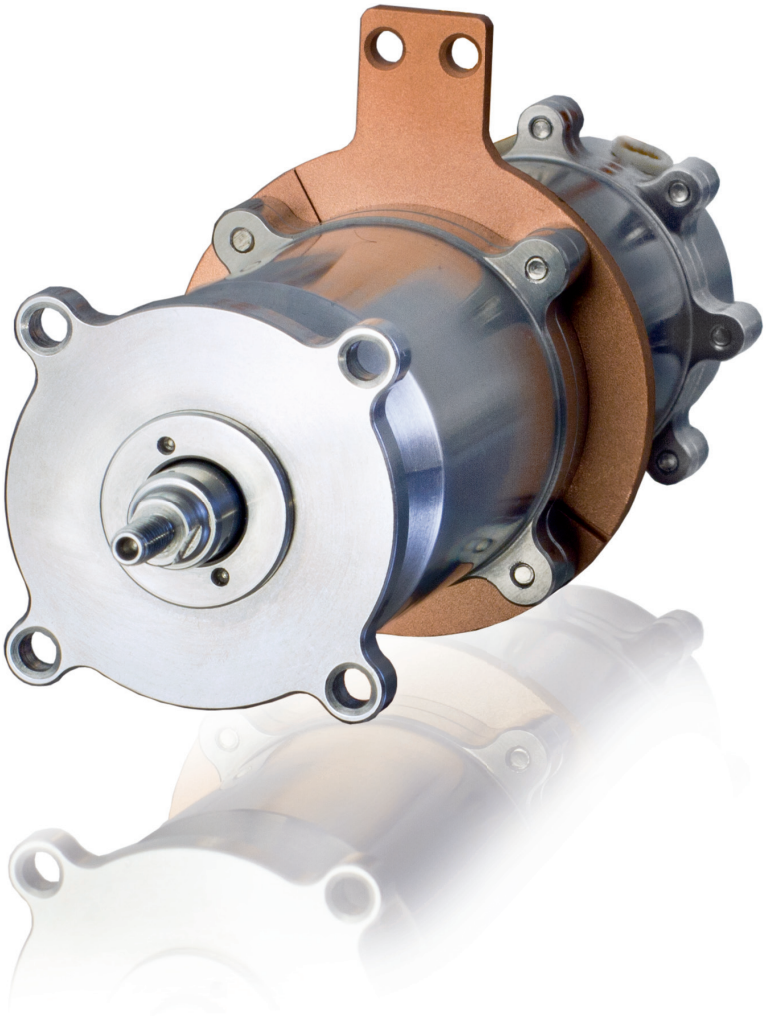
# LA Vacuum
# Linear Actuators for
# Vacuum and Cryogen Application

## How to Handle



Manual 1305-A001 EN

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# How to Handle LA Linear Actuators for Vacuum and Cryogen Application

**TRANSLATION OF THE GERMAN ORIGINAL MANUAL**

Phytron GmbH

Industriestraße 12

82194 Gröbenzell, Germany

Tel.: +49(0)8142/503-0

Fax: +49(0)8142/503-190

Every possible care has been taken to ensure the accuracy of this technical manual. All information contained in this manual is correct to the best of our knowledge and belief but cannot be guaranteed. Furthermore we reserve the right to make improvements and enhancements to the manual and / or the devices described herein without prior notification.

We appreciate suggestions and criticisms for further improvement.

E-Mail address: doku@phytron.de

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# 1 Legal Information

**This manual:**

*Read this manual very carefully before mounting, installing and operating the device and if necessary further manuals related to this product.*

- Please pay special attention to instructions that are marked as follows:

| | | |
|---|---|---|
| | **DANGER – Serious injury!** | *Indicates a high risk of serious injury or death!* |
| | **DANGER – Serious injury from electric shock!** | *Indicates a high risk of serious injury or death from electric shock!* |
| | **WARNING – Serious injury possible!** | *Indicates a possible risk of serious injury or death!* |
| | **WARNING – Serious injury from electric shock!** | *Indicates a possible risk of serious injury or death from electric shock!* |
| | **CAUTION – Possible injury!** | *Indicates a possible risk of personal injury.* |
| | **CAUTION – Possible damage!** | *Indicates a possible risk of damage to equipment.* |
| | **CAUTION – Possible damage due to ESD!** | *Refers to a possible risk of equipment damage from electrostatic discharge.* |
| | **”Any heading“** | *Refers to an important paragraph in the manual.* |

Observe the following safety instructions!

## 1.1 Qualified personnel

**WARNING – Serious injury possible!**

*Serious personal injury or serious damage to the machine and drives could be caused by insufficiently trained personnel!*

Without proper training and qualifications damage to devices and injury might result!

- Design, installation and operation of systems may only be performed by qualified and trained personnel.
- These persons should be able to recognize and handle risks emerging from electrical, mechanical or electronic system parts.
- The qualified personnel must know the content of this manual and be able to understand all documents belonging to the product. Safety instructions are to be provided.
- The trained personnel must know all valid standards, regulations and rules for the prevention of accidents, which are necessary for working with the product.

## 1.2 Safety Instructions

**Intended use:**

*The LA Linear actuators are designed for systems in which motion is performed linearly.*

- Commissioning is only possible if the requirements of the EC Machinery and EMC Directives are complied with.

**Part of a machine:**

*Since the product is used as part of an overall system, risk assessments with regard to the specific application must be carried out before the product is used.*

- According to the results, safety measures have to be taken and checked.
- Personnel safety must be guaranteed by the concept of this overall system (e.g. machine concept).

**WARNING – Injury due to rotation change!**

*Since the rotation is converted into a translation (e.g. via a spindle), locking and damage may occur.*

- Check the drive system before starting.

**WARNING – Injury due to electric shock!**

*During electrical installation cables, connectors, etc. can be live.*

- Do not plug or unplug devices while powered.
- Do not plug or unplug the connectors while powered.
- If the equipment has been energised, wait 3 minutes after power off to allow the capacitors to discharge and ensure that there are no residual charges on cables, connectors and boards.

**WARNING – Injury possible!**

*LA Linear actuators warm up during operation. The surface of the linear actuators can be cool / hot in the UHV-C1 / C2 medium down to -196 / -270 °C or in the UHVS medium between -40 and +150 °C.*

- Mount the linear actuator so that a good dissipation of the generated heat is ensured.
- Wait until the linear actuator has cooled / thawed to room temperature.
- Provide measures for operator protection.

## 1.3 Handling instruction

**CAUTION – Possible damage!**

*When handling the linear actuator in a vacuum, pay attention to appropriate cleanliness. Conditioning removes volatile organic substances from the LA linear actuator. For proper handling:*

- Do not touch the LA Linear actuator with bare hands. **Wear protective gloves!**
- Handle the LA Linear actuator only in a very clean environment!

**CAUTION – Possible damage!**

- Please note the wiring data on the nameplate and the permitted mechanical loads (see technical data in the data sheet).
- Switch off the supply voltage before mounting and wiring the LA linear actuator.
- LA linear actuators must not be operated with mains voltage. Linear actuators require special control units.
- Never lift the linear actuator by means of its cables or leads! Care for strain relief when stripping or shortening the leads.
- Remove the PTFE tube only from the one lead which you are connecting (see chapter 7.2.1). Comply with EMC conform wiring.
- Do not open the LA linear actuator! If the casing is opened, the linear actuator may be damaged. Phytron's warranty does not apply if linear actuators are opened by the customer. **When operating a linear actuator which was assembled improperly, danger to life could be caused by electric shock**.
- The customer must not carry out mechanical or electrical modifications of the linear actuator. The warranty does not apply if the motor is modified by the customer without the manufacturer's permission

## 1.4 European Standards and CE Mark

When installed appropriately, in-vacuum and LA linear actuators fulfil the requirements of the EMC and Low Voltage Directives. These LA linear actuators are qualified to be marked CE and comply with EN 60034-1 European Standard.

When wired correctly (see chap. 7.2), LA linear actuators fulfil the requirements of the EMC Directive. Information concerning the connection of the LA wires to the control unit or the power stage is given in the corresponding manuals.

According to the European Machine Directive, the LA Linear actuator is only a part of a machine. Putting it into operation is not allowed until the machine manufacturer takes appropriate measures to ensure that the entire system fulfils the requirements of the applicable EU Directives.

## 1.5 Declaration of Incorporation

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# Declaration of Incorporation

**according to EC directive 2006/42/EC on machinery (Annex II B)**
**for partly completed machinery**

**Name and address of the manufacturer:**
Phytron GmbH,
Industriestr. 12
82194 Gröbenzell

**Representative in EU, authorized to compile the relevant technical documentation:**
Rainer Gareis
Phytron GmbH,
Industriestr. 12
82194 Gröbenzell

**Description of the partly completed machinery:**
**Product denomination:**
**Model/Type:** Linearactuator LA 25

From serial number 1803xxxxx

**We declare that the product complies with the following essential requirements of the Machinery Directive2006/42/EC:**
1.1.2.; 1.1.5.; 1.3.1.; 1.3.2.; 1.3.3.; 1.3.4.; 1.3.7.; 1.5.1.; 1.5.5.; 1.5.6.; 1.7.2.; 1.7.3.; 1.7.4.

**In addition the partly completed machinery is in conformity with the following EC Directives:**
EC Directives 2014/35/EU relating to electrical equipment

**We declare that the relevant technical documentation is compiled in accordance with part B of Annex VII.**

We commit to transmit, in response to a reasoned request by the market surveillance authorities, relevant documents on the partly completed machinery.

**Important note! The partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of Directive 2006/42/EC on Machinery, where appropriate, and until the EC Declaration of Conformity according to Annex II A is issued.**

Gröbenzell, 2018-03-09

Adams

Rainer Adams
Technical Director

AP QM-0670-11
CE 7058 Rev. 1

Phytron GmbH
Industriestr. 12 – 82194 Gröbenzell
Postfach 1255 – 82180 Gröbenzell
T +49-8142-503-0 F +49-8142-503-190
E info@phytron.de W www.phytron.de

Geschäftsführung: Birgit Hartmann
Reg. Gericht München - HRB 206987
USt.-Ident-Nr. DE290476265
Steuernummer 117/135/11449

Genossenschaftsbank: IBAN: DE67 7016 9464 0000 0966 10 - BIC: GENODEF1M07
Volksbank FFB: IBAN: DE87 7016 3370 0000 7125 31 - BIC: GENODEF1FFB
Sparkasse FFB: IBAN: DE25 7005 3070 0001 8012 65 - BIC: BYLADEM1FFB
Deutsche Bank: IBAN: DE56 7007 0010 0161 8305 00 - BIC: DEUTDEMMXXX
Postbank München: IBAN: DE96 7001 0080 0286 0018 00 - BIC: PBNKDEFFXXX

# 2 Package

A special 3-stage package – transport package, outer package and protective film keeps the LA linear actuators from contamination, moisture and mechanical damage

## 2.1 Transportation Package

The transportation package is a cardboard box with moulded foam and bubble wrap.

Fig. 1: Transportation package

## 2.2 Outer Package

The **outer package** is a gas-tight, evacuated foil package with the nameplate fixed. A pair of protective gloves, a desiccant bag and the LA Linear actuator are shrink-wrapped in the outer package.


Fig. 2: Outer packaging with nameplate

**Outer package:**

- Before opening the outer package:
  Clean the outer package with a cleaning agent commonly used in vacuum technology, e.g. IPA.
- Remove outer package just short before mounting linear actuator.

## 2.3 Protective Film


Fig. 3: Linear actuator, desiccant bag, protective gloves

The LA Linear actuator is shrink-wrapped in evacuated protective film.

**Do not touch a LA Linear actuator with bare hands!**

*Wearing* protective *gloves helps to keep away finger sweat and oil residues from the linear actuator. Such residues can't be completely removed with IPA and may require the LA to be returned to Phytron for cleaning.*

- Before opening the protective film: Put on some protective gloves.
- After removing from the foil packaging the LA Linear actuator has to be stored in a clean box, clean room or closed container.

## 2.4 Nameplate

**Nameplate**

*On the nameplate you'll find important information about the LA Linear actuator.*

- Keep the nameplate!
- LA Linear actuators are only minimally marked (a serial number is engraved). Therefore we recommend removing the nameplate from the outer packaging and place it with the service documents or in the field below.

***Remove the nameplate from the package and stick it here!***

Rated current: See explanations in chap. 7.2.2

# 3 In-Vacuum and LA Linear Actuators in Cryogenic Environment

LA is a linear actuator for use in cryogenic environments, e. g. for operation in liquid nitrogen (Liquid $N_2$, UHV-C1) or in liquid helium (Liquid He, UHV-C2).

The LA linear actuator is a precision drive consisting of a 2-phase stepper motor that converts rotation to translation via a spindle nut system.

Two linear limit switches and a rotary encoder with switching cam enable precise positioning. The thermocouple type K may be used to monitor the motor temperature.

The copper ring fixed to the linear actuator housing is used for heat dissipation of the motor temperature.

LA Linear actuators are manufactured, cleaned, tested and packed with the greatest care. A 3-stage packaging protects LA linear actuator from contact, moisture and mechanical damage (see chap.2).

When opening the packaging, precautions must be observed (see chap.2) to ensure that the defined properties and functionality of the LA linear actuator are not impaired.

## 3.1 Linear Actuator - Overview

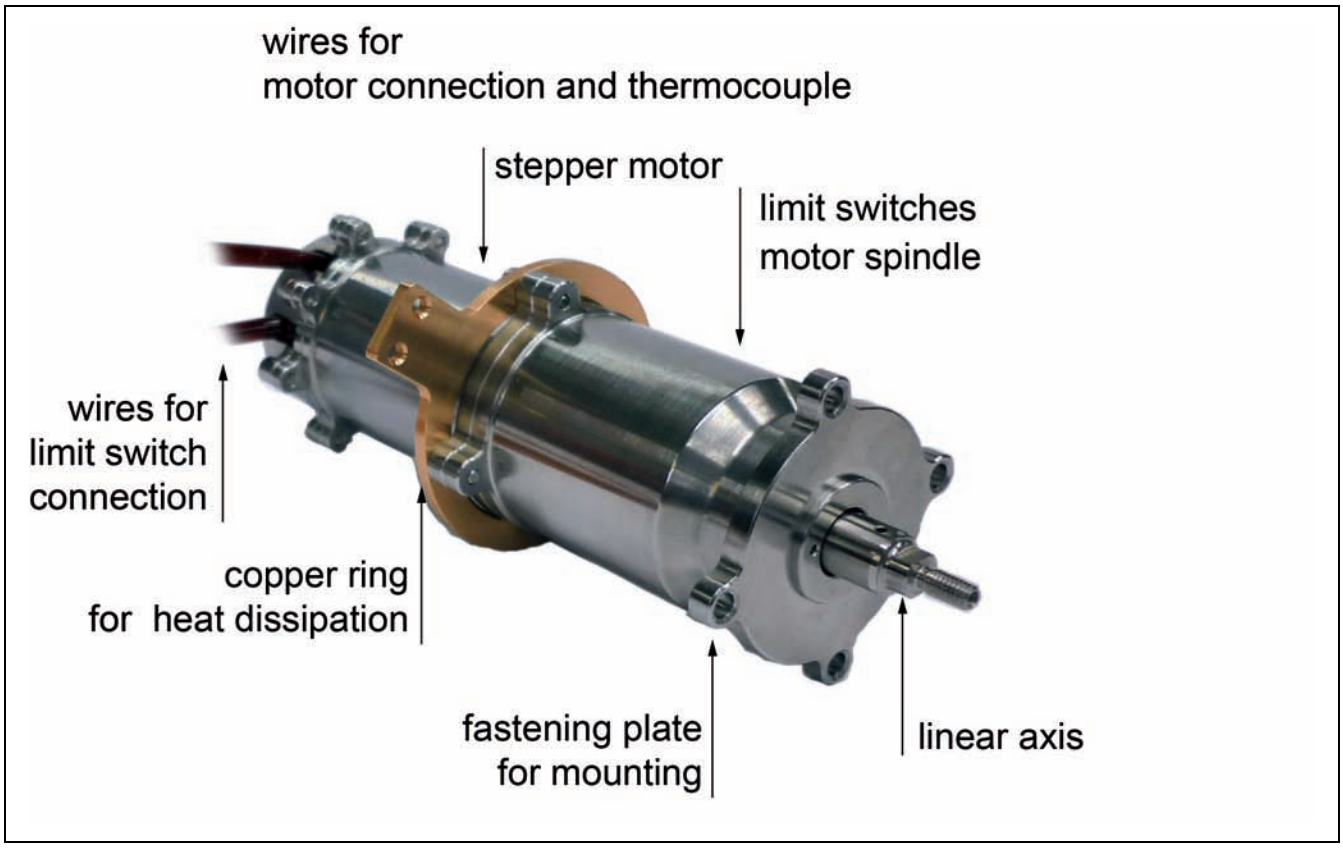


Fig. 4: The LA linear actuator for applications in cryogenic environment

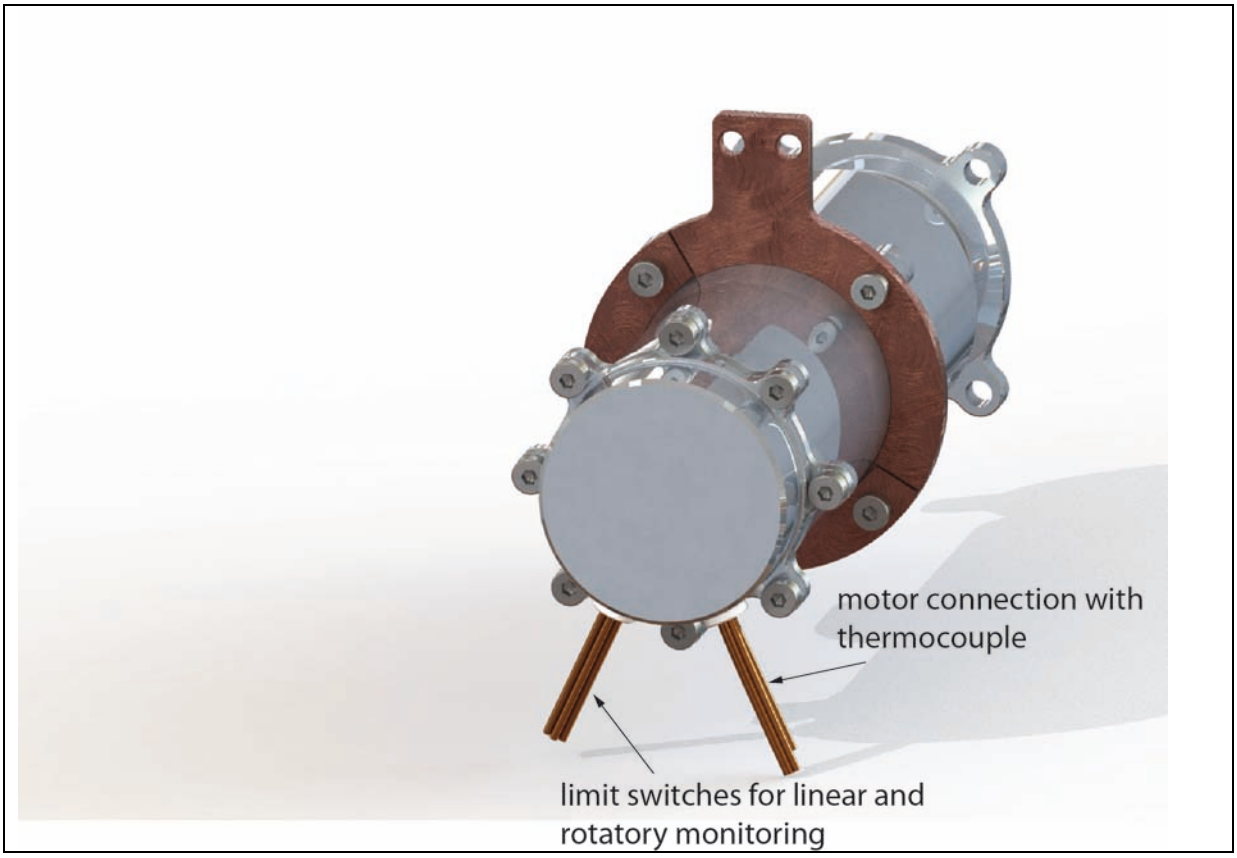


Fig. 5: Wire output

**Important rule for handling LA linear actuators in in-vacuum and cryogenic application:**

- Do not touch the linear actuator with bare hands!

## 3.2 Vacuum Operation

In a vacuum, the heat dissipation from the LA linear actuator is normally only carried out via the front motor flange. There is no convection and the amount of heat dissipated by radiation is negligibly low.
A copper ring is fixed to the linear actuator for heat removal.

To avoid overheating of the LA linear actuator, the duty cycle, run and stop current must always be selected taking into account the specified maximum temperature (vacuum class, see chap.3.3).

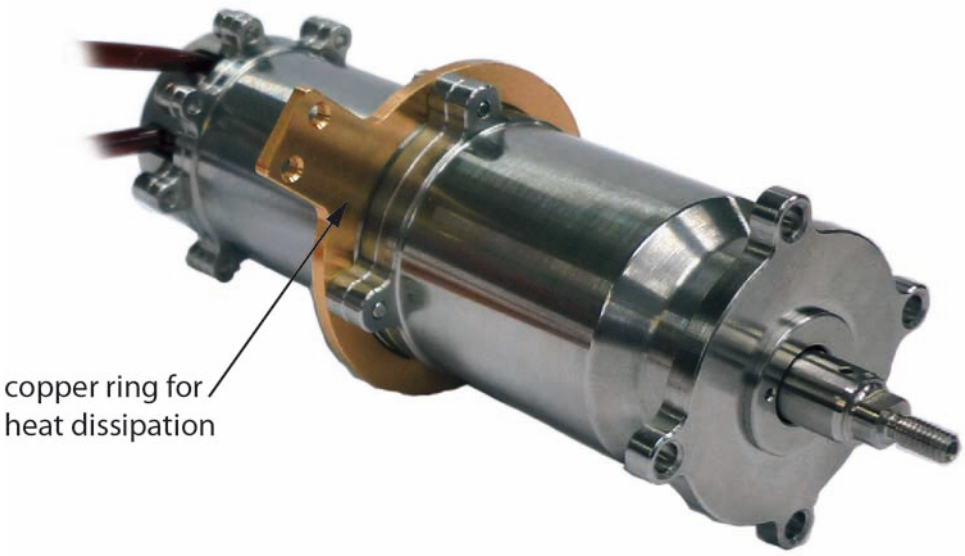


Fig. 6: LA linear actuator with copper ring

**CAUTION – Possible damage!**

*The copper ring is used exclusively for better heat dissipation of the linear actuator in the cryogenic application.*

- Do not attach the LA linear actuator from the copper ring!
- For heat dissipation from the linear actuator, mount copper wires to the two holes of the copper ring.

## 3.3 Vacuum Classes

| | vacuum class [hPa] | winding temperature during operation [°C] | radiation resistant up to [J/kg] | conditioning of the components | First conditioning at Phytron | TML [%] | CVCM [%] |
|---|---|---|---|---|---|---|---|
| **ultra high vacuum UHV-S** | $10^{-11}$ | –40 ... +150 | $10^{6}$ | yes | yes | < 1 | < 0.1 |
| **ultra high vacuum cryogenic UHV-C1** | $10^{-11}$ | –196 ... -50*) | $10^{6}$ | yes | – | – | – |
| **UHV-C2** | $10^{-11}$ | –269 … -50) | $10^{6}$ | yes | – | – | – |

*) Short term tests are possible at room temperature.

# 4 Conditioning of LA Linear Actuators (UHV-S)

In order to dissolve volatile organic substances from the materials used, UHV linear actuators are baked out. The heating process (conditioning) must be adapted to the specified requirements or operating conditions of the linear actuator. In **outgassing**, the linear actuator is baked in an oven, while in **bake-gassing** and **degas**, it is heated from within by energising the windings.

The temperature of the conditioning during bake-gassing (initial conditioning) and degas (short conditioning) is controlled by the motor current. It should be equal to the maximum permissible temperature of the linear actuator.

Rule of thumb: Each 100 Kelvin increase in the bake-out temperature improves the conditioning rate by a power of ten.

## 4.1 Initial Conditioning

The **UHV-S** linear actuators are first conditioned by Phytron (initial conditioning). This takes place under vacuum at a pressure of $10^{-6}$ hPa. The phase current is controlled so that the winding temperature is 200 °C for 24 hours.

With the **UHV-C1/C2** LA linear actuators, initial conditioning **up to 100 °C** for 24 hours is possible as an option.

## 4.2 **Degas** (Short Heating)

Degas means a short heating of the motor winding to 200 °C winding temperature before each new operation.

After the appropriate cooling time, the LA linear actuator should only be operated up to a maximum of 50 K below the degas temperature in order to avoid contamination (such as moisture or volatile substances).

# 5 Configuration and Use Limitation

## 5.1 Ambient Conditions

| | |
|---|---|
| **Ambient temperatures** | **Intended use:**<br>UHV-S: -40 to +150 °C<br>UHV-C1 ( liquid nitrogen, $LN_2$): -196 to -50 °C<br>UHV-C2 (liquid Helium, He): -269 to -50 °C |
| **Storage** | +5 to +50 °C<br>UHV-S or UHV-C1/C2 linear actuators can be stored at most 5 years in the original foil package without influence to function or specified characteristics.<br>After removing the foil package the stepper motor must only be kept in a clean box, clean room or closed container. |
| **Transport** | -15 to +50 °C |
| **Maintenance** | Dry lubrication, maintenance-free |

## 5.2 Limitation of Use in Short Operation at Room Temperature

For test purposes the LA linear actuator can be operated **for a short time** at room temperature under the following conditions:

- Maximum 90 rev./min
- Linear speed 1.5 mm/sec. max. at 300 Hz full step
- Phase current setting: ½ * $I_N$
  UHV-S: $I_N$=1.2 A → 0.6 A
  UHV-C1/C2: $I_N$=1.5 A → 0.75 A
- Monitoring the motor winding temperature by reading out the K-thermocouple: maximum 50 °C

# 6 Handling

**CAUTION**

**Risk of damage due to improper handling!**

The LA Linear actuator is a mechanical precision positioning device. The linear actuator, in particular the linear shaft, must be handled with care. Shocks, impacts and applied torques can damage the linear actuator.

**CAUTION**

**Risk of damage by applying torsion the linear shaft!**

The LA Linear actuator has not been developed for externally applied torques on the linear axis. During handling and installation, the actuator must be secured against rotation. Any torques on the linear axis are not permitted and may damage the linear actuator.

**CAUTION**

**Risk of damage due to bending moments!**

No bending moments may be applied to the linear actuator. This can damage the linear actuator and limit its function.

**DANGER**

**Danger from electric short!**

Always switch off the power supply before connecting or disconnecting to the LA Linear actuator. Never pull the assembly under voltage!

**WARNING**

**Danger if touched!**

*The surface of the linear actuators can be very cold / hot in the medium UHV-C1 / C2 down to -196 / -270 °C or in the medium UHV-S between -40 and +150 °C.*

- Wait until the linear actuator has settled to room temperature.
- Provide contact protection measures.

**WARNING**

**Risk of crushing during installation or operation!**

The linear actuator generates up to 30 N (with gear) or 10 N (without gear). This means that there is a danger of clamping and crushing during installation and when installed.

**CAUTION**

**Risk of damage due to improper storage!**

Store the LA Linear Actuator in its original packaging until final assembly to prevent damage.

Mechanical modification or disassembly of the LA Linear actuator is not permitted. The warranty expires if the housing parts are disconnected or the housing is opened.

# 7 Installation

For the requirements of in-vacuum projects, *phy***MOTION**™, Phytron's stepper motor control for in-vacuum applications, is recommended. In addition to temperature evaluation, compensation settings per axis for monitoring the driven linear actuators are also possible.

**Further manuals**

In the *phy***MOTION**™ *Modular Multi-axis Controller for Stepper Motors* manual you will find detailed information on hardware configuration, wiring, commissioning, diagnostics and the technical data of the modular stepper motor controller.

*For parameterisation of the phy***MOTION**™ controller *please refer to the following manual:*

"Principles of Positioning of the Stepper Motor Controllers"

## 7.1 Mounting

**CAUTION – Possible injury!**

- Disconnect the mounting area or stepper motor controller from the power supply.

**CAUTION – Possible wire breakage!**

*Wire breakage leads to failure of the LA linear actuator.*

- Mount the LA Linear actuator in such a way that the wires are not bent or pressed too much during operation.

**CAUTION – Possible damage!**

*When handling the linear actuator in a vacuum, care must be taken to ensure proper cleanliness. To maintain this condition:*

- Do not touch the LA Linear actuator with bare hands. **Wear protective gloves!**
- Only use the LA linear actuator in a clean environment!

**CAUTION – Possible damage!**

*During assembly of the linear actuator, it is absolutely necessary to avoid radial forces on the linear axis (for example, impacts of up to 10 N). The life of the ball bearings is shortened by this load.*

- Observe permissible axial load limit (LA without gear: <10 N)!

**CAUTION – Possible damage!**

*The copper ring is used exclusively for better heat dissipation of the linear actuator operated in the cryogenic environment.*

- Do not attach the LA linear actuator from the copper ring!

**CAUTION – Possible damage!**

*Make sure that the LA linear actuator and the mechanical mount are perfectly connected during installation.*

- Do not clamp around the housing!
- Use the four mounting holes on the LA linear actuator flange for mounting.
- Check the correct fitting of the LA Linear actuator in the mechanical system.

## 7.2 Electrical Connection

### 7.2.1 Leads

**Marking of the Leads**

The plain-coloured wires of the LA linear actuator are identified by coloured PTFE tubes:

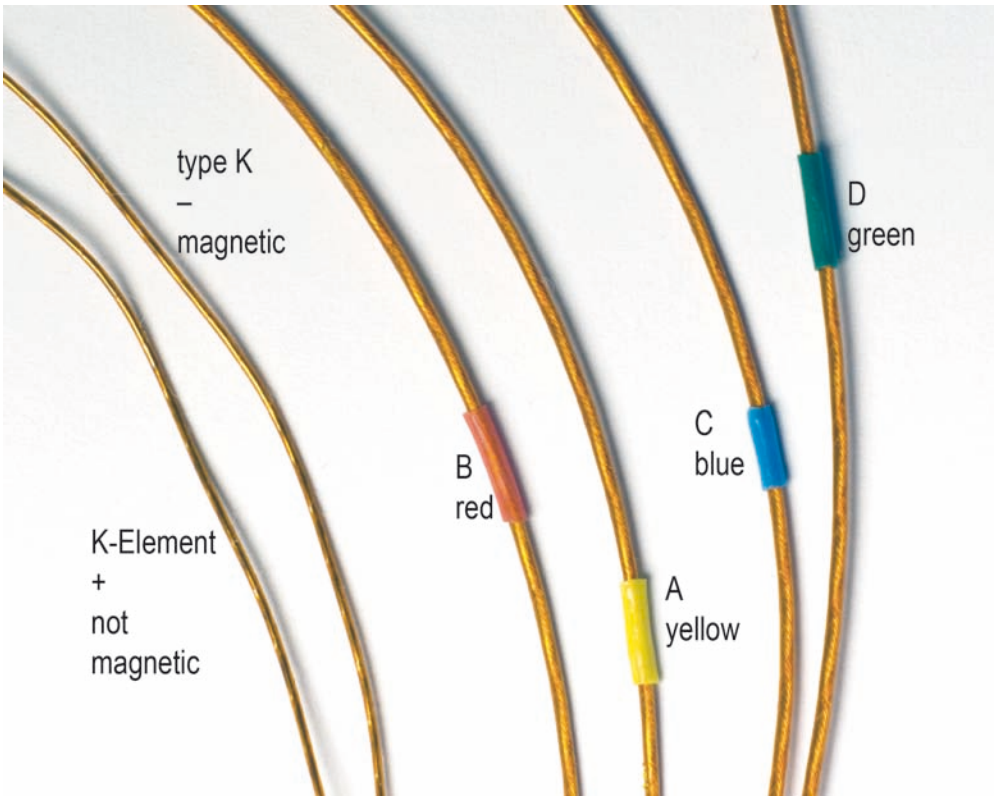


Fig. 7: Marking of motor and thermocouple type K

For built-in thermocouples type K the negative pole is magnetic.

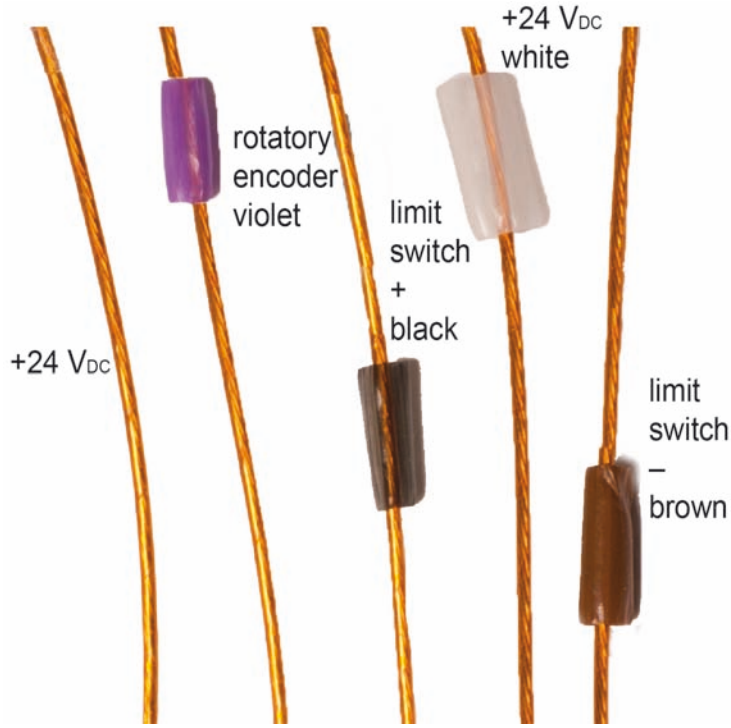


Fig. 8: Marking of limit switches and encoder

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**PTFE Tubes**

- The PTFE tubes have to be removed for cryogenic application before mounting.
- Before mounting the linear actuator: Do not remove the PTFE-tubes! The wires can only be identified by their markings.
- Connecting the wires: Only remove the PTFE tube from the wire being connected. The connecting wires must remain identifiable at all times.
- Recommendation: Do not throw away PTFE tubes! If the LA linear actuator should be disconnected, it is advisable to reattach the markings.

## How to handle the wires

**CAUTION – Possible damage!**

*Connection leads:*

- Keep the connection leads of the LA linear actuator as short as possible for control!
- If possible, twist the leads of a phase into pairs, e. g. A with B and C with D (see Fig. 9:)
- Pay attention to strain relief when twisting or shortening the connecting leads.

**CAUTION – Possible wire breakage!**

*Wire breakage leads to failure of the LA linear actuator.*

- Mount the LA Linear actuator in such a way that the wires are not bent or pressed too much during operation.

## 7.2.2 Permissible phase current

The motor nameplate shows the rated phase current [A] as the last digits of the motor's type number.

Example:
LA 25.200.**1,2** type size 25, 200-steps/rev., 1,2 A rated current with 13 mm stroke

The **rated current** is the maximum allowable current at full step operation, at bipolar control mode, with parallel connected windings (standard).

The **maximum allowable power dissipation** of a stepper motor is always the same for all connection modes. According to the connection mode, the motor windings receive different currents. Therefore the maximum allowable phase currents are determined by the connection mode.

At **half-step or mini-step** operation of the control unit, the rated current is the r.m.s value. The current tables in Phytron's power stage manuals show r.m.s. values

**IMPORTANT**

*The LA linear actuator is operated in the UHV-S medium with 1.2 A and in the UHV-C1 or UHV-C2 medium with 1.5 A rated current.*

### 7.2.3 Linear Actuator Connection

Phytron in-vacuum- and cryogenic LA linear actuators are 2-phase stepper motors. The windings are configured in a 4-leads parallel for bipolar control mode.

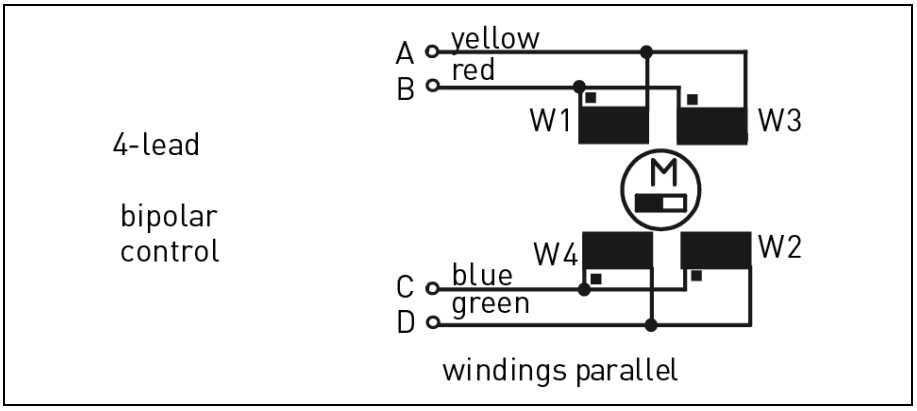


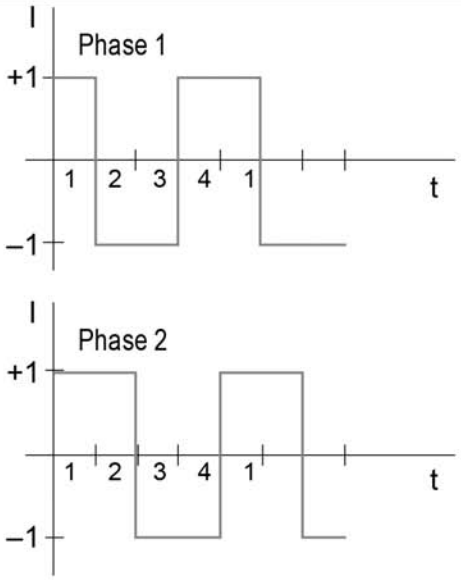

Fig. 9: 4-leads, parallel windings

## 7.2.4 Direction of Movement

With Phytron's stepper motors sizes 19 to 32, the drive shaft rotates counter clockwise (CW), on the front side of the linear actuator (DIN 42 401, part 1).
The direction of rotation can be changed by changing the linear actuator leads of a phase (e. g. A and B interchange when connected to the control unit).

Motor sizes 19 to 32 / bipolar control / full step mode

Function diagram
Direction of rotation: CW




| Motor phase current | | | Motor phase polarity | | | | Movement direction (view onto linear axis) | |
|---|---|---|---|---|---|---|---|---|
| Step | Phase 1 | Phase 2 | Phase 1 | | Phase 2 | | Direction of rotation of the motor | Movement direction of the linear axis |
| | | | A | B | D | C | | |
| 1 | +1 | +1 | + | – | – | + | CW ↓ | out ↻ |
| 2 | –1 | +1 | – | + | – | + | | |
| 3 | –1 | –1 | – | + | + | – | | |
| 4 | +1 | –1 | + | – | + | – | CCW ↑ | in ↺ |
| 1 | +1 | +1 | + | – | – | + | | |

CW = counterwise
CCW = counterclockwise

## 7.3 Thermocouple Type K

In vacuum environments there is a risk of overheating of the LA Linear actuator, as heat is not dissipated by ambient air. A built-in temperature sensor is provided to prevent damage.

Type K thermocouples (NiCr-Ni) with a temperature range of -270 to +1370 °C and accuracy class 1 are used are used as temperature sensors for LA linear actuators.

The temperature sensor is insulated between the motor windings. In contrast to temperature sensors mounted on the outside of the motor housing, the reaction time is very fast. The temperature is constantly measured, even if only one motor phase is powered.

Type K is a metal thermocouple with nickel-based alloy conductors. Temperature ranges, accuracy and characteristics for the thermocouples used in industrial applications are specified in IEC 584 standard (temperature measurement with thermocouples) .

The accuracy of the thermocouples used in class 1 is:

–40 to +300 °C +/– 0.004 x t  or  +/– 1.5 °C

t = actual temperature, the higher value is to be used.

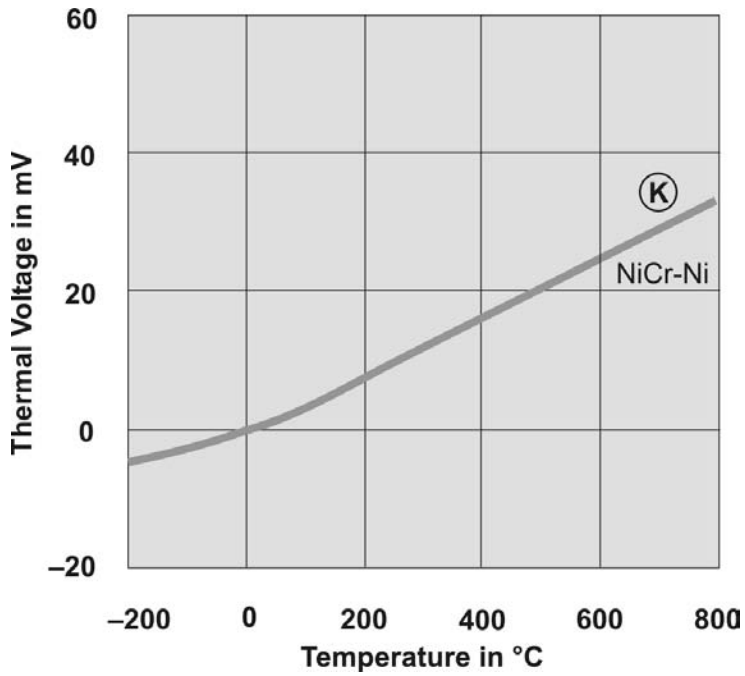



Fig. 10: Type K thermocouple characteristic curve

**CAUTION – Possible damage!**

*Thermocouple type K:*

- The thermocouple's leads are monochrome and insulated with Kapton™ foil.
- **Make sure that the polarity is correct!** The negative pole is magnetic.
- Only use connectors that are specified for K elements.

## 7.4 Limit Switch Connection

Two linear limit switches and a rotary encoder with switching cam enable precise positioning of the LA linear actuator. The linear limit switches give information about the end of travel. A zero point (offset) of the LA linear actuator can be defined with the rotary encoder.

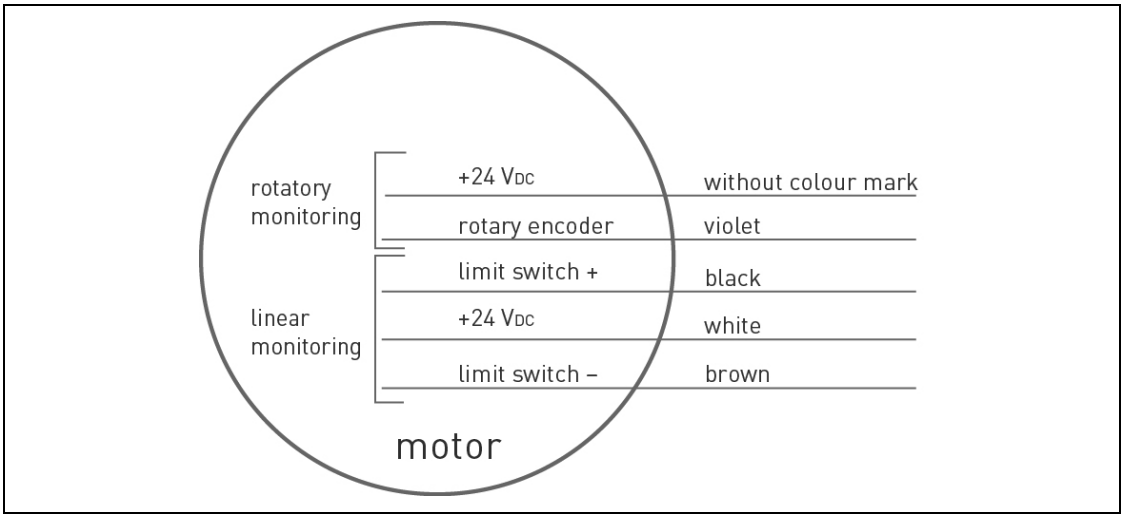



Fig. 11: Connection for linear and rotary monitoring

### Setting the offset (zero point)

Calculation procedure: Calculate stroke and reset the offset:

1. Move to limit switch + (or limit switch -) until the switching point is reached.
2. Release until contact opens, continue until the rotary encoder switches (switching cam). Run any number of steps.
3. Set the step counter to zero, i.e. the offset is set.
4. Count steps until contact limit switch - (or limit switch +) switches.
5. Release contact until the open state is reached.
6. The Number of steps between the limit switch contacts results in the available stroke.

## 7.5 Temperature Compensation

Operation in the cryogenic temperature range causes a change of the spindle pitch. This change can be compensated mathematically by means of a table.
The spindle pitch or the total stroke for different temperatures are calculated. For this purpose, the temperature curve values can be taken from the following table:

| Medium | Temperature (°C) | ΔTeta (K) | Change of the spindle pitch | Change of the total stroke |
|---|---|---|---|---|
| | +20 | 20 | 1.000 | 13.0000 |
| | -20 | 40 | 0.9996 | 12.9950 |
| Liquid $N_2$ | -40 | 60 | 0.9994 | 12.9925 |
| | -60 | 80 | 0.9992 | 12.9900 |
| | -80 | 100 | 0.9990 | 12.9875 |
| | -100 | 120 | 0.9988 | 12.9850 |
| | -120 | 140 | 0.9987 | 12.9825 |
| | -140 | 160 | 0.9985 | 12.9800 |
| | -160 | 180 | 0.9983 | 12.9775 |
| | -196 | 200 | 0.9981 | 12.9750 |
| Liquid He | -200 | 220 | 0.9979 | 12.9725 |
| | -220 | 240 | 0.9977 | 12.9700 |
| | -240 | 260 | 0.9975 | 12.9676 |
| | -260 | 280 | 0.9973 | 12.9651 |
| | -269 | 290 | 0.9972 | 12.9638 |

## Calculation of the linear distance under consideration of the thermal conditions

### Example calculation for T=-196°C

The LA linear actuator is operated at -196 °C.

P = spindle pitch

$P_{20\,°C}$ =1mm, $P_{-196°C}$ =0.9981 mm

1. Move to the rear limit switch; retraction until the rotary switching cam comes along
2. Set the offset: zero point.
3. Move forward until the contact is made, counting the steps.
4. Number of steps between contacts → e.g. 4930

The available stroke is calculated:

4930 steps / 400 x 0.9981 mm = 12.348 mm

400 steps = 0.9981 mm= 1 spindle rotation

The linear axis moves 0.9981 mm for one motor revolution at -196 ° C, and a path of 1 mm at + 20 °C.

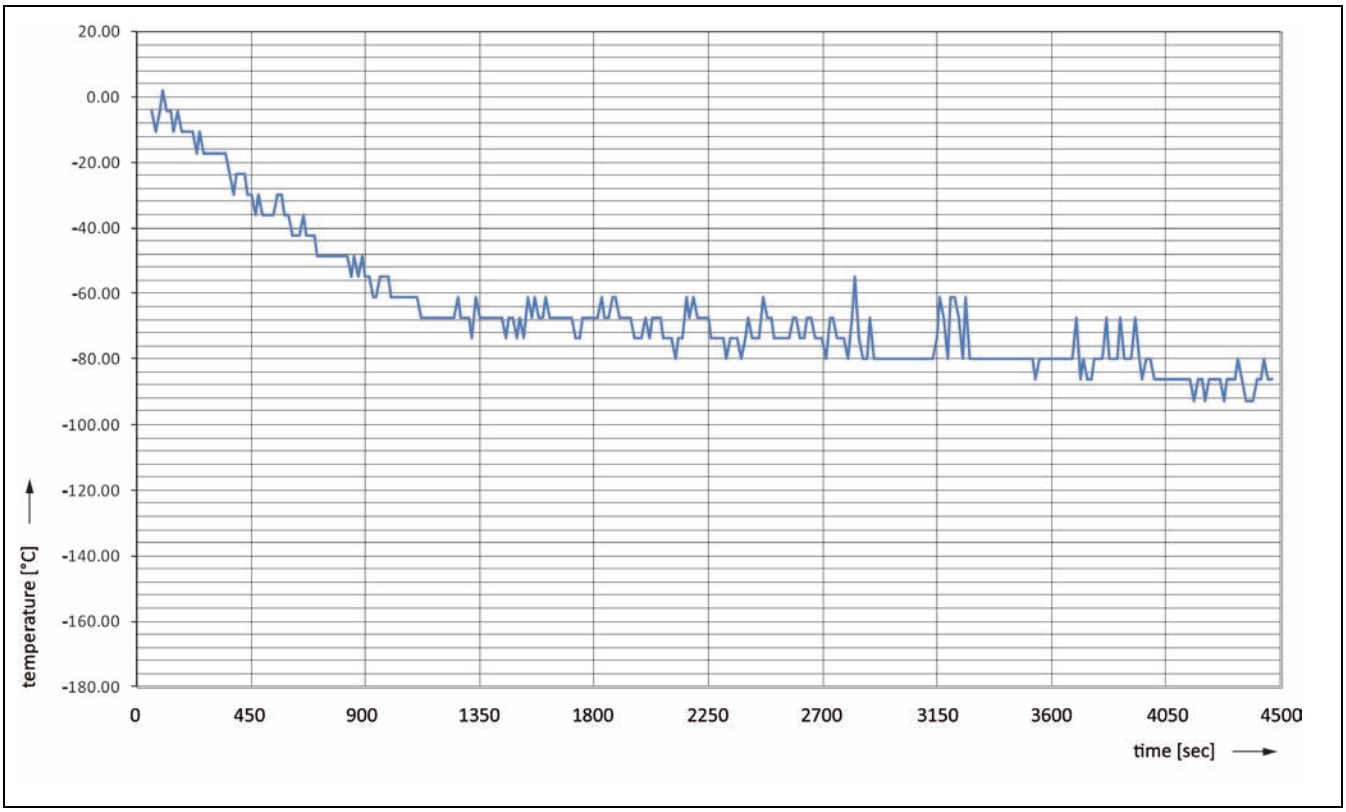



Fig. 12: Relation between system accuracy and temperature

The curve in Fig. 12 at the beginning shows the variations in the positioning accuracy of the LA linear actuator when the thermal state is not stable.

The thermal state is reached in Fig. 12 at approx. 1000 sec and then shows the high and consistent positioning accuracy of the system.

## 7.6 Compensation of the Backlash between Nut and Spindle (Loose Backlash Compensation)

Due to the manufacturing geometry, both nut and spindle have a mating clearance.
This pairing play becomes the backlash when the motor changes its direction of rotation or when the linear axis retracts or extends.

In the thread, the contact surfaces of the spindle thread flanks change to the thread flanks of the nut from right to left or vice versa.

If the linear axis is extended and at the same time the direction of rotation of the stepper motor is changed for retraction of the linear axis, the motor spindle already rotates a few steps in the changed direction, whereas the linear axis remains stationary.

Only when the thread flanks arrive the other side, the linear axis movement starts.

This geometric movement delay is the backlash. This backlash can be recorded and set in the *phy***MOTION**™ controller under parameter P25 (backlash compensation).

**Example:**

The backlash is 30 steps.
If 5000 steps are moved from a position A to a certain position B, the motor moves 5030 (5000 + 30) steps in order to reach position A again exactly when the direction of rotation changes.

**Further manual**

*For parameterisation of the Phytron phy**MOTION**™ controller for backlash compensation, please refer to the manual:*

"Principles of Positioning of the Stepper Motor Controllers"

# 8 Test Run

The LA linear actuator is designed to allow for a short test run at room temperature with limited positioning accuracy:

$I_{max}$= 1,2 $A_{r.m.s.}$

Maximum runtime: 180 sec

Ambient and system temperature: < 50 °C

**CAUTION – Possible damage!**

See also chap. 4.2!

**CAUTION – Possible damage!**

*Changing ambient temperatures: After operating the LA linear actuator in liquid $N_2$ temperatures, ice crystals form after removal from the medium.*

- To prevent damage to the motor, the linear actuator must be dried under the following conditions:
  3 to 5 hours at 70 °C under permanent nitrogen rinsing

# 9 Service

First try to identify the technical problem. Feel free to ask our support team for help. We are pleased to assist you. Tel.: 0049-8142-503252 (local rate).

# 10 Warranty, Disclaimer and Registered Trademarks

## 10.1 Disclaimer

Phytron GmbH has verified the contents of the manual to match with the hardware and software. However, errors and omissions are exempt and Phytron GmbH assumes no responsibility for complete compliance. The information contained in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

## 10.2 Warranty

The LA Linear actuator is subject to **legal warranty**. Phytron will repair or exchange devices which show a failure due to defects in material or caused by the production process. This warranty does not include damage caused by the customer, for example, not intended use, unauthorized modifications, incorrect handling or wiring.

## 10.3 Registered Trademarks

In this manual several trademarks are used which are no longer explicitly marked as trademarks within the text. The lack of these signs may not be used to draw the conclusion that these products are free from third parties' rights. For example, some product names used herein are:

- *phy***MOTION**™ is a trademark of Phytron GmbH.

## 11 Mechanical and Electrical Characteristics of the LA Linear actuator

| | |
|---|---|
| **Housing** | |
| Dimensions | ∅28 x 103.5 (116.5) mm (without gear)<br>∅28 x 129.8 (142.8) mm (with gear) |
| Material and surface protection | stainless steel |
| Mounting position | any |
| Fixing screws | 4xM2.5 |
| Mass | 230 g (320 g with gear) |
| **Mechanical Characteristics** | |
| Stepper motor | 25-200-1,5-4Lp (UHVC1/2)<br>25-200-1,2-4Lp (UHVS) |
| Linear force | 10 N (30 N with gear) |
| Linear stroke | 13 mm |
| Linear speed | 1.5 mm/sec (with gear 0.3 mm/sec) |
| Spindle pitch | 1 mm |
| Positioning accuracy | <0.01 mm |
| Limit switch | mechanical limit switches |
| Connection wires | AWG 26 |
| Wire length | 0.50 m |
| Lubrication | dry lubrication |
| **Electrical Characteristics** | |
| Phase resistance | ca. 0.95 Ω |
| Phase inductivity | ca.0.4 mH |
| Motor rated current | 1.2 $A_{r.m.s.}$ constant (UHVS)<br>1.5 $A_{r.m.s.}$ constant (UHVC1/2) |
| max. frequency (at full step) | 300 Hz |
| Operating voltage | 24 $V_{DC}$ |

## 11.1 Operating Voltage

| Motor size | max. Operating voltage | Remarks |
|---|---|---|
| 25 | 48 $V_{AC}$ | Operation with SELV type supplies |

## 11.2 Test Voltage

| Motor size | Housing – Motor Winding | Housing – Temperature Sensor | Motor Winding – Temperature Sensor |
|---|---|---|---|
| 25 | 480 $V_{AC}$ 1 min | 480 $V_{AC}$ 1 min | 480 $V_{AC}$ 1 min |

Phytron GmbH
Industriestraße 12 – 82194 Gröbenzell
T+49-8142-503-0 F +49-8142-503-190
www.phytron.eu