INSTRUCTION MANUAL

Endurance Line type 02

Installation, Operation and Maintenance

Document Number: 0100 78 00 94, rev -

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1 Safety precautions

1.1 General

KONI's hydraulic railway dampers are designed, developed and manufactured with state-of-the-art technologies in modern facilities. Our dampers are produced with great care and commitment to continuous quality control, utilising sophisticated quality techniques.

These instructions are intended to facilitate familiarization with the product and its use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. The instructions may not take into account local regulations; ensure such regulations are observed by all, including those installing the product. Always follow your company's safety requirements and applicable safety and health laws/regulations.

These instructions must be read prior to installing, operating and maintaining the dampers in any region worldwide. The dampers must not be put into service until all the conditions relating to safety, noted in the instructions, have been met. Failure to follow and apply the relevant user instructions is considered to be misuse. Personal injury, product damage, delay or failures caused by misuse are not covered by the KONI warranty.

1.2 Copyright

1.3 Safety

1.3.1 Marking

These user instructions contain a specific safety marking where non-observance of an instruction may cause danger. The specific safety marking is:

This symbol indicates safety instructions where non-compliance will involve risk to safe operation and personal safety and could damage the damper or train.

1.3.2 Personnel qualification and training

All personnel involved in the installation, inspection and maintenance of the damper must be qualified to carry out the work involved. If the personnel in question do not already possess the necessary knowledge and skills, appropriate training and instructions must be provided. If required the customer may commission KONI to provide applicable training.

1.3.3 Safety action

This is a summary of conditions and actions to prevent injury to personnel and damage to the environment and to equipment.

Although the damper has a strong construction, it must be treated with care. The damper must never be dropped. When working with the dampers proper protective clothing must be worn, such as steel-capped shoes, working gloves and safety glasses. During cleaning, degreasing and blow-cleaning the damper or components, the inhalation of dust or degreasing fumes must be prevented.

The dampers contain oil. Please use caution and do not spill oil on the workshop floor as this may lead to dangerous situations. During the maintenance work you should always comply with your local health, safety and environmental regulations.

1.4 Workshop

The major issue affecting damper performance and longevity is dirt inside the damper. It is therefore very important to prevent dirt entering the damper during re-assembly of the damper. For this reason it is advised that the workshop consists of two separate sections:

- A section where the damper is disassembled and its components are cleaned
- A clean section where only the assembly takes place

2 Storage Instruction

2.1 General

When the dampers are received, they should be inspected for damage or other signs of rough handling. Any damage found should be reported to the carrier immediately.

Any shortage and / or damage must be reported immediately to KONI.

Each damper has a unique serial number which can be found on the type plate. Check that this number corresponds with the sticker on the packing.

Do not drop dampers or damage dampers during handling.

2.2 Storage Conditions

Dampers should be stored in a horizontal position under normal industrial conditions. This means a dry (maximum humidity of 60%) and ventilated room with an ambient temperature between 0 ºC ~ 40ºC.

Furthermore the room should be ozone-free and protected from direct sunlight.

The shelf life of hydraulic dampers is 5 years.

If the shelf life is exceeded the dampers should be functionally checked at a KONI recognised service centre before use.

2.3 Recycling and end of product life

At the end of the service life of the damper, the relevant materials and parts should be recycled or disposed of by using an environmentally acceptable method and in accordance with local regulations.

KONI dampers contain components made of various types of steel, copper, rubber, plastic and contain a certain volume of mineral oil. The paint used on the dampers is generally water based without solvents, unless otherwise specified by the customer. The damper does not contain any dangerous substances.

Damper disposal can be realised as follows:

- Sending the dampers back to KONI
- Sending the dampers to a recognised and accredited disposal company
- Disassembling the damper at your own premises and sending parts to an accredited recycling or disposal company

2.3.1 Sending the dampers back to KONI

The KONI address and the addresses of KONI recognised service centres can be found at the KONI website www.KONI.com

2.3.2 Sending the dampers to a recognized disposal company

Disposal companies often are registered at the national government.

For local company names and addresses, please refer to the associated websites.

2.3.3 Disassembling the damper at your own premises

After disassembling, the parts and the oil must be disposed of according to the local regulations which comply with the separation and recycling processes available.

3 Damper description

3.1 General description on application

3.1.1 Primary vertical (axle box) dampers

These dampers control the vertical movements between axle box and bogie frame, in particular the motion of bogie bouncing on the axle boxes and more important, pitching of the bogie frame in relation to the axles. The latter is induced by irregularities in the track, rail joints and crossing. This causes the one end of the bogie frame to move down while the other moves upwards. Unless this motion is controlled, it can result in a serious wheel unloading with danger of derailment.

The primary vertical damper can be provided with a mechanical lift stop which provides the possibility to lift the bogie by means of the damper. The mechanical lift stop consists of a metal ring, mounted on the piston rod above the piston in order to safeguard the piston function. The maximum allowable static load is mentioned on the outline drawing and on the nameplate of the damper.

3.1.2 Secondary vertical dampers

The secondary vertical dampers control the vertical movements between car body and bogie frame, such as pitching. Correct damping is essential in relation to body mass and spring stiffness. Secondary vertical dampers, if widely spaced, will assist secondary springs to control rolling oscillations of the car body.

3.1.3 Secondary horizontal (lateral) dampers

The lateral dampers are used to control lateral movements of the car body (both ends of the body moving in the same direction relative to the bogie) as well as body nosing oscillations (one end of the body moving opposite to the other). It is essential to ensure correct lateral damping as both an under and over damped secondary lateral suspension can induce excessive sway to the car body.

It is very important to carefully select the lateral damper rates in relation to the vertical and lateral suspension stiffness.

3.1.4 Yaw dampers

Yaw dampers are special dampers designed to control small amplitude sinusoidal rotation movements. Without this damping the rotation of the bogie around the centre pivot of the bogie may become excessive. These hunting movements result in discomfort for the passengers and in case of high-speed trains in risk of derailment.

Yaw dampers are usually positioned longitudinally to control rotation of the bogie without influencing lateral damping. The damping rate must be carefully chosen. Excessive damping would result in too much resistance to bogie rotation with consequential risk of derailment, excessive wheel wear and noise.

3.2 General working principles

The KONI railway damper is a hydraulic system: the resistance of the liquid flowing through valves and restrictions generates the damping force. The damper has a two-way function: damping force is generated through both inward and outward movement. In nearly all cases, the compression and extension forces are basically equal; in other words, its characteristic is symmetrical.

3.2.1 Endurance Line type 02 dampers

3.2.1.1 General Technical Data

Maximum damping force	15,000 N
Nominal velocity	0.1 m/s
Maximum velocity	1.0 m/s
Maximum damping rate	170 kNs/m
Maximum allowable ambient temperature in service	-40°…+80°C (-50°C with special Arctic Pack)
Reservoir diameter	89 mm
Dust cover diameter	102 mm
Piston rod diameter	35 mm
Piston diameter	50 mm

3.2.1.2 Construction

The damper is constructed from a number of main components. Please refer to the general cross sectional drawing in Figure 3-1.

1. *Dust cover*; Protects the piston rod and bellow against flying particles from outside.
2. *Dust bellow*; Gives extra protection to the piston rod and the rod seals from penetrating dirt.
3. *Wiper ring*; Removes dirt film from the rod surface during the piston rod movements.
4. *Piston rod oil seal*; long-life piston rod oil seal, providing excellent fluid sealing while reducing the friction on the piston rod, even after long use.
5. *Piston rod guide*; Made from special perlitic cast-iron for minimal wear. The precision-ground working surfaces ensure maximum life. The oil pressure relief ports in the guide to the reservoir ensure that the rod oil seals are never overloaded by pressure.
6. *Adjustable damping valve*; By turning the adjusting screw the compression and extension forces can be altered. The pressure on the spring-loaded valve is changed to offer a higher or lower resistance to the oil as it flows out of the cylinder, through the damping valves, into the reservoir.
7. *Synthetic (non-metallic) ring in the guide*; With this synthetic bearing ring there is no metal-to-metal contact between piston rod and guide, thus further reducing wear.
8. *Cylinder*; Made from precision steel. Special attention is paid to the roundness and the superfinish of the bore.

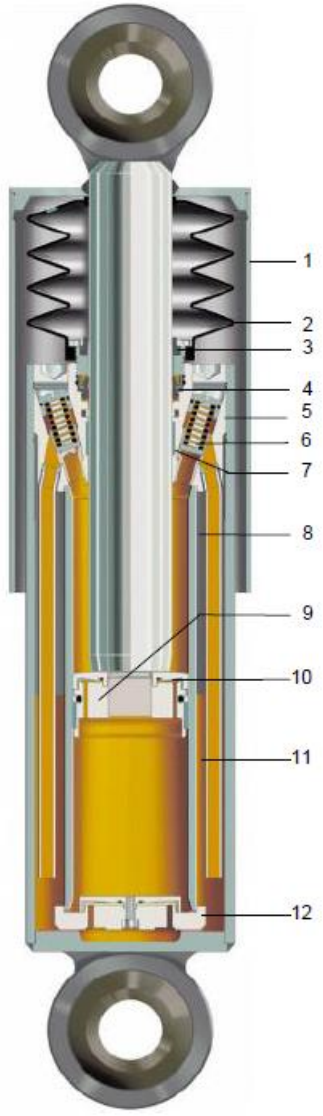


Figure 3-1 Cross sectional drawing

9. *Piston*; Made from special perlitic cast-iron. Around the piston a synthetic (non-metallic) ring is fitted, ensuring there is no metal-to-metal contact between piston rod and cylinder, thus further reducing wear.
10. *Non-return valve*; Special flat valves are used in both bottom valve and piston, ensuring a perfect seal.
11. *Oil Reservoir*; Ample capacity for adequate oil reserve, ensuring the proper functioning of the damper and lubrication of the oil seals.

12. *Bottom valve assembly*; Machined from solid steel, the body is provided with large oil-flow ports, to ensure efficient damper functioning at the high damping velocities required in today's railroad environment.

Not shown in the picture; when the damper is equipped with the so-called "Arctic Pack" or "Desert-Pack", whereby a special rubber bellow is fitted around the dust cover, protecting the damper against ingress of snow/ice/sand. This can be removed easily by loosening the hose clamp.

3.2.1.3 Principle of damping

This damper type has a circulating oil principle (Figure 3-2). On the extension stroke the non-return valve in the piston is closed and the oil above the piston is forced through the damping valves into the reservoir. At the same time, because of the increased volume below the piston, oil is forced through the non-return bottom valve.

During the compression stroke the non-return bottom valve is closed and because the piston is forced down in the cylinder, oil flows through the now open non-return valve in the piston. The oil displaced by the piston rod is forced through the damping valves. Therefore during the compression stroke the oil pressures above and below the piston are equal.

It is noteworthy that the oil flows, during both strokes, constantly in one direction. Any air bubbles in the cylinder, formed during transport, are therefore dispersed in a very short time.

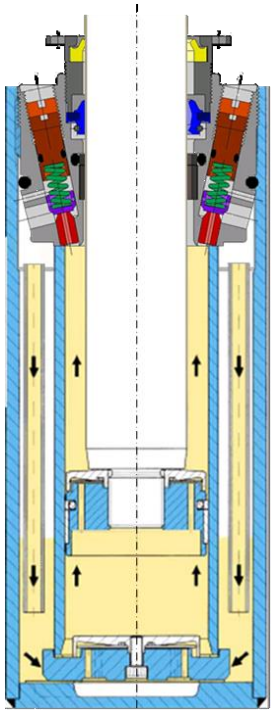


Figure 3-2 Circulating oil principle

3.2.1.4 Cooling

The circulating oil principle of the KONI dampers provides an excellent heat transfer between damper and the surrounding air, allowing a high maximum environmental temperature. This unique construction makes the KONI dampers especially suitable for warm climates (Figure 3-3).

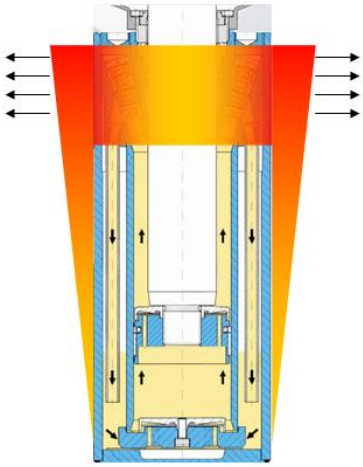


Figure 3-3; Heat transfer

3.3 Nameplate information

Every damper has a nameplate that provides information about the damper. The nameplate is located on the dust cover. In addition, the damper type number and serial number are also rolled in the reservoir tube.

When ordering spare parts, please always communicate the following damper information:

- Damper type
- Serial number
- Item numbers of the required parts

See Parts List for item numbers.

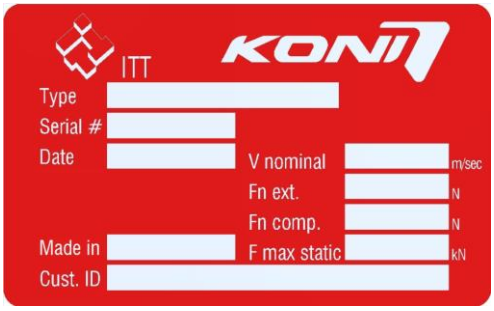


Figure 3-4; Nameplate

Table 3-1; Explanation of the nameplate

Nameplate field	Explanation	Example
Type	Damper type	02R 1201
Serial #	Serial number of the damper	70025
Date	Production date	2016 - 07
V nominal	Nominal test speed	0.1
Fn ext	Nominal damping force in extension at V nominal	7550
Fn comp	Nominal damping force in compression at V nominal	7550
F max static	Maximum static extension load (Lift Stop)	15
Made in	Indicates production location:	NL – OB: Netherlands – Oud-Beijerland CZ – OS: Czech Republic – Ostrava CN – WX: China – Wuxi Or blank, with “Assembled in USA” above it for Hebron
Cust. ID	Customer damper identification	12552

4 Installation

4.1 Mounting and priming instruction

Before mounting a damper or a damper batch, take a sample and verify that the shelf-life is not exceeded and the damper is in good visual condition.

Visual check points:

- Check the rubber of the attachments for cracks
- Check the damper for oil leakage and dents or other damages
- Check if the piston rod can rotate freely

Although the damper is self-priming in service; KONI advises to prime the dampers before mounting, this is especially advised for lateral dampers. Priming can be done by hand (when the damper has a “light” setting), or by using a damper test machine.

Priming instruction (using machine):

1. In vertical position, press the piston rod to the minimum length
2. For horizontal dampers: In horizontal position, pull the piston rod to the maximum length
3. For vertical dampers: In vertical position, pull the piston rod to the maximum length
4. Press the piston rod to the mounting length

Depending on the setting of the damper (force levels), it may be possible to prime by hand.
Priming instruction (by hand):

1. Position the damper in vertical position with the dust cover side up
2. Hold damper by placing two feet over the silentbloc end and pull with two hands on upper silentbloc until damper reaches maximum length
3. Compress damper by pushing by hand to minimum length
4. Repeat this action another 4 times
5. Press the piston rod to the mounting length

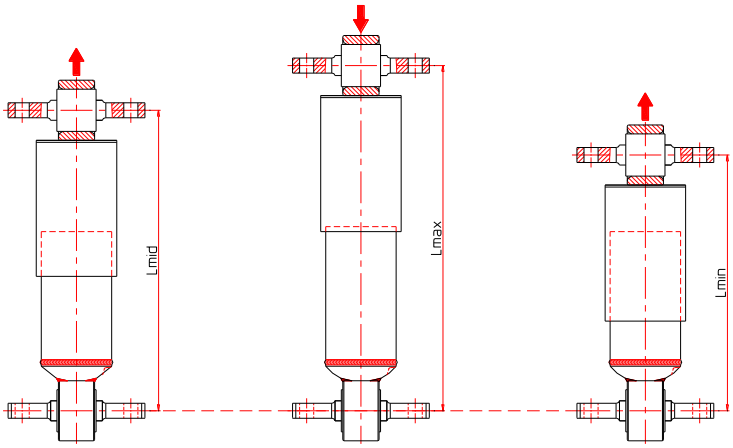


Figure 4-1 Priming positions

After these priming actions keep the dampers in vertical position until they are mounted on the bogie.

4.1.1 Primary vertical

For the primary vertical dampers no special priming actions are required.

Mounting
The primary vertical dampers are mounted vertically between the mounting brackets with the dust cover facing up.
The maximum allowable angle from the vertical is 45°.

Pin Attachment
The pin attachment must be tightened to the right mounting torque. The correct mounting torque is specified on the damper drawing (OFF drawing).

Silentbloc
The silentblocs must be bolted to the bracket and tightened at the right mounting torque. They must be mounted without any angular pre-tension as this could have a negative influence on the service life of these blocks.

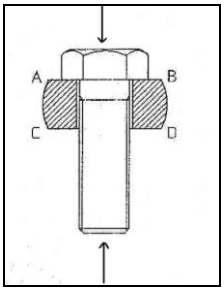


Figure 4-2; Mounting Advice

In order to avoid shearing forces in the mounting bolt, KONI advises to mount the bolt in longitudinal direction of the damper forces (Figure 4-2).

4.1.2 Secondary horizontal (lateral) and yaw dampers

The lateral and yaw dampers are mounted horizontally between the mounting brackets.

The dampers have a provision which prevents air from entering the cylinder. For this reason it is imperative that the dampers are mounted in the right position. The dampers are marked in the underside of the reservoir with the text “BELOW”, and clearly marked with a decal. In addition, the dampers also have a hard marking pressed into the reservoir. The location and shape can differ between individual damper types (see Figure 4-3), so always refer to the applicable damper drawing to see the details of the marking.

In some cases an extra air chamber (dome) is built on top of the damper. In this case the damper must be mounted with the dome facing up (Figure 4-4).

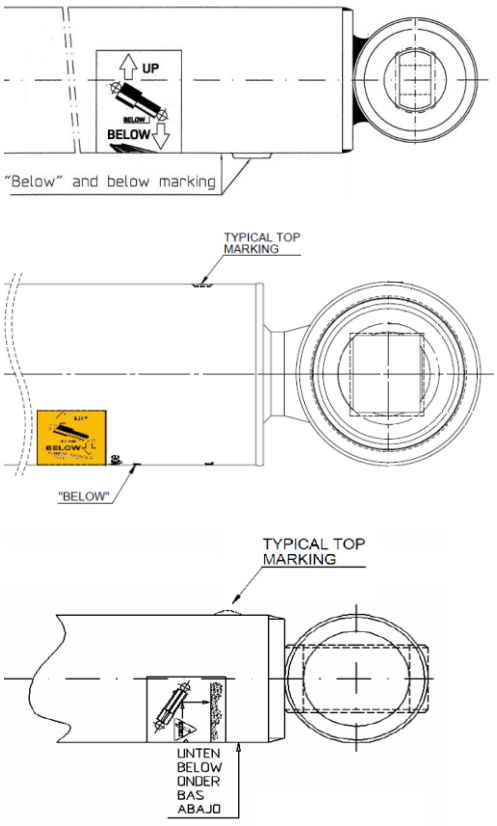


Figure 4-3; Different orientation markings

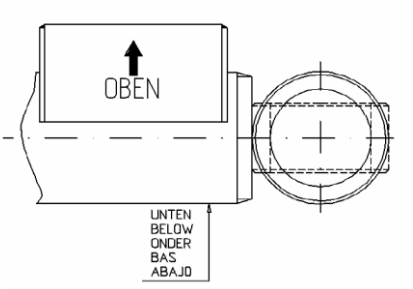


Figure 4-4; With dome

Furthermore the dampers must be mounted under a positive angle of 1° with the dust cover at the highest position (Figure 4-5).

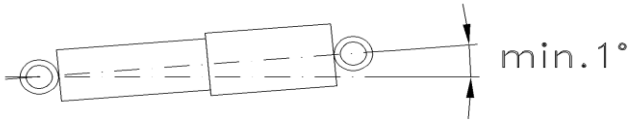


Figure 4-5; Mounting position

Pin Attachment
The pin attachment must be tightened to the right mounting torque. The correct mounting torque is specified on the damper drawing (OFF drawing).

Lateral dampers with a pin attachment are quite often provided with extra pins on the centring seat (chassis) to prevent the possibility of rotating of the damper

Silentbloc
The silentblocs must be bolted to the bracket and tightened with the right mounting torque. They must be mounted without any angular pre-tension as this could have a negative influence on the service life of these blocks.

In order to avoid shearing forces in the mounting bolt, KONI advises to mount the bolt in longitudinal direction of the damper forces (Figure 4-6).

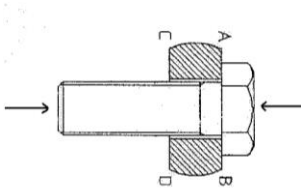


Figure 4-6; Mounting Advice

5 Operation

5.1 Planned inspection and overhaul/replacement schedule

KONI advises the periodical inspection and replacement of the dampers in accordance with Figure 5-1. These values are however indications and can vary by application and contractual agreement.

Frequency	Maintenance action	Chapter
Monthly	Visual inspection of the dampers	5.2
1.200.000 km Or 6 years in service	Overhaul or replacement of the dampers	6

Figure 5-1; Maintenance schedule

5.2 Visual inspection

5.2.1 General

The dampers are exposed to dirt and oil from outside sources due to the operating environment. Road dirt accumulation covering the entire outer surface of the damper is normal and will have no adverse effects on the damper's performance.

5.2.2 Inspection for oil leakage

Inspection on new dampers

Sometimes new KONI railway dampers can appear to show a little oil loss during the first service period and as a result are suspected of leakage. In almost all cases this is assembly lube which has nothing to do with oil leakage.

Assembly lubricants (greases) are yellow or black in colour, and can easily be distinguished from the red hydraulic damping fluid. When the damper is new, the assembly lube may cause a slightly moist piston rod or damper body. If this occurs, simply wipe off the excess oil and return the damper to service. If a new damper has red oil droplets, the damper should not be installed but returned under warranty.

Figure 5-2; KONI damper oil Fluid-A

For a long service life, it is necessary for the rod oil seal to remain lubricated. The continuous inward and outward movement of the piston rod may cause oil “sweat” from the rod oil seal. This loss of oil can be recognized by the outside of the damper being slightly moist and dirty. However, there should not be any droplets of oil clinging to the damper. A slight oil sweating will not affect the damping force and such a damper may remain in service.

Even in the case of a real leakage, the damping forces will not be reduced abruptly, but very slowly, pending on the amount of oil that is left in the damper. However, when red droplets of oil are clearly formed on the damper body, it is advised to remove the damper from the train and replace it.

5.2.3 Roadmap for oil leakage

The following steps can be helpful to identify a real leakage problem of a suspicious damper.

1 *Exclude an external source of oil (or another fluid)*
The external source could be wheel lubrication systems, gear boxes, hydraulic brakes during servicing or when being maintained, detergents, etc.

a) Check the upper damper tube (also "dust cover")
If the upper part of the damper (with larger diameter) is polluted on its outside with fluid, it could not come from the damper itself.

b) Compare with corresponding dampers of other bogies / wheelsets

It is also an indication for external sources, when there are significant differences between comparable dampers of bogies or wheelsets (e.g. no wheel lubrication at the second axle).

When no external source can be seen, please follow the next steps.

2 Clean the damper housing

The surface of the damper has to be freed completely from all dirt/moisture. For this action the damper should be dismounted from the bogie, pulled to its max. length and then cleaned. After cleaning, the damper should be mounted to the bogie again.

As an alternative action the oiled area can be marked at its lower edge on the lower damper tube, for instance with a felt pen. When the damper is then installed again and inspected after a certain period, it will be possible to see if the oiled area has been extended.

3 Operate the train with cleaned damper

4 *Check the cleaned damper*
Please check the damper after a period, which can last from a week up to the next maintenance period in the workshop. If the surface of the lower damper tube is now oiled and really wet over a wide range, or when even oil drops are visible (or the marked area is considerably extended) it is an indication for a leakage problem of the damper and the damper should be returned.

In addition to the above, the following criteria can also be used during the visual inspection of the dampers:

Visual appearance	Action	Picture
<u>Dirt</u> Normal contamination caused by the operating environment of the dampers is harmless. If a damper has a damp film over the whole body (including the dust cover), it is very probable that this is the result of an outside source of oil or dirt. In this case the damper can remain in service.	None	 *Figure 5-3; Dirt*

Visual appearance	Action	Picture
<u>Sweating</u> For a long service life, it is necessary for the rod oil seal to remain lubricated. The continuous inward and outward movement of the piston rod may cause oil “sweat” from the rod oil seal. This loss of oil can be recognized by the outside of the damper being slightly moist and dirty.However, there should not be any droplets of oil clinging to the damper. A slight oil sweating will not affect the damping force and this damper may remain in service.	None	 *Figure 5-4; Sweating*

Visual appearance	Action	Picture
<u>Oil drops</u> An oil leakage becomes apparent by a damp surface, which usually covers a large part of the reservoir tube. Isolated oil drop formation is possible. When wiping the damper with a paper cloth, clear oil stains are visible.	Replacement / Overhaul	 *Figure 5-5; Leakage*

5.2.4 Attachments

It is important to visually check the condition of all rubber attachments. Worn or deteriorated rubber parts may adversely affect the damper's performance and cause internal damage to the damper.

While inspecting the bushings, it is advised to examine the welds between the eye and the damper body. The welds should show no evidence of cracking or deterioration.

5.2.4.1 Pin attachments

The pin attachments do not have to be removed in the following cases

Small damages to the surface of the rubber are not affecting the service life.

The pin attachment should be removed in the following cases

Pin rubbers should be replaced when the rubber develops a cut or a split. Furthermore the centring seats should be free of any damage.

5.2.4.2 Rubber bushings

The rubber bushings do not have to be removed in the following cases

Small damages to the surface of the rubber are not affecting the service life.

The rubber bushing should be removed in the following cases

Rubber bushings should be replaced when the rubber develops a cut or a split. Special attention should be paid to the position of the bushings. They should never be further from the centre of the eye than a maximum of 5 mm (Figure 5-1).

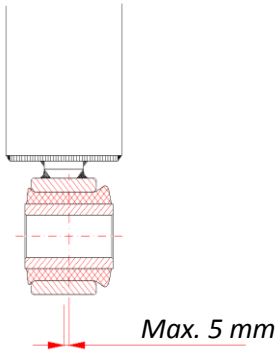


Figure 5-1; Bushing position

5.2.4.3 Silentblocs

The silentblocs do not have to be removed in the following cases

During service of the damper the rubber attachments are subject to wear. The wear is normal and if the rubber part has only developed small cracks on the surface, no action is required. The function of the silentbloc is secured mainly by the internal bonding of the rubber to the metal part. Small damages to the surface of the rubber are not affecting the service life. Please refer to below pictures.

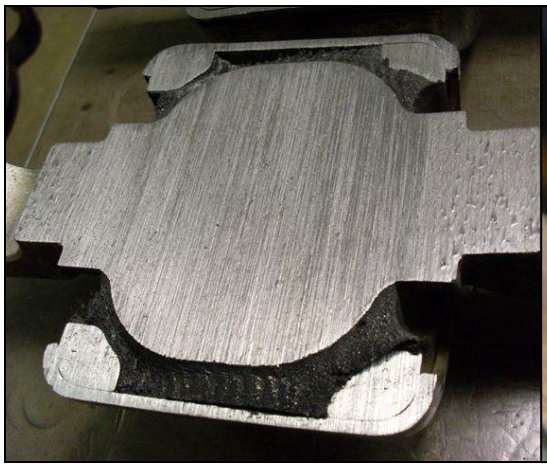


Figure 5-2; Bonding of the internal rubber

Figure 5-3; Acceptable surface cracks

The silentbloc should be removed in the following cases

Silentblocs should be replaced when the rubber develops a cut or a split. If the silent bloc has only developed small cracks on the surface of the rubber, no action is necessary.

If the rubber is deteriorated or the pin is loose in the rubber, the damper must be removed and the silentbloc replaced.

Figure 5-4; Examples of worn bushings

Guideline for replacement of silentblocs

Phenomenon	***Criteria***		***Action***
Cracks in rubber	Depth of crack	Max. 8mm	Replace attachment
	Surface cracks	Only a visual issue	No action required
De-bonding of metal and rubber	De-bonding	Max 10% of the total rubber	Replace attachment
Rubber deterioration	Pulverized rubber	Max. 10% of the total rubber	Replace attachment
Creeping of rubber	Loose collar	Only a cosmetic issue	No action required

5.3 Replacement of attachments

5.3.1 Pin attachment

In case of pin attachments the rubbers or centring seats can simply be replaced without the requirement of special tools, see Figure 5-5.

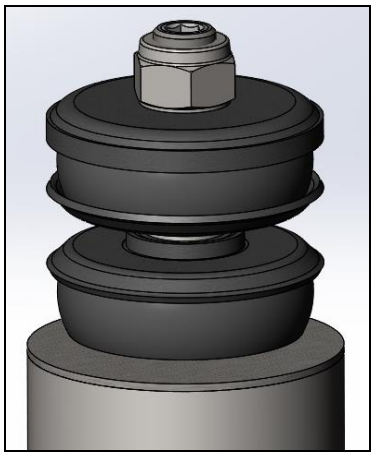


Figure 5-5; Pin attachment

5.3.2 Rubber bushing

5.3.2.1 Rubber block with a separate bush or trunnion

1. Remove the old rubber with bush or trunnion and clean the eye.
2. Immerse the new rubber in hot soapy water of about 60°C.
3. Place the eye on a suitable tool (Figure 5-6/1).
4. Place the rubber over the eye and press it in. If necessary, a plastic or wooden hammer can be used. The rubber must be pressed in so far that the collar of the rubber projects above the bottom side of the eye (Figure 5-6/2).
5. Rotate the damper 180° around the longitudinal axis and place the eye back on the tool (Figure 5-6/3).
6. Heat the assembly cone and the bush or trunnion to be mounted to about 60°C. Place the assembly cone in the rubber and the bush on the cone (Figure 5-6/4) or place the trunnion in the rubber and the assembly cone on the trunnion (Figure 5-6/5).
7. Press the bush or trunnion into the rubber as quickly as possible.
8. When the rubber has been pressed through the eye too far, the damper must be rotated to press it back in the centre.

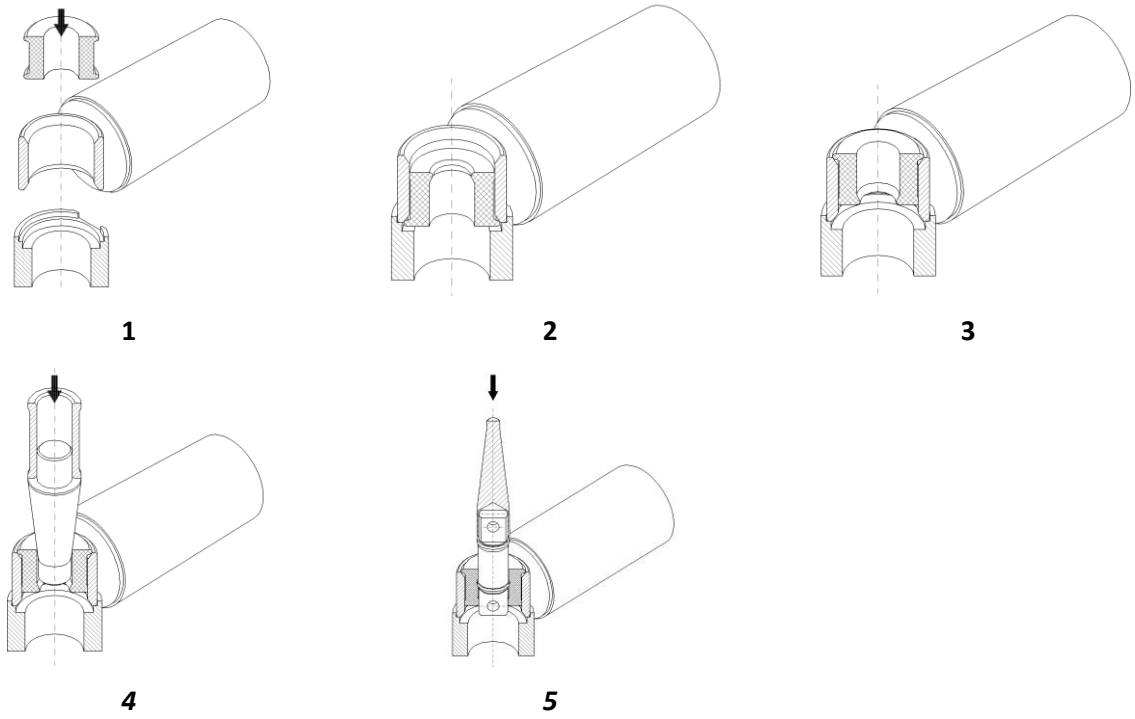
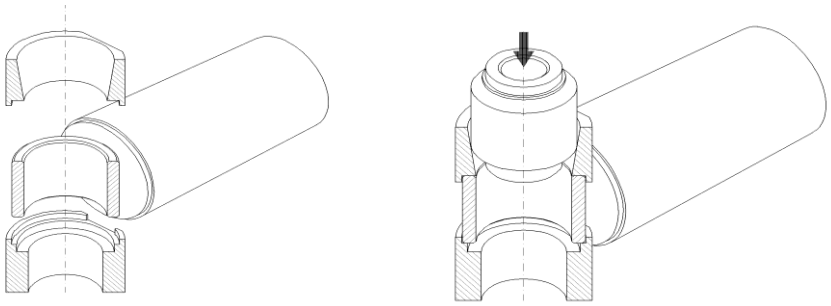


Figure 5-6 Replacement of rubber blocks

5.3.2.2 Rubber bloc with a vulcanized bush or trunnion

1. Remove the old rubber bloc and clean and degrease the eye and the rubber bloc.
2. Place the damper eye on a suitable tool (Figure 5-7/1).
3. Apply locking agent Loctite 601 to the inside of the eye and the outside of the rubber bloc.
4. Place the guiding tool on the eye (Figure 5-7/1)
5. Place the rubber bloc into the guiding tool (Figure 5-7/2)
6. Press the rubber bloc into the eye and press it in about 5 mm too far.
7. Rotate the damper 180° around its longitudinal axis and press the rubber bloc back into the middle.

Make sure you always press on the metal part of the bush.



1 ***2***

Figure 5-7 Replacement of vulcanized rubber blocks

5.3.3 Silentblocs

In case of a worn silentbloc, the complete part has to be removed from the damper eye. Since these attachments are locked in the eye by means of a press fitting and/or Loctite, they can only be removed or assembled by means of a tool set and a press (Figure 5-8, Figure 5-9).

Figure 5-8; Pressing adapter set

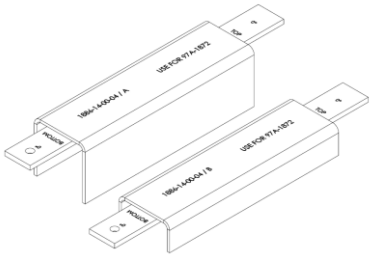


Figure 5-9; Auxiliary tooling set

Silentbloc removal

1. Place the eye of the damper on the big support tool.
2. Now place the smaller tool with the smaller diameter down, on the metal part of the silentbloc, and apply pressure. (Figure 5-10/1)

Be careful only to apply pressure on the metal part of the silentbloc, and not on the eye of the damper.

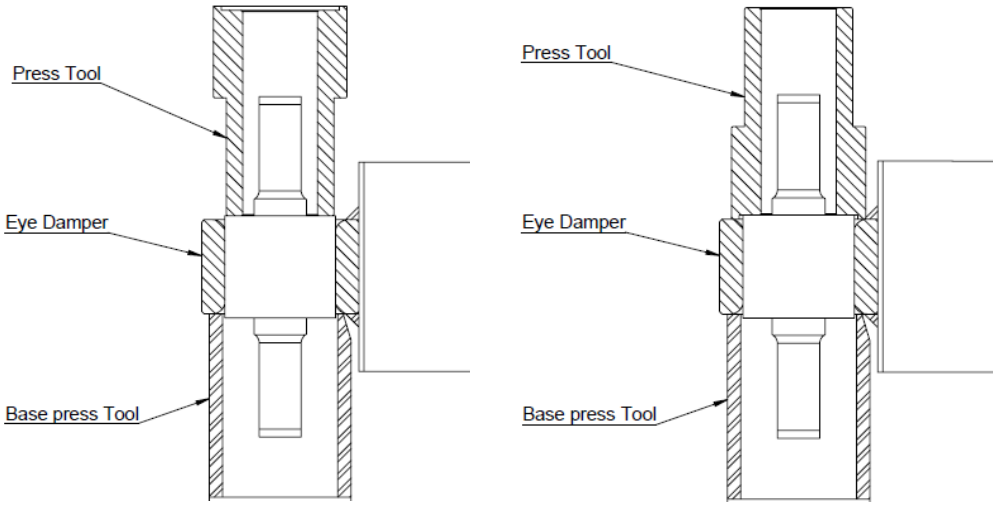
3. The block will now be pressed out of the eye.

Silentbloc assembly

1. Place the eye of the damper on the big support tool.
2. Apply Loctite 601 to the attachment and the eye.
3. Place the silentbloc onto the eye, and use the high version of the auxiliary tooling to verify the orientation of the silentbloc, according to the damper drawing. (Figure 5-11)
4. Now place the smaller tool with the bigger diameter down, on the metal part of the silentbloc, and apply pressure. (Figure 5-10/2)

Be careful only to put pressure on the metal part of the silentbloc.

5. The silentbloc will now be pressed into the eye.
6. Use the low auxiliary tool to check the angle after pressing it in. (Figure 5-12)



1 - Pressing out silentbloc

2 - Pressing in the silentbloc

Figure 5-10; Replacement of silentblocs

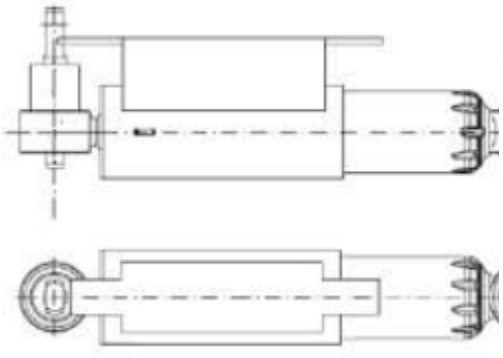


Figure 5-11: Auxiliary tool "High"

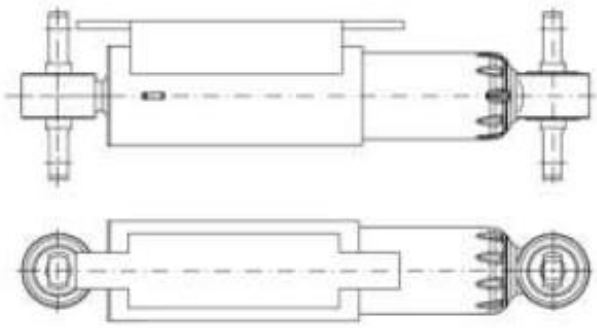


Figure 5-12: Auxiliary tool "Low"

6 Overhaul and Repair

6.1 Repair and service instructions

Please check the applicable spare parts list and cross sectional drawing for details. KONI advises to test the damper prior to overhaul, as this will give an indication of its condition.

6.2 Cleaning of components

- The cleaning of the components must be carried out very thoroughly by means of rinsing. Never clean components with cloth as this will always leave fibres on the surface. The tanks used for the rinsing must be big enough for the entire tubes to be submerged.
- Take extra care with the cleaning of the guide and piston assembly. Do not mix the valves and washers.
- All components with internal angles and orifices must be blow-cleaned with compressed air.
- Cleaned, grease-free components are susceptible to corrosion. For this reason all components that are not immediately mounted in a damper must be protected against corrosion with (preservative) oil, after which the components must be stored well away from dust and dirt.
- Check if the components are magnetic. If so, they must be de-magnetised.
- Before stored components can be used, they must first be rinsed clean again to remove the protective layer of oil and the dust contained in that layer.

6.3 Disassembly of the damper

6.3.1 General

This is a general description; please refer to the damper specific spare parts list including the cross-sectional drawing for the exact damper configuration.

For further inspection of the damper the dust cover (19) must be removed first.

6.3.2 Slide-on dust cover

Dampers with a pin attachment often have a slide-on dust cover. Firstly loosen the nut with a wrench. Then remove the attachment rubbers and the centring bush. Now the dust cover can be taken off the piston *(Figure 6-1).*

6.3.3 Screw-on dust cover

The dust cover has been screwed onto a cover welded onto the piston rod *(Figure 6-2).* Before disassembly break the locking agent by tapping the circumference of the dust cover at the thread. Then unscrew the dust cover with the help of a strap wrench.

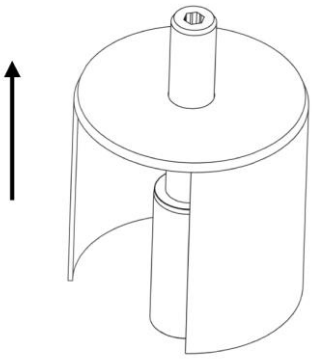


Figure 6-1; Slide-on dust cover

Figure 6-2; Screw-on dust cover

6.3.4 Bolted dust cover

The dust cover has been bolted to the cover using four small bolts *(Figure 6-3)*. The cover is fitted with four threaded holes. The bolts and the spring washers must be removed. Sometimes the dust cover can be pushed over the attachment (if necessary, turn the dust cover 90°). In most cases however, the attachment must be pressed out of the eye, prior to removal of the dust cover.

6.3.5 Flanged dust cover

The dust cover is fitted with a flange on the outside: this flange is attached to the cover by means of four small bolts and nuts *(Figure 6-4)*. This version is used for dampers with large fixing eyes where the dust cover cannot be moved over the fixing eye. In this case the dust cover must, after removal of the bolts, be pushed over the reservoir tube as far as possible.

The dust cover may have a cut-out at the bottom. If so, special attention must be paid to the position of the dust cover during assembly. The cut-out must be positioned on the side of the dome on the reservoir.

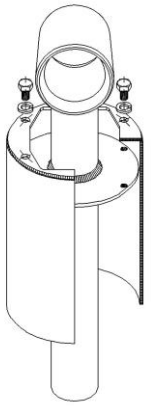


Figure 6-3; Bolted Dust Cover

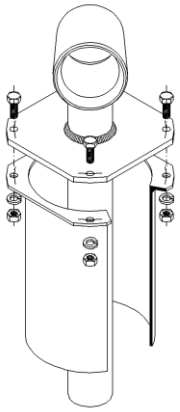


Figure 6-4; Flanged Dust Cover

6.3.6 Inspection of the bellows

The bellow *(74)* protects the piston rod against dirt. If the bellow is torn, the piston rod will wear sooner resulting in oil leakage and loss of damping forces. All damaged bellows must be replaced.

In case of a pin damper with slide-on dust cover the bellow can easily be pushed off the rod; in all cases where the cover has been welded onto the piston rod, the damper must be disassembled for bellow removal.

6.3.7 Disassembly of the complete guide section

If the damper is suspected of leakage, KONI advises to check if the rod oil seal nut *(27)* is tight. A loose rod oil seal nut can be a cause of oil leakage.

To remove the guide *(122)* KONI advises to loosen the rod oil seal nut *(27)* by half a turn. Then extent the damper to its maximum length. If this is very difficult, one of the valves in the guide can be loosened a few turns.

Both the rod oil seal nut and the guide must be loosened with either a special wrench (available from KONI), or dedicated machine. *Please refer to section 6.8*.

Important

The loosening of the guide requires a big torque. For this reason the damper must be properly clamped in a vice. In order to make the loosening easier the used wrench may be equipped with an extension pipe.

The damper can be clamped at the eye (bottom side), at the dome (if available) or with the help of special tools which fit around the reservoir tube *(*Figure 6-5*)*.

The reservoir tube must not be clamped without proper support as otherwise the reservoir tube might be deformed.

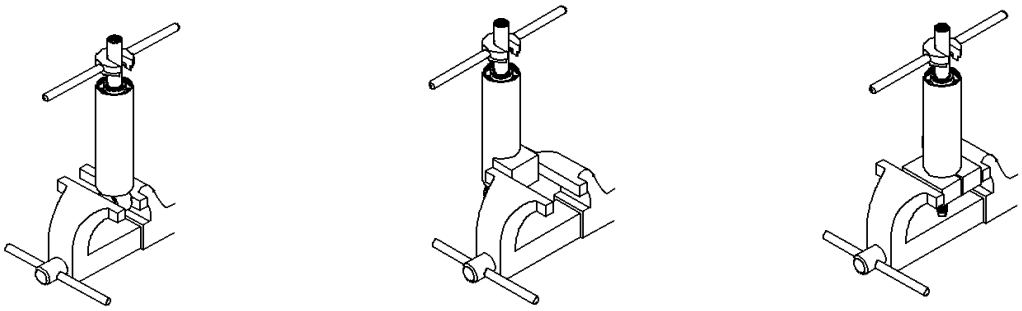


Figure 6-5; Various ways to clamp the damper

Once the guide has been loosened, it can be pulled out of the damper together with the piston rod and the piston (**Error! Reference source not found.**).

Usually the cylinder tube stays behind in the damper. When the cylinder tube is pulled out as well, take care that it does not fall back into the damper: that may damage the sealing rim of the tube.

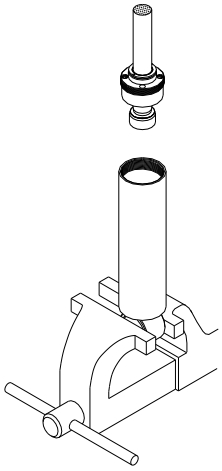


Figure 6-6; Removal of the guide

6.3.8 Disassembly of the other components

Pour the oil out of the damper (Figure 6-7), retaining the cylinder tube and any other components with one hand.

The colour and fragrance of the oil, as well as the state of the oil (including possible deposits inside the oil) are clear indications of the state of the damper.

Depending on the application and execution of the damper the following components should be retained.

- Cylinder tube
- Oil return assembly (Oil chamber, overflow receptacle, suction tube)
- Bottom valve assembly
- Washers

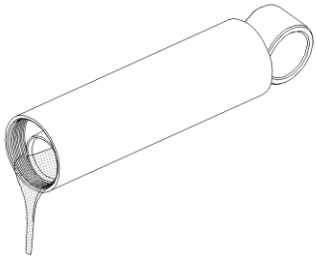
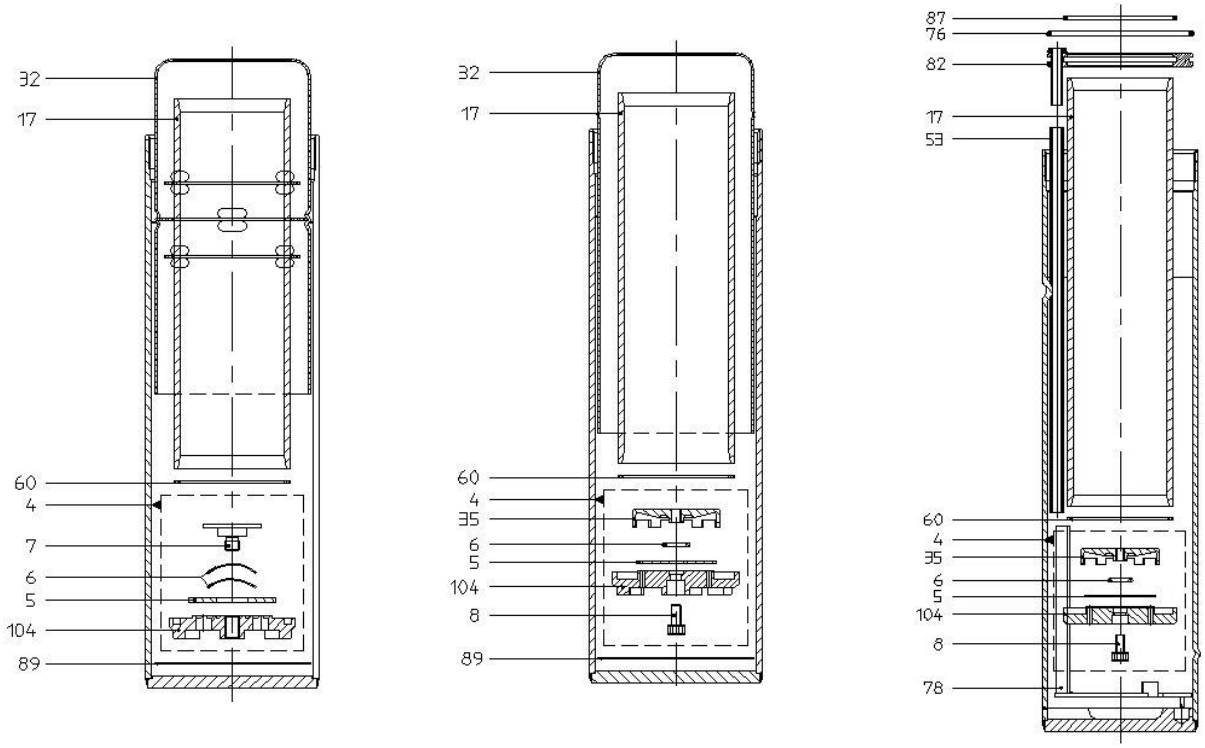


Figure 6-7; Oil removal

For the exact configuration and parts please refer to the damper specific parts list



Primary damper *Vertical damper* *Lateral/Yaw damper*

Figure 6-8; Various damper configurations

6.3.9 Disassembly of the copper gasket ring

The bottom valve assembly *(4)* is provided with a copper gasket ring *(60)*. The disassembly of the copper gasket ring can be carried out with help of a sharp knife. The knife should be brought under the ring whereupon the ring can be cut through.

The cutting action should be carried out with great care without damaging the bottom valve housing.

Please use hand gloves to protect your hands during these operations.

The copper gasket ring should always be replaced by a new one after opening the damper.

6.3.10 Bottom and reservoir tube

The reservoir tube (2) of the damper consists of a welded assembly of reservoir tube, bottom and fixing eye.

After disassembly of the damper, the reservoir must be carefully cleaned on the inside. The thread must be checked for damages.

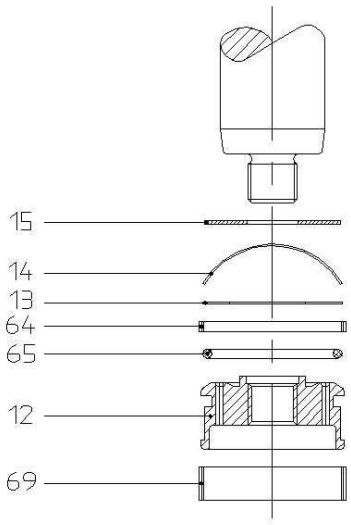
6.4 Disassembly and Inspection and of the internal damper parts

Carefully inspect all internal damper parts, such as:

- Piston
- Guide
- Piston rod
- Bottom valve assembly
- Cylinder tube

6.4.1 Piston section

Every piston section (Figure 6-9) consists of a piston screwed onto the piston rod, with a non-return valve and a spring. The non-return valve can allow the oil to flow with little resistance from the space below the piston to the space above the piston. During the outward movement of the piston rod the non-return valve is closed.



Parts List

12 Piston

13 Non return valve piston

14 Non return spring

15 Piston washer

64 Plastic ring for piston

65 O-ring piston

69 Plastic slide ring for piston

Figure 6-9; Piston Section

6.4.1.1 Inspection of the piston

The working surface and the closing function of the non-return valve must be checked. Wear of the working surface or a faulty non-return valve can be concluded from the test diagram. In that case the damper will generate less force outward than inward.

If the working surface shows clear evidence of wear, the piston must be replaced.

The closing function of the non-return valve can be checked by pouring a thin liquid into the orifices of the piston, holding the piston upside down. The liquid should not leak out.

6.4.1.2 Disassembly of the piston

All pistons have been screwed onto the piston rod and locked with Loctite. Disassembly can be carried out after heating the piston to about 150°C. This will largely neutralise the working of the locking agent.

Disassembly in case of piston replacement

In this case the piston rod can be clamped in a vice between soft clamping plates (over the longest possible length).

When the damper has two flat sides or a welded eye it is better to clamp the rod there.

Now the piston can be loosened with a pipe wrench (Figure 6-10).

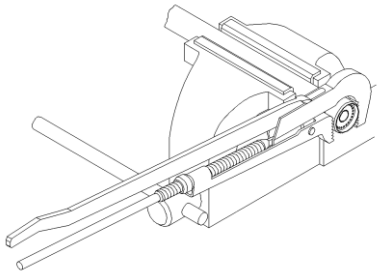


Figure 6-10; Disassembly

Disassembly in case of re-use of the piston

When the piston is re-used, the disassembly must always be carried out carefully.

Always use a properly fitting piston clamp

Please refer to section 6.8.

The torque required for loosening is high: you will need proper clamping force. For this reason place the piston clamp on the piston correctly, and apply sufficient clamping force (Figure 6-11). By doing this properly, the piston is prevented from 'slipping' in the clamp. Place the piston clamp in the vice. The piston can now be loosened with a bar or wrench.

If there is no eye welded onto the rod and if the rod has no flat sides, the rod itself can be clamped between soft clamping plates (over the longest possible length). In this case the piston clamp is clamped with a pipe wrench or with a bolt (depending on the version of the clamp), as indicated in Figure 6-10.

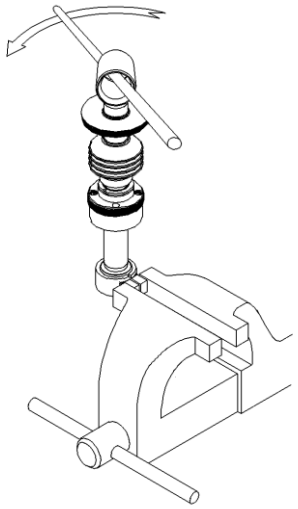


Figure 6-11; Clamping the piston

There will still be some Loctite clinging to the thread of the piston and/or piston rod. This must be removed, e.g. with a steel brush and compressed air. When this does not work you can use a thread cutting tool to remove the Loctite.

6.4.2 Non Return valves

The top of the piston is fitted with two ridges supporting the valve. In between these ridges there are orifices drilled in the piston (12). The valve (13) and the spring (14) centre on the piston (12).

If the non-return valve does not seal properly during the leakage test, this may point to dirt between valve and piston, a deformed non-return valve or a damaged ridge of the piston. Dirt must be removed carefully. A deformed or heavily indented non-return valve must be replaced.

The spring shall be checked on the lower side. When the contact faces are sharp the spring must be replaced.

When the ridge of the piston is slightly damaged, it can be repaired with help of a grinding/lapping compound (see 6.10.3), by lapping it on a flat surface. With larger damages, the piston has to be replaced. After lapping, test with the leakage test if the valve closes completely. When this is not the case, replace the piston.

After completion of work, the components must be carefully cleaned.

6.4.2.1 Low Noise version

In case of a low-noise version (Figure 6-12), the piston is fitted with a deviating non-return valve construction. In this case the non-return valve (13) also functions as spring.

The valve is pressed by a rubber O-ring (65) and is surrounded by a specially shaped cap (95). In this case the piston only is fitted with one (very low) ridge.

The causes of a leaking valve are the same as those described for the standard version. A damaged ridge must only be honed lightly with a grinding compound on a flat plate. The minimum height of the ridge is 0.05 mm. If the non-return valve continues to leak, the piston with the valve must be replaced.

Always replace the O-rings.

Parts List

12 Piston

13 Non return valve piston

64 Plastic ring for piston

65 O-ring piston

69 Plastic slide ring for piston

95 Piston cap

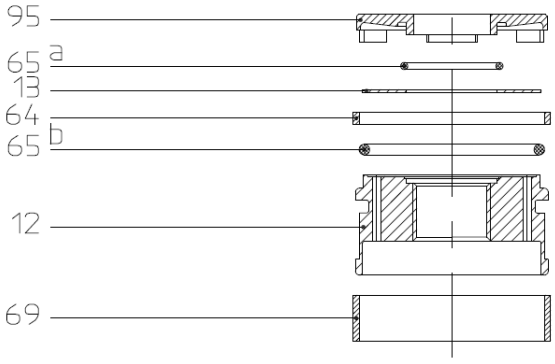


Figure 6-12; Low Noise piston

6.4.2.2 Air escape plate

For critical applications pistons may be fitted with an air escape plate (Figure 6-13). The purpose of this plate is to carry any air bubbles in the cylinder (between the piston and the bottom valve) to the space above the piston as quickly as possible.

The piston rod is fitted with a hole with internal thread. The air escape plate (159) is attached to the piston with a socket head screw (20).

Parts List

12 Piston

13 Non return valve

20 Bolt

64 Plastic ring for piston

65a O-ring piston

65b O-ring piston

69 Plastic slide ring for piston

95 Piston cap

159 Air escape plate piston

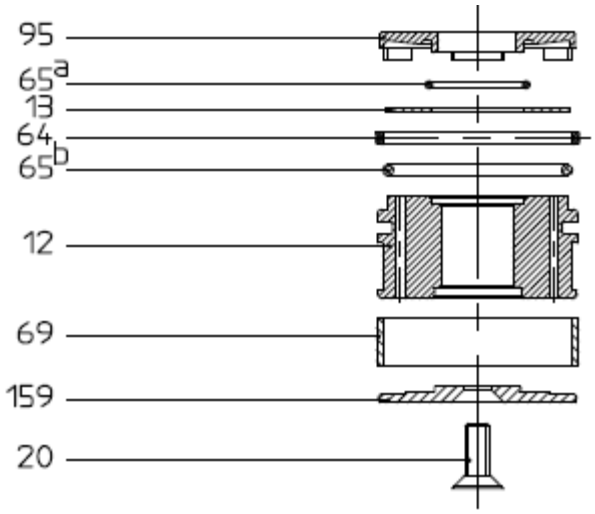


Figure 6-13; Piston with air escape plate

6.4.2.3 Working surfaces

As indicated above the piston is fitted with a plastic sealing ring *(64)* that is pre-tensioned by an O-ring *(65)* and a groove housing which holds a plastic slide ring *(69).*

When the damper is overhauled the plastic rings and O-ring must be replaced.

Disassembly

The rings can be removed by picking them out of the groove with a knife or a similar tool. During cutting please take care not to damage the piston and KONI advises to use hand gloves to protect your hands.

6.4.3 Guide section

The guide combines several functions; the guiding and sealing of the piston rod and the regulation of the damping force. The guide section also functions as the seal of the reservoir tube.

Please note that your actual guide can be slightly deviating from (Figure 6-14).

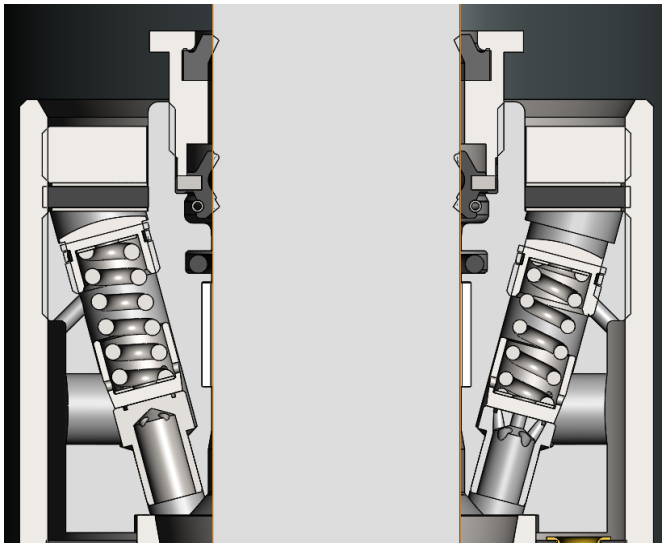


Figure 6-14; Cross-sectional of Guide

Parts List

27 Rod oil seal nut

31 Wiper ring

61 Plastic ring for guide

62 O-ring

63 Plastic slight ring for guide

122 Guide housing

126 Rod oil seal

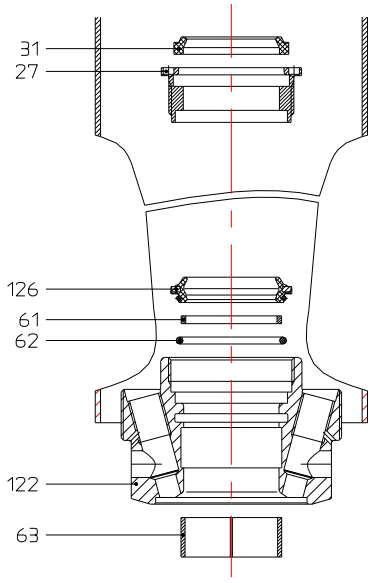


Figure 6-15; Guide Section Parts List

6.4.3.1 Disassembly of the guide section

In case of a pin attachment with a slide-on dust cover, the guide can be simply pushed off the piston rod. In all other cases the piston must be removed first. The removal of the guide must be carried out carefully to prevent damage to the running surface.

When the damper is overhauled all plastic rings, O-rings, seals and the wiper ring must be replaced.

6.4.3.2 Loosening the rod oil seal nut

Loosen the rod oil seal nut *(27)* and remove from the guide (122). The nut must be loosened with a special tool (available from KONI). *Please refer to section 6.8.*

6.4.3.3 Working surface

The working/running surface of the guide serves as the guide of the piston rod and for absorbing the lateral forces. The quality of the working surface largely determines the service life of the damper.

For this reason the guide is fitted with a plastic running surface in the form of a plastic slide ring *(63)*. This plastic slide ring prevents a metal to metal contact between the guide and the piston rod.

6.4.3.4 High pressure rod seal

The high-pressure seal (pressure within cylinder relative to pressure within reservoir tube) is located in the guide, just above the guide ring. This seal consists of a closed plastic ring (61), which contacts the piston rod under pre-tension: the pre-tension is provided by an O-ring (62) behind the seal.

Disassembly

The rings can be removed by picking them out of the groove with a knife or a similar tool. The knife should be brought under the ring whereupon the ring can be cut through. During cutting please take attention not to damage the guide and KONI advises to use hand gloves to protect your hands.

6.4.3.5 Low-pressure rod oil seal

The low-pressure seal (126) serves as a seal between the reservoir tube pressure and the outside air. This seal consists of a steel support with two plastic lips. The lower lip (A) is fitted with a steel spring washer (B) providing a static pre-tension on the seal. The upper lip (C) has a wiper function: dirt on the piston surface is wiped off the piston rod during the inward movement.

(Figure 6-16)

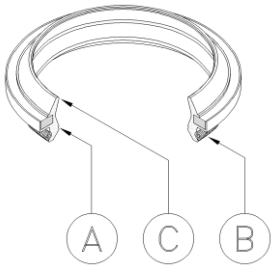


Figure 6-16; Lip seal

6.4.3.6 Wiper ring

The damper is fitted with a separate wiper ring (31) which wipes the dirt off the piston rod during the inward movement so that penetration of dirt into the guide and damage to the rod seal is prevented. The wiper ring is mounted in the rod oil seal nut (27). When the damper is overhauled, the wiper ring must be replaced. The wiper ring must be greased before mounting.

6.4.3.7 Damping valves

The guide contains a number of damping valves (Figure 6-17). These valves determine the characteristic of the damper. The components of the valves must be treated carefully during storage and assembly. The valve seat and the valve are manufactured and dimensioned with a high degree of precision. Scratches, dirt and corrosion must absolutely be avoided: they can affect the proper working of the damper to an important degree.

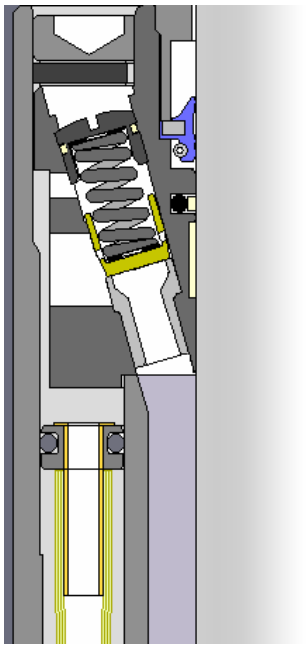


Figure 6-17; Damping Valves

The valves are numbered with an engraved number or number/letter combination on the guide. Each valve consists of a valve seat (38), valve (39), spring coil (40) and an adjusting screw (41). Furthermore a distance washer (45) is fitted on both sides of the spring.

When the valves are disassembled, do not exchange the components; the valve seats, valves and springs are mounted in a great number of versions and combinations.

Valve seats

The valve seats pressed into the guide have a very long service life. Yet, if a valve seat is dented, loose or otherwise damaged, it must be replaced.

The replacement of valve seats is a very critical operation. The position, press-in depth and locking of the valve seat must be exactly right. Any deviations may affect the working of the damper. KONI can carry out this work for you.

Valves and springs

The valves and springs are delivered in a great number of varieties. When disassembling the guide, the components must be kept together to avoid exchange. The valves or springs must be replaced if scratches or other signs of damage appear on the sealing surface.

6.4.3.8 Gasket reservoir tube seal

The reservoir tube of the damper is sealed off from the outside air by the guide. The oil tightness is provided by a rubber gasket reservoir tube seal (24).

6.4.4 Piston rod

6.4.4.1 Visual inspection

The working surface of the piston rod is hardened, chrome-plated and ground. Check the surface carefully for scratches and wear patterns. Damage may cause leakage and damper malfunction so a piston rod should be replaced if damaged.

6.4.4.2 Wear

The measured wear should be evaluated in combination with the number of running kilometres and the next maintenance period.

Perform the following actions in the described sequence to measure the wear.

1. For a proper function of the damper, the wear must not exceed a determined valve.

Measure the diameter in two places (S1 and S2) **around the circumference (!)**, as indicated in *(*Figure 6-18*)* with help of a suitable micrometre gauge. For the first point (S1), measure the working surface of the guide. Calculate the difference (D1-D2) of the diameters. The difference may not be higher than indicated in Table 6-1.

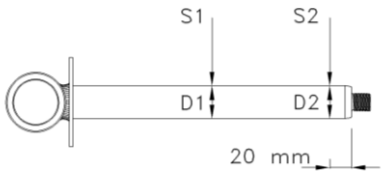


Figure 6-18; Wear measurement

Table 6-1

Type	*Measured wear on rod diameter*
Guide with plastic slide ring	When D1-D2 > 0,04 mm ; replace piston rod

2. The image of wear often shows that it has performed only at one side of the piston rod (Figure 6-19)

Measure the thickness of the chromium layer at position S1 and S2 around the circumference. The chromium layer at position S2 has the original layer thickness and should be used as reference. Determine the layer thickness, which has worn off during the last operating interval.

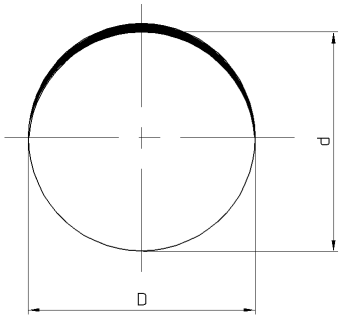


Figure 6-19; Typical wear pattern

The residual layer thickness at point S1 may not be less than the worn off chromium layer thickness (requested for the next maintenance interval.) With help of this measurement, experience over the maintenance interval can be gained.

The device, needed to measure the chromium layer thickness can be ordered through KONI.

3. The surface roughness may not exceed the value Ra = 0,1 micron. Areas with higher roughness values must be adequately repaired.

6.4.4.3 Deformation

Check the straightness of the piston rod *(*Figure 6-20*)*. Place the piston rod on two V-blocks, the distance between the blocks shall be 200 mm. Place a dial gauge in the middle between the V-blocks. Ensure sufficient stability. The maximum gauge deflection may not be higher than indicated in Table 6-2.

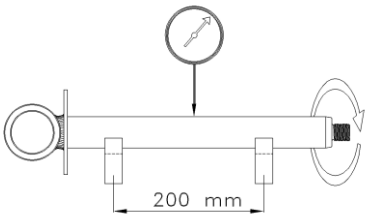


Figure 6-20 Straightness check

Table 6-2

Type	Maximum gauge deflection
Aluminum guide with Glacier bush	0,1 mm

6.4.5

6.4.6 Oil return

Special provisions have been made to guide the oil that flows from the valves to the reservoir tube.

6.4.6.1 Oil chamber

The 'oil chamber' (32) consists of a steel sleeve centered around the cylinder tube and clamped between the guide and the cylinder tube. A slot is formed between the oil chamber and the inside of the reservoir tube, through which the oil flows down in a controlled way.

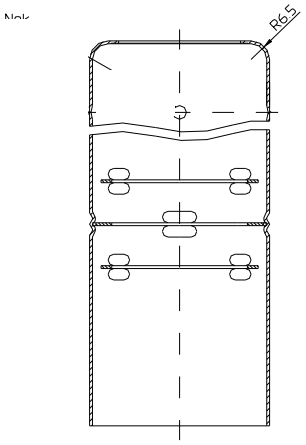


Figure 6-21; Oil chamber

Axle dampers are provided with an oil chamber which has small partitions to reduce the sloshing of the oil (Figure 6-21).

The oil chamber cannot be disassembled and needs no servicing. However, do check if the partitions are in place. Rattling partitions may cause noise and extra dirt.

Vertical dampers are provided with an oil chamber without these partitions

Older versions are provided with return tubes. In this case each outlet of the guide is fitted with a plastic return tube (53). These tubes have been screwed into the guide by means of a nipple (Figure 6-22).

The tubes must be replaced if damaged or hardened.

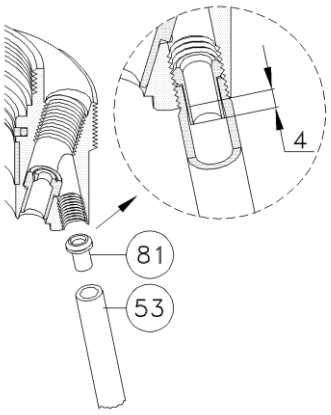


Figure 6-22; Fitting plastic return tubes (old type)

6.4.6.2 *Overflow receptacle*

The overflow receptacle (82) is applied in horizontal dampers. It is a device that collects the oil from the various valves and leads it to a particular outlet into the reservoir tube. The overflow receptacle consists of a steel ring as partition between the cylinder and reservoir tube below the guide. This ring is sealed against the wall of the cylinder and the wall of the reservoir tube with O-rings or a flat rubber plate. Nipples have been attached to the steel ring on which the nylon tubes have been mounted. When the damper is overhauled, it is recommended to replace the rubber components and nylon tubes.

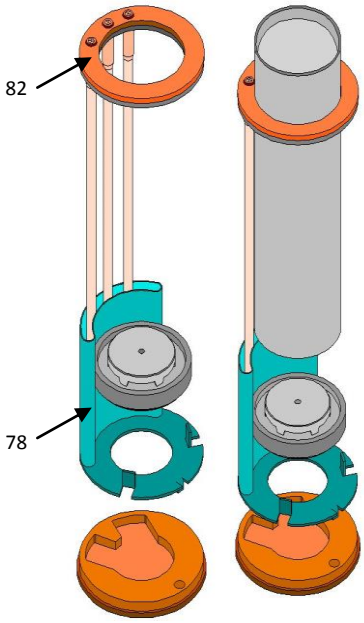


Figure 6-23; Overflow receptacle-suction tube assembly

6.4.6.3 *Suction tube*

The suction tube (78) collects the oil from the overflow receptacle and leads it to the bottom valve. In this way air is prevented from being drawn in.

It consists of a steel plate with a specially profiled tube mounted on it. The steel plate is clamped between the bottom valve and the bottom. The position of the plate relative to the bottom is fixed by means of a cam on the plate and a blind recess in the bottom: in this way the suction orifice is always on the bottom side. The suction tube cannot be disassembled and needs no servicing.

6.4.6.4 *Air escape plates*

The damper may be fitted with an air escape plate (158) between the guide and the cylinder tube. If there is an air bubble in the cylinder, this must be removed from the cylinder as quickly as possible. The air escape plate guides the oil along the inner diameter of the cylinder towards the valves. As the air collects at the top of the inner diameter, the flowing oil carries the air with it towards the reservoir tube.

A similar air escape plate can be applied on the piston, too. It is screwed against the bottom of the piston and works in a similar way.

If the damper is fitted with these air escape plates (please check parts list), it must not be fully extended or compressed to minimum length with force more than 500N! This would cause damage to the plates.

6.4.7 Bottom valve

The bottom valve closes the cylinder at the bottom. In the bottom valve the non-return valve is situated which allows the oil to flow from the reservoir to the cylinder during the outward movement.

A copper ring (60) has been mounted between the bottom valve and the cylinder tube, providing the seal between cylinder and bottom valve. This ring must always be replaced when the damper is assembled.

6.4.7.1 Disassembly of the bottom valve

When the damper is overhauled, it must be checked whether the non-return valve closes properly. This is done by placing the bottom valve upside down and pouring a thin liquid into the orifices. The liquid should not leak away. When the non-return valve does not close properly, the bottom valve must be disassembled.

6.4.7.2 Standard non return valve

The standard non-return valve is being used in axle dampers. This construction consists of a bottom valve housing with three ridges. Between these ridges there are orifices that connect the reservoir tube and the cylinder. The non-return valve (5) rests on the ridges and is pre-tensioned by 2 springs (6) and a valve stop (7) screwed into the bottom valve housing.

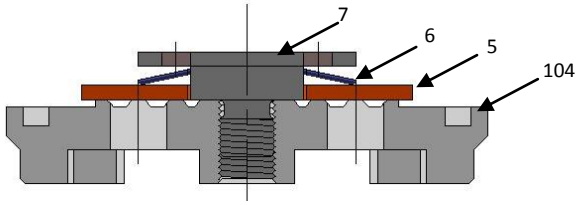


Figure 6-24; Cross-sectional bottom valve assembly for axle damper

Parts List

5 Non-return valve

6 Spring

7 Valve stop

104 Bottom valve housing

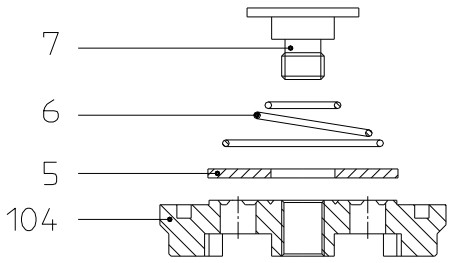


Figure 6-25; Bottom valve assembly Parts List

When the non-return valve does not close properly during the leak test, this may indicate dirt between the valve and bottom valve housing, a deformed non-return valve or a damaged ridge. Dirt must be removed carefully. A deformed or seriously indented non-return valve must be replaced.

If a ridge of the bottom valve housing is slightly damaged, the valve may be ground down on the ridges with grinding compound. In case of more serious damage the ridges can be turned

down on a lathe: however, the height of the ridges must be 0.5 mm at least. Test the closing function of the valve. If it is faulty, grind down the valve on the ridges.

After completion of the work, all components must be carefully cleaned.

6.4.7.3 Low-noise non-return valve

A low-noise bottom valve is being used in a vertical and horizontal damper.

In case of vertical dampers the bottom valve is fitted with suction grooves in the bottom valve itself. In case of horizontal dampers the bottom valve is flat and the suction groove is situated in the bottom of the damper.

The non-return valve (5) also functions as non-return spring. The valve is pressed in by a rubber O-ring (6) and surrounded by a specially shaped cover (35). The bottom valve housing is fitted with only one (very low) ridge in this case. The components are fitted with a socket bolt (8).

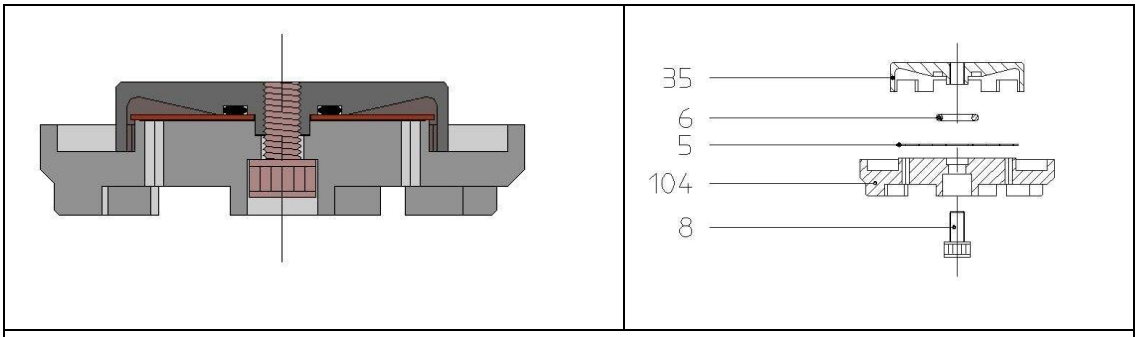


Figure 6-26; Bottom valve assembly for vertical damper

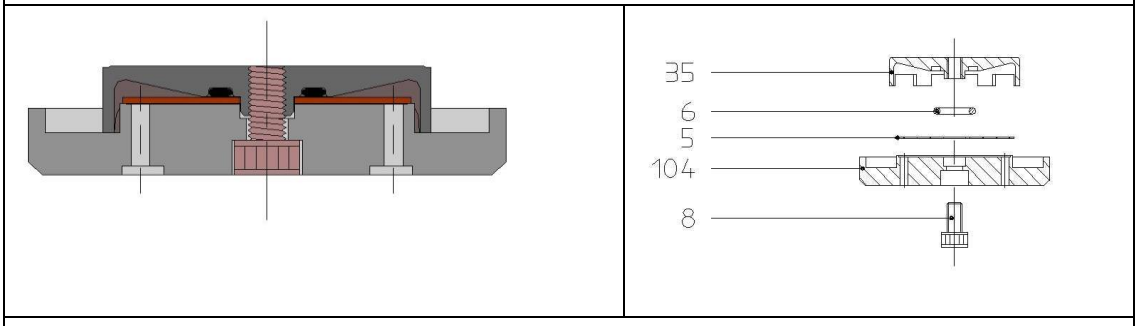


Figure 6-27; Bottom valve assembly for horizontal/yaw damper

Parts List

5 Non-return valve

6 O-ring

7 Valve stop

8 Set screw

35 Bottom valve cap

104 Bottom valve housing

Causes of a leaky valve are the same as described for the standard version.

A damaged ridge must only be ground lightly with grinding compound on a flat plate. The minimum height of the ridge is 0.05 mm. If the non-return valve continues to leak, the bottom valve housing with the valve must be replaced. Always replace the O-ring.

6.4.8 Bottom and reservoir tube

The reservoir of the damper consists of a welded assembly of reservoir tube, bottom and fixing eye. After disassembly of the damper the reservoir must be cleaned carefully on the inside. The thread must be checked for damage.

6.4.9 Cylinder tube

The cylinder should be clear from scratches and shall not show any damage on the end flats, as this will affect the sealing function.

6.5 Re-assembly of the damper

After disassembly all O-rings, seals, plastic bands, the wiper ring and the copper gasket ring must be replaced. In addition it is advised to replace all parts with signs of excessive wear.

Apply grease to all O-rings and other rubber seals before mounting.

Only original KONI spare parts shall be used during the overhaul.

During assembly various components must be greased or locked with prescribed torques or Loctite; *Please consult section 6.9 and 6.10.*

6.5.1 Assembly of the guide section

Before the guide is assembled, all components must be carefully cleaned. Pay special attention to the valves.

6.5.1.1 Damping valves

Reinstall the correct combinations of the valve seats (38), valves (39), spring coils (40), distance washers (45) and set screws (100) in the various damping valves (Figure 6-28).

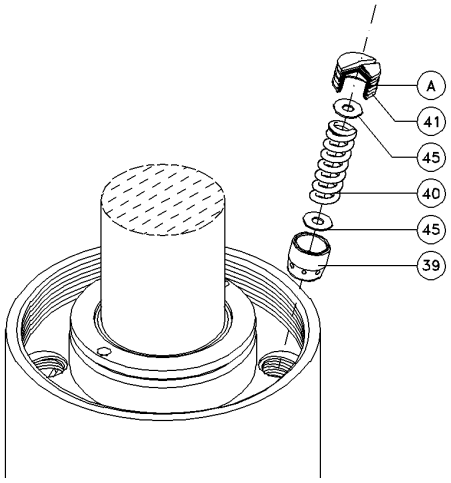


Figure 6-28; Damping valves

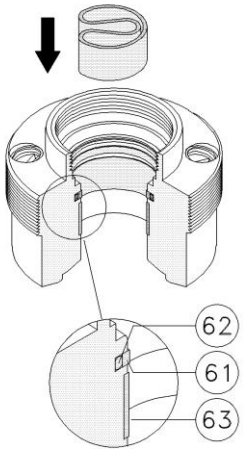


Figure 6-29; Mounting of plastic slide ring

6.5.1.2 High-pressure tube seal

First mount the O-ring (62) in the groove and assemble the sealing ring (61).

Repeat the above for the plastic slide ring (69).

Mounting of the slide rings is possible by first pressing them in as indicated in (Figure 6-29)

6.5.1.3 Low-pressure rod seal (rod oil seal)

Before mounting, grease must be applied to the rod oil seal (126). Then the rod oil seal (the spring washer at the bottom) is placed in the guide and tightened with the rod oil seal nut (27). In older types a separate distance washer (125) is being used. Nowadays the distance washer has been integrated in the rod oil seal nut (27) (Figure 6-30).

6.5.1.4 Wiper ring

The wiper ring is mounted in the rod oil seal nut (27). When the damper is overhauled, the wiper ring (31) must be replaced. The wiper ring must be greased before mounting. Always use a new wiper ring.

6.5.1.5 Rod oil seal nut

Tighten rod oil seal nut (27) at the prescribed torque with a special wrench. *Please consult section 6.9 and 6.10.*

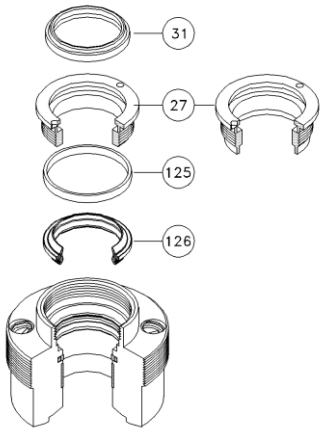


Figure 6-30; Mounting rod oil seal

6.5.1.6 Mounting the guide section on the piston rod

Before the piston rod section is mounted the guide section must be assembled first.

Carefully clean all components before mounting: they must be free of dirt, grease and remaining locking agent.

Clamp the piston rod vertically in a vice with the piston end facing up.

- Push the bellow (74) onto the piston rod
- Slide on Reservoir tube seal nut (25)
- Slide on Reservoir tube washer (86)
- Slide on Gasket reservoir tube seal (24)
- Slide on Reservoir tube washer (86)
- Now place the mounting sleeve (A) on the piston rod. *Please consult section 6.8 for the mounting sleeve*
- Apply grease to the inside of the piston rod seal
- Carefully push the guide section onto the rod and then remove the mounting sleeve (Figure 6-31).

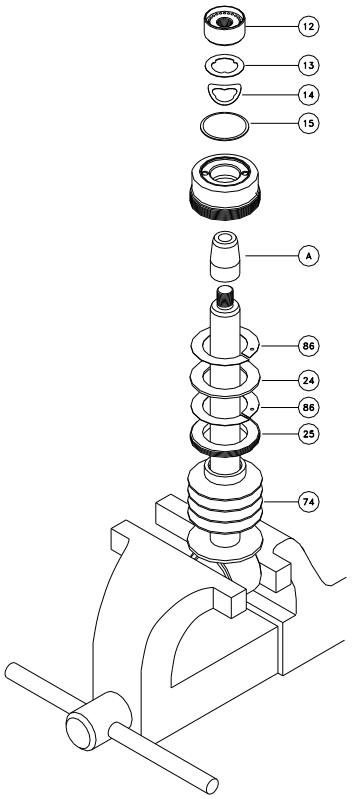


Figure 6-31; Mounting of the guide section

6.5.2 Assembly and mounting the piston section

Carefully clean all components before mounting: they must be free of dirt, grease and remaining locking agent.

Before assembly:

- Firstly place the piston washer (15), non-return spring (14) and the non-return valve on the piston.
- Apply some locking agent to the internal thread of the piston.
- Mount the piston on the piston rod. Ensure the non-return valve and non-return spring are not jammed between the piston and the piston rod.
- In case of a low-noise version, the O-ring must be carefully placed in the groove of the piston cover.

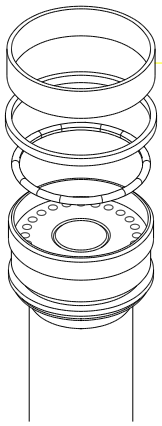


Figure 6-32; Assembly piston section

- Tighten the piston with a properly fitting piston clamp at the right tightening torque. Provide sufficient clamping force on the clamp so that the piston does not slip (refer to paragraph 6.8).
- In case of an air escape plate the piston rod is fitted with a hole with internal thread. The air escape plate (159) is attached to the piston with a socket head screw (20).

Check-up after mounting:

The non-return valve must be able to move freely. This can be checked by sticking a pen in one of the orifices of the piston and pressing the valve up (Figure 6-33). Never stick a screwdriver or a similar tool between the valve and the piston: this might damage the ridges.

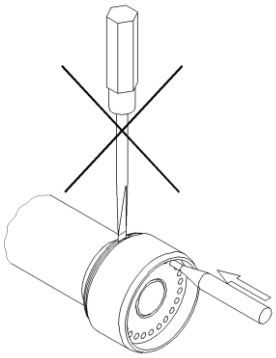


Figure 6-33; Check of the non-return valve

6.5.2.1 Working surface

For the assembly of the rings you require some special tools (Figure 6-34).

Please consult section 6.8.

- The mounting procedure is as follows:
- Mount the O-ring *(65)* in the groove.
- Place the assembly cone *(A)* on the piston.
- Place the sealing ring *(64)* on the cone.
- Push the sealing ring over the piston into the groove with the mounting tool *(B)*.
- Remove the assembly cone and the mounting tool.
- Push the calibration tool *(C)* over the piston: the sealing ring is now sized correctly.
- Repeat the above for the plastic slide ring *(69)*

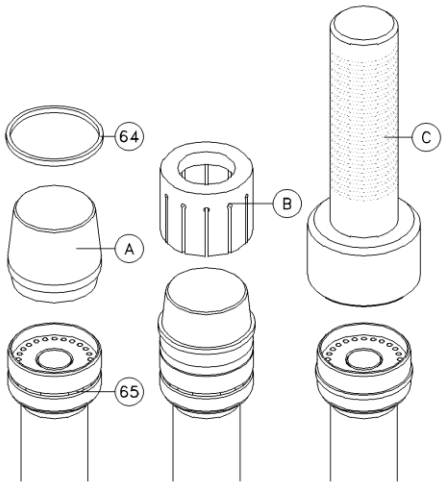


Figure 6-34; Mounting tools

6.5.3 Assembly of the bottom valve

Carefully clean all components before mounting: they must be free of dirt, grease and remaining locking agent.

- Mount the non-return valve (5) and the springs (6) and screw the valve stop (7) into the housing. In case of assembly always use a new valve and springs (Figure 6-35).
- In case of a low noise version the O-ring (6) must be mounted carefully in the groove of the bottom valve cap (35). In case of assembly always use a new valve and O-ring (
- Figure 6-36).
- See to it that the non-return valve and non-return springs are not jammed between the stop and the housing
- The valve stop (7) or the setscrew (8) must be locked with Loctite and tightened at the prescribed torque. *Please consult section 6.9 and 6.10.*
- Place a new copper ring (60) on the bottom valve

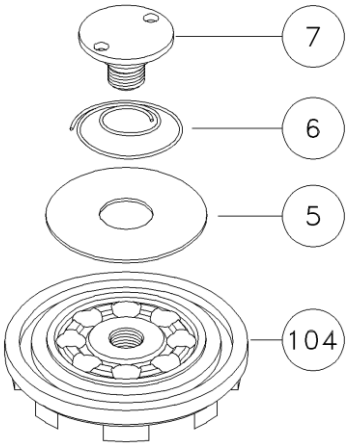


Figure 6-35; Standard bottom valve

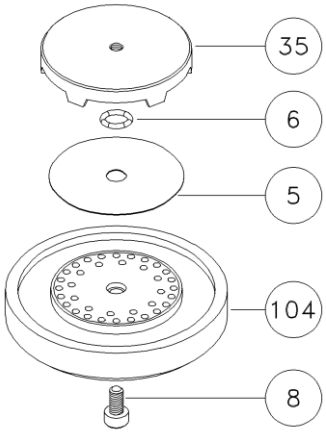


Figure 6-36; Low noise bottom valve

6.6 Final assembly of the damper

Before assembling the damper, all components must be carefully cleaned and blow-dried. This is a pre-condition to a properly working damper! Only use the specified KONI hydraulic oil.

6.6.1 General

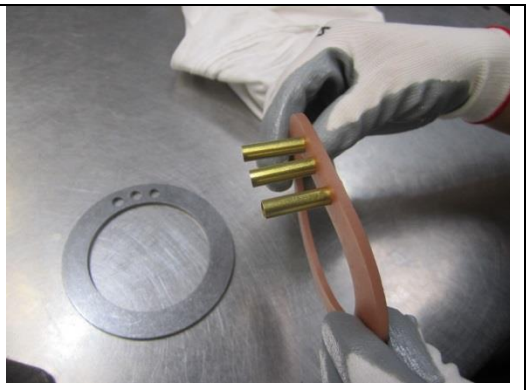
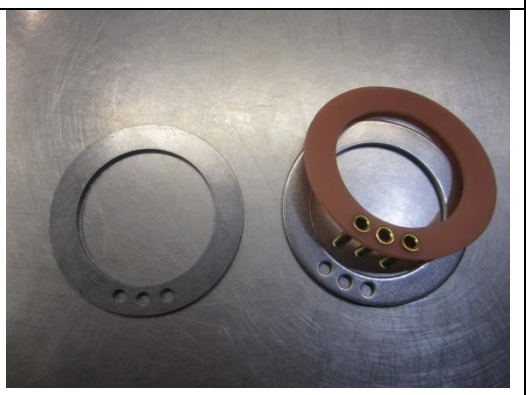
The final assembly of the damper can only be carried out once all components and subassemblies are ready. In the previous section the assembly was described of the guide section, the piston section, the bottom valve and the complete piston rod section.

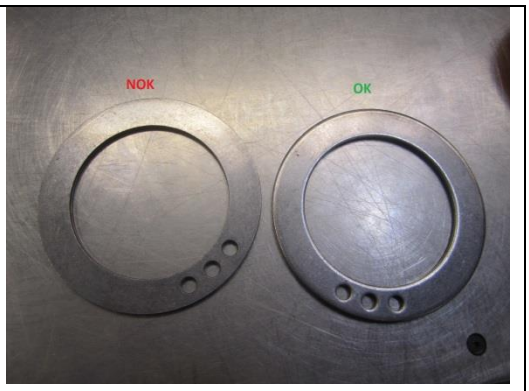
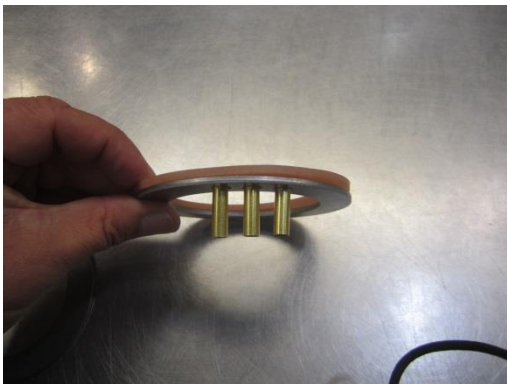
Before mounting apply grease to all O-rings and other rubber seals.

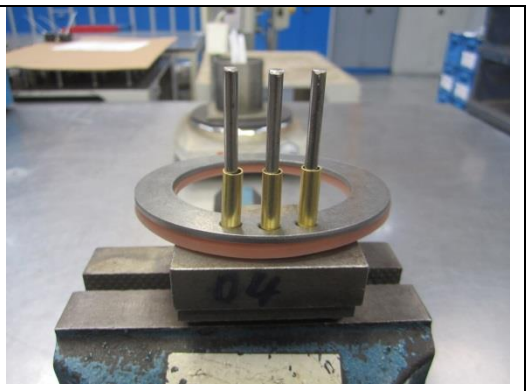
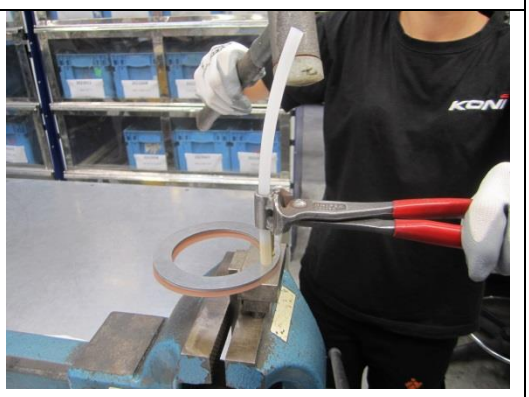
The assembly procedure is as follows.

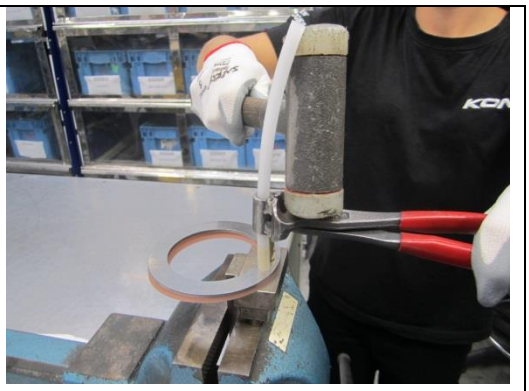
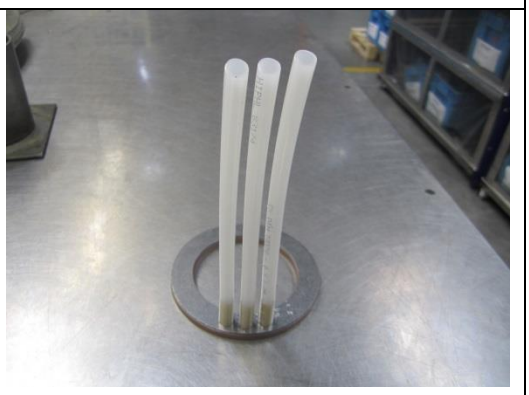
6.6.2 Assembly of return tubes

This paragraph is only applicable to horizontally mounted dampers.

1	Fit the three sleeves into the plastic ring	
2	Assemble the metal ring on the plastic ring. **Attention!!! Note correct orientation; (Radius side to the rubber gasket)**	

		 
3	Preheat the tubes in hot water by using the warming cup on an electrical heater	
4	Fix the return tube assembly tool in a vice	

5	Put overflow assembly on the return tube assembly tool	 
6	Hold the tube into the pliers jaw	
7	Fit a tube on the pin of the return tube tooling and use the hammer and pliers to lower the tube on the overflow assembly. Repeat this for all return tubes (3x)	

		  
8	Finished assembly	

6.6.3 Final assembly

Place the reservoir tube vertically in a vice in such a way that the tube is not deformed (Figure 6-37).

For Primary/Secondary Vertical dampers

Place distance washer (89) first.

Then the bottom valve-assembly (4) must be inserted by hand. It is not allowed to mount the bottom valve with the aid of a magnet, because then the bottom valve will be magnetised and will attract dirt particles. Check that the copper ring (60) is still in the correct position.

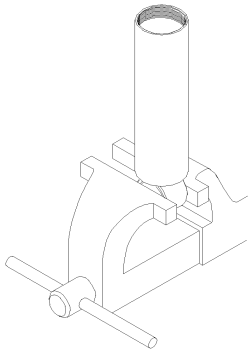


Figure 6-37; Proper clamping of damper in vice

Place the cylinder tube (17) on the bottom valve assembly. Check that the cylinder is centred to the reservoir tube and the bottom valve.

Fill a clean graduated beaker with the required amount of oil, as specified in the damper specific parts list. Only use the KONI oil as prescribed in the parts list. Prevent the oil from getting mixed with air when filling the beaker: do not 'splash' the oil in.

Pour the oil gently in the cylinder tube, completely filling the cylinder. The remaining oil will flow into the reservoir. Be careful not to ‘splash’ the oil. Pour the last bit of oil along the inner thread of the reservoir tube; this will make it easier to screw in the guide later.

Place the oil chamber (32) over the cylinder tube.

For Horizontal/Yaw Dampers

In case of a horizontal damper firstly mount the suction tube (78). Ensure the suction tube is positioned correctly. The suction orifice must be situated on the bottom side. For this reason the bottom plate of the suction tube is fitted with a bent lip. This should engage in a blind recess drilled in the bottom (Figure 6-38).

Then the bottom valve-assembly (4) must be inserted by hand. It is not allowed to mount the bottom valve with the aid of a magnet, because then the bottom valve will be magnetised and will attract dirt particles. Check that the copper ring (60) is still in the correct position.

Place the cylinder tube (17) on the bottom valve assembly. Check that the cylinder is centred to the reservoir tube and the bottom valve.

Place the overflow receptacle (82) (assembled in paragraph 6.6.2) in the damper.

Ensure that the tubes of the overflow receptacle reach into the suction tube (Figure 6-39). If necessary, stick steel pins into the tubes to make the positioning easier. Press the overflow receptacle against the stop in the reservoir tube.

Always use new rubber components (O-rings) and nylon tubes when installing the overflow receptacle.

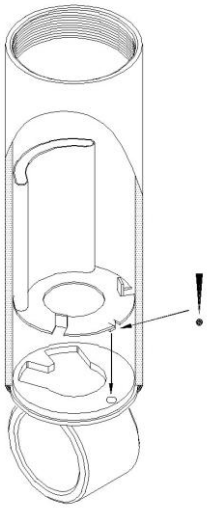


Figure 6-38; Placing the suction tube

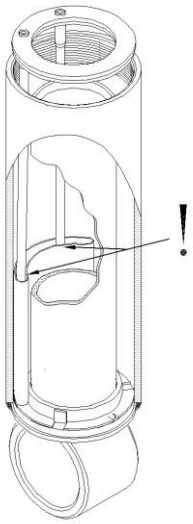


Figure 6-39; Placing the overflow receptacle

Fill a clean graduated beaker with the required amount of oil, as specified in the damper specific parts list. Only use the KONI oil as prescribed in the parts list. Prevent the oil from getting mixed with air when filling the beaker: do not 'splash' the oil in.

Pour the oil gently in the cylinder tube, completely filling the cylinder. The remaining oil will flow into the reservoir. Be careful not to ‘splash’ the oil. Pour the last bit of oil along the inner thread of the reservoir tube; this will make it easier to screw in the guide later.

For all damper applications

Push the guide over the piston rod against the piston section.

Carefully push the entire assembly into the reservoir tube, keeping the piston pressed against the guide. Lower the piston into the cylinder tube until the thread of the guide rests against the reservoir tube (Figure 6-40). Doing so, the guide must not be lifted because this also means lifting the cylinder tube: this might result in an incorrect position of the cylinder tube on the bottom valve. To avoid this, tighten the guide so the cylinder tube is secured, but do not torque at this stage.

Fully compress the piston rod once and then extend it completely (if necessary, slacken one of the valves), to align piston rod and cylinder.

Tighten the guide at the prescribed torque with a special wrench *Please refer to section 6.8 and 6.9.*

Important

The tightening of the guide requires a big torque. For this reason the damper must be properly fastened in a vice. In order to make the tightening easier the used wrench may be equipped with an extension pipe.

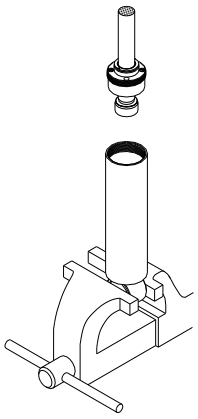


Figure 6-40; Mounting of the guide

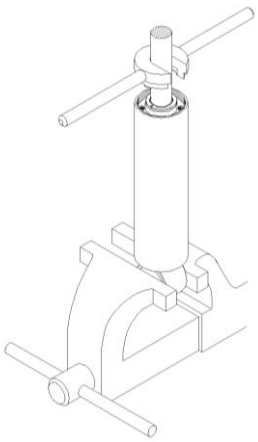


Figure 6-41; Tightening of the guide

During the tightening the piston must be checked regularly for the possibility of binding: do this by turning the piston rod. As soon as binding is detected loosen the guide and repeat the previous procedure.

If the damper cannot be assembled without binding, the components must be checked. A binding damper must never be used: this will result in accelerated wear.

Once the guide has been tightened, the copper ring (60) must be replaced when the damper is reopened again.

Now adjust the damper to the right forces according to the correct adjusting procedure. *Please refer to section 6.7.*

After adjustment the washer (86) must be mounted between the gasket reservoir tube seal (24) and the reservoir tube seal nut (25). At assembly special attention must be paid to the position of the washer. The cut part of the washer must not be placed above one of the holes for the valves (Figure 6-43).

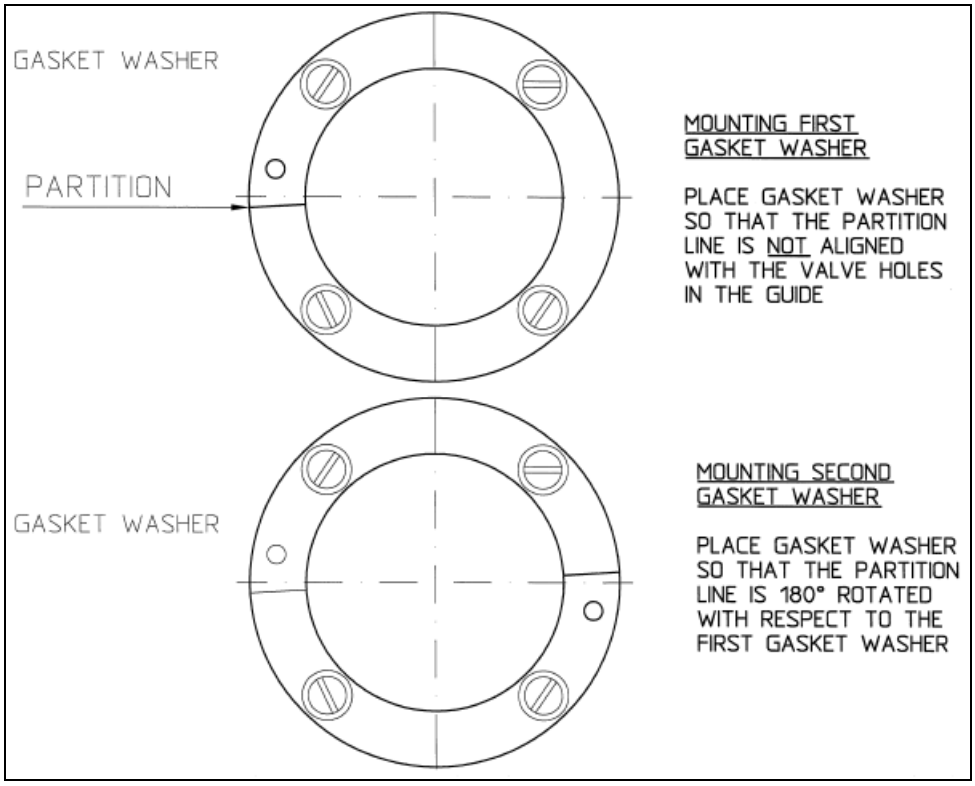


Figure 6-42; Installation of gasket washers

The easiest way to mount the gasket reservoir tube seal is to first place the outer edge in the tube (1). Then press in the inner edge (2) (Figure 6-44).

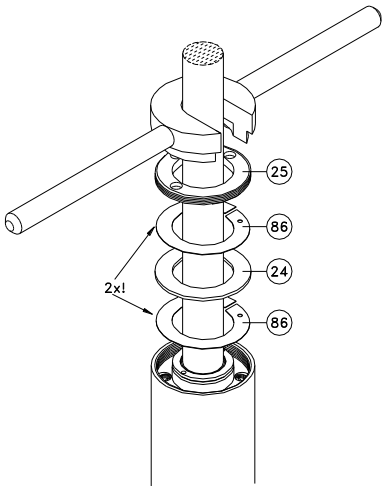


Figure 6-43; Mounting of the reservoir sealing

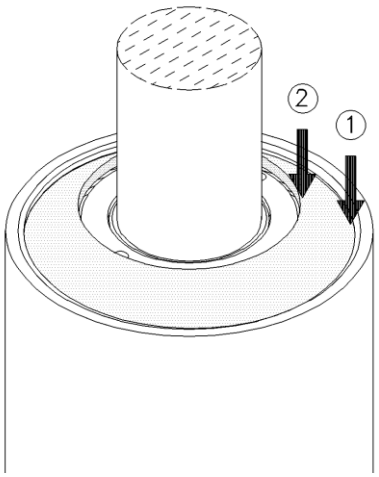


Figure 6-44; Mounting of the gasket

If a gasket reservoir tube seal must be replaced without dismantling the complete damper, a new seal can be cut through at an angle of 45°. When mounting the tube seal first press the gapped side into the tube (Figure 6-45).

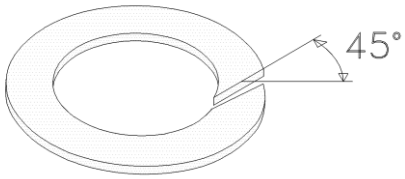


Figure 6-45; Tube seal

Now the reservoir tube seal nut (25) can be mounted at the right tightening torque.

Mount the dust bellow (74) over the rod oil seal nut (27).

Before mounting of the dust cover (19) first apply Loctite on the thread. The dust cover must then be tightened to the correct torque. A special tool (available through KONI) can be used to mount the dust cover at the correct torque. *Please refer to section 6.8 and 6.9.*

A loose dust cover with the centring bush can be mounted without any special tooling.

A new name plate and the attachments *(please refer to section 5)* can now be installed.

6.7 Re-adjustment of the shock damper

A proper adjustment is only possible if a calibrated test machine is used. This machine must be equipped with the proper auxiliary tools to mount the damper without clearance and without lateral load.

It is very important that the adjustment procedure is followed to the letter. Improper adjustment may damage both damper and test machine.

Before the damper is adjusted you must be certain it has been properly primed. This is already described in the previous sections.

6.7.1 Valve adjustment

The damping forces are regulated by the valves in the guide (Figure 6-46).

The adjustment of the valves must be carried out in the right order to achieve the required characteristic.

The damping force is determined by the pre-tension of valve (39) on the valve seat (pressed into the guide). The pre-tension is generated by coil spring (40) and adjusted by means of adjusting screw (41).

All adjusting screws are fitted with right-hand threading. Thus, for every valve a heavier setting is achieved by turning the adjusting screw clockwise.

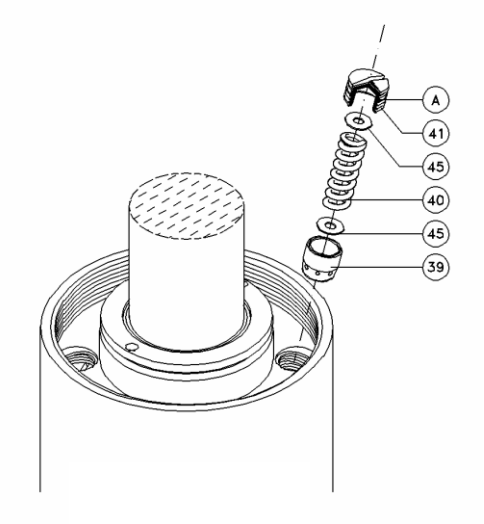


Figure 6-46; Damping valves

The adjusting screw must be locked after adjustment. Therefore the adjusting screw is fitted with a plastic lock washer (A), which is self-locking.

Check the adjusting screws after adjustment: they must not extend above the surface of the guide! If they do; check that the right components have been mounted and if all valves have been adjusted correctly.

6.7.2 Adjusting procedure

Please refer to the damper specific adjustment Instruction for the correct instructions.

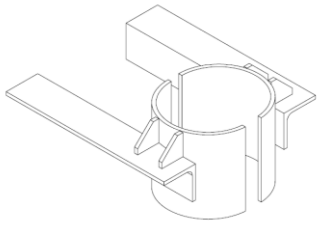
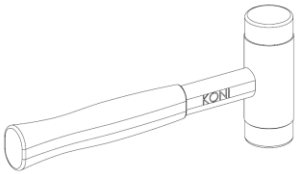
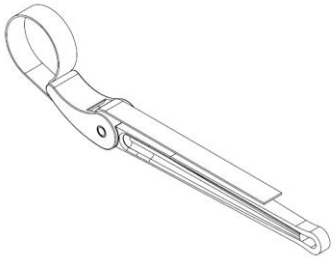
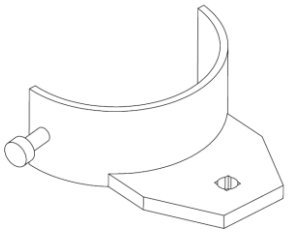
1. Partially open the valve that is to be adjusted first
2. Close all other valves
3. Start the test machine, with stroke and rpm as required for the adjustment of the first valve
4. Turn the adjusting screw of the valve to be adjusted first until the prescribed force is reached
5. Repeat 3 and 4 for the other valves

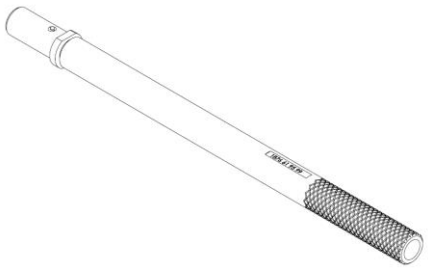
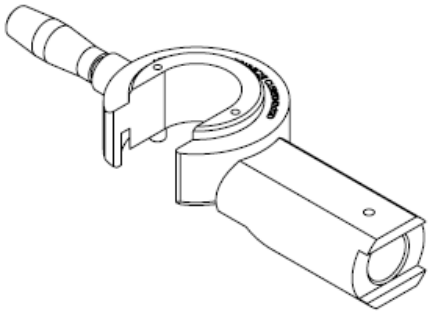
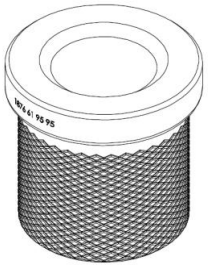
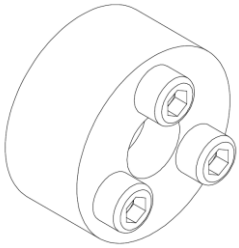
6.7.3 Tolerances on forces

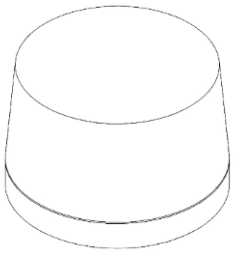
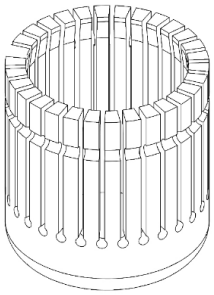
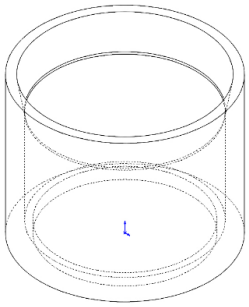
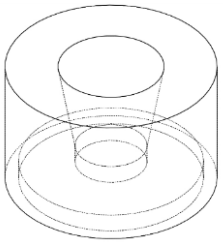
The tolerances on the adjustment- and check-forces are reported on the “Instruction for adjustment” for the referenced damper.

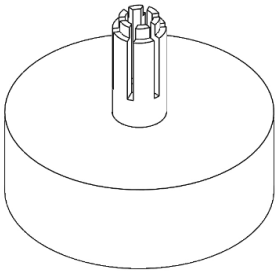
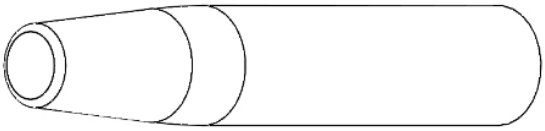
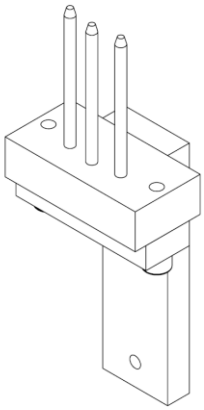
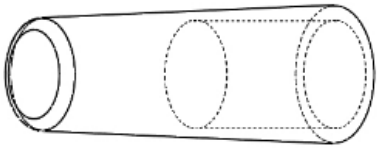
6.8 Special Tools

In order to efficiently overhaul the dampers the following specials tools are recommended. In addition to the special tools, normal workshop tools as well as a damper test machine are required.

Item	Description	Tool number
1	Clamping tool for in vice 	1876 02 48 89
2	Plastic hammer 	1958 01 00 02
3	Strap wrench 	1959 20 00 02
4	Adapter for torque wrench 	1877 01 13 12

5	Lever 	1876 61 95 99
6	Adapter for Gland nut installation/removal 	1876 61 95 78
7	Auxiliary tool (to loosen guide from cylinder) 	1876 61 95 97
8	Adapter (for torque wrench) 	13 09 003 0

9	Mounting cone for piston seal 	12 09 025 0
10	Mounting Sleeve for piston seal 	12 09 024 0
11	Calibration mandrel for piston seal 	12 09 021 0
12	Reduction Cone for piston bolt seal 	13 09 001 0

13	Assembly tool for piston bolt seal 	13 09 002 0
14	Calibration cone 	13 09 004 0
15	Return tubes assembly tool 	16 09 003 0
16	Protection cone 	12 09 022 0

6.9 Tightening torques and locking

The tightening torques for all threaded fastenings in the damper are specified below. When thread locking is required, this is indicated as well. The thread locking must be carried out with due care in order to achieve the required strength:

- Remove all loose dirt
- Clean and degrease all components.
- White spirit can be used for degreasing (boiling point range 140°C - 190°C)
- When using solvents, the local regulations must be complied with.
- Apply the locking agent: In case of the piston/ piston rod fastening it must be applied to the inside thread. For all other fastenings it must be applied on the outside thread.
- Apply Loctite as short as possible (Max. 10 min.) before assembly.
- After assembly the locking agent must cure for 2 hours at a temperature of minimum 20˚C: do not put any load on the fastening during this period.

Tightening torque's and locking type 02				
	Version	**Torque (Nm)**	**Tolerance (Nm)**	**Locking (Loctite no.)**
Piston	¾" UNF	150	±15	270 Steel-cast iron 648 steel-steel
	Air escape plate ¾"	60	±15	270 Steel-cast iron 648 steel-steel
Guide		550	±150	N.A.
Reservoir tube seal nut		350	±25	N.A.
Rod oil seal nut	Lip seal	40	±4	N.A.
Screwed dust cover	Primer Black	150	±30	2701
	Primer Brown / Yellow	150	±30	221
Valve stop (bottom valve)		18	±3	270
Screw (low noise bottom valve)		4	0 / +5	270
Bolts of dust cover	Hexagon-head bolt Hollow-head bolt	8 10	1/-0 ±1	N.A. N.A.
Valve seats		N.A.	N.A.	601

6.10 Oils, lubricants and grinding compound

6.10.1 Oil Type

Depending on the specific damper requirements, e.g. climatic requirements, different types of hydraulic oil can be used. It is imperative to use the correct KONI hydraulic damper oil. The characteristics and proper function of the damper are determined in combination with this specific oil. Please refer to the damper specific parts list for the correct damper oil.

6.10.2 Lubricants

Several lubricants are used for the assembly of the damper:

Polylub-GLY 801 Part number: 1006-02-00-42

Lip seal (rod oil seal) and wiper ring:
After the guide assembly, lubricate the work surface of the seal and the wiper ring.

Gasket reservoir tube seal:
The gasket reservoir tube seal of the damper is lubricated before assembly with the oil used in the damper.

O-rings:
Unless otherwise specified all O-rings must be lubricated before assembly.

6.10.3 Grinding compound

For grinding purposes use grinding compound:
Durolin fine + gross Part number: 1971-22-01-02

7 Testing and Troubleshooting

7.1 General

It is recommended to conduct all tests on a (KONI) test machine in order to verify correct damping forces. With the help of this machine the complete performance of the damper can be investigated.

Wear or incorrect assembly of the silentblocs in the eyes of the damper may result in incorrect performance graphs. If wear is found, the silentblocs should be disposed of and new ones should be used to fix the shock damper to the machine.

Before the dampers can be tested properly, ensure that there is no air left in the cylinder. It is therefore advised to prime the damper.

Priming instruction:

1. In vertical position, press the piston rod to the minimum length
2. For horizontal dampers: In horizontal position, pull the piston rod to the maximum length.
3. For vertical dampers: In vertical position, pull the piston rod to the maximum length.
4. Press the piston rod to the mounting length.

The vertical dampers have to be tested in a vertical position and the horizontal dampers have to be tested horizontally.

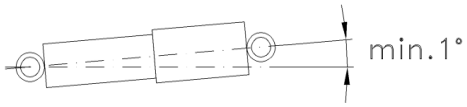


Figure 7-1: Mounting position lateral dampers

When testing horizontally, please note that the dampers are positioned in the right position (please note the “BELOW” mark on the damper) and under a positive angle of at least 1°.

When mounting the damper on the test machine, check if the full test stroke can be made. Furthermore the damper must be mounted in such a way that the test is conducted around the mid position of the damper.

7.2 Test data

The KONI Railway dampers have symmetrical forces, which mean that the forces during the extension and compression stroke are equal. The damper tests must be conducted at an ambient temperature of 20°C ± 5°C.

For more test details please refer to the applicable *Test instructions* of each damper type.

NOTE

Because of some wear of the inner parts during service, the forces can drop with a maximum of 30%.

7.3 Test machine

In general dampers can be tested on any machine that allows the two fixing points of the dampers to move relative to each other. The forces generated by the damper can be measured mechanically, electronically or hydraulically. A force stroke diagram can be produced by recording the force and the displacement simultaneously. Be very careful when adjusting the machine to the movement of the damper in order to prevent serious damage to machine or damper.

The performance graph should be made on the test machine after the damper performed 5 test strokes in order to prevent interference of adhesion of seals.

7.4 Diagram analysis

The KONI test machine produces a force-stroke diagram (clockwise) (Figure 7-2). The displacement is written on the horizontal axis of the diagram, while at the same time the damping force is registered along the vertical axis. The outward damping forces can be found above the zero level, the inward damping forces below. Point A in the diagram is the starting point of the outward movement. At point B the piston has reached its maximum speed: here the outward damping force must be measured. Then the outward speed decreases again to zero at point C. Here the inward movement starts so that at point D the maximum inward speed is reached.

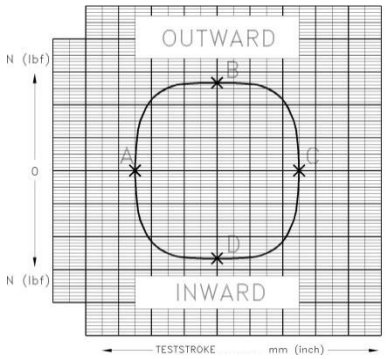
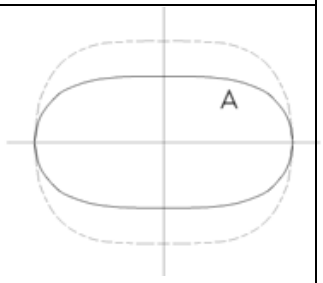
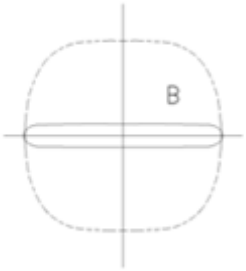
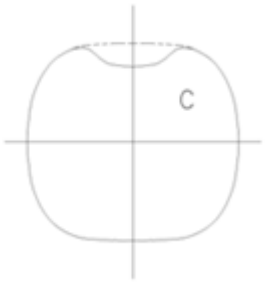
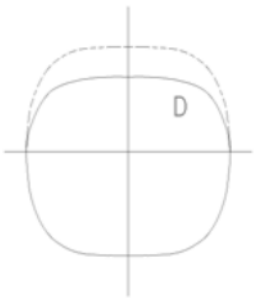
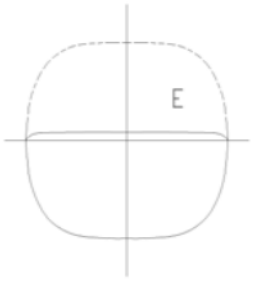
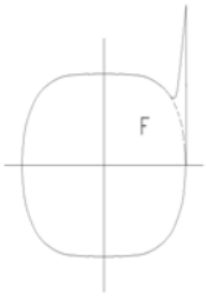
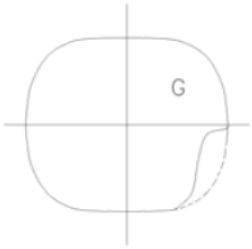


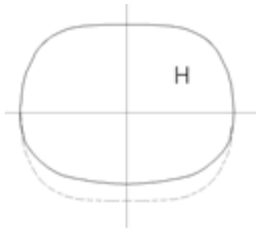
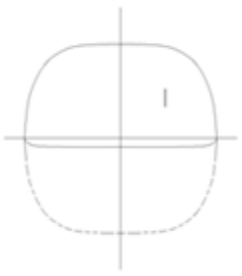
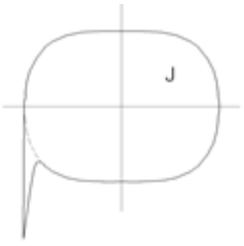
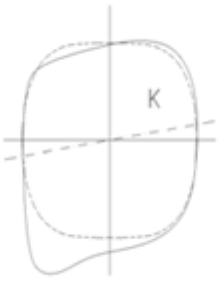
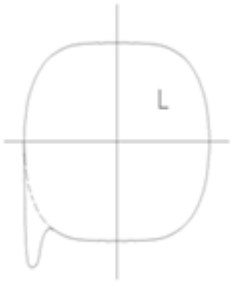
Figure 7-2 Typical Force-Stroke diagram

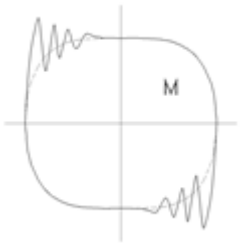
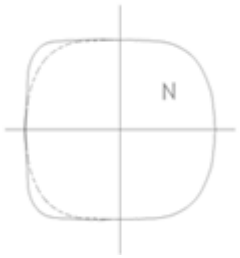
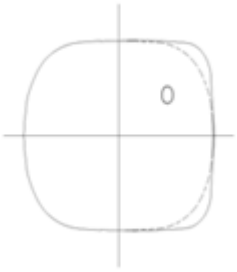
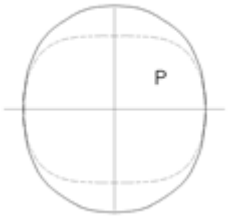
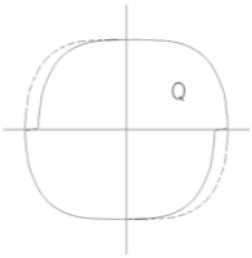
7.5 Deviating test diagrams

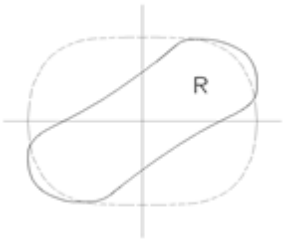
The following guidelines may be useful in case of malfunctions.

<table>
<tr><td colspan="3">Malfunction during both inward and outward movement.
This may be caused by:
• Oil deficiency.
• Malfunction in lock nut section (e.g. damping valve or rod guide).
• Faulty seal between guide and cylinder.
• A combination of the malfunctions below.</td></tr>
<tr><td colspan="3">Malfunction during inward movement.
This may be caused by:
• A malfunction in the bottom valve section.
• A faulty seal between bottom valve and cylinder.</td></tr>
<tr><td colspan="3">Malfunction during outward movement.
This may be caused by:
• A malfunction in the piston section.</td></tr>
<tr><td colspan="3">With the help of the diagrams below it is possible to determine the possible causes of deviating forces or deviating diagram shapes. For the component numbers mentioned: see Appendix A for the parts list of the damper.</td></tr>
<tr><td>A</td><td>Both the inward and outward damping force of the damper have lowered somewhat:
• Re-adjustment may restore the original damping forces.
• Too much wear of the piston rod guide.</td><td> 
</td></tr>
<tr><td>B</td><td>No or hardly any damping forces during both inward and outward movement:
• Adjusting screw (41) has come loose and has loosened so far that valve spring (40) has little or no pre-tension left;
• No or far too little oil present. The damper should show clear signs of oil leakage;
• Leakage of oil between cylinder tube (17) and guide (122);
• Too much wear between piston rod (16) and guide (122);
• Faulty valve (39) or valve seat (38);
• Valve seat (38) moves ;
• Dirt between valve (39) and valve seat (38).</td><td> 
</td></tr>
</table>

C	Outward the damper only works over a part of the stroke: • Local wear of cylinder tube (17)	
D	Damper is lighter outward than inward: • Non return valve (13) on piston (12) leaks a bit, e.g. because of dirt or damage of valve seat of piston (12). • Plastic ring for piston (64) is damaged.	
E	Damper does not work at all outward, but works properly inward: • Non return valve (13) on piston (12) is open, e.g. because of dirt or damage of valve seat of piston (12). • Piston (12) has come loose.	
F	Diagram shows a sharp outward peak: • Damper hits a stop during the outward stroke: incorrect mounting on the test machine or the stroke of the machine has been set too large.	
G	Damper has free stroke in inward direction: • Too little oil, resulting in air in cylinder tube. • Non return valve (5) in bottom valve opens with great difficulty. • Damper for vertical use has been tested horizontally. • Damper for horizontal use has been tested horizontally, but upside down, that is, the mark 'BELOW' facing up, or the mark 'ABOVE' facing down. • Return tube (53) has not been mounted or is leaking.	

H	Damper is lighter inward than outward (for a damper that should be symmetrical): • Non return valve (5) in bottom valve (4) is a bit leaky, e.g. because of dirt or damage of valve seat of bottom valve (4). • Oil leakage between cylinder tube (17) and bottom valve (4).	
I	Damper does not work at all inward, but works properly outward: • Non return valve (5) in bottom valve (4) remains open. • Valve stop (7) of bottom valve (4) is loose.	
J	Diagram shows a sharp inward peak: • Damper hits the stop during the inward stroke: incorrect mounting on the test machine or the stroke of the machine has been set too large.	
K	Diagram shows an inward peak and is tilted to one side: • Too much oil in the damper.	
L	Diagram shows a rounded inward peak: • Damper hits bellows (74) during the inward stroke: the damper has been mounted on the test machine incorrectly or the stroke of the machine has been set too long.	

M	Diagram rises steeply and shows vibrations in inward and / or outward direction: • Piston (12) cannot move freely in cylinder tube (17). • Piston rod (16) is warped and cannot move freely in guide (122). This phenomenon may also be caused by vibrations of the writing mechanism of the test machine, especially in case of dampers with an almost 'square' diagram.	
N	Diagram is 'square' inward and outward in lower and / or upper dead point: • Piston (12) cannot move freely in tube (17). • Piston rod (16) is warped and cannot move freely in guide (122).	
O		
	Damper has become heavier both inward and outward: • Valve seat (38) has been displaced so that valve spring (40) has too much pre-tension, or is even blocked entirely. • Valve seat (38) is blocked up (partially).	
Q	Diagram shows the same amount of free stroke both inward and outward: • Too much clearance of attachments. • Damper has not been mounted on the test machine properly.	

R	Top of diagram is tilted: • Too soft or worn fixing rubbers have been mounted.	
S	Diagram is inconsistent inwards and outwards: it shows variation below the nominal value: • Dirt in the damper.