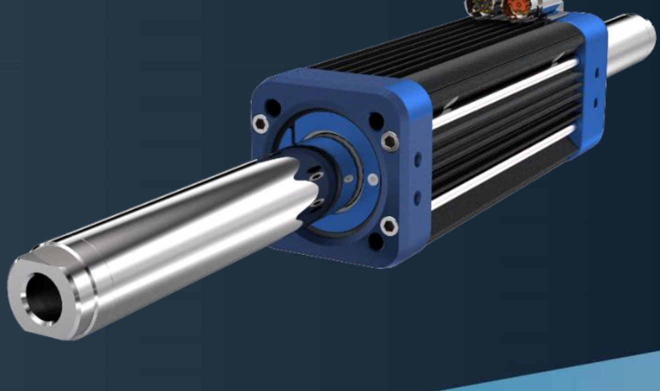
ANCA motion

Motion Control Solutions

LinX M-Series Linear Motor – User Guide



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LinX M-Series Linear Motor – User Guide

Catalogue Number: TLMM-xxxx-xxxx-x & TLS30-xxxx-S

Document Reference: AMDOC-000520 Rev 02

Effective: 22/12/2021

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1 Introduction

1.1 About this User Guide

This user guide provides the required information for installation planning, installation and servicing of the LinX® M-series tubular linear motor. It has been written specifically to meet the needs of qualified engineers, tradespersons, technicians and operators.

1.2 Terms and Abbreviations

GND	Ground
rms	root mean square
V / mV	Volt / millivolt
A / mA	Ampere / milliampere
Ω	ohms
AC / DC	Alternating Current / Direct Current
Hz	Hertz
ms	millisecond
AICD	Automatic Implantable Cardioverter-Defibrillator
EMC	Electromagnetic Compatibility

1.3 Trademarks

LinX® is a registered trademark of ANCA Motion Pty Ltd.

2 Product Overview

2.1 About LinX® M-Series

The ANCA Motion LinX® M-series products are 3-phase permanent magnet synchronous tubular linear motors designed to provide a flexible and high-performance linear motion solution. The cylindrical design allows for a high flux linkage without strong attractive or cogging forces seen in flat-bed linear motors and provides continuous forces in the range 80N to 280N and peak forces from 640 N to 1280 N.

LinX® M-series linear motors consist of a shaft containing strong rare-earth magnets and a forcer containing wound copper coils that when energised provide axial force between the shaft and forcer. M-series motors can be driven by standard servo drives and have integrated sensor to provide position feedback meaning that external sensor products are not required to run the motor. The motor housing forms part of the magnetic circuit increasing the motor force constant by ensuring minimal leakage flux. The M-series motor has several mounting and cooling options available, including a heatsink, fan kit or water-cooling jacket. In non-contact operation the shaft and forcer are separated by an air gap allowing for low maintenance requirements and long service lifetimes. Alternatively, the motor can be run with a bushing inserted between the shaft and forcer providing both alignment and support. When the configuration includes a bushing, external linear rails may not be required, which simplifies the system design and setup cost.

LinX® M-series has been specially designed as a flexible linear motion solution to cater for a wide range of automation, positioning and dynamic movement applications.

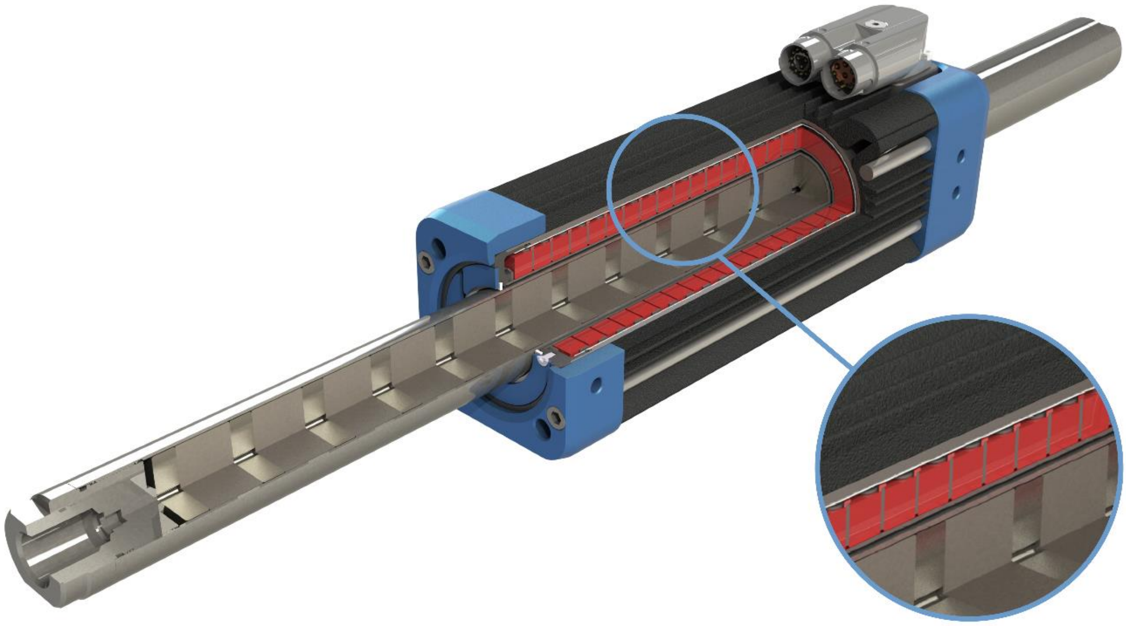


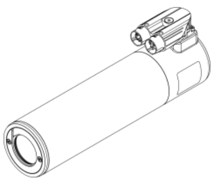
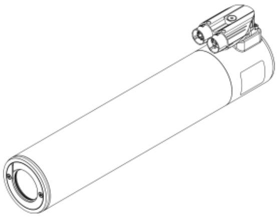
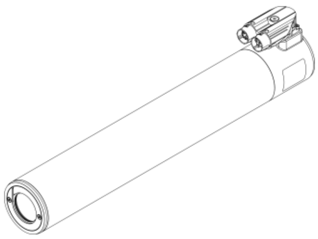
Figure 2-1 – M-series tubular linear motor structure

2.2 Product Range

2.2.1 Forcers

The forcer unit contains the motor windings that produce force against the shaft field as well as the internal sensor which provides feedback.

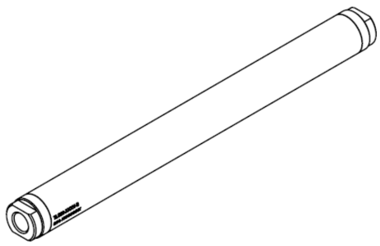
There are five different forcer variants in the M-series motor range. The five options consist of three different lengths and two winding variants. Longer forcers can produce greater continuous and peak force output than the shorter models, however they result in less stroke. Within the same forcer size models with several different force constants may be available. A higher forcer constant will allow for a greater force to be produced with at a lower motor current, but at the cost of increased back EMF which the servo drive must have enough voltage available to overcome. The back EMF is larger at high speed, meaning that a lower force constant may be desirable for high speed applications (see *3.1.3 Force vs Speed Characteristics*). In general, winding variants allow for greater flexibility in matching the motor and drive rating, but do not alter the continuous force rating or power capability of the motor.

TLMM-15P0-RE10 **TLMM-15H0-RE10**	**TLMM-22P0-RE10**	**TLMM-30P0-RE10** **TLMM-30H0-RE10**
		
Peak Force: 643 N	Peak Force: 965 N	Peak Force: 1287 N
Cont. Force /w Heatsink: 80 N	Cont. Force /w Heatsink 120 N	Cont. Force /w Heatsink: 155 N
Cont. Force /w Water Jacket: 148 N	Cont. Force /w Water Jacket: 222 N	Cont. Force /w Water Jacket: 287 N
Length: 221 mm	Length: 296 mm	Length: 371 mm

Refer to *3 Specifications* for more detailed information on performance of each forcer model.

2.2.2 Shafts

The M-series shafts consist of a stack of magnets enclosed in a stainless steel tube of outer diameter of 30mm. The internal magnets alternate between North and South orientations at a pitch of 50mm to provide the strong magnetic field which the forcer coils react against to produce linear motion. Shafts can be ordered in various lengths in order to suit the particular user application and are available in increments of the magnetic pitch of 50mm (see *2.3.3.1 Shaft – Length Options*). Note that either the forcer or the shaft can be moving element depending on how the system is designed. Accordingly, the shaft can be mounted into a user machine/application in several different configurations and depending on the configuration chosen either an internal bush *(section 2.3.2.7)* to locate the forcer relative to the shaft, or a linear rails to guide the shaft within the forcer, or both, will be required (see *section **4.2*** for more detailed info). The physical air-gap between the shaft and the force when a bushing is not used is 0.9mm when aligned correctly.



WARNING: The shaft produces a very strong magnetic field, always use caution when handling. To avoid injury, keep fingers and other body parts clear.

WARNING: Cylindrical motor shafts contain powerful permanent magnets. People with pacemakers, AICD or similar medical devices should not handle or work closely with the magnetic shaft.

2.2.3 Accessories

Forcers can be used with several different accessories which allow for flexibility in mounting configuration, as well as providing several different options for cooling the motor. These include mounting kits, heatsinks, fan-cooling kits, water-cooling jackets and internal bushes. More details on the forcer accessories available can be found in *section 2.3.2*.

The shafts are also available to be bought with a variety of optional mounting accessories to suit the user's specific requirements. Details of these accessories can be found in *section 2.3.4*.

2.3 Part Numbers and Dimensions

2.3.1 Forcer Catalogue Numbers

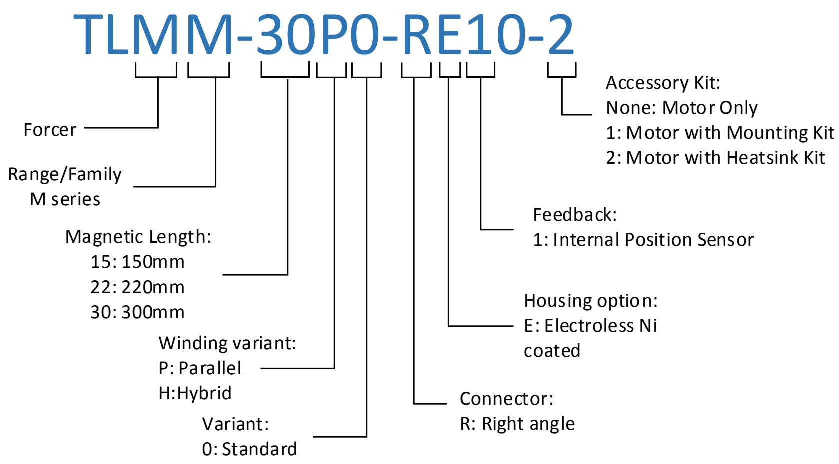


Figure 2-2 - Forcer catalogue number

The structure of the forcer catalogue number is shown above. The first four digits TLMM indicate a Tubular Linear Motor from M-series. The next fifth and sixth digits indicate the motor length, in particular, the length of coil occupation. The seventh digit is the winding type that can be either parallel or hybrid depending on the internal coil connection. The H variant has twice the force constant than the P variant. The ninth digit is connector type, tenth is the housing type and eleventh is the internal sensor type. Currently, only a single option is available for connector, housing and sensor types.

Lastly, the thirteenth digit allows the user to specify that the motor will come bundled with a specific forcer accessory kit. In particular, "-1" indicates a forcer with a mounting kit and "-2" indicates a forcer with a heatsink kit.

Catalogue Number with kit option	Parts Received
TLMM-15xx-xxxx-1	TLMM-15xx-xxxx 630-0-00-4079
TLMM-22xx-xxxx-1	TLMM-22xx-xxxx 630-0-00-4080
TLMM-30xx-xxxx-1	TLMM-30xx-xxxx 630-0-00-4081
TLMM-15xx-xxxx -2	TLMM-15xx-xxxx 630-0-00-4072
TLMM-22xx-xxxx -2	TLMM-22xx-xxxx 630-0-00-4073
TLMM-30xx-xxxx -2	TLMM-30xx-xxxx 630-0-00-4074

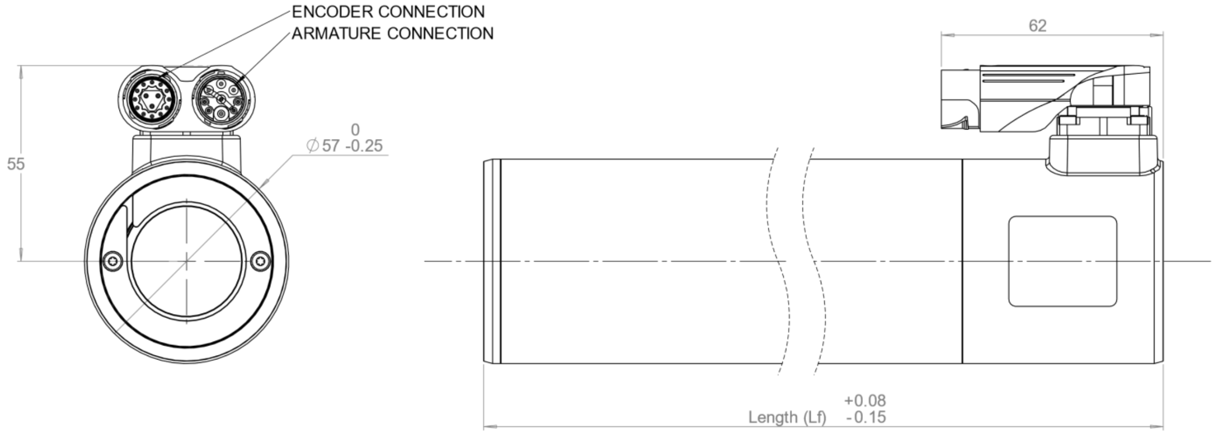
Table 2-1 - Forcer Kit Catalogue Numbers

2.3.2 **Forcer and Mounting Kit Dimensions**

This section contains part number information and dimensional drawings for the forcers and the various forcer mounting options which are available. The necessary combination of mounting and cooling accessories will depend on the application requirement and should be determined at the system design stage.

2.3.2.1 **Forcer**

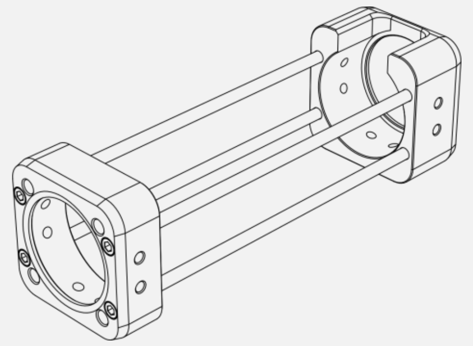
The forcer dimensions are shown in the drawings below. Typical installation of the forcer will use ANCA Motion mounting and cooling accessories which clamp over the cylindrical motor body to provide flat mounting surfaces and improved thermal performance.



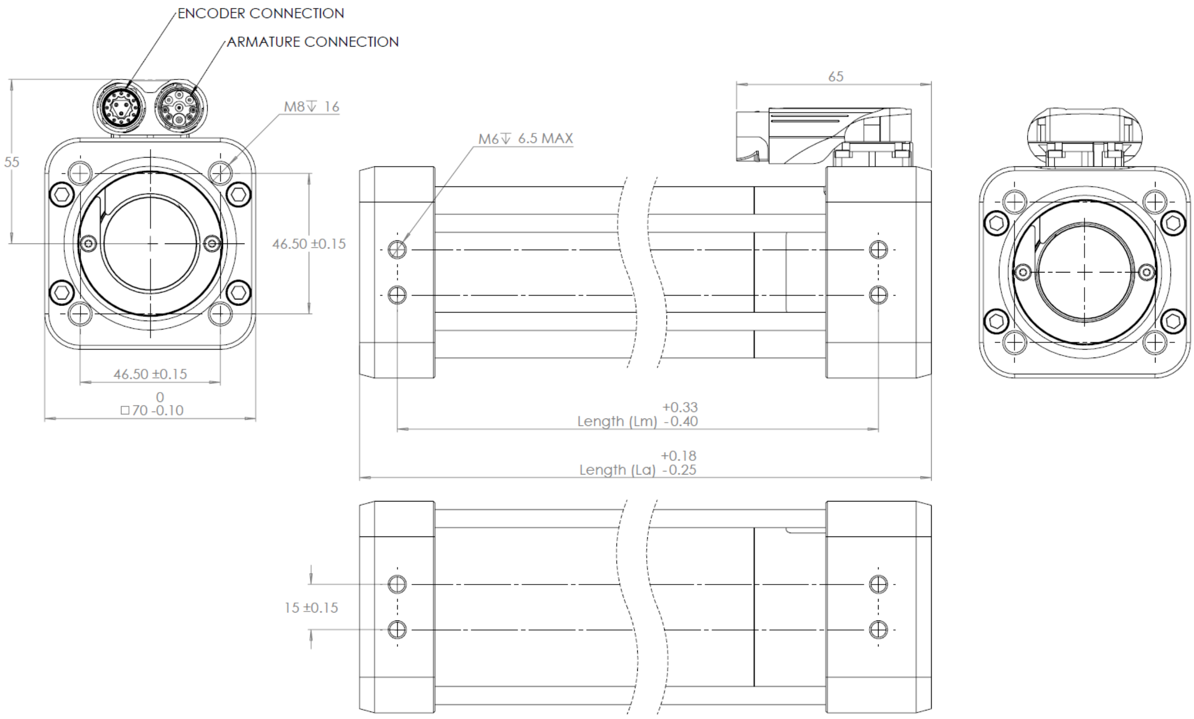
Part Number	Lf (mm)
TLMM-15xx-RExx	221.00
TLMM-22xx-RExx	296.00
TLMM-30xx-RExx	371.00

2.3.2.2 Mounting Kit

The standard mounting kit allows the round bore motor to be mounted against a flat surface or with ISO 15552 standard accessories and brackets. The kit consists of two anodized aluminum end-caps, stainless steel connecting rods and accompanying barrel nuts. Motor force ratings for this configuration correspond to the 'without cooling' values quoted in *Table 3-1.* The mounting kit comes in three different length variants to match against the short, medium and long forcers.

	Part Number	Description	Weight (kg)
	630-0-00-4079	MOUNTING KIT LinX® M SERIES TLMM-15	0.51
	630-0-00-4080	MOUNTING KIT LinX® M SERIES TLMM-22	0.58
	630-0-00-4081	MOUNTING KIT LinX® M SERIES TLMM-30	0.65

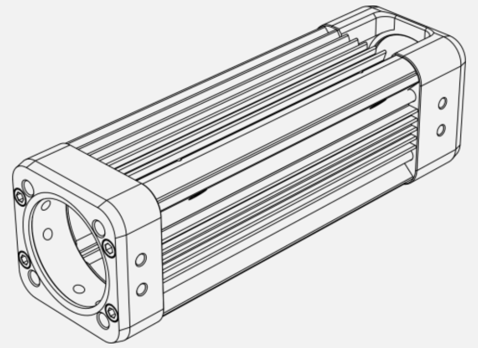
Installed dimensions



Part Number	La (mm)	Lm (mm)
TLMM-15xx-RExx-1	227.00	197.00
TLMM-22xx-RExx-1	302.00	272.00
TLMM-30xx-RExx-1	377.00	347.00

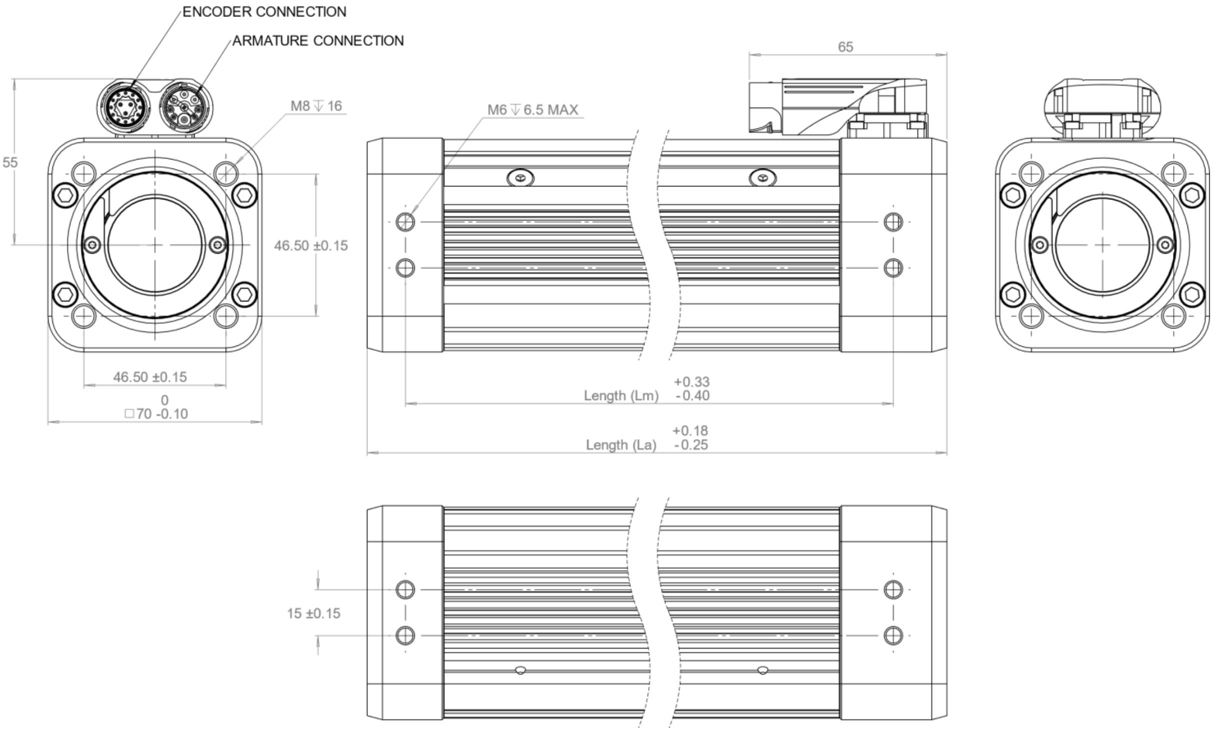
2.3.2.3 Heatsink Kit

The heatsink kit includes the standard mounting components from *section 3.2.3.1.1* above plus a finned aluminium heatsink that is clamped to the outer bore of the motor. The finned heatsink is the standard cooling option for the motor and corresponds to the 'heatsink' force ratings listed in *Table 3-1*. The heatsink kit comes in three different length variants to match the short, medium and long forcers. Instructions on installation of the heatsink and mounting endcaps can be found in *section* ***5.3.2***.



Part Number	Description	Weight (kg)
630-0-00-4072	HEATSINK KIT LinX® M SERIES TLMM-15	0.96
630-0-00-4073	HEATSINK KIT LinX® M SERIES TLMM-22	1.22
630-0-00-4074	HEATSINK KIT LinX® M SERIES TLMM-30	1.49

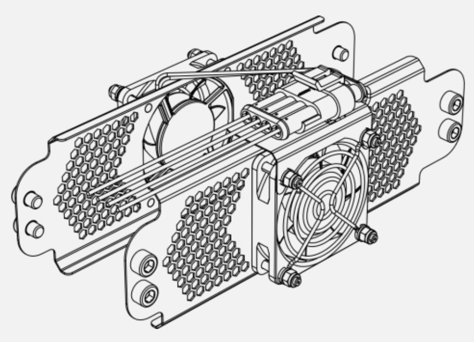
Installed dimensions



Part Number	La (mm)	Lm (mm)
TLMM-15xx-RExx-2	227.00	197.00
TLMM-22xx-RExx-2	302.00	272.00
TLMM-30xx-RExx-2	377.00	347.00

2.3.2.4 IP67 Fan Kit

The IP67 fan kit options can be used in addition to the heatsink to achieve improved continuous force rating of the motor due to increased air-flow over the fins. The motor force ratings for this configuration correspond to the 'HS + fan-forced' values quoted in *Table 3-1*. The IP67 fan kit includes two fans, two fan guards, IP67 rated connector, two mounting brackets and accompanying screws. The IP67 fan kit is a direct bolt-on accessory which uses four of the external mounting holes on the standard endcaps to affix the fan mounting plates. The IP67 fan kit comes in three different length variants to match the short, medium and long forcers.

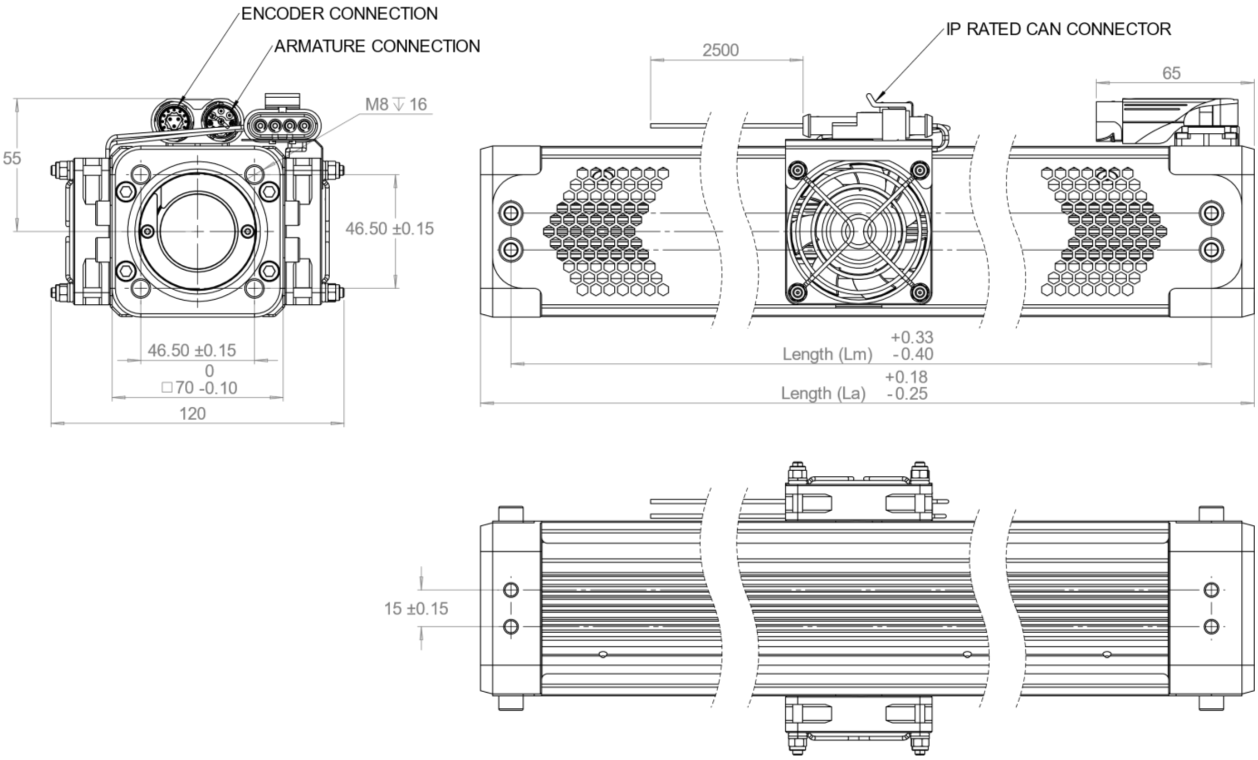
	Part Number	Description	Weight (kg)
	630-0-00-4065	FAN KIT IP67 LinX® M SERIES TLMM-15	0.32
	630-0-00-4066	FAN KIT IP67 LinX® M SERIES TLMM-22	0.40
	630-0-00-4067	FAN KIT IP67 LinX® M SERIES TLMM-30	0.47

The fans are pre terminated to an IP rated connector and 2.5m, 20 AWG Flying leads for ease of installation. The fan specifications are defined below (ratings listed are per fan).

Rated Voltage (V)	Operating Voltage (V)	Current (A)*	Input Power (W)*	Noise (dB)*
24	10-27.6	0.07	1.68	36.5

* Values are based on each fan in free air, application conditions may affect these values.

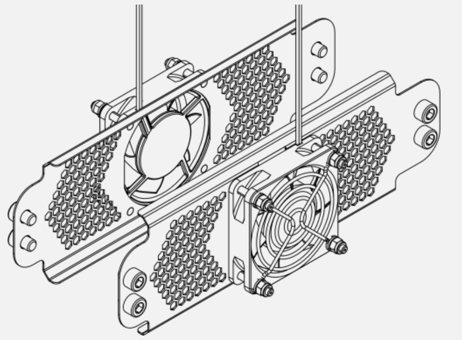
Installed Dimensions



Part Number	La (mm)	Lm (mm)
TLMM-15xx-RExx-2 630-0-00-4065	227.00	197.00
TLMM-22xx-RExx-2 630-0-00-4066	302.00	272.00
TLMM-30xx-RExx-2 630-0-00-4067	377.00	347.00

2.3.2.5 Fan Kit

The fan kit options can be used in addition to the heatsink to achieve improved continuous force rating of the motor due to increased air-flow over the fins. The motor force ratings for this configuration correspond to the 'HS + fan-forced' values quoted in *Table 3-1.* The fan kit includes two fans with flying leads, two fan guards, two mounting brackets and accompanying screws. The fan kit is a direct bolt-on accessory, using four of the external mounting holes on the standard endcaps to affix the fan mounting plates. The fan kit comes in three different length variants to match the short, medium and long forcers.



Part Number	Description	Weight (kg)
630-0-00-4057	FAN KIT LinX® M SERIES TLMM-15	0.32
630-0-00-4058	FAN KIT LinX® M SERIES TLMM-22	0.40
630-0-00-4059	FAN KIT LinX® M SERIES TLMM-30	0.47

The fan specifications are defined below (ratings listed are per fan).

Rated Voltage (V)	Operating Voltage (V)	Current (A)*	Input Power (W)*	Noise (dB)*
24	10-27.6	0.07	1.68	36.5

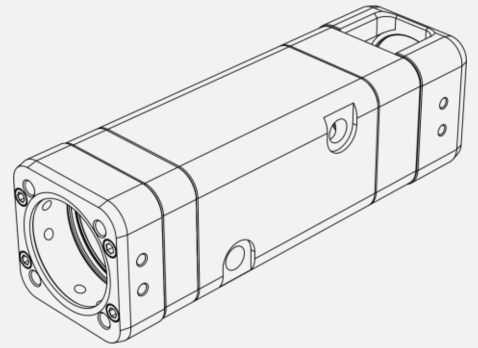
* Values are based on each fan in free air, application conditions may affect these values.

The non IP67 fan kit variant use the same fans and sheet metal mounting as the IP67 Kits, and therefore the same external dimensions, however the connector, lead extensions and connector bracket are removed.

2.3.2.6 **Water Cooling Kit**

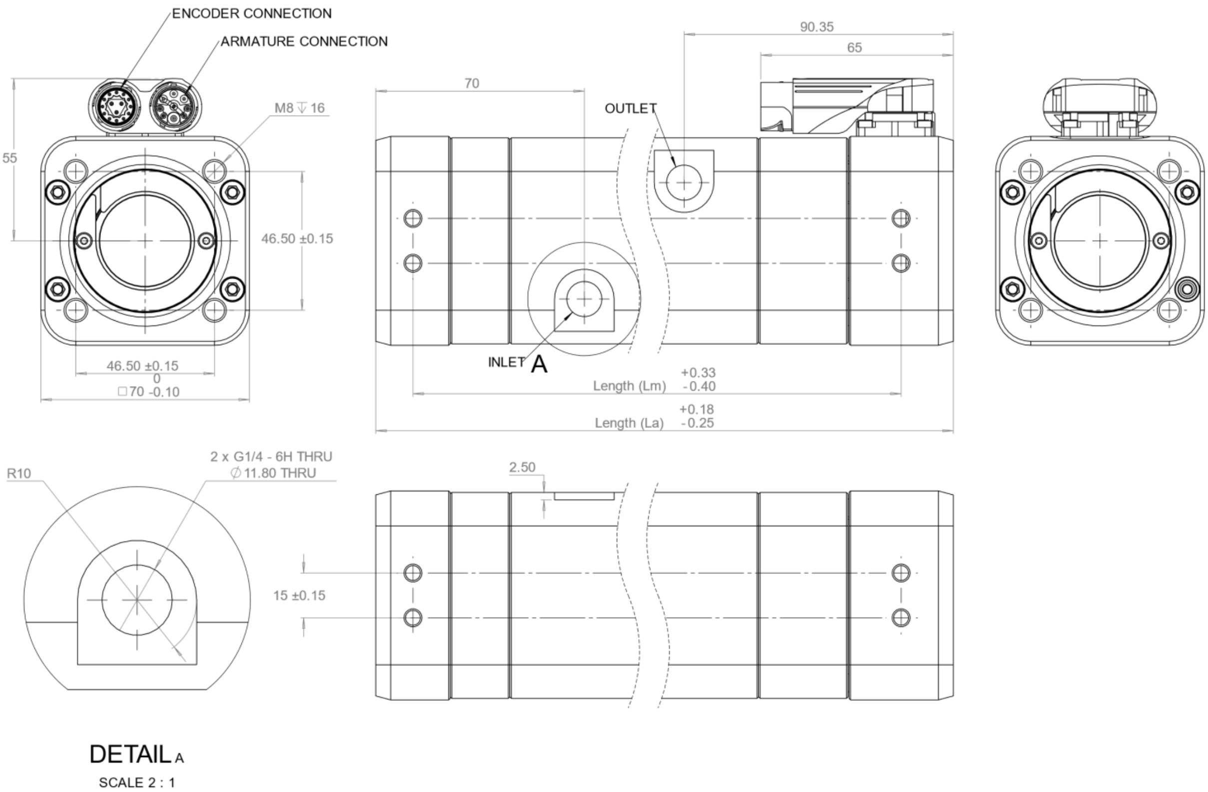
The water-cooling jacket functions by creating a fluid gallery around the outer motor bore through which coolant is circulated for efficient heat transfer. Using the water-cooling jacket kit provides the best possible cooling performance and the highest continuous force from the motor (*See Table 3-1*). When using the water-cooled jacket kit option, the heatsink and mounting kit are not required, as endcaps and mounting screws are included in the water-cooling kit. Instructions on installation can be found in *section* ***5.3.2.4***. The water-cooling kit comes in three different length variants to match against the short, medium and long forcers.

The cooling jacket center section can be rotated at 90 degree increments to allow for the inlet and outlet ports to be relocated. Note the water-cooling kit does not come with hose fittings.



Part Number	Description	Weight (kg)
630-0-00-4061	LIQUID COOLING KIT LinX® M SERIES TLMM-15	1.09
630-0-00-4062	LIQUID COOLING KIT LinX® M SERIES TLMM-22	1.43
630-0-00-4063	LIQUID COOLING KIT LinX® M SERIES TLMM-30	1.77

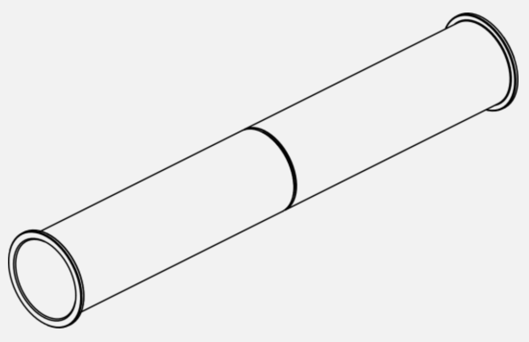
Installed Dimensions



Part Number	La (mm)	Lm (mm)
TLMM-15xx-RExx 630-0-00-4061	227.00	197.00
TLMM-22xx-RExx 630-0-00-4062	302.00	272.00
TLMM-30xx-RExx 630-0-00-4063	377.00	347.00

2.3.2.7 Bushing Kit

The bush insert is installed into the central bore of the forcer and will locate the forcer against the magnetic shaft. The bush accessory allows for multiple shaft and forcer mounting configuration where there is physical contact between shaft and forcer, as opposed to an air-gap operation (*see section* ***5.2*** for more details). The bush will wear over time due to physical contact with the shaft. Depending on the duty cycle and application, the bush may need to be replaced after prolonged use (see ***4.3 Internal Bushings*** for more details). Note that two bushing sleeves (630-0-00-4045) are required per forcer, one for each end of the motor and hence two bushing sleeves are provided in the bush kit (630-0-00-4082).

	Part Number	Description
	630-0-00-4082	BUSHING KIT TLMM TYPE 1*

***The bushing kit contains two bushing sleeves, one for each end of the motor.**

2.3.3 Shaft Catalogue Numbers

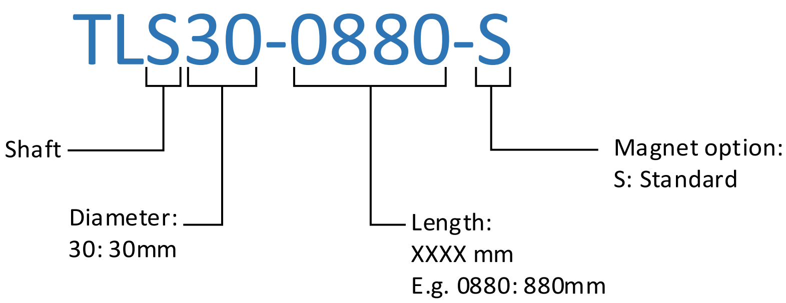
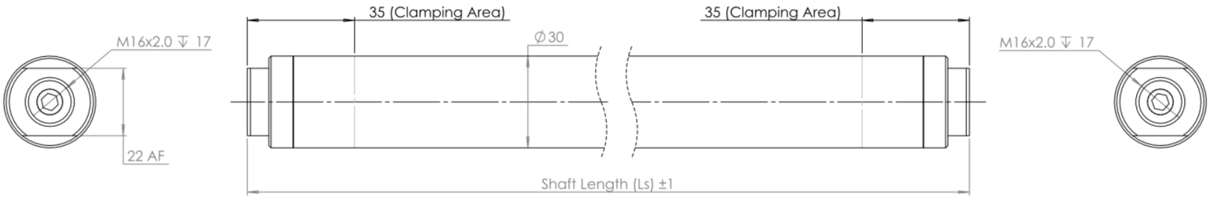


Figure 2-3 - Shaft catalogue numbers

The structure of the shaft catalogue number is shown above. The first five digits indicate a Tubular Linear Shaft of diameter 30mm. The next four digits denote the shaft length. Shafts are available from 330mm to 2130mm in increments of 50mm, refer to *Table 2-2* for a complete list of available shafts, along with the achievable stroke when paired with a forcer in the double mount configuration. The final digit denotes standard magnet type.

2.3.3.1 Shaft – Length Options

The LinX® M series motor uses the TLS30 linear motor shaft with a 30mm OD and dimensions as shown below. The shaft can be mounted either by clamping or by attaching to the M16 female thread. Note that the 35mm clamping area shown below is the region where the clamp should be fitted. Clamping outside of this area can damage the shaft due to compression directly onto the active magnetic material.



Shafts are manufactured in 50mm length increments up to a maximum length of 2130mm.
Table 2-1 below shows the overall length and weight of each shaft option, along with an example expected stroke when using double support mounting (*section **0***). Specifically, the stroke displayed here is based on allowing 50mm at one end for the sensor end effect (*section 3.3*) and a clamping length of 22mm at the other end. Note that a different placement of the clamp or use of the M16 thread would lead to different available stroke.

Stroke ranges for other configurations such as single-mount or 'no support' may also increase the amount of stroke available and are discussed in *section **4.2***. The M-series sizing tool has the facility to calculate available stroke based on selected components and can be used when sizing the application.

Part Number	Ls (mm)	Stroke with 72mm total end zone (mm)			Shaft Mass (kg)
		TLMM-15	TLMM-22	TLMM-30	
TLS30-0330-S	330	31			1.74
TLS30-0380-S	380	81	6		2.00
TLS30-0430-S	430	131	56		2.27
TLS30-0480-S	480	181	106	31	2.53
TLS30-0530-S	530	231	156	81	2.79
TLS30-0580-S	580	281	206	131	3.06
TLS30-0630-S	630	331	256	181	3.32
TLS30-0680-S	680	381	306	231	3.58
TLS30-0730-S	730	431	356	281	3.85
TLS30-0780-S	780	481	406	331	4.11
TLS30-0830-S	830	531	456	381	4.37
TLS30-0880-S	880	581	506	431	4.64
TLS30-0930-S	930	631	556	481	4.90
TLS30-0980-S	980	681	606	531	5.16
TLS30-1030-S	1030	731	656	581	5.43
TLS30-1080-S	1080	781	706	631	5.69
TLS30-1130-S	1130	831	756	681	5.96
TLS30-1180-S	1180	881	806	731	6.22
TLS30-1230-S	1230	931	856	781	6.48
TLS30-1280-S	1280	981	906	831	6.75
TLS30-1330-S	1330	1031	956	881	7.01
TLS30-1380-S	1380	1081	1006	931	7.27
TLS30-1430-S	1430	1131	1056	981	7.54
TLS30-1480-S	1480	1181	1106	1031	7.80
TLS30-1530-S	1530	1231	1156	1081	8.06
TLS30-1580-S	1580	1281	1206	1131	8.33
TLS30-1630-S	1630	1331	1256	1181	8.59
TLS30-1680-S	1680	1381	1306	1231	8.85
TLS30-1730-S	1730	1431	1356	1281	9.12
TLS30-1780-S	1780	1481	1406	1331	9.38
TLS30-1830-S	1830	1531	1456	1381	9.64
TLS30-1880-S	1880	1581	1506	1431	9.91
TLS30-1930-S	1930	1631	1556	1481	10.17
TLS30-1980-S	1980	1681	1606	1531	10.43
TLS30-2030-S	2030	1731	1656	1581	10.70
TLS30-2080-S	2080	1781	1706	1631	10.96
TLS30-2130-S	2130	1831	1756	1681	11.23

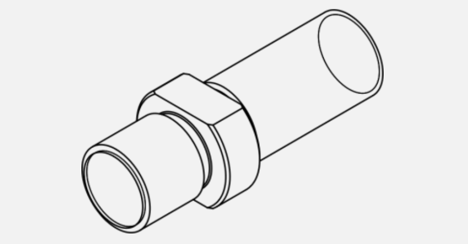
Table 2-2 - Available TLS30 shaft lengths

2.3.4 **Shaft accessories**

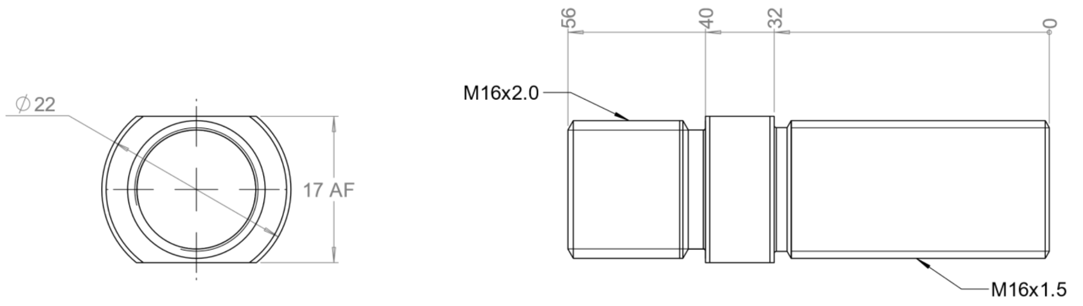
There are multiple shaft accessories available from ANCA Motion to make the installation of the motor easier. The drawings are also provided here as reference designs, should the customer wish to develop similar attachments integrate the shaft into their application.

2.3.4.1 **ISO15552 Adaptor**

This component allows for the threads in the end of the shaft to be converted to an ISO 15552 – 50 Bore compatible male thread for use with standard pneumatic end accessories like rod ends and clevises.

	Part Number	**Description**
	630-0-00-4068	TLS30 ISO 15552 THREAD ADAPTOR

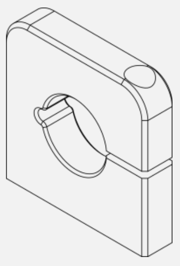
The drawing below is also intended as reference for customer designs.



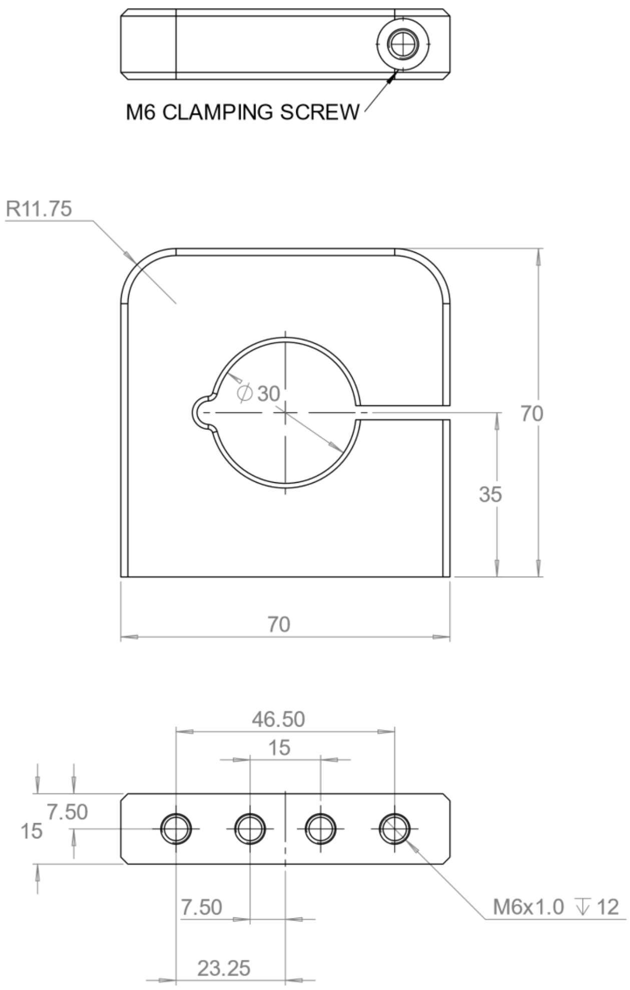
2.3.4.2 Shaft Clamp Kit

This simple mounting plate allows for one end of the shaft to be rigidly clamped. The component has mounting holes at the same spacing as the forcer to allow for easy design integration. The M6 Clamping screw should be done up to 5 Nm to stop the shaft from slipping

The mounting plate has mounting holes at the same spacing as the motor to allow for easy design integration.

	Part Number	Description	Contains
	630-0-00-4077	TLS30 CLAMP MOUNTING KIT	1 x Mounting Plate (630-0-00-4071) 1 x Clamp Screw

The drawing below is also intended as a reference for customer designs.

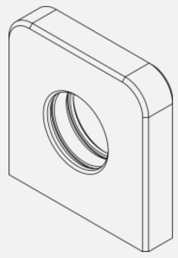


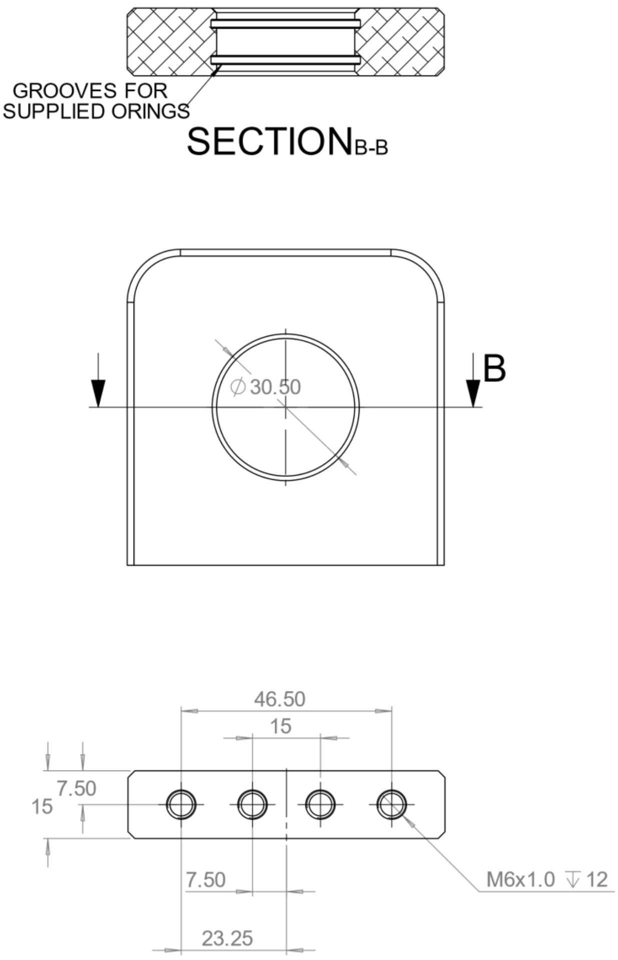
2.3.4.3 Floating Mount kit

This simple mounting plate allows for one end of the shaft to be supported while also allowing for thermal expansion along the length of the shaft. The O-rings provide support but allow the shaft to expand. This mounting also allows for some misalignment between the shaft and the motor and helps to prevent binding when using a bushing.

This mounting must be used with another rigid mounting method as this mounting does not provide enough axial strength to retain the shaft even under small loads.

The mounting plate has mounting holes at the same spacing as the motor to allow for easy design integration.

	Part Number	Description	Contains
	630-0-00-4076	TLS30 FLOATING MOUNTING KIT	1 x Mounting Plate (630-0-00-4070) 2 x NBR O-Rings

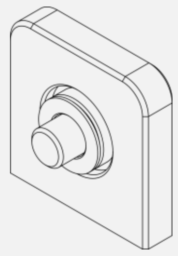


The drawing below is also intended as reference for customer designs.

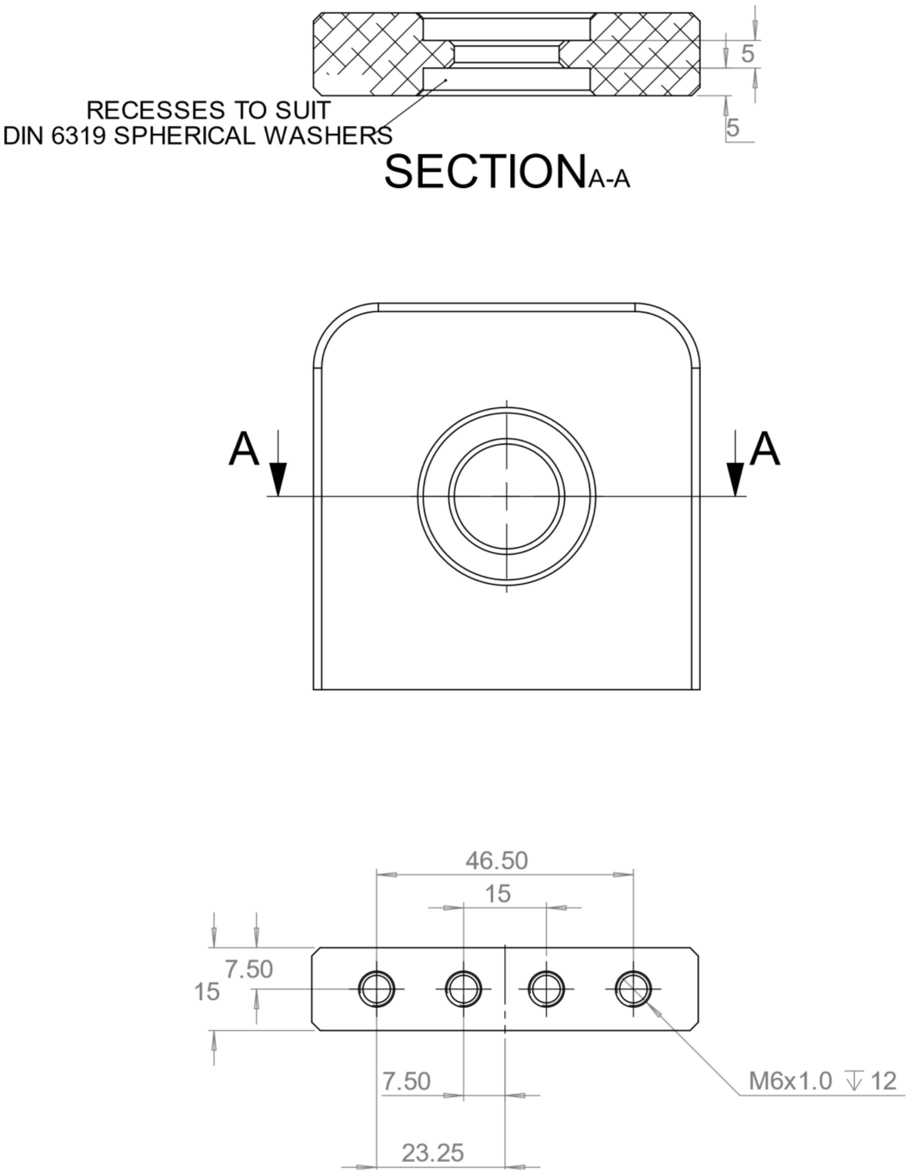
2.3.4.4 Through Mounting Kit

This simple mounting plate allows for one end of the shaft to be rigidly mounted using a spherical washer set. This allows for some misalignment between the shaft and the motor and helps to prevent binding when using a bushing.

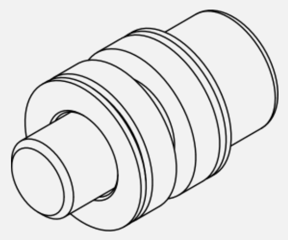
The mounting plate has mounting holes at the same spacing as the motor to allow for easy design integration.

	Part Number	Description	Contains
	630-0-00-4075	TLS30 THROUGH MOUNTING KIT	1 x Mounting Plate (630-0-00-4069) 1 x Spherical Washer Set (630-0-00-4078)

The drawing below is also intended as a reference for customer designs.

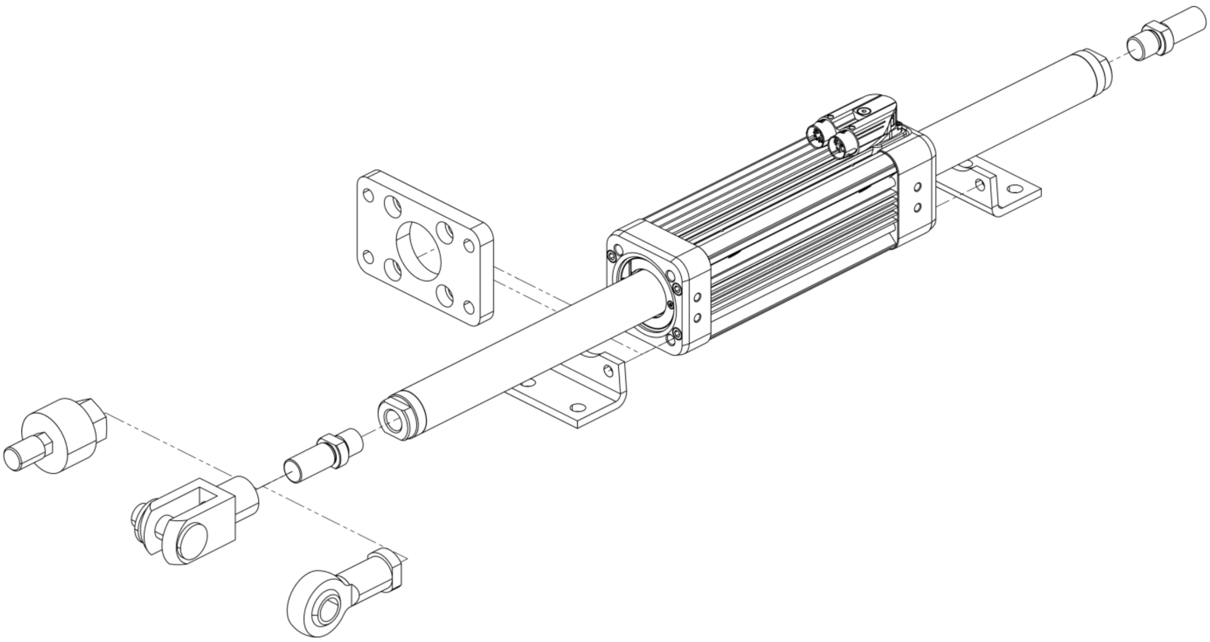


2.3.4.5 Spherical Washer Set

	Part Number	Description	Contains
	630-0-00-4078	TLS30 SPHERICAL WASHER KIT	1 x Mounting Screw 1 x Spherical Washer Male 1 x Spherical Washer Female

2.3.5 ISO 15552 Pneumatic Cylinder Compatibility

The M Series linear motor has been designed with pneumatics retrofit and replacement in mind. The motor mounting accessories and shaft accessories allow for the motor to interface with standard mounting components for a 50mm Bore ISO 15552 Pneumatic Cylinder.

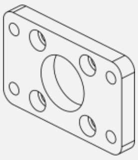
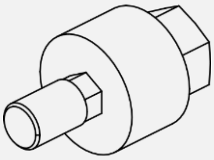
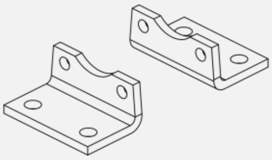
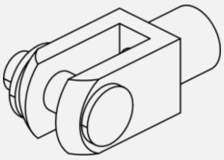
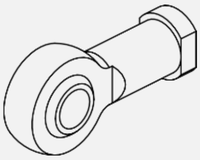


The forcers accessory end caps have four M8 tapped holes for interfacing with standard pneumatics mounting brackets and plates. This reduces the complexity and amount of work required to design the motor into and application as the mounting solution exists as an off the shelf component.

The shaft can be easily adapted to suit the standard pneumatics accessories with the TLS30 ISO15552 Thread Adaptor.

2.3.5.1 ISO 15552 Mounting Accessories

ANCA Motion has the following standard pneumatics mounting parts available for purchase directly.

	AM Part Number	OEM Part Number	Description
	ICN-3069-2071	F5050	SMC FLANGE MOUNT KIT 50 BORE ISO 15552
	ICN-3069-2119	JA50-16-150	SMC SHAFT FLOATING JOINT 50/63 BORE ISO 15552
	ICN-3069-2149	L5050	SMC FOOT MOUNT KIT 50 BORE ISO 15552
	ICN-3069-2150	GKM16-32	SMC SHAFT ROD CLEVIS 50/63 BORE ISO 15552
	ICN-3069-2151	KJ16D	SMC SHAFT BALL JOINT 50/63 BORE ISO 15552

2.3.6 Cable Catalogue Numbers

Both armature and encoder/feedback cables are available for use with the LinX® M-series motors. The catalogue labeling scheme for the M-series cables is as follows.

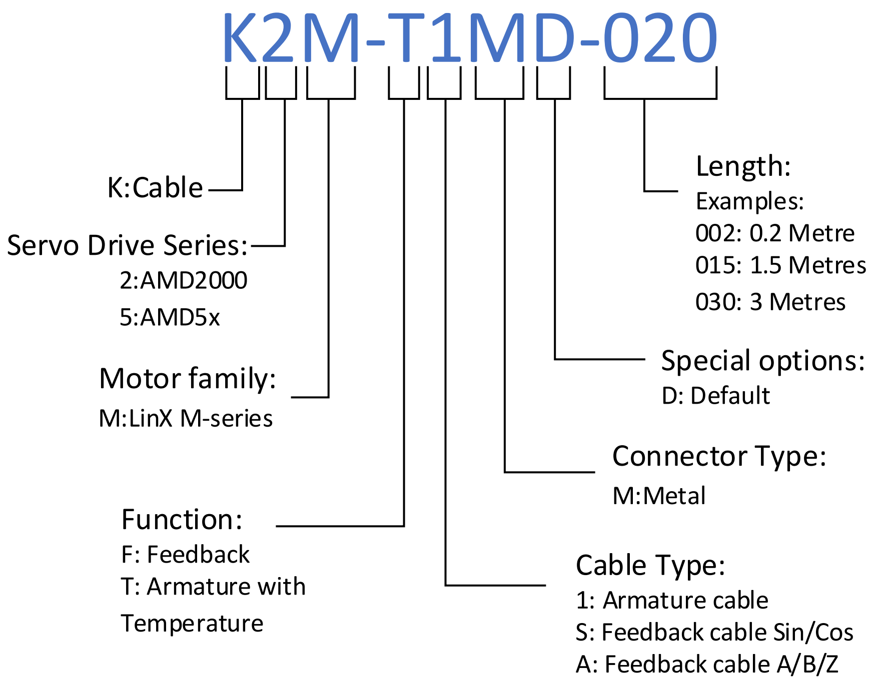


Figure 2-4 - Cable catalogue numbers

The ANCA motion M-series cable range has been designed for use with AMD2000 or AMD5x servo drives. Cable specifications and connections should be checked for compatibility when using third party drives.

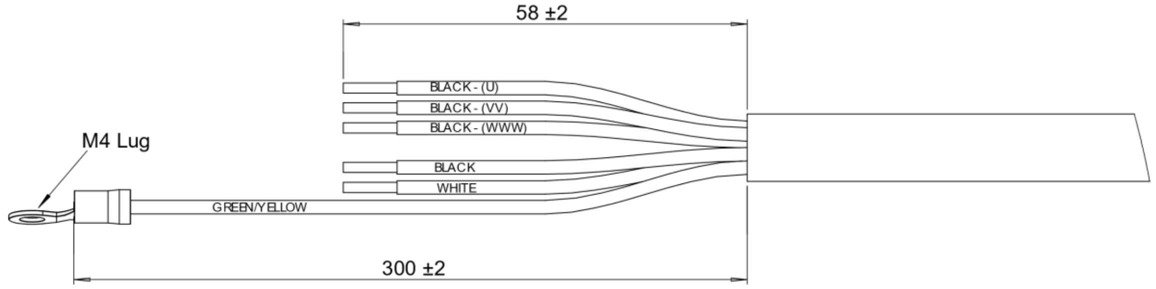
2.3.6.1 Armature Cables

Armature cables for running the M-series motors with AMD2000 or AMD5x drives are listed below. Note that the xxx in the part number is a placeholder for the desired length. The maximum available cable length is 30m.

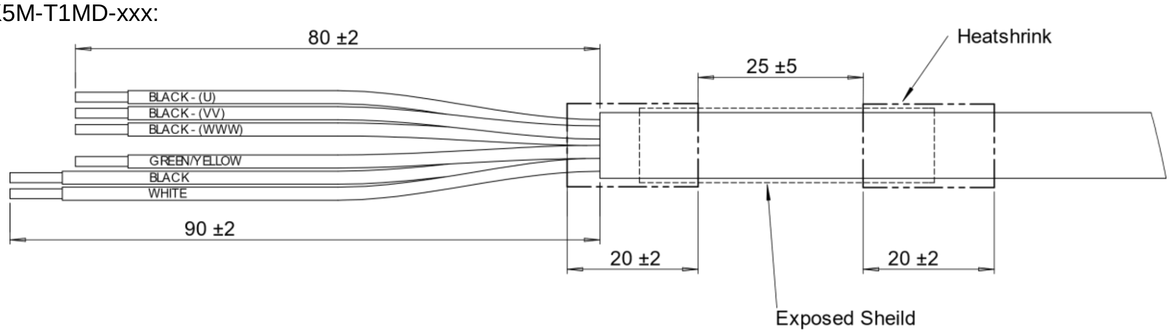
	Part Number	Description
	K2M-T1MD-xxx	ARMATURE CABLE FOR AMD2000 LinX® M MOTOR
	K5M-T1MD-xxx	ARMATURE CABLE FOR AMD5X LinX® M MOTOR

Details of the armature cable flying lead ends (at the drive) are as follows:

K2M-T1MD-xxx:



K5M-T1MD-xxx:



Performance specifications of the armature cables are listed in the table below. In this table "3 + E" indicates 3 power conductors plus an Earth and "S" indicates a shielding braid encompassing the conductors inside brackets.

Parameter	K5M-T1MD-xxx	K2M-T1MD-xxx
Cable Type	Armature - Brake	Armature - Brake
Drive	AMD5x	AMD2000
Motor End Connector	9 Pin Armature	9 Pin Armature
Driver End Connector	Flying Lead	Flying Lead
Conductor Description (# x mm^2)	[(3 + E) x 1.0 + (2 x 0.5)S]S	[(3 + E) x 1.0 + (2 x 0.5)S]S
Cable Outer Diameter (mm)	10	10
Voltage Rating (V)	600/1000	600/1000
Minimum Bending Radius Flexible	OD*10	OD*10
Flexing Operating Temperature (°C)	-5 to 70	-5 to 70
Minimum Bending Radius Static	OD*7.5	OD*7.5
Static Operating Temperature (°C)	-40 to 80	-40 to 80
Drag Chain Suitable	Yes	Yes
Jacket	PUR	PUR
Oil Resistance	Yes	Yes
Colour	Orange	Orange

Table 2-3 - Armature cable performance specifications

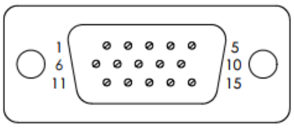
2.3.6.2 Encoder Cables

Encoder cables for running the M-series motors with AMD2000 or AMD5x drives are listed below. Note that the xxx in the part number is a placeholder for the desired length. Type “A” feedback cables are for use with the digital ABZ encoder signal and that type “S” type feedback cables are for use with the analogue Sin/Cos signal.

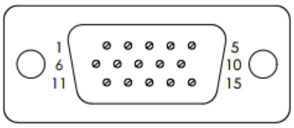
	Part Number	Description
	K2M-FAMD-xxx	ENCODER CABLE FOR AMD2000 LinX® M DIGITAL
	K2M-FSMD-xxx	ENCODER CABLE FOR AMD2000 LinX® M ANALOGUE
	K5M-FSMD-xxx	ENCODER CABLE FOR AMD5X LinX® M ANALOGUE

Details of the drive end connector are as follows below. If using 3rd party drives the connector end may need to be modified to fit your application:

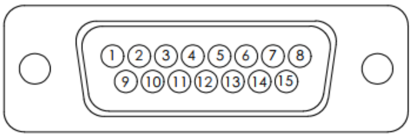
K2M-FAMD-xxx:

Drive End Connector	Pin	Function	Colour
	7	A	Blue
	8	/A	Red
	9	B	Brown
	10	/B	White
	11	Z	Pink
	12	/Z	Grey
	14	+5V	Yellow
	15	GND	Green
	Other	-	n.c.

K2M-FSMD-xxx:

Drive End Connector	Pin	Function	Colour
	2	Sin	Yellow
	1	/Sin	Green
	4	Cos	Black
	3	/Cos	Brown
	6	-	Red
	5	-	Orange
	14	+5V	Brown/Red
	15	GND	Brown/Blue
	Other	-	n.c.

K5M-FSMD-xxx:

Drive End Connector	Pin	Function	Colour
	14	Sin	Yellow
	7	/Sin	Green
	10	Cos	Black
	2	/Cos	Brown
	1	-	Red
	9	-	Orange
	8	+5V	Brown/Red
	15	GND	Brown/Blue
	Other	-	n.c.

Performance specifications of the encoder cables are listed in the table below: In this table S" indicates a shielding braid encompassing the conductors inside brackets.

Parameter	K2M-FAMD-xxx	K2M-FSMD-xxx	K5M-FSMD-xxx
Cable Type	Encoder	Encoder	Encoder
Drive	AMD2000	AMD2000	AMD5x
Motor End Connector	15 Pin Encoder	15 Pin Encoder	15 Pin Encoder
Driver End Connector	15 Pin Dsub	15 Pin Dsub	15 Pin Dsub
Conductor Description (# x mm^2)	4 x (2 x 0.34)S	(3 x (2 x 0.14)S + 2 x 0.5)S	(3 x (2 x 0.14)S + 2 x 0.5)S
Cable Outer Diameter (mm)	8.7	9.6	9.6
Voltage Rating (V)	300	30/30	30/30
Minimum Bending Radius Flexible	OD*7.5	OD*7.5	OD*7.5
Flexing Operating Temperature (°C)	-40 to 80	-40 to 90	-40 to 90
Minimum Bending Radius Static	OD*4	OD*4	OD*4
Static Operating Temperature (°C)	-40 to 80	-50 to 90	-50 to 90
Drag Chain Suitable	Yes	Yes	yes
Jacket	PUR	PUR	PUR
Oil Resistance	Yes	Yes	Yes
Colour	Grey	Green	Green

Table 2-4 - Encoder cable performance specifications

2.3.6.3 Mating Connectors

The appropriate female connectors which mate to the male motor connectors on the LinX® M forcers are listed below. These are the connectors which should be used if custom cables are to be created.

	Part Numbers	
Armature: 	ANCA MOTION PN:	ICN-3077-2065 - CNX 915 PLUG 9W+S FEMALE
	INTERCONTEC/TE PN:	ESTA202FR01330500000
Encoder: 	ANCA MOTION PN:	ICN-3077-2064 - CNX 915 PLUG 15W+S FEMALE
	INTERCONTEC/TE PN:	ESTA205FR08330003000

3 Specifications

3.1 Motor Ratings

3.1.1 Specifications table

	TLMM-15P	TLMM-22P	TLMM-30P	TLMM-15H	TLMM-30H
Rated Force (N) Heatsink [1]	80	120	155	80	155
Rated Current (Arms) Heatsink[1]	2.16	3.25	4.2	1.09	2.09
Rated Force (N) HS + Fan-forced [1]	112	168	217	112	217
Rated Current (Arms) HS + Fan-forced [1]	3.02	4.55	5.87	1.52	2.93
Rated Force (N) Water-Cooled [1,5]	148	222	287	148	287
Rated Current (Arms) Water-cooled [1,5]	4.32	6.5	8.39	2.18	4.19
Rated Force (N) w/o Cooling[1]	63	86	101	63	101
Rated Current (Arms) w/o Cooling[1]	1.7	2.32	2.73	0.851	1.365
Peak Force over 1 second (N) [2,3]	643	965	1287	643	1287
Peak Current over 1 second (Arms) [2,3]	15.7	23.6	31.4	7.85	15.7
Force Constant [K_f] (N/Arms)	41	41	41	82	82
Back EMF Constant [K_e] ($V_{rms\ L\text{-}L}$/(m/s))	23.7	23.7	23.7	47.3	47.3
Resistance @ 25°C (Ω) [5]	6.05	4.03	3.02	24.2	12.08
Inductance (mH) [5]	5.77	3.85	2.88	23.1	11.52
Electrical Time Constant (ms)	0.95	0.95	0.95	0.95	0.95
Magnetic Pitch (N-N) (mm)	50	50	50	50	50
Forcer Length (mm)	221	296	371	221	371
Forcer Weight w/o Accessories (kg)	1.6	2.3	3.0	1.6	3.0
Maximum Motor Voltage ($V_{rms\ L\text{-}L}$)	420	420	420	420	420

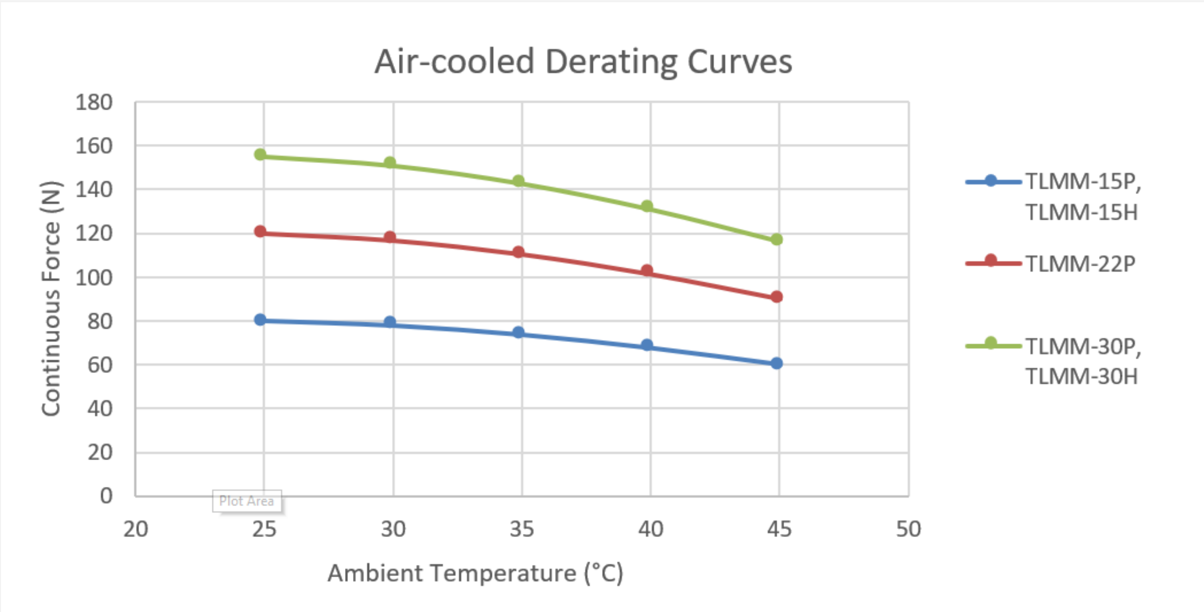
Table 3-1 - Motor ratings and electrical specifications

NOTES:

1. Heatsink, Heatsink + Fan and without Cooling ratings are based on an ambient temperature of 25°C.. NB: The maximum continuous ratings are based on a winding temperature of 130°C absolute maximum as per "Class B" operation. However, the windings are manufactured with "Class H" materials, and therefore have a safety margin of two full classes.
2. The maximum peak force and current is a limitation due to permanent magnet characteristics and should never be exceeded even for a short time.
3. If the linear motor is used repetitively at forces in excess of the continuous rating, the equivalent rms loading should be determined and compared to the continuous rating. The application duty cycle should be calculated over a period of 10 minutes.
4. The Resistance and Inductance values are line to line and are twice the per-phase parameters. The resistance quoted is the value at 25°C. Inductance measurement is performed at 1kHz.
5. Water-cooled ratings are based on a flow rate of 2L/min, an inlet temperature of 20°C and the use of the ANCA Motion cooling jacket. Refer to section *2.3.2.6 Water Cooling Kit* for further details on the use and installation of the water-cooling jacket.

3.1.2 Derating

The rated force performance listed above applies for an ambient temperature of 25°C. When the motor is operated continuously in a warmer environment then the curves below should be used to determine the achievable continuous force.



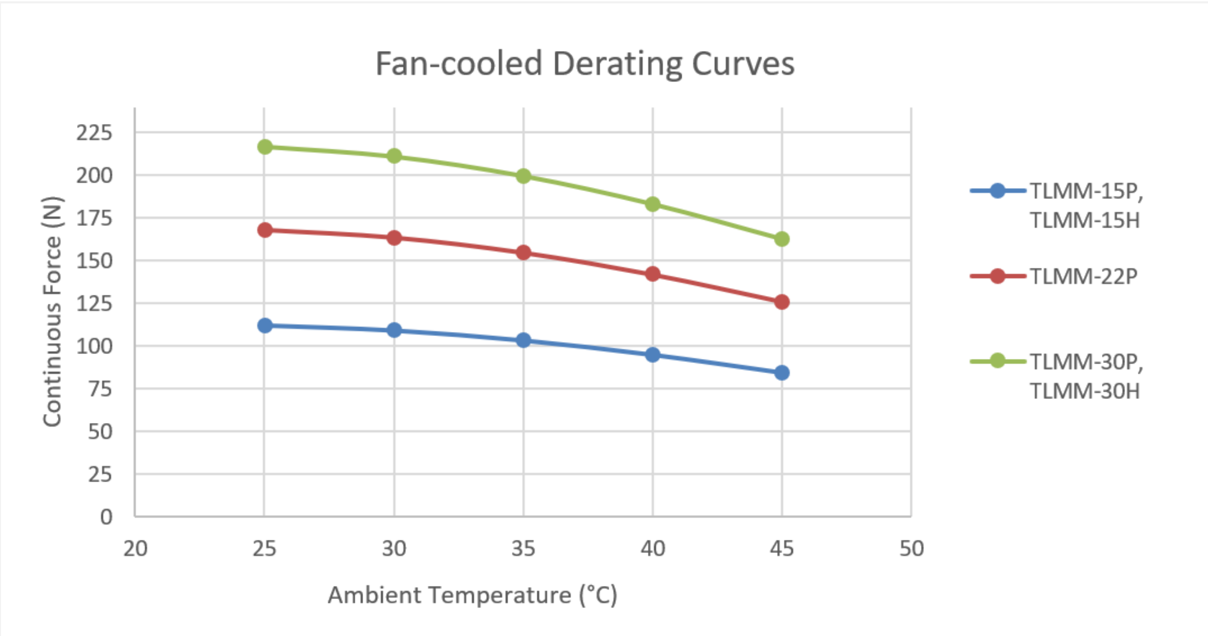
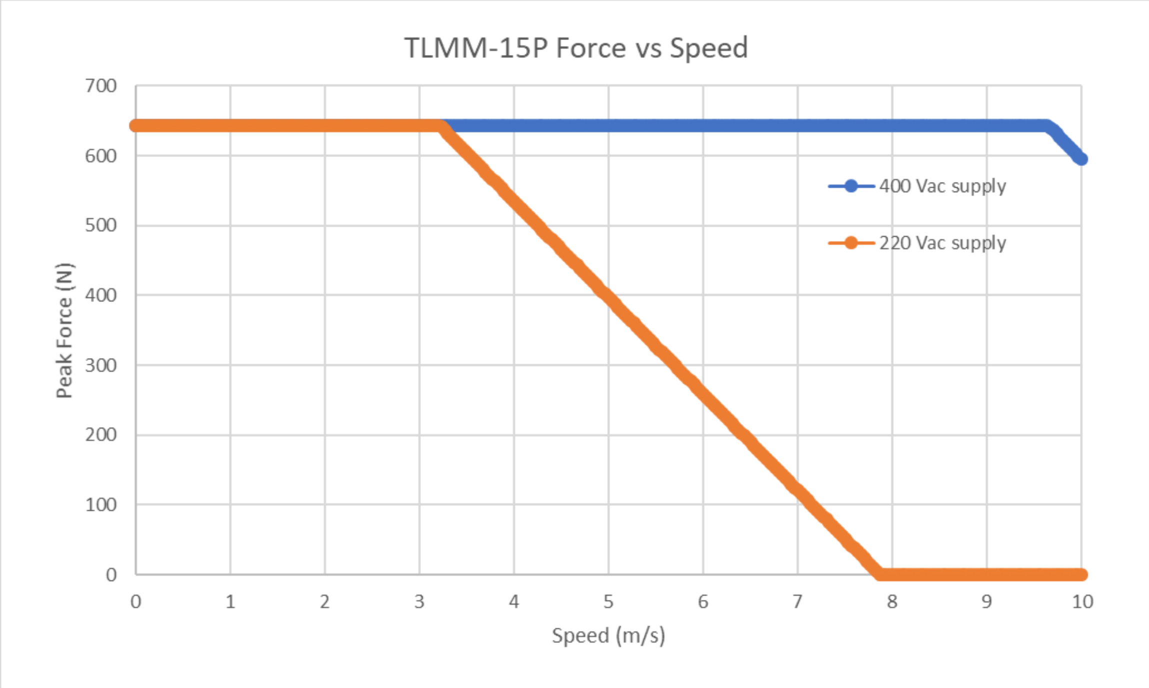


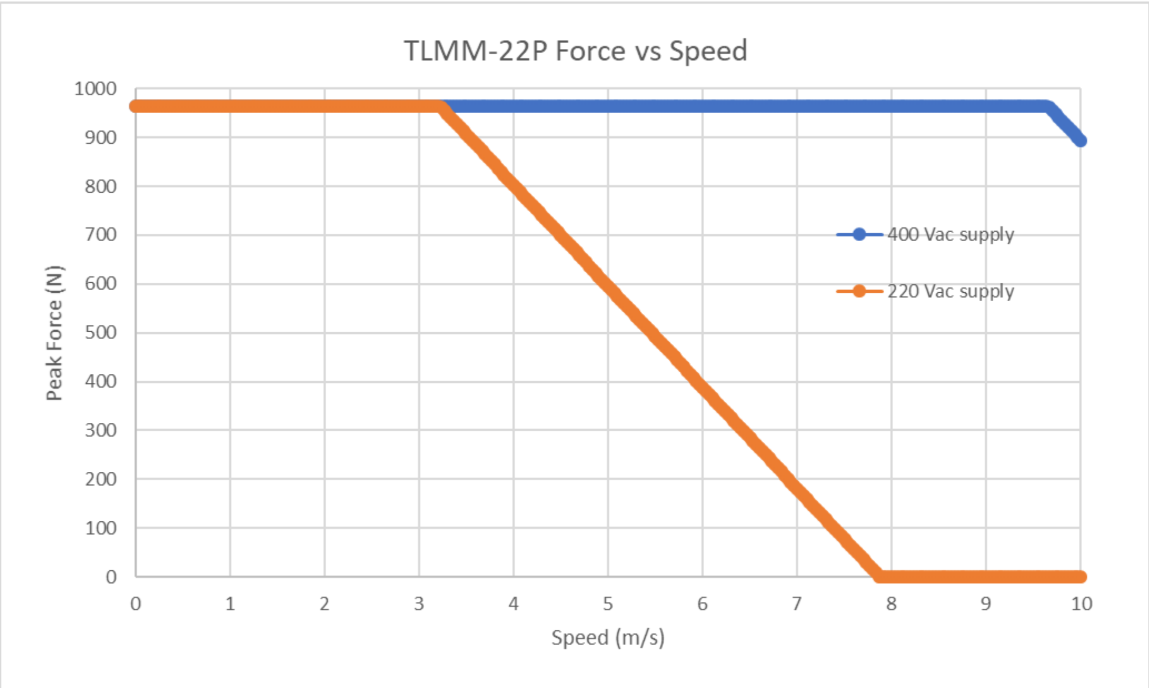
Figure 3-1 - Continuous Force derating with ambient temperature

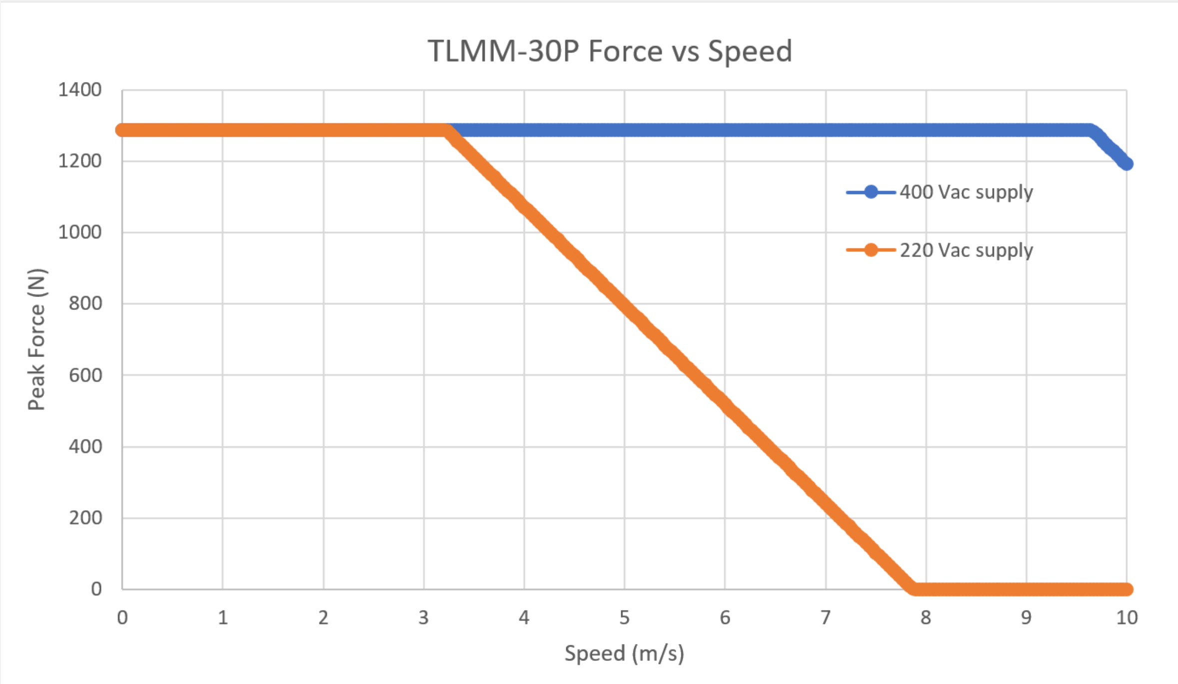
3.1.3 Force vs Speed Characteristics

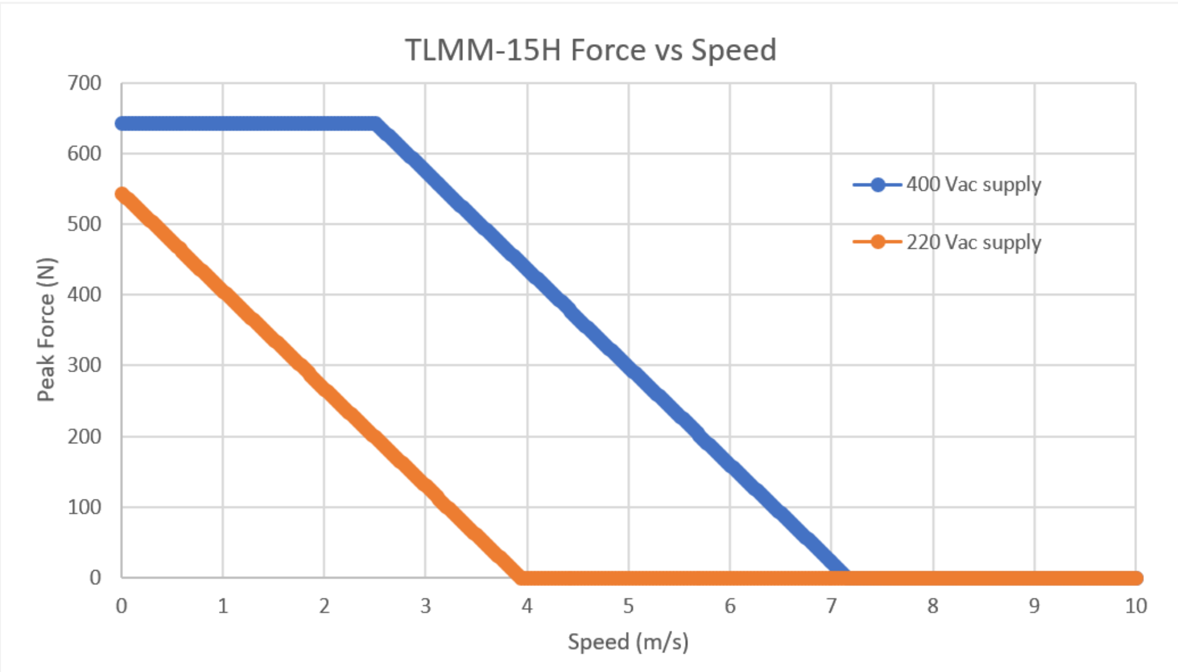
The maximum operating range of each forcer model is shown in *Figure 3-2*. These graphs indicate the maximum instantaneous force available from the motor at various speeds, given a particular infeed supply voltage. At higher linear speeds the maximum force is limited by the available drive voltage, and at lower speeds it is limited by the peak force available from the magnetic system.

Note that the continuous force limit (rated force), is a thermal limit which should be considered separately from the instantaneous limit displayed below.






TLMM-30P Force vs Speed
Peak Force (N)
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
9
10
Speed (m/s)
400 Vac supply
220 Vac supply


TLMM-15H Force vs Speed
Peak Force (N)
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
Speed (m/s)
400 Vac supply
220 Vac supply

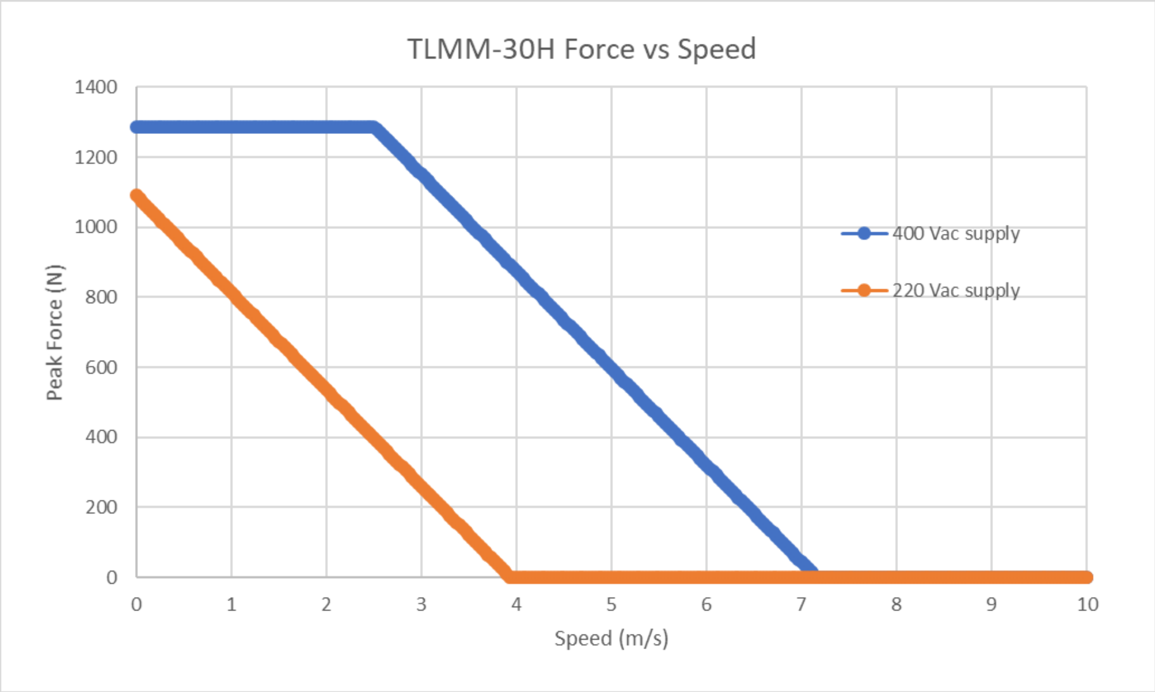


Figure 3-2 - Operating range graphs of M-series forcers

The operating range limits displayed on these graphs are determined from the peak force and voltage limitations of the motor only. As for any linear motor, there will also be a limitation on the top speed that can be reached in a given application due to the finite stroke and finite acceleration available. For example, with an available stroke of 0.5m, a load mass of 5kg and using the TLMM-30P0 motor with a standard heatsink kit, assuming peak acceleration and a triangular velocity profile, the highest speed that can be reached before needing to decelerate to stay within the stroke limitation is given by

$$V_{max} = \sqrt{stroke * a_{max}} = \sqrt{stroke * F_{max}/mass} = \sqrt{0.5 * 1287/(5 + 4.5)} = 8.23m/s$$

In this case, Vmax = 8.23m/s from finite stroke is a more stringent limitation than the operating range limit. As such the finite stroke limitation should also be taken into account when sizing a system application. The ANCA Motion LinX® sizing tool includes this type of calculation as well as other useful information about matching the motor capability to the application requirement (see ***4.1 Loading calculation and Motor selection***).

3.1.4 IP Rating

The M-series motors have an overall ingress protection level of IP66.

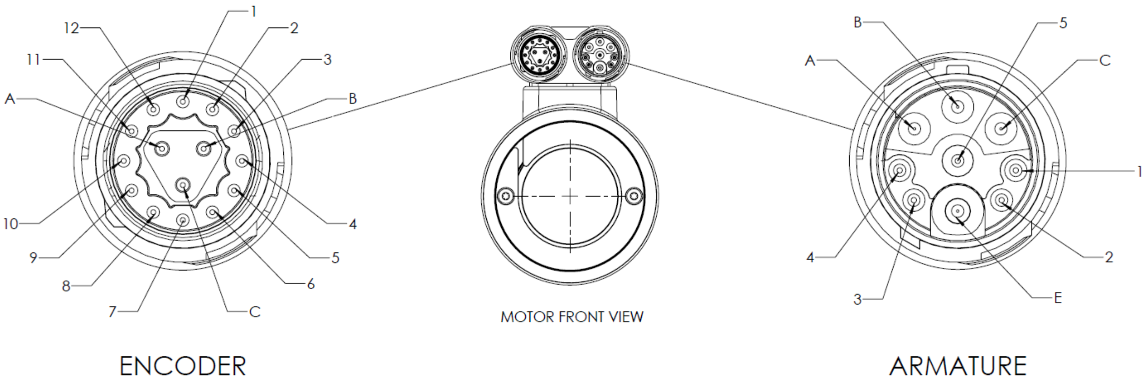
3.1.5 Standards and Conformity

Marking & Applicable Regulations	Standards	Test House
CE LVD 2014/35/EU (Low Voltage Directive) EMC 2014/30/EU (Electromagnetic Compatibility)	EN 60034-1:2010/AC:2010 Rotating Electrical Machines – Part 1: Rating and Performance IEC 61326-1: 2012 Electrical Equipment for Measurement, Control and Laboratory Use – EMC Requirements – Part 1: General requirements	EMC Bayswater Pty Ltd 18/88 Merrindale Drive Croydon South, Victoria, 3136, Australia
FC	CFR47 FCC Part 15, Subpart B (Class A)	

3.2 Motor Connector

The M-series forcer is fitted with a low profile M15 intercontec connector from the 615/915 series.

3.2.1 Pinouts



Motor Encoder Pin	Function	
1	+ Vcc	
2	GND	
3	A	U
4	/A	/U
5	B	V
6	/B	/V
7	Sin	
8	/Sin	
9	Cos	
10	/Cos	
11	Z	W
12	/Z	/W
A	N/A	
B	N/A	
C	N/A	

Motor Armature Pin	Function
A	U
B	V
C	W
E	Earth
1	Temp+
2	Temp-
3	NC
4	NC
5	NC

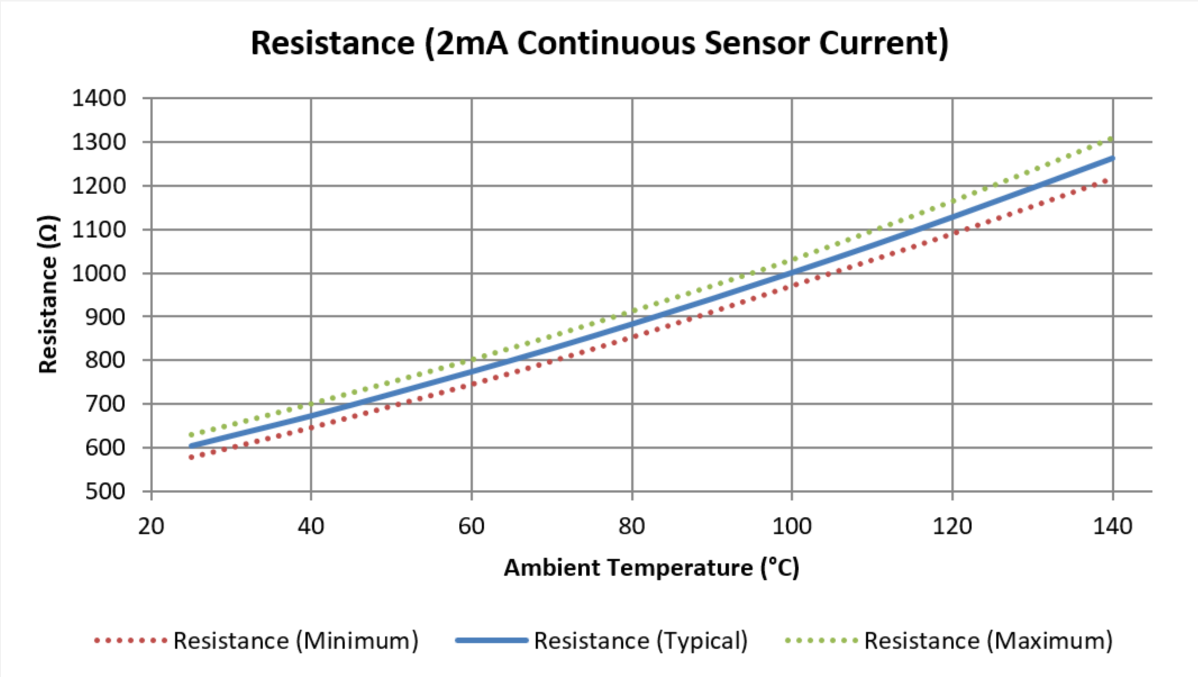
Figure 3-3 - M-series motor pinouts

3.2.2 **Temperature Sensor**

M-series forcers contain a KTY84/130 temperature sensor situated above the windings. The sensor increases in resistance as the motor winding temperature increases. For air-cooled operation, the recommend temperature trip limit is 105C and for water-cooled operation the recommended temperature trip level is 90C. In addition to temperature sensing protection, the motor should always be operated in such a way that the long term RMS current draw is within the rated current specification (see *3.1 Motor Ratings*) in order to prevent over-heating.

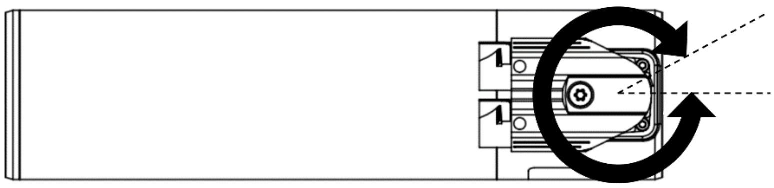
	Conditions	Min	Nominal	Max
Continuous sensor current (mA)[1]	25°C ambient	-	2	10
	300°C ambient	-	2	2
Sensed temperature (C)	-	-40	-	140
Sensor Resistance (Ω)	25°C	577R	603R	629R
Sensor Resistance (Ω)	140°C	1216R	1262R	1309R
Isolation between Sensor and UVW phases		Tested at 2400VDC for 1 second		

Table 3-2 - KTY84/130 Temperature Sensor Characteristics



3.2.3 **Rotation**

The connector can be rotated freely through 300° of travel, allowing for all four 90° orientations of the connector to the motor body to be reached. The sixty degrees of inaccessible angle are with the connector facing to the rear of the motor as shown below. It is recommended to minimize the number of times the connector is rotated to reduce wear on internal connections.



3.3 Sensor Specifications

The M series has an internal position sensor which operates by using magnetic field from the motor shaft to determine the forcer position. The position signal is available as either a digital incremental A/B/Z or as an analogue 1Vpp Sin/Cos signal. See the left of *Figure 3-3* for the pinning on the motor encoder connector.

Signal Type	Function/Spec	Value	Unit
Global	Power Supply	5-12	Vdc
Analogue 1Vpp	Sin/Cos signal period	50	mm
	Absolute Accuracy[1]	+/- 0.5	mm
	Repeatability[2]	0.03	mm
Digital A/B/Z	A/B Signal Period	0.04	mm
	Count Resolution	0.01	mm
	Absolute Accuracy[3]	+/- 0.5	mm
	Repeatability[2]	0.03	mm

Table 3-3 - Encoder specifications

NOTES:

1. Calibration of gain, phase and offset parameters is required to achieve best performance. See *3.3.2 Analogue 1Vpp* for further infomation.
2. Repeatability applies under constant environmental and operationing conditions. For example, for constant ambient temperature and consistent motor loading.
3. Correction factors are determined and applied within the sensor prior to generation of the A/B/Z signal, meaning no external calibration is required (see *3.3.3 Digital A/B/Z* for further information)

3.3.1 Sensor End Effect

As the position feedback is derived from the shaft field removing the shaft from the motor will result in loss of position signal. Similarly, close to the end of the shaft the magnetic field is distorted due to the lack of further magnets and this will result in some loss of position feedback accuracy.

To avoid the sensor end effect and achieve the specified position accuracy of +/- 0.5mm, the shaft should extend at least 50mm from the forcer at the connector end of the motor. Although a valid position signal will be returned from the sensor within this 50mm range, significant position error can be introduced and therefore it is recommended that the normal machine operations are NOT performed in the end effect region. Note that this is only an issue at the connector end of the motor where the sensor is located.

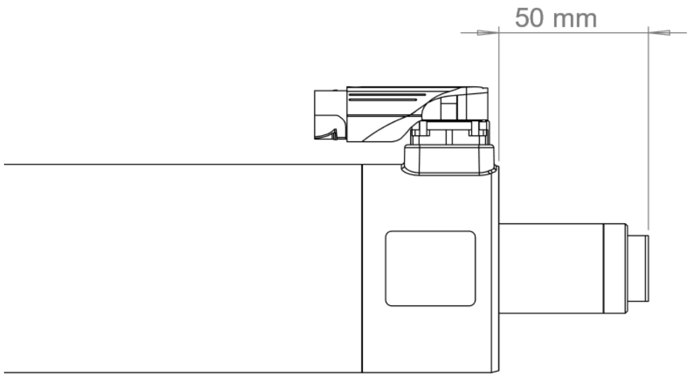
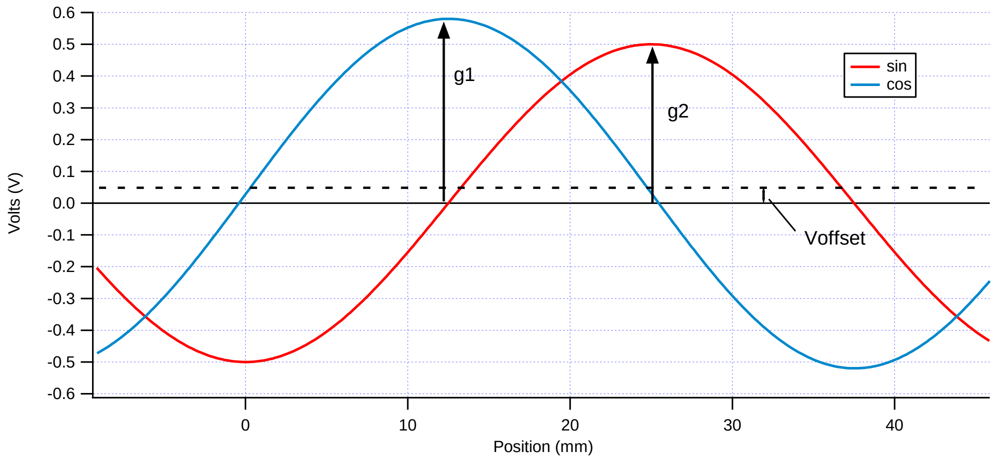


Figure 3-4 - Minimum shaft stick out required to avoid sensor end effects.

The sensor end effect should be included in determination of the available stroke. The facility to do this is available in the ANCA Motion sizing tool.

3.3.2 Analogue 1Vpp

As the 1Vpp Sin/Cos signal is derived directly from the motor field it has the same 50mm period as the shaft pitch. In order to achieve best positional accuracy calibration of the gain, phase and offset corrections should be applied when using the Sin/Cos signal. A diagram showing the definitions of the gain, phase and offset parameters is given below.



The voltage offset between Sin and Cos signals (Voffset) should be < 50mV. The ratio of Sin to Cos amplitude g1/g2 should be with 25% of unity, or equivalently 0.75 < g1/g2 < 1.25. The phase difference between Sin and Cos signal should be less than 12.5 degrees.

3.3.3 Digital A/B/Z

The digital pulse train has a period of 40um resulting in 10um per count. The digital signal is interpolated from the Sin/Cos signals after application of appropriate gain, phase and offset corrections. The sensor is self-calibrating meaning that after installation, for the first 10-20 field cycles the sensor will converge to the optimal calibration settings for best positional accuracy and continue to operate using these. If the shaft or motor mounting is changed at any point, the continuously running self-calibration will converge to find the updated optimal correction values to use. NB: The self-calibration algorithm requires that the sensor experiences more than one full period of Sin/Cos input. Therefore, during commissioning or a motor mounting change it is recommended that the sensor be run through a stroke of at least 100mm to ensure best performance.

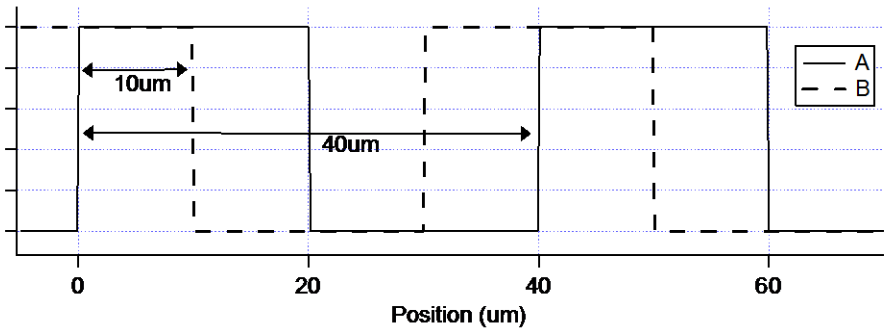


Figure 3-5 - AB digital positions signal

In addition to the A/B pulse train, an index pulse is provided on the Z channel. The index pulse appears once every 50mm and is located at the zero crossing of the U-phase back EMF (see *Figure 3-6* below).

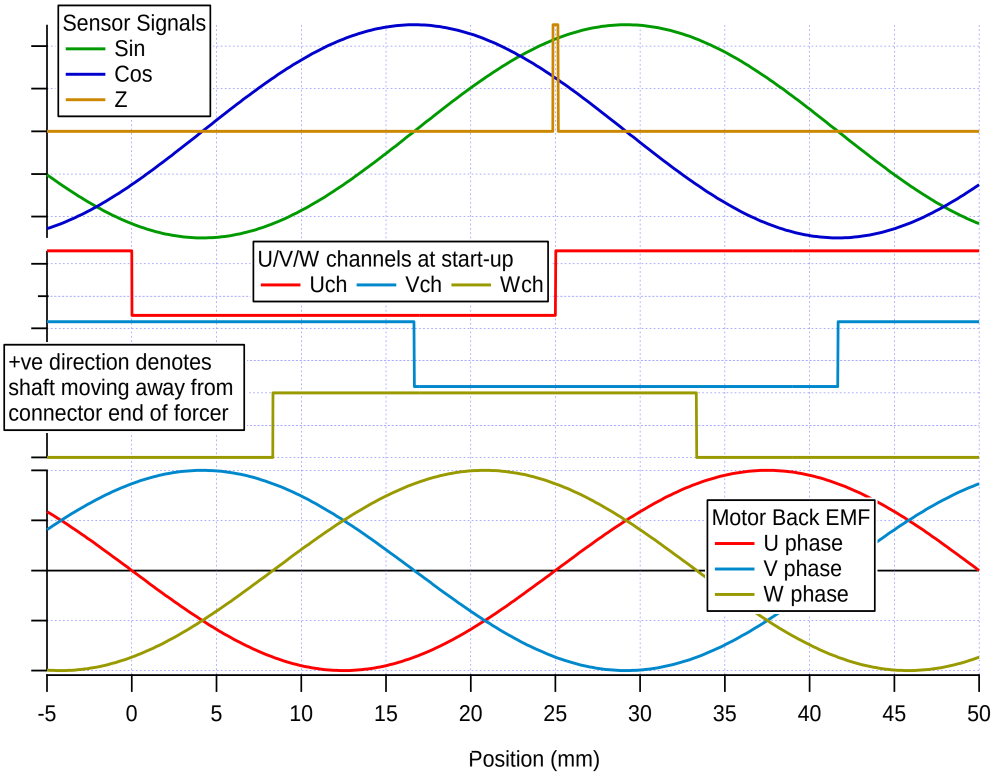


Figure 3-6 - M-series encoder signals relative to the motor phases

3.3.3.1 UVW wire-saving

The A/B/Z channels are equipped with a UVW wire-saving functionality where, for a short period after power-up of the encoder, the UVW hextant information (see *Figure 3-6* above) is available before the signal switches to the standard ABZ pulse train. The three UVW channels allow for the electrical angle of the motor at start-up to be determined to within 60 electrical degrees for initialization purposes. The motor can start running using the UVW angle estimate and this can be updated to a precise angle once the index pulse is detected. The timing diagram for the appearance of the UVW orientation signals is shown in *Figure 3-7* below.

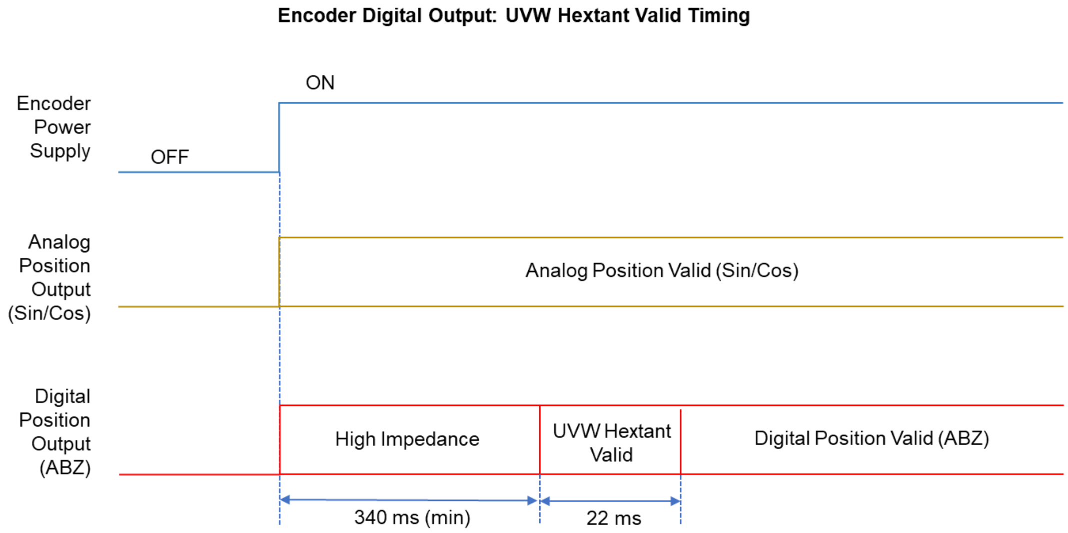


Figure 3-7 - ABZ channels start-up sequence timing diagram

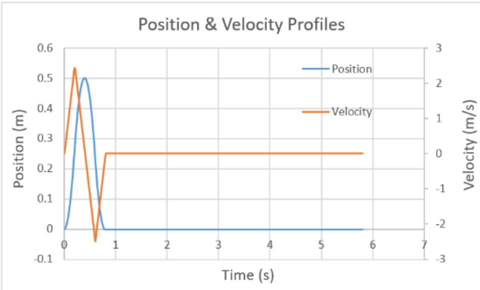
4 Application Selection Criteria

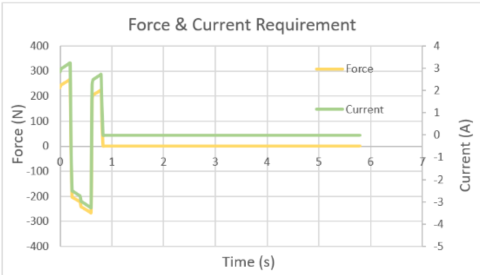
4.1 Loading calculation and Motor selection

In order to select an appropriate motor, accessories and cooling options, the equivalent continuous RMS force, peak motor force and maximum speed must be determined from the application requirements. In particular, with the required movement profile and load mass, the necessary force from the motor can be calculated. ANCA Motion has developed a calculation tool in the form of an Excel spreadsheet where the user can enter their application requirements and based on the movement profile and loading the motor models and accessories suitable for the application are displayed.

To give an example, say the application required a move of 500mm in 0.4s and then back in another 0.4s repeating every 5sec and carrying a15kg load, then this information can be entered into the sizing tool as follows:

Inputs		
Motion Profile:		
Required Stroke	500	mm
Movement Stroke	500	mm
Movement Period	0.8	s
Wait Period	5	s
Profile Shape	Triangle	
Acceleration Fraction	50	%
Acceleration Time (t1)	0.2	s
Loading:		
Load Mass	15	kg
Moving Element	Forcer	
Forcer Mass	3.68	kg
Coefficent of friction	0.05	
Vertically Mounted?	No	
External Force	0	N
Force On Time	0	s
Force Off Time	0.29	s





The tool will then determine the required force at each point in the movement profile and from that determine the equivalent RMS force requirement, peak force requirement and calculate the required drive voltage. These requirements are then compared to the selected forcer ratings to determine feasibility. In this case, using the TLMM-22P forcer with the heatsink accessory would achieve the required movement (see below). This is displayed in the tool by both showing the requirement as a percentage of the selected motor rating (% limit) and in terms of safety factor.

Forcer and Drive Selection:		
Forcer	TLMM-22P	
Cooling method	Heatsink	
Ambient/Coolant temp	25	C
Use Std Mounting Block	Yes	
Supply Type	Single-phase	
Input Voltage	220	Vac L-N
Drive	AMD2000 9A	

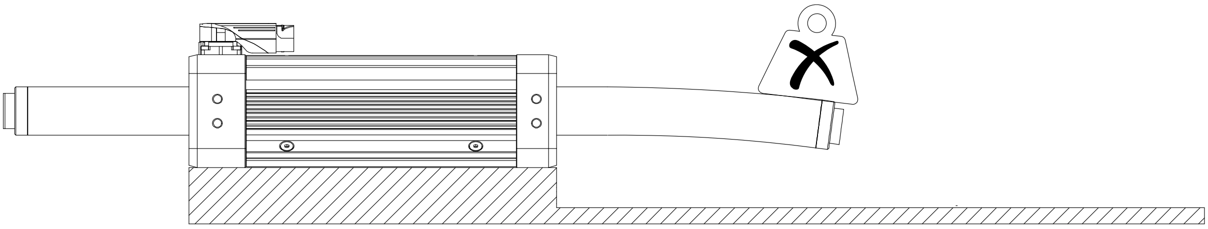
System Specifications:	Requirement	Motor Spec	% Limit	Safety Factor
Force Limit:				
Force_rms (N)	87.17	120.0	72.6	1.4
Force_max (N)	260.75	965	27.0	3.7
Current Limit:		Drive Spec		
Current_rms (A)	2.13	9	23.6	4.2
Current_max (A)	6.36	12.9	49.3	2.0
Voltage Limit:		Drive Capability		
Motor Voltage (VLL_rms)	90.21	173.9	51.9	1.9
DC bus Voltage (Vdc)	147.32	283.97	51.9	1.9

Note that there is more capability and features in the sizing tool than shown in the simple example above, as the tool is intended to cover a wide range of possible configurations and applications. In particular, shaft selection and determination of the available stroke based on the selected components is supported. More detailed instructions can be found in the usage notes that are included with the tool.

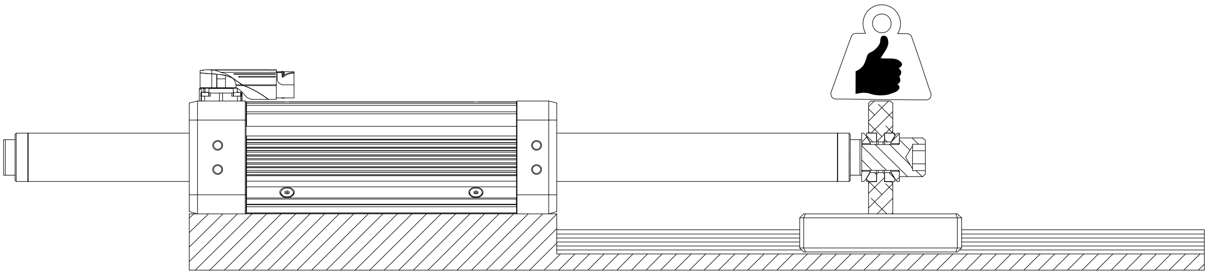
Please contact ANCA Motion to receive a copy of the LinX® Motor Sizing Tool.

4.2 Forcer and Shaft Mounting Configurations

Although, the shaft transmits the axial force developed by the motor, it is not considered a load bearing element of the system in the perpendicular directions. As such should not have any additional non-axial forces applied to it.



Applying non-axial load to the shaft could cause it to fail unexpectedly, excessively increase bushing wear and cause binding.



Depending on the configuration chosen, a suitable linear support may be required. Linear rails or linear bearings are ideal for supporting the mass as they offer smooth motion that adds minimal friction. The use of other support structures is acceptable, but they must be stable and not interfere with the motor's operation.

4.2.1 Mounting Types

The motor and shaft can be installed in many applications and configurations. Each configuration has a limitation on the maximum extent of the unsupported shaft section, due to the mechanical properties of the shaft. Note that these limits are based on the moment forces developed within the shaft due to its own weight and therefore apply in the case of a horizontal application only.

For each configuration outlined below, there is a maximum length of the unsupported shaft for segment "a" and segment "b". There is also a maximum overall shaft length limit that applies for the "Moving Motor – Double Support" application. Consider these maximum values when evaluating the required stroke for an application.

Configuration	(a) Max mm	(b) Max mm	Max (No Bushing) mm
Moving Shaft – Single Support	1000	2130*	-
Moving Forcer – Single Support	1000	2130*	-
Moving Forcer – Double Support	2130*	2130*	2130*
Moving Shaft – No Support	1000	1000	-

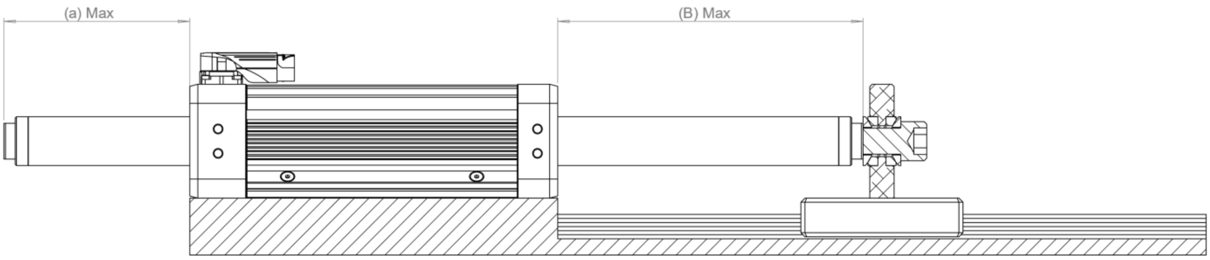
Table 4-1 - Unsupported shafts lengths for various mounting options

*These are the theoretical maximum values for the unsupported shaft sections a, b however as the current longest shaft offered is itself 2130mm it not possible to achieve 2130mm of unsupported length. Therefore, another way to read the 2130mm value is that there is no limitation to stroke length in that mounting configuration due to shaft bending moments for the current product range.

This is in contrast with the cases where the shaft end is not held and thus should only extend by 1000mm from the forcer due to the bending moment formed by the cantilever operation.

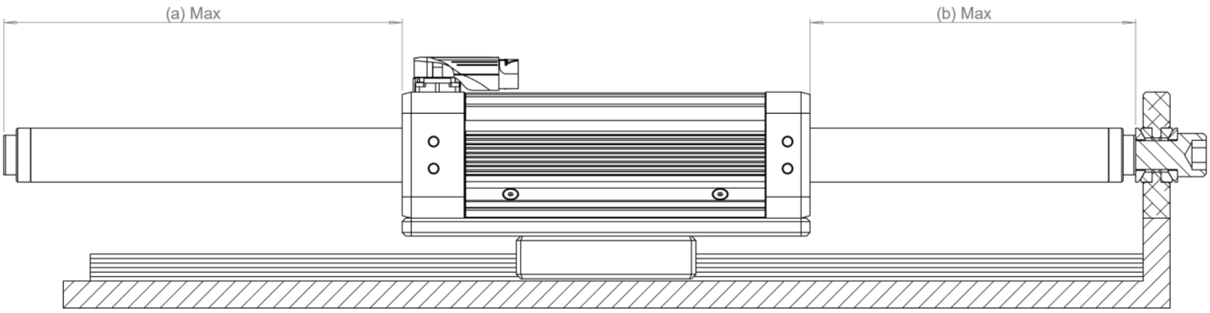
4.2.1.1 Moving Shaft – Single Support

In this configuration, a bush is essential as it supports the shaft's mass. The linear rail is included to support the application mass. A spherical washer set should be used for mounting the shaft as it will allow for misalignment between the forcer and shaft centerlines and help to prevent binding.



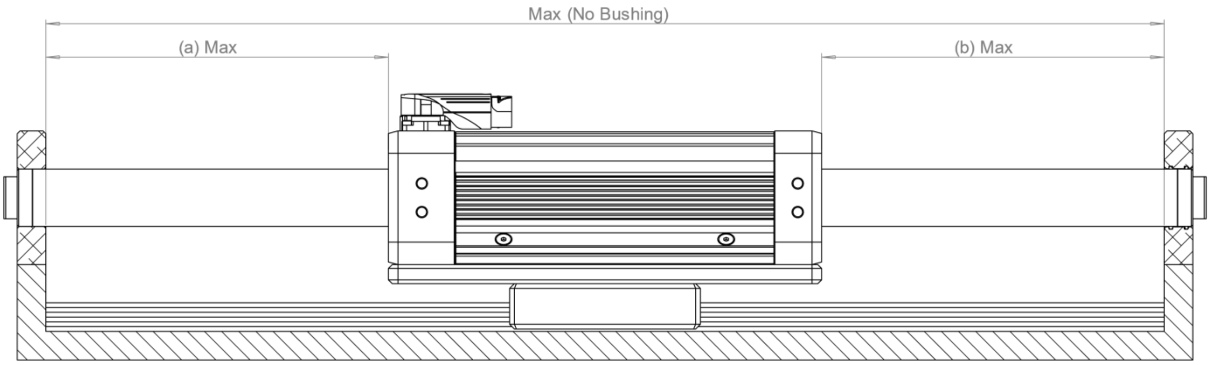
4.2.1.2 Moving Forcer – Single Support

In this configuration, a bush is essential as it supports the shafts mass, the linear rail is included to support the forcer and the application mass. A spherical washer set should be used for mounting the shaft as it will allow for misalignment between the forcer and shaft centerlines and help to prevent binding.



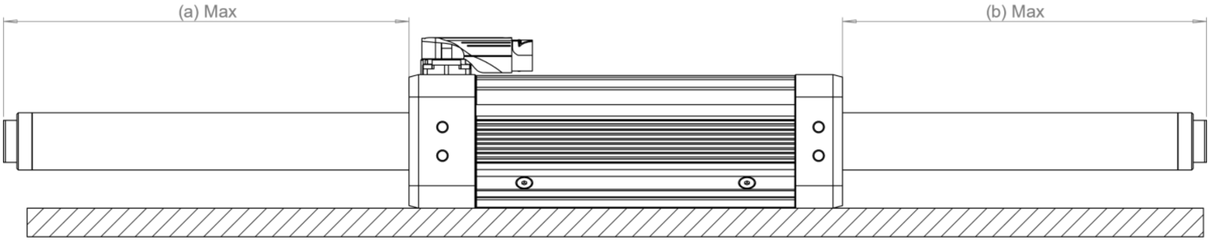
4.2.1.3 Moving Forcer – Double Support

In this configuration, as both ends of the shaft are supported there is no need for a bushing in the forcer if the unsupported shaft length does not exceed the value stated in the table above. Longer strokes can be achieved if a bushing is used, but there will be additional friction forces that are position dependent due to the bush contacting the shaft in the middle of the stroke. For applications that require an unsupported shaft length greater than those stated above please contact ANCA Motion.



4.2.1.4 Moving Shaft – No Support

In this application the bush is essential as it is supporting the shaft mass. The stroke of this configuration is limited due to having two unsupported ends of the shaft. This application in intended for short strokes where the goal may be to replace pneumatic cylinders.



4.2.2 Stroke Calculation

After the mounting strategy is chosen, the available stroke for a given forcer and shaft combination can be determined. In all cases the available stroke can be calculated as

Stroke = Shaft Length – Forcer Length – Front End Zone – Rear End Zone

where the end zones are region at the end of travel which cannot be move into. Their length may depend on the mounting strategy employed. Note that the 'rear end zone' refers to the connector end of the motor and should always be 50mm or longer if the internal position sensor is being used (see *3.3.1 Sensor End Effect* for further info). The ANCA Motion sizing tool includes a feature to automatically calculate available stroke based on stated end zone length and selected components.

An example stroke calculation when using the standard clamp mount accessory, a TLMM-15P0-RE-1 forcer kit, a TLS30-0730-S shaft and in the double support configuration (see diagram in *0*) is as follows. The clamp is 15mm wide and the end cap step on the shaft is 7mm, therefore can take

Front End Zone = 7 + 15 = 22mm
Rear End Zone = 50mm (sensor requirement)
Forcer Length = 227mm
Shaft Length = 730mm
Stroke = 730 - 227 - 50 -22 = 431mm

Note that this is the configuration referenced in *Table 2-2 - Available TLS30 shaft lengths,*

Instead, if we were using a single support configuration and attaching to the shaft threaded end rather than clamping (see diagram in *4.2.1.2*) then with the same forcer and shaft components the stroke calculation is as shown below. Note that with no clamp present the forcer can be run right up to the end of the shaft meaning that the front end zone can be taken as 0mm.

Front End Zone = 0mm
Rear End Zone = 50mm (sensor requirement)
Forcer Length = 227mm
Shaft Length = 730mm
Stroke = 730 - 227 - 50 -0 = 453mm

Note that the forcer bore should always be fully occupied with the motor shaft otherwise the available force from the motor will be reduced. In the calculation above this corresponds to not allowing the end zone length to be a negative value.

4.2.3 Tandem Forcers

It is possible to mount multiple forcers on the same shaft in order to increase the available force.

If the motors are to be independently controlled by their own servo drive there is no restriction in the separation distance between forcers, however, care should be taken during the system design to ensure that a) if moving relative to each other, there will be no collision between forcers b) if forcers are rigidly coupled, they are controlled in such a way as to produce force in the same direction.

Alternatively, it is possible to wire the armature connections in parallel so the that multiple rigidly coupled forcer units can be driven from the same servo drive. In this case, the armature phase connection should be made as below and there is a required separation distance between the motors that must be adhered to for the magnetic location of each forcer to be equivalent. Note that separation distances given are from the end of the bare forcers units (NOT from edge of the standard mounting cap).

Note also that when running in parallel the total continuous force available will be the sum of the two individual forcer ratings. Similarly, the current requirement from the drive will be the sum of the current requirement from each forcer. Due to the parallel connection, the back EMF and voltage requirements seen by the servo drive are the same tandem configuration as for a single forcer. For this reason, is only possible for forcers with the same winding type to be connected in this way, that is “P” variants with “P” variants and “H” variants with “H” variants.

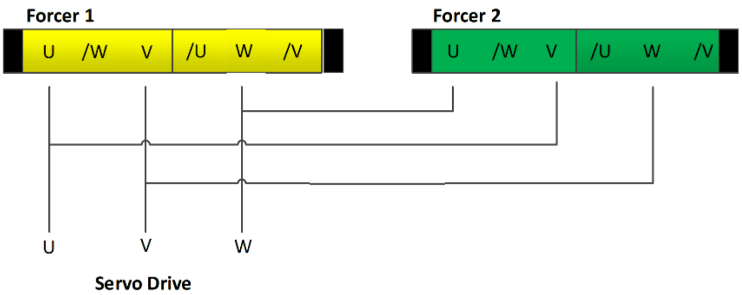
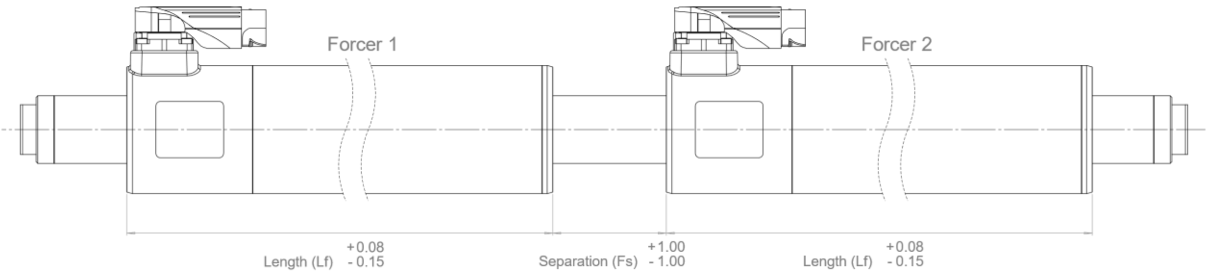


Figure 4-1 - Armature wiring diagram for parallel forcers



Forcer 1 PN	Forcer 2 PN	Lf (mm)	Fs (mm)	Fs (mm) N=1	Fs (mm) N=2
TLMM-15xx-RExx	TLMM-xxxx-RExx	221.00	29.00 + N * 50	79.00	129.00
TLMM-22Px-RExx	TLMM-xxPx-RExx	296.00	4.00 + N * 50	54.00	104.00
TLMM-30xx-RExx	TLMM-xxxx-RExx	371.00	29.00 + N * 50	79.00	129.00

Figure 4-2 - Valid separation distances of parallel forcers on the same shaft. N can be any integer.

4.3 Internal Bushings

The bushing is made of a high-performance acetal polymer selected for good lifetime characteristics.

The bushing is installed into the bore of the motor to support the shaft and is designed to wear no more than 0.75mm radially. Once the bushing has reached this wear at any point along its length, it needs to be replaced to avoid damage to the shaft or motor.

4.3.1 Material Specification

The bushing material is Delrin® 100AF, a high-performance acetal homopolymer containing 20% Teflon®.
This material has been selected due to its high wear resistance and low friction characteristics.
Please consider if this material specification meets the requirements for your application.

4.3.2 Lifetime Considerations

The bushing lifetime is application specific.

In particular, the bushing wear is dependent on the pressure applied and the total distance travelled. Key factors that influence the wear of the bushing include:

- Shaft Length
- Shaft Support Configuration
- Motion Profile
- Contamination or Debris
- Temperature
- Additional Non-axial loading

4.3.3 Lifetime Example

ANCA Motion has tested an example application to provide an indication of bushing lifetime for a strenuous application.

Using a TLS30-1230-S Shaft and TLMM-30 Forcer in a “Moving Shaft-No Support” configuration, running at up to 0.6m/s in continuous duty, test data and modelling shows an expected lifetime of 9-12 Months depending on the maintenance and cleaning schedule of the forcer and shaft.

For most applications the lifetime will be extended with lower perpendicular loading and/or different velocity profile. Bushing wear can also be reduced by operating the forcer and shaft in one of the single shaft support configurations.

As the bushing wears it will generate a small amount of debris. This can be cleaned off with periodic maintenance or can be controlled with the use of a high-performance grease. If any grease is used, ensure it is safe to use on Acetal homopolymers.

Please contact ANCA Motion for more information about bushing lifetime and your application.

4.4 Liquid Cooling

When using the water-cooling accessories for the M Series forcers, there are some additional considerations to ensure longevity and problem free operation.

4.4.1 Temperature monitoring

When using liquid cooling the thermal gradient in the forcer is quite high and there is very large heat load due to the additional continuous force that can be achieved. This means that the temperature being reported by the temperature sensor will be lower than the internal winding temperature of the forcer.

Section 3.2.2 outlines the different trip temperatures based on the forcer cooling method.

Failure to implement this correctly could lead to an over temperature event in the forcer causing permanent damage.

4.4.2 Flow Monitoring

In conjunction with monitoring the temperature of the forcer, it is recommended to implement flow monitoring for the coolant supply to ensure that in the event of either insufficient or no flow the system can be shut down. This helps to prevent the forcer from having an over temperature event in the case the forcer temperature monitoring fails.

4.4.3 Coolant

All ratings specified in 3.1.1 are based on the coolant being demineralized water.

It is recommended that corrosion inhibitors and/or antibacterial additives are used to ensure the coolant stays clean and does not damage the components in the cooling loop.

If additives are being used please ensure the flow rates coolant temperatures are adjusted to allow for the difference in specific heat capacity that this may cause.

4.4.4 Heat Dissipation

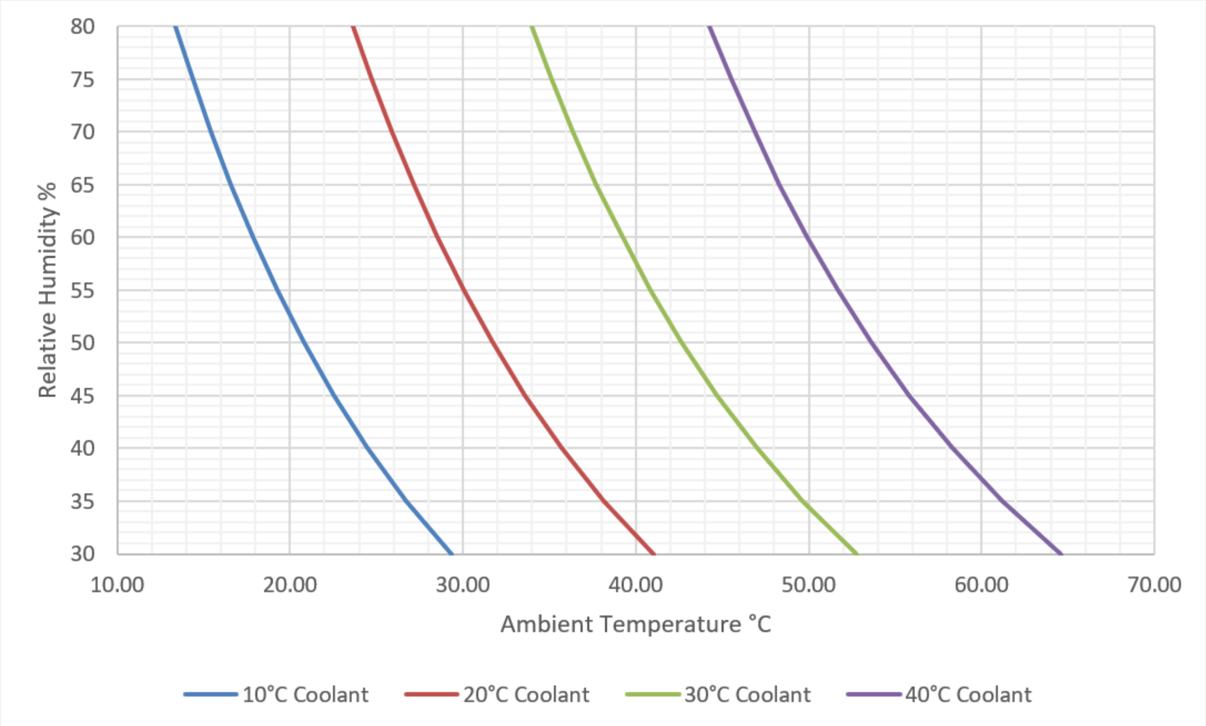
The cooling solution should be sized appropriately for the thermal output of the forcer at peak operating conditions.

As outlined in Section 3.2.2 the following parameters should be met to achieve the specified ratings.

Flow rate of 2L/min
Inlet temperature of 20°C
Use of the ANCA Motion cooling jacket

4.4.5 Condensation

When using liquid cooling, due to the possible low temperatures of the forcer relative to the ambient condition, condensation needs to be considered. When condensation forms it may drip onto other areas of the system potentially causing damage. The below chart shows the condensation points for various coolant temperatures given the ambient temperature and relative humidity.



Condensation on the forcer is not an issue for its operation but condensation can form inside the connector body and cause potential shorts. This will most commonly occur when the forcer is at idle or very low power output. Because of this it is recommended that the cooling circuit is disabled when the forcer is in this state to avoid the forcer and connector becoming cooler than the ambient temperature, potentially resulting in condensation within the connector depending on the relative humidity.

4.4.6 Galvanic Corrosion

Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially when it is in electrical contact with another, often in the presence of an electrolyte such as water. This occurs due to dissimilar metals and alloys having different electrode potentials, so that when connected through an electrolyte the resulting charge and ion transfer causes one of the metals to corrode.

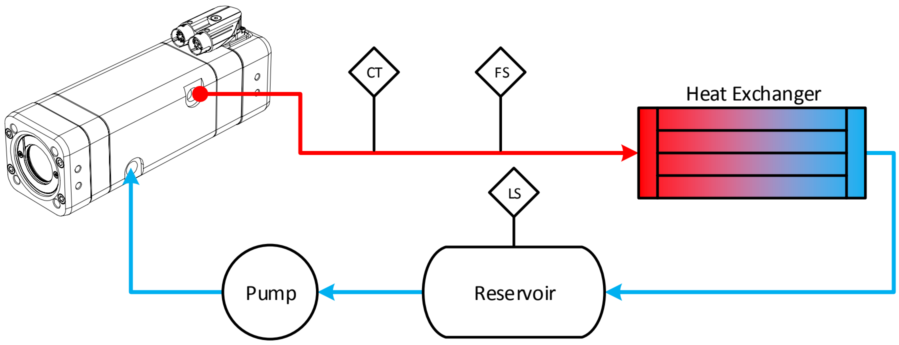
The easiest way to mitigate this issue when water cooling industrial hardware is to avoid using dissimilar materials in the water-cooling loop. If this is not possible then materials should be selected with the least amount of galvanic potential to reduce potential corrosion.

For consideration on this issue, the M series Forcer body is Electroless Nickel coated steel and the Cooling jacket is anodized 6000 series aluminum.

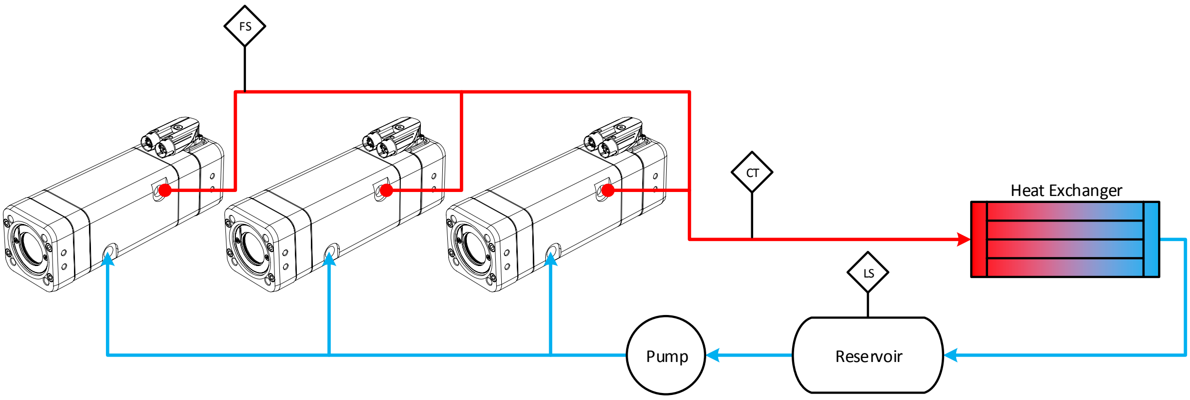
4.4.7 Application Example

Below is an example of a basic cooling loop with a single forcer, heat exchanger, reservoir and pump.
The 3 diamonds represent a series of sensors for monitoring the loop.

CT: Coolant Temp
FS: Flow Switch/Flow Rate
LS: Level Switch (optional)



Depending on the requirements the cooling components need to be sized appropriately.
This will depend on the number of forcers being cooled and their heat output. If multiple forcers are being cooled it is recommended that they are plumbed in parallel to avoid coolant preheating, thus derating the forcers further down the loop. The below diagram is an example showing three forcers plumbed up in parallel.



The position for FS needs to be moved to monitor the forcer with the longest piping from the pump as the pressure drop will have a significant effect on the flow rate. To ensure all forcers are getting adequate flow this value should not be below the 2 L/min specified value.

In these diagrams the heat exchanger represents multiple options for removing heat from the system. This unit could be a:

Liquid to Air Heat Exchanger (Radiator)
Liquid to Liquid Heat Exchanger
Chiller

Note that all these options are closed loop cooling solutions to help to minimize evaporation of the cooling liquids and help to keep the loop clean.

5 Installation

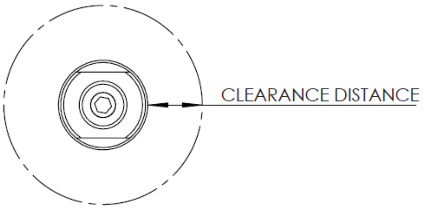
5.1 Handling and safety

WARNING: The shaft produces a very strong magnetic field, always use caution when handling. To avoid injury, keep fingers and other body parts clear.

WARNING: Cylindrical motor shafts contain powerful permanent magnets. People with pacemakers, AICD or similar medical devices should not handle or work closely with the magnetic shaft.

5.1.1 Shaft General Clearance

When working with the magnetic shaft, it is good practice to keep all ferrous objects, including tools outside the shafts influence. The same principles should be applied when storing the magnetic shaft.



As a rule, the clearance distance from the surface of the shaft to ferrous materials should be kept greater than 40mm. Inside this region ferrous objects can become attracted to the shaft and this can lead to pinch type injuries as well as damage to the shaft. Note it is also good practice to keep a plenty of margin in tool separation when working as the onset of force with distance is quite rapid.

5.1.2 Shaft to Shaft Minimum Distances

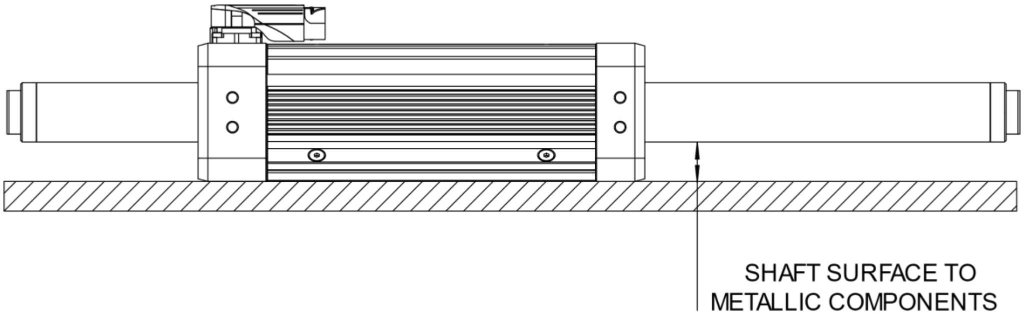
When installing LinX® M series motors, considerations need to be made to ensure the magnetic shafts are not allowed to operate near one another. If the shafts are installed too close to one another the attractive forces will make it difficult to safely install the shafts as well as place additional forces on the system.

To avoid this, the shaft-to-shaft centerline minimum separation distance of 110mm should be adhered to during system design of a multiple shaft installation.

5.1.3 Installed Shaft to Structure Minimum Distance

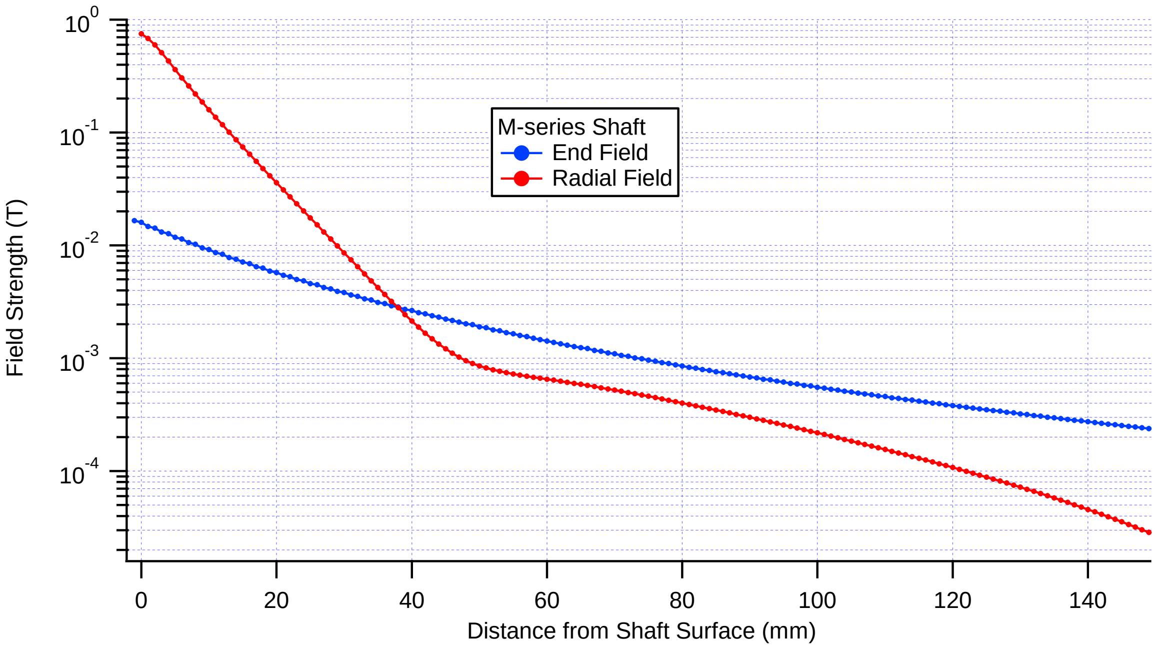
If metallic or ferrous objects are located too close to a moving shaft, motor operation can be affected due to unexpected force contribution and/or additional drag forces. It is recommended the motor installation ensures a separation distance of

(a) 40mm gap between the shaft surface and any ferromagnetic parts (eg steel, iron). This will ensure no strong magnetic interaction between the shaft and the part, preventing both unwanted forces and any magnetisation of surrounding material.
(b) 20mm gap between the surface of a moving shaft an any metallic or conductive parts (eg aluminum, stainless steel, copper). This separation will prevent inducing eddy currents that would cause a drag force on the motor and lead to heating of nearby parts.



5.1.4 Shaft Field Strength Drop-off

The indicative reduction in field strength from the surface of the shaft is shown below. The plot is for radial distance from shaft surface, as well as axial distance from the shaft end. This information can be used to determine if any interference with nearby devices (eg sensors, medical devices) from the static shaft can be expected. For reference a typical value for the strength of the Earth's magnetic field is 50µT. Note that the presence of ferrous material in the nearby region may affect the field distribution.



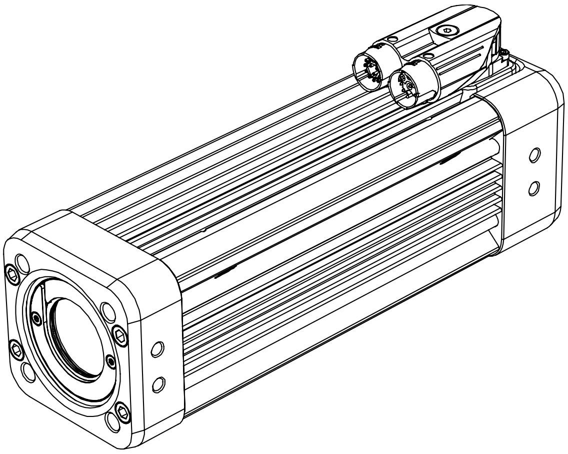
5.2 Mounting options

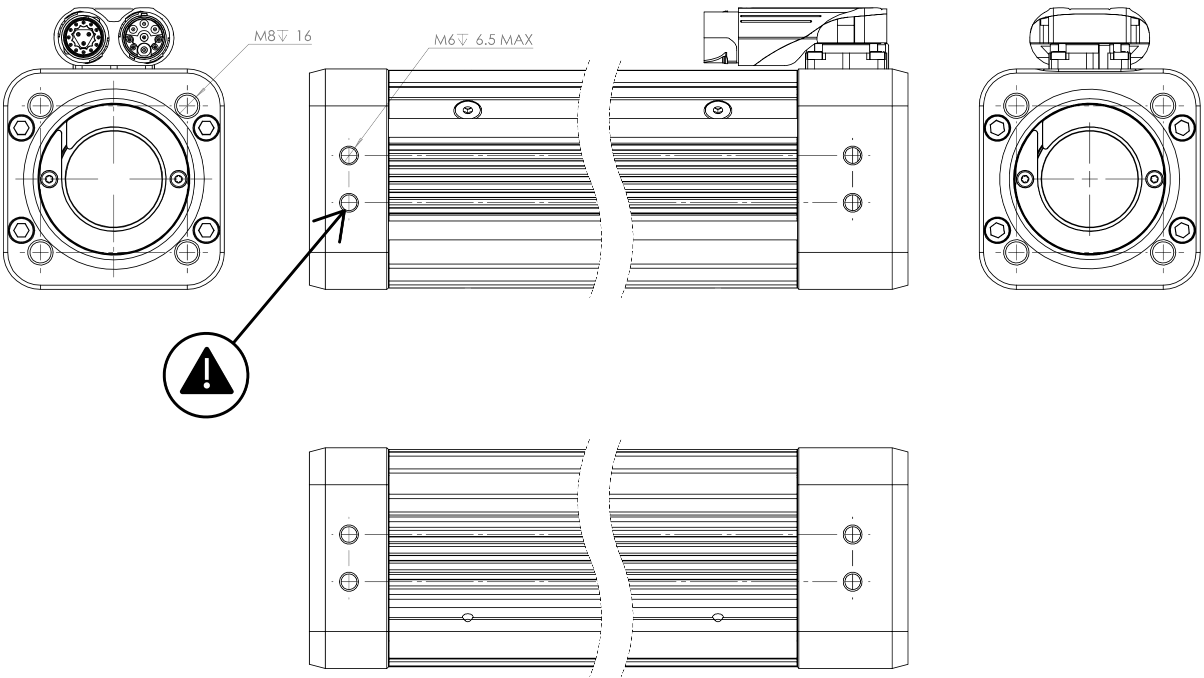
Depending on the application the method for mounting the motor and shaft will vary. This section covers the motor and shaft general mounting specifications.

For dimensional drawings including specifications of mounting features see *Section 2.3.2*

5.2.1 Forcer Mounting Options

The bare forcer does not have many specific mounting features, as the standard mounting accessories provide this function. The only way to mount the forcer without accessories is by clamping the main body of the forcer with cylindrical clamps.





When accessories are installed, the motor has two main mounting options:

1. ISO 15552 – 50 Bore Pneumatic Cylinder compatible mounting points: there are eight M8 mounting points provided on the front face of the end caps. These can be used with a range of standard mounting components for pneumatic cylinders as well as custom mounts to suit the application. It is recommended to use a minimum of 4 holes when using this interface.

   Do not exceed a torque of 16 Nm for applications where there is no axial force on the mounting. If there is axial force on the mounting, reduce the torque to avoid stripping of the threads.

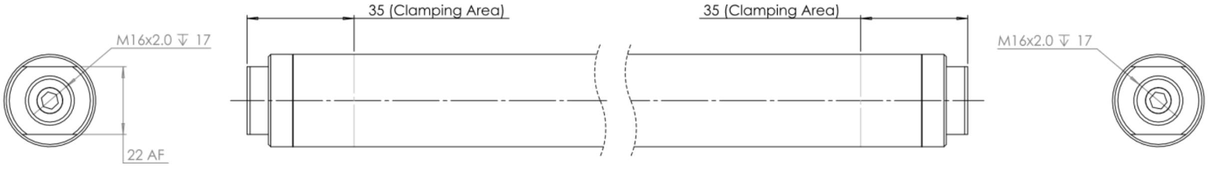
2. General purpose mounting holes: there are 12 x M6 general purpose mounting holes on the endcaps side and bottom faces. These holes are relatively shallow and only have a thread depth of 6mm. Do not use screws that result in a thread depth of more than 6mm. Damage to the motor could occur due to the screws crushing the motor housing.

   When used as primary mounting for the motor, use a minimum of 4 holes and **do not exceed a torque of 6 Nm.**

   Some accessories may utilise these mounting screws and limit the number of choices available.

5.2.2 **Shaft Mounting Options**

As the shaft can be either a moving or static element within the motor assembly, careful consideration needs to be taken to ensure the chosen mounting option is appropriate. *Section 4.2.1* outlines the motor and shaft mounting configurations and the limitations of each. The shaft can be mounted in two main ways.



1. Clamping. The ends of the shaft can be clamped to mount it to an assembly. The clamping force should be enough to ensure there is no shaft slip under the motor's peak force. If clamping is used, **DO NOT clamp outside the areas shown on the diagram above**. There is a risk that the tube could be crushed and weakened causing the tube to fail.

2. Threaded mounting holes. The ends of the shaft have a M16 threaded mounting hole for end mounting the shaft. These holes can be used to mount the shaft the spherical bearings or direct mount to the application. If required, an ISO 15552 Thread Adaptor (PN: 630-0-00-4068) can be used of convert the M16 x 2 Female thread to an ISO 15552 compatible M16 x 1.5 male thread.

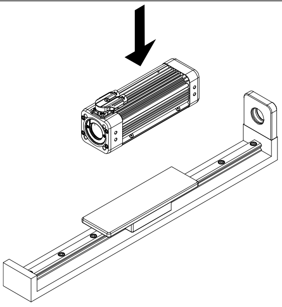
   When using the threaded mounting holes. **DO NOT exceed a torque of 70 Nm**. When installing threads into the mounting holes always use a spanner to prevent the rotation of the shaft at the end where the thread is being installed. Applying excessive torque to the shaft could result in damage and lead to failure.

5.3 Installation instructions

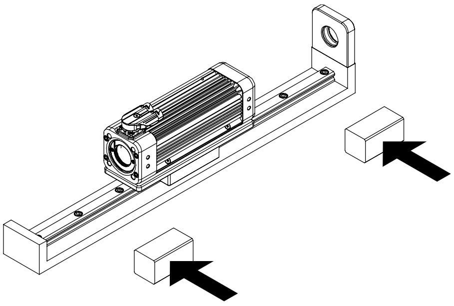
5.3.1 Forcer and Shaft Installation

When installing the forcer and shaft it is a good idea to ensure that all tools and fixtures needed are at hand and that the area is free from any loose objects that may be attracted to the magnetic shaft.

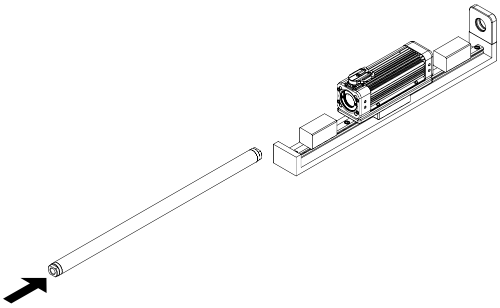
These instructions are generic and are intended as a guide. Your application may differ, but the same processes should be followed.



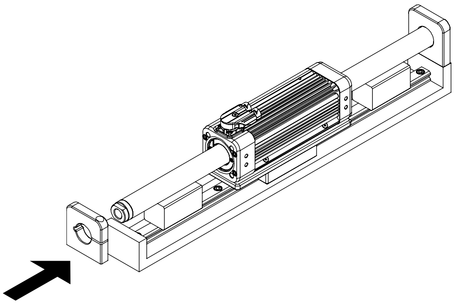
1. Once any accessories have been fitted install the forcer.



2. It is recommended to use some small wood or plastic blocks to prevent the magnetic shaft coming into contact with magnetic surfaces as well as to assist with guiding it into the motor and mounts.



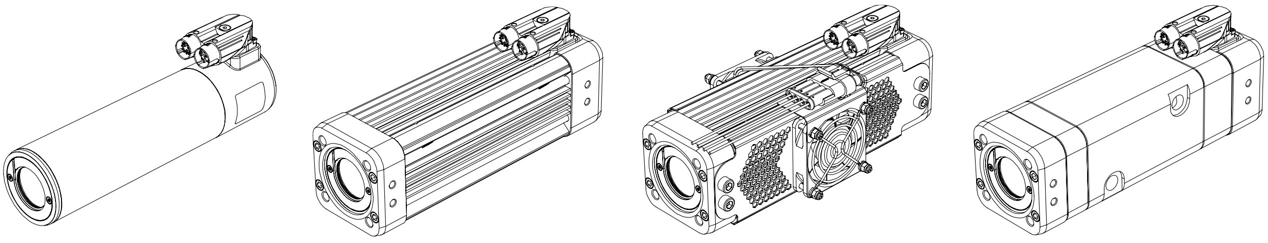
3. Remove the shaft from the packaging, clean any residue off with a soft cloth and slide it through the motor and into a mount.



4. Depending on the mounting configuration, if there is a second shaft mount, install this now. Remove the wooded blocks and move the motor or shaft through its full range of motion and ensure there is no contact on the motor bore, or if using a bushing that there is no binding. Tighten down any bolts once this is complete.

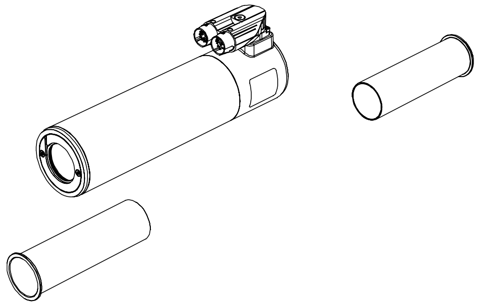
5.3.2 **Accessory Assembly**

The LinX® M series linear motor is available with a range of standard accessories. Details about the performance and ordering of these options and are covered in the above sections *3 Specifications and 2.3.2 Forcer and Mounting.* This section will provide information about the fitment of these accessories prior to the application installation.

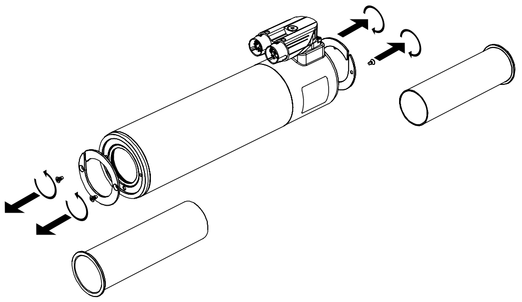


5.3.2.1 **Internal Bushing**

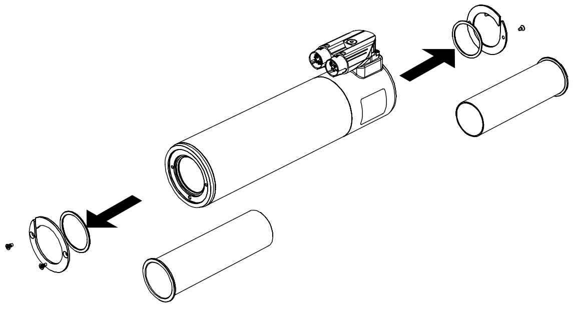
The internal bushing allows for the shaft to run on the inside of the forcer bore and support multiple shaft and forcer mounting configurations. This part is a consumable so it will need to be replaced periodically. Refer to *4.3 Internal Bushings* for guidance on expected bush lifetime. If you need to order new bushings the part number information can be found in *2.3.2.7 Bushing Kit*.



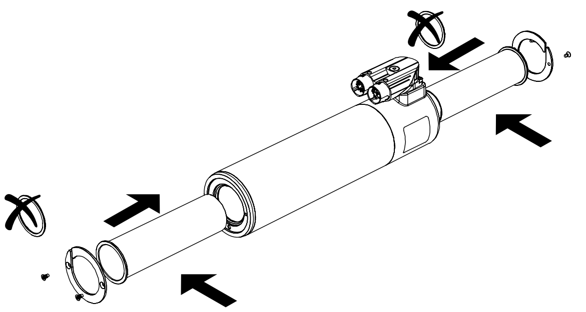
1. If replacing in an existing installation, first remove the shaft from forcer bore and store it in the packaging it came in or in such a way that the requirements in *5.1 Handling and safety* are met.



2. Remove the 4 small Torx screws on the front and rear of the forcer.

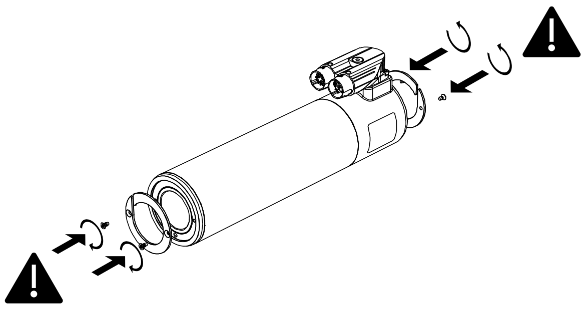


3. Remove the wiper retainer plate as well as the wiper from both ends. Inspect the bore of the forcer, ensure it is clean and free from residue as it may impact the installation of the bushings.

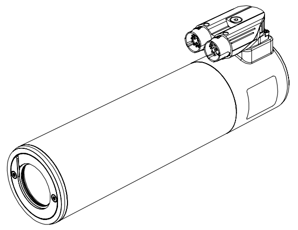


4. Insert the bushings, one in each end such that the flange seats inside the groove where the wiper plate was. Ensure the bushing is pushed all the way in.

   The standard wiper plates cannot be used with bushings installed. Please dispose of them accordingly.



5. Replace the wiper retainer plates and the 4 small torx screws. DO NOT exceed 0.2 Nm torque.

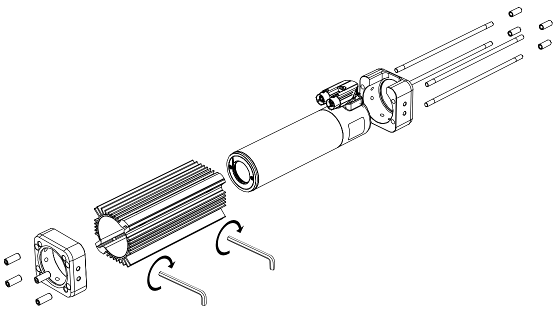


6. The forcer can now be installed, or the shaft can be reinstalled if in an existing application.

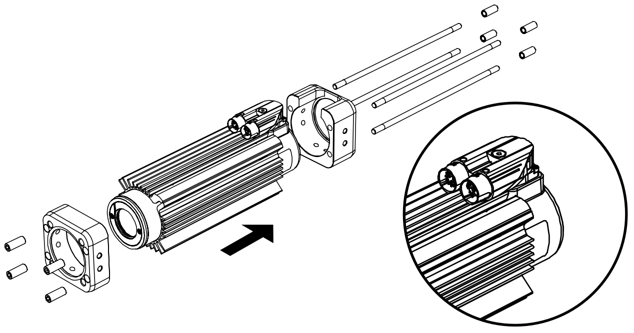
5.3.2.2 Heatsink Kit

The heatsink allows for efficient hat removal from the forcer and improves the continuous force rating of the motor. The heatsink kit requires the use of the modular mounting components included in the kit. The heatsink kit should be installed before installing the forcer into the intended application.

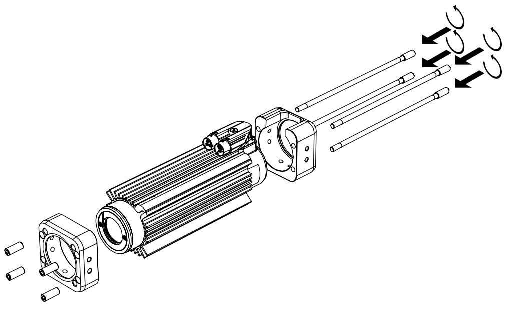
Note, these steps also apply for the mounting kit accessory, just without the heatsink steps.



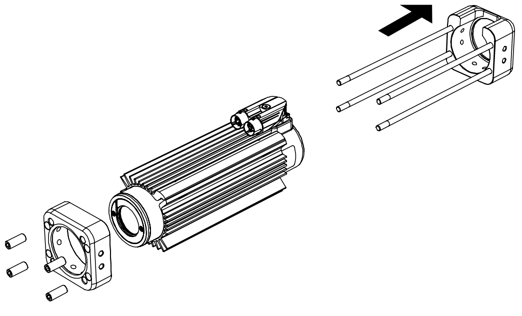
1. Take the two heatsink segments and place them so they form a circular bore. Make sure the countersunk holes align with the tapped holes on the opposing section. Loosely install the countersunk screws. Depending on the motor variant (TLMM-15, TLMM-22, TLMM-30) there will be 4, 6 or 8 screws in total.



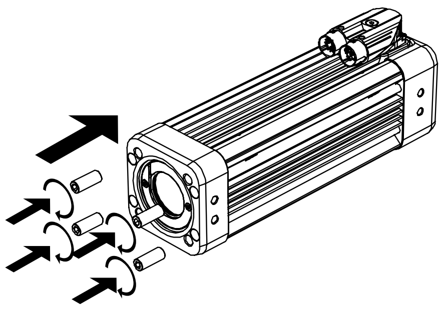
2. Slide the heatsink over the forcer body. Note the orientation.



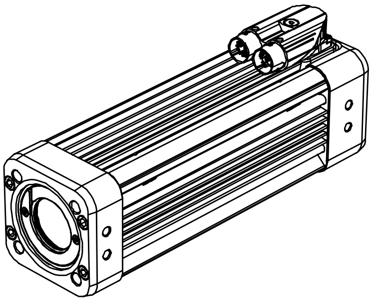
3. Install four of the barrel nuts on to one end of four tie rods. Screw them on so that ½ to ¼ of the thread on the tie rod is still visible.



4. Insert the tie rods with the barrel nuts into the four counterbored holes in the endcap with the square section removed.



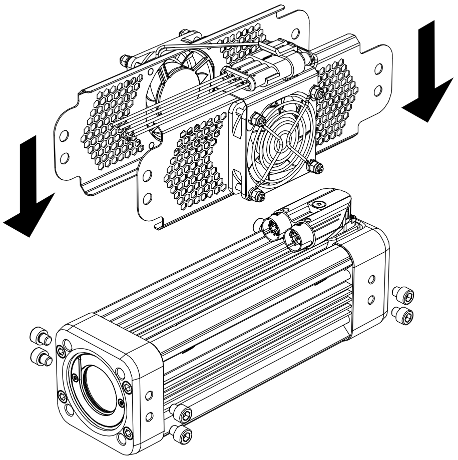
5. Slide the tie rods through the gaps in the heatsink and make sure the endcap seats with the rear face of the forcer. Install the front endcap in the orientation shown and install the last four barrel nuts. Placing the motor on a flat surface, torque all eight barrel nuts to 2 Nm in a cross pattern. Then torque all the heatsink screws to 2 Nm.



6. The forcer can now be installed in the application. It is possible for the bolts to loosen off after a short period due to the initial thermal cycling of the motor. It is recommended that they are checked after the application has been run for short time and tightened if required. It is acceptable to use thread locking compounds for these components.

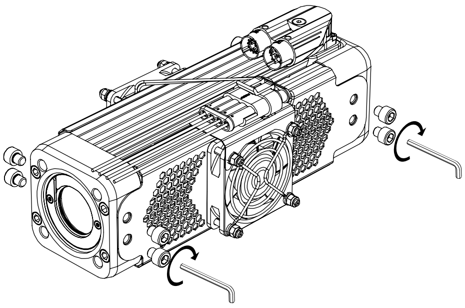
5.3.2.3 **Fan Kit**

The fan kit is an accessory for the heatsink kit. The fan kit allows for further improvement of the motors continuous force. The fans are included in the kit as they have been optimised for the application.

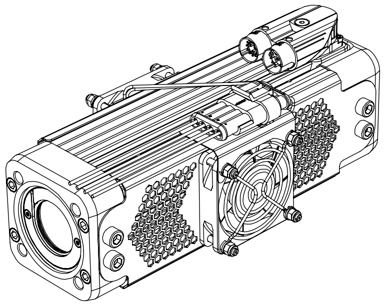


1. Place the heatsink kit assembly over the forcer heatsink. The long mounting tabs on the fan baffles face to the rear of the motor and the flying leads should exit to the front of the motor.

   Note: The direction of the fan flying leads can be changed if required by removing the fans from the baffles and swapping the fans and connector mounting bracket to the opposite side.



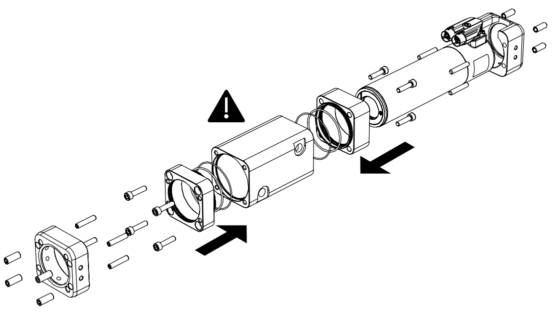
2. Install the eight screws through the fan baffles and into the end caps and torque the bolts to 4 Nm.



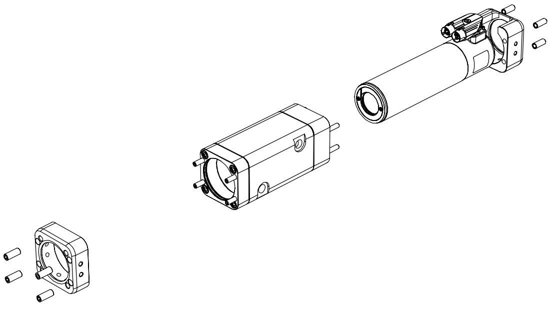
3. The forcer can now be installed in the application and the fans can now be connected. Refer to *3.1 Motor Ratings* for the fan operating specifications.

5.3.2.4 Water Cooling Jacket

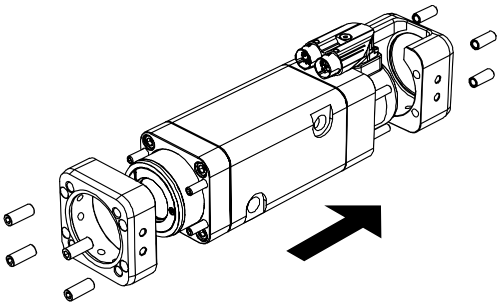
The water-cooling jacket allows for efficient heat removal from the forcer and improves the continuous force rating of the motor. The water-cooling jacket requires the use of the modular mounting components included in the kit. The water-cooling jacket should be fitted before installing the forcer into the intended application.



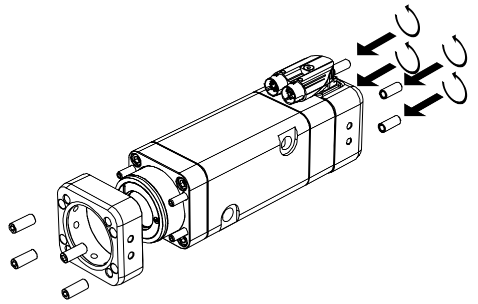
1. Assemble the water cooling jacket components as per the supplementary instructions.



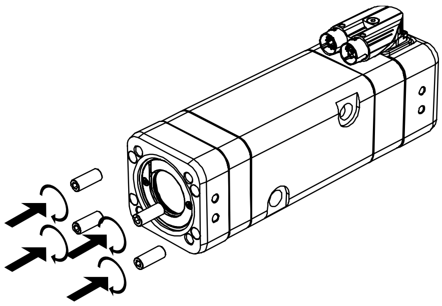
2. Apply a small amount of grease to the O-rings inside the water-cooling jacket and a small amount to the forcer body. Marine grease or assembly grease is acceptable as it stops the O-rings from pinching.



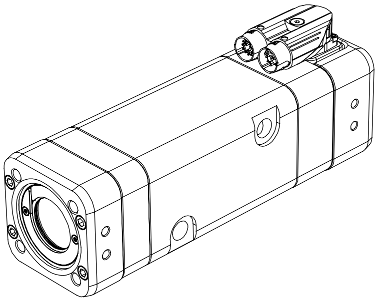
3. Slide the water-cooling jack over the forcer with the large rear section facing the connector end of the forcer. Be careful not to dislodge or pinch the O-rings.



4. Install the rear endcap in the orientation shown and loosely install the four barrel nuts.



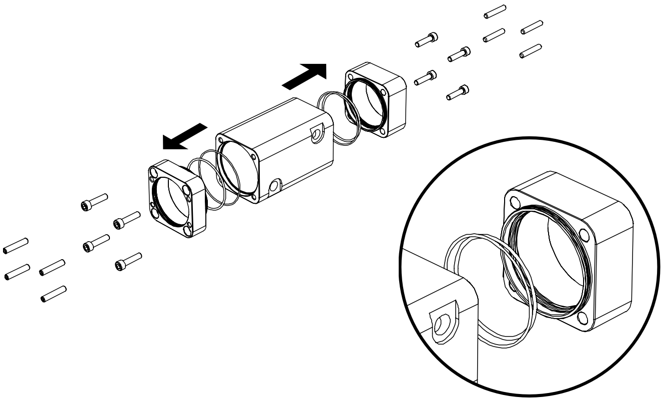
5. Install the front endcap in the orientation shown and install the last four barrel nuts. Placing the motor on a flat surface, Torque all eight barrel nuts to 2 Nm in a cross pattern.



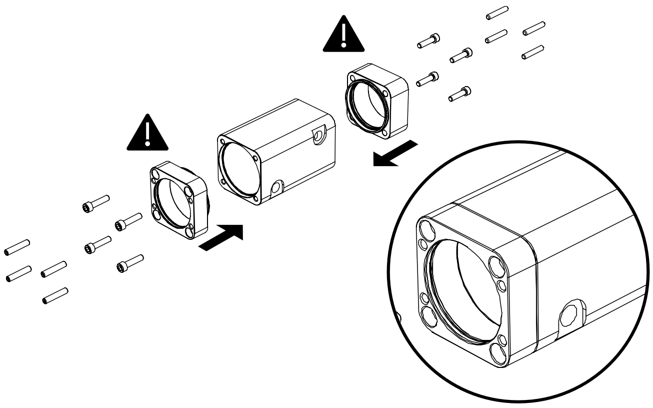
6. It is HIGHLY recommended to leak test the forcer prior to installing in the application. If any leaks are found, disassembly may be needed to check if any O-rings have been damaged.
The forcer can now be installed in the application. It is possible for the bolts to loosen off after a short period due to the initial thermal cycling of the motor. It is recommended that they are checked after the application has been run for short time and tightened if required. It is acceptable to use thread locking compounds for these components.

Water Cooling Jacker Sub Assembly

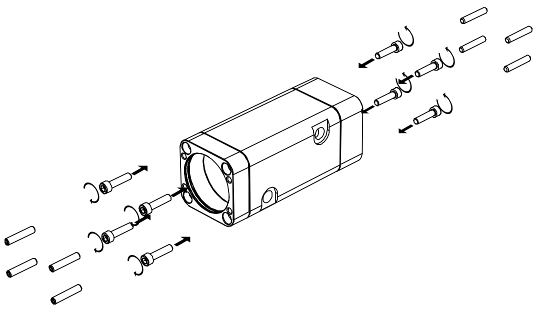
These steps detail the assembly the water-cooling jacket prior to installation onto the forcer.



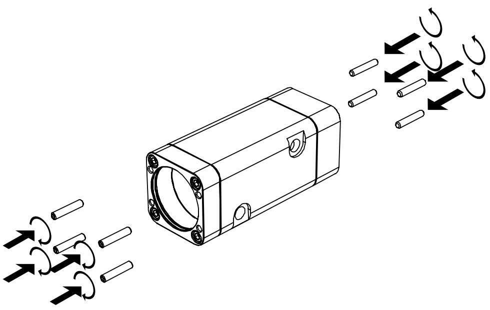
1. Install the O-rings into the water-cooling endcaps. Use a small amount of marine or assembly grease on each O-ring. There are two types or O-rings. The larger cross section O-ring is to be placed in the inside groove in each endcap. The smaller cross section O-ring is to be installed in the external O-ring groove on each end cap.



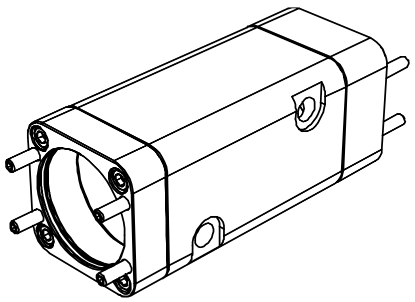
2. Apply a small amount of grease to the inside surface of the central water-cooling jacket body and carefully install the end caps in the orientation shown.



3. Install the eight socket head cap screws into the counterbored holes. Torque the bolts to 7 Nm in a cross pattern.



4. Install the four long studs in the rear endcap so that there is 20mm of thread exposed. Do the same for the four short studs so there is 5mm of thread exposed. It is recommended to use thread locking compound on the studs.



5. The water-cooling jacket is now ready for assembly onto the forcer.

6 Accessories

6.1 Compatible AM Servo Drives

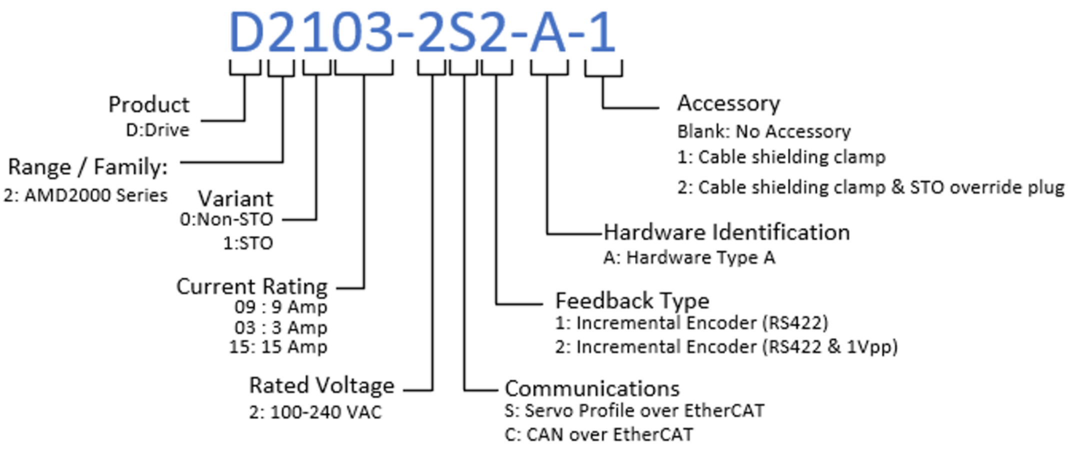
ANCA Motion has two ranges of servo drives that can be used to power and control LinX® motors. These are the AMD2000 and AMD5x drive series. More detailed information on these products, including their specifications, installation and usage instructions can be found on the ANCA Motion website and in their corresponding user manuals.

Drive Catalogue Number	Description
D2103-2S2-A-x	AMD2000 Servo Drive 3A STO SoE
D2109-2S2-A-x	AMD2000 Servo Drive 9A STO SoE
D2115-2S2-A-x	AMD2000 Servo Drive 15A SoE
AMD5-10300-xAx0	AMD5x Series 3A Drive
AMD5-10600-xAx0	AMD5x Series 6A Drive
AMD5-11200-xAx0	AMD5x Series 12A Drive
AMD5-12000-xAx0	AMD5x Series 20A Drive
AMD5-P6150-xAx0	AMD5x Series Passive Infeed Unit 15kW

AMD5x PIU and Servo Drive

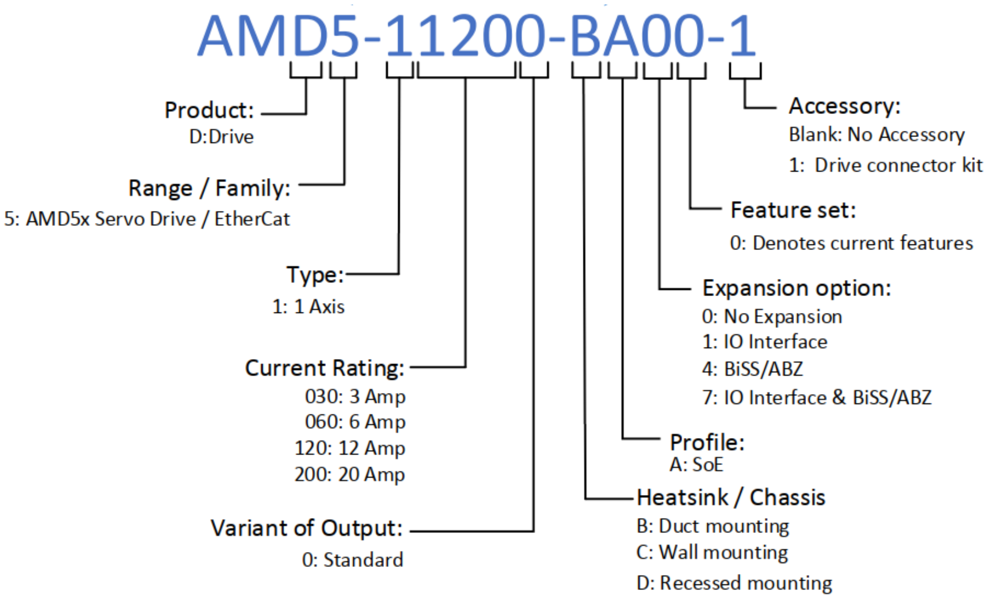
AMD2000 servo drives

The part number description of AMD2000 drives and their options that are compatible with the LinX® M-series motors are as follows:



Note that the AMD2000 15A drive is not yet available with STO functionality.

The part number description of AMD5x drives and their options that are compatible with the LinX® M-series motors are as follows:



Note that the cables in *2.3.6 Cable Catalogue Numbers* have been designed to be compatible with the above drive series.

7 Product, Sales and Service Enquiries

If after reading the User Manual you still require assistance for installation, training or other customer support issues, please contact the closest ANCA Motion Customer Service Office in your area for details.

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