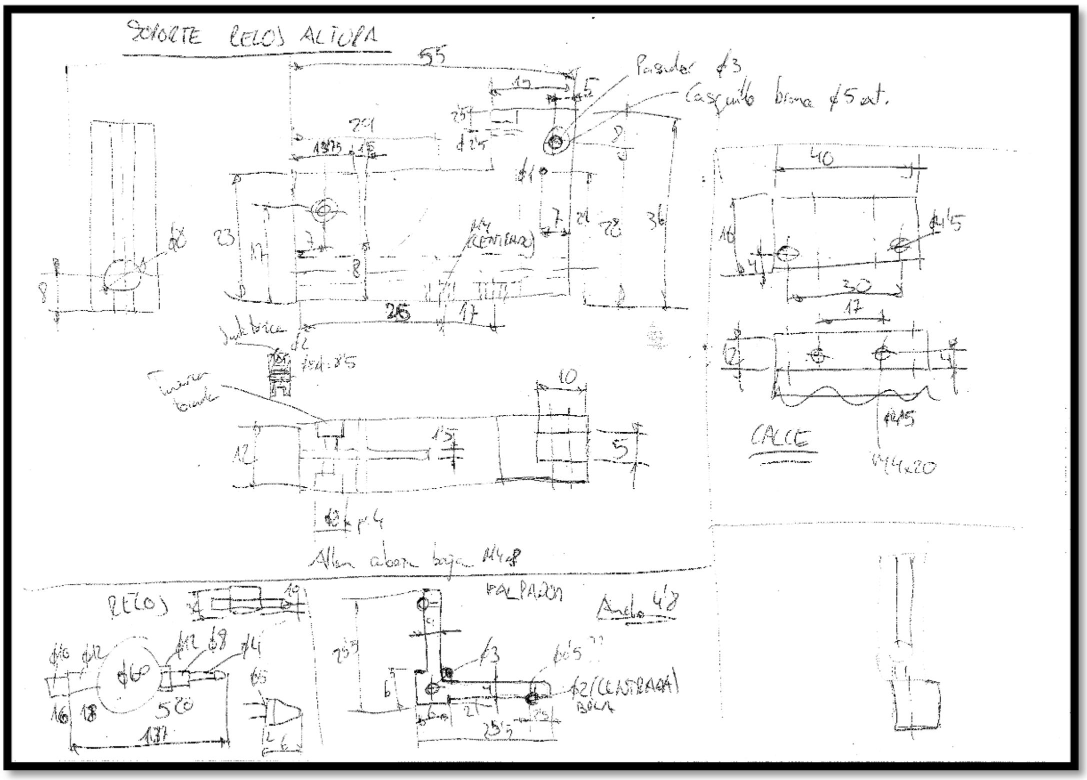




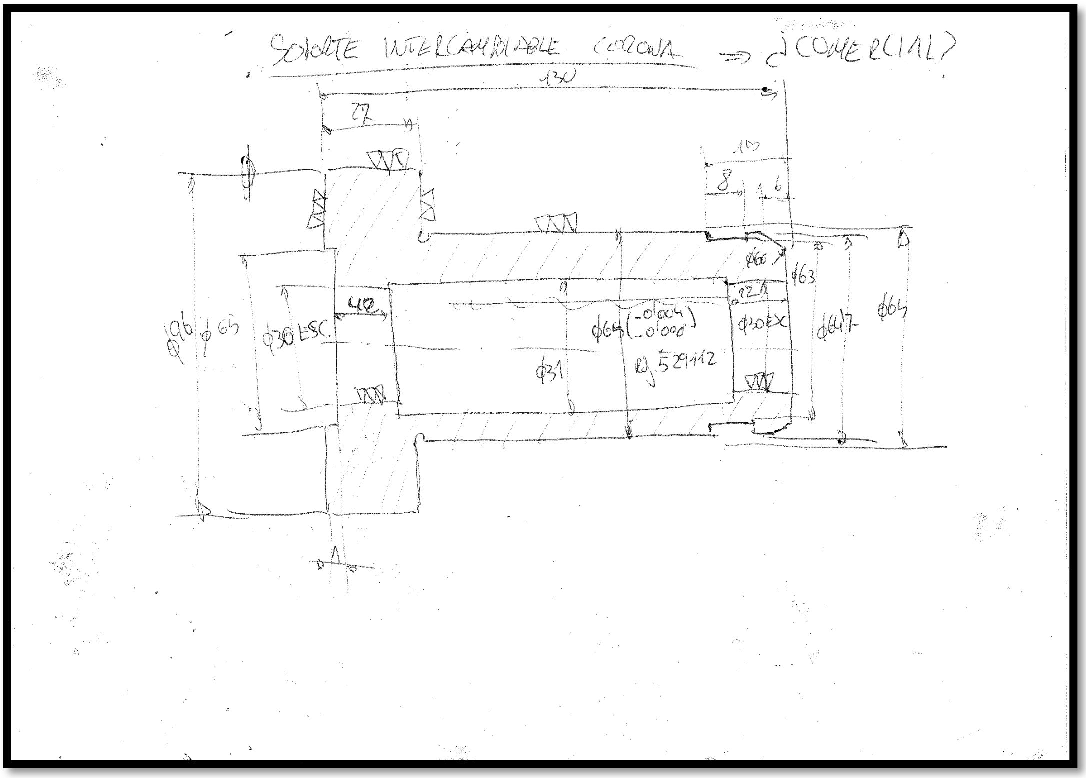
Croquis 17 *Actuador regulación altura corona*



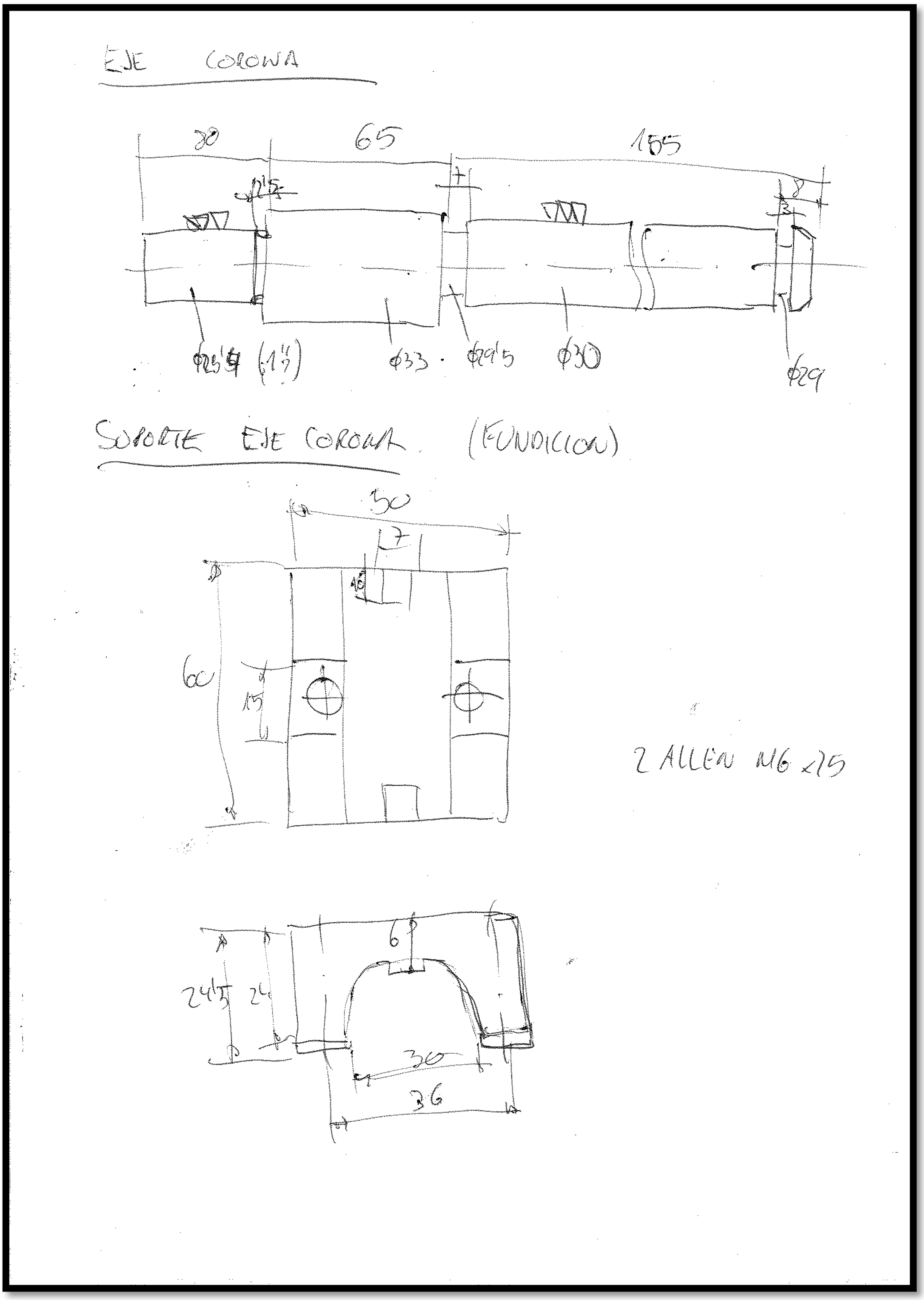
Croquis 18 *Control altura corona*



Croquis 19 *Utillaje corona*



Croquis 20 *Eje soporte utillaje corona*



ANEXO II: Características Técnicas Componentes Seleccionados

En este anexo se incluye toda la documentación técnica y catálogos de los nuevos componentes de medida seleccionados y sus posibles alternativas descritos en el apartado 2.4.2 de la memoria.

Los documentos son:

Doc. 1 *Accionamiento sinfín FAULHABER 3257G*

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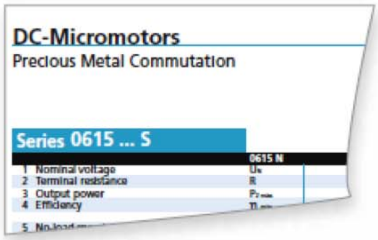
DC-Micromotors

Technical Information



General information

The lifetime, depending on the application type, may exceed the 10 000 hours. Higher speeds cause accelerated mechanical wear, resulting in reduced lifetime.
Also excessively high current and temperature shortens the lifetime. On the average, lifetime of up to 1 000 hours for metal brushes, and more than 3 000 hours for graphite brushes can be expected when the motors are operated within recommended values indicated on the data sheet. These values do not influence each other. It is advisable that the current under load in continuous operation should not be higher than one third of the stall current.
In motors with graphite brushes the relationship between stall current and current under load depends on the delivered power and frame size. The motors should not be operated at the stall torque M_H, otherwise after a short period of time, the commutation or the windings could be damaged.

The motor develops its maximum power $P_{2\,max.}$ at exactly half the stall torque M_H which also corresponds to half the speed. For reasons of life performance, this working point should only be selected for intermittent periods.
For exceptional long life performance, brushless DC-Motors are available.

Unspecified tolerances:
Tolerances in accordance with ISO 2768 medium.

≤ 6	= ± 0,1 mm
≤ 30	= ± 0,2 mm
≤ 120	= ± 0,3 mm

Motors with tighter tolerances and tolerances of values not specified are given on request.

Bearing options:

– Standard:	Unless otherwise stated, vacuum impregnated sintered bearings are used
– Optional:	Shielded ball bearings

Motor shaft:
All dimensions with shaft pushed against motor.

Motor choice:
The listed motor types represent standardised executions. However, a variety of further coil possibilities are available.

Notes on technical data

All values at 22 °C.
All values at nominal voltage, motor only, without load.

Nominal voltage U_N [Volt]
The nominal voltage at which all other characteristics indicated are measured.

Terminal resistance R [Ω] ±12%
The resistance measured across the motor terminals. The value is directly affected by the coil temperature (temperature coefficient: $\alpha_{22} = 0{,}004\ K^{-1}$).

Output power $P_{2\,max.}$ [W]
The maximum obtainable mechanical power achieved at the nominal voltage.

$$P_{2\,max.} = \frac{R}{4} \cdot \left(\frac{U_N}{R} - I_o\right)^2$$

Efficiency $\eta_{max.}$ [%]
The max. ratio between the absorbed electrical power and the obtained mechanical power of the motor.
It does not always correspond to the optimum working point of the motor.

$$\eta_{max.} = \left(1 - \sqrt{\frac{I_o \cdot R}{U_N}}\right)^2 \cdot 100$$

No-load speed n_o [rpm] ±12%
Describes the maximum speed under no-load conditions at steady state and 22 °C ambient temperature. If not otherwise defined the tolerance for the no-load speed is assumed to be ±12%.

$$n_o = (U_N - I_o \cdot R) \cdot k_n$$

No-load current I_o [A] ±50%
Describes the current consumption of the motor without load at an ambient temperature of 22°C after reaching a steady state condition. The tolerance is given at +/-50%.

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DC-Micromotors

Technical Information

General information

The lifetime, depending on the application type, may exceed the 10 000 hours. Higher speeds cause accelerated mechanical wear, resulting in reduced lifetime.
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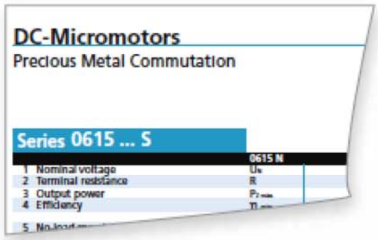

Notes on technical data

All values at 22 °C.
All values at nominal voltage, motor only, without load.

Nominal voltage U_N [Volt]
The nominal voltage at which all other characteristics indicated are measured.

Terminal resistance R [Ω] ±12%
The resistance measured across the motor terminals. The value is directly affected by the coil temperature (temperature coefficient: $\alpha_{22} = 0{,}004\ K^{-1}$).

Output power $P_{2\,max.}$ [W]
The maximum obtainable mechanical power achieved at the nominal voltage.

$$P_{2\,max.} = \frac{R}{4} \cdot \left(\frac{U_N}{R} - I_o\right)^2$$

Efficiency $\eta_{max.}$ [%]
The max. ratio between the absorbed electrical power and the obtained mechanical power of the motor.
It does not always correspond to the optimum working point of the motor.

$$\eta_{max.} = \left(1 - \sqrt{\frac{I_o \cdot R}{U_N}}\right)^2 \cdot 100$$

No-load speed n_o [rpm] ±12%
Describes the maximum speed under no-load conditions at steady state and 22 °C ambient temperature. If not otherwise defined the tolerance for the no-load speed is assumed to be ±12%.

$$n_o = (U_N - I_o \cdot R) \cdot k_n$$

No-load current I_o [A] ±50%
Describes the current consumption of the motor without load at an ambient temperature of 22°C after reaching a steady state condition. The tolerance is given at +/-50%.

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The no-load current is speed and temperature dependent. Changes in ambient temperature or cooling conditions will influence the value. In addition, modifications to the shaft, bearing, lubrication, and commutation system or combinations with other components such as gearheads or encoders will all result in a change to the no-load current of the motor.

Stall torque M_H [mNm]
The torque developed by the motor at zero speed and nominal voltage. This value is greatly influenced by temperature.

$$M_H = k_M \cdot \left(\frac{U_N}{R} - I_o\right)$$

Friction torque M_R [mNm]
Torque losses caused by the friction of brushes, bearings and commutators. This value is influenced by temperature.

$$M_R = k_M \cdot I_o$$

Speed constant k_n [rpm/V]
The speed variation per Volt applied to the motor terminals at constant load.

$$k_n = \frac{n_o}{U_N - I_o \cdot R} = \frac{1\,000}{k_E}$$

Back-EMF constant k_E [mV/rpm]
The constant corresponding to the relationship between the induced voltage in the rotor at the speed of rotation.

$$k_E = \frac{2\pi \cdot k_M}{60}$$

Torque constant k_M [mNm/A]
The constant corresponding to the relationship between the torque developed by the motor and the current drawn.

Current constant k_I [A/mNm]
The constant between the current in the motor and the torque developed.

$$k_I = \frac{1}{k_M}$$

Slope of n-M curve $\Delta n/\Delta M$ [rpm/mNm]
The ratio of the speed variation to the torque variation. The smaller the value, the more powerful the motor.

$$\frac{\Delta n}{\Delta M} = \frac{30\,000}{\pi} \cdot \frac{R}{k_M^2}$$

Rotor inductance L [μH]
The inductance measured on the motor terminals at 1 kHz.

Mechanical time constant τ_m [ms]
The time required for the motor to reach a speed of 63% of its final no-load speed, from standstill.

$$\tau_m = \frac{100 \cdot R \cdot J}{k_M^2}$$

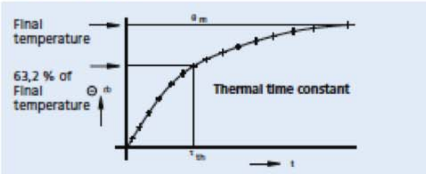
Rotor inertia J [gcm²]
Rotor's mass dynamic inertia moment.

Angular acceleration $\alpha_{max.}$ [$\cdot 10^3$ rad/s²]
The acceleration obtained from standstill under no-load-conditions and at nominal voltage.

$$\alpha_{max} = \frac{M_H \cdot 10}{J}$$

Thermal resistance R_{th1}/R_{th2} [K/W]
R_{th1} corresponds to the value between the rotor and housing. R_{th2} corresponds to the value between the housing and the ambient air.
R_{th2} can be reduced by enabling exchange of heat between the motor and the ambient air (for example using a heat sink or forced air cooling).

Thermal time constant τ_{w1} / τ_{w2} [s]
The thermal time constant specifies the time needed for the rotor and housing to reach a temperature equal to 63% of final value.



Operating temperature range [°C]
Indicates the min. and max. motor operating temperature, as well as the maximum permitted rotor temperature.

Shaft bearings
The bearings used for the DC-Micromotors.

Shaft load max. [N]
The output shaft load at a specified shaft diameter for the primary output shaft. For motors with ball bearings the load and lifetime are in accordance with the values given by the bearing manufacturers. This value does not apply to second, or rear shaft ends.

Shaft play [mm]
The shaft play on the bearings, measured at the bearing exit.

Housing material
The housing material and the surface protection.

Weight [g]
The average weight of the basic motor type.

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FAULHABER

DC-Micromotors

Technical Information

Direction of rotation

The direction of rotation is viewed from the front face. Positive voltage to the + terminal gives clockwise rotation of the motor shaft. All motors are designed for clockwise (CW) and counterclockwise (CCW) operation; the direction of rotation is reversible.

Recommended values

The maximum recommended values for continuous operation to obtain optimum life performance are listed below. The values are independent of each other.
The values will be reduced with thermal insulation and elevated temperature but can be increased with forced cooling.

Speed $n_{e\,max.}$ [rpm]
The maximum recommended operating speed.

Torque $M_{e\,max.}$ [mNm]
The maximum recommended torque rating.

Current $I_{e\,max.}$ [A]
The maximum allowable current, based on the thermal limits of the max. permissible standard rotor temperature at 22 °C ambient.

How to select a DC-Micromotor

This section reviews a step-by-step procedure on how to select a DC-Micromotor. The procedure allows calculation of the parameters in order to produce a graph of the characteristics and per-mitting the definition of the motor's behaviour. To simplify the calculation, in this example continuous operation and optimum life performance are assumed and the influence of temperature and tolerances has been omitted.

Application data:

The basic data required for any given application are:

Required torque	M	[mNm]
Required speed	n	[rpm]
Duty cycle	δ	[%]
Available supply voltage, max.	U	[V DC]
Available current source, max.	I	[A]
Available space, max.	diameter/length	[mm]
Shaft load	radial/axial	[N]

The assumed application data for the selected example are:

Output torque	M	= 3	mNm
Speed	n	= 5 500	rpm
Duty cycle	δ	= 100	%
Supply voltage	U	= 20	V DC
Current source, max.	I	= 0,5	A
Space max.	diameter	= 25	mm
	length	= 50	mm
Shaft load	radial	= 1,0	N
	axial	= 0,2	N

Preselection

The first step is to calculate the power the motor is expected to deliver:

$$P_2 = M \cdot n \frac{\pi}{30 \cdot 1\,000} \qquad [W]$$

$$P_2 = 3 \cdot 5\,500 \frac{\pi}{30 \cdot 1\,000} = 1{,}73 \quad W$$

A motor is then selected from the catalogue which will give at least 1,5 to 2 times the output power [$P_{2\,max.}$] than the one obtained by calculation, and where the nominal voltage is equal to or higher than the one required in the application data.

The physical dimensions (diameter and length) of the motor selected from the data sheets should not exceed the available space in the application.

$$P_{2\,max.} \geq P_2 \qquad U_N \geq U$$

The motor selected from the catalogue for this particular application, is **series 2233 T 024 S** with the following characteristics:

Nominal voltage		U_N	= 24	V DC
Output power, max.		$P_{2\,max.}$	= 2,47	W
Frame size:	diameter	Ø	= 22	mm
	length	L	= 33	mm
Shaft load, max.:		radial	= 1,2	N
		axial	= 0,2	N
No-load current		I_o	= 0,005	A
No-load speed		n_o	= 8 800	rpm
Stall torque		M_H	= 10,70	mNm

Caution:

Should the available supply voltage be lower than the nominal voltage of the selected DC-Micromotor, it will be necessary to calculate [$P_{2\,max.}$] with the following equation:

$$P_{2\,max.} = \frac{R}{4} \cdot \left(\frac{U_N}{R} - I_o\right)^2 \qquad [W]$$

$$P_{2\,max.}(20\,V) = \frac{57}{4} \cdot \left(\frac{20}{57} - 0{,}005\right)^2 = 1{,}70 \quad W$$

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Optimizing the preselection

To optimize the motor's operation and life performance, the required speed [n] has to be higher than half the no-load speed [n_o] at nominal voltage, and the load torque [M] has to be less than half the stall torque [M_H].

$$n \geq \frac{n_o}{2} \qquad M \leq \frac{M_H}{2}$$

From the data sheet for the DC-Micromotor, **2233 T 024 S** the parameters meet the above requirements.

$$n\ (5\,500\ \text{rpm}) \geq \frac{n_o}{2} \quad \text{is greater than} \quad \frac{8\,800}{2} = 4\,400 \quad \text{rpm}$$

$$M\ (3\ \text{mNm}) \leq \frac{M_H}{2} \quad \text{is less than} \quad \frac{10{,}70}{2} = 5{,}35 \quad \text{mNm}$$

This DC-Micromotor will be a good first choice to test in this application. Should the required speed [n] be less than half the no-load speed [n_o], and the load torque [M] be less than half the stall torque [M_H], try the next voltage motor up.

Should the required torque [M] be compliant but the required speed [n] be less than half the no-load speed [n_o], try a lower supply voltage or another smaller frame size motor.

Should the required speed be well below half the no-load speed and or the load torque [M] be more than half the stall torque [M_H], a gearhead or a larger frame size motor has to be selected.

Performance characteristics at nominal voltage (24 V DC)

A graphic presentation of the motor's characteristics can be obtained by calculating the stall current [I] and the torque [M] at its point of max. efficiency [$M_{opt.}$]. All other parameters are taken directly from the data sheet of the selected motor.

Stall current

$$I = \frac{U_N}{R} \qquad [A]$$

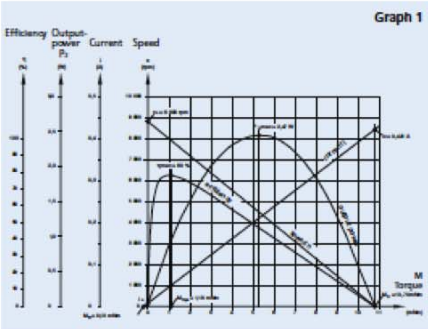
$$I = \frac{24}{57} = 0{,}421 \quad A$$

Torque at max. efficiency

$$M_{opt.} = \sqrt{M_H \cdot M_R} \qquad [\text{mNm}]$$

$$M_{opt.} = \sqrt{10{,}70 \cdot 0{,}13} = 1{,}18 \quad \text{mNm}$$

It is now possible to make a graphic presentation and draw the motor diagram (see graph 1).



Calculation of the main parameters

In this application the available supply voltage is lower than the nominal voltage of the selected motor.
The calculation under load therefore is made at 20 V DC.

No-load speed n_o at 20 V DC

$$n_o = \frac{U - (I_o \cdot R)}{k_E} \cdot 1\,000 \qquad [\text{rpm}]$$

inserting the values

Supply voltage	U	= 20	V DC
Terminal resistance	R	= 57	Ω
No-load current	I_o	= 0,005	A
Back-EMF constant	k_E	= 2,690	mV/rpm

$$n_o = \frac{20 - (0{,}005 \cdot 57)}{2{,}690} \cdot 1\,000 = 7\,315 \quad \text{rpm}$$

Stall current I_H

$$I_H = \frac{U}{R}$$

$$I_H = \frac{20}{57} = 0{,}351 \quad A \qquad [A]$$

Stall torque M_H

$$M_H = k_M (I_H - I_o)$$

inserting the value

Torque constant	k_M	= 25,70	[mNm] mNm/A
M_H = 25,70 (0,351 – 0,005)		= 8,91	mNm

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DC-Micromotors

Technical Information

Output power, max. $P_{2\,max.}$

$$P_{2\,max.} = \frac{R}{4} \cdot \left(\frac{U_N}{R} - I_0\right)^2 \qquad [W]$$

$$P_{2\,max.}(20V) = \frac{57}{4} \cdot \left(\frac{20}{57} - 0{,}005\right)^2 \qquad = 1{,}70 \quad W$$

Efficiency, max. $\eta_{max.}$

$$\eta_{max.} = \left(1 - \sqrt{\frac{I_0}{I_H}}\right)^2 \cdot 100 \qquad [\%]$$

$$\eta_{max.} = \left(1 - \sqrt{\frac{0{,}005}{0{,}351}}\right)^2 \cdot 100 \qquad = 77{,}6 \quad \%$$

At the point of max. efficiency, the torque delivered is:

$$M_{opt.} = \sqrt{M_H \cdot M_R} \qquad [mNm]$$

inserting the values

Friction torque	M_R	=	0,13	mNm
and				
Stall torque at 20 V DC	M_H	=	8,91	mNm

$$M_{opt.} = \sqrt{8{,}91 \cdot 0{,}13} \qquad = 1{,}08 \quad mNm$$

Calculation of the operating point at 20 V DC

When the torque (M=3 mNm) at the working point is taken into consideration I, n, P_2 and η can be calculated:

Current at the operating point

$$I = \frac{M + M_R}{k_M} \qquad [A]$$

$$I = \frac{3 + 0{,}13}{25{,}70} \qquad = 0{,}122 \quad A$$

Speed at the operating point

$$n = \frac{U - R \cdot I}{k_E} \cdot 1\,000 \qquad [rpm]$$

$$n = \frac{20 - 57 \cdot 0{,}122}{2{,}690} \cdot 1000 \qquad = 4\,841 \quad rpm$$

Output power at the operating point

$$P_2 = M \cdot n \cdot \frac{\pi}{30 \cdot 1\,000} \qquad [W]$$

$$P_2 = 3 \cdot 4\,841 \cdot \frac{\pi}{30 \cdot 1\,000} \qquad = 1{,}52 \quad W$$

Efficiency at the operating point

$$\eta = \frac{P_2}{U \cdot I} \cdot 100 \qquad [\%]$$

$$\eta = \frac{1{,}52}{20 \cdot 0{,}122} \cdot 100 \qquad = 62{,}3 \quad \%$$

In this example the calculated speed at the working point is different to the required speed, therefore the supply voltage has to be changed and the calculation repeated.

Supply voltage at the operating point

The exact supply voltage at the operating point can now be obtained with the following equation:

$$U = R \cdot I + k_E \cdot n \cdot 10^{-3}$$

$$U = 57 \cdot 0{,}122 + 2{,}695 \cdot 5\,500 \cdot 10^{-3} \qquad = 21{,}78 \text{ V DC}$$

In this calculated example, the parameters at the operating point are summarized as follows:

Supply voltage	U	= 21,78	V DC
Speed	n	= 5 500	rpm
Output torque	M_N	= 3	mNm
Current	I	= 0,12	A
Output power	P_2	= 1,72	W
Efficiency	η	= 66	%

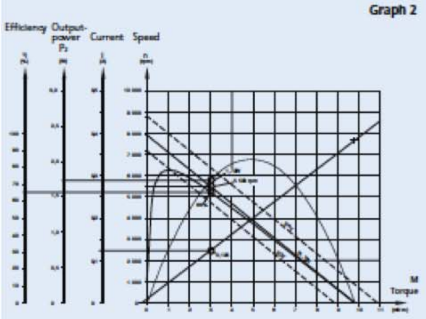
Motor characteristic curves

For a specific torque, the various parameters can be read on graph 2.

To simplify the calculation, the influence of temperature and tolerances has deliberately been omitted.

In certain cases the influence of temperature should, however, be taken into consideration.

Graph 2



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DC-Micromotors

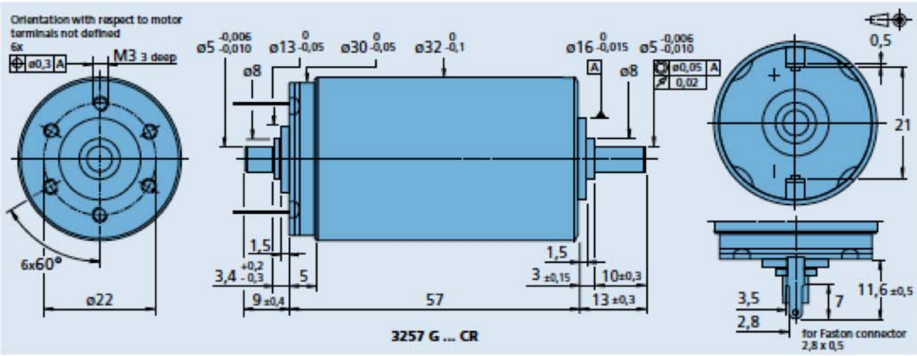
Graphite Commutation

70 mNm

For combination with
Gearheads:
32/3, 32/3 S, 32A, 38/1, 38/1 S, 38/2, 38/2 S, 38A
Encoders:
HEDL 5540, HEDM 5500, HEDS 5500, HEDS 5540, IE2-1024, IE2-16, IE3-1024, IE3-1024 L

Series 3257 ... CR

	3257 G			012 CR	024 CR	048 CR	
1	Nominal voltage	U_N		12	24	48	V
2	Terminal resistance	R		0,41	1,63	6,56	Ω
3	Output power	$P_{2\,max.}$		79,2	83,2	84,5	W
4	Efficiency, max.	$\eta_{max.}$		83	83	83	%
5	No-load speed	n_0		5 700	5 900	5 900	rpm
6	No-load current (with shaft ø 5 mm)	I_0		0,258	0,129	0,064	A
7	Stall torque	M_H		531	539	547	mNm
8	Friction torque	M_R		4,9	4,9	4,9	mNm
9	Speed constant	k_n		500	253	125	rpm/V
10	Back-EMF constant	k_E		2	3,95	7,98	mV/rpm
11	Torque constant	k_M		19,1	37,7	76,2	mNm/A
12	Current constant	k_I		0,052	0,027	0,013	A/mNm
13	Slope of n-M curve	$\Delta n/\Delta M$		10,7	10,9	10,8	rpm/mNm
14	Rotor inductance	L		70	270	1 100	µH
15	Mechanical time constant	τ_m		4,7	4,7	4,7	ms
16	Rotor inertia	J		42	41	42	gcm^2
17	Angular acceleration	$\alpha_{max.}$		130	130	130	$\cdot 10^3 rad/s^2$
18	Thermal resistance	R_{th1} / R_{th2}	2 / 8				K/W
19	Thermal time constant	τ_{w1} / τ_{w2}	17 / 810				s
20	Operating temperature range:						
	– motor		-30 ... +125				°C
	– rotor, max. permissible		+155				°C
21	Shaft bearings		ball bearings, preloaded				
22	Shaft load max.:						
	– with shaft diameter		5				mm
	– radial at 3 000 rpm (3 mm from bearing)		50				N
	– axial at 3 000 rpm		5				N
	– axial at standstill		50				N
23	Shaft play						
	– radial	≤	0,015				mm
	– axial	=	0				mm
24	Housing material		steel, black coated				
25	Weight		242				g
26	Direction of rotation		clockwise, viewed from the front face				
Recommended values - mathematically independent of each other							
27	Speed up to	$n_{e\,max.}$		5 000	5 000	5 000	rpm
28	Torque up to	$M_{e\,max.}$		70	70	70	mNm
29	Current up to (thermal limits)	$I_{e\,max.}$		4,6	2,3	1,15	A



For notes on technical data and lifetime performance refer to "Technical Information".
Edition 2011 – 2012

FAULHABER

Planetary Gearheads

10 Nm

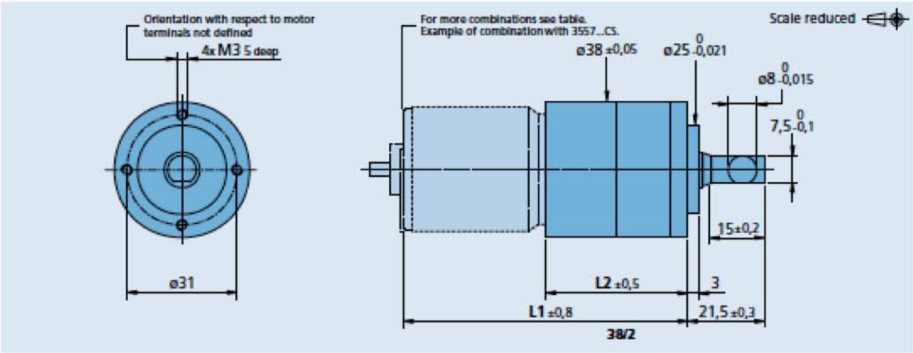
For combination with
DC-Micromotors
Brushless DC-Motors

Series 38/2

	38/2
Housing material	metal
Geartrain material	plastic/steel
Recommended max. input speed for:	
– continuous operation	4 000 rpm
Backlash, at no-load	≤ 1 °
Bearings on output shaft	ball bearings, preloaded
Shaft load, max.:	
– radial (10 mm from mounting face)	≤ 300 N
– axial	≤ 300 N
Shaft press fit force, max.	≤ 350 N
Shaft play	
– radial (10 mm from mounting face)	≤ 0,03 mm
– axial	≤ 0,15 mm
Operating temperature range	- 20 ... + 125 °C

Specifications									
Number of gear stages		1	2	3	3	4	4	4	5
Continuous torque	Nm	6	0,4	1,4	2,2	4,5	5,3	8,2	10
Intermittent torque	Nm	8	0,6	1,9	2,9	6	7	11	15
Weight without motor, ca.	g	145	195	245	245	296	296	296	348
Efficiency, max.	%	88	80	70	70	60	60	60	55
Direction of rotation, drive to output		=	=	=	=	=	=	=	=
Reduction ratio [1] (rounded)		**3,71:1**	**14:1**	**43:1**	**66:1**	**134:1**	**159:1**	**246:1**	**415:1** **592:1** **989:1** **1 526:1**
L2 [mm] = length without motor [2]		32,3	40,1	47,9	47,9	55,7	55,7	55,7	63,5
L1 [mm] = length with motor	3242G...CR	74,3	82,1	89,9	89,9	97,7	97,7	97,7	105,5
	3257G...CR	89,3	97,1	104,9	104,9	112,7	112,7	112,7	120,5
	3557K...CS	89,3	97,1	104,9	104,9	112,7	112,7	112,7	120,5
	3863A...C	91,3	99,1	106,9	106,9	114,7	114,7	114,7	122,5
	3056K...B	88,3	96,1	103,9	103,9	111,7	111,7	111,7	119,5
	3242G...BX4	76,5	84,3	92,1	92,1	99,9	99,9	99,9	107,7
	3268G...BX4	102,5	110,3	118,1	118,1	125,9	125,9	125,9	133,7
	3564K...B	96,3	104,1	111,9	111,9	119,7	119,7	119,7	127,5

[1] The reduction ratios are rounded, the exact values are available on request or at www.faulhaber.com.
[2] L2 - 5 mm, in combination with 3863A...C.



For notes on technical data and lifetime performance refer to "Technical Information".
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FAULHABER

Encoders

Optical Encoders

Features:
100 to 1024 Lines per revolution
2 or 3 Channels
Digital output

Series 5500, 5540

		HEDS 5500	HEDS 5540	HEDM 5500	
Lines per revolution	N	100 - 500	100 - 500	1 000 - 1 024	
Signal output, square wave		2	2+1 index	2	channels
Supply voltage	V_{CC}	4,5 ... 5,5			V DC
Current consumption, typical (V_{CC} = 5 V DC)	I_{CC}	17	57	57	mA
Pulse width	P	180 ± 45	180 ± 35	180 ± 45	°e
Phase shift, channel A to B	Φ	90 ± 20	90 ± 15	90 ± 15	°e
Logic state width	S	90 ± 45	90 ± 35	90 ± 45	°e
Cycle	C	360 ± 5,5	360 ± 5,5	360 ± 7,5	°e
Signal rise/fall time, typical	tr/tf	0,25 / 0,25			µs
Frequency range [1]	f	up to 100	up to 100 [2]	up to 100	kHz
Inertia of code disc	J	0,6			gcm^2
Operating temperature range		– 40 ... + 100		– 40 ... + 70	°C

[1] Velocity (rpm) = f (Hz) x 60/N
[2] HEDS 5540 requires pull-up resistors of 2,7 kΩ between pins 2, 3, 5 and 4 (V_{CC})

Ordering information

Encoder type	number of channels	lines per revolution	For combination with:
HEDS 5500 C	2	100	**DC-Micromotors and DC-Motor-Tachos Series**
HEDS 5500 A	2	500	**2230, 2233, 2251**
HEDS 5540 C	2+1	100	**2342**
HEDS 5540 A	2+1	500	**2642, 2657**
HEDM 5500 B	2	1 000	**3242, 3257, 3557, 3863**
HEDM 5500 J	2	1 024	
			brushless DC-Servomotors Series
			2036, 2057, 2444, 3056, 3564

Interlocking connector options: extension cables 300 mm length, on request.

Features

These incremental shaft encoders in combination with the DC-Micromotors and brushless DC-Servomotors are designed for the indication and control of both shaft velocity and direction of rotation as well as for positioning.

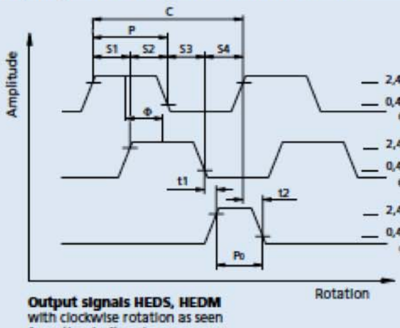
A LED source and lens system transmits collimated light through a low inertia metal disc to give two channels with 90° phase shift.

The single 5 volt supply and the two or three channel digital output signals are interfaced with a 5-pin connector.

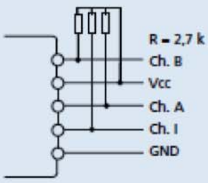
Motors with ball bearings are recommended for continuous operation at low and high speeds and for elevated radial shaft load.

Details for the Motors and suitable reduction gearheads are on separate catalogue pages.

Output signals / Circuit diagram / Connector information

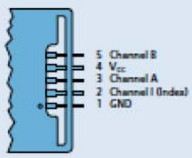


Output signals HEDS, HEDM
with clockwise rotation as seen from the shaft end



Connection diagram
HEDS 5540 requires pull-up resistors

Pin Function



Connector
suggested connectors
AMP 103686-4/640442-5,
Molex 2695/2759
FCI 65039-032 / 4825x-000

For notes on technical data and lifetime performance refer to "Technical Information".
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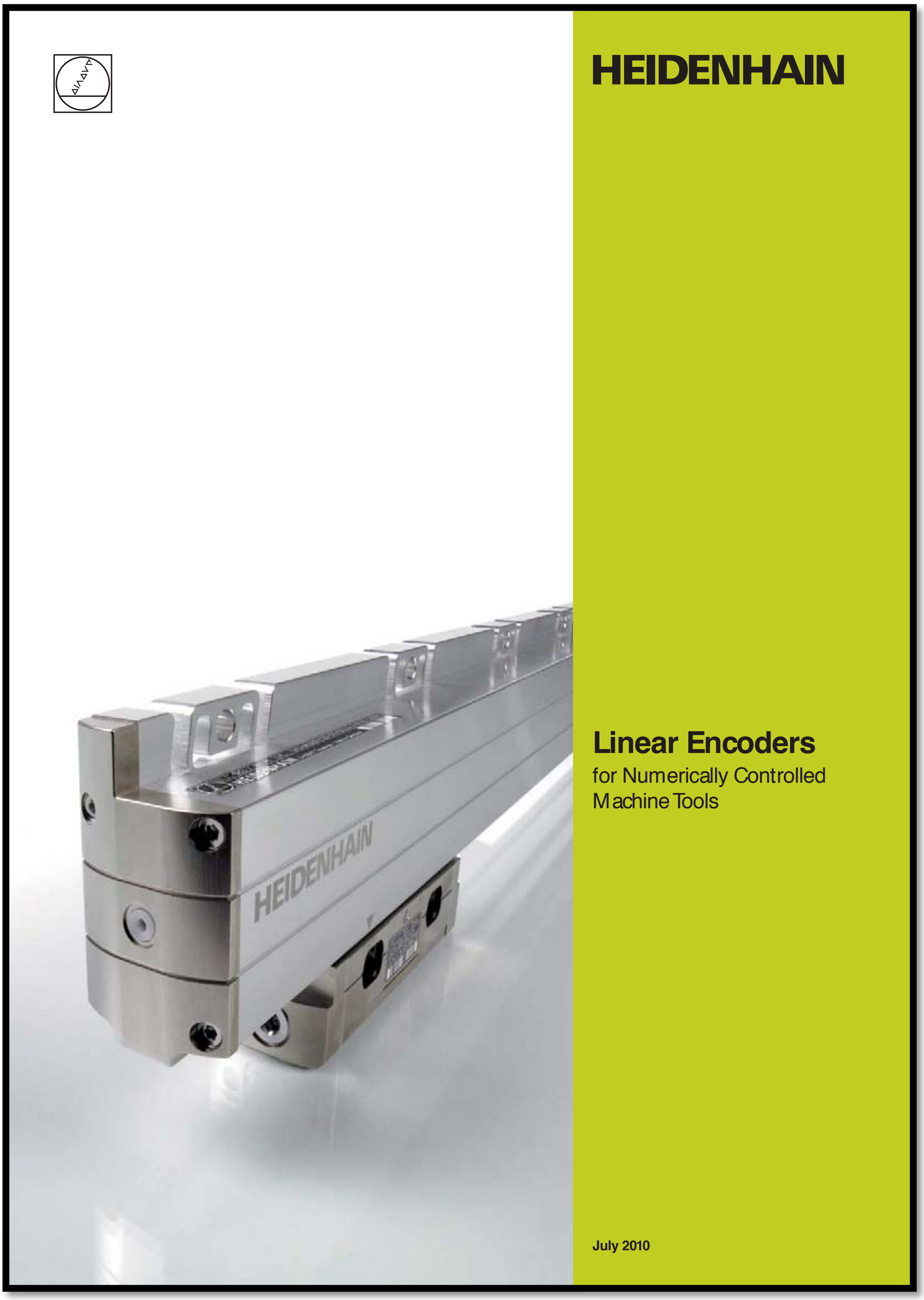
Doc. 2 *Encoder lineal carro porta-sinfín HEIDENHAIN LF481C*



HEIDENHAIN

Linear Encoders
for Numerically Controlled
Machine Tools

July 2010

Measuring Principles
Measuring Standard

HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations.
These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

These precision graduations are manufactured in various photolithographic processes. Graduations can be fabricated from:
- extremely hard chromium lines on glass,
- matte-etched lines on gold-plated steel tape, or
- three-dimensional grid structures on glass or steel substrates.

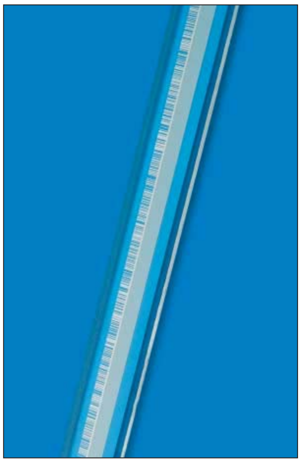
The photolithographic manufacturing processes developed by HEIDENHAIN produce grating periods of typically 40 µm to 4 µm.

Along with these very fine grating periods, these processes permit a high definition and homogeneity of the line edges. Together with the photoelectric scanning method, this high edge definition is a precondition for the high quality of the output signals.

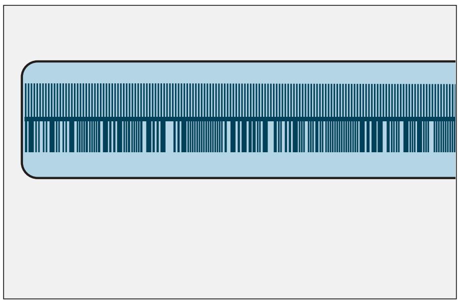
The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

Absolute Measuring Method

With the **absolute measuring method,** the position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics. There is no need to move the axes to find the reference position. The absolute position information is read **from the scale graduation,** which is formed from a serial absolute code structure. A separate incremental track is interpolated for the position value and at the same time is used to generate an optional incremental signal.



Graduation of an absolute linear encoder



Schematic representation of an absolute code structure with an additional incremental track (LC 483 as example)

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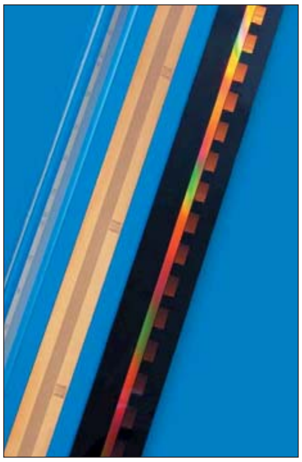
Incremental Measuring Method

With the **incremental measuring method,** the graduation consists of a periodic grating structure. The position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is required to ascertain positions, the scales or scale tapes are provided with an additional track that bears a **reference mark.** The absolute position on the scale, established by the reference mark, is gated with exactly one signal period. The reference mark must therefore be scanned to establish an absolute reference or to find the last selected datum.

In some cases this may necessitate machine movement over large lengths of the measuring range. To speed and simplify such "reference runs," many encoders feature **distance-coded reference marks**—multiple reference marks that are individually spaced according to a mathematical algorithm. The subsequent electronics find the absolute reference after traversing two successive reference marks—only a few millimeters traverse (see table).
Encoders with distance-coded reference marks are identified with a "C" behind the model designation (e.g. LS 487C).

With distance-coded reference marks, the **absolute reference** is calculated by counting the signal periods between two reference marks and using the following formula:



Graduations of incremental linear encoders

$$P_1 = (\text{abs } B - \text{sgn } B - 1) \times \frac{N}{2} + (\text{sgn } B - \text{sgn } D) \times \frac{\text{abs } M_{RR}}{2}$$

where:

$$B = 2 \times M_{RR} - N$$

and:

P_1 = Position of the first traversed reference mark in signal periods

abs = Absolute value

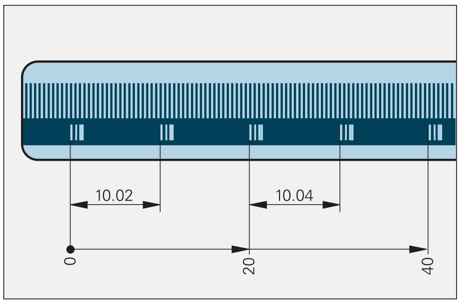
sgn = Sign function ("+1" or "–1")

M_{RR} = Number of signal periods between the traversed reference marks

N = Nominal increment between two fixed reference marks in signal periods (see table below)

D = Direction of traverse (+1 or –1). Traverse of scanning unit to the right (when properly installed) equals +1.

Technical Features and Mounting Information



Schematic representation of an incremental graduation with distance-coded reference marks (LS as example)

	Signal period	Nominal increment *N* in signal periods	Maximum traverse
LF	4 µm	5000	20 mm
LS	20 µm	1000	20 mm
LB	40 µm	2000	80 mm

9

Photoelectric Scanning

Most HEIDENHAIN encoders operate using the principle of photoelectric scanning. The photoelectric scanning of a measuring standard is contact-free, and therefore without wear. This method detects even very fine lines, no more than a few microns wide, and generates output signals with very small signal periods.

The finer the grating period of a measuring standard is, the greater the effect of diffraction on photoelectric scanning. HEIDENHAIN uses two scanning principles with linear encoders:

- The **imaging scanning principle** for grating periods from 20 µm and 40 µm
- The **interferential scanning principle** for very fine graduations with grating periods of 8 µm and smaller.

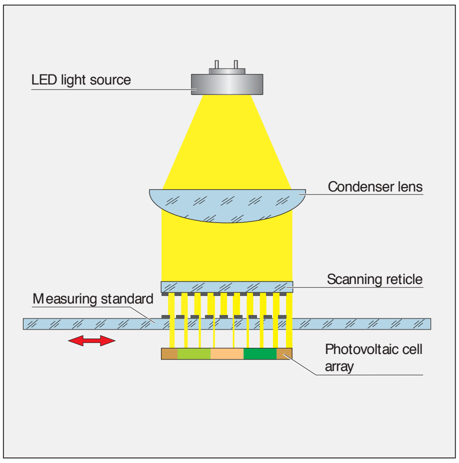
Imaging scanning principle
To put it simply, the imaging scanning principle functions by means of projected-light signal generation: two scale gratings with equal or similar grating periods are moved relative to each other—the scale and the scanning reticle. The carrier material of the scanning reticle is transparent, whereas the graduation on the measuring standard may be applied to a transparent or reflective surface.

When parallel light passes through a grating, light and dark surfaces are projected at a certain distance, where there is an index grating. When the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. An array of photovoltaic cells converts these variations in light intensity into electrical signals. The specially structured grating of the scanning reticle filters the light current to generate nearly sinusoidal output signals.

The smaller the period of the grating structure is, the closer and more tightly toleranced the gap must be between the scanning reticle and scale.

The LC, LS and LB linear encoders operate according to the imaging scanning principle.

Imaging scanning principle



10

Interferential scanning principle
The interferential scanning principle exploits the diffraction and interference of light on a fine graduation to produce signals used to measure displacement.

A step grating is used as the measuring standard: reflective lines 0.2 µm high are applied to a flat, reflective surface. In front of that is the scanning reticle—a transparent phase grating with the same grating period as the scale.

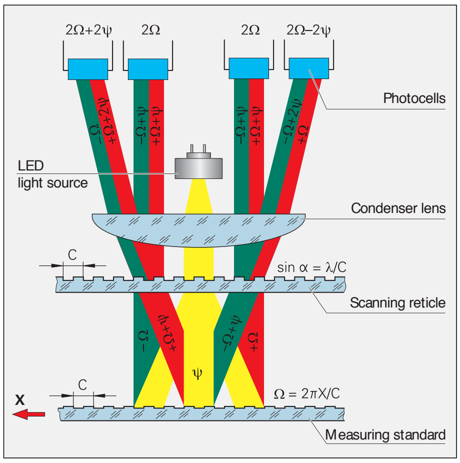
When a light wave passes through the scanning reticle, it is diffracted into three partial waves of the orders –1, 0, and +1, with approximately equal luminous intensity. The waves are diffracted by the scale such that most of the luminous intensity is found in the reflected diffraction orders +1 and –1. These partial waves meet again at the phase grating of the scanning reticle where they are diffracted again and interfere. This produces essentially three waves that leave the scanning reticle at different angles. Photovoltaic cells convert this alternating light intensity into electrical signals.

A relative motion of the scanning reticle to the scale causes the diffracted wave fronts to undergo a phase shift: when the grating moves by one period, the wave front of the first order is displaced by one wavelength in the positive direction, and the wavelength of diffraction order –1 is displaced by one wavelength in the negative direction. Since the two waves interfere with each other when exiting the grating, the waves are shifted relative to each other by two wavelengths. This results in two signal periods from the relative motion of just one grating period.

Interferential encoders function with grating periods of, for example, 8 µm, 4 µm and finer. Their scanning signals are largely free of harmonics and can be highly interpolated. These encoders are therefore especially suited for high resolution and high accuracy.

Sealed linear encoders that operate according to the interferential scanning principle are given the designation LF.

Interferential scanning principle (optics schematics)
C Grating period
ψ Phase shift of the light wave when passing through the scanning reticle
Ω Phase shift of the light wave due to motion X of the scale



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Measuring Accuracy

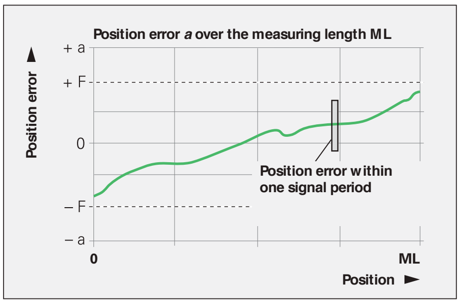
The accuracy of linear measurement is mainly determined by:

- The quality of the graduation
- The quality of the scanning process
- The quality of the signal processing electronics
- The error from the scanning unit guideway to the scale

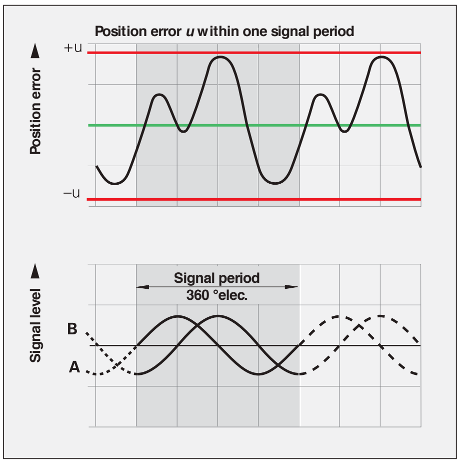
A distinction is made between position errors over relatively large paths of traverse—for example the entire measuring length—and those within one signal period.

Position error over the measuring range
The accuracy of sealed linear encoders is specified in grades, which are defined as follows:
The extreme values ± F of the measuring curves over any max. one-meter section of the measuring length lie within the accuracy grade ± a. They are ascertained during the final inspection, and are indicated on the calibration chart.

With sealed linear encoders, these values apply to the complete encoder system including the scanning unit. It is then referred to as the system accuracy.



Position error within one signal period
The position error within one signal period is determined by the signal period of the encoder, as well as the quality of the graduation and the scanning thereof. At any measuring position, it does not exceed ± 2% of the signal period, and for the LC and LS linear encoders it is typically ± 1%. The smaller the signal period, the smaller the position error within one signal period.



	Signal period of scanning signals	Max. position error *u* within one signal period
LF	4 µm	Approx. 0.08 µm
LC	20 µm	Approx. 0.2 µm
LS	20 µm	Approx. 0.2 µm
LB	40 µm	Approx. 0.8 µm

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All HEIDENHAIN linear encoders are inspected before shipping for positioning accuracy and proper function.

The position errors are measured by traversing in both directions, and the averaged curve is shown in the calibration chart.

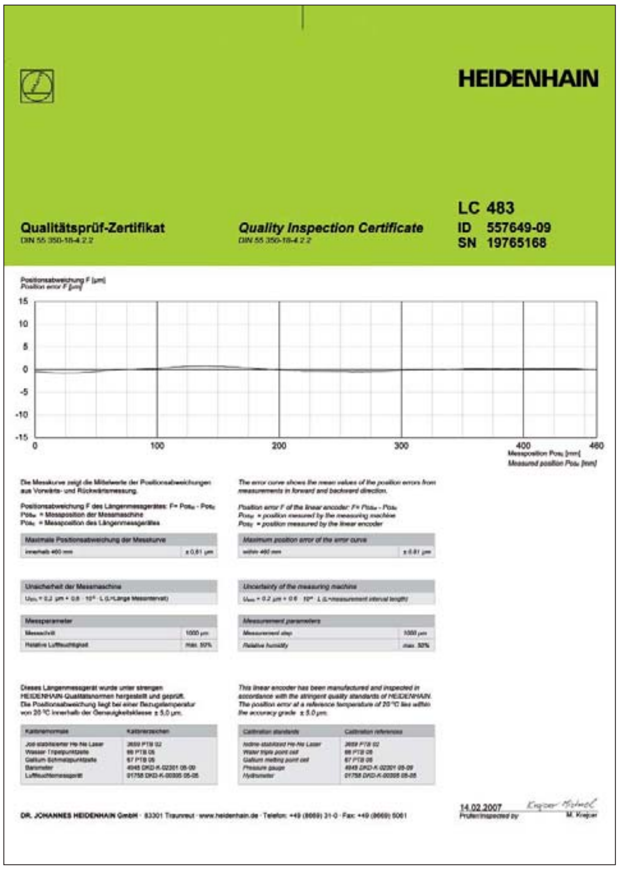
The **Quality Inspection Certificate** confirms the specified system accuracy of each encoder. The **calibration standards** ensure the traceability—as required by ISO 9001—to recognized national or international standards.

For the LC, LF and LS series listed in this brochure, a calibration chart documents the additional **position error** over the measuring length. The measurement parameters and uncertainty of the measuring machine are also stated.

Temperature range

The linear encoders are inspected at a **reference temperature** of 20 °C. The system accuracy given in the calibration chart applies at this temperature.

The **operating temperature range** indicates the ambient temperature limits between which the linear encoders will function properly. The **storage temperature range** of –20 °C to 70 °C applies for the unit in its packaging. Starting from a measuring length of 3240 mm, the permissible storage temperature range for encoders of the LC 183/LC 193 series is restricted to –10 °C to +50 °C.



Example

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Mechanical Design Types and Mounting Guidelines
Linear Encoders with Small Cross Section

The LC, LF and LS slimline linear encoders should be fastened to a machined surface over their entire length, especially for highly-dynamic requirements. Larger measuring lengths and higher vibration loads are made possible by using mounting spars or clamping elements (only for LC 4x3).

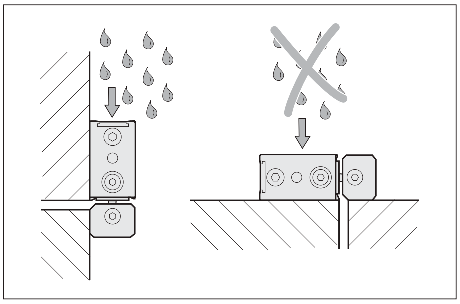
The encoder is mounted so that the sealing lips are directed downward or away from splashing water (also see *General Mechanical Information*).

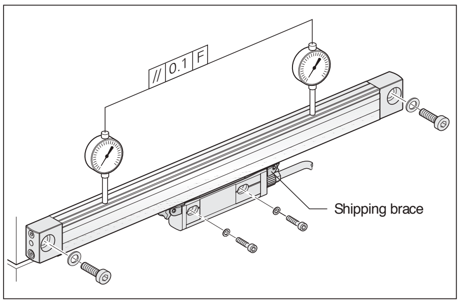
Thermal behavior
Because they are rigidly fastened using two M8 screws, the linear encoders largely adapt themselves to the mounting surface. When fastened over the mounting spar, the encoder is fixed at its midpoint to the mounting surface. The flexible fastening elements ensure reproducible thermal behavior.
The **LF 481** with its graduation carrier of steel has the same coefficient of thermal expansion as a mounting surface of gray cast iron or steel.

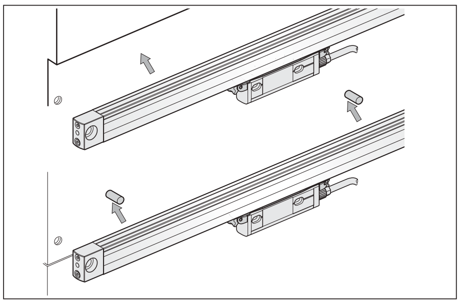
Mounting
It is surprisingly simple to mount the sealed linear encoders from HEIDENHAIN: You need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used for this. The shipping brace already sets the proper gap between the scale unit and the scanning unit, as well as the lateral tolerance. If the shipping brace needs to be removed before mounting due to a lack of space, then the mounting gauge is used to set the gap between the scale unit and the scanning unit easily and exactly. You must also ensure that the lateral tolerances are maintained.

Accessories:
Mounting and test gauges for slimline linear encoders

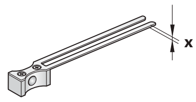
The **mounting gauge** is used to set the gap between the scale unit and the scanning unit if the shipping brace needs to be removed before mounting. The **test gauges** are used to quickly and easily check the gap of the mounted linear encoder.







	x	Color	ID
Mounting gauge	1.0 mm	Gray	528753-01
Max. test gauge	1.3 mm	Red	528753-02
Min. test gauge	0.7 mm	Blue	528753-03



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Along with the standard procedure of using two M8 screws to mount the scale unit on a plane surface, there are also other mounting possibilities:

Installation with mounting spar
The use of a mounting spar can be of great benefit when mounting slimline linear encoders. They can be fastened as part of the machine assembly process. The encoder is then simply clamped on during final mounting. Easy exchange also facilitates servicing.

A mounting spar is recommended for highly-dynamic applications with ML greater than 640 mm. It is always necessary for measuring lengths starting from 1240 mm.

The **universal mounting spar** was developed specifically for the LC 4x3 and LS 4x7. It can be mounted very easily, since the components necessary for clamping are premounted. Linear encoders with normal head mounting blocks and—if compatibility considerations require them—linear encoders with short end blocks can be mounted. Other advantages:

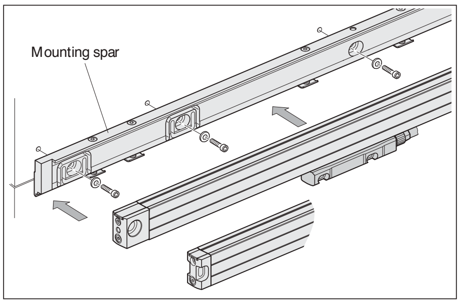
- **Mechanically compatible versions**
  The universal mounting spar and the LC 4x3 and the LS 4x7 are compatible in their mating dimensions to the previous versions. Any combinations are possible, such as the LS 4x6 with the universal mounting spar, or the LC 4x3 with the previous mounting spar.
- **Freely selectable cable outlet**
  The LC 4x3 and the LS 4x7 can be mounted with either side facing the universal mounting spar. This permits the cable exit to be located on the left or right—a very important feature if installation space is limited.

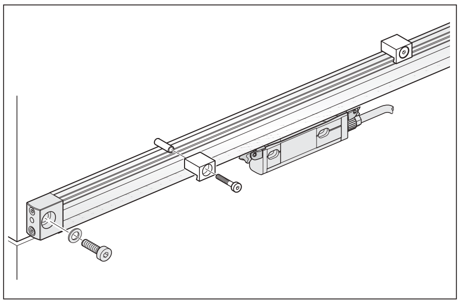
The universal mounting spar must be ordered separately, even for measuring lengths over 1240 mm.

Accessory:
Universal mounting spar
ID 571 613-xx

Mounting with clamping elements
The scale unit of the LC 4x3 is fastened at both ends. In addition, it can also be attached to the mounting surface by clamping elements. This way the fastening at the center of the measuring length (recommended for highly-dynamic applications with ML greater than 620 mm) is easy and reliable. This makes mounting without the mounting spar possible for measuring lengths greater than 1240 mm.

Accessory:
Clamping elements
With pin and M5x10 screw
ID 556 975-01 (10 units per package)





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Linear Encoders with Large Cross Section

The LB, LC, LF and LS full-size linear encoders are fastened over their entire length onto a machined surface. This gives them a **high vibration rating.** The inclined arrangement of the sealing lips permits **universal mounting** with vertical or horizontal scale housing with equally high protection rating.

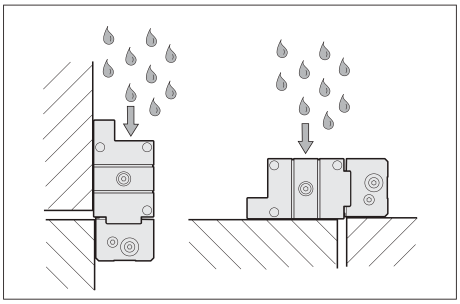
Thermal behavior
The thermal behavior of the LB, LC, LF and LS 100 linear encoders with large cross section has been optimized:

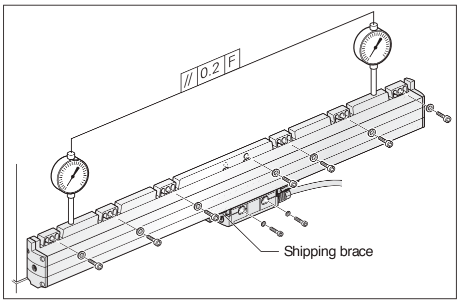
On the **LF** the steel scale is cemented to a steel carrier that is fastened directly to the machine element.

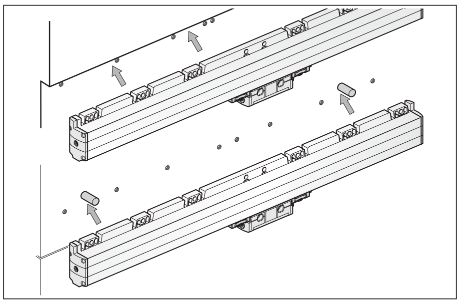
On the **LB** the steel scale tape is clamped directly onto the machine element. The LB therefore takes part in all thermal changes of the mounting surface.

LC and **LS** are fixed to the mounting surface at their midpoint. The flexible fastening elements permit reproducible thermal behavior.

Mounting
It is surprisingly simple to mount the sealed linear encoders from HEIDENHAIN: You need only align the scale unit at several points along the machine guideway. Stop surfaces or stop pins can also be used for this. The shipping brace already sets the proper gap between the scale unit and the scanning unit. The lateral gap is to be set during mounting. If the shipping brace needs to be removed before mounting due to a lack of space, then the mounting gauge is used to set the gap between the scale unit and the scanning unit easily and exactly. You must also ensure that the lateral tolerances are maintained.







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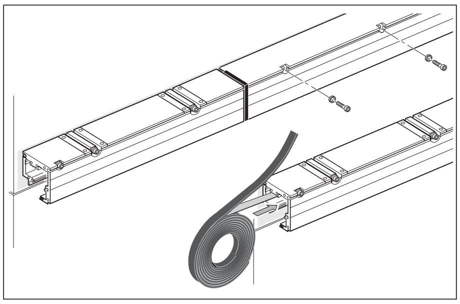
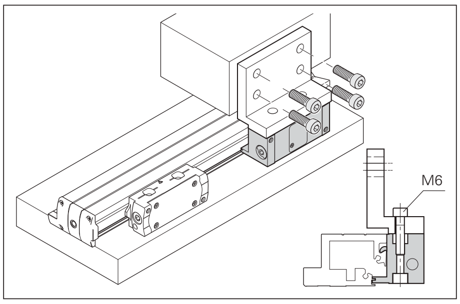
Mounting the multi-section LB 382
The LB 382 with measuring lengths over 3240 mm is mounted on the machine in individual sections:
- Mount and align the individual housing sections
- Pull in the scale tape over the entire length and tension it
- Pull in the sealing lips
- Insert the scanning unit

Adjustment of the tensioning of the scale tape enables linear machine error compensation up to ± 100 µm/m.



Accessory:
Mounting aid for LC 1x3 and LS 1x7
ID 547793-01

The mounting aid is locked onto the scale unit, simulating an optimally adjusted scanning unit. The customer's mating surface for the scanning unit can then be aligned to it. The mounting aid is then removed and the scanning unit is attached to the mounting bracket.



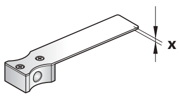
Example

Accessories:
Mounting and test gauges for full-size linear encoders

The **mounting gauge** is used to set the gap between the scale unit and the scanning unit if the shipping brace needs to be removed before mounting. The **test gauges** are used to quickly and easily check the gap of the mounted linear encoder.

LC, LS	x	Color	ID
Mounting gauge	1.5 mm	Gray	575832-01
Max. test gauge	1.8 mm	Red	575832-02
Min. test gauge	1.2 mm	Blue	575832-03

LB	x	Color	ID
Mounting gauge	1.0 mm	Gray	647933-01
Max. test gauge	1.3 mm	Red	647933-02
Min. test gauge	0.7 mm	Blue	647933-03



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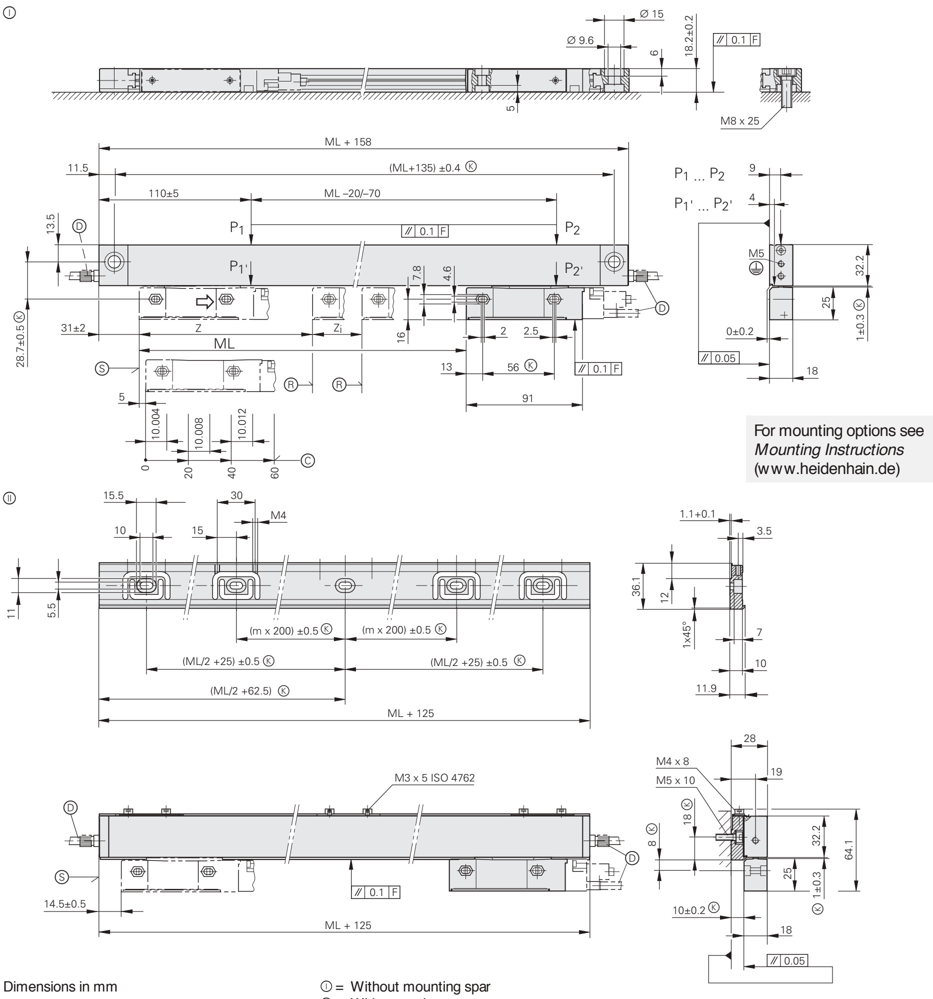
LF 481

- Incremental linear encoder for measuring steps to 0.1 µm
- Thermal behavior similar to steel or cast iron
- For limited installation space



For mounting options see *Mounting Instructions* (www.heidenhain.de)

Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓘ = Without mounting spar
Ⓘⓘ = With mounting spar
F = Machine guideway
P = Gauging points for alignment
Ⓚ = Required mating dimensions
Ⓓ = Compressed air inlet
Ⓡ = Reference-mark position on LF 481
2 reference marks for measuring lengths

50 ... 1000	1120 ... 1220
z = 25 z_i = ML – 50	z = 35 z_i = ML – 70

Ⓒ = Reference-mark position on LF 481 C
Ⓢ = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

Mounting spar

ML	m
50 ... 500	0
550 ... 900	1
1000 ... 1220	2

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LF 481 without mounting spar

LF 481 with mounting spar

Specifications	**LF 481**
Measuring standard Expansion coefficient	DIADUR phase grating on steel $\alpha_{therm} \approx 10 \times 10^{-6}\ K^{-1}$
Accuracy grade*	± 3 μm; ± 5 μm
Measuring length ML* in mm	Mounting spar* recommended 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 900 1000 1 120 1 220
Incremental signals	~ 1 V_{PP}
Grating period Signal period	8 μm 4 μm
Reference marks* *LF 481* *LF 481 C*	*ML 50 mm:* 1 reference mark at midpoint *ML 100 to 1000 mm:* 2, located 25 mm from the beginning and end of the measuring length *From ML 1120 mm:* 2, located 35 mm from the beginning and end of the measuring length Distance-coded
Cutoff frequency –3dB	≥ 200 kHz
Power supply without load	5 V ± 5 %/< 200 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[1]	≤ 150 m
Traversing speed	≤ 30 m/min
Required moving force	≤ 5 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 80 m/s^2 (IEC 60068-2-6) ≤ 100 m/s^2 (IEC 60068-2-27) ≤ 30 m/s^2 in measuring direction
Operating temperature	0 °C to 50 °C
Protection IEC 60529	IP 53 when mounted according to the mounting instructions IP 64 if compressed air is connected via DA 300
Weight without mounting spar	0.4 kg + 0.5 kg/m measuring length

* Please indicate when ordering
[1] With HEIDENHAIN cable

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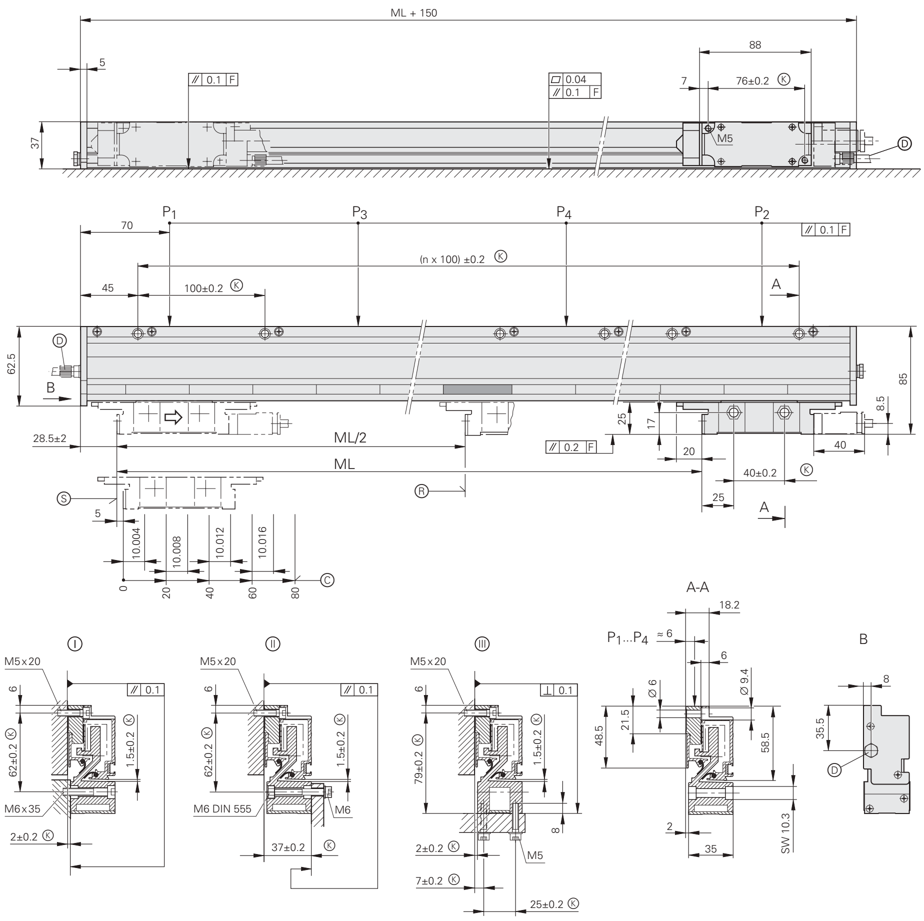
Doc. 3 Alternativa encoder lineal HEIDENHAIN LF183

LF 183

- Incremental linear encoder for measuring steps to 0.1 µm
- Thermal behavior similar to steel or cast iron
- High vibration rating
- Horizontal mounting possible



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

I, II,
III = Mounting options
F = Machine guideway
P = Gauging points for alignment
K = Required mating dimensions
D = Compressed air inlet
R = Reference-mark position on LF 183
C = Reference-mark position on LF 183C
S = Beginning of measuring length (ML)
⇨ = Direction of scanning unit motion for output signals in accordance with interface description

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Specifications	**LF 183**
Measuring standard Expansion coefficient	DIADUR phase grating on steel $\alpha_{therm} \approx 10 \times 10^{-6}\ K^{-1}$
Accuracy grade*	± 3 µm; ± 2 µm
Measuring length ML* in mm	140 240 340 440 540 640 740 840 940 1040 1140 1240 1340 1440 1540 1640 1740 1840 2040 2240 2440 2640 2840 3040
Incremental signals	∼ 1 V_{PP}
Grating period Signal period	8 µm 4 µm
Reference marks* *LF 183* *LF 183 C*	Selectable with magnets every 50 mm Standard setting: 1 reference mark at midpoint of measuring length Distance-coded
Cutoff frequency –3dB	≥ 200 kHz
Power supply without load	5 V ± 5 %/< 200 mA
Electrical connection	Separate adapter cable (1 m/3 m/6 m/9 m) connectable to mounting block
Cable length[1)]	≤ 150 m
Traversing speed	≤ 60 m/min
Required moving force	≤ 4 N
Vibration 55 to 2000 Hz **Shock** 11 ms **Acceleration**	≤ 150 m/s^2 (IEC 60068-2-6) ≤ 300 m/s^2 (IEC 60068-2-27) ≤ 100 m/s^2 in measuring direction
Operating temperature	0 °C to 40 °C
Protection IEC 60529	IP 53 when mounted according to the mounting instructions IP 64 if compressed air is connected via DA 300
Weight	1.1 kg + 3.8 kg/m measuring length

* Please indicate when ordering
1) With HEIDENHAIN cable

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Doc. 4 *Alternativas encoder lineal RENISHAW*

Data sheet
L-9517-0166-07-A

RENISHAW
apply innovation™

RGH24 series readhead

Renishaw's RG2 linear encoder system is a non-contact optical encoder designed for position feedback solutions.

The system uses a common reflective tape scale scanned by a readhead chosen from a range of options offering industry standard digital square wave or analogue sinusoidal output signal formats.

Renishaw's unique patented optical scheme is used in all readhead series to provide high tolerance to scale contamination.

RGH24 is an ideal feedback solution wherever precision controlled movement is required.

The RGH24 readheads offer a wide selection of output configurations and their compact size and low mass makes the system ideal for small XY stages and actuators.

An integral set-up LED enables quick and easy installation.

Common applications include semiconductor/electronics manufacturing and inspection, coordinate measuring and layout machines, height gauges, linear motors, pre-press printing and a variety of custom linear motion solutions.

Digital range

RGH24D - 5 µm resolution

RGH24X - 1 µm resolution

RGH24Z - 0.5 µm resolution

RGH24W - 0.2 µm resolution

RGH24Y - 0.1 µm resolution

RGH24H - 50 nm resolution

RGH24I - 20 nm resolution

RGH24O - 10 nm resolution

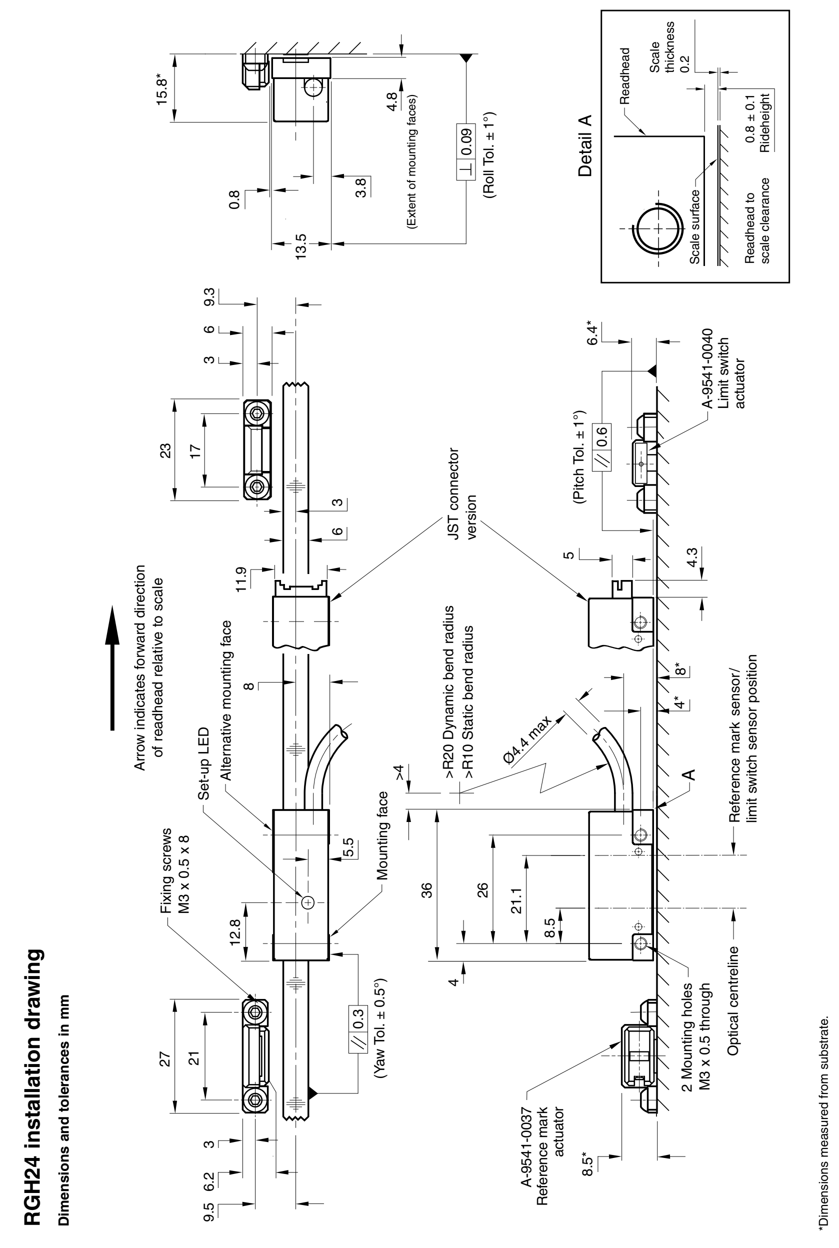
Analogue range

RGH24B - 1 Vpp differential

RGH24C - 12 µA differential

- **Non-contact open optical system**
- **Compact size**
- **Low mass**
- **Integral interpolation**
- **Digital and analogue output options**
- **Resolutions from 5 µm to 10 nm**
- **Integral set-up LED**
- **Uses RGS20-S self-adhesive scale**
- **Reference mark or limit switch capability**

Data sheet
RGH24



RENISHAW
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Operating and electrical specifications

Clocked outputs

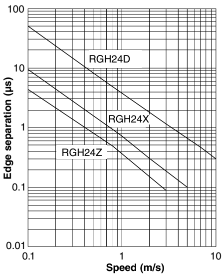
The RGH24W (0.2 µm), RGH24Y (0.1 µm), RGH24H (50 nm), RGH24I (20 nm) and RGH24O (10 nm) readheads have clocked outputs. These are designed to prevent fine edge separations being missed by receiving electronics utilising slower clock speeds. The table below shows the maximum speed and associated minimum recommended counter clock frequency for these readheads.

Head type	Maximum speed (m/s)	Minimum recommended counter clock frequency (MHz)
D (5 µm) **X** (1 µm) **Z** (0.5 µm)	10 5 3	$\left(\dfrac{\text{encoder velocity (m/s)}}{\text{resolution (µm)}}\right)$ x 4 safety factor

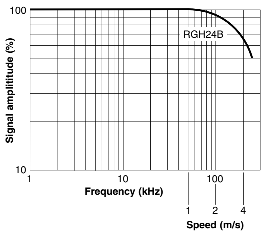
Std. option	JST option	Maximum speed (mm/s)					Minimum recommended counter clock frequency (MHz)
Head type		W (0.2 µm)	Y (0.1 µm)	H (50 nm)	I (20 nm)	O (10 nm)	
30	35	–	700	350	130	65	12
31	36	–	500	250	90	45	8
32	37	700	–	–	–	–	6
33	38	500	250	120	40	20	4

NOTE: Maximum speeds of clocked output variants assume 3 m maximum cable length and minimum 5 V supply at readhead connector.

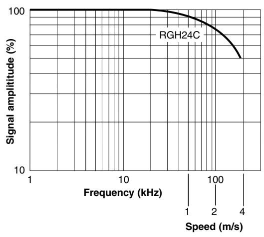
Edge separation - digital readheads



Speed - analogue type B readheads (1Vpp)



Speed - analogue type C readheads (12µA)



Power supply	5 V± 5% 120 mA Ripple 200 mVpp maximum @ frequency up to 500 kHz maximum **NOTE:** For digital outputs, current consumption figures refer to unterminated readheads. A further 25 mA per channel pair (eg A+, A-) will be drawn when terminated with 120 Ω. For analogue type B readheads, a further 20 mA will be drawn when terminated with 120 Ω. Renishaw encoder systems must be powered from a 5 V dc supply complying with the requirements for SELV of standard EN (IEC) 60950.
Temperature	Storage -20 °C to +70 °C Operating 0 °C to +55 °C
Humidity	Storage 95% maximum relative humidity (non-condensing) Operating 80% maximum relative humidity (non-condensing)
Sealing	IP40
Acceleration	Operating 500 m/s² BS EN 60068-2-7:1993 (IEC 68-2-7:1983)
Shock (non-operating)	1000 m/s², 6 ms, ½ sine BS EN 60068-2-27:1993 (IEC 68-2-27:1987)
Vibration (operating)	100 m/s² max @ 55 Hz to 2000 Hz BS EN 60068-2-6:1996 (IEC 68-2-6:1995)
Mass	Readhead 11 g Cable 34 g/m
EMC compliance (system)	BS EN 61000 BS EN 55011
Cable	Double-shielded maximum diameter 4.4 mm cable. Flex life >20 x 10⁶ cycles at 20 mm bend radius
Connector options	**Code - connector type** / **Application** A - 9 pin D type plug / All readheads C - 9 pin circular plug / RGH24C D - 15 pin D type plug / RGH24D, X, Z, W, Y, H, I, O L - 15 pin D type plug / RGH24B F - Flying lead / All readheads Z - JST Connector / RGH24D, X, Z, W, Y, H, I, O
Electrical integration (JST connector versions)	The RGH24 JST connector series readheads have been designed to the relevant EMC standards but must be correctly integrated to achieve EMC compliance. In particular attention to shielding and earthing arrangements is critical. Renishaw recommends the use of a double screened cable as used in the cable variants of the RGH24. Refer to RGH24 readhead installation guide for electrical connection information for these readheads.

Renishaw plc
New Mills, Wotton-under-Edge,
Gloucestershire GL12 8JR
United Kingdom

T +44 (0)1453 524524
F +44 (0)1453 524901
E uk@renishaw.com
www.renishaw.com

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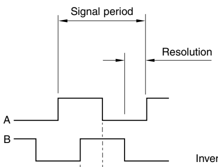
Output specifications

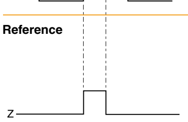
Digital output signals - type RGH24D, X, Z, W, Y, H, I, O
Form - Square wave differential line driver to EIA RS422A

Incremental 2 channels A and B in quadrature (90° phase shifted)



Inverse signals not shown for clarity

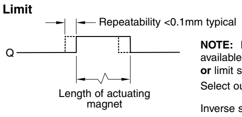
Reference



Synchronised pulse Z, duration equal to the resolution. Repeatability of position (uni-directional) maintained within ±10 °C from installation temperature and for speed <250 mm/s.

Inverse signal not shown for clarity
Actuation device A-9541-0037

Limit



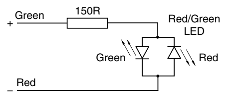
Asynchronous pulse Q

NOTE: RGH24 readheads are available with reference mark **or** limit switch detection.
Select output option at order

Inverse signal not shown for clarity
Actuation device A-9541-0040

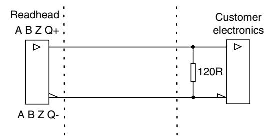
Alarm
3-state alarm
Incremental channels forced open circuit for >20 ms when signal too low for reliable operation. For RGH24W, Y, H, I and O only, incremental channels forced open circuit for >10ms when signal, too low or speed too high for reliable operation.

Remote LED driver
Recommended termination



The output of the integral set-up LED is available from the JST connector versions only to allow remote monitoring of readhead installation.

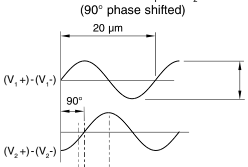
Recommended signal termination



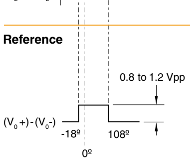
Standard RS422A line receiver circuitry. Contact Renishaw for further details on receiver termination for 3-state output

Analogue output signals type RGH24B (1Vpp)

Incremental 2 channels V_1 and V_2 differential sinusoids in quadrature (90° phase shifted)

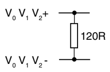


Reference



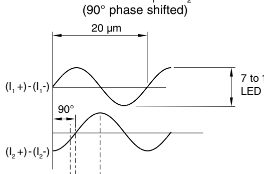
Differential pulse V_0 - 18° to 108°
Duration 126° (electrical)
Repeatability of position (uni-directional) maintained within ±10 °C from installation temperature and for speed <250 mm/s
Actuation device A-9541-0037

Termination

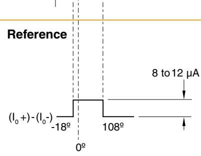


Analogue output signals type RGH24C (12µA)

Incremental 2 channels I_1 and I_2 differential sinusoids in quadrature (90° phase shifted)



Reference

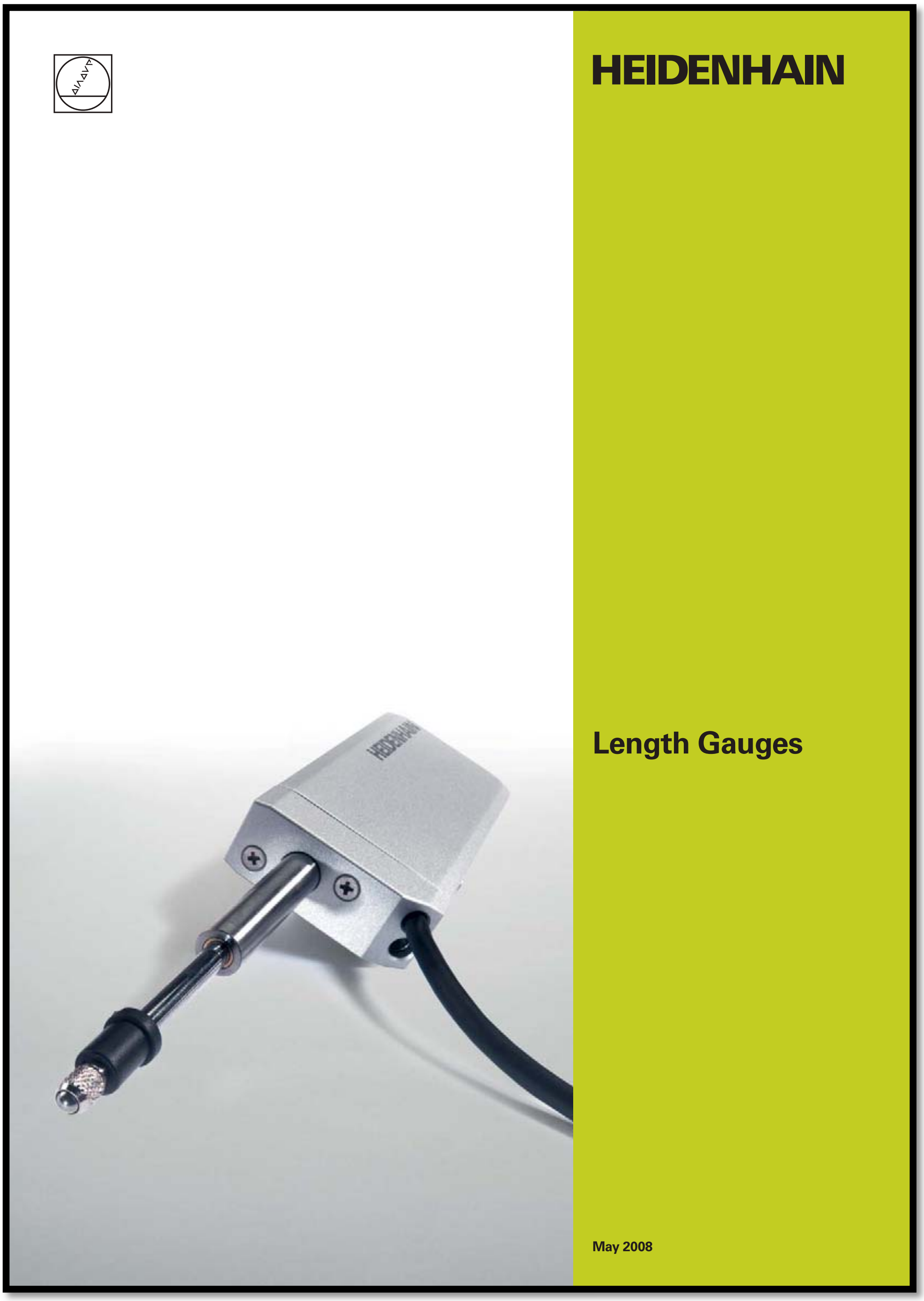


Differential pulse I_0 - 18° to 108°
Duration 126° (electrical)
Repeatability of position (uni-directional) maintained within ±10 °C from installation temperature and for speed <250 mm/s.
Actuation device A-9541-0037

For worldwide contact details, please visit our main website at www.renishaw.com/contact

L-9517-0166-07

Doc. 5 *Palpador lineal HEIDENHAIN-SPECTO ST1288*



HEIDENHAIN

Length Gauges

May 2008

Principle of Function

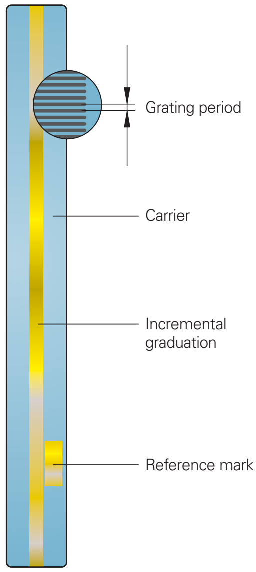
HEIDENHAIN length gauges are characterized by long measuring ranges and consistently high accuracy. The basis for both is the measuring principle of photoelectrically scanning an incremental scale.

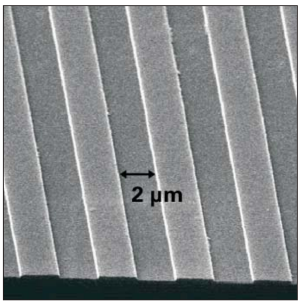
HEIDENHAIN linear encoders use material measuring standards consisting of **incremental graduations** on substrates of glass or glass ceramic. These measuring standards permit large measuring ranges, are insensitive to vibration and shock, and have a defined thermal behavior. Changes in atmospheric pressure or relative humidity have no influence on the accuracy of the measuring standard—which is the prerequisite for the **high long-term stability** of HEIDENHAIN length gauges.

The masters for these graduations are fabricated on dividing engines developed and built by HEIDENHAIN. High thermal stability during the manufacturing process ensures that the graduations have **high accuracy** over the measuring length. The master graduation is applied to the carrier using the DIADUR copying process developed by HEIDENHAIN, which produces very thin but durable graduation structures of chromium.

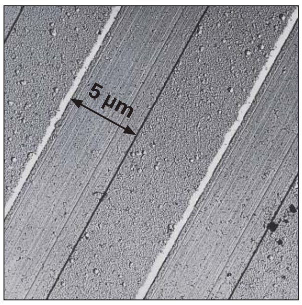
The incremental graduation is **photoelectrically scanned** without mechanical contact and therefore without wear. Light passes through the structured scanning reticle and over the scale onto photovoltaic cells. The photovoltaic cells produce sinusoidal output signals with a small signal period. Interpolation in the subsequent electronics makes very small measuring steps into the nanometer range possible. The scanning principle, together with the extremely fine graduation lines and their high edge definition ensure the quality of the output signals as well as the **small position error within one signal period.** This applies particularly to HEIDENHAIN length gauges, which use a DIADUR phase grating as measuring standard. The interferential scanning method produces sinusoidal incremental signals with a period of only 2 µm.

Reference mark
Photoelectric scanning of grid structures results in an incremental, i.e. counting, measurement. To ascertain positions, an absolute reference is required. The reference mark enables the exact reestablishment of the most recently defined datum, for example after an interruption in power. It is photoelectrically scanned and is permanently associated with exactly one measuring step, regardless of the direction or velocity of traverse.





DIADUR phase grating with approx. 0.25 µm grating height



DIADUR scale

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Mechanical Design

HEIDENHAIN length gauges function according to the **Abbe measuring principle,** i.e. the measuring standard and the plunger are exactly aligned. All components comprising the **measuring loop,** such as the measuring standard, plunger, holder and scanning head are designed in terms of their mechanical and thermal stability for the highest possible accuracy of the length gauge.

HEIDENHAIN length gauges have a defined **thermal behavior.** Since temperature variations during measurement can result in changes in the measuring loop, HEIDENHAIN uses special materials with low α_{therm} coefficients of expansion for the components of the measuring loop, for example in the CERTO length gauges. The scale is manufactured of Zerodur® ($\alpha_{therm} \approx 0\ K^{-1}$), and the plunger and holder are of Invar ($\alpha_{therm} \approx 1 \cdot 10^{-6}\ K^{-1}$). This makes it possible to guarantee its high measuring accuracy over a relatively large temperature range.

Length gauges from HEIDENHAIN have a **sturdy design.** Even high vibration and shock loads have no negative influence on the accuracy.

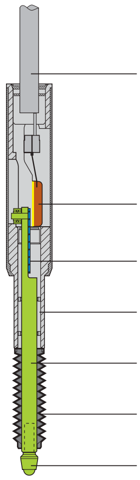
The **ball-bush guided plunger** tolerates high radial forces and moves with very low friction. It has an M2.5 thread to hold measuring contacts.

Parts subject to wear
HEIDENHAIN length gauges contain components that are subject to wear, depending on the application and manipulation. These include in particular the following parts:

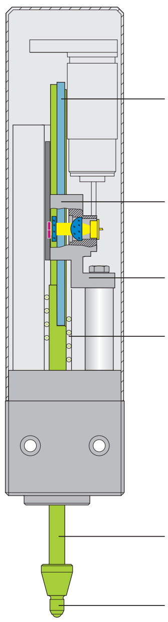
- LED light source
- Guideway (tested for at least 5 million strokes*)
- Cable link for CT, MT 60 and MT 101 (tested for at least 1 million strokes*)
- Scraper rings
- Rubber bellows on ST 1200

* On CT, MT 60 M and MT 101 M only with actuation by switch box

Design of ST 1200



Design of CT 6000 MT 60



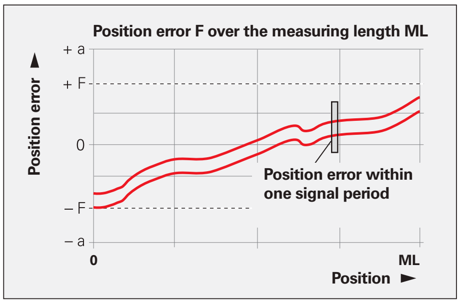
Measuring Accuracy

The accuracy of position measurement with length gauges is mainly determined by the following factors:

- The quality of the graduation
- The quality of the scanning process
- The quality of the signal processing electronics
- The error from the scale guideway relative to the scanning unit

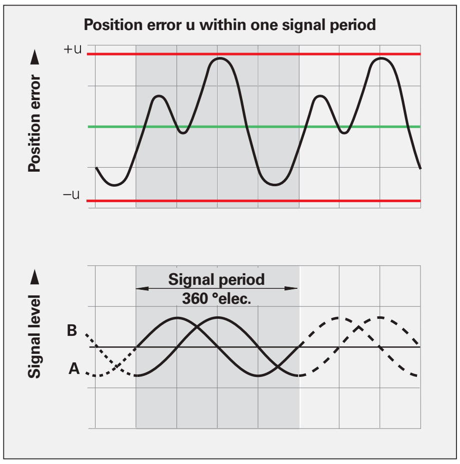
A distinction is made between position error over relatively large paths of traverse—for example the entire measuring range—and that within one signal period.

Position error over the measuring range
Length gauge accuracy is specified as system accuracy, which is defined as follows:
The extreme values of the ***total error F*** *— with reference to their mean value—lie over the entire measuring length within the system accuracy ± a. They are measured during the final inspection and documented in the calibration chart.*



Position error within one signal period
The **position error u** within one signal period is determined by the signal period of the length gauge, as well as the quality of the graduation and its scanning. At any position over the entire measuring length, it does not exceed approx. ± 1 % of the signal period.

The smaller the signal period, the smaller the position error within one signal period. In the calibration chart of the HEIDENHAIN-CERTO, this position error within one signal period is shown as a tolerance band.



	Signal period of the scanning signals	Max. position error u within one signal period
CT 2500 **CT 6000**	2 µm	Approx. ± 0.02 µm
MT 1200 **MT 2500**	2 µm	Approx. ± 0.02 µm
MT 60 **MT 101**	10 µm	Approx. ± 0.1 µm
ST 1200 **ST 3000**	20 µm	Approx. ± 0.2 µm

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All HEIDENHAIN length gauges are inspected before shipping for accuracy and proper function.

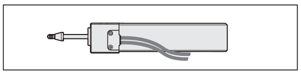
They are calibrated for accuracy during retraction and extension of the plunger. For the HEIDENHAIN-CERTO, the number of measuring positions is selected to ascertain very exactly not only the long-range error, but also the position error within one signal period.

The **Manufacturer's Inspection Certificate** confirms the specified system accuracy of each length gauge. The **calibration standards** ensure the traceability—as required by EN ISO 9001—to recognized national or international standards.

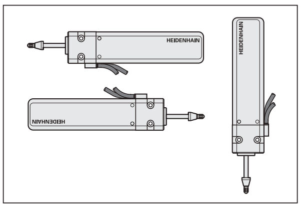
For the HEIDENHAIN-METRO and HEIDENHAIN CERTO series, a **calibration chart** documents the position error over the measuring range. It also shows the measuring step and the measuring uncertainty of the calibration measurement.

For the HEIDENHAIN-METRO the calibration chart shows the mean value of one forward and one backward measuring stroke.

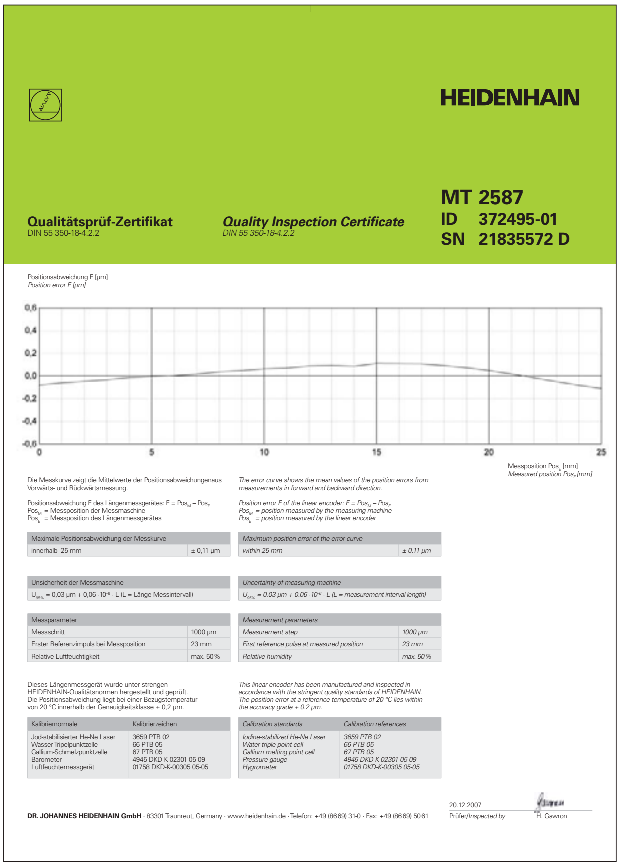
The HEIDENHAIN-CERTO is represented in the calibration chart as the envelope curve of the measured error. The HEIDENHAIN-CERTO length gauges are supplied with two calibration charts, each for different operating attitudes.



Operating attitude for calibration chart 1



Operating attitude for calibration chart 2



HEIDENHAIN

Qualitätsprüf-Zertifikat
DIN 55 350-18-4.2.2

Quality Inspection Certificate
DIN 55 350-18-4.2.2

MT 2587
ID 372495-01
SN 21835572 D

Die Messkurve zeigt die Mittelwerte der Positionsabweichungenaus Vorwärts- und Rückwärtsmessung.

The error curve shows the mean values of the position errors from measurements in forward and backward direction.

Positionsabweichung F des Längenmessgerätes: $F = Pos_M - Pos_E$
Pos_M = Messposition der Messmaschine
Pos_E = Messposition des Längenmessgerätes

Position error F of the linear encoder: $F = Pos_M - Pos_E$
Pos_M = position measured by the measuring machine
Pos_E = position measured by the linear encoder

Maximale Positionsabweichung der Messkurve	
innerhalb 25 mm	± 0,11 µm

Maximum position error of the error curve	
within 25 mm	*± 0.11 µm*

Unsicherheit der Messmaschine
$U_{95\%} = 0{,}03\ \mu m + 0{,}06 \cdot 10^{-6} \cdot L$ (L = Länge Messintervall)

Uncertainty of measuring machine
$U_{95\%} = 0.03\ \mu m + 0.06 \cdot 10^{-6} \cdot L$ (L = measurement interval length)

Messparameter	
Messschritt	1000 µm
Erster Referenzimpuls bei Messposition	23 mm
Relative Luftfeuchtigkeit	max. 50 %

Measurement parameters	
Measurement step	*1000 µm*
First reference pulse at measured position	*23 mm*
Relative humidity	*max. 50 %*

Dieses Längenmessgerät wurde unter strengen HEIDENHAIN-Qualitätsnormen hergestellt und geprüft. Die Positionsabweichung liegt bei einer Bezugstemperatur von 20 °C innerhalb der Genauigkeitsklasse ± 0,2 µm.

This linear encoder has been manufactured and inspected in accordance with the stringent quality standards of HEIDENHAIN. The position error at a reference temperature of 20 °C lies within the accuracy grade ± 0.2 µm.

Kalibriernormale	Kalibrierzeichen
Jod-stabilisierter He-Ne Laser	3659 PTB 02
Wasser-Tripelpunktzelle	66 PTB 05
Gallium-Schmelzpunktzelle	67 PTB 05
Barometer	4945 DKD-K-02301 05-09
Luftfeuchtemessgerät	01758 DKD-K-00305 05-05

Calibration standards	*Calibration references*
Iodine-stabilized He-Ne Laser	*3659 PTB 02*
Water triple point cell	*66 PTB 05*
Gallium melting point cell	*67 PTB 05*
Pressure gauge	*4945 DKD-K-02301 05-09*
Hygrometer	*01758 DKD-K-00305 05-05*

DR. JOHANNES HEIDENHAIN GmbH · 83301 Traunreut, Germany · www.heidenhain.de · Telefon: +49 (8669) 31-0 · Fax: +49 (8669) 5061

20.12.2007
Prüfer/*Inspected by* H. Gawron

Example

Temperature range
The length gauges are inspected at a **reference temperature** of 20 °C. The system accuracy given in the calibration chart applies at this temperature. The **operating temperature range** indicates the ambient temperature limits between which the length gauges will function properly. The **storage temperature range** of –20 °C to 60 °C applies for the unit in its packaging.

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Gauging Force—Plunger Actuation

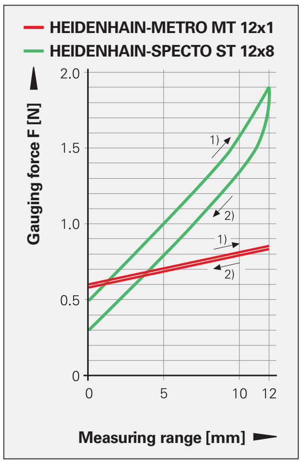
Gauging force
Gauging force is the force that the plunger exercises on the measured object. An excessively large gauging force can cause deformation of the measuring contact and the measured object. If the gauging force is too small, an existing dust film or other obstacle may prevent the plunger from fully contacting the measured object. The gauging force depends on the type of plunger actuation.

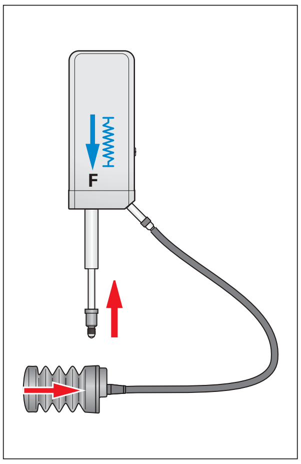
Plunger actuation by spring
For the MT 12x1, MT 25x1, ST 12x8 and ST 30x8, the integral spring extends the plunger to the measuring position and applies the **gauging force.** In its resting position, the plunger is extended. The gauging force depends on:
- The operating attitude
- The plunger position, because the gauging force changes over the measuring range
- The measuring direction, i.e., whether the gauge measures with extending or retracting plunger

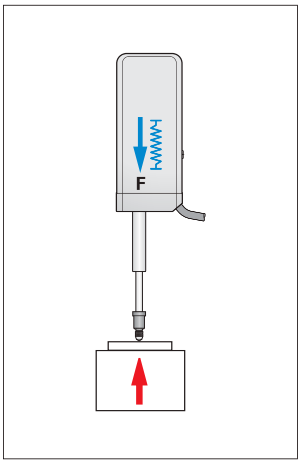
There are several ways of actuating the length gauge plunger:

Plunger actuation by cable-type lifter
Through a cable mechanism, the plunger is retracted by hand and then extended onto the measured object. The measurement is made with extending plunger.

Plunger actuation by measured object
The complete length gauge is moved relative to the measured object. The measurement is made with retracting plunger.







1) Plunger retraction
2) Plunger extension

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Pneumatic plunger actuation
The pneumatically actuated plungers of the MT 1287, MT 2587, ST 12x7 and ST 30x7 length gauges are extended by the application of compressed air. When the air connection is ventilated, the integral spring retracts the plunger to a protected resting position within the housing.

The **gauging force** can be adjusted to the measuring task through the level of air pressure. At constant pressure, it depends on the operating attitude and the plunger position. The vertically downward position with retracted plunger, for example, has the greatest gauging force, and the vertically upward position with extended plunger the lowest. The data given in the specifications are approximate and are subject to variation due to tolerances and to wear in the seal.

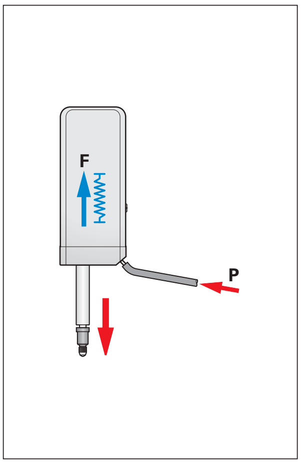
The length gauges with pneumatic plunger actuation are particularly well suited for automated measuring systems.

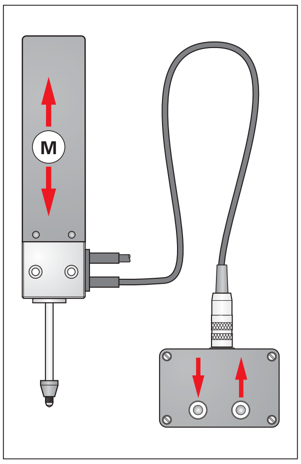
Motorized plunger actuation
The CT 2501, CT 6001, MT 60 M and MT 101 M length gauges feature an integral motor that moves the plunge. It is operated through the switch box either by push button or over the connection for external operation. The plungers of the CT 2501, CT 6001, and MT 60 M length gauges must not be moved by hand if the switch box is connected.

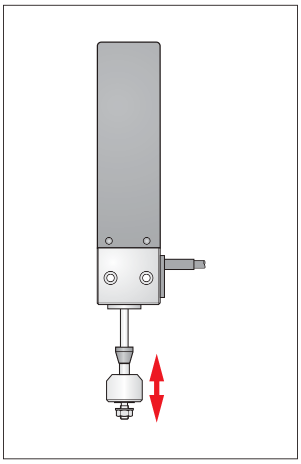
The **gauging force** of the CT 2501, CT 6001, and MT 60 M motorized length gauges is adjustable in three stages through the switch box. The force remains constant over the measuring range but depends on the operating attitude. Regardless of the operating attitude—whether it measures vertically downward (with the SG 101 V switchbox) or horizontally (with the SG 101 H switch box)—the MT 101 M exercises a constant gauging force.

Switch box and power adapter (only with MT101 M) must be ordered separately.

External plunger actuation by coupling
For the CT 2502, CT 6002, MT 60 K, MT 101 K and special versions "without spring" of the MT 1200 and MT 2500, the plunger is freely movable. For position measurement, the plunger is connected by a coupling with a moving machine element. The force needed to move the plunger is specified as the required **moving force.** It depends on the operating attitude.







15

Mounting

In addition to the length gauge itself, the mechanical design of the measuring setup also plays a role in defining the quality of measurement.

Abbe principle
HEIDENHAIN length gauges enable you to work according to the Abbe measuring principle: The measured object and scale must be in alignment to avoid additional measuring error.

Measuring loop
All components included in the measuring loop such as the holder for the measured object, the gauge stand with holder, and the length gauge itself influence the result of measurement. Expansion or deformation of the measuring setup through mechanical or thermal influences adds directly to the error.

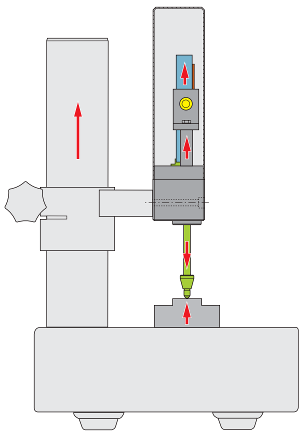
Mechanical Design
A stable measuring setup must be ensured. Long lateral elements within the measuring loop are to be avoided. HEIDENHAIN offers a stable gauge stand as an accessory. The force resulting from the measurement must not cause any measurable deformation of the measuring loop. Incremental length gauges from HEIDENHAIN operate with small gauging force and have very little influence on the measuring setup.

Thermal behavior
Temperature variations during measurement cause changes in length or deformation of the measuring setup. After a change in temperature of 5 K, a steel bar of 200 mm length expands by 10 µm.

Length changes resulting from a uniform deviation from the reference temperature can largely be compensated by resetting the datum on the measuring plate or a master; only the expansion of the scale and measured object go into the result of measurement. Temperature changes during measurement cannot be ascertained mathematically.

For critical components, HEIDENHAIN therefore uses special materials with low coefficients of expansion, such as are found in the HEIDENHAIN-CERTO gauge stand. This makes it possible to guarantee the high accuracy of HEIDENHAIN-CERTO even at ambient temperatures of 19 °C to 21 °C and variations of ± 0.1 K during measurement.

The measuring loop:
All components involved in the measuring assembly, including the length gauge



Thermally induced length change
Expansion of the measuring loop components as a result of heat

Acceleration
Shock and vibration of any kind is to be avoided during measurement so as not to impair the high accuracy of the length gauge.

The maximum values given in the specifications apply to the effect of external acceleration on the length gauge. They describe only the mechanical stability of the length gauge, and imply no guarantee of function or accuracy.

In the length gauge itself, unchecked extension of the spring-driven or non-coupled moving plunger can cause high acceleration onto the measured object or measuring plate surface. For the MT 1200 and MT 2500 series length gauges, use the cable-type lifter whenever possible (see *Accessories*). The cable lifter features adjustable pneumatic damping to limit the extension velocity to a non-critical value.

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HEIDENHAIN-SPECTO

Length Gauges with ± 1 µm Accuracy

- **Very compact dimensions**
- **Splash-proof**

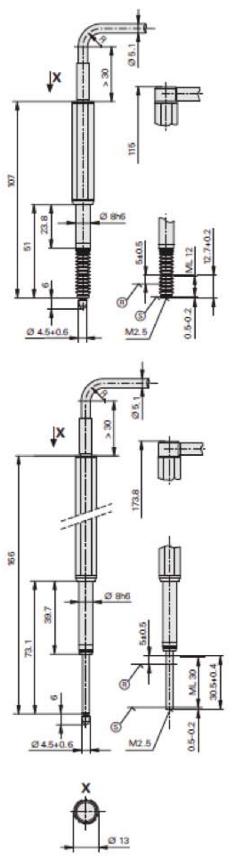
Thanks to their very small dimensions, the HEIDENHAIN-SPECTO length gauges are the product of choice for multipoint inspection apparatus and testing equipment.

Plunger actuation
The length gauges of the **ST 12x8** and **ST 30x8** series feature a spring-tensioned plunger that is extended at rest.

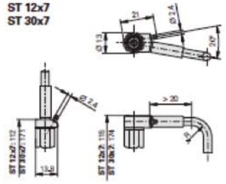
In the pneumatic length gauges **ST 12x7** and **ST 30x7** the plunger is retracted to its rest position by the integral spring. It is extended to the measuring position by the application of compressed air.

Mounting
The HEIDENHAIN-SPECTO length gauges are fastened by their 8h6 standard clamping shank.

Output signals
The HEIDENHAIN-SPECTO length gauges are available with various output signals. The **ST 128x** and **ST 308x** length gauges provide sinusoidal voltage signals with **1 Vpp** levels, which permit high interpolation. The **ST 127x** and **ST 307x** feature integrated digitizing and interpolation electronics with 5-fold or 10-fold interpolation (as ordered) and square-wave signals in **TTL** levels.



ST 12x7
ST 30x7



Dimensions in mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length

Mechanical Data	ST 1278 ⊓⊔TTL ST 1288 ∿ 1 Vpp	ST 3078 ⊓⊔TTL ST 3088 ∿ 1 Vpp	ST 1277 ⊓⊔TTL ST 1287 ∿ 1 Vpp	ST 3077 ⊓⊔TTL ST 3087 ∿ 1 Vpp
Plunger actuation Position of plunger at rest	By measured object Extended		Pneumatic Retracted	
Measuring standard	DIADUR grating on glass; grating period 20 µm			
System accuracy	± 1 µm			
Reference mark	Approx. 5 mm below upper stop			
Measuring range	12 mm	30 mm	12 mm	30 mm
Gauging force with retracting plunger[1] Vertically downward Vertically upward Horizontal	0.6 to 2.4 N 0.4 to 2.2 N 0.5 to 2.3 N	0.6 to 1.4 N 0.4 to 1.2 N 0.5 to 1.3 N	0.4 to 3.0 N (depending on pressure and operating attitude)	0.4 to 3.0 N (depending on pressure and operating attitude)
Radial force	≤ 0.8 N (mechanically permissible)			
Operating attitude	Any			
Vibration 55 to 2000 Hz **Shock** 11 ms	≤ 100 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27)			
Protection EN 60529	IP 64 (for connecting elements see *Connecting Elements and Cables*)			
Operating temperature	10 to 40 °C; ref. temperature 20 °C			
Fastening	Clamping shank Ø 8h8			
Weight without cable	40 g	50 g	40 g	50 g

Electrical Data *For length gauges*	⊓⊔TTL *ST 127x* *ST 307x*		∿ 1 Vpp *ST 128x* *ST 308x*
Incremental signals* **Signal period**	⊓⊔TTL x 5 4 µm	⊓⊔TTL x 10 2 µm	∿ 1 Vpp 20 µm
Recommended measuring step	1 µm[2]	0.5 µm[2]	1 µm/0.5 µm
Mech. permissible traversing speed	≤ 72 m/min		
Edge separation a at scanning frequency*/traverse speed 100 kHz ≤ 72 m/min[3] 50 kHz ≤ 60 m/min 25 kHz ≤ 30 m/min	≥ 0.48 µs ≥ 0.98 µs ≥ 1.98 µs	≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs	–
Electrical connection*	Cable, 1.5 m, with 15-pin D-sub connector (interface electronics integrated)		Cable 1.5 m with • D-sub connector, 15-pin • M23 connector, 12 pin
Cable outlet*	Axial or radial		
Cable length	≤ 30 m with HEIDENHAIN cable		
Power supply	5 V ± 10 %/< 230 mA (without load)		5 V ± 10 %/< 90 mA

* Please indicate when ordering
1) See also *Gauging Force—Plunger Actuation*
2) After 4-fold evaluation
3) Mechanically limited

ST 1200

ST 3000

24 25

Doc. 6 Alternativa palpador lineal HEIDENHAI-METRO MT1281

HEIDENHAIN-METRO

Length Gauges with ± 0.2 µm Accuracy

- **High repeatability**
- **Plunger actuation by cable release, by the workpiece or pneumatically**

With their high system accuracy and small signal period, the HEIDENHAIN-METRO MT 1200 and MT 2500 length gauges are ideal for precision measuring stations and testing equipment. They feature ball-bush guided plungers and therefore permit high radial forces.

Plunger actuation
The length gauges of the **MT 12x1** and **MT 25x1** series feature a spring-tensioned plunger that is extended at rest. In a special version without spring it exercises particularly low force on the measured object.

In the pneumatic length gauges **MT 1287** and **MT 2587**, the plunger is retracted to its rest position by the integral spring. It is extended to the measuring position by the application of compressed air.

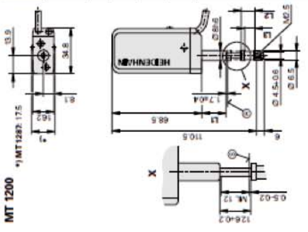
Mounting
The MT 1200 and MT 2500 length gauges are fastened by their 8h6 standard clamping shank. A mounting bracket is available as an accessory to mount the length gauges to plane surfaces or to the MS 200 from HEIDENHAIN.

Output signals
The MT 1200 and MT 2500 length gauges are available with various output signals. The **MT 128x** and **MT 258x** length gauges provide sinusoidal voltage signals with **1 Vpp** levels, which permit high interpolation. The **MT 1271** and **MT 2571** feature integrated digitizing and interpolation electronics with 5-fold or 10-fold interpolation (as ordered) and square-wave signals in **TTL** levels.

MT 1287
MT 2587

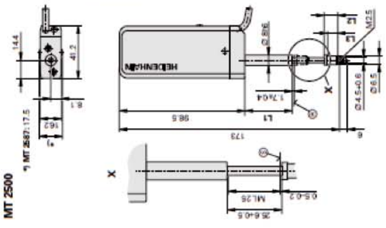
Dimensions in mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm
Ⓡ = Reference mark position
Ⓘ = Beginning of measuring length
Ⓖ = Air connection for 2 mm tube

MT 1200



	MT 12x1	MT 12x7
L1	18,5	22,0
L2	10,1	6,2
L3	8,1	4,2

MT 2500



	MT 25x1	MT 25x7
L1	32,0	41,0
L2	10,1	6,2
L3	8,1	4,2

20

Mechanical Data	MT 1271 TTL / MT 1281 ∿ 1 Vpp	MT 2571 TTL / MT 2581 ∿ 1 Vpp	MT 1287 ∿ 1 Vpp	MT 2587 ∿ 1 Vpp
Plunger actuation Position of plunger at rest	By cable or measured object Extended		Pneumatic Retracted	
Measuring standard	DIADUR phase grating on Zerodur glass ceramic; grating period 4 µm			
System accuracy	± 0.2 µm			
Reference mark	Approx. 1.7 mm below upper stop			
Measuring range	12 mm	25 mm	12 mm	25 mm
Gauging force[1] Vertically downward / Vertically upward / Horizontal	0.6 to 0.85 N / 0.35 to 0.6 N / 0.48 to 0.73 N	0.6 N / 0.28 N / 0.44 N	0.2 to 0.9 N / 0.2 to 0.6 N / 0.2 to 0.7 N	0.2 to 1.2 N / 0.2 to 0.9 N / 0.2 to 1.1 N
Version "without spring" Vertically downward	0.12 N	0.16 N		
Radial force	≤ 0.8 N (mechanically permissible)			
Operating attitude	Any; *for version "without spring"*: vertically downward			
Vibration 55 to 2000 Hz / **Shock** 11 ms	≤ 100 m/s² (EN 60068-2-6) / ≤ 1000 m/s² (EN 60068-2-27)			
Protection EN 60529	IP 50		IP 64 (with sealing air)	
Operating temperature	10 to 40 °C; ref. temperature 20 °C			
Fastening	Clamping shank Ø 8h8			
Weight without cable	100 g	180 g	110 g	190 g

Electrical Data *For length gauges*	TTL *MT 1271 MT 2571*		∿ 1 Vpp *MT 128x MT 258x*
Incremental signals* **Signal period**	TTL x 5 0.4 µm	TTL x 10 0.2 µm	∿ 1 Vpp 2 µm
Recommended measuring step	0.1 µm[2]	0.05 µm[2]	0.1 µm/0.05 µm
Mech. permissible traversing speed	≤ 30 m/min		
Edge separation a at scanning frequency*/traverse speed 200 kHz ≤ 24 m/min / 100 kHz ≤ 12 m/min / 50 kHz ≤ 6 m/min / 25 kHz ≤ 3 m/min	≥ 0.23 µs / ≥ 0.48 µs / ≥ 0.98 µs / –	– / ≥ 0.23 µs / ≥ 0.48 µs / ≥ 0.98 µs	–
Electrical connection*	Cable, 1.5 m, with 15-pin D-sub connector (interface electronics integrated)		Cable 1.5 m with • D-sub connector, 15-pin • M23 connector, 12 pin
Cable length	≤ 30 m with HEIDENHAIN cable		
Power supply	5 V ± 5 %/< 160 mA (without load)		5 V ± 5 %/< 130 mA

* Please indicate when ordering

[1] See also *Gauging Force—Plunger Actuation*
[2] After 4-fold evaluation

MT 1200

MT 2500

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Doc. 7 Alternativa palpador MARPOSS HBT 3441557005

TESTAR · MARPOSS DIVISION

Red Crown

LÍNEA DE CABEZAS LÁPIZ

La línea de cabezas lápiz RED CROWN™ ha sido desarrollada por TESTAR una División de MARPOSS, para resolver las exigencias de control de calidad en ambiente de taller, se presentan en 4 variantes:

Línea base:
Presenta 52 modelos standard con un campo de medida comprendido entre ± 0,5 mm y ± 5 mm. Las cabezas lápiz están disponibles con transductor LVDT (puente entero) o HBT (medio puente) calibrado para su conexión a las unidades electrónicas de visualización TESTAR E18, E4, E4N, Quick Read Microcolumna y mediante el sistema de adquisición de datos Easy Box™ o Gage-Box™ a una Central de Medida E9066s™.

Línea compatible:
Una línea completa de cabezas lápiz con campo de medida standard TESTAR, dotadas del conector eléctrico adecuado y tarado para su conexión a la unidad electrónica que se disponga.

Línea sin conector:
Los 52 modelos de la línea base pueden ser suministrados sin conector. Sobre la base de las características eléctricas específicas para cada cabeza, el usuario puede montar el conector necesario y realizar la calibración para la electrónica que se disponga.

Línea Soft-Touch:
Cabezas lápiz proyectadas con fuerza de medida muy baja para la medición del vidrio, tubos de rayos catódicos, parabrisas del automóvil y materiales plásticos. Estas cabezas están disponibles en la configuración base o compatible.

Cabezas lápiz RED CROWN™: la elección más fácil para la medición de cualquier pieza.

La fiabilidad y la duración de las cabezas lápiz está garantizada por los innovativos diseños y la utilización de los materiales apropiados, desarrollados gracias a la experiencia de Testar en el campo del control de calidad.
Con la utilización de las cabezas lápiz Red Crown™ se garantiza una gran precisión de la medida, incluso inferior a la micra, mejorando la calidad de los datos de medida y su elaboración estadística.

El programa Red Crown ofrece:

- Gama completa de modelos standards y compatibles
- Gran calidad y precisión
- Precio competitivo
- Corto plazo de entrega
- Larga duración

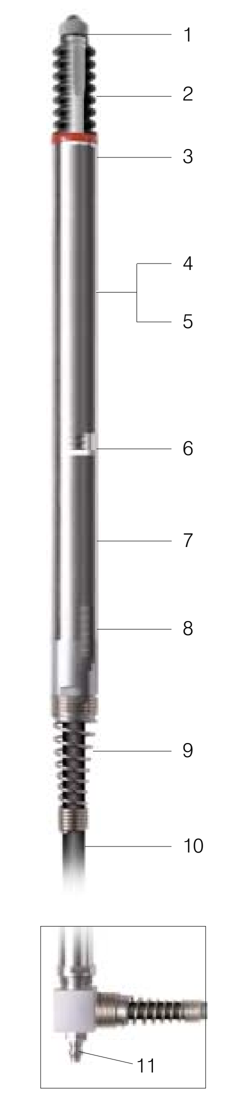
GARANTÍA DE CALIDAD

El personal técnico TESTAR goza de una gran experiencia en la fabricación y la aplicación de las cabezas lápiz, en las soluciones propias y en las de terceros. La experiencia obtenida en el ambiente productivo de taller, ha sido fundamental para desarrollar el nuevo programa RED CROWN™. TESTAR, certificada ISO 9000, fabrica cada una de las cabeza lápiz realizando un severo test de calidad, fruto de la experiencia y de la garantía que un medidor de calidad debe ofrecer. El producto se controla al 100%, siguiendo procedimientos internacionalmente reconocidos y utilizando equipos automáticos que definen sus características fundamentales.

TRANSDUCTORES Y REENVIOS DE MEDIDA
TAMPONES PARA LA VERIFICACIÓN DE TALADROS
HORQUILLAS Y ANILLOS DE MEDIDA
BANCOS DE MEDIDA
COMPARADORES Y VISUALIZADORES DE MEDIDA
CAJAS DE INTERFACE PARA ADQUISICIÓN DE DATOS
SOFTWARE

El Producto

La experiencia de TESTAR ha permitido el desarrollo del producto “Red Crown”, con las características innovativas que responden a las máximas exigencias standards del mercado.



Las partes fundamentales de una cabeza lápiz del programa Red Crown son:

1 - **Palpador.** Es intercambiable (standard en carburo de tungsteno con radio = 1,5 mm). Se dispone de una amplia gama de palpadores opcionales, para resolver problemas específicos de medida. Los modelos “Soft-Touch” están fabricados con palpador intercambiable de **nylon** para evitar dañar la superficie de la pieza a medir.

2 - **Guarnición.** Fabricada de goma (Fluoroelastómero) protege los elementos mecánicos internos contra la penetración de polvos o líquidos (IP65). Permite el funcionamiento seguro del producto en ambiente de taller, incluso en duras condiciones. Los modelos “Soft-Touch” están fabricados sin guarnición para conseguir una fuerza de medida muy baja.

3 - **Cuerpo de la cabeza lápiz.** Está fabricado en acero inoxidable endurecido superficialmente para evitar dañar a los elementos mecánicos internos que permiten el movimiento, en caso de realizar la fijación con pares de torsión elevados. El programa completo de las cabezas lápiz incluye las versiones con diámetro externo de 8 h6 mm y 3/8”.

4 - **Sistema de guía.** Está montado sobre un casquillo de bolas, que garantiza un óptimo movimiento de los elementos mecánicos.

5 - **Sistema anti-rotación.** Facilita la operación de montaje/desmontaje del palpador.

6 - **Muelle.** Determina la fuerza de medida con la que el palpador toca la pieza. Los modelos “Soft-Touch” están equipados con un muelle especial para conseguir una fuerza de medida muy baja (0,30 N en el cero eléctrico con la cabeza lápiz situada horizontalmente).

7 - **Transductor.** Está realizado con materiales y procedimientos productivos tecnológicamente avanzados, en grado de garantizar una precisión muy elevada. Se encuentra disponible en dos configuraciones, LVDT (puente entero) y HBT (medio puente), permitiendo su personalización a los distintos tipos de electrónicas presentes en el mercado.

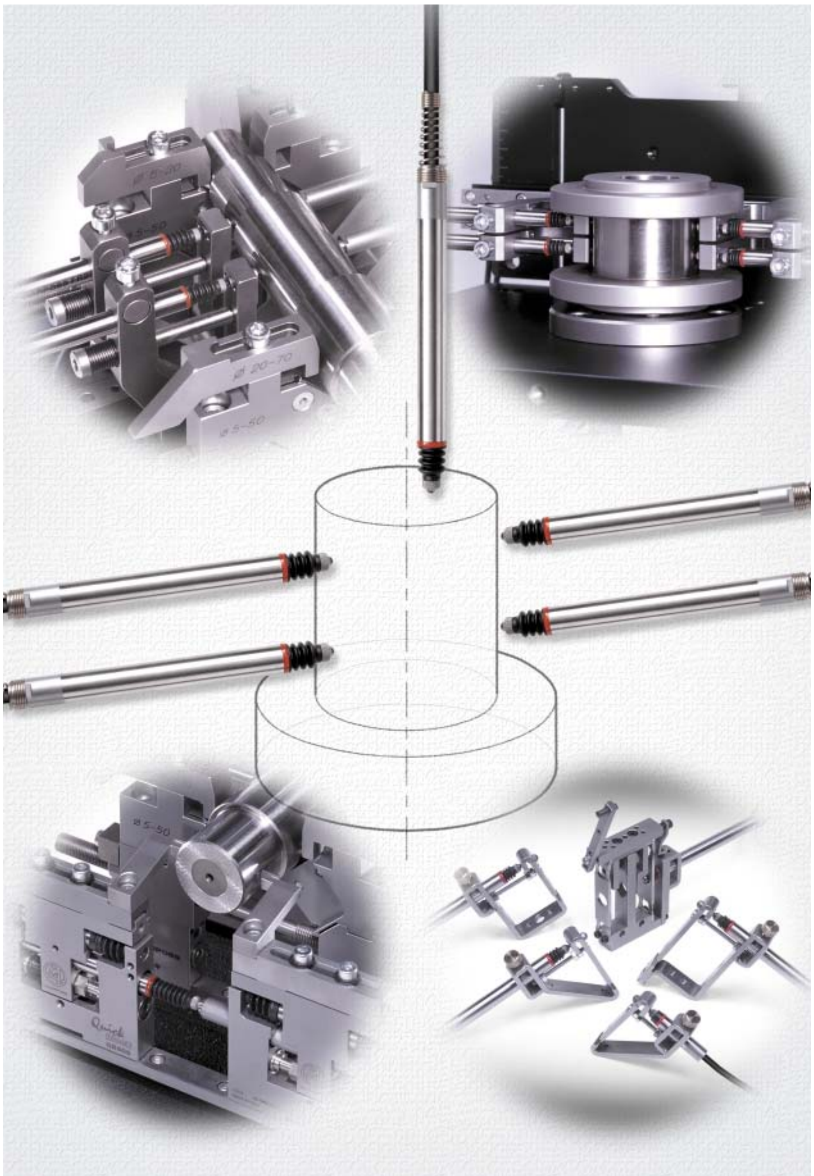
8 - **Regulación de la pre-carrera.** Es el dispositivo que permite de modo óptimo la regulación de la interferencia tangencial del palpador con la pieza a controlar. La correcta regulación de la pre-carrera alarga la vida de los elementos mecánicos internos de la cabeza lápiz.

9 - **Muelle pasa-cable.** Siempre presente, garantiza un óptimo radio de curvatura del cable, protegiéndolo de eventuales daños.

10 - **Cable.** El cable de longitud 2 metros (a normas EMC - directiva 89/336/EEC) tiene como características la alta resistencia a tirones y está recubierto de una vaina de material especial ofreciendo una elevada resistencia a las taladrinas y refrigerantes. La salida del cable puede ser axial o radial. Para longitudes de cable mayores de la standard, se disponen de prolongaciones de diferentes longitudes.

11 - **Pneumatic Push - Vacuum Retract.** Algunos modelos del programa, pueden ser dotados de un dispositivo neumático manual o automático para recarga neumática del palpador (Vacuum Retract) o para desplazar neumáticamente el palpador a la posición de medida (Pneumatic Push).
Estas funciones son particularmente útiles en aplicaciones automáticas. Los modelos “Soft-Touch” están proyectados para garantizar una fuerza de medida de 0,18 N en el cero eléctrico.

Ejemplos de Aplicaciones



Red Crown - 3

TRANSDUCTORES Y REENVÍOS DE MEDIDA
TAMPONES PARA LA VERIFICACIÓN DE TALADROS
HORQUILLAS Y ANILLOS DE MEDIDA
BANCOS DE MEDIDA
COMPARADORES Y VISUALIZADORES DE MEDIDA
CAJAS DE INTERFACE PARA ADQUISICIÓN DE DATOS
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TRANSDUCTORES Y REENVIOS DE MEDIDA

TAMPONES PARA LA VERIFICACIÓN DE TALADROS

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CAJAS DE INTERFACE PARA ADQUISICIÓN DE DATOS

SOFTWARE

LÍNEA BASE

El nuevo programa Red Crown incluye 52 modelos para satisfacer las múltiples necesidades del mercado.

ESPECIFICACIONES TÉCNICAS / CÓDIGOS DE PEDIDO

Características mecánicas

DESCRIPCIÓN	CAMPO DE MEDIDA											
	± 0,5 mm	± 1mm					± 2,5mm			± 5mm		
	Standard	*Standard*		*P. Push*	*Gran Carrera (GC) Standard*	*Gran Carrera (GC) P. Push*	*Standard*		*P. Push*	*Standard*		*P. Push*
Pre-carrera en el cero eléctrico (mm)	0,6/0,7	1,1/1,2					2,6/2,7			5,1/5,2		
Extra-carrera desde el cero eléctrico (mm)	≥ 0,65	≥ 1,5			≥ 9		≥ 3			≥ 5,1		
Pre-carrera regulable	Si	Si					Si			Si		
Pneumatic Push (PP) Vacuum Retract (VR)	-	-	VR(*)	PP	VR(*)	PP	-	VR(*)	PP	-	VR(*)	PP
Presión de trabajo bar	-	-		0,4÷1	-	0,5÷1	-		0,4÷1	-		0,4÷1
Presión de trabajo psi				6÷14,5		7,3÷14,5			6÷14,5			6÷14,5
Fuerza del muelle standard (N/mm ± 15%)	0,17	0,14		0,08	0,1	0,02	0,08		0,03	0,06		0,02
Fuerza desde el cero eléctrico (N ± 25%)	1	0,7		0,8÷2,5	0,7	0,5÷2	0,7		0,6÷2,3	0,7		0,7÷2,4
Sistema de guía	Bolas	Bolas					Bolas			Bolas		
Repetibilidad (σ x 2,77) (μm)	≤ 0,15	≤ 0,15			≤ 0,3		≤ 0,2			≤ 0,4		
Grado de protección CEI/IEC 529	IP65	IP65					IP65			IP65		
Palpador standard (R...mm)	1,5	1,5					1,5			1,5		
Palpadores opcionales	Si	Si					Si			Si		
Error de linealidad (μm)	≤ 3 (0,3%)	≤ 5 (0,25%)					≤ 25 (0,5%)			≤ 50 (0,5%)		
Deriva desde el cero (μm/°C)	≤ 0,25	≤ 0,25					≤ 0,25			≤ 0,5		
Temperatura de trabajo (°C)	-10 +65	-10 +65					-10 +65			-10 +65		
Guarnición standard	Fluoroelastómero	Fluoroelastómero					Fluoroelastómero			Fluoroelastómero		
Conector standard (DIN 45322) Lumberg	SV50/6	SV50/6					SV50/6			SV50/6		
Longitud del cable (m)	2	2					2			2		

(*) En estos modelos se puede añadir la función Vacuum Retract (recarga neumática del palpador) utilizando los accesorios cód. 4430245031 ó 4430240679. Además, es necesario sustituir los muelles standard por los indicados:

±1 VR	muelle **1024099711**
±1 LR	muelle **1024099735**
±2,5 VR	muelle **1024099721**
±5 VR	muelle **1024099735** + guía de muelle **1024099660**

Características técnicas de las versiones LVDT (puente entero)

Sigla comercial	F05				F10										F25						F50					
			FR05				FR10		FP10		FR11		FP11				FR25		FP25				FR50		FP50	
Frecuencia de calibración (KHz)	7,5				7,5										7,5						7,5					
Calibrado a	3,5V RMS con carga 1MOhm //360 pF																									
Corriente máx. (mA RMS)	9				9										9						9					
Desfase Input/Output	≤ 10°				≤ 10°										≤ 10°						≤ 10°					
Sensibilidad específica (mV/V/mm)	230 ±1%				230 ±1%										115 ±1%						115 ±1%					
Salida del cable axial	ø 8	ø 3/8"			ø 8	ø 3/8"									ø 8	ø 3/8"					ø 8	ø 3/8"				
Salida del cable radial			ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"
CÓDIGO DE PEDIDO	**3441552000**	**3441552002**	**3441552001**	**3441552003**	**3441554000**	**3441554005**	**3441554001**	**3441554006**	**3441554002**	**3441554007**	**3441554003**	**3441554008**	**3441554004**	**3441554009**	**3441556000**	**3441556003**	**3441556001**	**3441556004**	**3441556002**	**3441556005**	**3441558000**	**3441558003**	**3441558001**	**3441558004**	**3441558002**	**3441558005**

Características técnicas de las versiones HBT (medio puente)

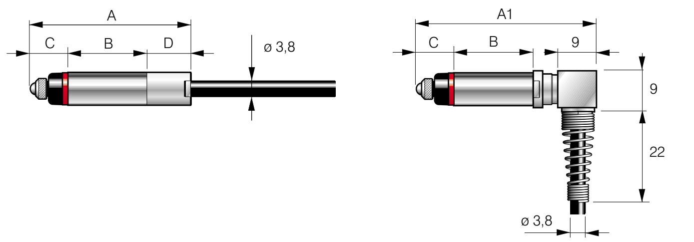
Sigla comercial	H05				H10										H25						H50					
			HR05				HR10		HP10		HR11		HP11				HR25		HP25				HR50		HP50	
Frecuencia de calibración (KHz)	7,5				7,5										7,5						7,5					
Calibrado a	3,5V RMS con carga 2 KOhm ± 0,1%																									
Corriente máx. (mA RMS)	5				5										5						5					
Desfase Input/Output	≤ 5°				≤ 5°										≤ 5°						≤ 5°					
Sensibilidad específica (mV/V/mm)	73,75 ±1%				73,75 ±1%										36,9 ±1%						29,5 ±1%					
Salida del cable axial	ø 8	ø 3/8"			ø 8	ø 3/8"									ø 8	ø 3/8"					ø 8	ø 3/8"				
Salida del cable radial			ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"
CÓDIGO DE PEDIDO	**3441551000**	**3441551002**	**3441551001**	**3441551003**	**3441553000**	**3441553005**	**3441553001**	**3441553006**	**3441553002**	**3441553007**	**3441553003**	**3441553008**	**3441553004**	**3441553009**	**3441555000**	**3441555003**	**3441555001**	**3441555004**	**3441555002**	**3441555005**	**3441557000**	**3441557003**	**3441557001**	**3441557004**	**3441557002**	**3441557005**

NOTE : El manual de instrucciones se suministra junto a cada cabeza (incluido en el embalaje)

DIMENSIONES (mm)

Para todas las versiones de las cabezas lápiz, el diámetro externo puede ser de 8 h6 mm o 3/8".

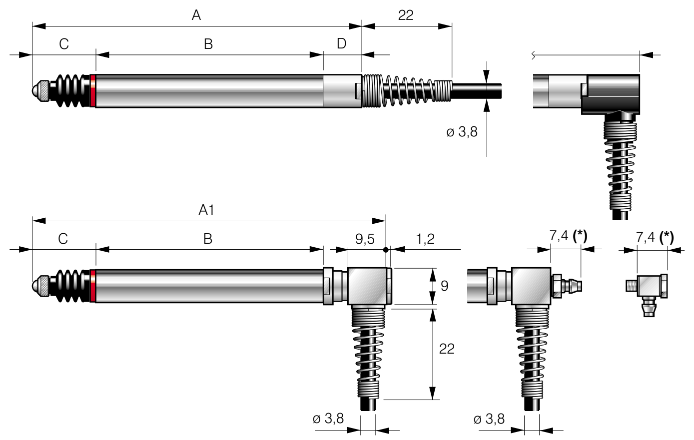
± 0,5 mm



± 1 mm

± 2,5 mm

± 5 mm



DIMENSIONES	CAMPO DE MEDIDA								
	± 0,5 mm	**± 1mm**				**± 2,5mm**		**± 5mm**	
				Gran Carrera (GC)					
	Standard	*Standard*	*Neumática*	*Standard*	*Neumática*	*Standard*	*Neumática*	*Standard*	*Neumática*
A	39,2	80	-	-	-	92,5	-	118	-
A1	42.8	86	86	116,6	116,6	98,9	98,9	124	124
A2	-	92,5	-	-	-	105	-	130,5	-
B	19,2	57	57	76	76	68	68	84,5	84,5
C	9,2	13,5	13,5	25	25	15	15	21	21
D	10,8	9,5	-	-	-	9,5	-	12,5	-

(*) Sólo para vérsion neumática.
(**) El deflector de cable radial a 90º se incluye junto a todas las cabezas que dispongan de salida de cable axial.

A / A1 / A2 / C están referidas al cero eléctrico

Línea Compatible

TESTAR ha desarrollado una línea de modelos Red Crown con el conector y el tarado necesario, que permiten ser utilizadas en sustitución de cabezas de otros fabricantes. Esto permite al usuario, aprovecharse de la tecnología utilizada por el producto Red Crown, sin tener que sustituir la electrónica existente.
Las características técnicas y las dimensiones de estas cabezas son las mismas que los modelos correspondientes a la Línea Base. La línea compatible está en continuo desarrollo, por lo que pueden consultar la lista actualizada con los correspondientes códigos, en la página web www.testar.com.

Modelos Base			**CAMPO DE MEDIDA**								
			± 0,5 mm		**± 1 mm**		**± 1 mm Gran Carrera**	**± 2,5 mm**		**± 5 mm**	
FABRICANTE	**Tipo Trans**	**Ø**	**H05**	**HR05**	**H10**	**HR10**	**HR11**	**H25**	**HR25**	**H50**	**HR50**
TESA	Medio puente (HBT)	8	3441561000	3441561001	3441561002	3441561003 (*)	3441561005 (*)	3441561007	3441561008 (*)	3441561010	3441561011 (*)
MERCER		8	3441564000	3441564001	3441564002	3441564003 (*)	3441564005 (*)	3441564007	3441564008 (*)	3441564010	3441564011 (*)
METEM		8	3441569000	3441569001	3441569002	3441569003 (*)	3441569005 (*)	3441569007	3441569008 (*)	3441569010	3441569011 (*)
METREL		8	3441563000	3441563001	3441563002	3441563003 (*)	3441563005 (*)	3441563007	3441563008 (*)	-	-
MAHR-FEINPRUEF		8	3441567000	3441567001	3441567002	3441567003 (*)	3441567005 (*)	3441567007	3441567008 (*)	3441567010	3441567011 (*)
NOVIBRA		8	-	-	3441568003	-	-	-	-	-	-
MACHSIZE-SYSTEM E		8	3441562009	3441562010	3441562008	3441562011	3441562013	-	-	-	-
AIR GAGE		3/8"	3441562000	3441562001	3441562002	3441562003 (*)	-	3441562005	3441562006 (*)	-	-
FABRICANTE	**Tipo Trans**	**Ø**	**F05**	**FR5**	**F10**	**FR10**	**FR11**	**F25**	**FR25**	**F50**	**FR50**
ETAMIC (ZDB)	Puente entero (LVDT)	8	3441565009	3441565010	3441565006	3441565011	3441565013	3441565007	3441565015	3441565008	3441565017

(*) En estos modelos se puede añadir la función Vacuum Retract (recarga neumática del palpador) utilizando los accesorios cód. 4430245031 ó 4430240679. Es necesario, asimismo, sustituir el muelle estándar por el indicado en la tabla de la página 4.

Modelos Pneumatic Push			**CAMPO DE MEDIDA**			
			± 1 mm	**± 1 mm Gran Carrera**	**± 2,5 mm**	**± 5 mm**
FABRICANTE	**Tipo Trans**	**Ø**	**HP10**	**HP11**	**HP25**	**HP50**
TESA	Medio puente (HBT)	8	3441561004	3441561006	3441561009	3441561012
MERCER		8	3441564004	3441564006	3441564009	3441564012
METEM		8	3441569004	3441569006	3441569009	3441569012
METREL		8	3441563004	3441563006	3441563009	-
MAHR-FEINPRUEF		8	3441567004	3441567006	3441567009	3441567012
MACHSIZE-SYSTEM E		8	3441562012	3441562014	-	-
AIR GAGE		3/8"	3441562004	-	3441562007	-
FABRICANTE	**Tipo Trans**	**Ø**	**FP10**	**FP11**	**FP25**	**FP50**
ETAMIC (ZDB)	Puente entero (LVDT)	8	3441565012	3441565014	3441565016	3441565018

NOTE : El manual de instrucciones se suministra junto a cada cabeza (incluido en el embalaje)

LÍNEA SIN CONECTOR

ESPECIFICACIONES TÉCNICAS / CÓDIGOS DE PEDIDO

Características mecánicas

DESCRIPCIÓN	CAMPO DE MEDIDA											
	± 0,5 mm	± 1mm					± 2,5mm			± 5mm		
	Standard	*Standard*		*P. Push*	*Gran Carrera (GC)*		*Standard*		*P. Push*	*Standard*		*P. Push*
					Standard	*P. Push*						
Pre-carrera en el cero eléctrico (mm)	0,6/0,7	1,1/1,2					2,6/2,7			5,1/5,2		
Extra-carrera desde el cero eléctrico (mm)	≥ 0,65	≥ 1,5			≥ 9		≥ 3			≥ 5,1		
Pre-carrera regulable	Oui	Oui					Oui			Oui		
Pneumatic Push (PP) Vacuum Retract (VR)	-	-	VR(*)	PP	VR(*)	PP	-	VR(*)	PP	-	VR(*)	PP
Presión de trabajo bar	-	-		0,4÷1	-	0,5÷1	-		0,4÷1	-		0,4÷1
psi				6÷14,5		7,3÷14,5			6÷14,5			6÷14,5
Fuerza del muelle standard (N/mm ± 15%)	0,17	0,14		0,08	0,10	0,02	0,08		0,03	0,06		0,02
Fuerza desde el cero eléctrico (N ± 25%)	1	0,75		0,8÷2,5	0,7	0,5÷2	0,7		0,6÷2,3	0,7		0,7÷2,4
Sistema de guía	bolas	bolas					bolas			bolas		
Repetibilidad (σ x 2,77) (μm)	≤ 0,15	≤ 0,15			≤ 0,3		≤ 0,2			≤ 0,4		
Grado de protección CEI/IEC 529	IP65	IP65					IP65			IP65		
Palpador standard (R...mm)	1,5	1,5					1,5			1,5		
Palpadores opcionales	Sì	Sì					Sì			Sì		
Deriva desde el cero (μm/°C)	≤ 0,25	≤ 0,25					≤ 0,25			≤ 0,5		
Temperatura de trabajo (°C)	-10 +65	-10 +65					-10 +65			-10 +65		
Guarnición standard	Fluoroelastómero	Fluoroelastómero					Fluoroelastómero			Fluoroelastómero		
Longitud del cable (m)	3,5	3,5					3,5			3,5		

(*) En estos modelos se puede añadir la función Vacuum Retract (recarga neumática del palpador) utilizando los accesorios cód. 4430245031 ó 4430240679. Es necesario, asimismo, sustituir el muelle estándar por el indicado en la tabla de la página 4.

Características técnicas de las versiones LVDT (puente entero)

Sigla comercial	F05				F10										F25						F50					
			FR05				FR10		FP10		FR11		FP11				FR25		FP25				FR50		FP50	
Sensibilidad específica (mV/mm/V)	152÷ 248				217÷ 228										112÷ 120						114÷ 122					
Error de linealidad (μm)	≤ 2,7 (0,3%)				≤ 3,6 (0,2%)										≤ 15 (0,3%)						≤ 38 (0,4%)					
Campo frecuencia alimentación (kHz)	2÷ 20				2÷ 20										2÷ 20						4÷ 9					
Campo tensión alimentación (Vms)	1÷ 7				1÷ 7										1÷ 7						1÷ 7					
Campo absorción corriente aliment.(mA/V)	5,9÷ 0,8				5,4÷ 0,6										3,2÷ 0,5						2,6÷ 1,5					
Desfase entrada/salida (°)	38÷ -1,2				13÷ -7										10÷ -8						-3,3÷ -8,4					
Frecuencia desfase del cero (kHz)	17,5				7,5										6						-					
Carga calibración (kΩ)	100				100										100						100					
Frecuencia de test (kHz)	7,5				7,5										7,5						7,5					
Tensión alimentación de test (Vrms)	3,54				3,54										3,54						3,54					
Carga de test	1 MΩ//360 pF				1 MΩ//360 pF										1 MΩ//360 pF						1 MΩ//360 pF					
Sensibilidad condición de test (mV/mm/V)	240 ±5%				239 ±5%										118 ±5%						116 ±5%					
Linealidad condición de test (μm)	≤ 3 (0,3%)				≤ 2 (0,1%)										≤ 25 (0,5%)						≤ 50 (0,5%)					
Absorción corriente condición de test (mA/V)	2				2										1						2					
Desfase entrada/salida condición de test (°)	10±2				1,5±1										2±2						7±2					
Salida del cable axial	ø 8	ø 3/8"			ø 8	ø 3/8"									ø 8	ø 3/8"					ø 8	ø 3/8"				
radial			ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"
CÓDIGO DE PEDIDO	**3441566002**	**3441566008**	**3441566007**	**3441566009**	**3441566023**	**3441566028**	**3441566024**	**3441566029**	**3441566025**	**3441566030**	**3441566026**	**3441566031**	**3441566027**	**3441566032**	**3441566039**	**3441566042**	**3441566040**	**3441566043**	**3441566041**	**3441566044**	**3441566051**	**3441566054**	**3441566052**	**3441566055**	**3441566053**	**3441566056**

Características técnicas de las versiones HBT (medio puente)

Sigla comercial	H05				H10										H25						H50					
			HR05				HR10		HP10		HR11		HP11				HR25		HP25				HR50		HP50	
Sensibilidad específica (mV/mm/V)	70÷ 87				79÷ 87										59÷ 74						31÷ 33					
Error de linealidad (μm)	≤ 2,5 (0,3%)				≤ 0,9 (0,05%)										≤ 16,2 (0,3%)						≤ 23 (0,2%)					
Campo frecuencia alimentación (kHz)	2÷ 20				2÷ 20										2÷ 20						2÷ 20					
Campo tensión alimentación (Vrms)	2÷ 5				2÷ 5										2÷ 5						3÷ 5					
Campo absorción corriente aliment. (mA/V)	1,8÷ 0,2				2,9÷ 0,4										2,1÷ 0,3						1,8÷ 0,3					
Desfase entrada/salida (°)	25÷ -17				17÷ -14										27÷ -19						16÷ -11					
Frecuencia desfase del clero (kHz)	7,5				7										7						7					
Carga calibración (kΩ)	1				1										1						1					
Frecuencia de test (kHz)	7,5				7,5										7,5						7,5					
Tensión alimentación de test (Vrms)	3,54				3,54										3,54						3,54					
Carga de test (kΩ)	2				2										2						2					
Sensibilidad condición test (mV/mm/V)	91,5 ±5%				89 ±5%										77 ±5%						34,5 ±5%					
Linealidad condición test (μm)	≤ 3				≤ 5										≤ 25						≤ 50					
Absorción corriente condición de test (mA/V)					0,6										0,6						0,7 0,7					
Desfase entrada/salida condición de test (°)					3,5±2										1±2						3±2 1±2					
Salida del cable axial	ø 8	ø 3/8"			ø 8	ø 3/8"									ø 8	ø 3/8"					ø 8	ø 3/8"				
radial			ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"			ø 8	ø 3/8"	ø 8	ø 3/8"
CÓDIGO DE PEDIDO	**3441566001**	**3441566005**	**3441566004**	**3441566006**	**3441566003**	**3441566018**	**3441566014**	**3441566019**	**3441566015**	**3441566020**	**3441566016**	**3441566021**	**3441566017**	**3441566022**	**3441566033**	**3441566036**	**3441566034**	**3441566037**	**3441566035**	**3441566038**	**3441566045**	**3441566048**	**3441566046**	**3441566049**	**3441566047**	**3441566050**

NOTE : El manual de instrucciones se suministra junto a cada cabeza (incluido en el embalaje)

Línea "Soft-Touch"

Estos modelos permiten satisfacer las características solicitadas en las que la fuerza de medida debe ser mantenida en un valor muy bajo. Aplicaciones típicas de este tipo son para la industria del vidrio, tubos de rayos catódicos, parabrisas del automóvil y en general, material plástico para la industria electrónica (carcasa de teléfonos móviles, componentes para ordenadores e impresoras, etc).

ESPECIFICACIONES TÉCNICAS / CÓDIGOS DE PEDIDO

Características mecánicas

DESCRIPCIÓN	CAMPO DE MEDIDA																
	± 0,5 mm	± 1mm								± 2,5mm				± 5mm			
	Standard	Standard		Pneumatic Push (*)		Gran Carrera (GC)				Standard		Pneumatic Push (*)		Standard		Pneumatic Push (*)	
						Standard		Pneum. Push (*)									
Pre-carrera en el cero eléctrico (mm)	0,6/0,7	1,1/1,2								2,6/2,7				5,1/5,2			
Extra-carrera desde el cero eléctrico (mm)	≥ 0,65	≥ 1,5				≥ 9				≥ 3				≥ 5,1			
Pre-carrera regulable	Si	Si								Si				Si			
Pneumatic Push (PP)	-	-		PP	PP	-		PP	PP	-		PP	PP	-		PP	PP
Vacuum Retract (VR)	-	-		-	VR	-		-	VR	-		-	VR	-		-	VR
Presión de trabajo bar	-	-		0,5÷2	0,125÷2	-		0,5÷2	0,125÷2	-		0,5÷2	0,125÷2	-		0,5÷2	0,125÷2
Presión de trabajo psi				7,3÷29	1,825÷29			7,3÷29	1,825÷29			7,3÷29	1,825÷29			7,3÷29	1,825÷29
Perdida de aire a 1 bar (ml/min)	-	-		<350		-		<350		-		<350		-		<350	
Fuerza del muelle standard (N/mm ± 15%)	0,07	-	0,13	0,045	-	-	0,033	0,014	-	-	0,033	0,0135	-	-	0,034	0,0137	-
Fuerza desde el cero eléctrico (N ± 30%)	0,29	0,06	0,29	0,18÷1,23	0,09÷1,41	0,06	0,18	0,12÷1,17	0,09÷1,41	0,06	0,29	0,18÷1,23	0,09÷1,41	0,065	0,29	0,18÷1,23	0,09÷1,41
Sistema de guía																	
Repetibilidad (σ x 2,77) (μm)	≤ 0,15	≤ 0,15		≤ 0,15		≤ 0,3		≤ 0,3		≤ 0,2		≤ 0,2		≤ 0,4		≤ 0,4	
Grado de protección CEI/IEC 529	IP50	IP50		IP53	IP50	IP50		IP53	IP50	IP50		IP53	IP50	IP50		IP53	IP50
Palpador standard (R...mm)	1,5	1,5		1,5		1,5		1,5		1,5		1,5		1,5		1,5	
Palpadores opcionales	Oui	Oui		Oui		Oui		Oui		Oui		Oui		Oui		Oui	
Error de linealidad (μm)	≤ 3 (0,3%)	≤ 5 (0,25%)		≤ 5 (0,25%)		≤ 5 (0,25%)		≤ 5 (0,25%)		≤ 25 (0,5%)		≤ 25 (0,5%)		≤ 50 (0,5%)		≤ 50 (0,5%)	
Deriva desde el cero (μm/°C)	≤ 0,25	≤ 0,25		≤ 0,25		≤ 0,25		≤ 0,25		≤ 0,25		≤ 0,25		≤ 0,5		≤ 0,5	
Temperatura de trabajo (°C)	-10 +65	-10 +65		-10 +65		-10 +65		-10 +65		-10 +65		-10 +65		-10 +65		-10 +65	
Guarnición standard	-	-		-		-		-		-		-		-		-	
Conector standard (DIN 45322) Lumberg	SV50/6	SV50/6		SV50/6		SV50/6		SV50/6		SV50/6		SV50/6		SV50/6		SV50/6	
Longitud del cable (m)	2	2		2		2		2		2		2		2		2	

(*) Aire comprimido seco, con un grado de filtrado de 5 μm y un punto de rocío comprendido entre 2ºC y 5ºC, a la presión de la red.

Características técnicas de las versiones LVDT (puente entero)

Sigla comercial	F05L	FS10L	F10L	FPA10L	FP10L	FPVA10L	FPV10L	FS11L	FR11L	FPA11L	FP11L	FPVA11L	FPV11L	FS25L	F25L	FPA25L	FP25L	FPVA25L	FPV25L	FS50L	F50L	FPA50L	FP50L	FPVA50L	FPV50L
Campo frecuencia alimentación (kHz)	7,5	7,5												7,5						7,5					
Calibrado a	3,5V RMS con carga 1 MOhm 360 pF																								
Corriente máx. (mA RMS)	9	9												9						9					
Desfase entrada/salida (°)	≤ 10°	≤ 10°												≤ 10°						≤ 10°					
Sensibilidad específica (mV/V/mm)	230 ±1%	230 ±1%												115 ±1%						115 ±1%					
Salida de cable axial	•		•	•		•				•		•			•	•		•			•	•		•	
Salida de cable radial		•			•		•	•	•		•		•	•			•		•	•			•		•
Código de pedido	**3441552005**	**3441554019**	**3441554017**	**3441554021**	**3441554015**	**3441554023**	**3441554013**	**3441554020**	**3441554018**	**3441554022**	**3441554016**	**3441554024**	**3441554014**	**3441556011**	**3441556008**	**3441556012**	**3441556009**	**3441556013**	**3441556010**	**3441558011**	**3441558008**	**3441558012**	**3441558009**	**3441558013**	**3441558010**

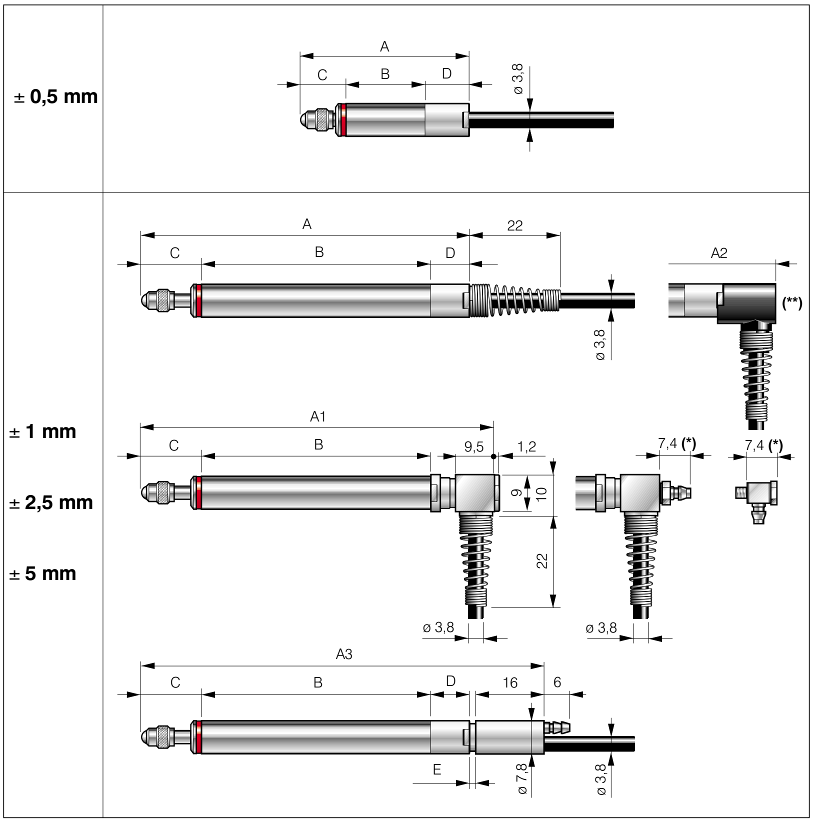
Características técnicas de las versiones HBT (medio puente) compatibles con amplificadores TESA

Sigla comercial	H05L	HS10L	H10L	HPA10L	HP10L	HPVA10L	HPV10L	HS11L	HR11L	HPA11L	HP11L	HPVA11L	HPV11L	HS25L	H25L	HPA25L	HP25L	HPVA25L	HPV25L	HS50L	H50L	HPA50L	HP50L	HPVA50L	HPV50L
Campo frecuencia alimentación (kHz)	13	13												13						13					
Calibrado a	3V RMS con carga 2 KOhm ± 0,1%																								
Corriente máx. (mA RMS)	2	2												2						2					
Desfase entrada/salida (°)	≤ 2°	≤ 2°												≤ 2°						≤ 3°					
Sensibilidad específica (mV/V/mm)	73,75± 0,2%	73,75 ±0,2%												73,75 ±0,2%						29,5 ±0,3%					
Salida de cable axial	•		•	•		•				•		•			•	•		•			•	•		•	
Salida de cable radial		•			•		•	•	•		•		•	•			•		•	•			•		•
Código de pedido	**3441561028**	**3441561031**	**3441561029**	**3441561034**	**3441561026**	**3441561038**	**3441561022**	**3441561021**	**3441561030**	**3441561037**	**3441561027**	**3441561041**	**3441561025**	**3441561032**	**3441561015**	**3441561035**	**3441561016**	**3441561039**	**3441561023**	**3441561033**	**3441561017**	**3441561036**	**3441561018**	**3441561040**	**3441561024**

NOTE : El manual de instrucciones se suministra junto a cada cabeza (incluido en el embalaje)

DIMENSIONES

Para todas las versiones, el diámetro externo de la camisa es de 8 h6 mm.

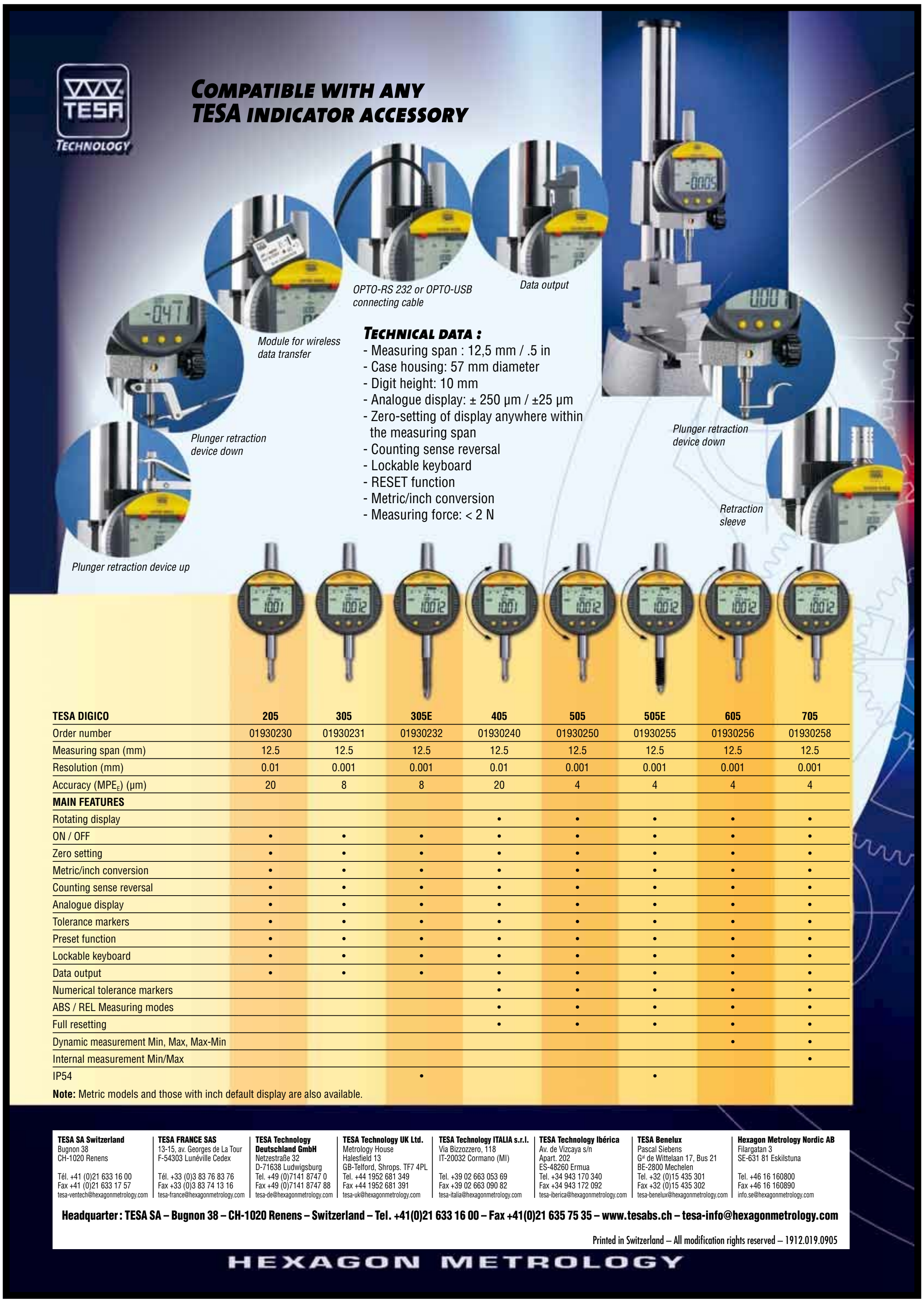


DIMENSIONES	CAMPO DE MEDIDA								
	± 0,5 mm	± 1mm				± 2,5mm		± 5mm	
				Gran Carrera (GC)					
	Standard	*Standard*	*Neumática*	*Standard*	*Neumática*	*Standard*	*Neumática*	*Standard*	*Neumática*
A	42,15	78,5	-	-	-	91	-	113	-
A1	-	84,5	84,5	111,6	111,6	97,35	97,35	119,45	119,45
A2	-	91	-	-	-	103,5	-	125,5	-
A3	-	-	96	-	122,8	-	108,6	-	130,95
B	19,2	57	57	76	76	68	68	84,5	84,5
C	12,15	12	12	19,9	19,9	13,5	13,5	16	16
D	10,8	9,5	9,5	9,5	9,5	9,5	9,5	12,5	12,5
E	-	-	1,475	-	1,375	-	1,55	-	1,95

(*) Sólo para vérsion neumática. A / A1 / A2 / A3 / C están referidas al cero eléctrico

(**) El deflector de cable radial a 90º se incluye junto a todas las cabezas F10L, F25L, F50L, H10L, H25L, H50L con salida de cable axial.

Reloj comparador altura corona TESA DIGICO 305M



TESA TECHNOLOGY

COMPATIBLE WITH ANY TESA INDICATOR ACCESSORY

Module for wireless data transfer

OPTO-RS 232 or OPTO-USB connecting cable

Data output

Plunger retraction device down

Plunger retraction device up

Plunger retraction device down

Retraction sleeve

TECHNICAL DATA :

- Measuring span : 12,5 mm / .5 in
- Case housing: 57 mm diameter
- Digit height: 10 mm
- Analogue display: ± 250 µm / ±25 µm
- Zero-setting of display anywhere within the measuring span
- Counting sense reversal
- Lockable keyboard
- RESET function
- Metric/inch conversion
- Measuring force: < 2 N

TESA DIGICO	205	305	305E	405	505	505E	605	705
Order number	01930230	01930231	01930232	01930240	01930250	01930255	01930256	01930258
Measuring span (mm)	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Resolution (mm)	0.01	0.001	0.001	0.01	0.001	0.001	0.001	0.001
Accuracy (MPE_E) (µm)	20	8	8	20	4	4	4	4
MAIN FEATURES								
Rotating display				•	•	•	•	•
ON / OFF	•	•	•	•	•	•	•	•
Zero setting	•	•	•	•	•	•	•	•
Metric/inch conversion	•	•	•	•	•	•	•	•
Counting sense reversal	•	•	•	•	•	•	•	•
Analogue display	•	•	•	•	•	•	•	•
Tolerance markers	•	•	•	•	•	•	•	•
Preset function	•	•	•	•	•	•	•	•
Lockable keyboard	•	•	•	•	•	•	•	•
Data output	•	•	•	•	•	•	•	•
Numerical tolerance markers				•	•	•	•	•
ABS / REL Measuring modes				•	•	•	•	•
Full resetting				•	•	•	•	•
Dynamic measurement Min, Max, Max-Min							•	•
Internal measurement Min/Max								•
IP54			•			•		

Note: Metric models and those with inch default display are also available.

TESA SA Switzerland
Bugnon 38
CH-1020 Renens
Tél. +41 (0)21 633 16 00
Fax +41 (0)21 633 17 57
tesa-ventech@hexagonmetrology.com

TESA FRANCE SAS
13-15, av. Georges de La Tour
F-54303 Lunéville Cedex
Tél. +33 (0)3 83 76 83 76
Fax +33 (0)3 83 74 13 16
tesa-france@hexagonmetrology.com

TESA Technology Deutschland GmbH
Netzestraße 32
D-71638 Ludwigsburg
Tel. +49 (0)7141 8747 0
Fax +49 (0)7141 8747 88
tesa-de@hexagonmetrology.com

TESA Technology UK Ltd.
Metrology House
Halesfield 13
GB-Telford, Shrops. TF7 4PL
Tel. +44 1952 681 349
Fax +44 1952 681 391
tesa-uk@hexagonmetrology.com

TESA Technology ITALIA s.r.l.
Via Bizzozzero, 118
IT-20032 Cormano (MI)
Tel. +39 02 663 053 69
Fax +39 02 663 090 82
tesa-italia@hexagonmetrology.com

TESA Technology Ibérica
Av. de Vizcaya s/n
Apart. 202
ES-48260 Ermua
Tel. +34 943 170 340
Fax +34 943 172 092
tesa-iberica@hexagonmetrology.com

TESA Benelux
Pascal Siebens
Gal de Wittelaan 17, Bus 21
BE-2800 Mechelen
Tel. +32 (0)15 435 301
Fax +32 (0)15 435 302
tesa-benelux@hexagonmetrology.com

Hexagon Metrology Nordic AB
Filargatan 3
SE-631 81 Eskilstuna
Tel. +46 16 160800
Fax +46 16 160890
info.se@hexagonmetrology.com

Headquarter : TESA SA – Bugnon 38 – CH-1020 Renens – Switzerland – Tel. +41(0)21 633 16 00 – Fax +41(0)21 635 75 35 – www.tesabs.ch – tesa-info@hexagonmetrology.com

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HEXAGON METROLOGY

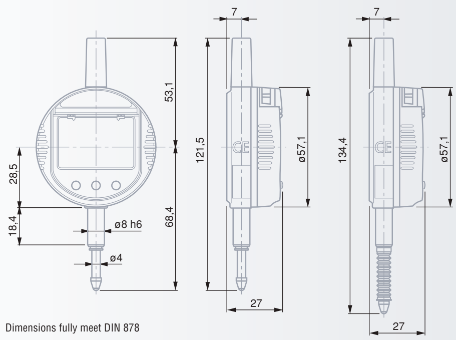
ELECTRONIC INDICATORS

TESA DIGICO 205 and 305

- Dual LC Display.
- Mechanical tolerance marks.
- Dimensions according to DIN 878.

Main functions
ON/Auto OFF – Data output – Counting sense reversal – Keypad lock.

Nº		mm / *in*	mm / *in*	µm	µm
TESA DIGICO 205					
01910230	DIGICO 205 M	12,5 / –	0,01 / –	20	10
01930230	DIGICO 205 MI	12,5 / *0.5*	0,01 / *0.0005*	20	10
TESA DIGICO 305					
01910231	DIGICO 305 M	12,5 / –	0,001 / –	8	2
01930231	DIGICO 305 MI	12,5 / *0.5*	0,001 / *0.00005*	8	2
TESA DIGICO 305 IP54					
01930232	DIGICO 305 MIE	12,5 / *0.5*	0,001 / *0.00005*	8	2



Dimensions fully meet DIN 878

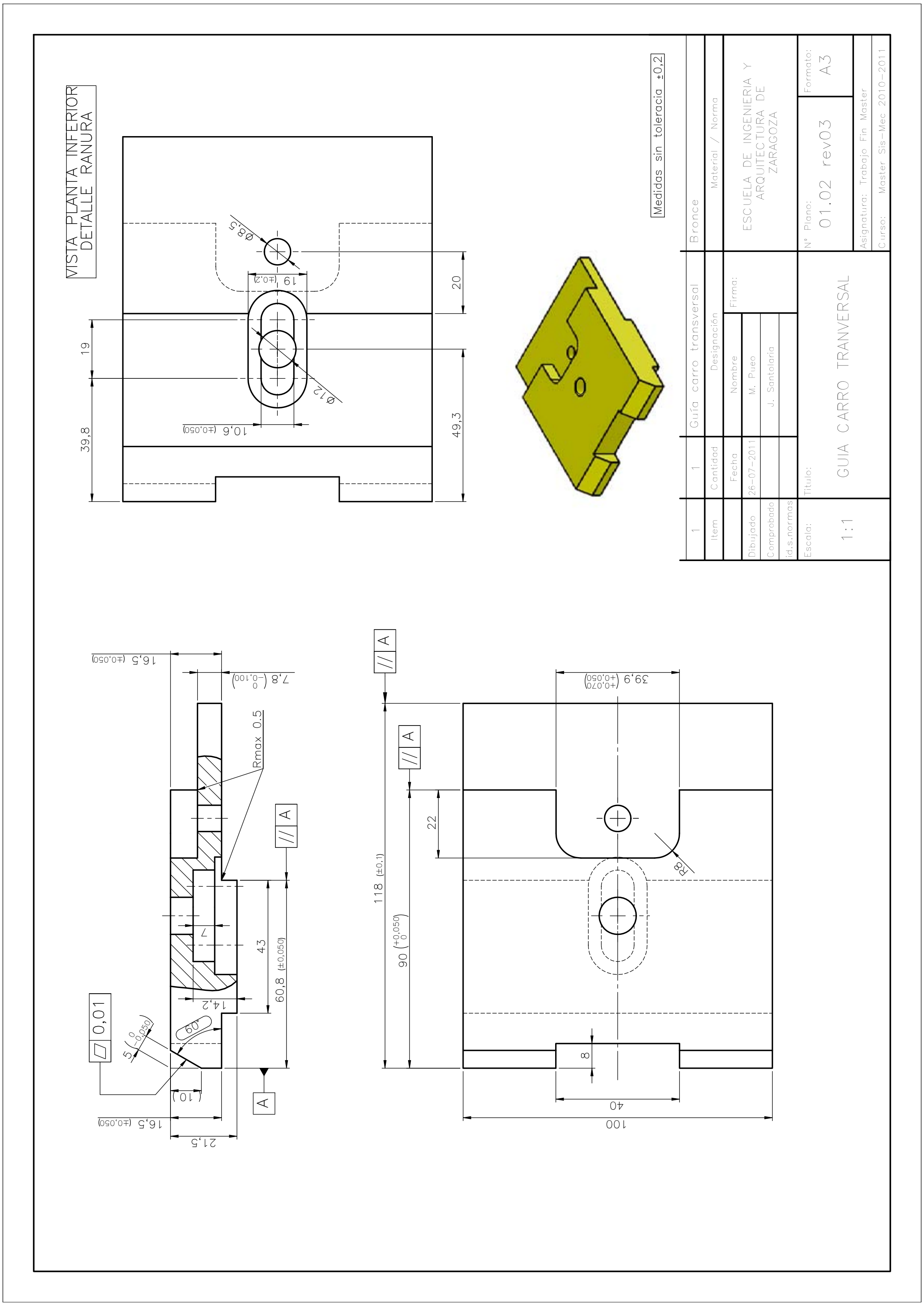
✓
Combined analogue and numerical display
6-decade LC display field plus minus sign
10 x 5 mm Digit size (H x L)
Resolution to 0,01 mm = ±0,25 mm
Resolution to 0,001 mm = ±0,025 mm
MI or MIE type: metric/inch conversion
Glass scale with incremental divi-sions, capacitive
≤ 2 m/s
Full-metal housing with front face in polyamide.
Stainless steel plunger.
M2,5 mounting thread for the measuring insert.
≤ 2N
RS232, opto-coupled
3V lithium battery, type CR2032
1 year to 2 years
10°C to 40°C
−10°C to 60°C
80%
EN 50081-1
EN 50082-1
150 g
Shipping case including a lithium battery 01961000
Identification number
Inspection report with a declaration of conformity

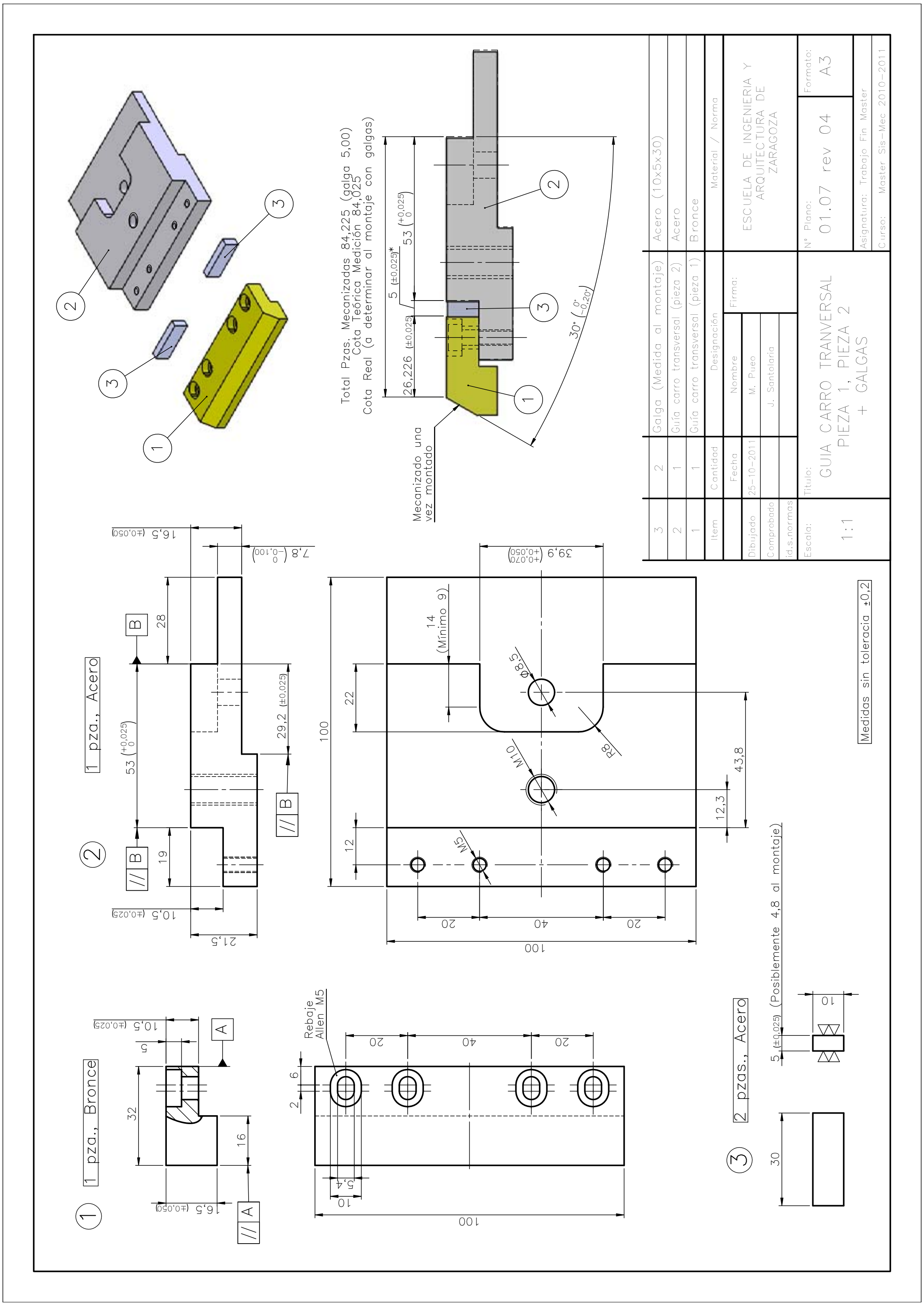
F-4

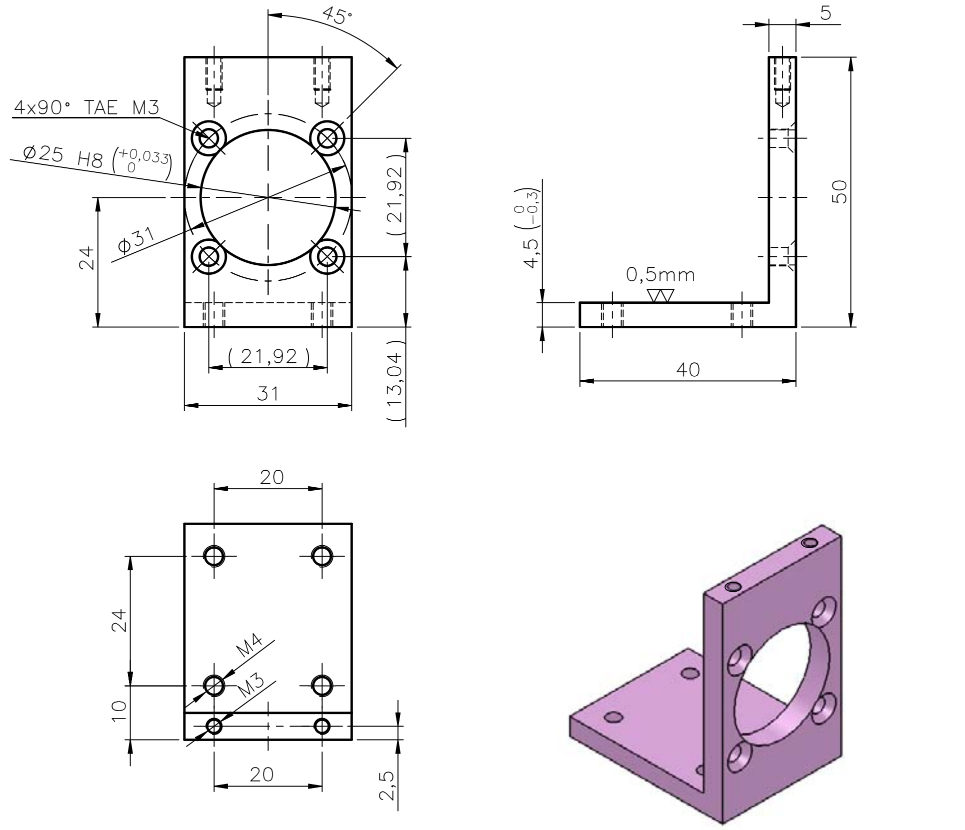
ANEXO III: Planos

En este anexo se incluyen todos los planos de las piezas de nueva fabricación o en su defecto de modificación definidas en el proyecto para el montaje y puesta en marcha de la máquina con los nuevos componentes de medida.

Los planos que podemos encontrar son los siguientes:

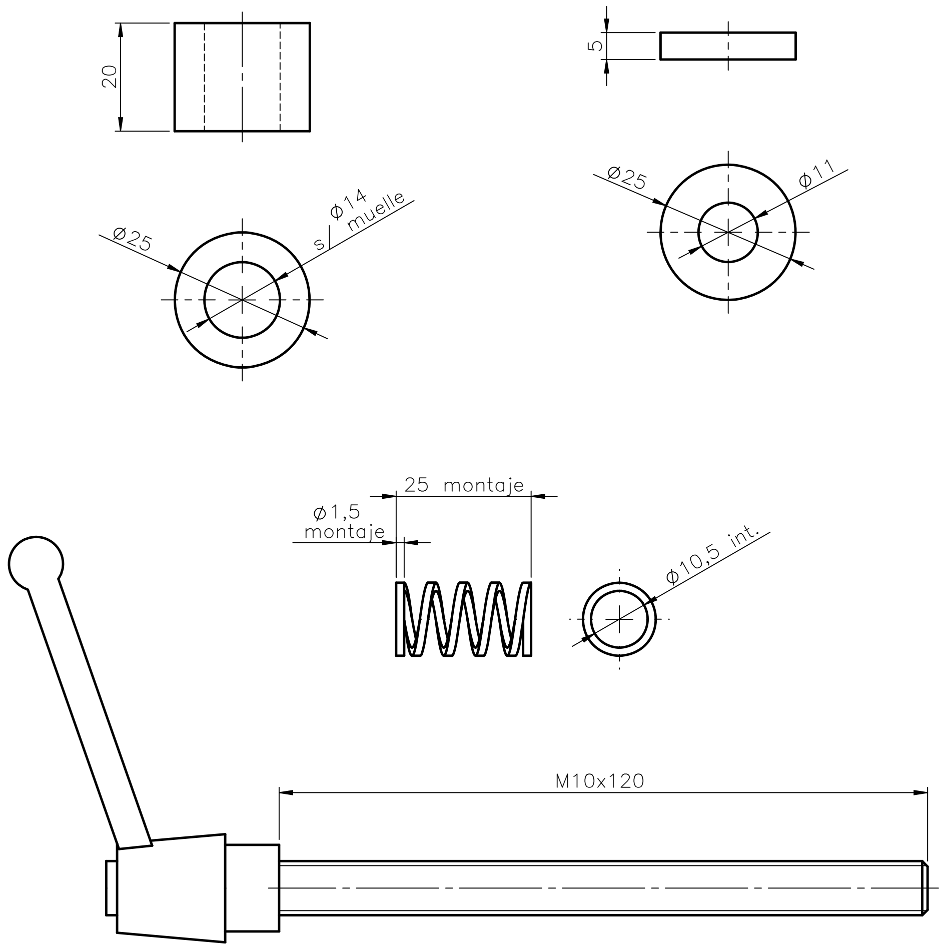

VISTA PLANTA INFERIOR
DETALLE RANURA
Medidas sin toleracia ±0,2
1
1
Guía carro transversal
Bronce
Item
Cantidad
Designación
Material / Norma
Fecha
Nombre
Firma:
Dibujado
26-07-2011
M. Pueo
Comprobado
J. Santolaria
id.s.normas
ESCUELA DE INGENIERIA Y
ARQUITECTURA DE
ZARAGOZA
Escala:
1:1
Título:
GUIA CARRO TRANVERSAL
Nº Plano:
01.02 rev03
Formato:
A3
Asignatura: Trabajo Fin Master
Curso: Master Sis-Mec 2010-2011


Total Pzas. Mecanizadas 84,225 (galga 5,00)
Cota Teórica Medición 84,025
Cota Real (a determinar al montaje con galgas)
Mecanizado una vez montado
1 pza., Bronce
1 pza., Acero
2 pzas., Acero
Rebaje Allen M5
(Posiblemente 4,8 al montaje)
Medidas sin toleracia ±0,2
3 | 2 | Galga (Medida al montaje) | Acero (10x5x30)
2 | 1 | Guía carro transversal (pieza 2) | Acero
1 | 1 | Guía carro transversal (pieza 1) | Bronce
Item | Cantidad | Designación | Material / Norma
Dibujado 25-10-2011 M. Pueo
Comprobado J. Santolaria
ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Escala: 1:1
Título: GUIA CARRO TRANVERSAL PIEZA 1, PIEZA 2 + GALGAS
Nº Plano: 01.07 rev 04
Formato: A3
Asignatura: Trabajo Fin Master
Curso: Master Sis-Mec 2010-2011



Medidas sin toleracia ±0,2

1	1	Soporte motorreductor		Angular calibrado (Acero)
Item	Cantidad	Designación		Material / Norma
	Fecha	Nombre	Firma:	ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Dibujado	26-07-2011	M. Pueo		
Comprobado		J. Santolaria		
id.s.normas				
Escala: 1:1	Titulo: SOPORTE MOTORREDUCTOR FAULHABER 3257G024CR+38/2S(134:1)			Nº Plano: 02.17 rev00 — Formato: A4
				Asignatura: Trabajo Fin Master
				Curso: Master Sis-Mec 2010-2011



Item	Cantidad	Designación	Material / Norma
1	1	Muelle Ø10x1,5x(25)	Muelle
1	1	Posicionador M10x120	Varilla roscada M10
1	1+1	Caquillo + Arandela	Acero / Acero

	Fecha	Nombre	Firma:
Dibujado	26-07-2011	M. Pueo	
Comprobado		J. Santolaria	
id.s.normas			

ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA

Escala: 1:1

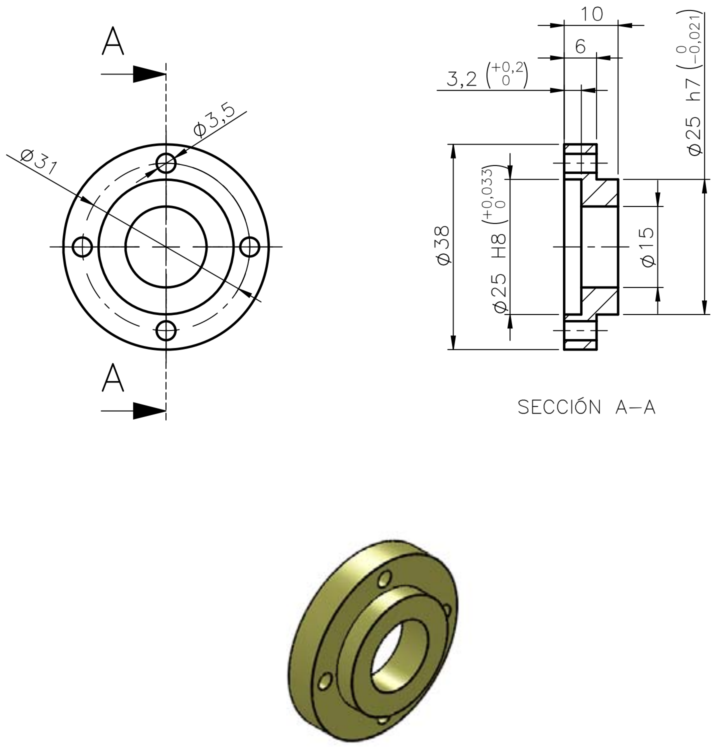
Titulo: CASQUILLO TOPE + ARANDELA + POSICIONADOR + MUELLE

Nº Plano: 02.19 rev00

Formato: A4

Asignatura: Trabajo Fin Master

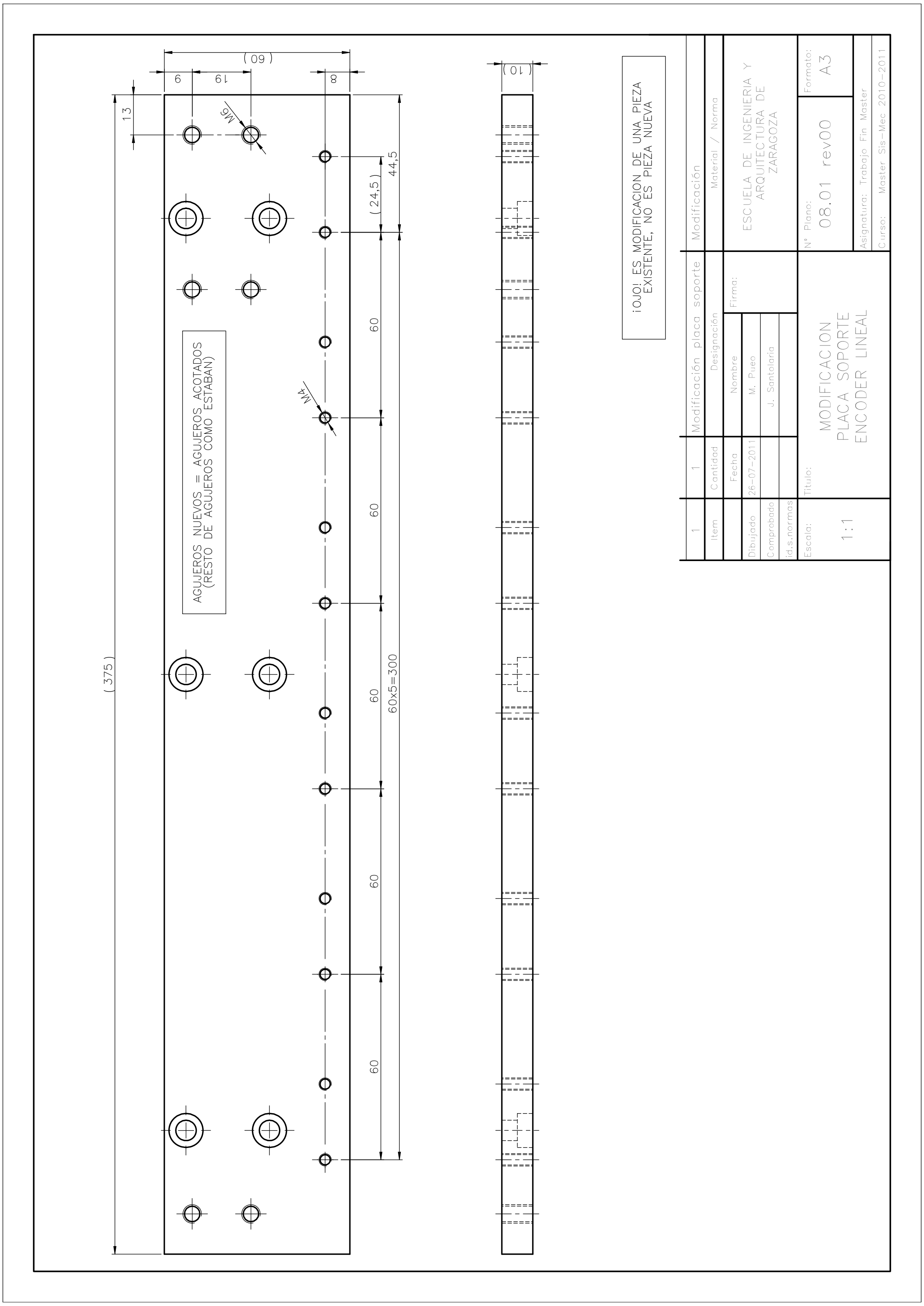
Curso: Master Sis-Mec 2010-2011

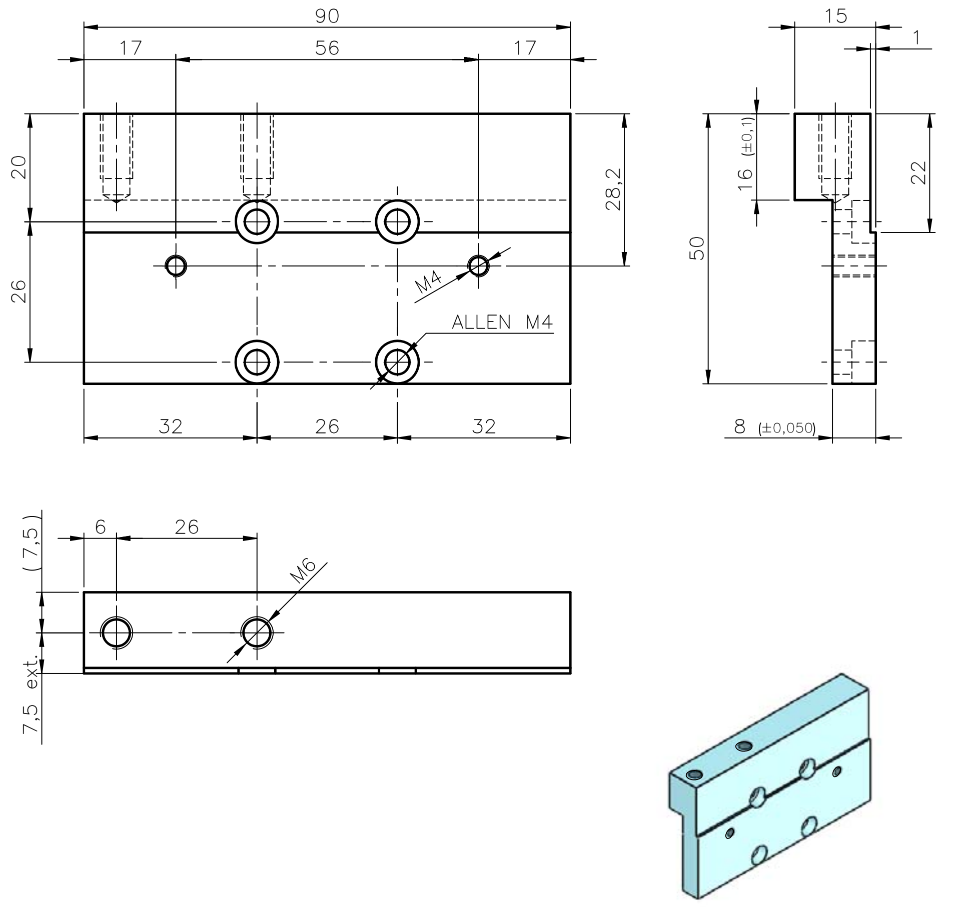


NOTA DE OTRA PIEZA: HAY QUE RECRECER EL DIAMETRO DEL PIÑON DEL REDUCTOR DE ⌀6 A ⌀8

Medidas sin toleracia ±0,2

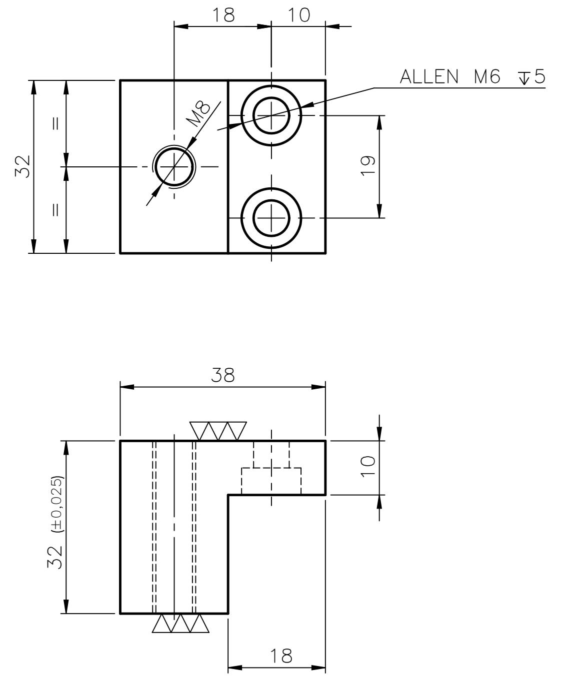
1	1	Casquillo calce reductor		Acero
Item	Cantidad	Designación		Material / Norma
	Fecha	Nombre	Firma:	ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Dibujado	26-07-2011	M. Pueo		
Comprobado		J. Santolaria		
id.s.normas				
Escala: 1:1	Titulo: CASQUILLO CALCE MOTORREDUCTOR		Nº Plano: 02.20 rev00	Formato: A4
			Asignatura: Trabajo Fin Master	
			Curso: Master Sis-Mec 2010-2011	

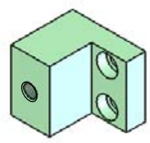

¡OJO! ES MODIFICACION DE UNA PIEZA EXISTENTE, NO ES PIEZA NUEVA
AGUJEROS NUEVOS = AGUJEROS ACOTADOS (RESTO DE AGUJEROS COMO ESTABAN)
(60)
6
19
8
13
M6
M4
(24,5)
44,5
60
60x5=300
(375)
(10)
1
1
Modificación placa soporte
Modificación
Item
Cantidad
Designación
Material / Norma
Fecha
Nombre
Firma:
ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Dibujado
26-07-2011
M. Pueo
Comprobado
J. Santolaria
id.s.normas
Escala:
1:1
Título:
MODIFICACION PLACA SOPORTE ENCODER LINEAL
Nº Plano:
08.01 rev00
Formato:
A3
Asignatura: Trabajo Fin Master
Curso: Master Sis-Mec 2010-2011



Medidas sin toleracia ±0,2

1	1	Carro rodamiento lineal		Acero
Item	Cantidad	Designación		Material / Norma
	Fecha	Nombre	Firma:	ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Dibujado	26-07-2011	M. Pueo		
Comprobado		J. Santolaria		
id.s.normas				
Escala: 1:1	Titulo: CARRO RODAMIENTO LINEAL			Nº Plano: 08.05 rev00 / Formato: A4
				Asignatura: Trabajo Fin Master
				Curso: Master Sis-Mec 2010-2011

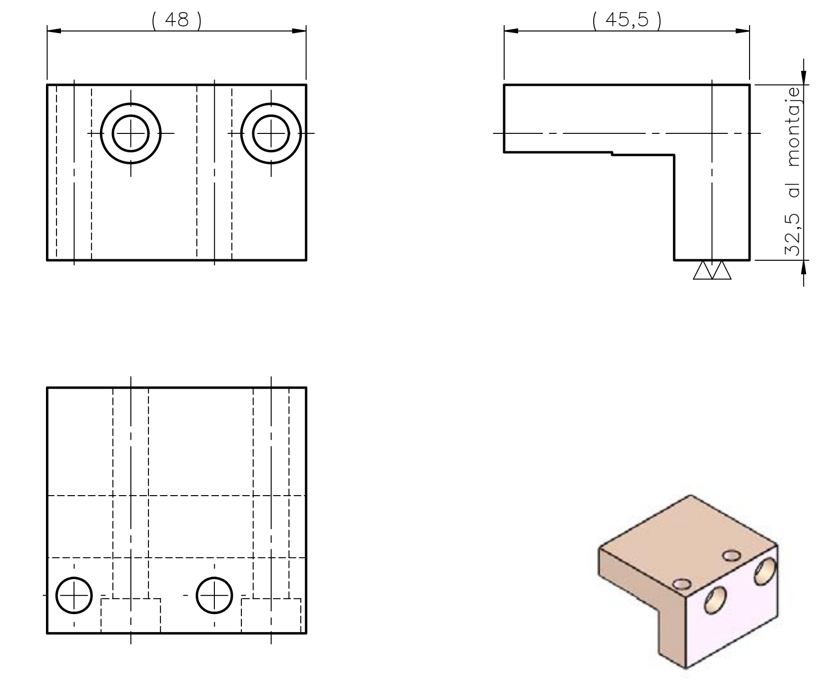




MECANIZAR LAS 2 PZAS. A LA VEZ
(COTA 32±0,025)

Medidas sin toleracia ±0,2

1	2	Calce encoder lineal		Acero
Item	Cantidad	Designación		Material / Norma
	Fecha	Nombre	Firma:	ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Dibujado	26-07-2011	M. Pueo		
Comprobado		J. Santolaria		
id.s.normas				
Escala: 1:1	Titulo: CALCE ENCODER LINEAL			Nº Plano: 08.07 rev00 — Formato: A4
				Asignatura: Trabajo Fin Master
				Curso: Master Sis-Mec 2010-2011



¡OJO ES MODIFICACION DE PIEZA EXISTENTE!
COMPROBAR DIMENSION A MECANIZAR AL MONTAJE
(COTA 32,5)

1	1	Modificación unión carro		Modificación
Item	Cantidad	Designación		Material / Norma
	Fecha	Nombre	Firma:	ESCUELA DE INGENIERIA Y ARQUITECTURA DE ZARAGOZA
Dibujado	26-07-2011	M. Pueo		
Comprobado		J. Santolaria		
id.s.normas				
Escala: 1:1	Titulo: MODIFICACION UNION CARRO A ENCODER LINEAL			N° Plano: 08.08 rev00 — Formato: A4
				Asignatura: Trabajo Fin Master
				Curso: Master Sis-Mec 2010-2011