

Installing Tecnotion Ironcore Linear Motors



TECNOTION

TECNOTION B.V.
PO BOX 23
7600 AA ALMELO
THE NETHERLANDS
Document nr. 4022.363.4196.1
Version 2.1
Issue Date: February 2005

Contents

Co

Contents

Installing Tecnotion Ironcore Linear Motors

Contents	1
Introduction	2
1. Before you start	3
1.1. Important notice	3
1.2. Safety warnings	4
1.3. EC declaration	5
2. Components	6
2.1. Basic components	7
2.2. Special features	8
2.3. Additional Features	10
2.3.1. Bolts and dowel pins	10
2.3.2. Controller and measurement unit	11
2.3.3. Tools	11
3. Installation	12
3.1. Installation order	13
3.2. Mounting of the Coil Unit	15
3.2.1. Mounting instructions	15
3.3. Mounting the magnet plates	17
3.3.1. Warning	18
3.3.2. Mounting the magnet plates	19
3.3.3. Covering the magnet plate	22
3.4. Electrical Connections	25
3.4.1. General remarks	25
3.4.2. Power lines	27
3.4.3. Protective earth	27
3.4.4. Temperature Sensor	28
3.4.5. PTC specification	28
3.4.6. KTY specification	29
3.4.7. Polarization test	30
3.5. De-installation order	31
4. Additional installations	32
4.1. General remarks	32
4.2. Installation water cooling unit (TL only)	32
4.2.1. Requirements	32
4.2.2. Fitting Water-cooling Connections	33
4.2.3. Connection of hoses	33
5. Operation	35
5.1. General	35
5.2. Configuring	35
5.3. Optimization of control settings	37

Intro

I

Introduction

Generally a linear motor system is a part of a specific machine. Tecnotion's linear motors can be combined with numerous application devices. This installation manual is intended for those technicians who construct a machine that includes a linear motor system

When installing a linear motor system one should be familiar with some important safety remarks. In the first chapter these remarks are made. Please, read them carefully.

Besides mounting the coil unit and the magnet plates, the installation includes the electrical wiring and the connections between the motor, the servo-controller and the linear encoder.

Before starting up, some required settings will be discussed. Finally your linear motor can take off for it's first ride.

For further information and support, please contact:

TECNOTION B.V. PO Box 23 7600 AA Almelo The Netherlands	Telephone: +31(0)546 536 300 Fax: +31(0)546 536 310 sales@tecnotion.com www.tecnotion.com
--	--

Chapter

Ch

1. Before you start

Please read the following instructions very carefully. They are important for a safe and warranted installation and operation of the Linear Motor.

1.1. Important notice



Before installing and using the Linear Motor, read this instruction manual carefully. The manufacturer declines all responsibility in case of accident or damage due to negligence or lack of observance of the instructions described in this manual. The manufacturer also declines all responsibility in case of accident or damage in conditions that differ from those indicated in the manual; Tecnotion also declines all responsibility for damage caused by improper use of the Linear Motor.



Handle the components of the Linear Motor with care, packed as well as unpacked. Especially the magnet plates are sensitive to mechanical shocks. Never drop a magnet plate or release it in an uncontrolled way. Do not expose the magnets to temperatures higher than 70° C. The magnets may be demagnetized at higher temperatures.



Unpack the Linear Motor and check its integrity. If there is any irregularity, contact the dealer or manufacturer, signalling the nature of the defects. Make a note of the serial number. This facilitates the correspondence with the supplier.

1.2. Safety warnings



The Linear Motor is used as a part of a machine. The user has to take care that the machine as a whole fulfils all CE requirements.



The magnet plates show large attraction forces on all soft magnetic objects such as iron. These forces cannot be controlled by hand. They may cause serious jamming danger.



Do not bring any soft magnetic objects (iron) nearer than 10cm of the magnetic side of the magnet plates.

Be sure that the magnetic plates are fixed into your machine before removing the magnetic field neutralizing protection plates.

Put the magnetic field neutralizing protection plates on the magnetic plates again before dismounting them.



If at any time and in any situation there is any doubt about the safety of the Linear Motor, do not use it and contact your supplier.



The Linear Motor is powered by a servo amplifier. In case of a power disruption or fatal error this may automatically result in a free run out of the motor. Make mechanical precautions to prevent damage on the motor or your machine in the case of such an event.



Before installing the motor, make sure that the supply mains are grounded and operate in conformity with the regulations in force.



Make sure that there is an effective protective earth. Make sure that there is no voltage at the line wire terminals before connecting.



An earth connection does not work on non-conducting mounting surfaces like granite. In these cases the protective earth must be established by an earthing wire



Before carrying out checks or doing any maintenance, clear the system by disconnecting the voltage. Be sure that there is no possibility of accidental connections.



Be aware of electrical danger when the cooling liquid comes in contact with the supply means.

1.3. EC declaration

Tecnotion B.V. declares that the all linear motors produced by Tecnotion are manufactured in accordance with the applicable European directives and in conformity with the following standards:

Standard #	Date of issue	Name of Standard
EN 60034	05-1998	Rotating electrical machines
EN 60204 (-1)	02-1995	Safety of machinery
EN 50081-2	08-1993	Emission requirements for products in an industrial environment
EN 50082-2	03-1995	Immunity requirements for products in an industrial environment

Chapter
Ch

2. Components

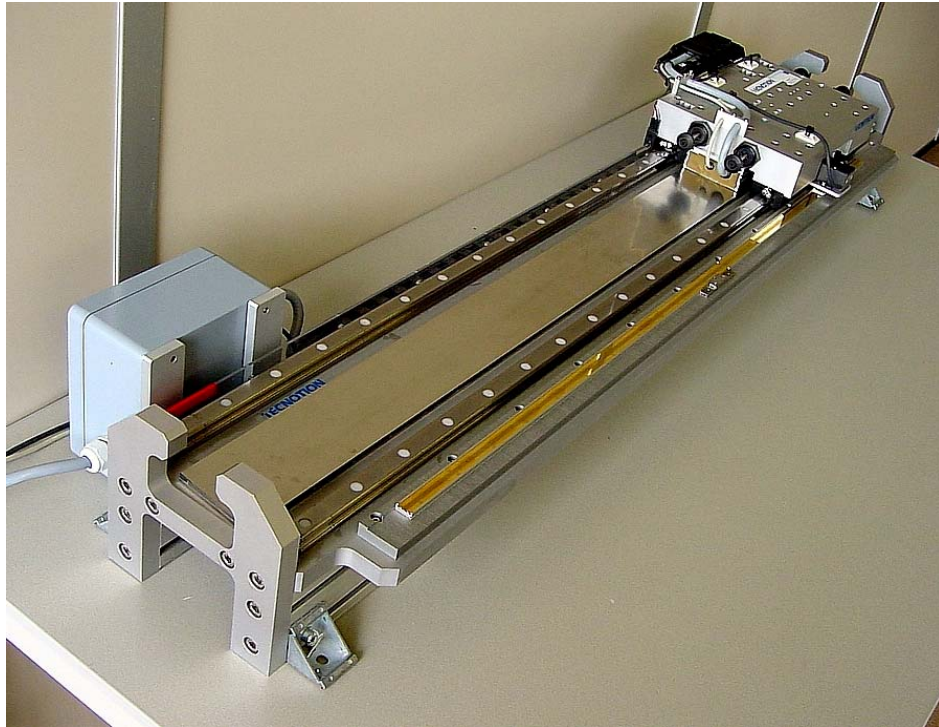


Figure 1: A complete iron core linear motor system

An iron core linear motor of Tecnotion is not a system on itself. It contains several components, such as a coil unit and magnet plates. The components should be built within a total machine concept or a working unit. The size and the shape of the mounting frame, the design of the slide, the type of rails and bearings or the kind of dampers depend of the required application. For instance the mounting frame and the slide should be designed in such a way that a correct air gap between coil unit and magnet track will be obtained.

Tecnotion provides standard and special components which are suitable for numerous linear motor applications. These components can easily be applied in your system.

2.1. Basic components

The basic Linear Motor components supplied by Tecnotion are:

- The ***coil unit*** (the N- and S-versions differ in voltage and current requirements)

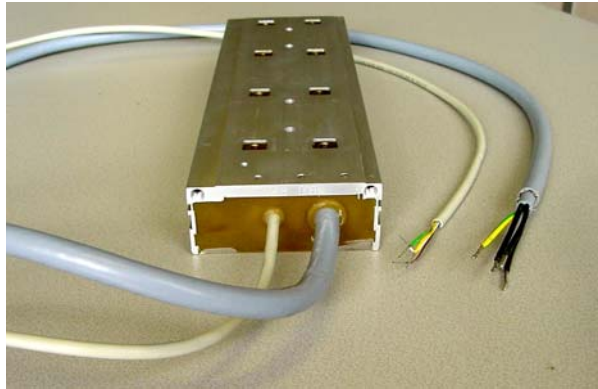


Figure 2: Coil unit

- The ***magnet plates*** (in different lengths)



Figure 3: Magnet plate

2.2. Special features

In addition special features are supplied by Tecnotion. These include:

- Magnetic field neutralizing **protection plates** for mounting and dismounting purposes.



Figure 4: Magnet plate covered with protection plate

- Stainless steel **cover plate** to avoid contamination; one plate for the whole axis length.

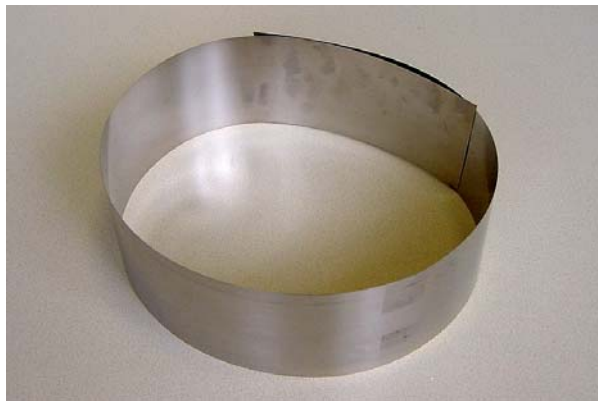


Figure 5: Magnet track cover plate

- **End frets** (used as earthing equipment for cover plate).

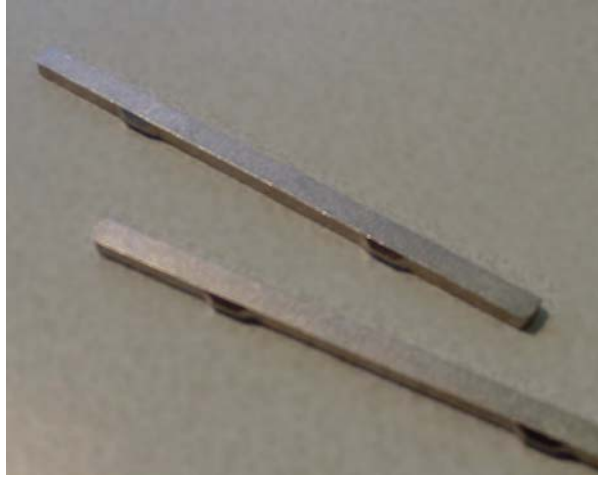


Figure 6: End frets

The previous mentioned standard components are delivered by Tecnotion.



Before starting the installation, check the presence of the right number and type of the delivered components. In case of doubt, please contact Tecnotion immediately.

2.3. Additional Features

For a proper installation of your linear motor system you also need

- fixing components, like bolts and pins;
- additional devices, like a servo controller and a linear encoder;
- the right mounting tools.

These features are no part of Tecnotion's standard delivery.

2.3.1. Bolts and dowel pins



Figure 7: Bolts and dowel pins

The following bolts and dowel pins are required for positioning and connecting the coil unit to the slide as well as connecting the magnet plates to the mounting frame:

Features	TM	TL	TB
Bolts for magnet plates (stainless)	M5x10, DIN7984	M5x10, DIN7984	M5x16, DIN912
Bolts for coil unit (steel), length depends on thickness slide	M4 DIN912	M5 DIN912	M5 DIN912
Dowel pins (stainless)	5h8 M3		

2.3.2. Controller and measurement unit

Required is:

- An appropriate servo controller/amplifier
- A ruler and a linear encoder or an analogue Hall module
- Power supply, cabling and connectors

For more information please contact Tecnotion.

2.3.3. Tools

Necessary for the installation is:

- Allen key set
- Protective gloves (for handling the cover plate)

Chapter
Ch

3. Installation



3.1. Installation order



The installation order of this instruction manual must be followed. A different order may cause dangerous situations and damage due to uncontrolled magnetic attraction forces.

Before installing the linear motor components, the installation of the mounting frame should be completed. The rails should be properly positioned and mounted on the frame, as well as the ruler. The slide should be provided with bearings, dampers, linear probe and required cabling in such a way that a smooth, save and well positioned transport of the slide over the stroke is established. The operation of bearings and dampers should be tested as well as the guidance of the moving cables.



Tip: In case of the installation of an optional water cooling unit, please refer to chapter 4.

Now the correct installation order in headlines is:

1. Mount the connections for water cooling on coil unit (when used).
2. Mount coil unit to the slide.
3. Move slide to the end of the stroke. Secure slide against unwanted movements.
4. Mount magnet plates on the exposed part of the track. Make sure the magnet plates are covered with the protection plates. Keep magnet plates at least 10 cm away from coil unit.
5. Remove protection plates from the mounted magnet plates.
6. Move slide above the newly mounted magnet plates. Secure slide against unwanted movements.

7. Mount the remaining magnet plates.
8. Mount the end frets, the stainless steel cover plate and the earth connection of the plate.
9. Check earth connection of the cover plate
10. Connect wiring and hoses for water cooling to coil unit.

These steps will be discussed in detail in the next paragraphs.

3.2. Mounting of the Coil Unit

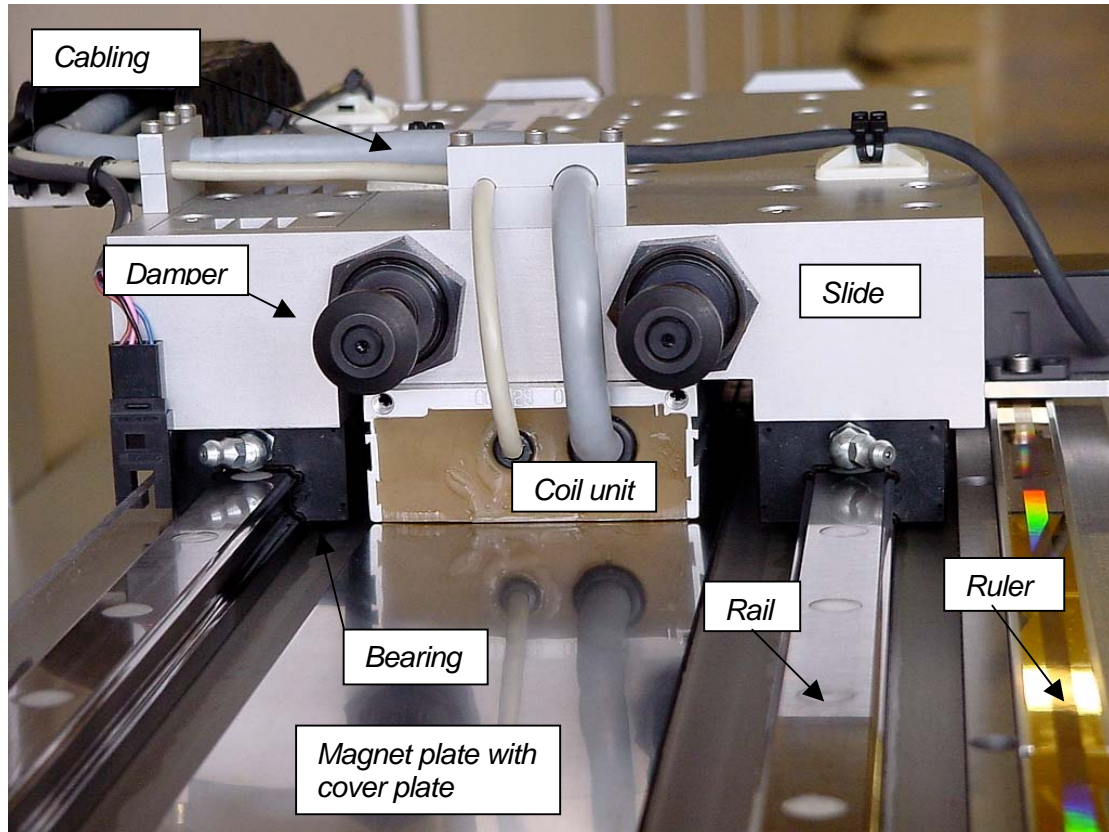


Figure 8: Coil unit mounted underneath a slide

3.2.1. Mounting instructions

Before mounting, notice the following remarks. The flatness of the mounting surface for the coil unit must be better than 0.1 mm. The coil unit has to be mounted parallel to the magnet plate. The parallelism has to be better than 0.20 mm. For this purpose the side of the coil unit or the round holes in the mounting surface can be used. Dowel pins can be applied for the round holes. Sideward positioning of the coil unit to the magnet plates is not very critical. A tolerance of up to ± 0.5 mm is acceptable.

Please note the following remarks and specifications.

Tip: use dowel pins with M3 internal thread to facilitate dismantlement afterwards.

Tip: Apply crosswise tightening of the bolts in order to obtain an equal distribution of fixing force.



Applying too long bolts for the coil unit may inconspicuously cause damage and dangerous situations.

Please, check

- (1) bolt length before mounting and**
- (2) bolt height after mounting.**

Bolts for coil unit	TM	TL	TB
Bolts (steel)	M4	M5	M5
Depth bolt in thread hole	Min: 4 mm Max: 5 mm	Min 4 mm Max: 5 mm	Min: 4.5 mm Max: 6.5 mm
Tightening torque	2.0 – 3.0 Nm	3.0 – 5.0 Nm	3.0 – 5.0 Nm

In case of applying water cooling: be aware that the connections for the water cooling unit can lay up to 1 mm above the mounting surface. Create enough space or use an intermediate plate of at least 1 mm thickness. Also see chapter 4: Additional installations.

3.3. Mounting the magnet plates

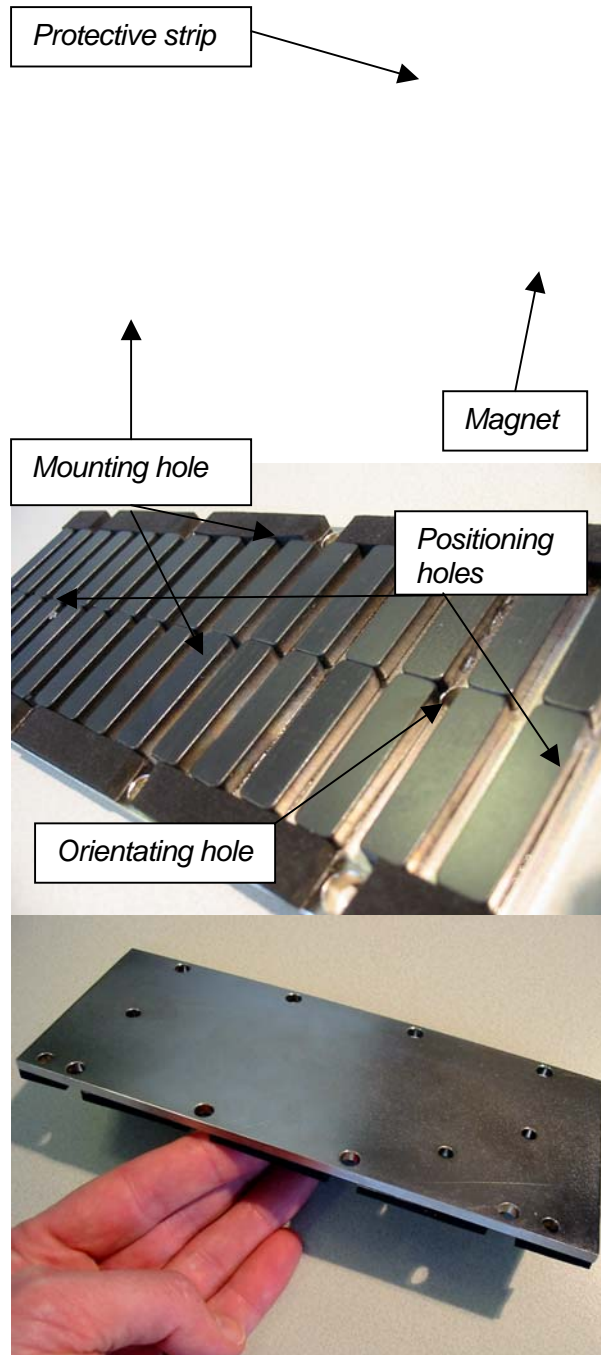


Figure 9: Magnet plate, details

3.3.1. Warning



Especially the magnet plates must be handled with care. They are sensitive to mechanical shocks. Never drop a magnet plate or release it in an uncontrolled way!

The magnetic side of the plates is the structured side. The magnet plates do show large attraction forces on all soft magnetic objects such as iron. These forces cannot be controlled by hand. They could cause serious jamming danger. Therefore, consider the following warnings.



CHAMP MAGNÉTIQUE
DANGER
MAGNETIC FIELD

Only handle the magnet plates if covered with the magnetic field neutralizing protection plates.

Be sure that the magnet plates are fixed into your machine before removing the magnetic field neutralizing protection plates.

Put the magnetic field neutralizing protection plates on the magnet plates again before dismantling them.

Do not bring any soft magnetic objects (iron) nearer than 10 cm of the magnetic side of the magnet plates.

3.3.2. Mounting the magnet plates

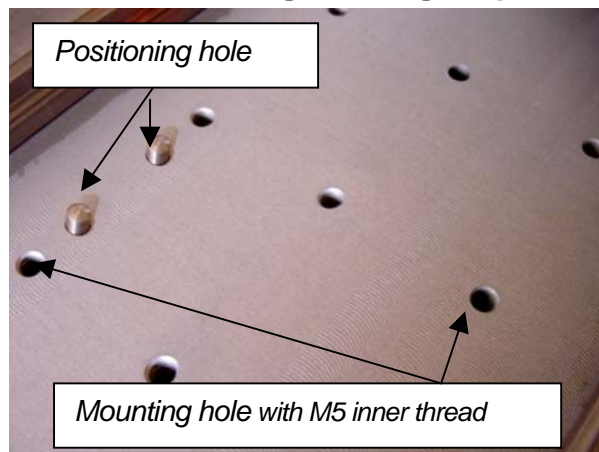


Figure 10: Mounting frame, detail

1. Move the slide to one end of the stroke. The first magnet plate will be mounted against the other end of the stroke. Secure the slide against unwanted movements. Make sure the mounting surface is free of dust and small particles.
2. Apply dowel pins for the positioning holes in the mounting frame (see Figure 10: Mounting frame, detail). Choose the holes according to the position of the accurate $\varnothing 5$ positioning holes in the magnet plate (see Figure 9: Magnet plate, details)



Tip: Use pins with M3 internal thread to facilitate dismantlement afterwards.

The total height of the dowel pin above the mounting surface should be 3.5 mm at most.

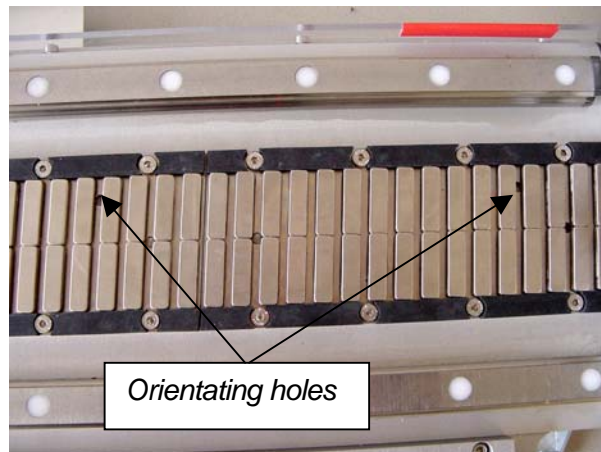


Figure 11: Orientating the magnet plates

3. Take care that magnet plate is well orientated. Finally all magnet plates should be orientated in an equal direction. For example, all magnet plates could be placed in such a way that the orientating holes are directed in the right upper corner (see Figure 11: Orientating the magnet plates)
4. Fix the magnet plate to the mounting frame. Depth of thread should be at least 6.5 mm. Tightening torque: 2.5 to 3.5 Nm for stainless steel. All holes must be used!
5. Remove the protection plate from the mounted magnet plate and move the slide to the other end of the stroke. Secure the slide against unwanted movements (now this could be done by replacing a protection plate, see Figure 12: Securing the slide with a protection plate). Once again, make sure the mounting surface is free of dust and small particles.



Figure 12: Securing the slide with a protection plate

6. Now the rest of the magnet plates can be mounted in a similar way. The right orientation of the plates can also be noticed when another plate is placed. The adjacent plates should attract each other. When they are repelling each other the plates are wrongly orientated.



Figure 13: Placing another magnet plate

7. Finally remove all protection plates and check whether the slide can move freely and smoothly over the magnet plates. When there is a strong force ripple at the edges of the magnet plates, please check the orientation of the plates.

3.3.3. Covering the magnet plate

Now the magnet plates are mounted, the finishing touch can be made. This means that the end frets must be placed and that the magnet track is covered by a stainless steel cover.

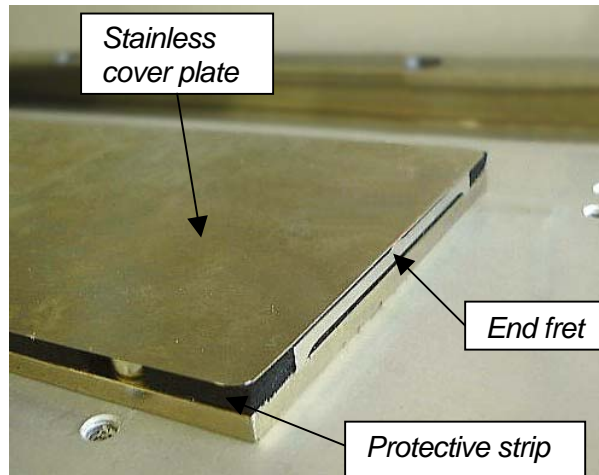


Figure 14: The end of the stroke, detail

1. Place the end frets at the edges of the magnet track. They are kept in position by magnetic forces.
2. The magnet plate cover must be placed according to the steps below.



Be careful! The stainless steel magnetplate cover could have sharp edges. Wear protecting gloves while handling the cover.



Because of the high magnetic forces the cover will adhere firmly to the magnet plates. Placing is easily performed by rolling off the flexible cover. Removing is best performed by rolling up.

For the next steps also see Figure 15: Placing the stainless magnet cover.

- a. Move the slide to one end of the stroke to clear the major part of the magnet track.
- b. Unroll the cover over the cleared magnet track.
- c. Move the slide to the middle of the stroke.
- d. Now lift up the ends of the cover so that only a small part of the cover (underneath the slide) sticks to the magnet plate. This could best be handled by two persons.
- e. In this position the cover can be slipped over the magnet track. Now position the cover so that there is a small overlay at each end of the stroke.
- f. Cut off the overlay and place the cover accurately. The stainless cover should precisely cover the protective strips and the end frets.

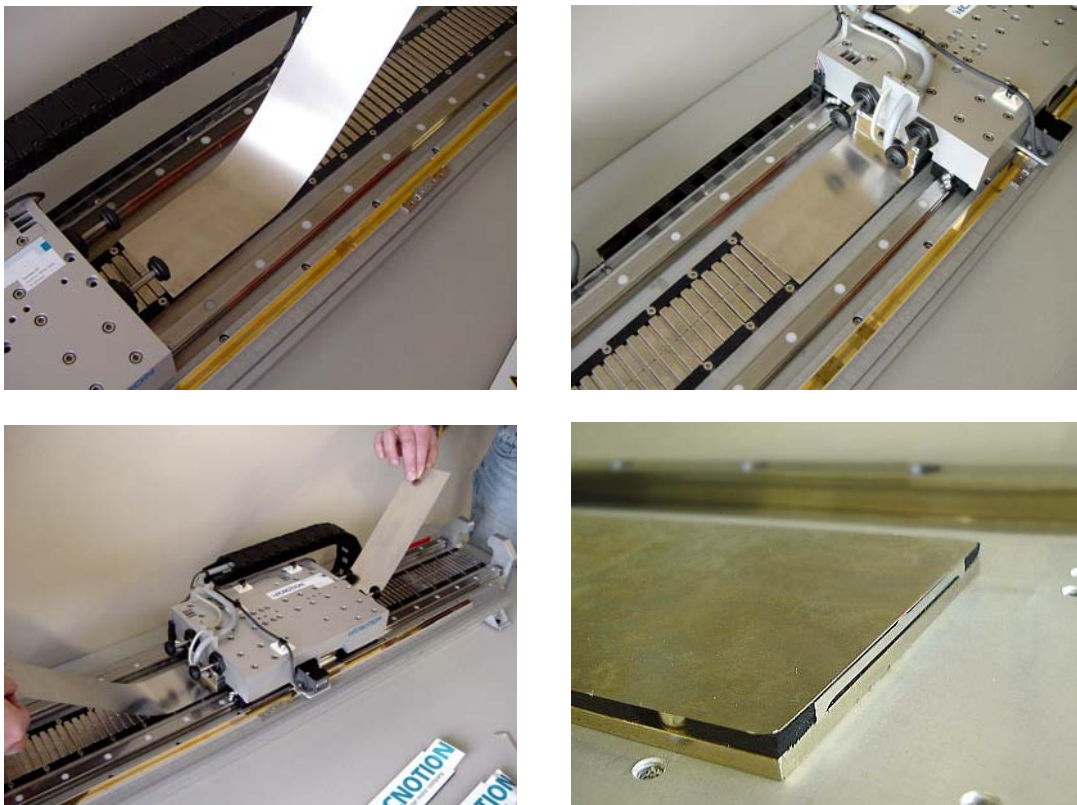


Figure 15: Placing the stainless magnet cover



Note that the magnets and the end frets are fixed obliquely on the stroke.

3. Finally the earth connection of the stainless cover has to be checked in accordance with the machine's safety standards.



Before operation make sure that there is an effective protective earth.

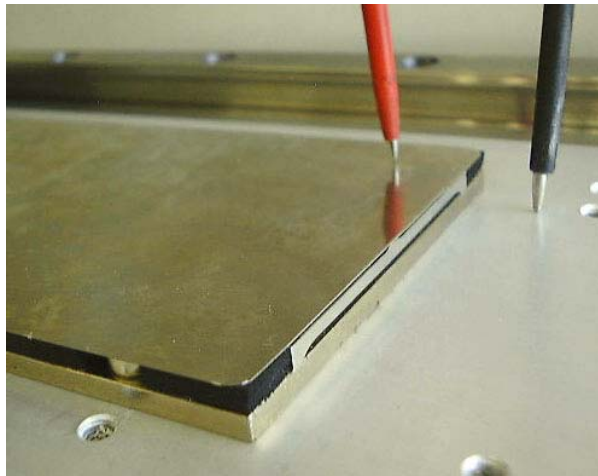


Figure 16: Protective earth test for stainless cover

3.4. Electrical Connections



Before starting any activity on the wiring, make sure that the mains are disconnected. Work carefully according to the instructions belonging to the applied servo controller. Be sure your machine meets the requirements of the EN 60204 standard.

3.4.1. General remarks

The linear motor's electrical wiring is externally configured with two one meter cables: a power cable and a temperature cable. For wiring scheme see figure below. If desired you can shorten these cables and provide them with appropriate connectors. Note that these cables are not meant for use within cable chains. Therefore user defined cables should be used that meet the specifications concerning bending radius, length, replaceability, etcetera. In this case the motor's standard cables must be connected properly to the user defined cables. Both power cable and temperature cable are shielded with a plaited metal cable sheath for electromagnetic immunity.

Besides this manual you should follow carefully the installation instructions of your servo amplifier supplier. Make sure that the linear motor system as a whole meets all the applicable electrical directives.

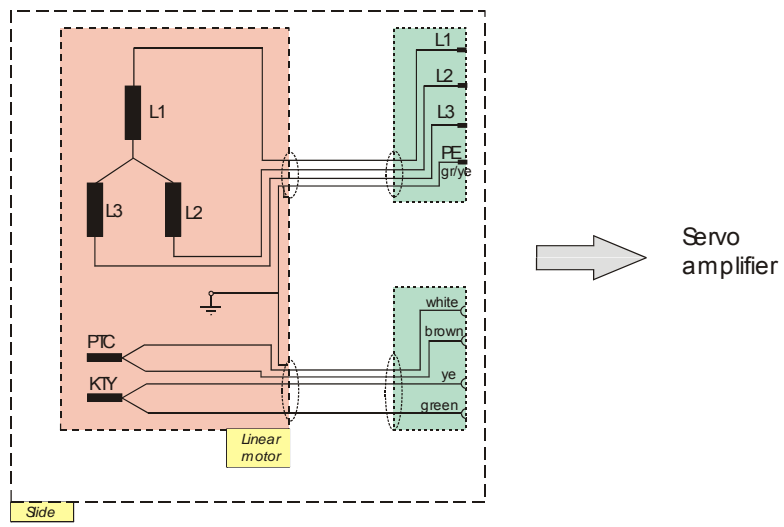


Figure 17: Wiring scheme iron core

3.4.2. Power lines

The three phases of the motor's power cable has to be connected to the servo amplifier in such a way that the positive three phase direction of the motor conforms the positive direction of the linear encoder. This polarization has to be tested, it cannot be seen at first sight.



Testing the polarization is very important, because a wrong polarization will result in an uncontrolled run out of the slide.

The power cable can be confectioned by the user to fit on the servo drive. For moving cables it is advised to make the moving parts replaceable. This can be done by making a connection of the coil unit cable to the moving cable on the slide.

Powerlines		Color TL/TB	Color TM	Connection to servo controller
3-phases	L1	black '1'	black	3-phases
	L2	black '2'	red	
	L3	black '3'	white	
Protective Earth		green/yellow	green	Protective Earth
Shield				(Protective) Earth

3.4.3. Protective earth

Be sure that the earth shield of the cable is well connected – also through the connecting devices – to the PE connector or the housing of the amplifier. Most TL linear motors are driven on the principle of pulse width modulation. This involves large electrical impulses and causes a significant risk of electromagnetical interference.

Internally the motor's PE wire is galvanic connected to the motor housing. This wire must be connected to the PE connector of the servo amplifier. Provide the motor system with PE lines to the amplifier that are as short as possible.

3.4.4. Temperature Sensor

The coil unit is equipped with two temperature sensors, one of the PTC-1k-type and one of the KTY21-6 type. The PTC resistor is the motor's standard device for checking the heat production in the coil unit.

The temperature cable consists of four wires. For wire color and function, see table below.

Sensor Lines (color)	Connection to servo controller
PTC (white)	PTC
PTC (brown)	PTC
KTY21 (green)	KTY21-6
KTY21 (yellow)	KTY21-6
Shield	Protective Earth

3.4.5. PTC specification

The PTC-1k type is a sensor which has a very sudden resistance rise near the critical temperature of the coils. It is almost a digital indicator: temperature below vs. over critical temperature. Therefore it is very useful for signaling over temperature without requiring sensitive electronics. Disadvantage is that it is not possible to obtain a temperate signal.

At room temperature the PTC has an electrical resistance of about 65 Ohms. When the temperature raises to the critical temperature the resistance will increase rather uniformly up to 1000 Ohms. Above this temperature the resistance increases exponentially. Now, 1000 Ohms is the switching resistance. The amplifier should immediately stop the power supply when this resistance is exceeded. In this way overheating and motor damage can be prevented. No need to say that the PTC cable must be connected properly to the amplifier.

Temperature	Resistance
Up to 20°C below critical temperature	< 250 Ω
Up to 5°C below critical temperature	< 550 Ω
Nominal switching resistance	1000 Ω
Above critical temperature	> 1330 Ω

3.4.6. KTY specification

The KTY 21-6 has a rather stable and slow temperature coefficient. It can supply a temperature reading in the whole range. Therefore it is useful to monitor the coil temperature during tests and to decide whether the thermal margins are enough to guarantee error-free running of the machine under certain conditions. Disadvantage is that the sensor requires sensitive and accurate electronics to obtain a reliable reading

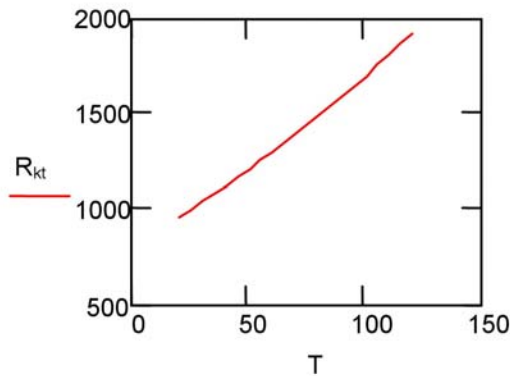


Figure 18: Temperature dependance of KTY sensor

T (°C)	0	10	20	30	40	50	60	70	80	90	100	110	120	130
$R_{KTY} (\Omega)$	815	886	961	1040	1123	1209	1300	1394	1492	1594	1700	1810	1923	2041

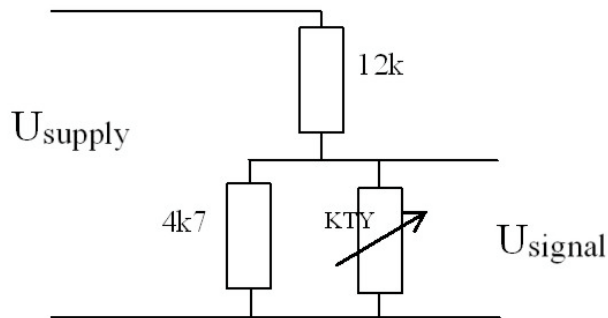


Figure 19: Scheme for obtaining a linear voltage signal from the KTY-sensor

3.4.7. Polarization test



Before testing, make sure that the electrical and mechanical protection of the linear motor system is well configured!

There is one regular way of testing the polarization. Most servo amplifiers can operate in an *in moment service* mode. By means of regulating an external resolver manually, it can be determined whether the motor's direction of running conforms the resolver's sense of rotation. If so, the motor is well connected. If not, two phases of the power cable – phase 1 and 3 – must be changed.

Internally all iron core linear motors are equally wired and connected, so one test satisfies to find out the polarization of a motor ruler combination. If more axes are constructed in a similar way the polarization will be equal.

For more information, please contact Tecnotoin.

3.5. De-installation order



The de-installation order of this instruction manual must be followed. A different order may cause dangerous situations and damage due to uncontrolled magnetic attraction forces.

The correct de-installation order in headlines is:

1. Disconnect wiring and (when applied) hoses for water cooling of the coil unit.
2. Move slide to one side. Secure slide against unwanted movements.
3. Dismount the earth connection of the plate, the stainless steel cover plate and the end frets.
4. Adhere the protection plate to each magnet plate that needs to be removed.
5. Remove one or more magnet plates. Keep magnet plates at least 10 cm away from coil unit.
6. Move slide to other end. Secure slide against unwanted movements.
7. Remove remaining magnet plates.
8. Remove coil unit from the slide.

Chapter

Ch 4. Additional installations

4.1. General remarks

In this chapter additional attention is paid to the installation of an optional water cooling unit. In Tecnotion's standard program of iron core linear motor the water cooling option has only been intended for the TL series.

If you intend to construct a linear motor system based on the TM or TB series and if water cooling is required, please contact Tecnotion.



Note that Tecnotion does not accept any responsibility for the effects of leakage.

4.2. Installation water cooling unit (TL only)

4.2.1. Requirements

For connecting the water cooling unit to the coil unit you need at least:

- PVC hoses (ø4 inner)
- 4 M5 hose connections
- M5 plastic sealings
- Loctite sealant 638/648

For the dimensions of the coil unit and the position of the standard water-cooling connections please contact Tecnotion



The use of other connections may cause higher pressure drops than indicated due to smaller throughput.

4.2.2. Fitting Water-cooling Connections

If desired M5 connections can be mounted. Take care that the flow diameter is at least $\varnothing 2.5\text{mm}$ and hose $\varnothing 4\text{mm}$ inside.

1. Degrease connection and thread hole. Before continuing make sure the degreasing agent has vaporized completely.
2. Place plastic sealing ring on connection.
3. Put one drop of Loctite 638/648 glue on thread and distribute glue around.
4. Mount connection and turn until the sealing ring is deformed visibly. (This only requires about 0.2 - 0.3 Nm torque. Do not turn too hard!)
5. Remove surplus of glue.
6. Let glue harden for 4 hours before applying loads.
7. Let glue harden for 12 hours before applying pressure.
8. Hoses must fit with the connections chosen.

Examples of water-cooling connections which are suitable for hoses $\varnothing 4$ inside are for example: Festo PU-4 pneumatic or the very flexible PVC-hose Rauclair E 4x1. Both hoses and connections can take 2 bar of pressure.

4.2.3. Connection of hoses

When fitting the hoses, the connections have to be free of greases and oil.

Connections of both cooling channels in series is possible. The minimum flow is 1 l/min, causing a pressure drop below 1 bar.

Both cooling channels can also be used in parallel. This connection reduces the pressure drop, but only if cavitationless $\varnothing 6\text{mm}-\varnothing 8\text{mm}$ Y-joints are used.

5. Operation

5.1. General

When you are convinced that your application's linear motor system is assembled in a proper way, both mechanically and electrically, you can do the next step. You can put your motor system into operation.

But before powering the system, please do have a final check:



- 1. Does the slide have a free run over the whole magnet track, without touching small mechanical parts like bolts or contamination?***
- 2. Are the mechanical end stops, end switches and the dampers well dimensioned and properly configured?***
- 3. Does your system have an emergency stop?***
- 4. Is the temperature cable properly connected?***
- 5. Does the motor ruler combination have the right polarization?***
- 6. Has the power cable been connected properly?***

5.2. Configuring

After the amplifier is powered up some input and output signals need to be examined.

1. Check the end switches by pushing the slide manually to the switch position. Simultaneously check whether the signal is detected by the amplifier.
2. Check the presence of the PTC signal.

The following motor items should be configured as parameter settings of the servo amplifier:

3. Maximum continuous current.
4. Maximum peak current.
5. Amount of self induction poles.
6. Maximum speed (rpm).
7. Presence/absence of an electromechanical motor brake.
8. Magnet interval (North-South distance) and/or polepitch (North-North distance).
9. Switching resistance of PTC.

The following settings for the ruler system should be configured as parameters of the servo amplifier:

10. Type of interface of the ruler system.
11. Resolution or period of the linear encoder.

These are the I/O parameters to be configured:

12. Settings of the available digital inputs and outputs. For instance, pay attention to the type of end switches.
13. Settings of the available analog inputs and outputs.

Finally the controlling parameters must be configured.

14. Current control settings. These settings depend on both motor and amplifier.
15. Speed control settings.
16. Position control settings.



For configuring several types of servo amplifiers Tecnotion can offer parameter files. With these files motor specific settings can be configured. Nevertheless, application specific settings should be configured by yourself. Please contact Tecnotion for information.

5.3. Optimization of control settings

Now the current control is configured, the speed control can be adjusted. Supply the motor with several step signals (for example $v=0$... to ... 1m/s). Depending on the response the amplification factor and the integration time have to be adjusted according to the common rules of standard control technology. After this the position control can be adjusted in a similar way.