LINEAR MOTOR CATALOG
GRYPHON

Vacuum Compatible Ironless Motors

February 2023

Linear motors
integrated in a custom mechatronic system

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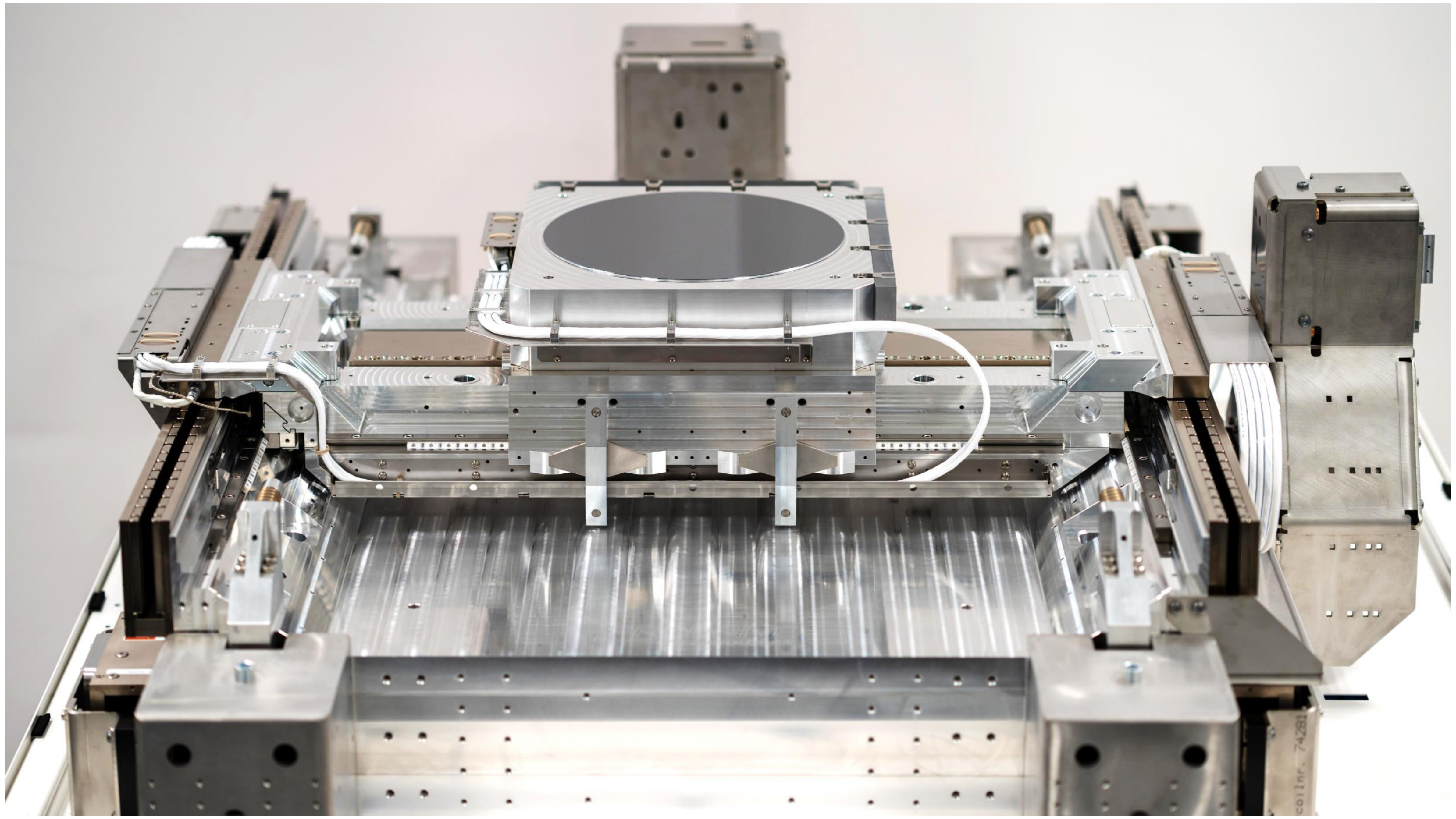

Linear motors integrated in a motion stage

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Knowledge

Engineering excellence is the driving force behind linear motor innovation in both design and manufacturing. Prodrive has a highly skilled group of (electro-)mechanical engineers capable of customizing linear motor technology towards your needs.

Quality

Quality is in the DNA of Prodrive Technologies. With a long history in electronics manufacturing, Prodrive continues in the area of linear motor manufacturing with the same philosophy and processes, setting a new standard within the linear motor market.

Automation

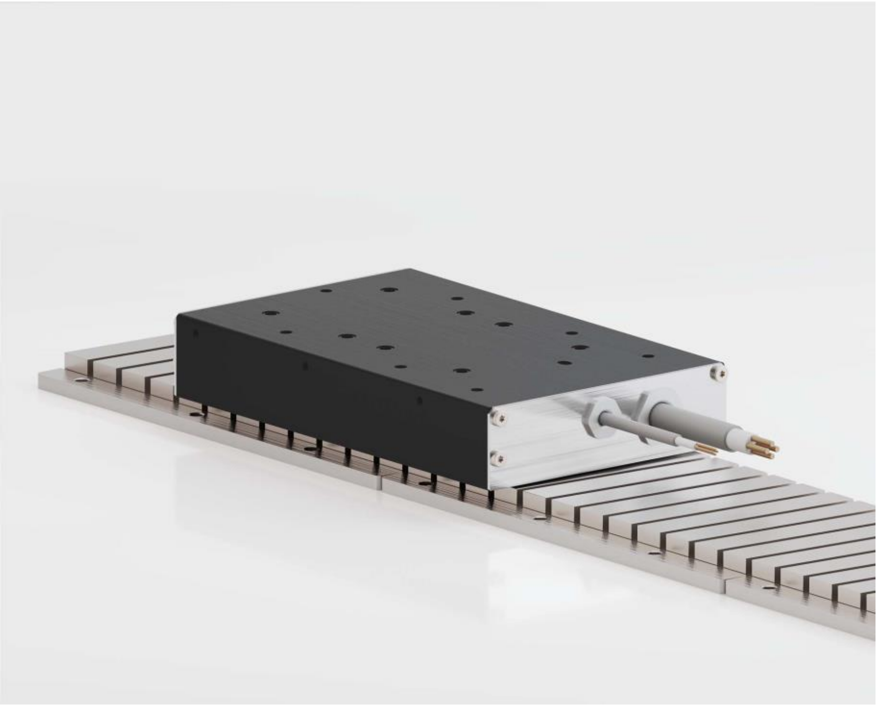
Design for manufacturing is key to reduce cost and guarantee quality. Winding, assembly, vacuum potting and magnet gluing are highly automated processes which guarantees a constant quality at minimum cost.

Time to market

Due to the agility of Prodrive Technologies' large development department, customization can be performed in a very short time, providing a short time to market for challenging mechatronic applications.

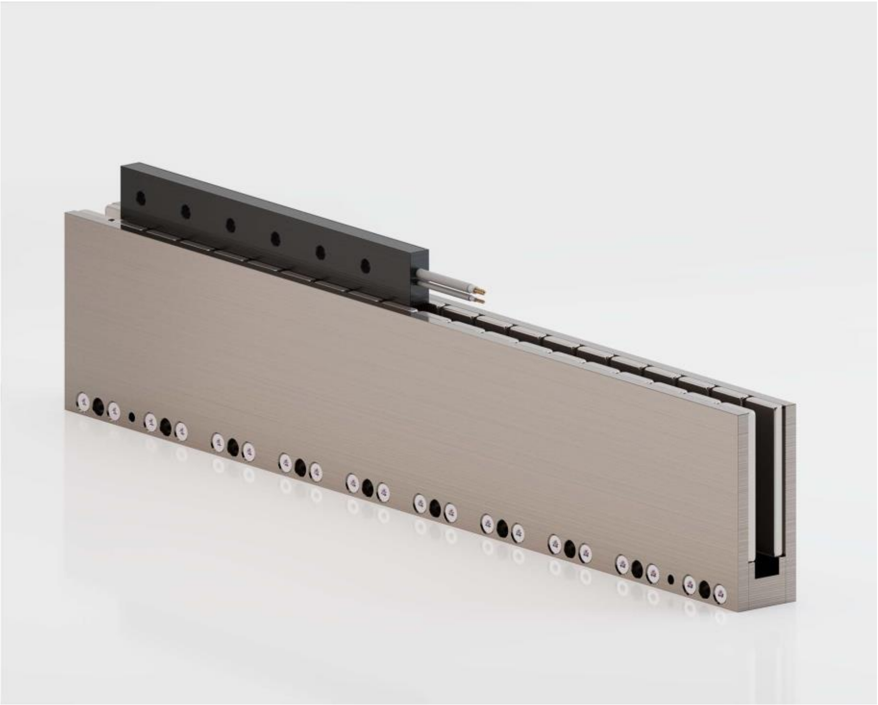
Prodrive Technologies HQ Campus, The Netherlands

OVERVIEW



Chiron

The Chiron line offers iron core linear motors which are optimized for high force and high efficiency. Find the optimal fit for your application due to the many different available form factors.

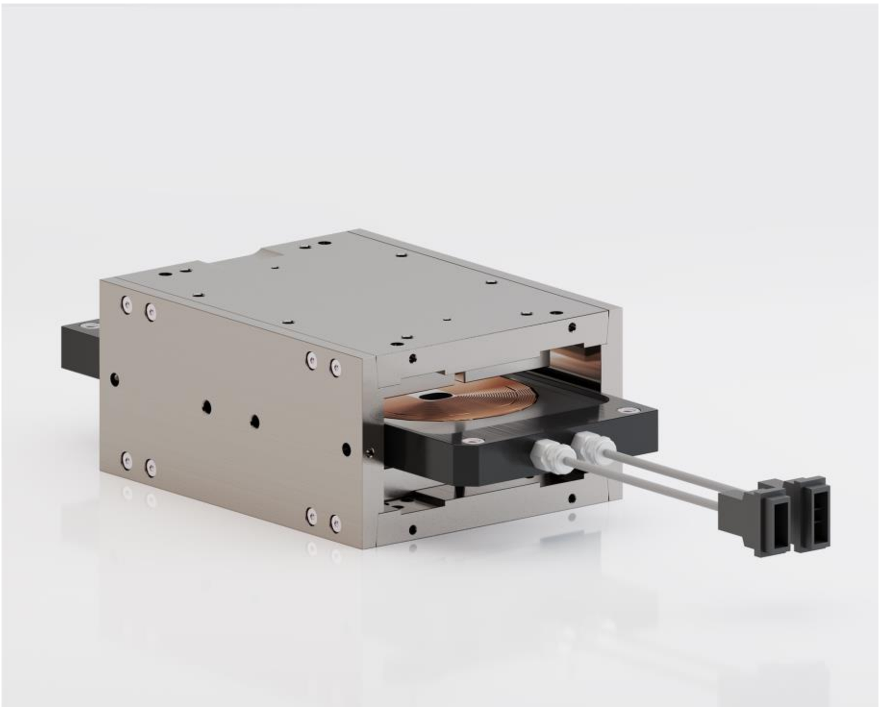


Phoenix

The Phoenix line offers ironless linear motors, for applications requiring an extremely low force ripple for excellent servo performance without attraction forces. Available in a large range of sizes.

Gryphon

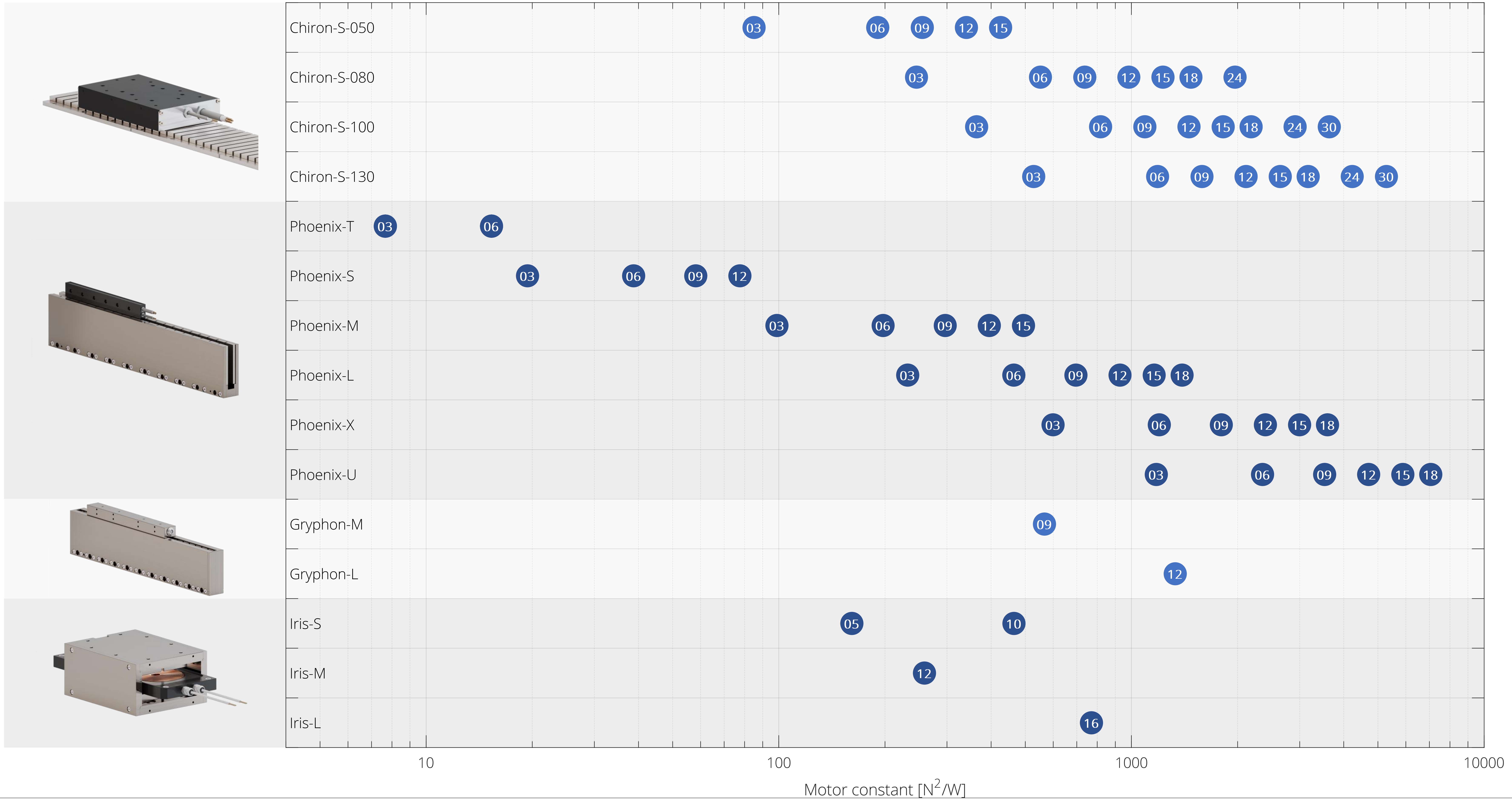
The Gryphon line offers a cost-effective solution for vacuum-compatible ironless linear motors. These motors also contain features providing magnetic shielding.



Iris

For short stroke applications requiring a relatively large displacement in three directions, the Iris line provides a high force density with zero attraction forces in a rectangular form factor.

OVERVIEW


Chiron-S-050 03 06 09 12 15
Chiron-S-080 03 06 09 12 15 18 24
Chiron-S-100 03 06 09 12 15 18 24 30
Chiron-S-130 03 06 09 12 15 18 24 30
Phoenix-T 03 06
Phoenix-S 03 06 09 12
Phoenix-M 03 06 09 12 15
Phoenix-L 03 06 09 12 15 18
Phoenix-X 03 06 09 12 15 18
Phoenix-U 03 06 09 12 15 18
Gryphon-M 09
Gryphon-L 12
Iris-S 05 10
Iris-M 12
Iris-L 16
10
100
1000
10000
Motor constant [N2/W]

WINDING CONFIGURATIONS

The phases of all three-phase linear motors are star-connected.

The Chiron, Phoenix and Gryphon line can be selected with different winding configurations to create an optimal fit for your application.

Winding configuration A

The windings are configured such that independent of the number of coils, the force constant remains equal, and the maximum velocity remains unchanged. The maximum current increases with the number of coils.

Winding configuration B

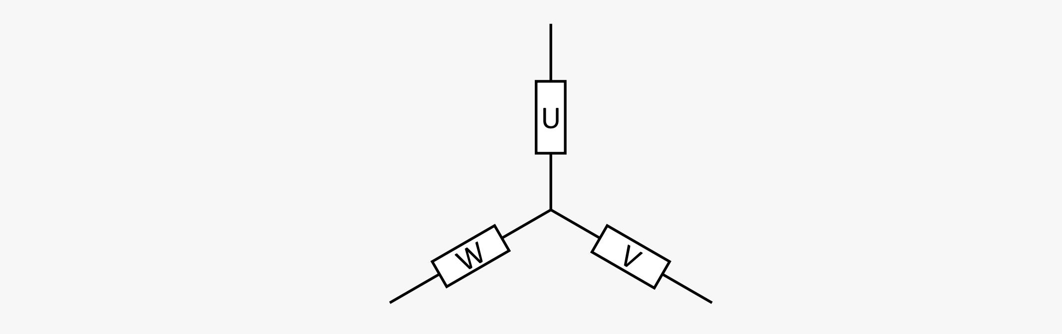
The windings are configured like winding configuration A, but this winding configuration can reach higher velocities at the expense of a lower force constant.

Winding configuration C

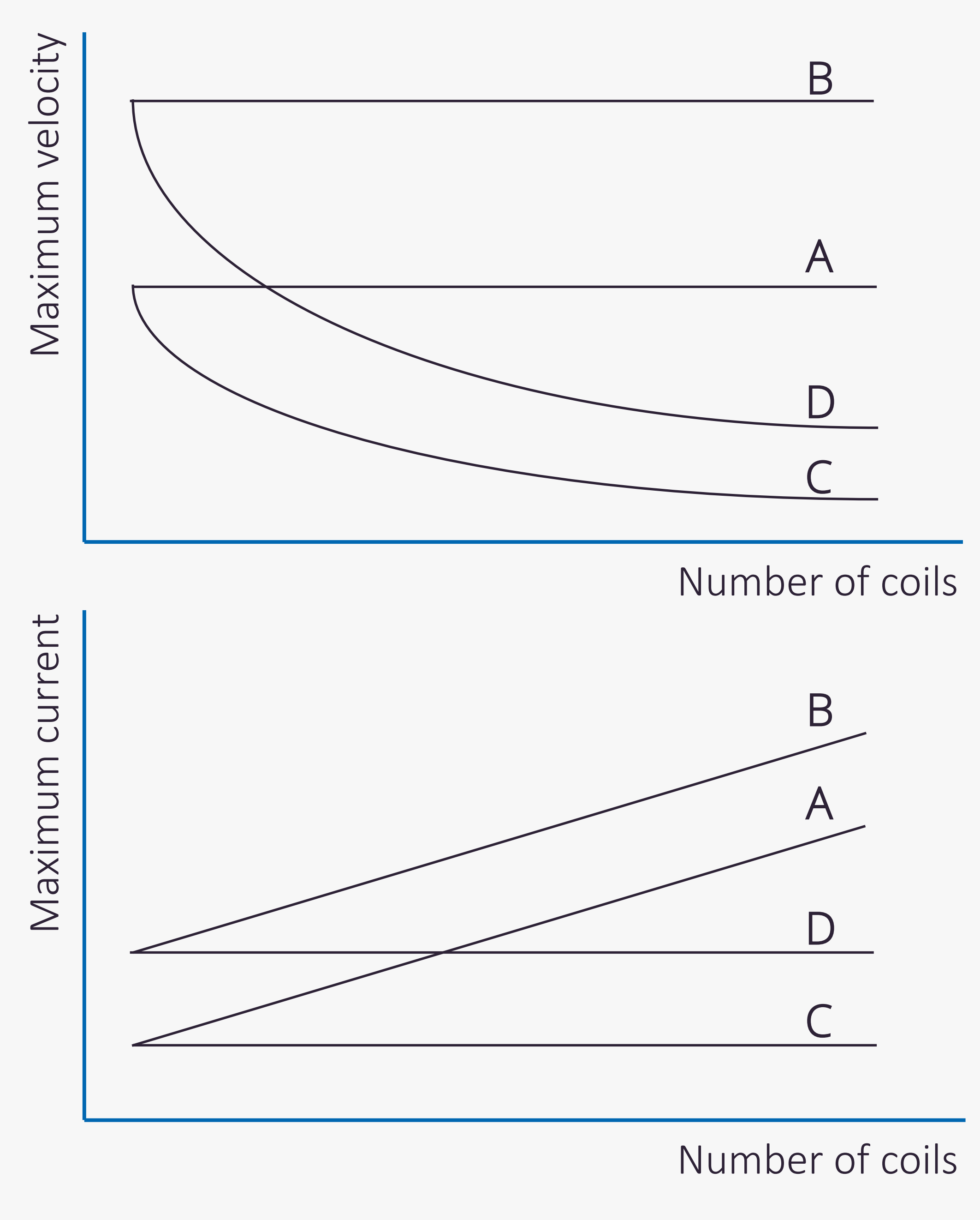
The windings are configured such that the current remains constant with increasing number of coils at the expense of reducing the maximum velocity. For the Chiron, Phoenix and Gryphon line, this configuration allows moving magnet applications with partial coil unit overlap.

Winding configuration D

The windings are configured such that the current remains constant with increasing number of coils at the expense of reducing the maximum velocity. This configuration has a higher maximum velocity compared to winding configuration C. For the Phoenix line, this configuration allows moving magnet applications with partial coil unit overlap.



Phase connection chart



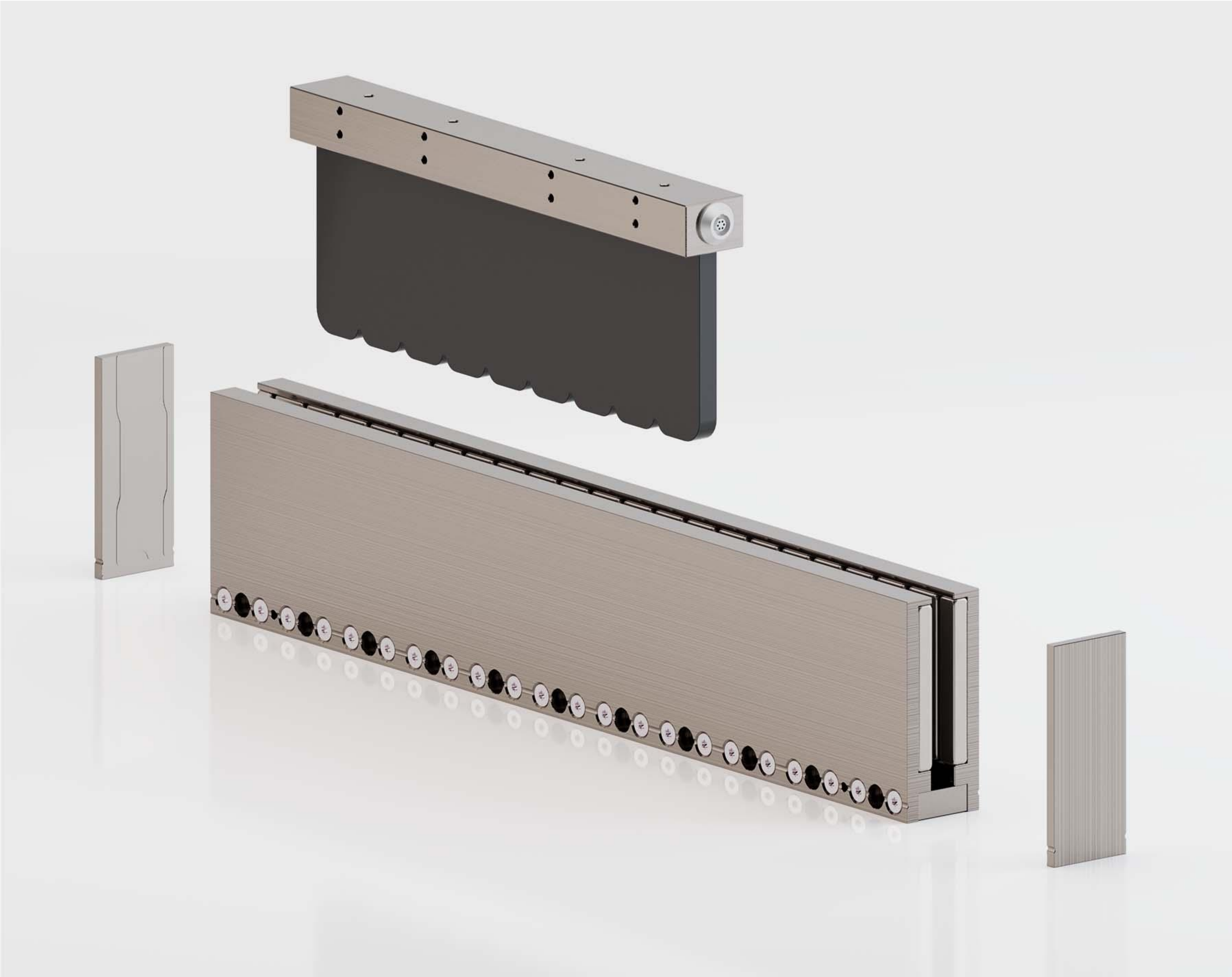
Winding configurations chart

GRYPHON LINE

The Gryphon line offers a cost-effective solution for vacuum-compatible ironless linear motors. These motors also contain features providing magnetic shielding.

Gryphon line in medium and large configuration

GRYPHON - FEATURES



Gryphon magnet yoke (Gryphon-MY-M-22-EB-G00) and coil unit (Gryphon-CU-M-09-C-C)

Gryphon-CU-M-09-C-C

Connector
Winding configuration (C)
# of coils
Size (M / L)
Coil unit

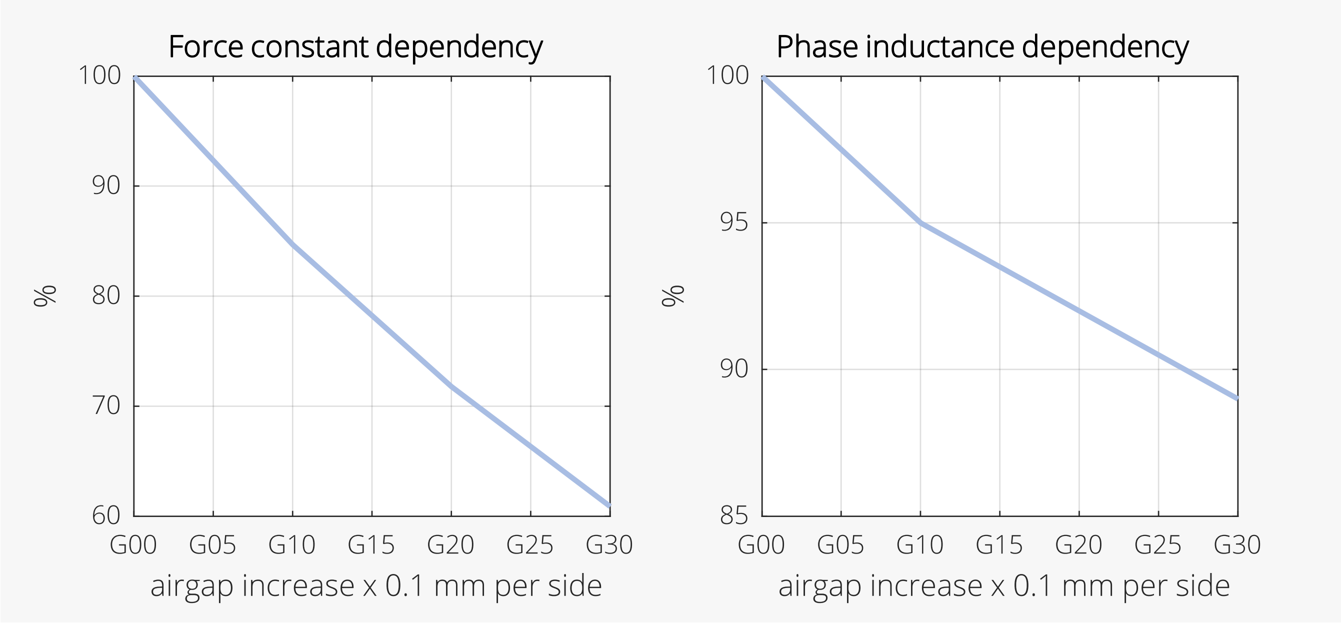
Gryphon-MY-M-12-FX-G00

Additional airgap x 0.1 mm on each side
End plates (X, L, R, B)
Half pole location (C, D, E, F)
# of poles
Size (M / L)
Magnet yoke

- Magnet yokes and coil units are made of low outgassing materials
- Coil units have a temperature protection (PTC)
- Coil units have a vacuum compatible connector
- Magnet yokes can be butted together
- Magnet yokes can be selected with larger airgaps to allow higher installation tolerances
- Magnet yokes have optional half poles at the end to improve magnetic shielding:
  - C: Half pole on the left side
  - D: Half pole on the right side
  - E: Half pole on both sides
  - F: Full pole on both sides
- Magnet yokes of size M have optional end plates to improve magnetic shielding:
  - X: no end plates
  - L: end plate on the left
  - R: end plate on the right
  - B: end plates on both sides
- IP rating of coil units is IP4X

GRYPHON-M/L PERFORMANCE SPECIFICATIONS

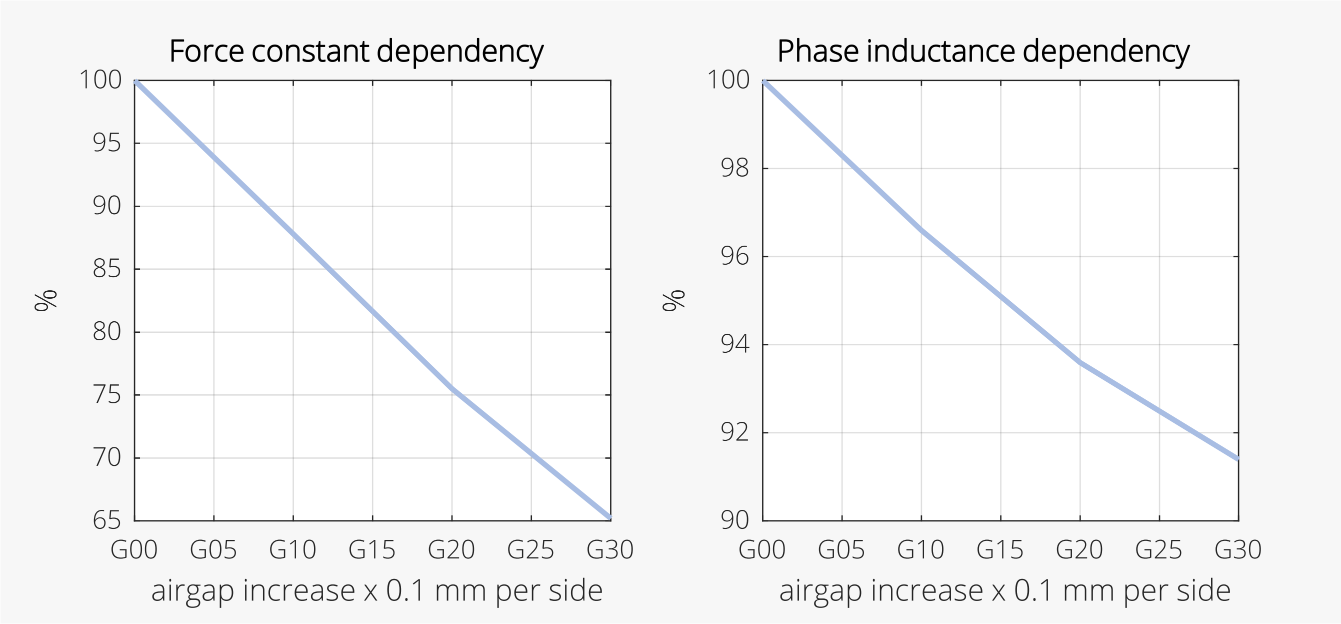
	Parameter	Symbol	Unit	T_{coil} (°C)	CU-M-09	CU-L-12
	Winding configuration	-	-	-	C	C
Electromechanical	Peak force	F_p	N	20	269	414
Electromechanical	Continuous force, interface at 20°C	F_c	N	50	161	249
Electromechanical	Attraction force (I = 0)	F_{att}	N	-	0	0
Electromechanical	Motor constant	S	N^2/W	20	566	1330
Electromechanical	Force constant	K_f	N/A_{rms}	-	54	83
Electromechanical	Maximum velocity (F = 0)	v_m	m/s	-	2.3	1.5
Electromechanical	Maximum velocity (F = F_p)	v_i	m/s	20	1.8	1.2
Electrical	Maximum dc bus voltage	V_{dc}	V	-	100	100
Electrical	Phase resistance	$R_{ph,20}$	Ohm	20	1.7	1.7
Electrical	Phase inductance	L_{ph}	mH	20	2.3	2.6
Electrical	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	44	68
Electrical	Maximum rms current	I_p	A_{rms}	20	5.0	5.0
Electrical	Continuous rms current	I_c	A_{rms}	50	3.0	3.0
Thermal	Continuous dissipation	$P_{d,c}$	W	50	51	52
Thermal	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	0.37	0.19
Thermal	Thermal time constant, interface at 20°C	τ_{th}	s	-	627	541



Airgap dependency M-size

Notes

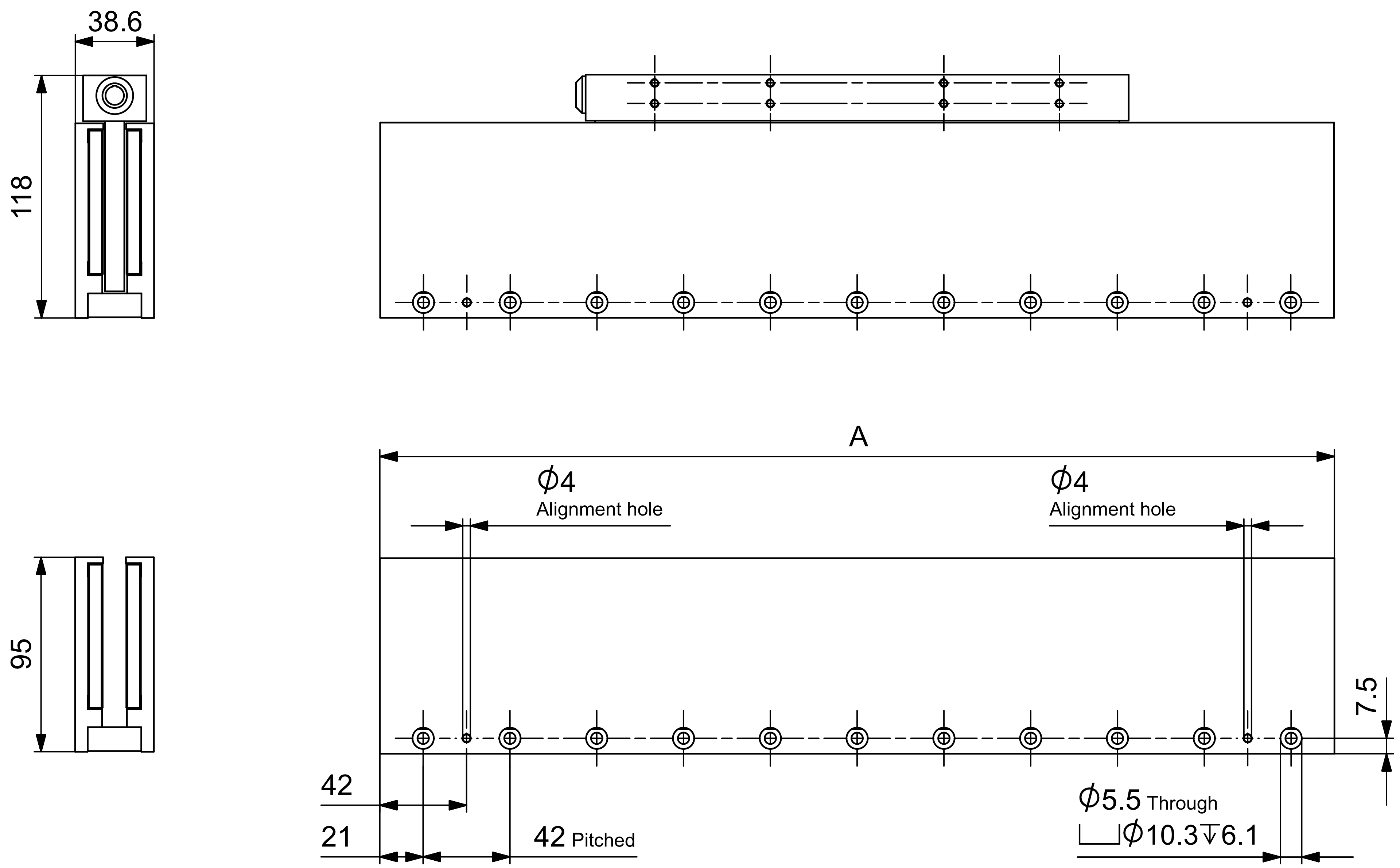
- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Specifications consider a magnet yoke with nominal airgap (G00)
- See 'definitions' section at the end of the catalog for more details

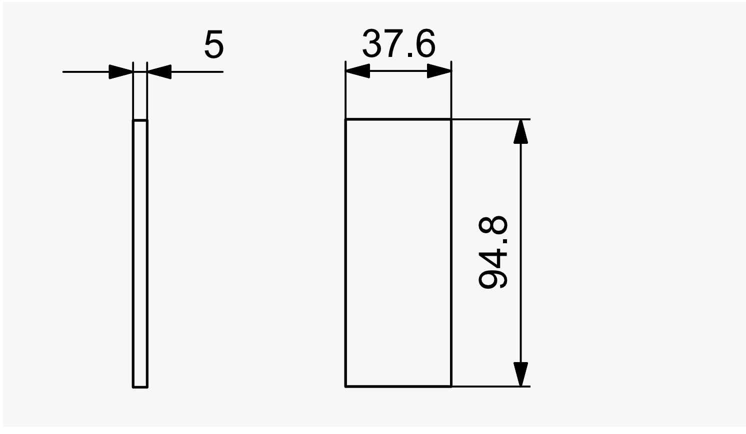


Airgap dependency L-size

Product marking / approvals

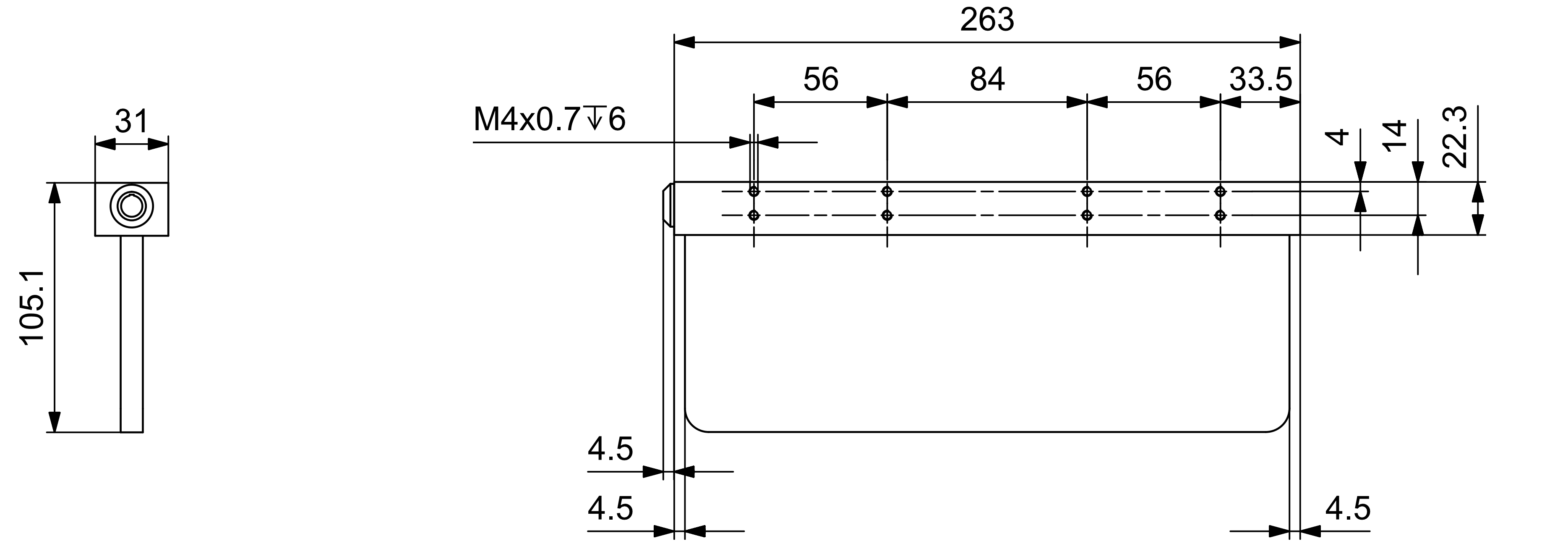
GRYPHON-M MECHANICAL SPECIFICATIONS





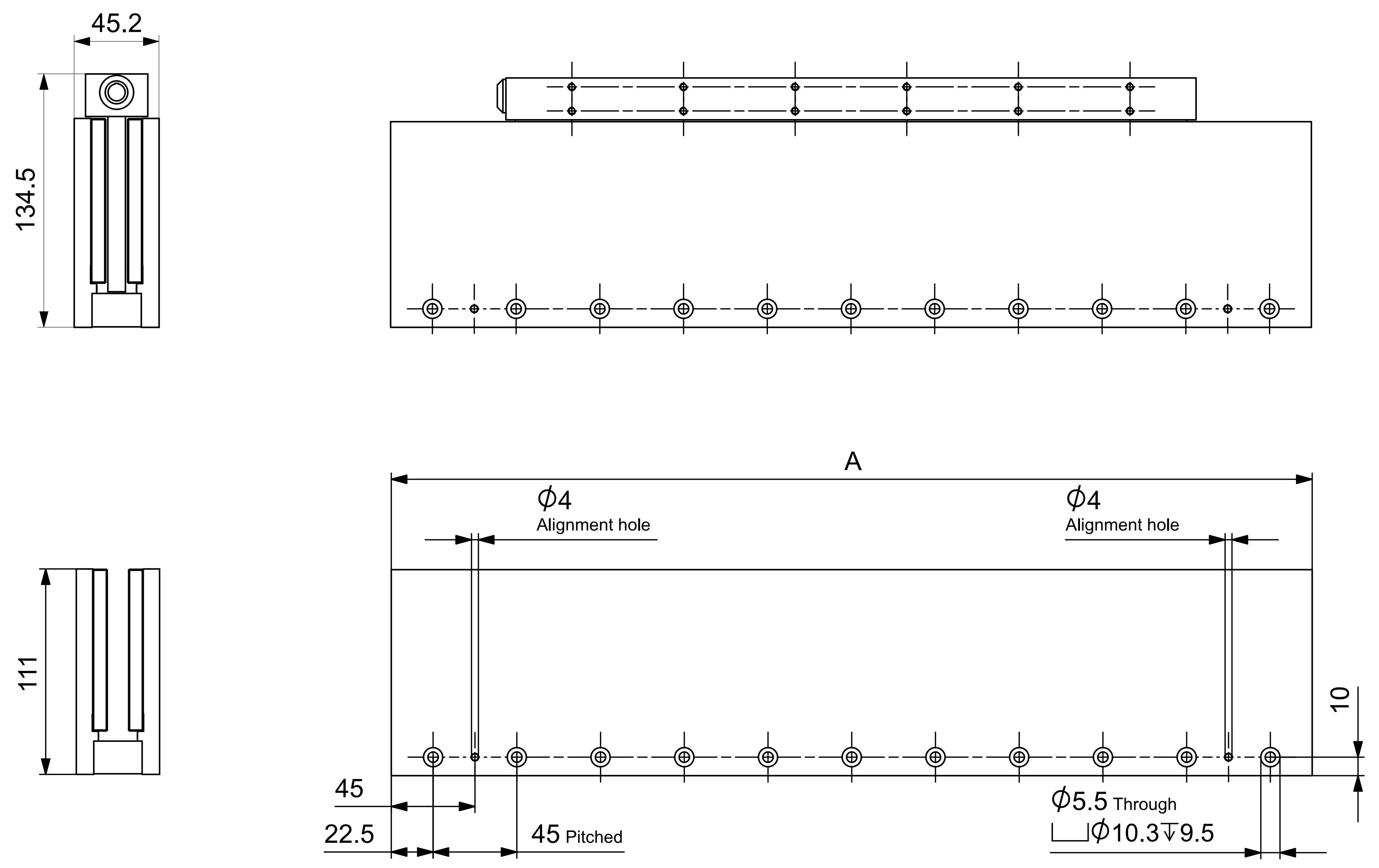
End plate

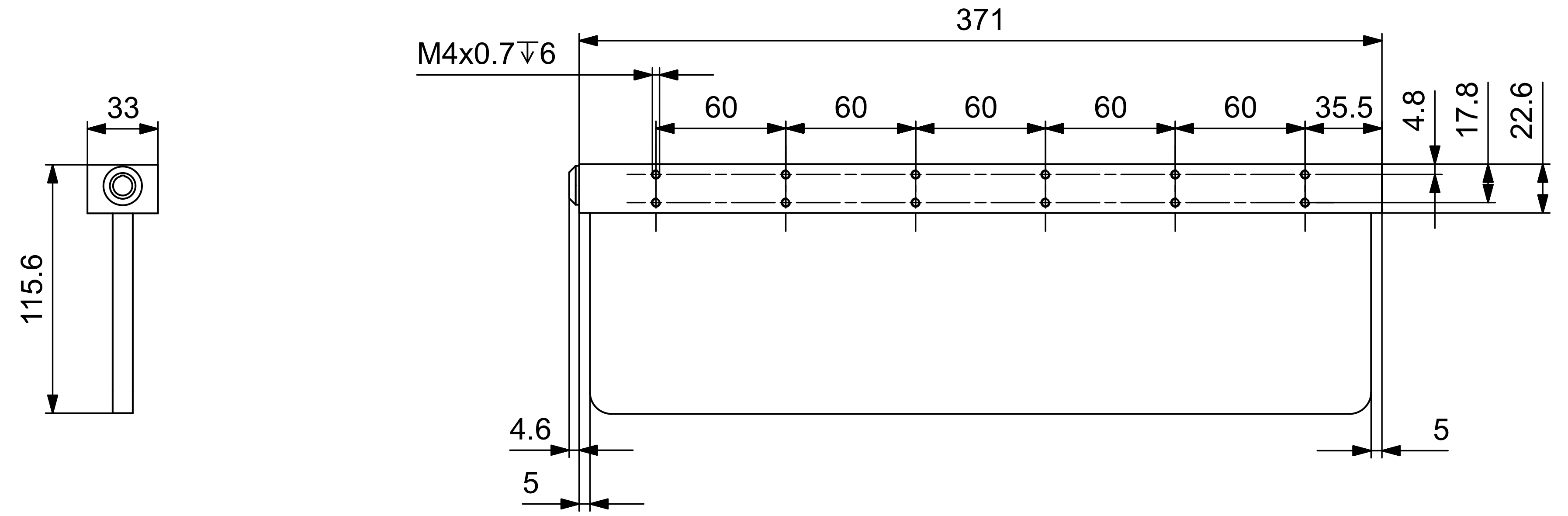
Magnet Yokes	Parameter	Symbol	Unit	MY-M-12	MY-M-22
	Number of poles	N_p	-	12	22
	Pole pitch (N-N)	$2\tau_p$	mm	42	42
	Width	A	mm	252	462
	Mass	M_{my}	kg	4.6	8.4



Coil Units	Parameter	Symbol	Unit	CU-M-09
	Number of coils	N_{coil}	-	9
	Coil pitch	τ_{coil}	mm	28
	Width	B	mm	263
	Mass	M_{cu}	kg	1.4

GRYPHON-L MECHANICAL SPECIFICATIONS

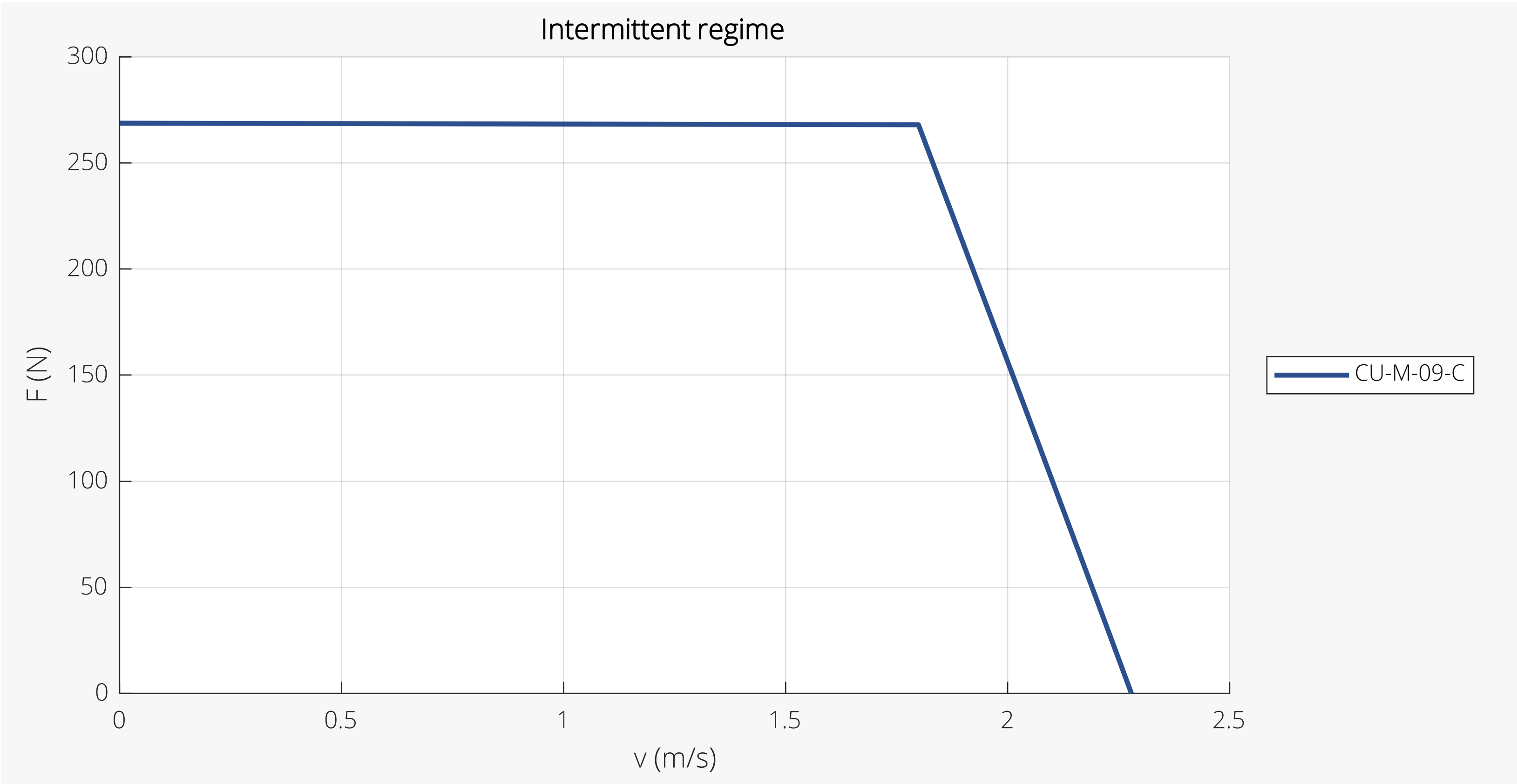




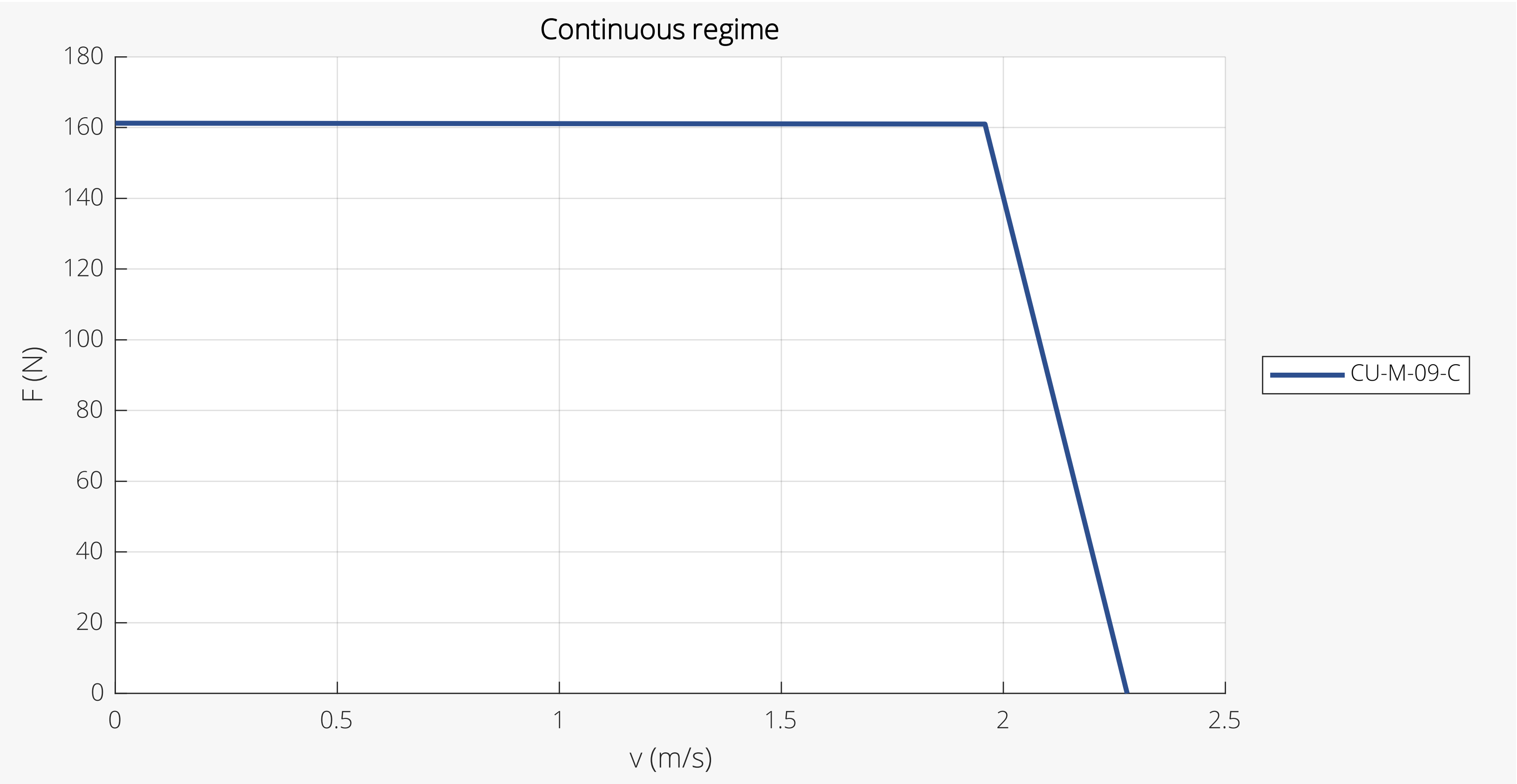
	Parameter	Symbol	Unit	MY-L-22	MY-L-24
Magnet Yokes	Number of poles	N_p	-	22	24
	Pole pitch (N-N)	$2\tau_p$	mm	45	45
	Width	A	mm	495	540
	Mass	M_{my}	kg	13.1	14.2

	Parameter	Symbol	Unit	CU-L-12
Coil Units	Number of coils	N_{coil}	-	12
	Coil pitch	τ_{coil}	mm	30
	Width	B	mm	371
	Mass	M_{cu}	kg	2.4

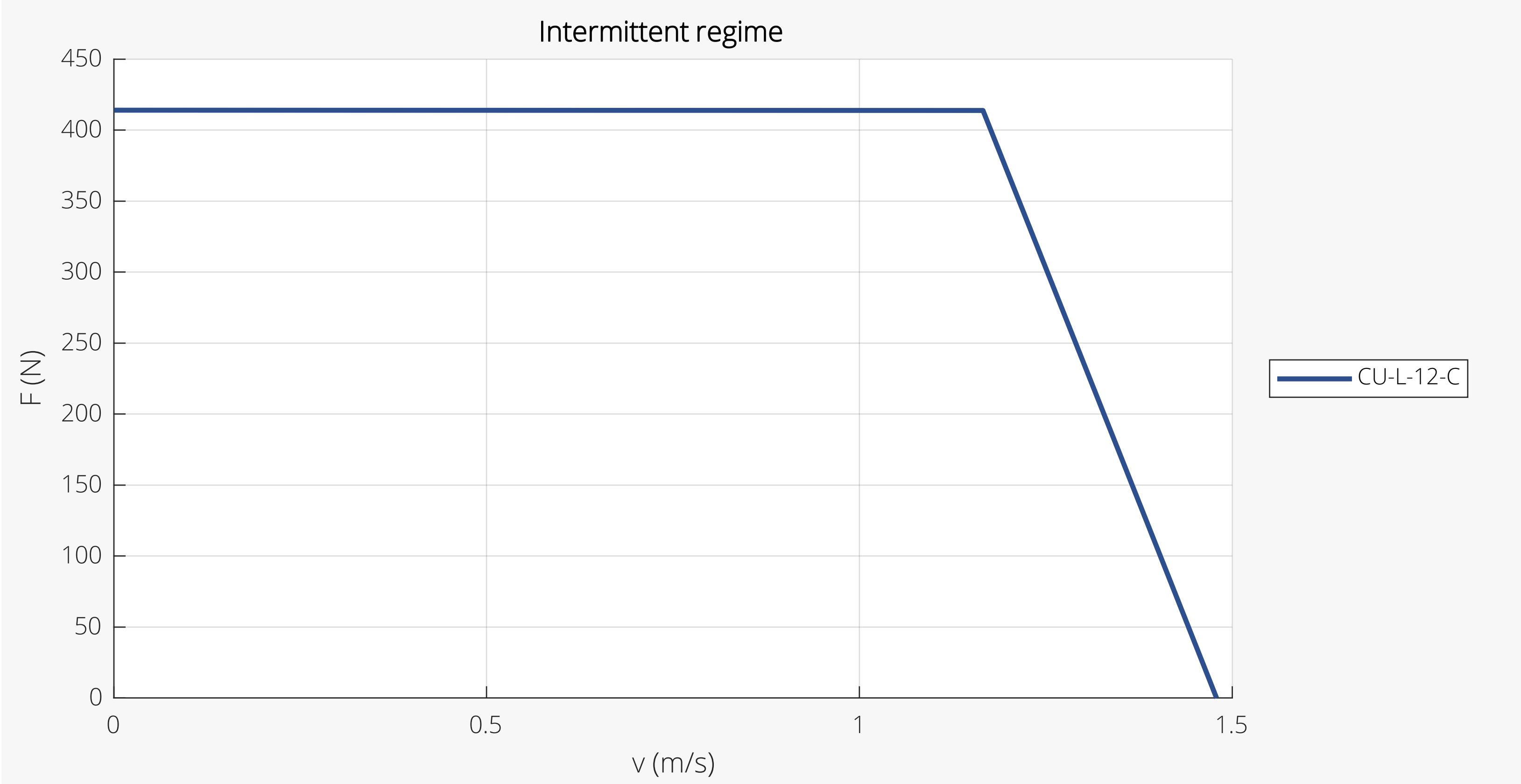
GRYPHON-M/L FORCE-VELOCITY DIAGRAMS



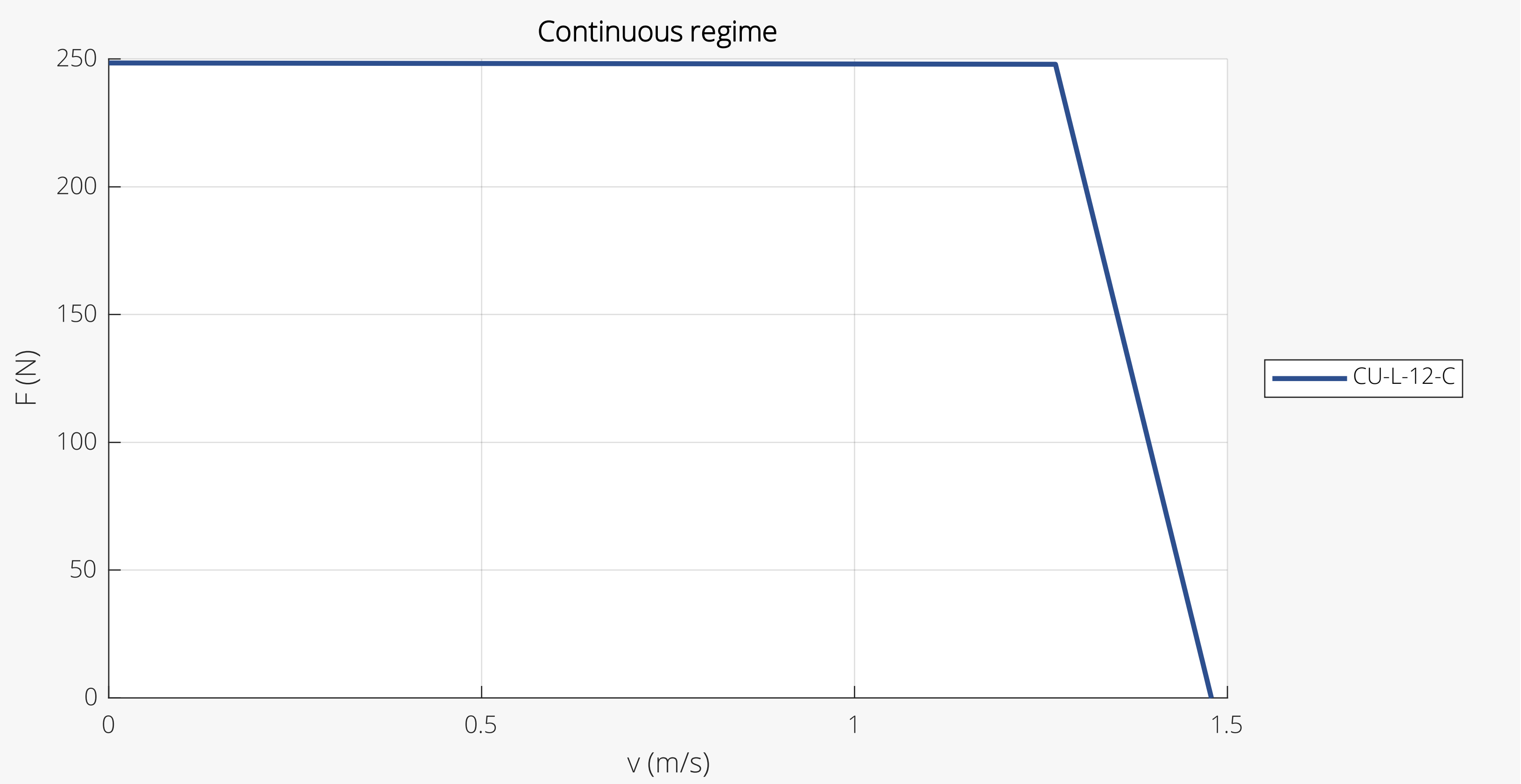
Force-Velocity Diagrams Size M Intermittent Regime



Force-Velocity Diagrams Size M Continuous Regime



Force-Velocity Diagrams Size L Intermittent Regime

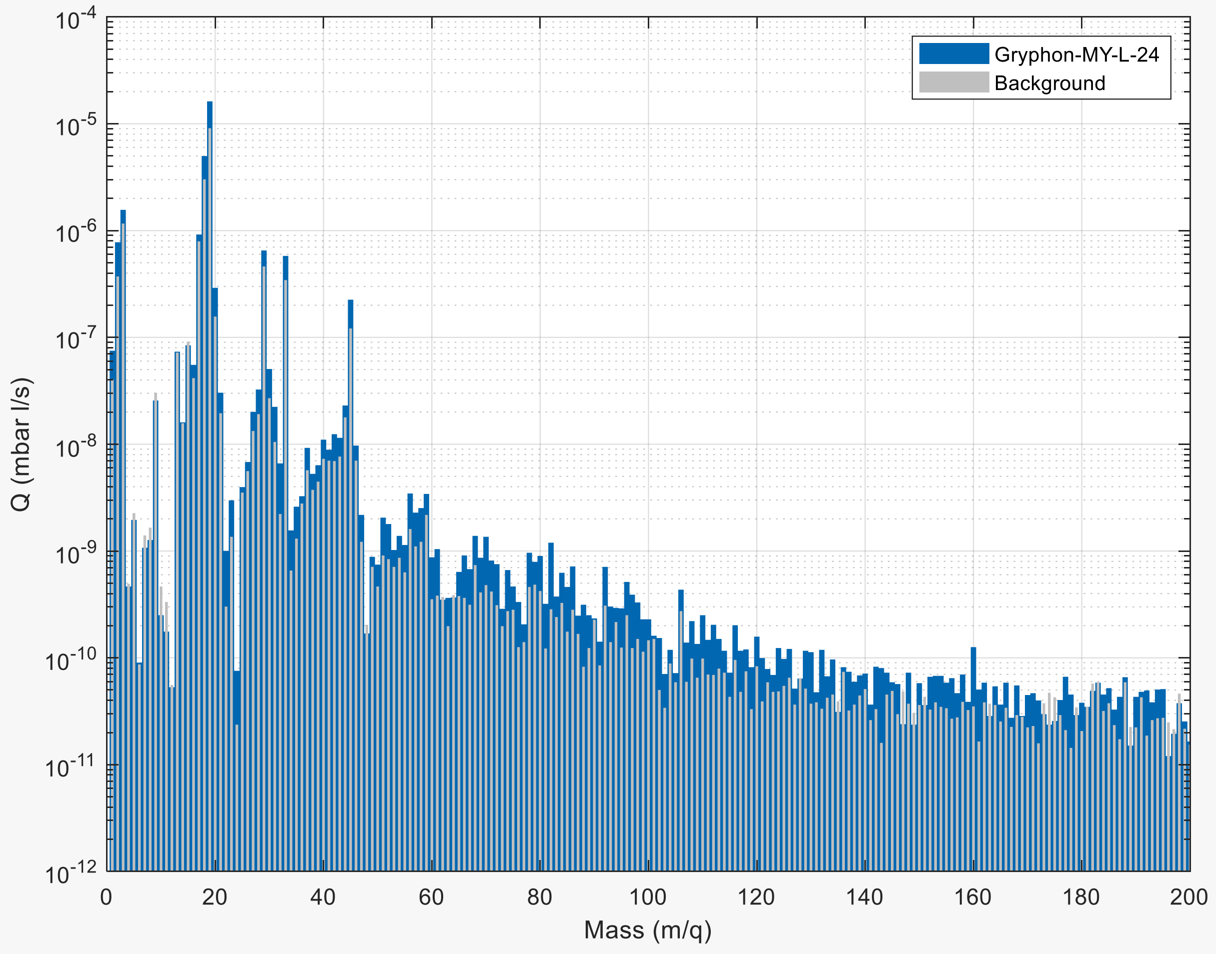


Force-Velocity Diagrams Size L Continuous Regime

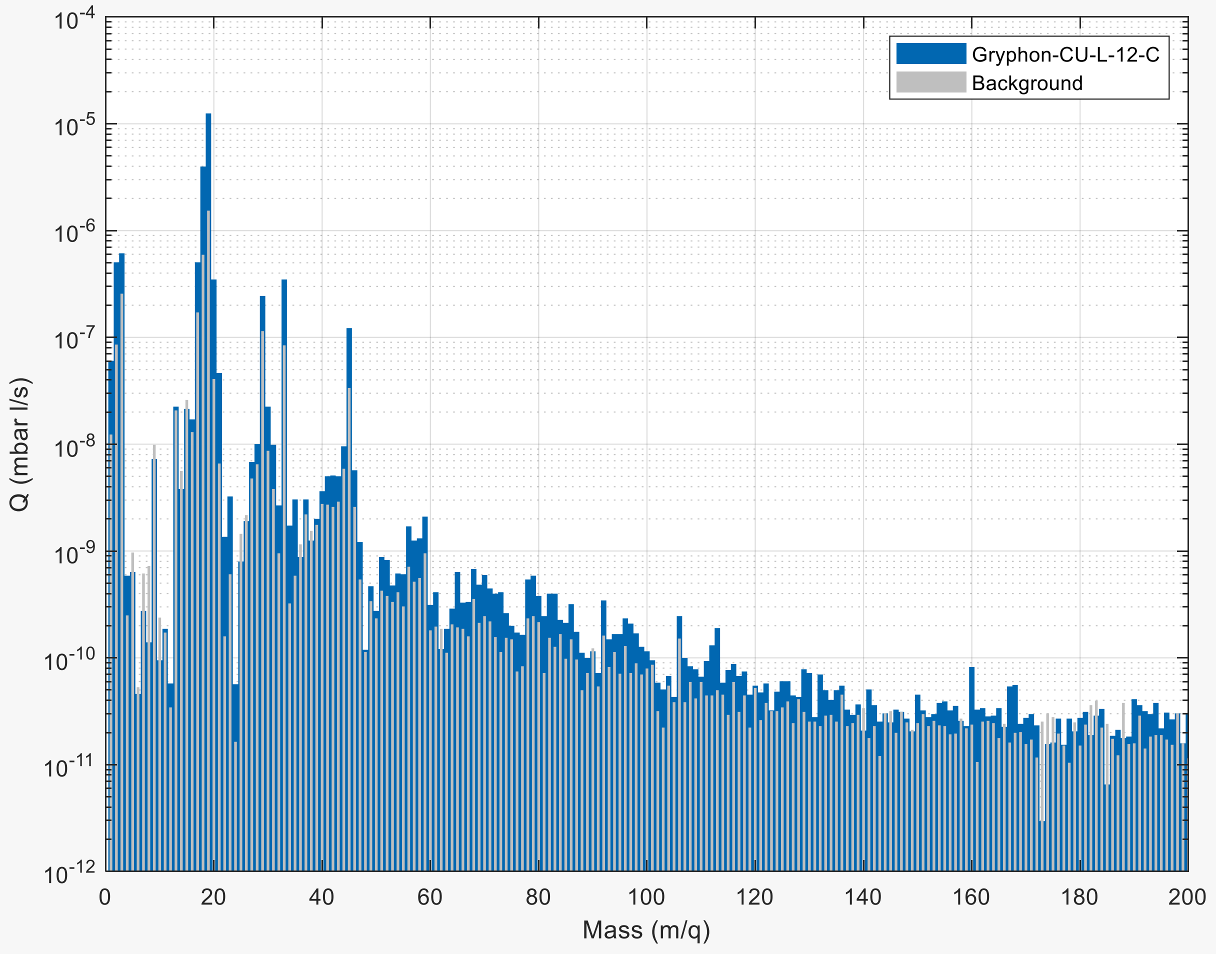
GRYPHON-L OUTGASSING MEASUREMENTS

The outgassing measurement results below are obtained after bakeout of the magnet yoke segments and coil units. Results are obtained at room temperature, 10 hours after TMP start. Vacuum level 1e-7 mbar (1e-5 Pa or 7.5e-8 Torr).

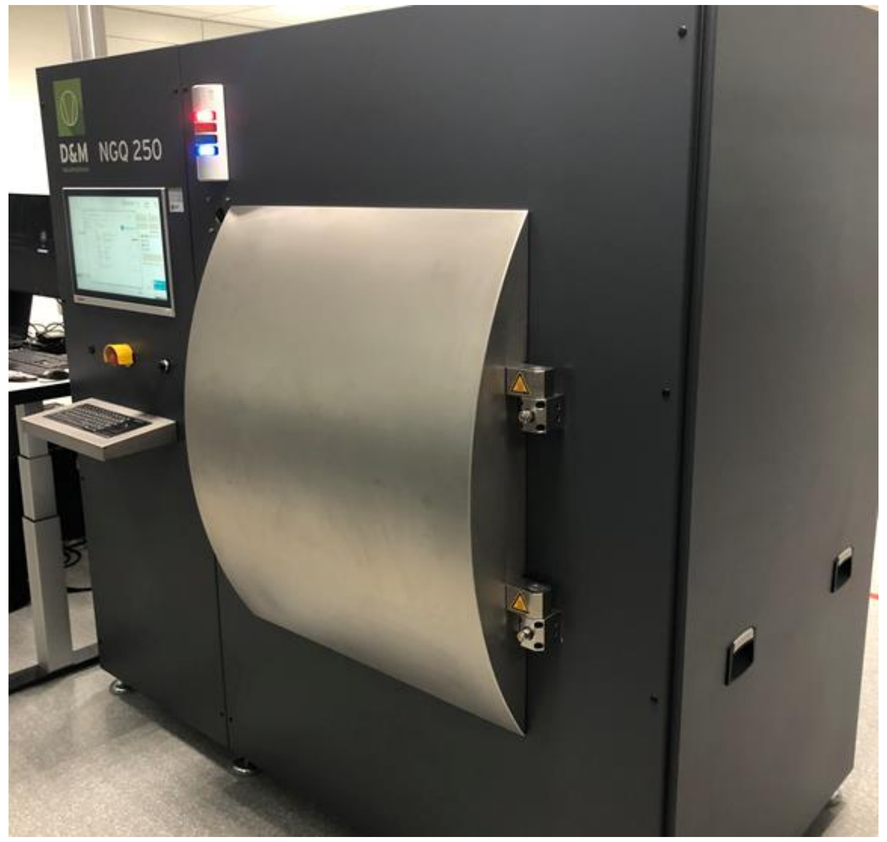
Gryphon-MY-L-24



Gryphon-CU-L-12-C



Outgassing measurements



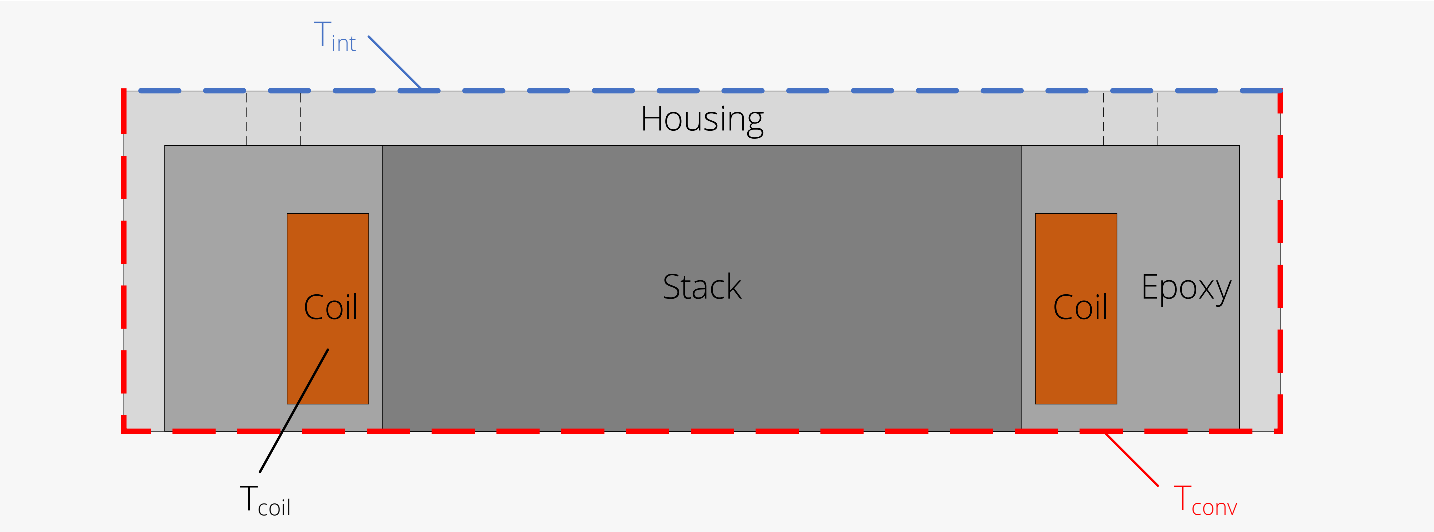
Top picture: In-house RGA equipment
Bottom Picture: In-house bake out equipment

DEFINITIONS

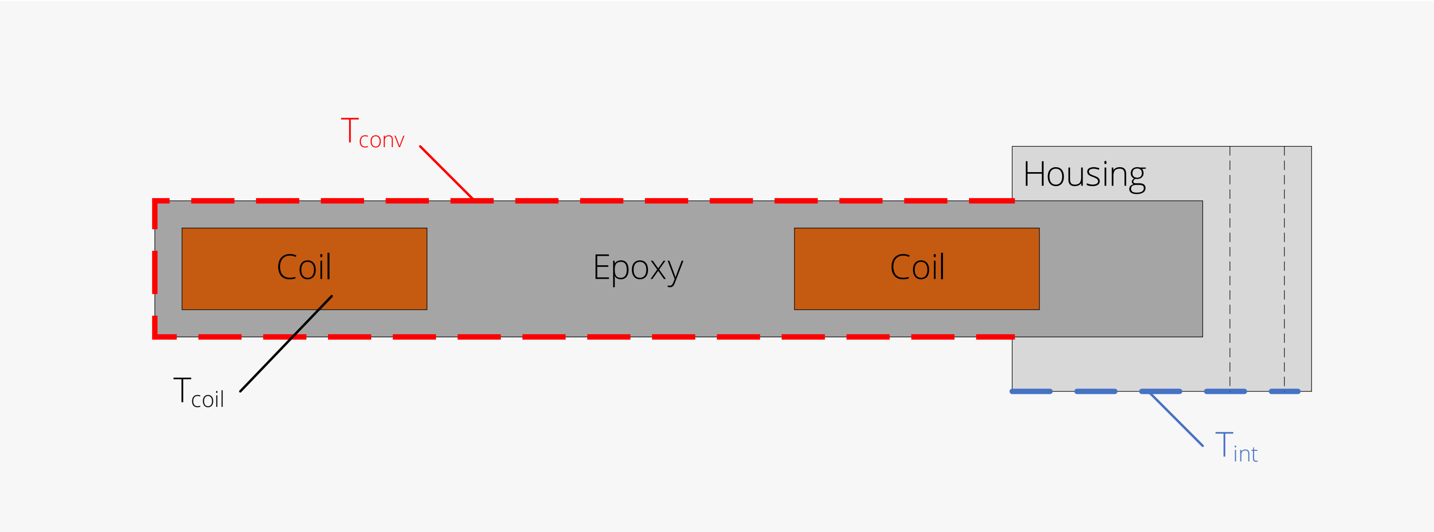
Parameter	Symbol / Equation	Unit	Remarks
Coil temperature	T_{coil}	°C	Average temperature over the complete coil volume
Interface temperature	T_{int}	°C	Average temperature over the complete interface surface
Convective surface temperature	T_{conv}	°C	Average temperature over the complete convective surface
Thermal resistance	$R_{th,i}$	K/W	From average coil temperature to average interface temperature
Thermal resistance	$R_{th,c}$	K/W	From average coil temperature to average convective surface temperature
Thermal time constant	τ_{th}	s	The time to reach 63.7% of the steady state temperature considering T_{int} = 20°C

The actual continuous force is strongly dependent on the cooling conditions available in the application. Depending on the situation (vacuum environment, natural convection, forced convection or other), the thermal resistances of the coil unit ($R_{th,i}$ and $R_{th,c}$) should be combined with the thermal resistances of the cooling interfaces to determine the overall thermal resistance (R_{th}). This overall thermal resistance provides the maximum dissipated power and continuous force.

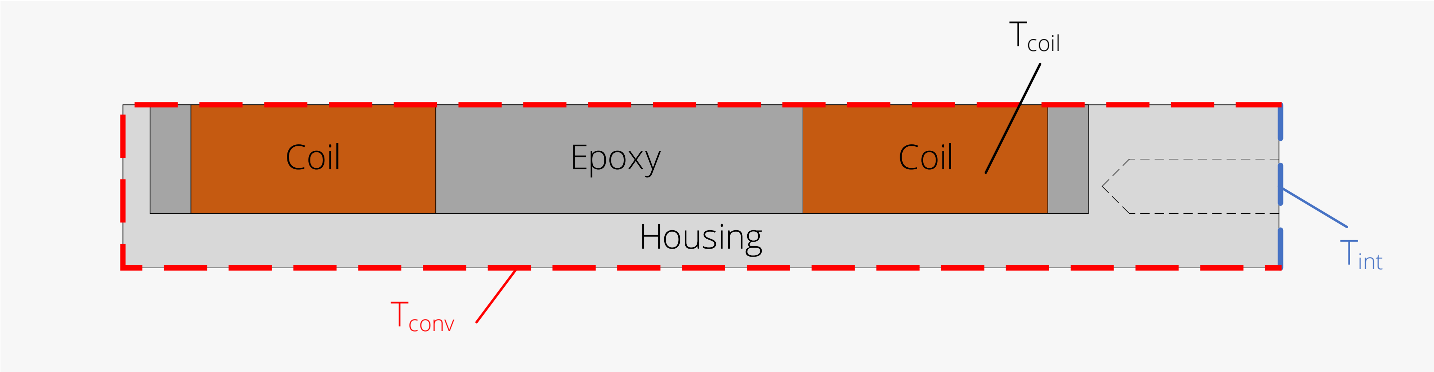
Please contact us for any support to calculate your specific application.



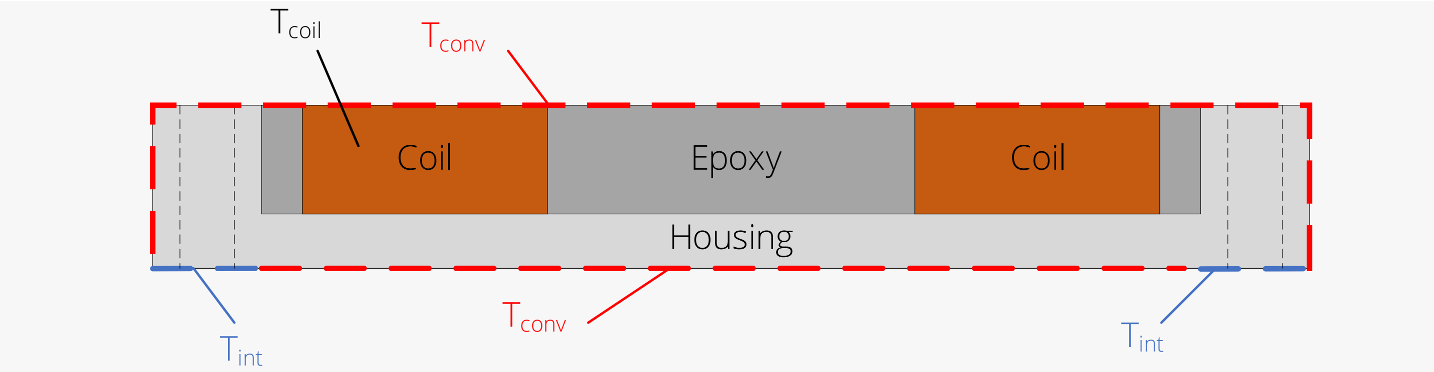
Chiron temperature definitions



Phoenix / Gryphon temperature definitions



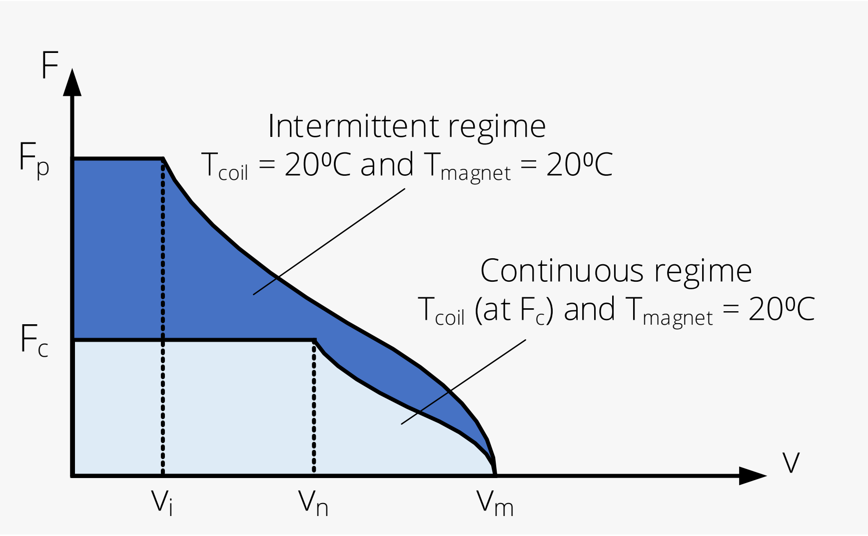
Iris-S temperature definitions



Iris-M/L temperature definitions

DEFINITIONS

Description	Equation	Unit	Remarks
Phase resistance at T_{coil}	$R_{ph} = R_{ph,20}\left(1+0.0039(T_{coil}-20)\right)$	Ohm	
Force constant at no load	$K_{f,0} = \sqrt{3/2}\,K_{e,ll,p}$	N/A_{rms}	For Phoenix and Gryphon: $K_{f,0} = K_f$.
Continuous dissipation	$P_{d,c} = (T_{coil}-T_{int})/R_{th,i}$	W	Only copper losses are considered. This catalog considers T_{int} = 20ºC and only heat dissipation towards the interface.
Peak dissipation	$P_{d,p} = C_{th}\alpha_T$	W	α_T is mentioned at the peak force specification. C_{th} is the heat capacitance of the coils only and not specified seperately in the catalog.
Continuous rms current	$I_c = \min\left(\sqrt{\frac{P_{d,c}}{3R_{ph}}}, \frac{V_{dc}}{\sqrt{6}R_{ph}}\right)$	A_{rms}	Limited either by continuous dissipation or dc voltage and resistance or connector ratings (if applicable).
Peak rms current	$I_p = \min\left(\sqrt{\frac{P_{d,p}}{3R_{ph,20}}}, \frac{V_{dc}}{\sqrt{6}R_{ph,20}}\right)$	A_{rms}	Limited either by peak dissipation or dc voltage and resistance or connector ratings (if applicable).
Continuous force	$F_c = K_{f,c}I_c$	N	For Phoenix and Gryphon: $K_{f,c} = K_f$.
Peak force	$F_p = K_{f,p}I_p$	N	For Phoenix and Gryphon: $K_{f,p} = K_f$.
Steepness	$S = \frac{K_{f,0}^2}{3R_{ph,20}}$	N^2/W	For Phoenix and Gryphon: $K_{f,0} = K_f$.
Maximum velocity (F = 0)	$v_m = \frac{V_{dc}}{K_{e,ll,p}}$	m/s	Iron losses are not considered.
Maximum velocity ($F = F_p$)	$v_i = \left(\tau_p\sqrt{6\tau_p^2K_{f,p}^2V_{dc}^2+54\pi^2(L_{ph}^2I_p^2V_{dc}^2-6L_{ph}^2R_{ph,20}^2I_p^4)}-6\tau_p^2K_{f,p}R_{ph,20}I_p\right)\left(2\tau_p^2K_{f,p}^2+18\pi^2L_{ph}^2I_p^2\right)^{-1}$	m/s	For Phoenix and Gryphon: $K_{f,p} = K_f$. Iron losses are not considered.
Maximum velocity ($F = F_c$)	$v_n = \left(\tau_p\sqrt{6\tau_p^2K_{f,c}^2V_{dc}^2+54\pi^2(L_{ph}^2I_c^2V_{dc}^2-6L_{ph}^2R_{ph,100}^2I_p^4)}-6\tau_p^2K_{f,c}R_{ph,100}I_c\right)\left(2\tau_p^2K_{f,c}^2+18\pi^2L_{ph}^2I_c^2\right)^{-1}$	m/s	For Phoenix and Gryphon: $K_{f,c} = K_f$. Iron losses are not considered.



Force-velocity curves

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