

HLEZ Product manual

Mounting, start-up, maintenance and repair



Figure: HLEZ single actuator

HAUSER
We automate motion



Parker Hannifin GmbH & Co. KG
Electromechanical Automation
Postfach: 77607-1720
Robert-Bosch-Str. 22
D-77656 Offenburg
Tel.: (0781) 509-0
Fax (0781) 509-98176

Sales in Great Britain:
Parker Digiplan Ltd.
21 Balena Close
Poole, Dorset
England. BH17 7DX
phone: (01202) 690911
fax: (01202) 600820

Contents

| | |
|--|-----------|
| 1 Safety..... | 1 |
| 1.1 Intended Use..... | 1 |
| 1.2 Identifying Residual Dangers and Hazardous Areas..... | 1 |
| 1.3 General Hazards on Non-Compliance with the Safety Instructions | 1 |
| 1.4 Safety-conscious working..... | 2 |
| 1.4.1 Observing Instructions | 2 |
| 1.4.2 Operating Personnel | 2 |
| 1.5 Safety Instructions for the Company Using the System | 2 |
| 1.6 Safety Instructions for Operating Personnel.. | 2 |
| 1.7 Instructions concerning Special Hazards..... | 2 |
| 1.8 User Conversions and Changes are Not Permitted | 3 |
| 1.9 Transport | 3 |
| 2 Technical Data | 4 |
| 2.1 Product design and description..... | 4 |
| 2.2 Technical Data | 5 |
| 2.3 Dimensional drawings..... | 7 |
| 2.3.1 Dimensional drawing HLEZ 150/50..... | 7 |
| 2.3.2 Dimensional drawing HLEZ 150/75..... | 7 |
| 2.3.3 Dimensional drawing HLEZ 150/100..... | 8 |
| 2.3.4 Gear mounting – example HLEZ 150 | 8 |
| 3 Commissioning and Startup | 10 |
| 3.1 General..... | 10 |
| 3.2 Preparations for Substructure | 10 |
| 3.3 Mounting..... | 11 |
| 3.3.1 Mounting of a single acuator | 11 |
| 3.3.2 Mounting of a double axis actuator..... | 11 |
| 3.3.3 Mounting of a three-axis actuator | 12 |
| 3.4 Initiators/Sensors | 12 |
| 3.4.1 General aspects | 12 |
| 3.4.2 Wiring the initiators/sensors..... | 13 |
| 3.4.3 Setting up End Limits..... | 14 |
| 3.4.3.1 External initiators and mechanical switches..... | 14 |
| 4 Maintenance..... | 15 |
| 4.1 Maintenance Schedule | 15 |
| 4.2 Causes for abnormal timing belt wear | 15 |
| 5 Mounting/Repair | 17 |
| 5.1 Safety Instructions | 17 |
| 5.2 Mounting of tooth rack..... | 17 |
| 5.3 Replace, tension and align timing belt..... | 18 |
| 5.3.1 General notes on timing belts | 18 |
| 5.3.2 Necessary tools / components | 18 |
| 5.3.3 Dismounting the module from the HLE | 19 |
| 5.3.4 Replace and tension timing belt | 20 |
| 5.3.5 Check belt tension..... | 21 |
| 5.3.6 Mounting the module to the HLE | 22 |
| 5.3.7 Alignment of the HLEZ-module to the racks..... | 23 |
| 5.4 Set carriage play..... | 25 |
| 5.4.1 Replace and set rollers (flow chart)..... | 25 |
| 5.4.2 Checking Carriage Play..... | 26 |
| 5.4.3 Dismounting the carriage | 26 |
| 5.4.4 Replace individual rollers..... | 26 |
| 5.4.4.1 General..... | 26 |
| 5.4.4.2 Replacing and setting rigid rollers..... | 27 |
| 5.4.4.3 Replace and set eccentric roller | 27 |
| 5.4.5 Mounting the carriage | 28 |
| 5.4.6 Setting the reference point..... | 28 |
| 5.5 Extended axes..... | 29 |
| 5.5.1 General..... | 29 |
| 5.5.2 Mounting of longitudinal flanges | 29 |
| 6 Repair..... | 31 |
| 6.1 Spare and Wearing Parts | 31 |
| 6.1.1 Spare and wearing parts of HLEZ 150..... | 31 |
| 6.1.2 Spare and wearing parts of the HLEZ basic drive module..... | 31 |
| 6.1.3 Permanent lubricating system..... | 33 |
| 7 Index | 34 |
| 8 System key | 35 |

1 Safety

1.1 Intended Use

The HAUSER HLEZ linear actuator has a number of uses including:

Positioning, transporting, feeding, removing, pallet handling, loading, unloading, processing and manipulating workpieces or tools.

Since the HLEZ can be used in a very wide range of applications, the user is responsible for its use in specific applications.

The user must ensure that mounting workpieces or tools on the carriage of the linear actuator does not cause danger of injury to persons and/or damage to property. This also applies, for example, to the case of a broken timing belt.





The linear actuator must only be used in areas that are not accessible to persons during operation.

If the linear actuator is used in areas accessible to people, it must be installed in such a manner that no one can be endangered during operation.

1.2 Identifying Residual Dangers and Hazardous Areas

If there are still residual dangers present to persons or property from the linear actuator in spite of operating it in a safe manner, the user must make reference to these residual dangers through signs and written rules requiring appropriate procedures.

The following safety signal words are used:

| | |
|--|---|
|  Danger | Indicates that an imminent hazardous situation may lead to death or serious bodily harm if not prevented using appropriate safety measures. |
|  Warning | Indicates a potentially hazardous situation which, if not avoided using appropriate safety measures, could result in serious or minor injury. |
|  Caution | Indicates a potentially hazardous situation which, if not avoided using appropriate safety measures, may result in minor injury or damage. |
|  Hint | Provides important information about the product, how to handle the product or about the part of the manual to which particular attention must be paid. |

1.3 General Hazards on Non-Compliance with the Safety Instructions

This machine component has been designed in accordance with state-of-the-art technical developments and is operationally reliable. If it is not operated by qualified or at least trained personnel or if it is operated improperly or not in accordance with the operating instructions, however, the unit may bear the risk of hazards.

This may cause:

- Physical danger and threat to the life of the user or other parties
- Detriment to the machine and the property of the user

If the linear actuator is installed in a machine, the safety requirements noted in the operating instructions for that machine must be combined with those described in this manual.

1.4 Safety-conscious working

1.4.1 Observing Instructions

The information (such as instructions and notes) contained in the commissioning instructions must be heeded for all work involved in installing, commissioning, setting up, operating, changing operating conditions and modes, servicing, inspecting and repairing the unit.

1.4.2 Operating Personnel

The following jobs must only be performed by appropriately trained and authorised personnel:

- Installation and set-up tasks on the linear actuator
- Attaching safety transmitter switches (initiators)
- Attaching and connecting the drive and testing the rotation direction

1.5 Safety Instructions for the Company Using the System

Supervisors must also become familiar with the entire chapter entitled "Safety" and handling required on the linear actuator.

Supervisors must ensure that installation and operating personnel have read and understand the chapter entitled "Safety" and the description of how to work with the machine, and that they observe the instructions.

The linear actuator must always be in flawless condition during operation.

1.6 Safety Instructions for Operating Personnel

Any work step that has a negative effect on the operating safety of the linear actuator must be omitted.

Operating and supervisory personnel are required to check the linear actuator or machine at least once per shift for externally visible damage or defects. Changes that have occurred (including the operating behaviour) that could have a negative effect on the operating safety must be reported immediately.

Components and accessories are designed especially for this product. When purchasing spare and wearing parts, use only original Parker parts. We note here explicitly that we are unable to check or release spare parts or accessories that were not provided by us. Installing and/or using such products may cause negative changes in the required design properties in some circumstances, which in turn could negatively effect the active and/or passive operating safety of the machine.

The manufacturer is unable to accept any liability for damage caused by using non-original parts and accessories.

As a rule, it is impermissible to dismount or take out of operation any safety devices!

Safety devices must not be rendered inoperative or bypassed.

Applicable requirements and national accident prevention regulations must always be observed when installing and operating our mechanical linear actuators.

1.7 Instructions concerning Special Hazards

The HLEZ must be fastened or supported at the required minimum distances according to information provided in this manual.



The operator must ensure that movements of the HLEZ do not cause any danger.

If the HLEZ moves in hazardous areas, these areas can be safeguarded with safety transmitter switches.

1.8 User Conversions and Changes are Not Permitted

The linear actuator must not be changed in its design or in terms of safety without our approval. Any change as defined here made by the user excludes any liability on our part.

1.9 Transport

| | |
|--|---|
|  Danger | Never step under overhead loads – danger of being injured! Moving parts must always be secured against slipping or moving. |
|  Caution | Danger when transporting long actuators. Because the actuator bends under its own weight, guiding accuracy may deteriorate significantly. In addition, the shape of the profile may change and the travel behaviour of the carriage may be negatively affected. |

Use only transport equipment with sufficient lifting capacity. When using ropes, make certain they are not twisted or knotted. If you are using more than one rope, all the ropes should be equally taut.

When transporting the HLEZ with a forklift, establish a condition of equilibrium and secure the load if necessary.

An estimated value for the weight of the HLEZ can be determined as follows:

- Measure the length L of the profile and read the rough guiding value for the weight from the diagram below.

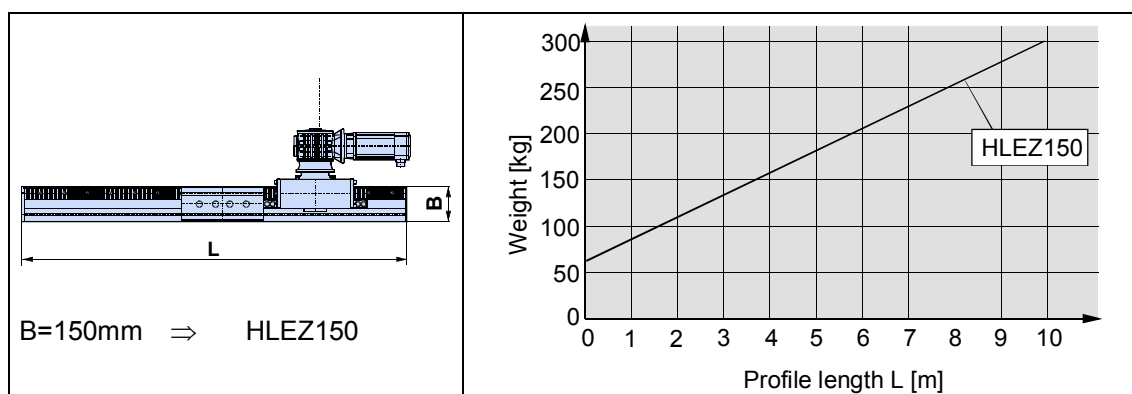


Fig. 1-1: Rough guiding values for the HLEZ transport weight (with motor and gearing)

2 Technical Data

2.1 Product design and description

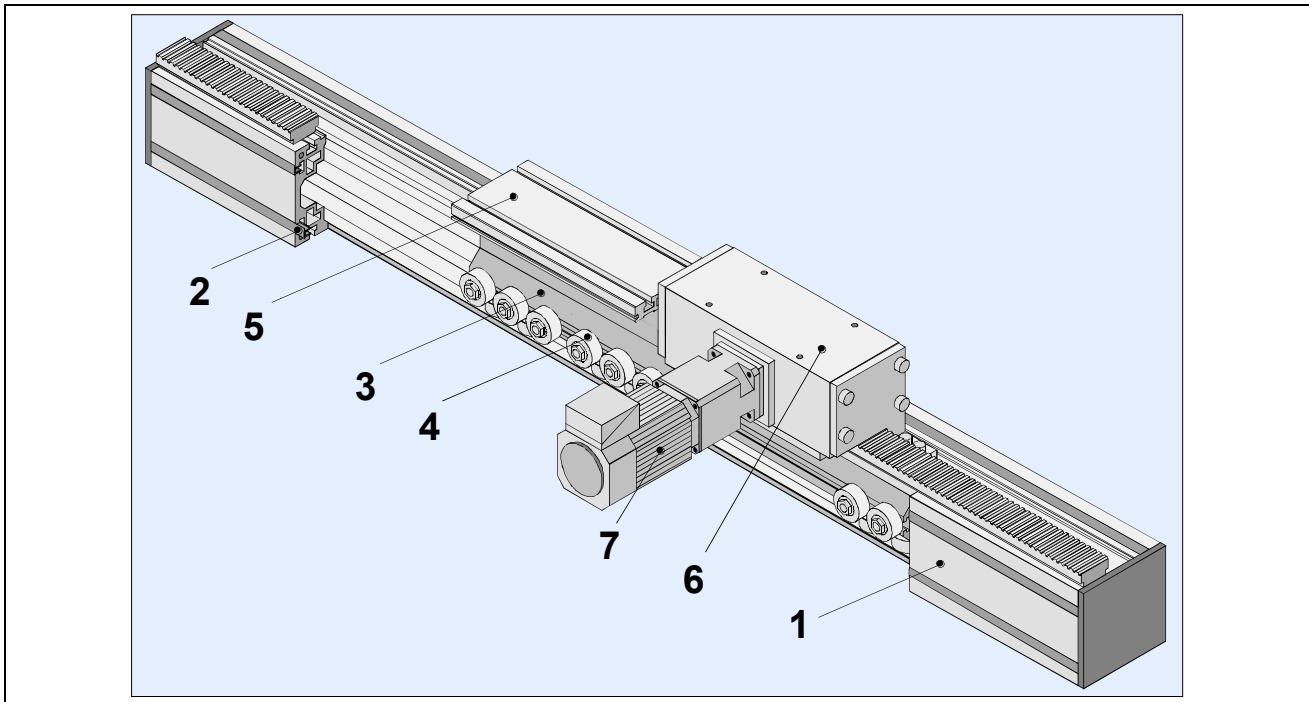


Fig. 2-1

The Aluminium Profile (1)

Light, compact and self-supporting construction made from an aluminium profile. Available in the cross section:

150x150 mm (HLEZ150)

All profiles feature seven lengthwise clamping grooves for the attachment of additional mechanical components and for the connection of several HLEZ and HLE actuators. These grooves can also be used to attach initiators and mechanical switches.

Combined with the HAUSER cover profile (2), they do also serve as cable ducts.

The carriage (3)

Low-mass carriage with rolling-contact plastic bearings (4) and eccentric axes for a backlash-free alignment of the carriage in all directions. High mechanical efficiency and almost wear-free operation. The carriage is available in two lengths as a normal or an extended version.

Customer-specific special carriages are available on request. The carriage carries the load and performs the movement. It is fitted backlash-free into the slides of the aluminium profile with the aid of rollers (4).

Roller (4)

Plastic rollers mounted on roller bearings in two versions:

Rigid roller: transmits the main charge to the aluminium profile.

Eccentric roller: for the backlash-free alignment of the carriage

The load attachment plate (5)

Many possibilities to mount parts by integrated longitudinal grooves at the upper side of the plate. In connection with the HAUSER clamping profiles, this allows an easy integration into multi-axis systems.

Simple and variable attachment of switching cam or cam switch at the longitudinal grooves placed on the sides or underneath the plate.

Special versions are available on request.


The drive module (6)

Compact drive module can be mounted on both sides of the load attachment plate. Description of the drive principle: see on page 2.

HAUSER servo motor (7) with resolver and flange compatible gearing for the speed and torque modulation. We provide the suitable drive concept for dynamic and precision applications.

In connection with the compact Compax3 servo controller, you can dispose of a complete, plug-in automation system for single and multi-axis linear- and path control.

2.2 Technical Data

| | | |
|---|-------------|---|
|  | Hint | The characteristics given in this chapter are not to be exceeded. Please respect especially the maximum permissible speed, which might be exceeded in combination with some drives. |
|---|-------------|---|

| HLEZ - Size | Unit | 150/50 | 150/75 | 150/100 |
|-------------|------|--------|--------|---------|
|-------------|------|--------|--------|---------|

Weight and mass moments of inertia

| | | | | |
|---|-------------------|-------|-------|-------|
| Weight of base unit with zero stroke | | | | |
| HLEZ with standard carriage | kg | 53 | 64 | 71 |
| HLEZ with extended carriage | kg | 61 | 68 | 75 |
| Mass of standard carriage with load attachment plate and drive module | kg | 25.7 | 32.7 | 39.7 |
| Mass of extended carriage with load attachment plate and drive module | kg | 29.7 | 36.7 | 43.7 |
| Mass per meter of additional length (guiding profile + rack) | kg/m | 23.9 | 25.2 | 26.5 |
| Mass moment of inertia with respect to the drive shaft *1 (allowed for: carriage with load attachment plate and drive module) | | | | |
| Standard carriage S | kgcm ² | 325 | 361 | 396 |
| extended carriage E | kgcm ² | 363.4 | 399.4 | 434.4 |

Strokes, travel speeds and efficiency

| | | | | |
|---|-----|-------|----|----|
| Maximum travel speed *2 | m/s | 3.0 | | |
| Maximum stroke, standard carriage S/T ³ with one profile | mm | 8888 | | |
| Maximum stroke, extended carriage E/F ³ with one profile | mm | 8738 | | |
| Maximum stroke with longitudinal flanges *4 | mm | 50000 | | |
| Efficiency | % | 85 | 80 | 80 |

Overall dimensions and physical data of guiding profile

| | | | | |
|--|-------------------|----------------------|--|--|
| Cross-section (height x width x profile width) | mmxmm | 150 x 150 | | |
| Moment of inertia I _x | cm ⁴ | 1940 | | |
| Moment of inertia I _y | cm ⁴ | 2147 | | |
| Moment of inertia I _t | cm ⁴ | 391 | | |
| E-modulus (aluminium) | N/mm ² | 0.72*10 ⁵ | | |

Pulley data, torques and forces

| | | | | |
|---|--------|---------|---------|----------|
| Travel distance per revolution | mm/rev | 200 | 200 | 200 |
| Pulley diameter of drive pinion (D _A) | mm | 63.66 | 63.66 | 63.66 |
| Number of teeth of drive pinion | | 20 | 20 | 20 |
| Timing belt width / pitch | mm | 50 / 10 | 75 / 10 | 100 / 10 |
| Drive torque | Nm | 32 | 95 | 127 |
| Thrust force in continuous operation | N | 1000 | 1500 | 2000 |
| Position repeatability *5 | mm | ± 0.05 | ± 0.05 | ± 0.05 |

Please contact HAUSER in the event of the following deviations from the standard technical data:

*1: Additional mass moment of inertia caused by the payload: $J_{\text{payload}} = m_{\text{payload}} \times \frac{1}{4} D_A^2$ (motor and gear weight are added to the payload)

*2: Velocities above 3m/s on request.

*3: Longitudinal flanges possible in order to obtain longer strokes (see on page 29).

*4: The stroke is unlimited by the linear actuator – it depends however on the energy supply of the drive.

*5: Applies for the linear actuator with drive module, without drive.



Technical data, issued 04/06, safety factor taken into consideration S=1. Data applies for a temperature range of between -10°C and +40°C

Permissible loads on the carriage and the timing belt

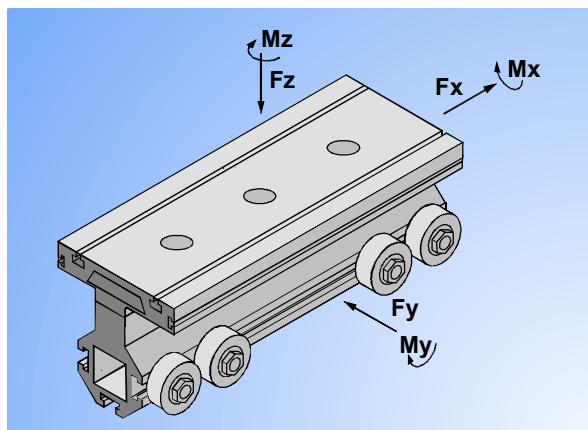


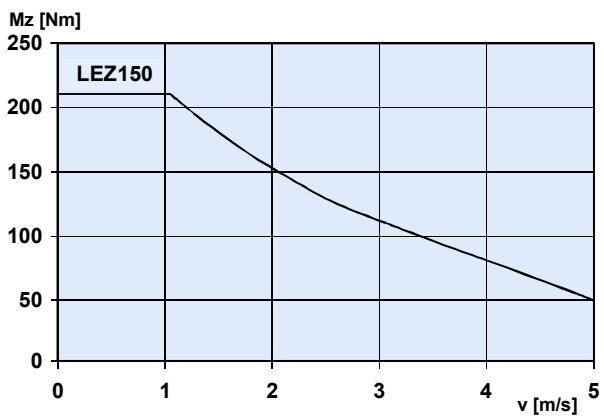
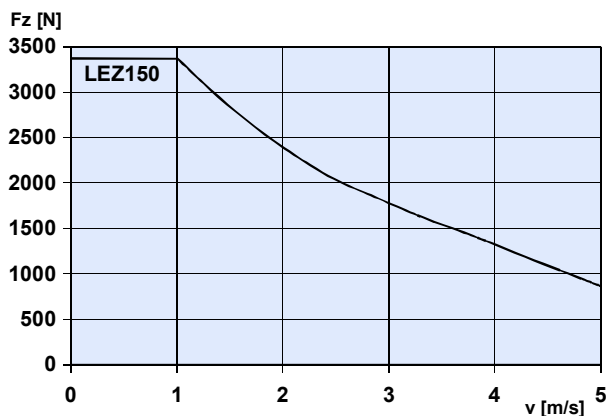
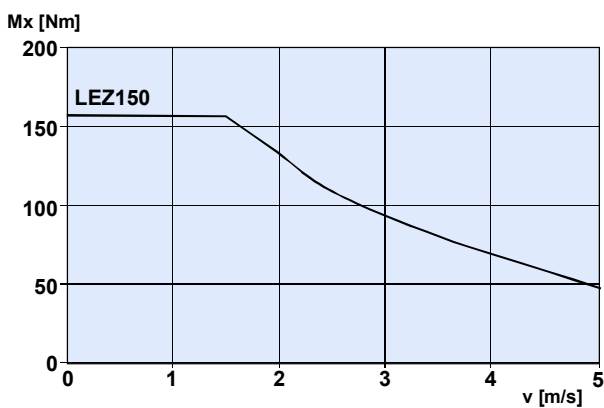
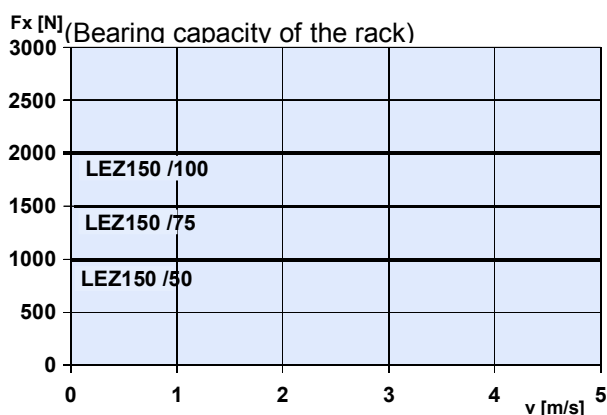
Figure 2-2

Forces and drive torques transferred by the carriage are speed-dependant.

The graphs shown in the diagrams only apply to standard carriages (S/T).

In the case of extended carriages (E/F), all values can be doubled if the load is introduced in pairs or evenly over the entire length of the carriage.

The curves show the maximum load-bearing capacity of a roller in one direction of force or torque. If several loads are applied in different directions, the values specified in the curves **may not be fully exploited**, i.e. the load or speed should be reduced if necessary. For precise dimensioning, our software "DimAxes" is available (calculation identical to HLE150) (Part No. 840-014400).



2.3 Dimensional drawings

2.3.1 Dimensional drawing HLEZ 150/50

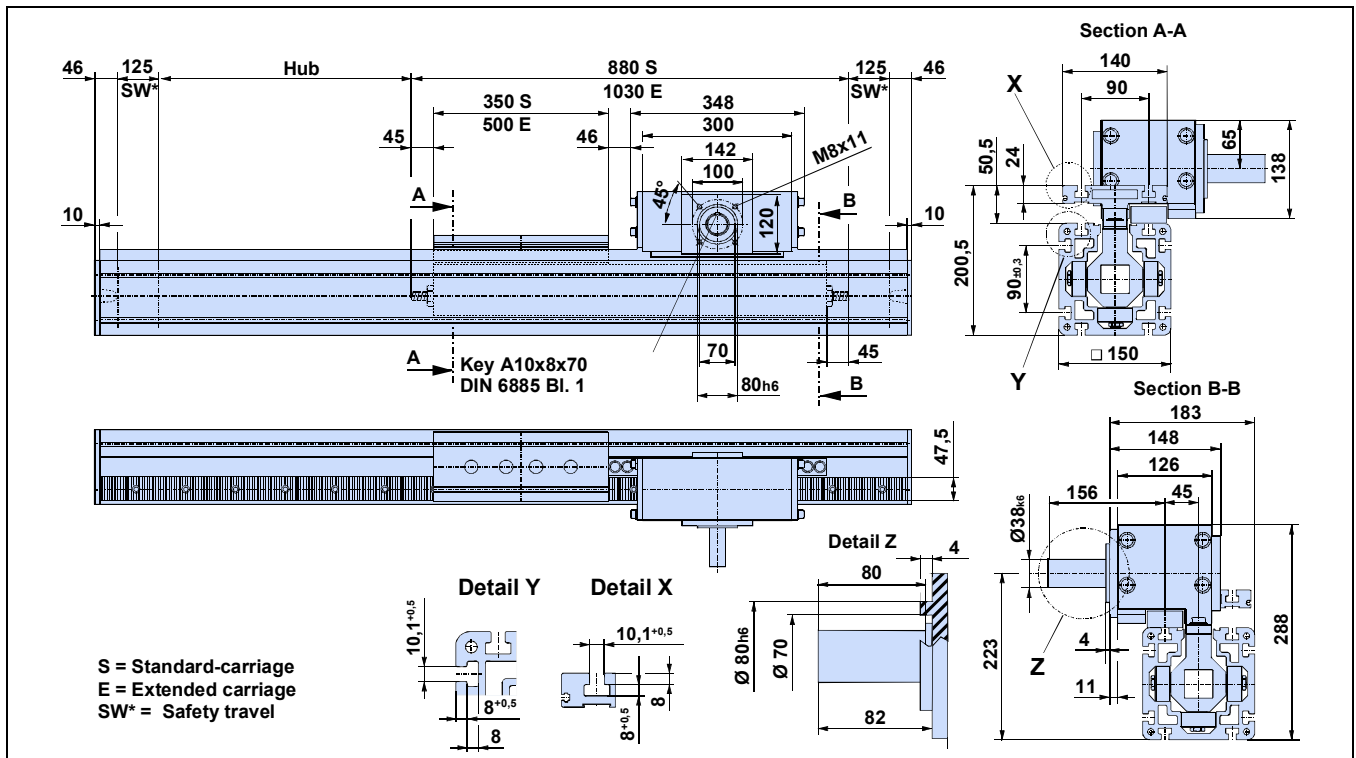


Fig.: 2-3

2.3.2 Dimensional drawing HLEZ 150/75

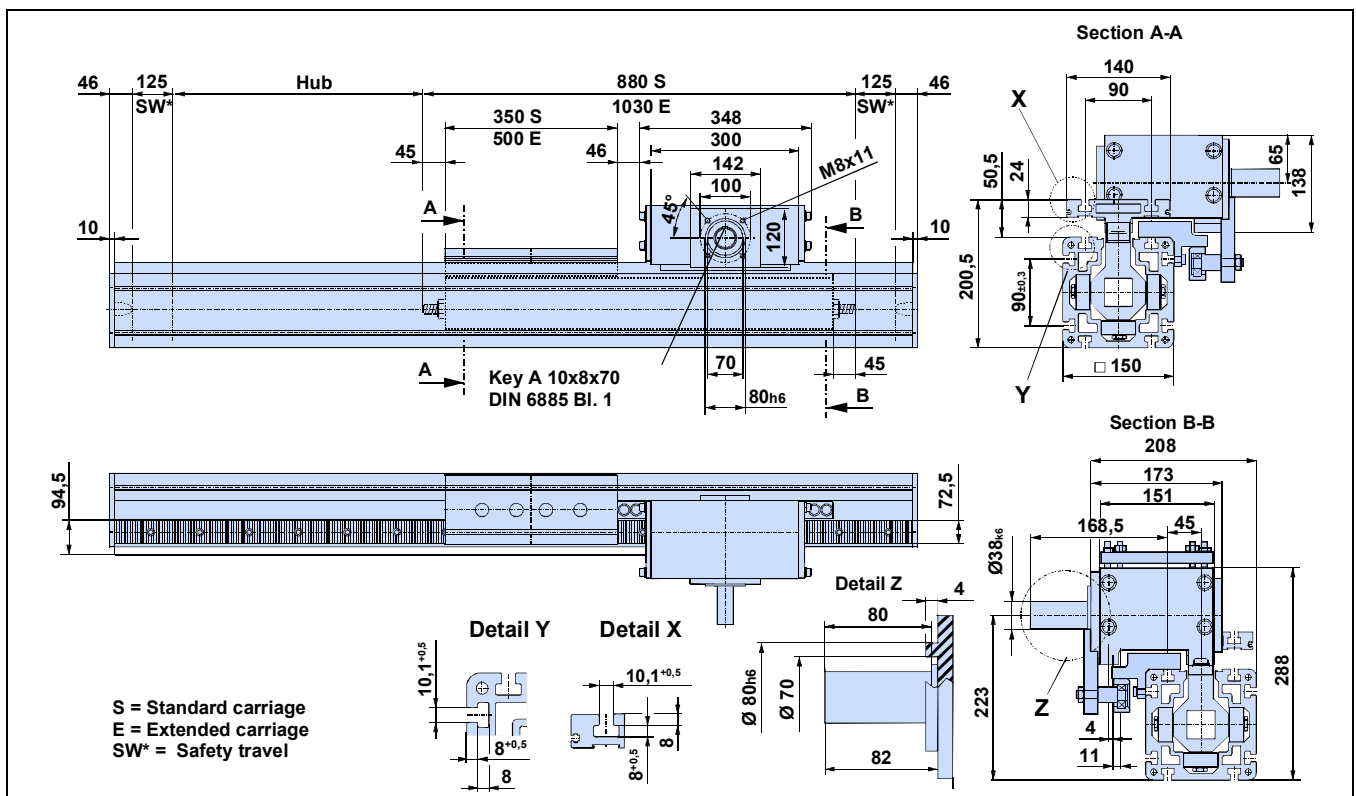


Fig.: 2-4

LEZ150 with worm gearbox 52.314.06

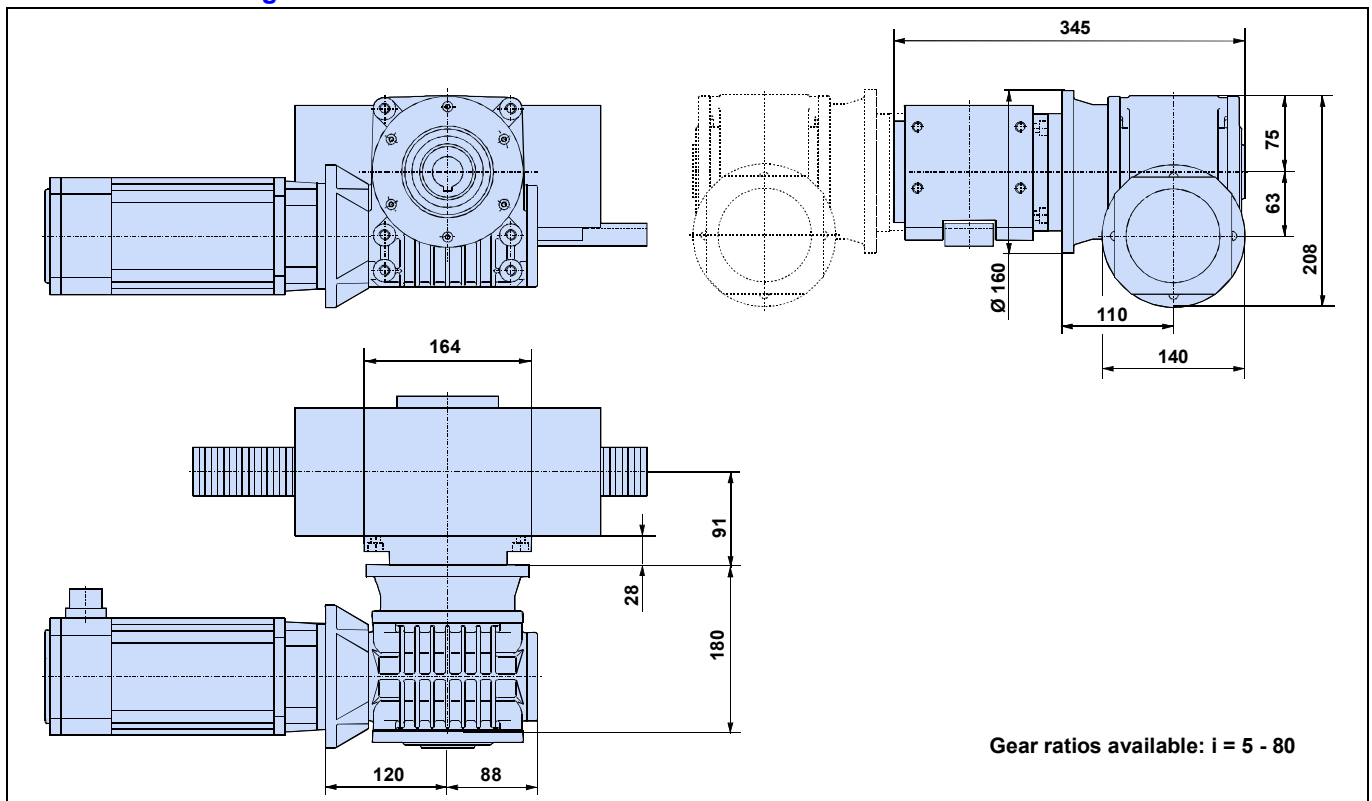


Fig. 2-7

3 Commissioning and Startup

3.1 General

If you ordered the HLEZ standard actuator with drive and initiators, it will be delivered completely mounted and mechanically ready to operate.

Long HLEZ actuators, HLEZ double actuators or HLEZ triple actuators are delivered in dismantled state for reasons of transport and safety. (Mounting instructions Chapter 5.5).

If no HAUSER drive is provided, attach your motor-gearbox combination according to the instructions of the respective supplier.

The installation position of the HLEZ is, if not otherwise projected, always horizontal with the profile opening on the top or the bottom.

3.2 Preparations for Substructure

- Each holding point must be even with a flat parallelism of 0.2 mm.
- All holding points must be aligned with parallelism to each other of better than 0.5 mm.
- In double actuator systems, an axis parallelism of 0.2 mm must be ensured.
- Ideal distance between supports (axis sag is about 1 mm) see diagram 1
- To simplify installation and adjustment, the holding points for the HLEZ attachment can also consist of adapter plates. They can be aligned with tightening and pressure screws.

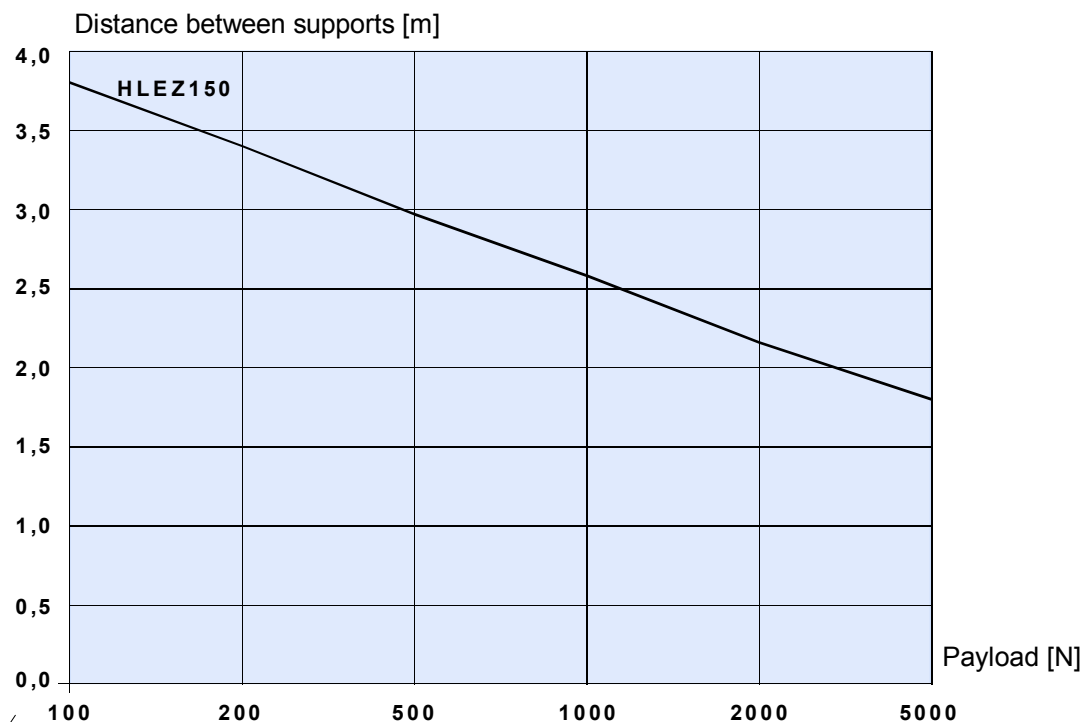


Diagram 1: Ideal distance between supports axis sag is about 1 mm)

3.3 Mounting



Caution

Danger when transporting long actuators. Because the actuator bends under its own weight, guiding accuracy may deteriorate significantly. In addition, the shape of the profile may change and the travel behaviour of the carriage may be negatively affected.



Hint

If the HLEZ is mounted with the opening at the top, remove the adhesive foil only after all mounting work has been completed so that no dirt can get inside the HLEZ.

3.3.1 Mounting of a single actuator

1. Take the HLEZ actuator out of the shipping crate.
2. Place the HLEZ on the connection points, which have been previously leveled (water level, leveling device).
3. Fasten the actuator. Insert nuts into the t-slots of the profile and fasten with screws at the fixing points. You can also use t-bolts which are secured with nuts. Do not bore into the profile!
4. Fasten the connection parts in place.
5. Remove the protective covering (adhesive foil).

3.3.2 Mounting of a double axis actuator

1. Take the HLEZ actuator out of the shipping crate.
2. Place the HLEZ on the connection points, which have been previously levelled (water level, levelling device).
3. Fasten the actuator. Insert nuts into the t-slots of the profile and fasten with screws at the fixing points. You can also use t-bolts which are secured with nuts. Do not bore into the profile!
4. Place second axis and fix lightly.
5. Verify parallelism (measuring tape) [see figure 3-1 below].
6. Measure both diagonals in order to verify rectangularity (measuring tape) [see figure 3-1 below]. Correct diagonal measure by parallel movement of the second linear actuator, if necessary.
7. Verify the horizontal alignment of the actuators (water level, levelling device) and correct if needs be. The orthogonal alignment of the actuators can also be determined with the aid of the Theorem of Pythagoras $a^2 + b^2 = c^2$ if the distances are very large. The theoretical length c must then be measured and set. [Figure 3-1 left] and [figure 3-1 right].
8. Final fixing of the second actuator.
9. Fasten the connection parts in place.
10. Remove the protective covering (adhesive foil).
11. A third axis (for three-axis actuators) is aligned afterwards with the second axis. In order to verify the correct alignment, align the third axis to the first axis. [Figure 3-2]

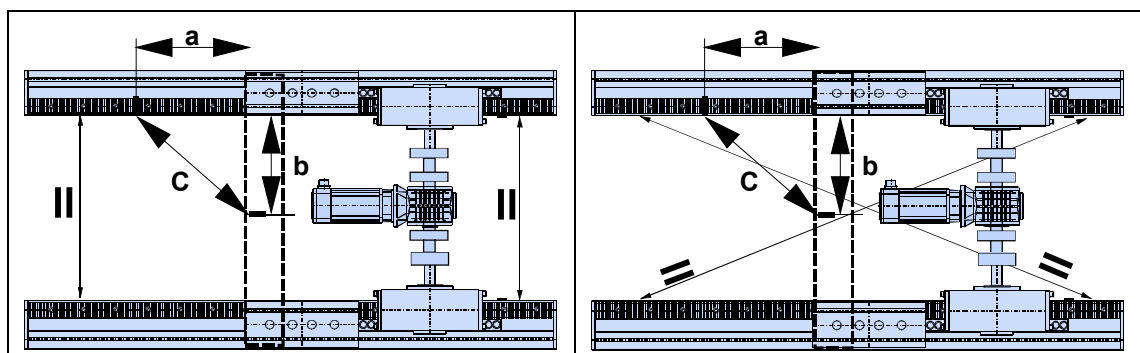


Fig. 3-1: Alignment of a double-axis actuator

3.3.3 Mounting of a three-axis actuator

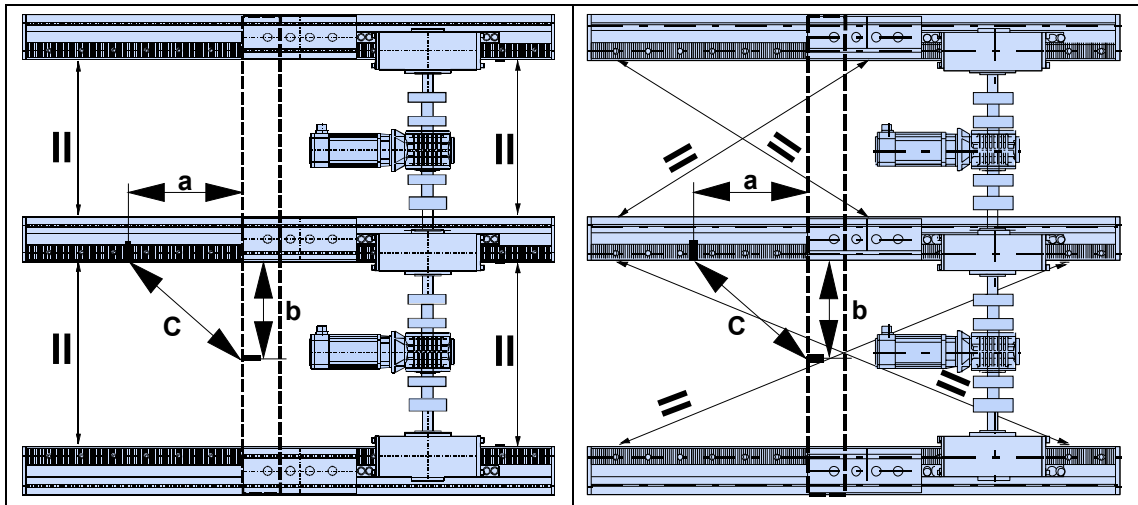


Fig. 3-2: Alignment of a triple axis

3.4 Initiators/Sensors

3.4.1 General aspects

- If you ordered the linear actuator complete with initiators and distribution box, it is furnished completely wired and with preset limits and machine zero sensor.



Hint

Some servo controllers (for example the COMPAX S made by HAUSER) work with software end limits – which may for example be 10 mm in front of the initiators. For the exact software end limit of your control, please refer to the respective documentation.

Recommendation: The following safety travels should be heeded:

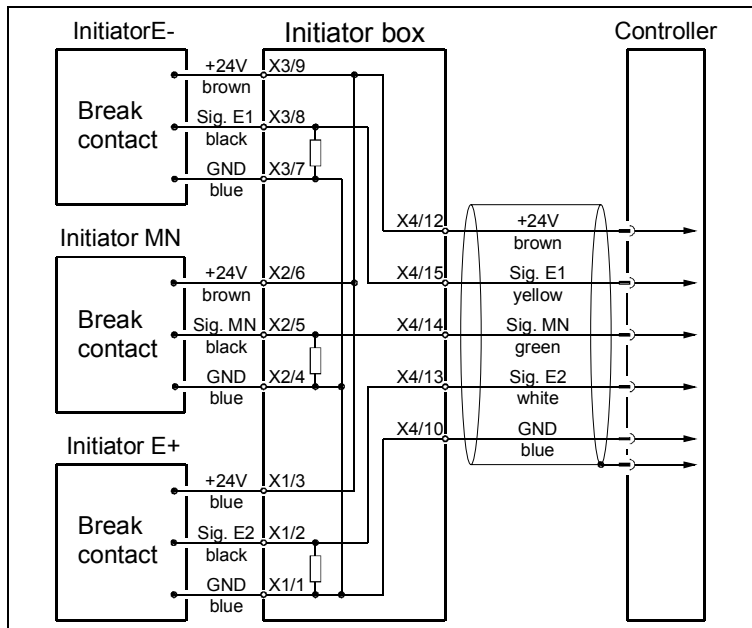
- Standard: 125 mm
- When transporting high masses at high speeds you should, if the stroke of the axis permits, increase the safety travel.



Hint

The working stroke of the linear actuator results from:
Working stroke – safety travel.

3.4.2 Wiring the initiators/sensors



If the HLEZ is furnished complete with initiators and initiator box, the components are wired according to the drawing at the left (figure 3-3).


Depending on the order configuration, a cable with the assignments shown in the drawing at the left is already connected to the initiator box.

For information on the connection of the cable to the controller, please refer to the respective manual.

Fig. 3-3: Connection of the travel initiators; **MN:** Machine zero; **Sig.:** Signal

3.4.3 Setting up End Limits

3.4.3.1 External initiators and mechanical switches

| | |
|---|---|
|  Hint | In general the tripping plate, the initiators and the distribution box are fixed on the flange side of the motor. |
|---|---|

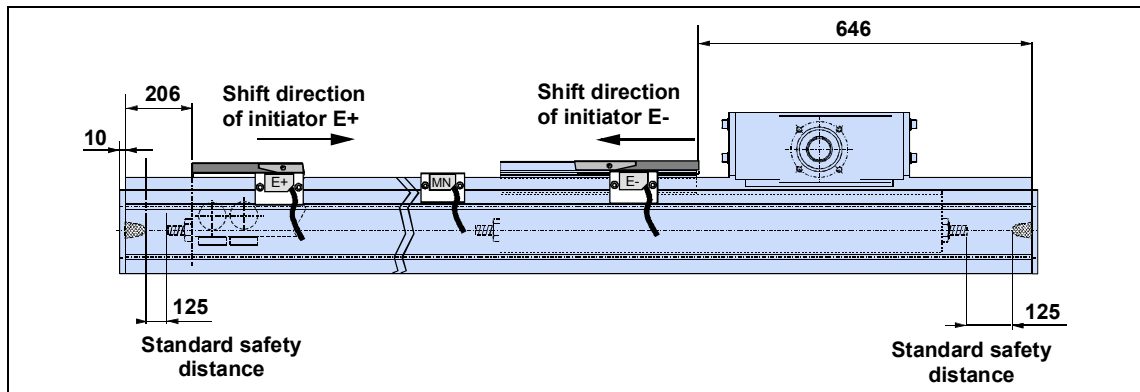



Fig. 3-4: External initiators: Setting up end limits and safety travels

Setting up the end limits E- and E+

1. Fix tripping plate with the aid of the furnished screws centered on the load attachment plate.
2. Place limit switches as shown in figure 3-4.
3. **E-**: Bring carriage with load attachment plate to the position given in figure 3-4. Move **E-** limit switch from right towards the stop until it reacts.
4. **E+**: Bring carriage with load attachment plate to the position given in figure 3-4. Move **E+** limit switch from left towards the right stop until it reacts.
5. The carriage must move freely. With an electronic transducer, the distance between the tripping plates and the limit switches should be approximately 1.5 mm (see supplier documentation).

| | |
|---|--|
|  Hint | The same applies also if the unit is installed with the profile opening at the bottom; then the directions must be inverted. |
|---|--|

Setting the machine zero point MN

The transducer for the machine zero point is fixed with an offset of about 150 mm from the E- limit switch in the direction of the clamping station. With an electronic transducer, the distance between the tripping plate and the limit switches should be approximately 1.5 mm (see supplier documentation).

4 Maintenance

4.1 Maintenance Schedule


| When | What | Action | Elimination |
|---|--------------------------------------|---|---------------|
| after the first travel movements | Carriage | Check backlash and adjust if necessary. | Chapter 5.4ff |
| | Setting the HLEZ module and the rack | Make correct setting with the aid of an adhesive tape. Check alignment of HLEZ module with reference to rack. | Chapter 5.3.7 |
| | Lubrication function | Verify that no air bubbles are in the lubricant supply pipe! This could interrupt the lubrication and impair the performance of the timing belt. | Chapter 6.1.3 |
| Monthly or if necessary sooner in the case of high stress | Orthogonal alignment | Reference travel to marks. Cause study: Timing belt "jumps" due to crash movement. Belt wear | Chapter 3.3 |
| Monthly | Contamination (if any) | depending on the degree of contamination all contaminated parts: Clean guiding, carriage (if accessible), drive module. | |
| | Damages at the timing belt | Unscrew the 2 joints at the HLEZ module housing for visual inspection. Check all teeth of the belt individually for firmness and durability with the aid of a screwdriver or similar.  | |
| Semi annually | Carriage | Check backlash of carriage (visual inspection is possible at face sides). | Chapter 5.4.2 |
| | Rollers | Check wear (visual inspection is possible at face sides). | Chapter 5.4.4 |
| | Lubrication | Check the lubrication (fill level) and function. | Chapter 5.2 |

Table 1: HLEZ maintenance plan

4.2 Causes for abnormal timing belt wear

A sign of wear may have different causes so that it is not always possible, to determine the exact cause. The following table shows possible causes for typical damages:

| Problem | Cause | Elimination |
|--|--|---|
| Abnormal wear of loaded tooth flanks of the belt | Faulty belt pre-tension | Replace timing belt, set pretension Chapter 5.2ff. |
| | Overload | Replace timing belt, set pretension Chapter 5.2ff. Check, if the load is in the admissible range. |
| Abnormal wear in the tooth root surface of the belt | Pre-tension too high | Replace timing belt, set pretension Chapter 5.2ff. |
| | Drive torque too high | Verify drive dimensioning |
| Abnormal wear at the side flank of the belt | Faulty alignment of timing belt. Timing belt rubs against the edge of the rack. A flash has formed at the rack because the HLEZ housing touches the rack. The center distance is not properly aligned. | Replace timing belt, set pretension Chapter 5.2ff. Replace damaged rack and timing belt and align axes correctly (see chapter 3.3 mounting). |
| Sheared off belt teeth | Pre-tensioning too weak | Replace timing belt, set pretension Chapter 5.2ff. |
| | Overload (for example by collision) | |
| Splits at the belt teeth | Faulty belt pre-tension | Replace timing belt, set pretension Chapter 5.2ff. |
| | Overload | Replace timing belt, set pretension Chapter 5.2ff. Check, if the load is in the admissible range. |
| | Deterioration of the belt material | Replace timing belt, set pretension Chapter 5.2ff. |
| Breaking of the timing belt | Faulty belt pre-tension | Replace timing belt, set pretension Chapter 5.2ff. |
| | Overload | Replace timing belt, set pretension Chapter 5.2ff. Check, if the load is in the admissible range. |
| Softening of the belt material | Operating temperature too high | Replace timing belt, set pretension Chapter 5.2ff. Lower operating temperature |
| | Contact with solvent | Replace timing belt, set pretension Chapter 5.2ff. Do not clean belt with solvents |
| Skipping of teeth, loss of machine zero | Pre-tension too low Wrong motor position (below) with vertical application | Set pre-tension correctly If possible move drive upwards Alternatively: Increase pre-tension or reduce load in lengthwise direction |

Table 2: Causes for abnormal tooth wear

5 Mounting/Repair

Use only original repair parts of Parker Hannifin GmbH, Hauser Division.

Improper or unprofessional repair will lead to an expiry of any warranty granted by Parker Hannifin GmbH, Hauser Division.

If you encounter problems, please contact:

Parker Hannifin GmbH & Co. KG
Electromechanical Automation
Abteilung Service

☎ D - 0781 / 509-4381

5.1 Safety Instructions

Before performing any maintenance or repair work, turn the power switch to the '0' setting and secure it with a padlock against manipulation. If the unit needs to be operable for specific repair works, you have to be especially cautious: Ensure by all means that no persons are in the hazardous area. If required, safeguard the hazardous area with additional barriers or gratings against unauthorised persons.

Only qualified expert personnel or HAUSER personnel are permitted to perform repair works.

Only qualified expert personnel is permitted to perform works on the electric equipment. All the applicable regulations and provisions must be heeded (IEC, EN, national accident prevention - regulations etc.).

If set-up, repair or maintenance works require that safety installations be dismantled, these must be reinstalled immediately after the respective works have been completed. The unit must be shut down before any of the safety installations are dismantled.

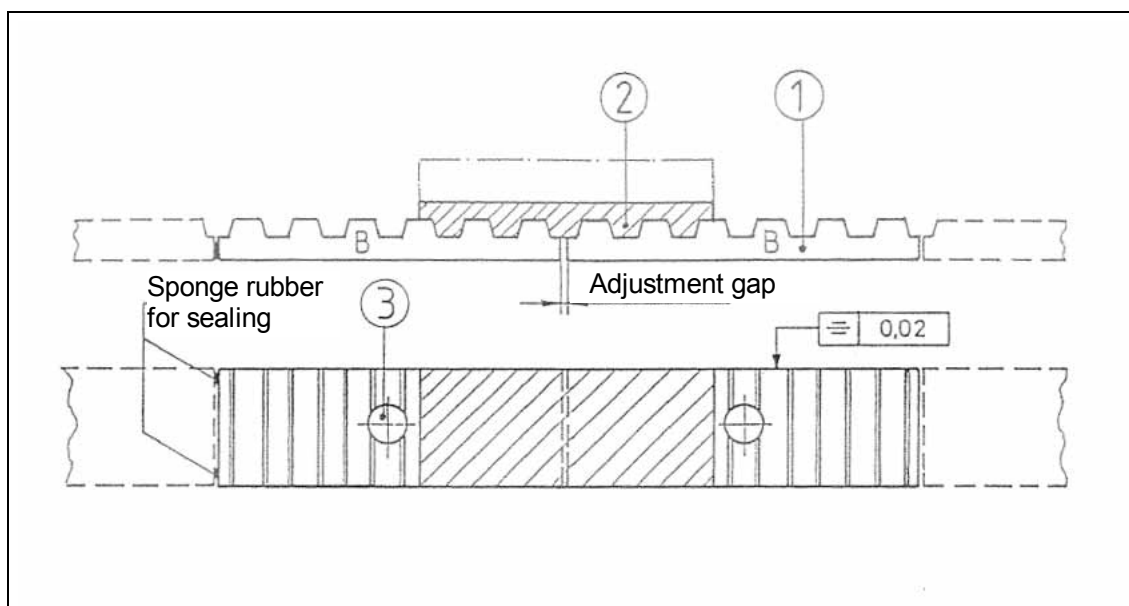
Since the entire system may be exposed to continuous vibrations during operations, all screws and nuts must be tightened.

Depending on the case

- Loctite 243 or
- a lock washer made by Schnorr

is used. If nothing else is mentioned, Loctite 243 must be used.

5.2 Mounting of tooth rack



System key

1. Preassembly of 2 tooth racks Pos. 1 beginning from the middle. Proceed step by step in both directions. Orient mark "B" towards the reference side.
2. Insert nuts into t-groove (5 pcs. per 500mm of tooth rack)
3. Align tooth racks parallel to the HLEZ profile with the aid of the measuring device fixed to the carriage (+/- 0.01mm, alternatively, a depth gauge can be used)
4. Insert fixing screws Pos. 3 and check alignment again.
5. Adjust Pos. 2 with drive module or timing belt. (put additional weight on timing belt area).
5. Mount second (and all additional) rack(s) with timing belt negative at correct distance to the first rack.
6. Tighten screws pos.3 (with 30Nm) after test run.

Timing belt negative



Parallelism to HLEZ profile



5.3 Replace, tension and align timing belt

5.3.1 General notes on timing belts

- Unpack new timing belts immediately. Store at room temperature in dry rooms in circular form (not squeezed).
- Do not fold timing belts.
- The pitch of timing belt and pulleys as well as racks must correspond.
- Max. permissible permanent temperature: 80°C. Short-time peak temperatures up to 120°C are possible.
- Protect the drives from dust, dirt, hot water, steam as well as acids and leaches.

5.3.2 Necessary tools / components

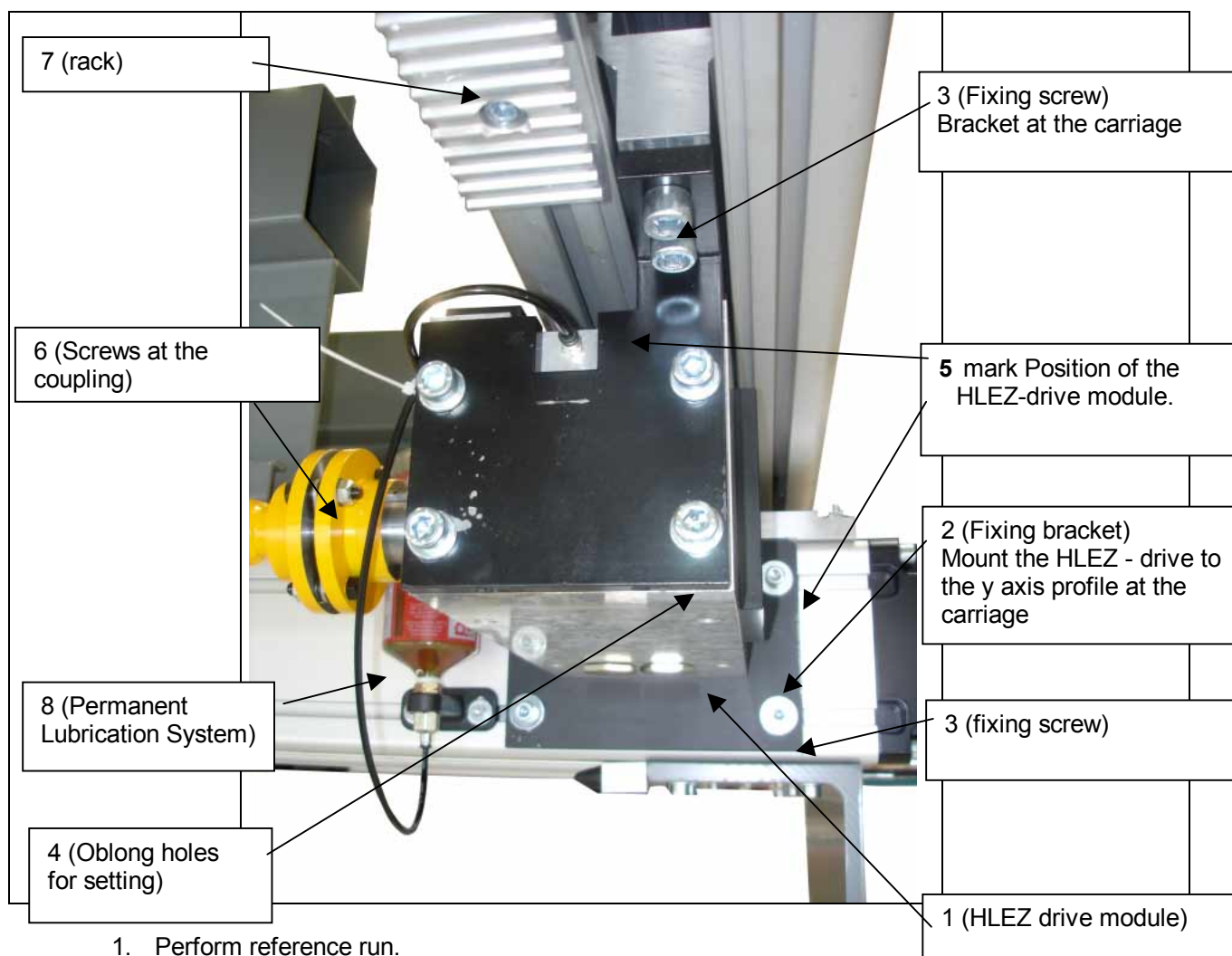
- Allen wrench SW5, SW6 (DIN 6911 with pivot)
- Flat wrench SW10
- Torque key (No. 5, hexagon, 4-20Nm or 8-40Nm)
- Stop bracket
- Spacer Ø6mm; 0,1mm; 0,2mm; 0,5mm
- Toothed belt

| infinite timing belt | HLEZ drive module | Art. No. |
|----------------------|-------------------|--------------|
| 50 ATS 10/730 | z.2-50.200 | 420-101852 |
| 75 ATS 10 | z.2-75.200 | 420-101840 |
| 100 ATS 10 | z.2-100.200 | 420-101832 |
| (50 ATS5/390) | (z.2-50.100) | (420-101865) |
| | | |

Table 3: Replacement parts for timing belt

- Timing belt pretension measurement device, RSM2000, V1.10, Art. No.: 037-000201
- Magnet holder for sensor
- Adhesive tape 50 (75, 100) mm (3M, Post-it, 0.1 mm, 3M, Scotch, Magic Tape 0.06mm).

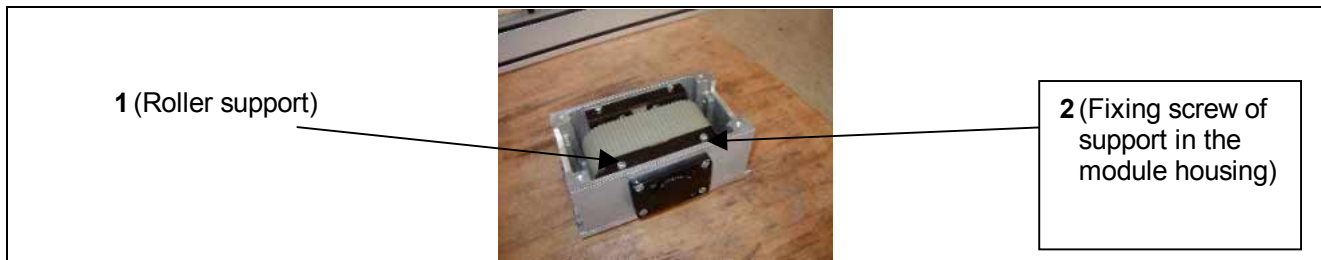
5.3.3 Dismounting the module from the HLE



1. Perform reference run.
2. Mark module position (5) before dismounting the HLEZ module
3. then remove the screws (6) at the coupling, deactivate lubricating system and remove lubricant hose.
4. Loosen fixing screws (3) and remove module.

System key

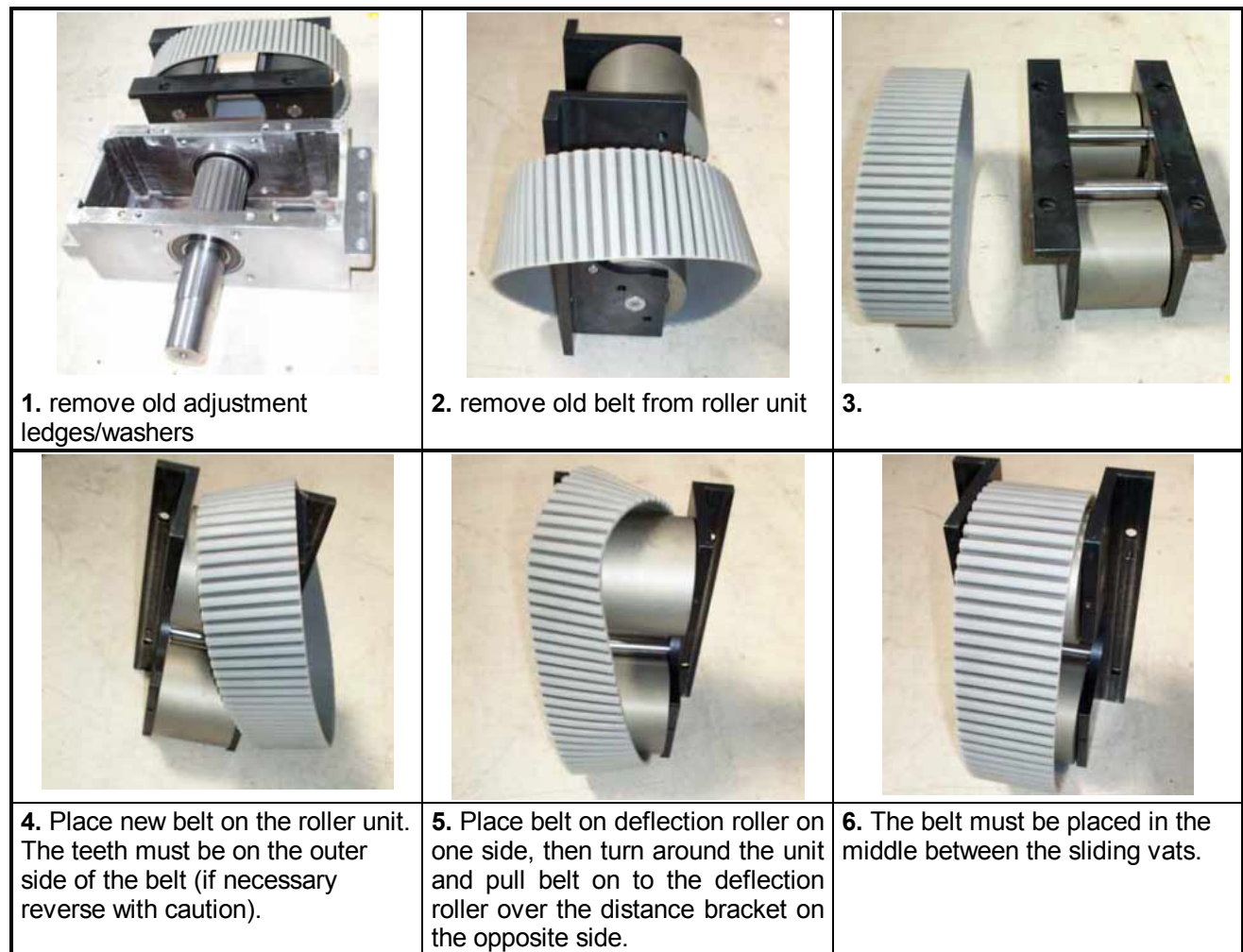
5.3.4 Replace and tension timing belt



- Setting values of measurement device:

| | HLEZ-150/50 | HLEZ-150/75 | HLEZ-150/100 |
|--------------|----------------------------------|-------------|--------------|
| Length [mm] | 170 | | |
| Weight [g/m] | 310 | 430 | 520 |
| Belt tension | 1300N +/- 100N or 190Hz +/- 10Hz | | |

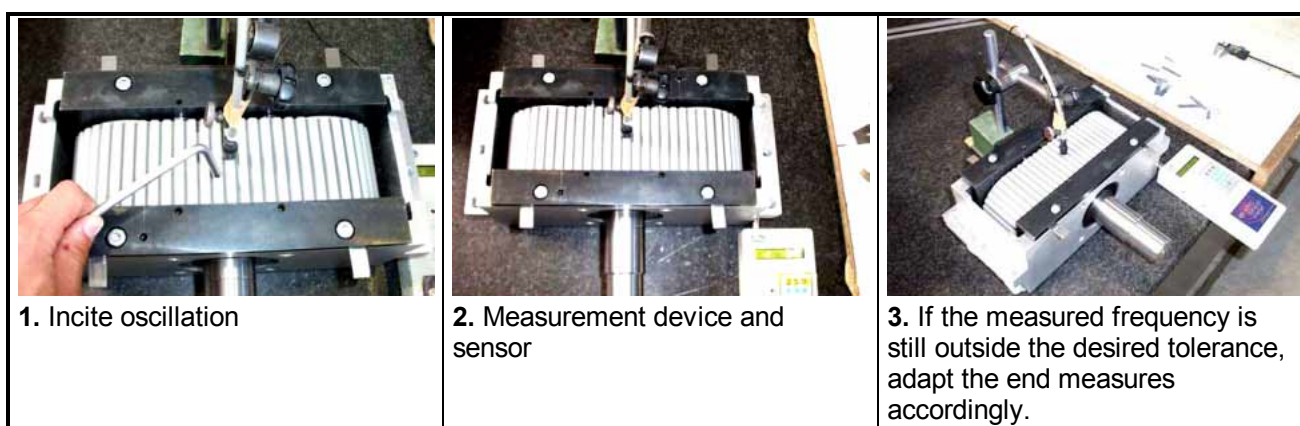
- Measurement of the belt tension as ist is (for statistical reasons)
- Loosen the fixing screws (2)
- Remove roller mount (1), **heed the washers**
- Replace/fit the new timing belt



6. Mounting of the roller unit using the old washers of the tensioning device.
7. Tighten the fixing screws (2) of the basic unit
8. Measure the timing belt tension; use a magnet rack for positioning the sensor (for further details please refer to the timing belt tension measurement device manual).

5.3.5 Check belt tension

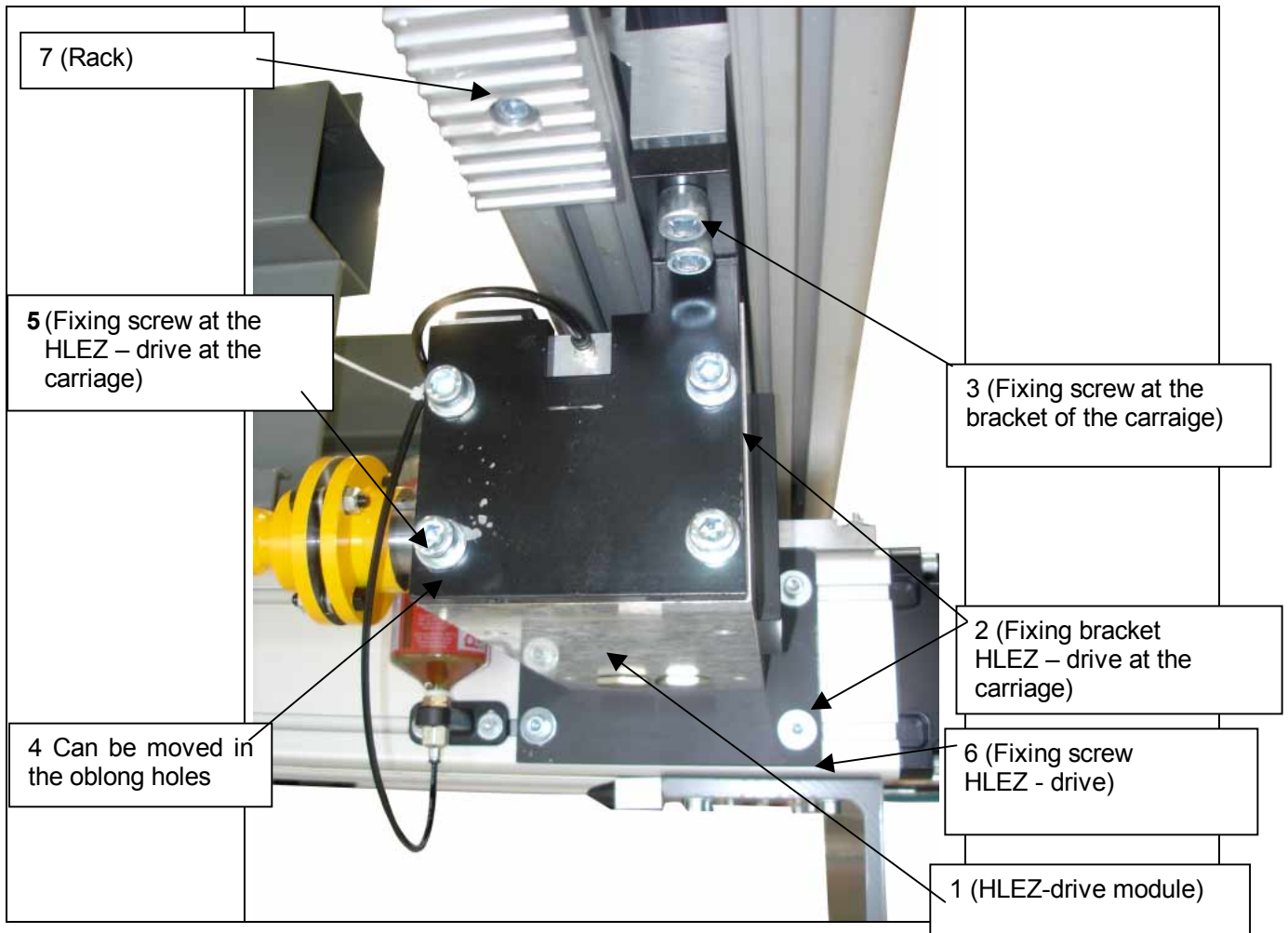
If the belt is tensioned, verify the tension with the aid of a frequency measurement device (190 ± 10 Hz). Switch on measurement device and switch display to Hz (see device manual). Place sensor in the middle between the sliding vats at a distance of about 1 mm to the belt. Please heed that the belt does not touch the sliding vats at the sides. If it touches the vats, turn in one direction until the belt moves to the other side (in necessary, change direction). Then knock on the belt near the sensor in order to incite an oscillation. (do not touch the sensor). Measure at several places of the belt by turning the drive shaft.



9. If the tension is too high, insert more washers
if the tension is too low, remove some washers or replace them by thinner washers (see figure 1 on page 20)
10. If the distance has changed, the HLEZ module must be aligned with the rack again (see chapter 5.3.7).





System key

5.3.6 Mounting the module to the HLE



1. Align a fixing bracket (2) with end bracket orthogonally to the HLE profile and fix with the corresponding cylinder head screws (3) (25Nm).
2. Fix module (1) lightly (approx. 5Nm) to the aligned bracket in the middle of the rack with the fixing screws.
3. Fix the second fixing bracket / or plate (2) to the module with the aid of the fixing screws (5) and screw lightly (approx. 5Nm) with fixing screws (6) to the y axis profile or with fixing screws (3) to carriage (25Nm).
4. The HLEZ module can be shifted in height relative to the racks (7) in the oblong holes (4). Important for "alignment of the HLEZ module to the racks."
5. Tighten fixing screws (5) and (6) lightly (approx. 5Nm).

5.3.7 Alignment of the HLEZ-module to the racks.

| | |
|--|--|
|  | <ol style="list-style-type: none"> 1. Place adhesive tape on the rack at the right and at the left of the module. Clean racks before if necessary. <p>Important: Do not travel beyond tape, travel only so far that the tape is completely beneath the module in order to verify pitch setting of the module.</p> <ol style="list-style-type: none"> 2. Move module back from the tape. 3. Move module from right to left over the tape. |
|  | <ol style="list-style-type: none"> 4. Move module back from the tape. 5. Check the tooth imprints on both tapes for pitch and rolling |
| <p>Pitch Module is not aligned evenly in travel direction on left or right.</p> | <p>Rolling Module is not aligned evenly crosswise to the travel direction at front or back.</p> |
|  |  |

6. If the tooth imprints are not correct, repeat steps 1-5 (in general 3-5 trials should be sufficient).

System key

Tooth imprints not correct
Tooth imprints too strong/deep
Tape is damaged!



Tooth imprints too weak/high
Tape did not enter toothing completely!



Correct tooth imprints

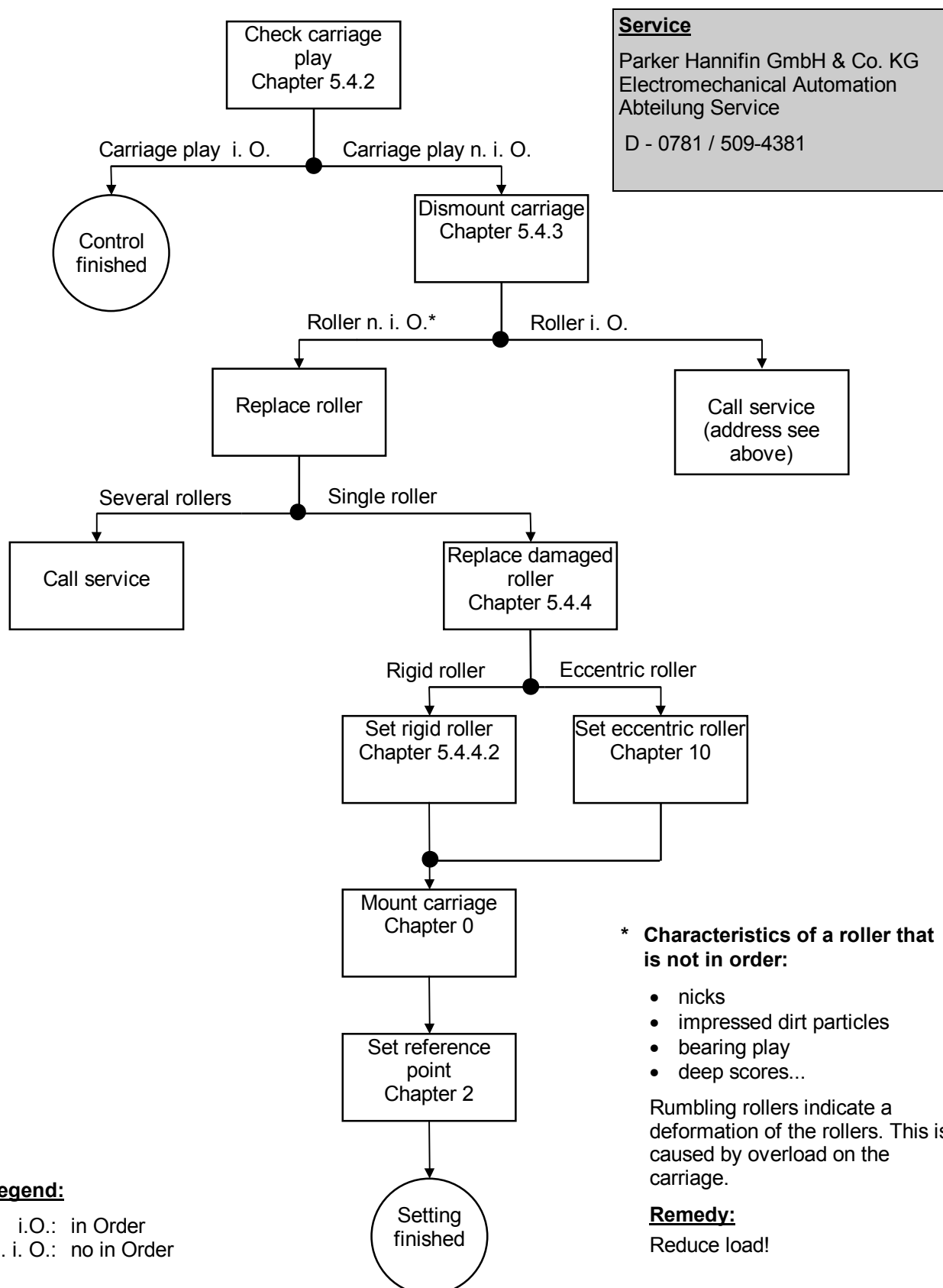
Tape is correctly imprinted into the toothing and is not damaged!
Tooth imprints are uniform over the entire surface upon travel to the left and to the right!



7. Remove tape.
8. Tighten fixing screws (5) and (6) (9Nm).

5.4 Set carriage play

5.4.1 Replace and set rollers (flow chart)



5.4.2 Checking Carriage Play



Hint

The HLEZ module is mounted on a carriage and a second carriage is connected with the HLEZ module carriage via a threaded pin. In order to dismount the carriage, the threaded pin must be loosened. The carriage play may apply to only one of the carriages. For a rough estimate, you can tell if there is any carriage play by shaking the carriage or the attachment. The following steps provide a more precise method:

1. Prepare as long a travel path as possible.
2. To move the carriage by hand and be able to see the rollers: Dismount attachments and HLEZ drive module from the carriage.
3. Push the carriage along over the entire travel path. All rollers must turn when the carriage moves.
4. To check the contact force, stop the roller from turning with your index finger. You should be able to stop the roller with just a little force.

Characteristics of a correctly set carriage:

- Carriage does not wobble any more
- Carriage can be moved along the entire travel area without great differences in force.
- Carriage can be inserted into the profile without pressure point (requires dismounting of the tensioning station, see below)



Hint

Guiding rollers that are set too tightly will get dents, which will then cause noises and defects. Replace defective rollers (see below).

5.4.3 Dismounting the carriage



Danger

If the axis is mounted upright, the carriage must be secured against moving. If the carriage is not secured, it may fall due to gravity. This may lead to injuries or damages to property.

1. Move carriage to a reference point (e.g. machine zero, real zero,...). Mark the position of the carriage on the HLE profile (with a felt-tip pen).
2. Dismount attachments and HLEZ drive module from the carriage.
3. Remove end plate of profile by loosening the four fixing screws (59).
4. Remove carriage from the profile and mark its running direction on the carriage.



Hint

The carriage must later be inserted in the same running direction in order to ensure the correct setting of the rollers!

5.4.4 Replace individual rollers

5.4.4.1 General

- The rollers consist of ball bearings with plastic coating.
- After long standstill periods, the rollers show slight flattening, which will however entirely degenerate during continuous operation.
- The ball bearings used correspond to the common standards for rolling-contact bearings and are lifetime lubricated.
- The rollers are suitable for ambient temperatures from -40°C to $+80^{\circ}\text{C}$.
-



Warning

The control of the roll behaviour is only possible while the actuator is moving. Proceed with the utmost caution, danger of injury. If possible, move actuator only by hand (if needs be, dismount motor and gearbox before and bring actuator into horizontal position). Unless, operate actuator at crawling speed (speed < 1 m/min).

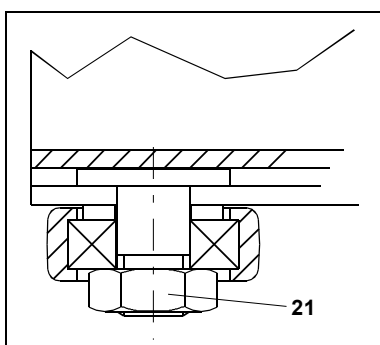


Hint

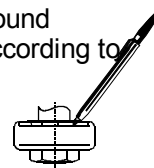
The correct setting of a carriage requires a lot of experience and special knowledge. Therefore, rollers should, if possible, only be replaced by HAUSER staff.

5.4.4.2

Replacing and setting rigid rollers



1. Dismount carriage (Chapter 5.4.3)
2. Mark position of the roller at the carriage.
3. Unscrew and remove hex nut (21).
4. Remove old roller, place new roller and correct its position at the carriage.
5. Place hex nut (21) with thread locking compound (LOCTITE 243) and tighten with torque Ma according to table 4 on page 28.
6. In order to verify the roller movement, make felt-tip pen markings on the roller.



7. Remove dirt and chips from the travel surface of the actuator.
8. Insert the carriage in the correct running direction into the profile and verify the roller setting over the entire travel distance. The rollers should turn over the entire travel distance.



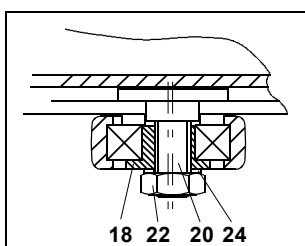
Hint

When setting the roller play, only the roller that was replaced, should be adjusted. If this does not lead to a correct setting of the carriage, the entire carriage must be set again. This task requires a lot of experience and special knowledge and is therefore only to be performed by a HAUSER technician.

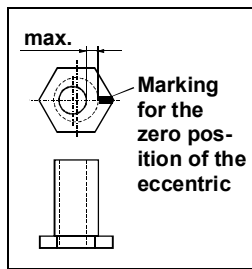
9. To check the contact force, stop the roller from turning with your index finger. You should be able to stop the roller with just a little force.
10. If the settings are made correctly, the task is finished. Unless, correct roller setting.

5.4.4.3

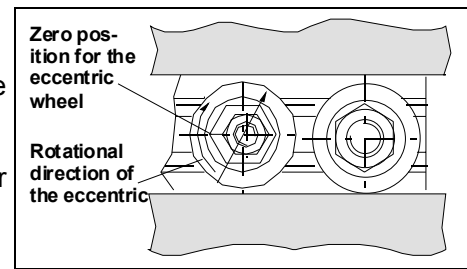
Replace and set eccentric roller



1. Dismount carriage (Chapter 5.4.3)
2. Mark position of the roller at the carriage.
3. Unscrew and remove hex nut (22), remove old washer.
4. Remove old roller and press out eccentric sleeve (18).
5. Fit eccentric sleeve and new roller together and place the parts onto the screw (20). Place new Schnorr washer (24) and hex nut (22). Correct position at the carriage. Tighten hex nut lightly.



6. When turning the eccentric in clockwise direction (18), set the position of the sleeve so that the roller will be positioned at the same guide as the old roller before dismounting.



7. Tighten hex nut (22) with tightening torque M_a according to table 4.
8. In order to verify the roller movement, make felt-tip pen markings on the roller.
9. Remove dirt and chips from the travel surface of the actuator.
10. Insert the carriage in the correct running direction into the profile and verify the roller setting over the entire travel distance. The rollers should turn over the entire travel distance.



Hint

When setting the roller play, only the roller that was replaced, should be adjusted. If this does not lead to a correct setting of the carriage, the entire carriage must be set again. This task requires a lot of experience and special knowledge and is therefore only to be performed by a HAUSER technician.

11. Set the eccentric of the guiding roller in small steps so that the carriage can be pushed easily and without play through the HLEZ profile. Guiding rollers that are set too tightly will get dents, which will then cause noises.
12. To check the contact force, stop the roller from turning with your index finger. You should be able to stop the roller with just a little force.
13. If the settings are made correctly, the task is finished. Unless repeat steps 10 and 11 until the carriage settings are in order.

| HLEZ | Mounting | rigid roller | eccentric roller |
|------|----------|--------------|------------------|
| 150c | Nut | 39.6 Nm | 26.6 Nm |

Table 4: Tightening torque of the roller fastenings

5.4.5 Mounting the carriage

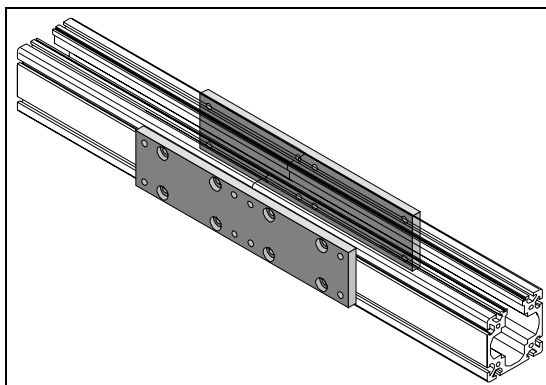
1. Insert the carriage into the profile in the previous running direction.
2. Mount the HLEZ drive module

5.4.6 Setting the reference point

Correct the machine zero point according to the carriage position marked before. Depending on the motor and on the controller, there are several possibilities. For further details, please refer to the manual of the controller.

5.5 Extended axes

5.5.1 General



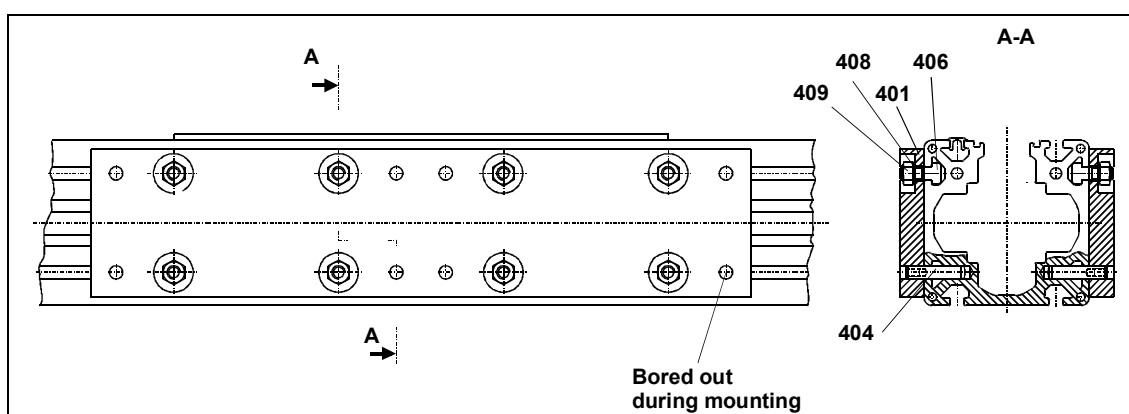
- Longitudinal flanges are used to obtain a longer travel or in order to improve the mounting conditions in mounting places that are difficult to access.
- The cut-off point for the longitudinal flanges should always be located near a fixation point.
- The distance between supports should in general be between 1.0m and 1.5m.

- As a standard, the cut-off point is located in the middle in order to obtain two profile elements of the same length.
- If longitudinal flanges are used to increase the stroke, the performance data must be reduced accordingly. (Table 5)

| HLE | Unit | 150c |
|-----------------------|---------|-----------------------|
| Max. permissible load | N | $0.5 \times F_z^{13}$ |
| max. drive torque | Nm | 54 |
| Speed: | m/s | < 1 |
| Acceleration: | m/s^2 | < 1 |
| Repeatability: | mm | > $\pm 0,5$ |

Table 5: Reduced performance data for extended axes

5.5.2 Mounting of longitudinal flanges



1. Align the profiles.
2. Insert t-bolts (406) (4 pcs. per profile and side).
3. Place perforated plate (401) on the profiles, place safety washers (408) and nuts (409) and fix.
4. Align profiles exactly, check the travel surfaces. Align if necessary. Check joint manually. It must feel smooth without a notch.

System key

5. Check if the pin bores are aligned with each other, if needs be readjust the position of the HLE. Insert pins (404).
6. Tighten nuts (409).

6 Repair

The unit should be repaired by qualified expert personnel only. Please contact Parker for this purpose.

The safety instructions laid down in Chapter 3 and especially those laid down in the present Chapter must be heeded by all means!

Use only authentic spare parts provided by Parker!

Inexpert repairs lead to an expiry of any warranty granted by Parker.

6.1 Spare and Wearing Parts

6.1.1 Spare and wearing parts of HLEZ 150

| Pos. | Name | No. of stitches | | | | Unit | Article Number |
|------|---------------------------|-----------------|----|------|------|------|----------------|
| | | NL | VL | NL D | VL D | | |
| 16 | Roller R4OL0025 | 6 | 12 | 12 | 24 | Pcs. | 416-201020 |
| 17 | Roller R4OL0026 | 6 | 12 | 12 | 24 | Pcs. | 416-201010 |
| 18 | Eccentric sleeve E4XZ0001 | 6 | 12 | 12 | 24 | Pcs. | 125-071100 |
| 21 | Hex nut M12 | 6 | 12 | 12 | 24 | Pcs. | 135-702032 |
| 22 | Hex nut M10 | 6 | 12 | 12 | 24 | Pcs. | 135-702031 |
| 23 | Safety washer 12 | 8 | 14 | 16 | 28 | Pcs. | 135-201055 |
| 24 | Safety washer 10 | 6 | 12 | 12 | 24 | Pcs. | 135-201054 |

Table 6: HLEZ 150

| Pos. | Name | No. of stitches | | | | Unit | Article Number |
|------|---------------------------|-----------------|----|------|------|------|----------------|
| | | NL | VL | NL D | VL D | | |
| 16 | Roller R4OL0025 | 6 | 12 | 12 | 24 | Pcs. | 416-201022 |
| 17 | Roller R4OL0026 | 6 | 12 | 12 | 24 | Pcs. | 416-201012 |
| 18 | Eccentric sleeve E4XZ0001 | 6 | 12 | 12 | 24 | Pcs. | 125-719100 |
| 21 | Hex nut M12 | 6 | 12 | 12 | 24 | Pcs. | 135-728416 |
| 22 | Hex nut M10 | 6 | 12 | 12 | 24 | Pcs. | 135-728415 |
| 23 | Safety washer 12 | 8 | 14 | 16 | 28 | Pcs. | 135-728730 |
| 24 | Safety washer 10 | 6 | 12 | 12 | 24 | Pcs. | 135-728725 |

Table 7: HLEZ 150 - stainless

6.1.2 Spare and wearing parts of the HLEZ basic drive module

Order information for spare parts – assembly group of the module, pos. No.

| Pos. | Name | No. of stitches | Unit | Article Number |
|------|--------------------------------|-----------------|------|----------------|
| 1 | Chassis | 1 | Pcs. | z2-50.200-1 |
| 3 | Pinion shaft I | 1 | Pcs. | z2-50.200-3 |
| 4 | Grooved ball bearing two rowed | 1 | Pcs. | z2-50.200-4 |
| 5 | Grooved ball bearing two rowed | 1 | Pcs. | z2-50.200-5 |
| 6 | Stop ring A | 1 | Pcs. | z2-50.200-6 |
| 7 | Stop ring B | 1 | Pcs. | z2-50.200-7 |
| 8 | Deflection roller | 2 | Pcs. | z2-50.200-8 |
| 9 | Distance bracket | 2 | Pcs. | z2-50.200-9 |
| 10 | Grooved ball bearing | 4 | Pcs. | z2-50.200-10 |

System key

| | | | | |
|----|-------------------------------|---|------|---|
| 11 | Axis | 2 | Pcs. | z2-50.200-11 |
| 12 | Washer | 4 | Pcs. | z2-50.200-12 |
| 13 | Downholder roller | 2 | Pcs. | z2-50.200-13 |
| 14 | Needle bush sealed | 4 | Pcs. | z2-50.200-14 |
| 15 | Cylinder pin | 4 | Pcs. | z2-50.200-15 |
| 16 | Axial washer | 4 | Pcs. | z2-50.200-16 |
| 17 | Hexagon socket cylinder screw | 4 | Pcs. | z2-50.200-17 |
| 18 | Washer | 4 | Pcs. | z2-50.200-18 |
| 19 | Hexagon socket cylinder screw | 8 | Pcs. | z2-50.200-19 |
| 22 | Safety ring for bore | 4 | Pcs. | z2-50.200-22 |
| 23 | Bearing cap A | 1 | Pcs. | z2-50.200-23 |
| 24 | Bearing cap B | 1 | Pcs. | z2-50.200-24 |
| 27 | Sliding vat | 2 | Pcs. | z2-50.200-27 |
| 28 | Nilos ring | 2 | Pcs. | z2-50.200-28 |
| 30 | inifinite timing belt | 1 | Pcs. | see table 3: Replacement parts for timing belt Page 19 |

Table 8: HLEZ-basic drive module

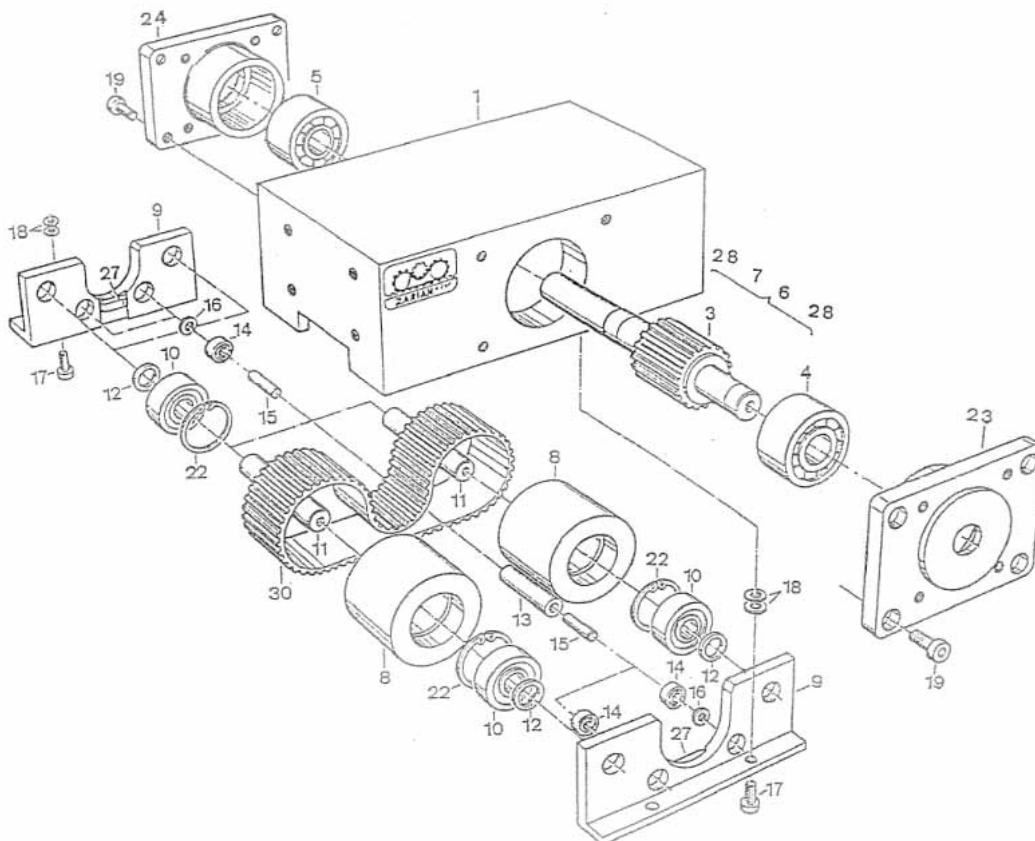
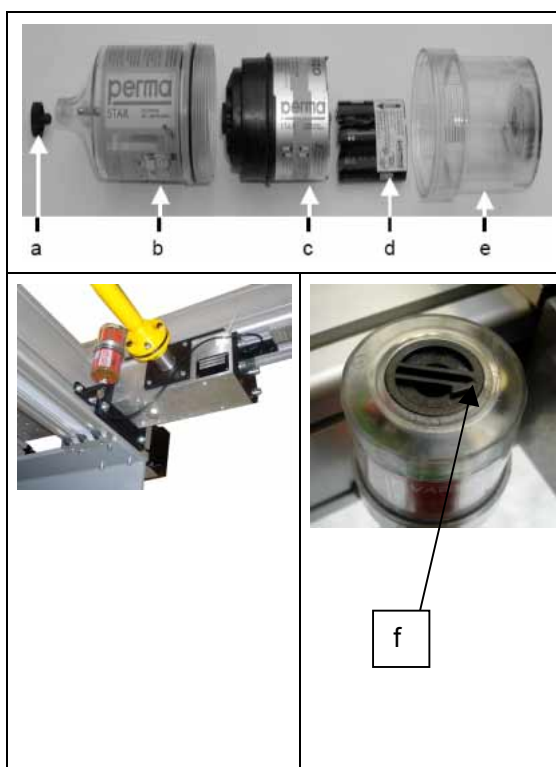


Fig. 6-1: Exploded drawing of the HLEZ module

6.1.3 Permanent lubricating system



The lubricating system is placed near the HLEZ module.

Description:

- a Sealing plug
 - b LC unit (Lubrication Canister). Filled with Shell Omala 220
Art.: 180-006026. Filling is done by the Parker service
 - c Drive system
 - d Battery. Replacement is done by the Parker service
 - e Closing lid for the drive system, reusable.
- Rotary switch for start and stop of distribution

Replace LC-unit → see detailed "perma STAR VARIO" manual . **The LC unit cannot be refilled.**

Fig. 6-2: Central "perma STAR VARIO" lubricating system



Caution

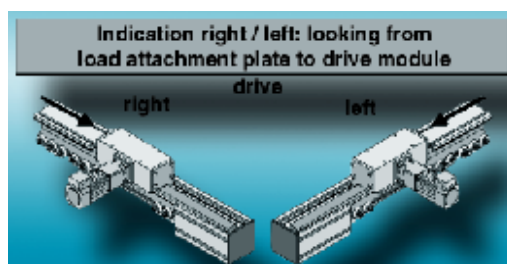
Please make sure that there are **NO** air bubbles in the entire supply hose after the replacement of the "Perma" lubricating cartridge or after refilling the oil. Air bubbles could interrupt the lubrication and impair the performance of the timing belt.

34

8 System key

The system key is used for the non-ambiguous designation of a HLEZ.

| | | | | | | | | | | | | | | | | | | | | |
|---|----------|----------|----------|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| HLEZ linear module | L | E | Z | | | | | P | | | | | | | | | | N | N | N |
| Drive system | | | | | | | | | | | | | | | | | | | | |
| Rack-and-pinion drive | | | Z | | | | | | | | | | | | | | | | | |
| Model /size | | | | | | | | | | | | | | | | | | | | |
| 150 (Dimensional drawing, page 7) | | | | | 1 | 5 | 0 | | | | | | | | | | | | | |
| Carriage | | | | | | | | | | | | | | | | | | | | |
| Standard carriage with load attachment plate | | | | | | | | S | | | | | | | | | | | | |
| Standard carriage with bar | | | | | | | | T | | | | | | | | | | | | |
| Extended carriage with load attachment plate | | | | | | | | E | | | | | | | | | | | | |
| Extended carriage with bar | | | | | | | | F | | | | | | | | | | | | |
| Special carriage with load attachment plate (on request) | | | | | | | | C | | | | | | | | | | | | |
| Special carriage with bar (on request) | | | | | | | | D | | | | | | | | | | | | |
| Extra (for example two or more carriages) | | | | | | | | X | | | | | | | | | | | | |
| Guide system | | | | | | | | | | | | | | | | | | | | |
| Plastic-coated rollers | | | | | | | | P | | | | | | | | | | | | |
| Stroke | | | | | | | | | | | | | | | | | | | | |
| Specify required stroke (in mm) | | | | | | | | | n | n | n | n | n | | | | | | | |
| Drive options (for definition of on right / on left: see picture below)) | | | | | | | | | | | | | | | | | | | | |
| Shaft on left | | | | | | | | | | | | | S | L | | | | | | |
| Shaft on right | | | | | | | | | | | | | S | R | | | | | | |
| Gearbox on left | | | | | | | | | | | | | D | L | | | | | | |
| Gearbox on right | | | | | | | | | | | | | D | R | | | | | | |
| Extras (other drive versions) | | | | | | | | | | | | | X | X | | | | | | |
| Gearbox flange | | | | | | | | | | | | | | | | | | | | |
| Flange suitable for worm gearbox 52.314.06 | | | | | | | | | | | | | | | L | | | | | |
| Flange suitable for planetary gearbox PL5 OP11 or PE5 | | | | | | | | | | | | | | | R | | | | | |
| Without gearbox flange – with drive options SL, SR | | | | | | | | | | | | | | | N | | | | | |
| Extras (others, not standard, on request) | | | | | | | | | | | | | | | X | | | | | |
| Axis distance for double actuators (center distance) | | | | | | | | | | | | | | | | | | | | |
| State for single acutator or following axis (in mm) | | | | | | | | | | | | | | | | 0 | 0 | 0 | 0 | 0 |
| State desired center distance (in mm) – no standard – only on request! | | | | | | | | | | | | | | | | n | n | n | n | n |
| Steel band cover | | | | | | | | | | | | | | | | | | | | |
| Without steel strip cover (standard) | | | | | | | | | | | | | | | | | | | N | |
| Material design | | | | | | | | | | | | | | | | | | | | |
| Standard design | | | | | | | | | | | | | | | | | | | N | |
| Linear encoder | | | | | | | | | | | | | | | | | | | | |
| Without linear encoder (standard) | | | | | | | | | | | | | | | | | | | | N |



Further documentation available:

- ☞ HLEc catalogue
- ☞ HLEc DXF and MI files (manual and CD-ROM)
- ☞ HLEZ catalogue (HLE with rack-and-pinion drive)
- ☞ HPLA catalogue (state-of-the-art modular linear actuator)
- ☞ HZR catalogue (vertical actuator)
- ☞ HTR catalogue (telescopic actuator)
- ☞ HTR manual (start-up and project development)
- ☞ ET electro-thrust cylinder catalogue
- ☞ Handling and production automation (prospectus)
- ☞ Gantry robots (prospectus)
- ☞ perma STAR VARIO manual