Inside TTX

The Öhlins TTX40 manual

ÖHLINS
ADVANCED SUSPENSION TECHNOLOGY

***HVM (nee Herdez Competition)** was one of the first Champ car teams to test the TTX.*

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Figure 1.1 *A complete TTX damper with spring*

1 Introduction

Congratulations on choosing the Öhlins TTX damper, the latest generation of twin tube dampers from Öhlins.

Get to know your TTX, and be sure to read this manual thoroughly before using the dampers. We recommend that you keep this manual handy.

The TTX damper is the culmination of three decades of Öhlins' successful participation in world championship events winning more than 100 World Championships. Many years of work together with some of the world's most successful racing teams together with advanced dynamic analysis methods developed at Öhlins Racing headquarter in Sweden has given Öhlins the unique knowledge needed to design the TTX damper.

The Öhlins TTX damper, originally developed for formula racing, is designed to handle the demanding damping characteristics needed for all types of tracks, from street courses to super speedways.

The TTX damper is fully adjustable with maximised damper response together with qualities you've never seen before when it comes to "settings".

Low and high speed compression and rebound damping are externally adjustable and fully independent. The adjustment range is huge with equal increments of force throughout the adjustment range. Even the shape of the damping curve can easily be changed. All adjusters affect the flow from the main piston, not the piston rod displacement volume.

The compression damping forces of the TTX damper are not, as in a conventional damper, caused by a pressure drop on the rebound side, but by increased pressure on the compression side. This reduces the risk of cavitation and makes any reservoir valve or high gas pressure unnecessary. So, no balancing of reservoir damping to main piston damping is needed to avoid cavitation and improve damping response. Maximum response and minimum risk of cavitation will always occur. With no reservoir valve, the internal pressure of the damper unit will be kept to a minimum. The low amount of hysteresis results

Figure 1.2 *A TTX damper unit.*

in excellent short stroke/high force performance. Also, a very low gas pressure can be used without any loss of damping performance.

Along with the damper comes a unique Valving Reference Program (available for download free of charge at www.ohlins.com). This computer model of the damper will allow you to find damping curves without a dynamometer. It will reduce building time tremendously and allow exact damper adjustments in pit lane. The TTX product will revolutionise the work for mechanics and engineers in the racing business.

This manual text is based on TTX dampers starting with Öhlins part number TTX NE0. These are through rod type dampers loaded with several new concepts. As always, all dampers are tested before they are delivered to the customer. In keeping with Öhlins long tradition of perfection, quality is outstanding and long life is to be expected.

Welcome to the World of Öhlins.

2 Design Criteria

After the Öhlins TT44 was introduced to the market in 1996, it very quickly became one of the most popular dampers in formula racing. For some period, more than 95% of the cars in The Champ Car World Series were using TT44 dampers.

There are several reasons why the TT44 became so popular. One reason is that it came with some new features not available on other dampers. One of them is the powerful low speed adjusters, totally independent and with the compression adjuster restricting the oil flow from the main piston, not only from the piston rod displacement. Another is the compression high speed adjuster, giving new possibilities to reshape the compression curve.

When designing the new TTX, the goal was to come up with a damper which would be just as big a step forward as the TT44 had been. Highest priority should be not only to design a damper with excellent performance, but also a damper easier to work on and use than any other product available.

During the development several patent applications were made.

Six of the most important design criteria for the TTX are listed below *(Figure 2.1)*.

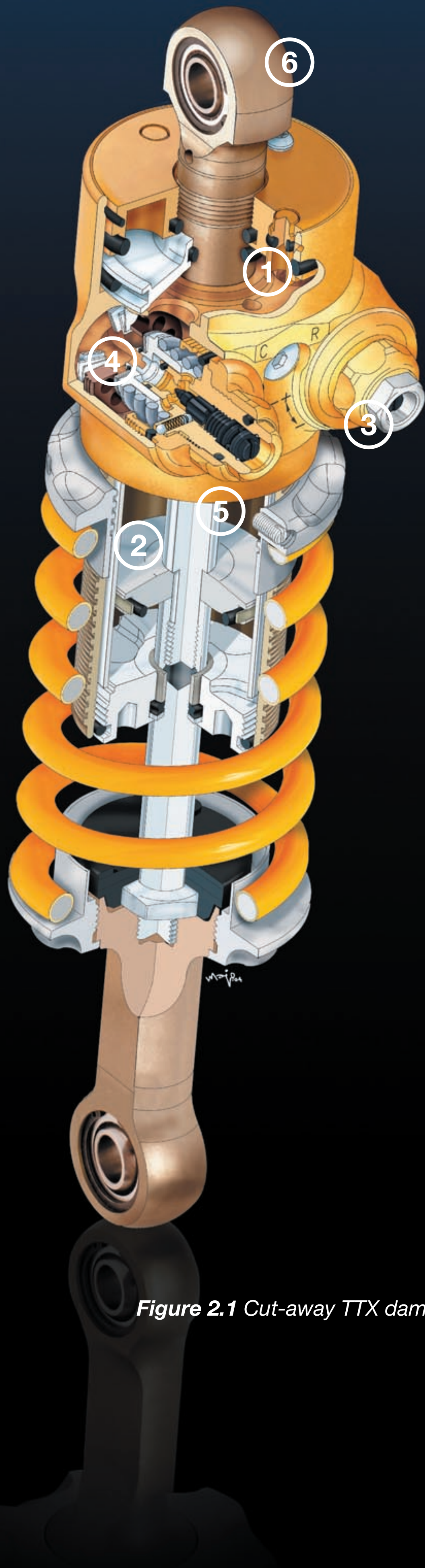


Figure 2.1 *Cut-away TTX damper.*

1. No reservoir valve

The damper design should be with no reservoir valve. In dampers where reservoir valves have to be used to avoid cavitation, one more parameter has to be optimised – the right amount of reservoir damping.

The hysteresis will be minimised, as no reservoir valve has to be used. All damping comes from the pressure drop over the main piston. Damping forces from a reservoir valve always causes more delay in the damping force build up. See chapter Hysteresis for more information.

Using reservoir valves always increases the internal pressure. The friction from the piston rod seal/ seals can be kept low because of the low internal pressures.

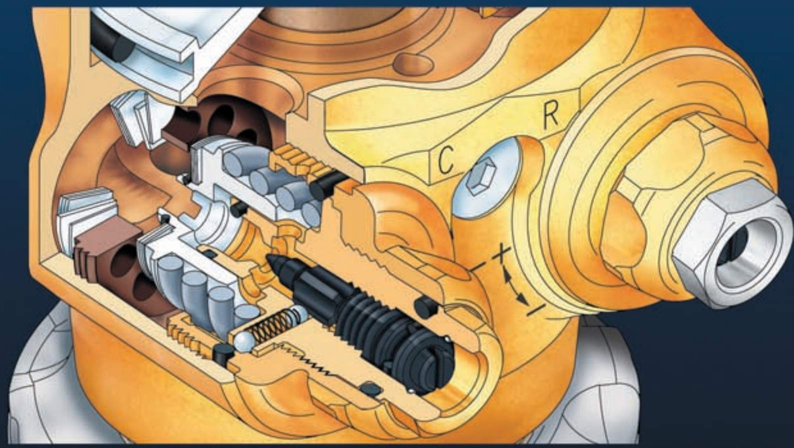


Figure 2.2 *High speed Compression and Rebound adjusters.*

2. Main piston flow

Another criterion was to have all the adjusters regulate the flow from the main piston. This will give the maximum pressure area and because of this, the maximum oil volume to regulate.

The larger the pressure area is, the lower the internal pressure will be for a given damping force. The lower the internal pressure, the less flex there will be. The flex is caused by expansion/ compression of the damper body and compression/expansion of the oil. The result is excellent short stroke/high force performance.

With a large volume of oil passing through the valves , it becomes easier to control the restriction of the oil. In other words, the matching of dampers will be improved.

3. Full adjustability

On the TT44/TT40, it was never possible to use a high speed rebound adjuster in combination with a high speed compression adjuster. On the TTX, we wanted to be able to combine those two while keeping them completely independent from each other, as with the low speed compression and rebound adjusters.

Poppet valves preloaded by coil springs were picked to become the high speed valves, as they can be made very compact in size and precise in opening pressure. This type of valve very often gives an abrupt opening characteristic, resulting in a sharp ”knee” in the damping curve. To make the ”knee” more rounded and to be able to change its shape, some shims are added to the face of the poppet valves. By changing these shims, the shape of the ”knee” can be affected.

4. Simple valve changing

Even if the adjustment range of the external adjusters is huge, sometimes there might still be a need to change the valving of the dampers. In other words, change one or several of the following parts: poppet valve/valve seat, coil springs and nose shims. As this very often is done at the track and has to be done quickly, this job has to be simplified as much as possible. Compared to reshimming a conventional damper, any of the changes in the TTX will be a lot quicker. The result exceeded our demands.

Also it should be possible to fill the damper without a vacuum-filling machine, as this otherwise would be a limiting factor.

5. Through rod damper

A through rod damper has some technical benefits. One is packaging, which is a main issue on formula cars. The reservoir volume can be very small, as there is no piston rod displacement. Here no external reservoir is needed. Also there is no gas force pushing the piston rod out of the damper body. (The word ”nose pressure” is sometimes used for this force.) Here the nose pressure is zero. This has several advantages. The nose pressure doesn’t vary due to temperature changes and you don’t have to fight the gas force when installing the damper on the car or in the dynamometer.

Designing a through rod damper gives the possibility to separate the rod bushings and keeps the distance between them constant. If coilover springs are used, the amount of friction will be tremendously reduced.

As the piston area for compression and rebound are identical, the damping forces will be the same if the same valving is used and the adjusters are set the same. To some degree, this simplifies the use of the damper.

For all the above reasons, race teams have been interested in through rod dampers. Also, when introducing the TTX, we wanted it to be something very different from the other products out on the market.

6. External clocking

Another strong side of the TT44/ TT40 was the possibility to clock the reservoir bracket at any angle. This function we wanted to keep on the TTX damper, to ensure an optimum installation on any car. Just as on the TT44/TT40, the clocking of the adjusters on the TTX in relation to the top eye should be possible to change without opening the damper.

3 How the Damper Works

The description below is divided into compression and rebound damping cycle.

- Compression damping cycle.
- Rebound damping cycle.

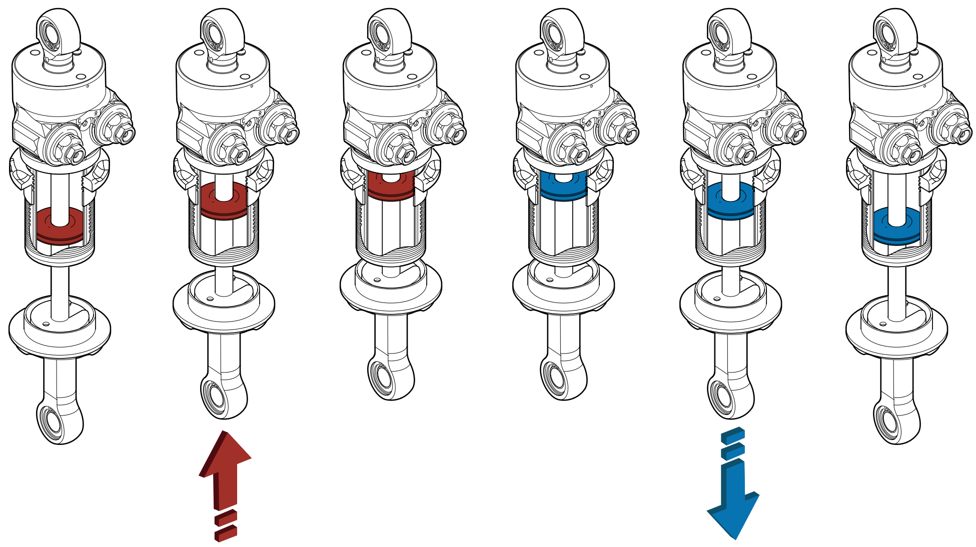


Figure 3.1 *Compression and Rebound damping cycle.*

General description

The compression damping cycle describes the situation when the rod and piston unit moves into the damper body shortening the length of the damper. While the rebound damping cycle describes the situation when the rod and piston unit moves out from the damper body extending the length of the damper.

The terminology ”compression side” of the piston here refers to the oil volume in front of the piston when the external piston rod is moving into the damper body (compression cycle). The ”rebound side ” of the piston refers to the oil volume in front of the piston when the external piston rod is moving out of the damper body (rebound cycle).

When the rod and piston unit doesn’t move, the internal pressure in the whole damper unit is equal with the set gas pressure. When track conditions cause the vehicle suspension to move, the damper piston will attempt to move through the damper oil. In order for the piston to move, oil must flow from one side of the main piston to the other. The restriction of the valves causes a pressure difference between the two sides of the piston, resulting in damping forces. In the TTX, this pressure difference comes from increased pressure on the forward side of the piston and not reduced pressure on the backside, as in conventional dampers.

Unless a different valve configuration is used compression to rebound, the compression and rebound valves are identical. On both sides there are three type of valves used for adjusting the damping characteristics.

- Bleed valve
- Shim valve
- Poppet valve

The compression bleed valve is in parallel with the compression poppet valve and the rebound bleed valve is in parallel with the rebound poppet valve. The poppet valves are pushed against their seats by preloaded coil springs. The preload is externally adjustable. The amount of preload of the poppet valves determines the pressure differentials across the main piston necessary to make the poppet valves open. For more information about the bleed valves and the poppet valves, see chapter *External adjusters.*

The shim valves are placed on the nose of the poppet valves. These shim stacks affect the opening characteristic of the poppet valves. The shim configuration can be changed to achieve different opening characteristics of the poppet valve. See chapter *Internal adjustments* for more information.

Also, there are two check valves installed in the damper, making the compression and rebound valves fully independent.

Paul Tracy, *Forsythe Championship Racing*.

Jason Bright, *Ford Performance Racing.*

Flow circuit at compression cycle

How the oil flows from the compression side to the rebound side of the piston will be described here. This is caused by increased pressure on the compression side of the main piston, while the pressure on the rebound side is almost constant at the set gas pressure.

1. The oil will reach the compression valves by passing through the port of the separating plate *(Figure 3.3-A*) extending into the cylinder head and leading the oil into a chamber below the compression valves *(Figure 3.3-B)*. Because of the small restriction of this port, the pressure in this camber will be very much the same as the compression side of the cylinder tube. The piston velocity and how the valves are set determine the pressure in the camber. The pressure will help to close the check valve in this camber.

2. Depending on the pressure, different things will occur. As the velocity increases, the pressure will rise.

a) In the initial part of a compression stroke, when the velocity of the piston is low, the oil will pass through the adjustable low speed compression valve. In this bleed valve, the restriction takes place in the passage *(Figure 3.3-C)* between the needle seat (integrated to the needle housing) and the needle. As long as the piston is moving and the bleed valve is not fully closed, some oil will always flow through the bleed valve. If the bleed valve is fully closed, this passage will be blocked.

b) As the velocity increases, the shim stack on the nose of the poppet valve will start to open and oil can pass between the shim stack and the poppet valve seat *(Figure 3.2-D and 3.3-D*. The stack configuration will decide the opening pressure. An increased stiffness of the stack will raise the opening pressure and thus raise the damping force. The shape of the nose on the poppet valve gives the shims freedom to bend and lift from the seat, no matter how much preload from spring there is on the poppet valve. This will allow the shim stack to always open gradually and therefore a small amount of oil will pass through the shim stack even with a very low pressure drop over the piston.

c) As the piston velocity increases further, the internal pressure rises. At a certain velocity the movement of the piston creates a pressure difference across the main piston that is equal to the predetermined pressure required to open the poppet valve. The oil is now free to flow between the poppet valve and the seat *(Figure 3.2-E and Figure 3.3-E)*. Due to the oil flow, the nose shims will follow the poppet valve up from the seat.

NOTE:
In practice, the piston often does not reach a velocity high enough to cause a sufficient pressure drop and open the poppet valve.

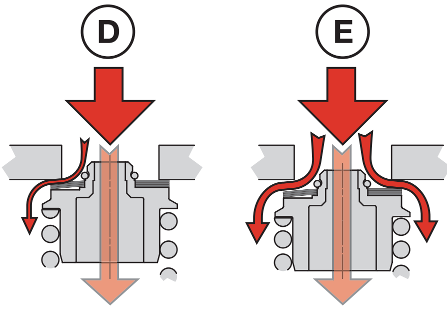


Figure 3.2 *Poppet valve*

By using a very stiff shim stack in combination with little preload on the poppet valve, the oil flow through the shim stack will be very limited before the poppet valve opens. This will make the opening of the poppet valve more abrupt and the shim stack will open at a higher velocity. This will change the characteristics of the damping curve.

NOTE:
The opening characteristic of the poppet valve is always abrupt, unlike the gradual opening characteristic of the shim stack.

3. The oil has now reached the low-pressure zone at the gas reservoir *(Figure 3.3-F)*. This volume is in direct contact with the separating piston, separating the oil from the nitrogen gas. Here the pressure is always equal to the set gas pressure.
   As the TTX is a through rod damper, there will be no fluid displacement by the piston rod. However, a gas volume is still needed to reduce changes of the static internal pressure due to volume changes caused by temperature variations.
   The rising temperature of the damper will increase the volume of the oil. Also the damper body will expand as the temperature increases, but not all to the same extent.

4. Now the oil will flow through the compression check valve *(Figure 3.3-G)* positioned at the rebound valves. However, as long as the low speed rebound bleed valve isn't fully closed, some oil will flow the through this valve backwards (*Figure 3.3-H)*.

NOTE:
The compression check valve is placed together with the rebound valves.

5. From here the oil flows between the two tubes *(Figure 3.3-I)*. The oil re-enters the main tube on the rebound side through ports placed between the end cap and the inner tube (Figure 3.3-J). The compression flow circuit is completed.

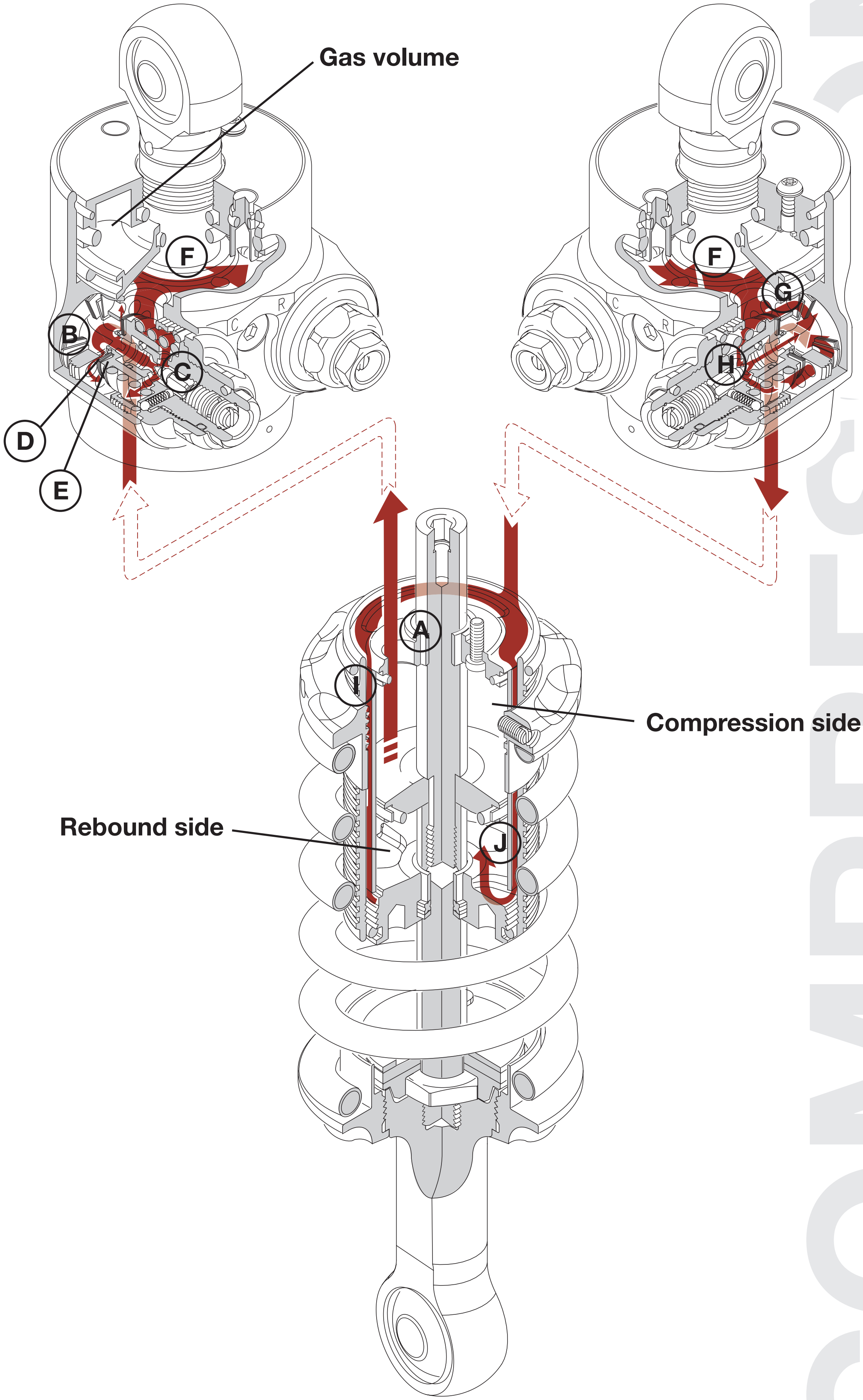


Figure 3.3 *Flow cicuit during compression cycle.*

Flow circuit at rebound cycle

Below is a description of how the oil flows from the rebound side to the compression side of the piston. The rebound cycle is very similar to the compression cycle, but the flow will be in the opposite direction and the oil will move through other valves. During the rebound stroke, the pressure of the rebound side of the main piston is increased, while the pressure of the compression side is kept almost constant.

1. First the oil has to get to the rebound valves. The ports between the end cap and the inner tube *(Figure 3.5-A)* will lead the oil to the volume between the tubes *(Figure 3.5-B)* from where the oil will reach the chamber below the rebound valves *(Figure 3.5-C)*. The pressure here will be roughly the same as in the rebound side of the cylinder tube due to small restrictions of the oil flow. The pressure will help to close the check valve in this camber.

2. See "section 2" above in chapter *Flow circuit at compression cycle* for more detailed information as the rebound valves are identical to the compression valves.

a) Unless the low speed rebound valve is fully closed, the oil will first pass through this valve *(Figure 3.5-D)*.

b) The second valve to open is normally the nose shim stack *(Figure 3.4-E and Figure 3.5-E)*.

c) If the pressure level reaches the opening pressure of the poppet valve, the poppet valve will open *(Figure 3.4-F and Figure 3.5-F)*.

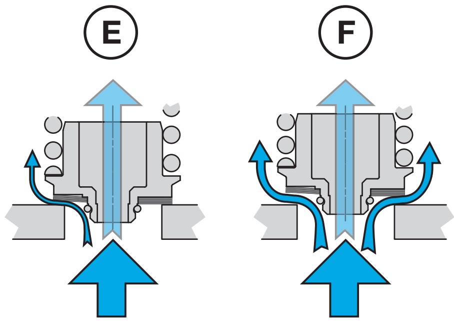


Figure 3.4 *Poppet valve*

3. Now the oil has reached the low-pressure zone at the gas reservoir *(Figure 3.5-G)*, where the pressure is equal to the gas pressure.

4. The oil will now flow through the rebound check valve *(Figure 3.5-H)* positioned at the compression valves. Some oil can, in the same way as described above in *Flow circuit at compression cycle*, flow backwards through the low speed compression valve *(Figure 3.5-I)* unless it is set to the fully closed position.

NOTE:
The compression check valve is located together with the rebound valves.

5. Finally the oil re-enters the main tube on the compression side through a port in the separating plate *(Figure 3.5-J)*. The rebound circuit is completed.

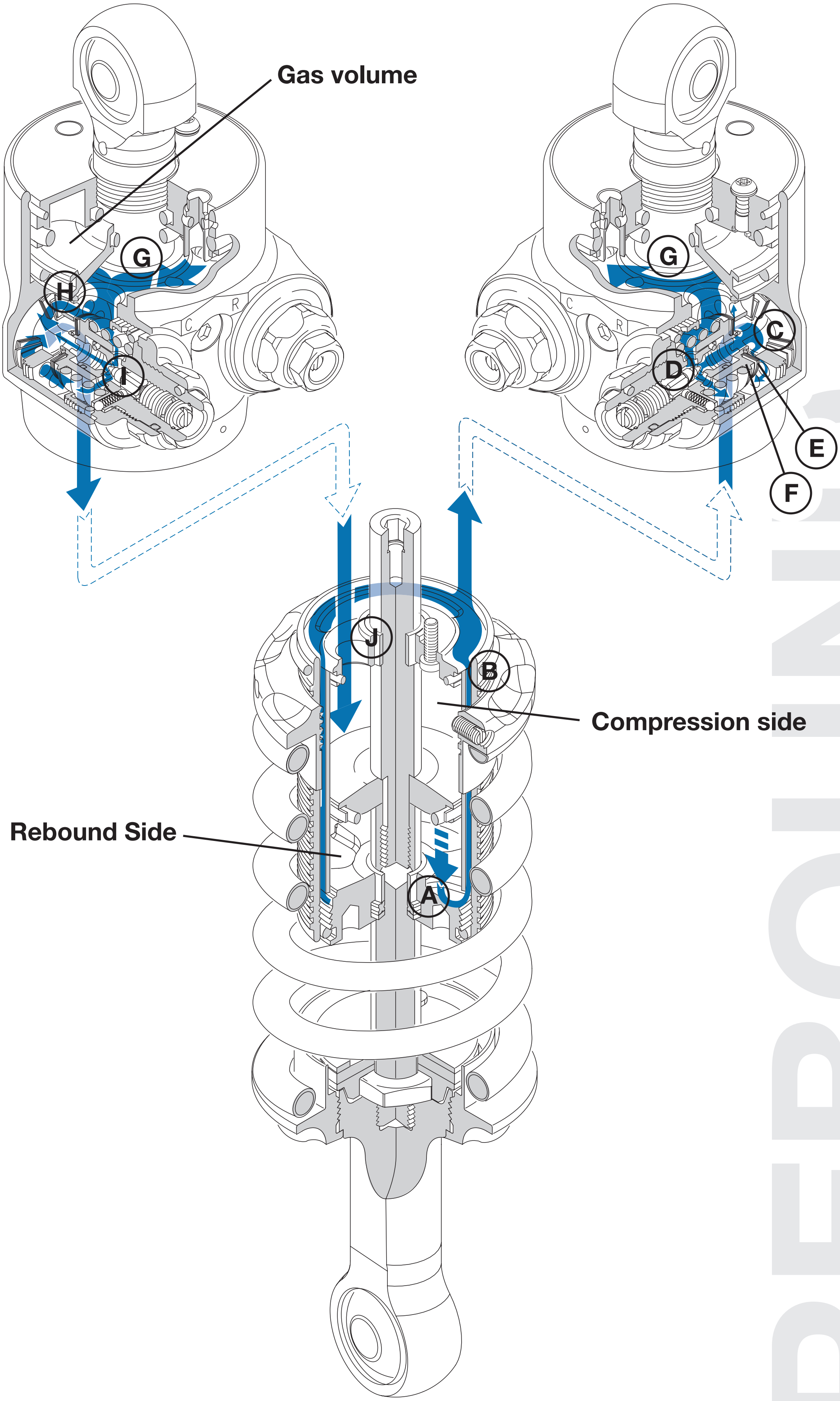


Figure 3.5 *Flow cicuit during rebound cycle.*

Figure 4.0 *TTX cylinder head*

4 Hardware Description

The TTX damper uses some concepts not used by any other damper manufacturer. In this chapter there will be information about some of this unique hardware. For information about the valves, see External adjusters and internal adjustments. For information regarding assembly or disassembly, see chapter *Work section*.

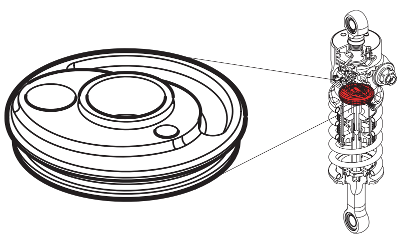


Figure 4.1 *Separating plate.*

Separating plate

Separating plates have been used by Öhlins since 1992 with development teams. The first product with separating plate available for the public was the TT44 introduced on the market in 1997.

The separating plate separates compression side from rebound side and guides the oil flow to and from the valves.

Thanks to the separating plate, the machining of the cylinder head will be simplified and the damper length minimised. Sometimes the desired design would not even be possible to do without a separating plate.

Unlike the separating plate of the TT44/TT40 there are no check valves installed in the separating plate of the TTX.

No seal has to be used between the plate and the cylinder head. Flat and smooth surfaces and large clamping force will ensure negligible leakage.

The mounting of the separating plate of the TTX is simpler than ever. The cylinder head will centre the plate and a screw will guarantee the correct mounting angle. In the TTX damper a bushing is installed in the separating plate, making the installation of support ring and x-ring in the cylinder head very simple.

The o-ring between the plate and the inner tube is mainly to ensure that the inner tube doesn't come loose when removing the end cap.

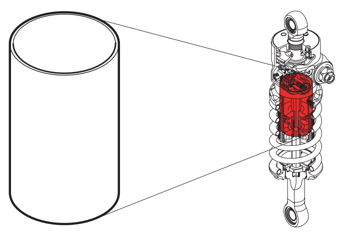


Figure 4.2 *Inner tube.*

Inner tube

Just as on the TT44, a steel inner tube is used to ensure maximum stiffness, but to make the assembly of the damper easier, the inner tube is now made symmetrical. Therefore the tube can be installed with either end first.

As the end cap bottoms against the inner tube, the inner tube will push the separating plate against the cylinder head. In so doing the inner tube does not only serve as a wall between fluid flows, but also ensures clamping the separating plate to the cylinder head.

NOTE:
The steel inner tube has to be protected from corrosion when not installed.

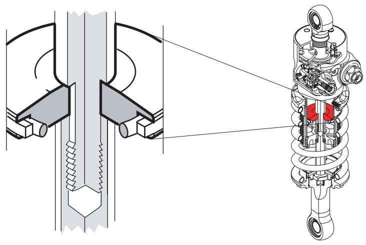


***Figure 4.3** Piston installation.*

Piston installation

The TTX damper uses a solid symmetrical main piston without shims. Instead of being the main path for fluid to flow to the opposite side of the piston, it acts more as a plunger, pushing fluid through the valves in the cylinder head. The piston band in this case, is not a load bearing seal (as described below in the *"Piston rod guide/seal"* section.) and contributes with very little friction to the damper.

The internal and external piston rods are screwed together clamping the piston, so here the ”displacement rod” (internal) also serves as a lock nut – two functions in one. The long, thin ”screw” works excellent as a screw element as it is very elastic.

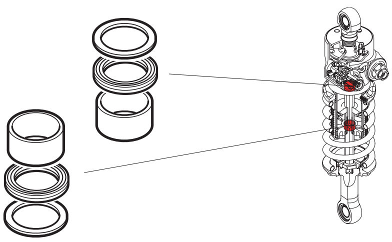


***Figure 4.4** Piston guide/seal*

Piston rod guide/seal

The two piston rod bushings are static bushings placed at the largest possible distance from each other to minimise friction and give maximum stiffness – one is, as in most other dampers, placed in the end cap, the other is placed in the separating plate. No piston bushing is needed, or even desired, because the entire side load is taken by the rod bushing and not the piston. Instead, a piston seal that can handle some misalignment between piston and piston rod is used.

Two identical piston rod seals of x-ring type are used, one for the external piston rod and one for the internal (displacement) piston rod. Due to the low gas pressure that is used, the level of friction can be kept low.

When using the damper as a coil over unit most of the friction in the damper comes from side load, caused by the torque from the springs acting on the bushings. By separating the bushings in the TTX the effect of this side load can be reduced significantly.

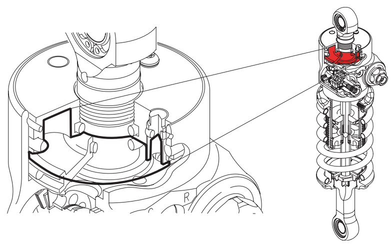


***Figure 4.5** Gas reservoir.*

Gas reservoir

By using the volume outside the area needed for the internal rod on top of the valves for the gas volume, a very compact installation can be made. Because the separating piston does not move along with the rod, friction from the separating piston is not important to the damper function. Therefore, the use of both internal and external seals is not a problem here.

Due to the fact that the TTX is a through rod damper, the eye to eye length can become the limiting factor when fitting the damper to a car. Therefore Öhlins has put a lot of effort in making the design extremely compact. In all types of pressurised dampers, there has to be some volume of fluid directly below the separating piston, making it possible to move some distance before it bottoms. This gives the separating piston margin from bottoming due to oil flex in the damper when pressurising the reservoir, oil leakage or temperature drop. As the gas reservoir of the TTX is placed on roughly the same diameter as the valves, it has been possible to design the damper so the oil volume between the separating piston and the cylinder head can be used to transport oil between the two valves

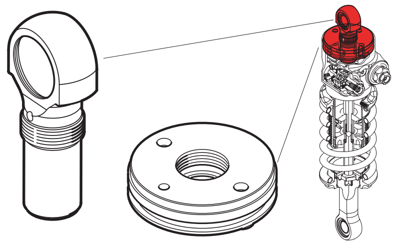


***Figure 4.6** Reservoir end cap and top eye.*

Reservoir end cap and top eye

The reservoir end cap has the function of preventing the pressurised nitrogen gas from leaking out and as a lock for the top eye which threads into the centre of the cap. The top eye can be positioned in any angle. See section *Reclocking top eye* in *Work section*.

The top eye has an open bore in the centre. This is the cavity that the displacement rod (internal) enters as it leaves the main body through the separating plate. The cross holes in the top eye, just below the spherical bearing, keep this cavity at atmospheric pressure.

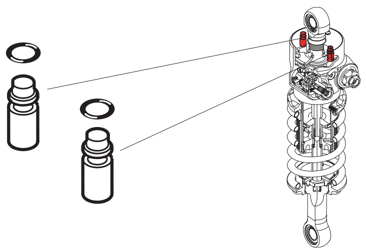


Figure 4.7 Pressure indicators.

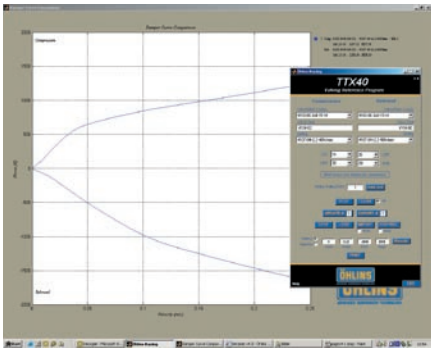


Figure 4.8 VRP user interface.

Pressure indicators

On the reservoir end cap there are two buttons, we call these “pressure indicators”. They have several uses. One is just as the name says to indicate if the damper is pressurised or not. In a through rod damper, as mentioned earlier, there is no force from the internal pressure pushing the piston rod out of the damper body. Therefore, it can be hard to tell if a through rod damper is pressurised or not.

By pushing in one or both pressure indicators, you are able to tell if the damper is pressurised or not by observing if they return to their static position. If the reservoir isn’t pressurised, the indicators will remain depressed. At 5 bar of internal pressure, more than 16 N (3.7 lbs) of force will be needed per indicator button to push them in.

The holes in the reservoir cap, where the pressure indicators can be seen are used to tighten/loosen the top eye. See section *Reclocking top eye* in *Work section* for information about reclocking the top eye.

Finally the pres sure indicators are used to position the separating piston when adding oil to the damper. Two special Öhlins tools are needed to do this. The tools use the two bosses on the top eye for positioning the separating piston. See section *Using Öhlins filling machine* in *Work section* for how to positioning the separating piston.

Valving Reference program

The use of Öhlins’ unique Valving Reference Program (VRP) for the TTX was obvious after the success of the previous VRPs for the TT44 and the DR4. This time the program is free of charge, to show the power of the TTX damper to as many as possible. The program is available on the Internet at www.ohlins.com

The TTX VRP is very easy to use. By positioning the cursor above the different ”buttons” in the program, information about how to operate the program will appear.

The damping forces used in this program have been measured on an Instron hydraulic dynamometer at constant velocity. For more information, see chapter *Damping force measurement*.

Figure 5.0 A crank dynamometer from Roehrig.

5 Damping Force Measurement

Damping forces are a frequent subject of discussions at race weekends. It is important to understand that depending on how the damping forces are measured, the force values can turn out very differently.

Within a race team, where the values normally always come from the same source this is normally not a problem. A team mainly needs a damper dynamometer to ensure their dampers produce the damping forces that are expected. This means that no "heavy duty" dynamometer is needed. For formula racing applications and many other types of asphalt racing a dynamometer that can reach 5 inch/second (0.127 m/s) is enough. The type of dynamometers mainly used are of the "crank type". The price tag, size and simplicity are the strengths of these machines. A crank dynamometer can be used for "continuous measurement" or "peak velocity measurement". A hydraulic dynamometer can be used for any type of measurement.

The requirements for a damper manufacturer, doing research and development, are very different and other types of machines are needed.

There is not one perfect way of measuring damping forces, as different situations ask for different needs.

See chapter *Damping curve terminology* for information about how to read damping graphs.

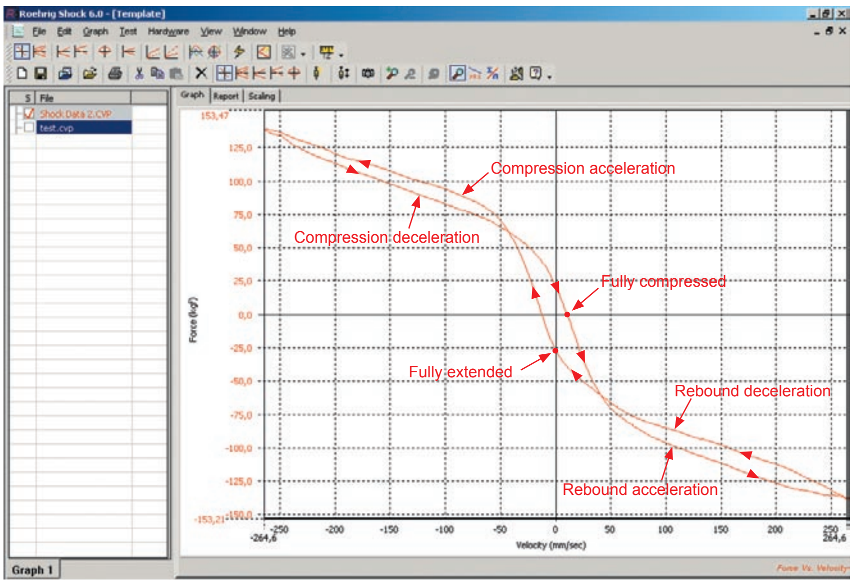


Figure 5.1 *Damping force measured continuously in a Roehrig dynamometer. The bleeds are fully closed.*

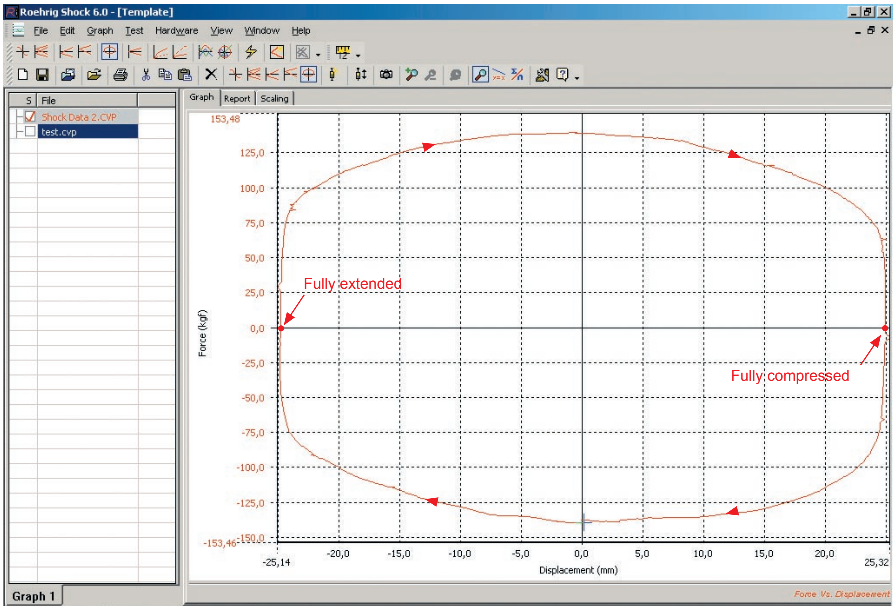


Figure 5.2 *Damping force measured continuously in a Roehrig dynamometer. Here the result is presented in a force-displacement graph. The data comes from the same run as in the previous figure.*

For a race team a continuous measurement of the damping force is very good: the measurement is quick, makes it very easy to tune the damping curve to a desired shape, hysteresis and cavitation is easy to detect and “dynamic problems” can be found. An example of a dynamic problem that can be detected this way is sticking check valves.

With continuous measurement of the damping force, the damper movement mimics a “sine wave”, often in the region of 1.6 Hz. As both the acceleration and the deceleration part can be seen, there will be two force values for any given velocity except for the maximum velocity. Sometimes the terminology “dynamic testing” is used for this type of damper testing, including other types of movements than just sine wave movements, but with the common factor that the measurements are done during variations in velocity. As can be seen in the figure, the acceleration force values are lower than the deceleration force values when passing zero velocity. This separation at low velocities is called “hysteresis”. See chapter *Hysteresis* for more information. When ”matching” dampers, the teams often pick half of the cycle to keep the overlay of curves from different dampers as clean as possible. It is common to use compression opening (measurement during acceleration) and rebound closing (measurement during deceleration).

Many times the result of continuous damping force measurement can be presented in a force-displacement graph. These types of curves are sometimes named “egg curves”.

If continuous measurement is used, the forces given are dependent on the stroke and frequency being used. By changing the crank length and the frequency of the dynamometer machine so to maintain the same peak velocity, let say 5 inch/second, the damping force curves will change. From the formula below, you find that, for example, a reduction of the amplitude to half will give the same peak speed if the frequency is doubled.

$v_{max} = A \bullet 2\pi \bullet f \quad [\, m/s \,]$
v_{max} = *peak velocity* [*m/s*]
A = *amplitude* [*m*]
f = *frequency* [*Hz*]

The less travel required to reach a specific velocity, the more pronounced the hysteresis will be in the graph. As hysteresis is found when the movement change direction, in other words at zero velocity, tests where different stokes have been used to produce the same peak velocity will differ at low velocities due to hysteresis. See chapter *Hystersis* for more information.

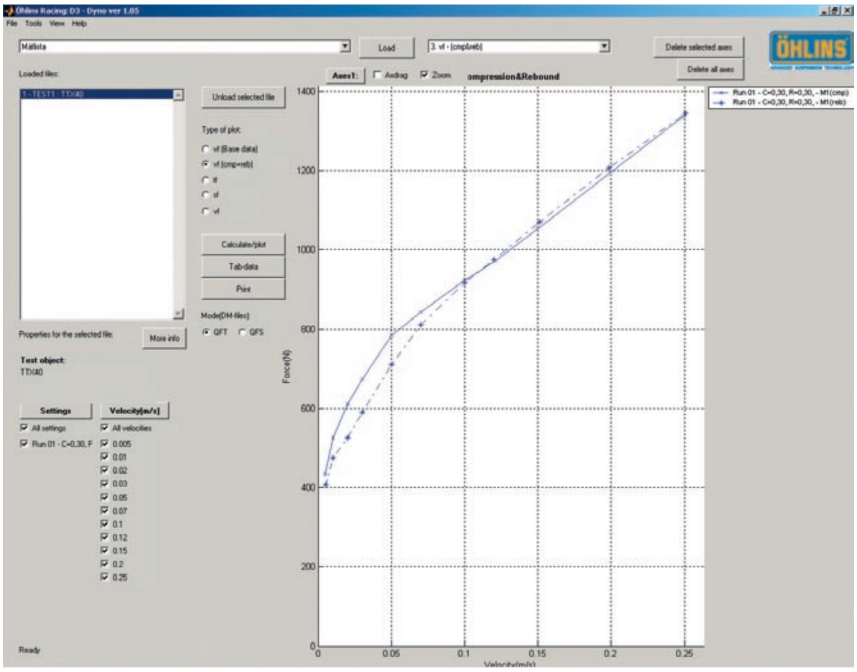


Figure 5.3 *Damping force measured at constant velocity. The lined curve is compression, the dotted curve is rebound. The setting is the same as in the two previous figures.*

Sometimes the software uses a filter to reduce the level of noise in the graphs.

NOTE:

Comparing the forces figures 5.2 with the force of 5.3, there is a huge difference in force at low speed. When the damping force is measured continuously the hysteresis give the impression that the bleeds are quite open and a small bleed change can be hard to notice in the graph

Some race teams do damping force measurement at constant velocity. Sometimes the terminology "static testing" is used for this type of testing. For matching dampers this method is excellent. For a damper manufacturer, working with different race teams using different methods of measuring damping forces, measuring at a constant velocity is preferred. Otherwise as explained above, when using continuous measurement, there is always a risk that the values discussed comes from different methods of measuring.

When the damping force is given at a constant velocity, there is only one value of the damping force at each specific velocity. A crank dynamometer can't be used for constant velocity measurement, but by measuring the damping force at different peak velocities, the result is normally very close. When a crank dynamometer is used, the machine always produces sine wave movement. By changing the frequency of the dynamometer, different peak velocities are reached. The number of runs varies depending on the needs. Of course small steps extend the test time. In a hydraulic dynamometer, the piston rod is accelerating to the desired velocity in a short distance, and the flow of oil through the valves in the damper is kept "static" during a large part of the stroke. This makes it possible to take hundreds of measurement before the dynamometer decelerates the piston rod.

NOTE:

In this manual, if there is no other information, all graphs illustrated come from Öhlins TTX VRP. The data used in the TTX VRP are produced by an Instron hydraulic dynamometer at Öhlins Laboratory. The forces are measured at constant velocity.

It is very important to know when dynamometer testing dampers if the forces measured are compensated for gas force or not.

Most racing dampers (pressurised, and not through rod type) add a gas force to the damping force. The gas force should be seen as an extra spring force from a spring with very low rate. This force is position dependant (close to constant) and not velocity dependant and should therefore be removed when damping force is plotted.

An idea of the amount of gas force a damper produces at a specific piston position (normally small variations at piston positions) can be found by compressing the damper by hand and keeping it at a static position. The gas force will now try to push the piston rod out of the damper body. This force is calculated as

$$F_{rod} = p_{gas} \bullet A_{rod} \quad [\,N\,]$$

p_{gas} = gas pressure above atmosphere pressure (the value read on the pressure gauge when pressurizing the damper) [N/m^2, 1 bar=10^5 N/m^2 = 15 psi]

A_{rod} = piston rod area

For example, at 10 bar (150 psi) gas pressure in the TT44/40 (∅16 mm piston rod), the gas force is approximately 200 N (45 lbs).

When you look at a dynamometer curve that has been gas force compensated, you are looking at the actual damping forces produced by the damper.

For non gas compensated dynamometer curves, the actual damping forces are calculated from the formulas below.

Compression damping = measured compression force – F_{rod}

Rebound damping = measured rebound force + F_{rod}

The TTX damper has no resulting force from the gas pressure (F_{rod} = 0), so it always gives the same forces no matter if the testing is gas compensated or not.

NOTE:

If matching the forces from a TTX damper with the forces from a conventional damper tested without gas compensation, the forces of the conventional damper has to be gas force compensated with the formulas above to get the same amount of damping.

NOTE:

Keep in mind that even if the method for measuring the damping forces is identical there can be some small variations in the result from different damper dynamometers, due to individual variations between the machines.

NOTE:

All damping curves will change with temperature, so always keep track of the temperature. See chapter Temperature stability for more information.

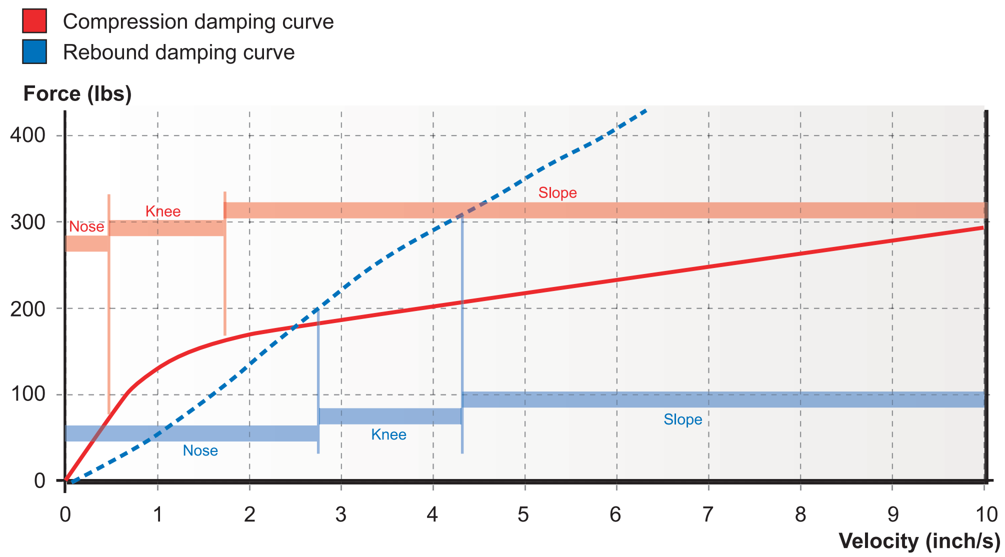


Figure 6.0 *Terminology*

6 Damping Curve Terminology

In order to understand the next part of this manual we must all speak the same language. In the damper industry there are terms used to help describe different parts of a dynamometer graph. The three key words are *nose (low speed), knee* and *slope (high speed)*. Careful study of this section will yield a complete understanding of these terms and allow you to read damper curves. Later chapters will show you how to manipulate the damper to produce alternate curves.

The horizontal axis in the figure gives damper velocity and the vertical axis shows damping force.

NOTE:
The velocity of the damper refers to the velocity of the piston rod movements, not to the speed of the car. Most of the piston rod movements on a race car reach only low velocities and the percentage number of strokes going though all zones described below is low.

Take a look at the figure above and notice the first portion of the damping curves – starting at 0 inch/second and ending at about 0.4 inch/second on the compression curve and about 2.7 inch/second on the rebound curve. This part of the curve is called the *nose* and is also referred to as *low speed*. The valve affecting this part of the curve is the low speed adjuster. It is always of a fixed orifice type (the size of the orifice is not variable by pressure, but by clicker adjustments) and is often called *bleed*. The design and size of the bleed determines the characteristics and shape of the nose. For further information, see section *Low speed adjusters* in *External adjusters*.

The finish of the nose zone coincides with the beginning of the *knee* zone. Its location in the curve can be found by identifying where the upwards curve first begins to level off into a radius. Locating where the knee radius stops and blends into the straight line identifies the end of the knee zone and the beginning of the *slope* zone.

The shape of the knee is determined by the opening characteristic, gradual or abrupt. The more abrupt the opening phase is, the sharper the knee will be. The converse is also true.

Normally the shape of the curve in the knee zone comes from the transition of the nose shim stack from closed to open position. Many times the poppet valve is set to blow of just after the nose shim stack has opened. Then the opening of the poppet will constitute the end of the knee zone. This is the case here on the compression side at approximately 1.2 inch/second.

The TTX damper has the possibility to produce two knees that can be very much separated (not in this example). Here the first knee is determined by the initial opening of the shim stack (at about 0.4 inch/second) and the second knee by the opening of the poppet valve (at about 1.2 inch/second). The abrupt opening of the poppet valve gives a shorter knee than the more gradual opening of the nose shim stack.

Due to the more open bleed on the rebound. The kneesare not so pronounced.

NOTE:

The knee from the poppet valve is extremely sharp compared to the knee from the shim stack. Both the low and high speed adjustment in combination with the poppet valve hardware including the shim stack in the nose determines the position and shape of the knee/knees. For further information, see section Nose shims effect on damping curve and section High speed adjusters effect on damping curve.

NOTE:

Wide open bleeds in combination with a stiff shim stack and a lot of preload on the poppet valve can allow the low speed zone to extend into relatively high velocities.

The size of the poppet valve and the rate of the coil spring normally determine the slope, also referred to as high speed. In most cases the slope will continue to rise in a straight line to damper speeds well beyond those found in most racing dynamometer charts. Eventually the slope will increase at an exponential rate. This happens when the size of the channels transporting the oil begin to restrict the oil flow (channels are also fixed orifices). The slope angle relative to the horizontal plane defines the magnitude of the slope and can be quantified as Pound/(Inch/Sec.) or N/(m/s).

Some special cases should also be mentioned here. A combination of a stiff nose shim stack and low preload of the poppet valve could take the nose shims more or less out of action. This would give only one sharp knee. More likely is that single knee curves are achieved by running high preload on the poppet, so it never comes off the seat. If so, the high speed is determined by the shim stack only.

The nose, knee and slope are key words to understanding the following concepts.

Figure 7.0 *External adjusters*

7 External Adjusters

General description

Most dampers that are external adjustable have some type of low speed adjuster. Low speed adjusters are almost always externally adjustable orifices that become fixed after adjustment. Fixed in the sense that the orifice area is not dependent on the pressure drop over the orifice. In the damper industry, these adjustable orifices are often referred to as bleeds or low speed adjusters. Unlike shim stacks, bleed orifices do not change size in response to changes in pressure. Because oil will always travels the path of least resistance, it will first flow through the open bleeds until there is enough pressure to open any other valves. Oil flows through the bleeds any time the piston rod is moving, and continues to flow in parallel with the flow through the piston shim stack after the stack has opened.

The most common type of external high speed adjuster is an adjuster that moves the knee up or down without changing the slope, or just marginally changing it. To achieve this, the amount of force pushing the valve, shim or poppet valve, against its seat is varied. That is done by changing the preload of the spring element, shim stack, coil spring, cup spring etc.

The oil flow that is controlled by the external adjusters varies between different type of dampers. The larger the flow is, the better the conditions will be for a powerful adjuster. There are two reasons for that.

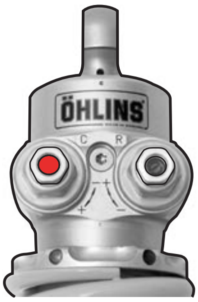
- A larger flow is easier to control. The tolerances for the dimensions on the valve parts have to be tightened if the flow is reduced.

- A larger pressure area, the pressure area is proportional to the oil flow, will keep the internal pressure of the damper at a lower level. This increases the damper response and the damper will build up damping force quicker.

External adjusters summarised

The TTX damper from Öhlins comes as a 4-way externally adjustable damper.

As some racing classes have rules about the maximum number of external adjusters there might be some optional parts available in the future reducing the number of external adjusters.

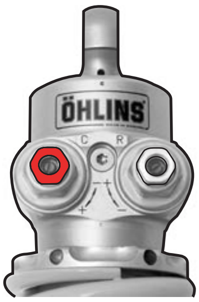


Low Speed Compression Damping Adjuster (LSC)

Type of adjuster:	Bleed adjuster.
Effects:	The flow from the main piston during a compression stroke only.
Pressure area*:	1143 mm^2 (∅40 - ∅12)
Identification:	The black screw with an internal 3 mm hex** inside the gold 12***mm hex at the cylinder head.
Number of positions:	40
Click position 0:	Fully clockwise at maximum force (orifice closed).

Low Speed Rebound Damping Adjuster (LSR)

Type of adjuster:	Bleed adjuster.
Effects:	The flow from the main piston during a rebound stroke only.
Pressure area*:	1143 mm^2 (∅40 - ∅12)
Identification:	The black screw with an internal 3 mm hex** inside the silver 12***mm hex at the cylinder head.
Number of positions:	40
Click position 0:	Fully clockwise at maximum force (orifice closed).



High Speed Compression Adjuster (HSC)****

Type of adjuster:	Poppet valve.
Effects:	The flow from the main piston during a compression stroke only.
Pressure area*:	1143 mm^2 (∅40 - ∅12)
Identification:	The golden 12**mm hex at the cylinder head.
Number of positions:	Approx 50
Click position 0:	Fully clockwise at maximum force (spring max preloaded).

High Speed Rebound Adjuster (HSR)****

Type of adjuster:	Poppet valve.
Effects:	The flow from the main piston during a rebound stroke only.
Pressure area*:	1143 mm^2 (∅40 - ∅12)
Identification:	The silver 12**mm hex at the cylinder head.
Number of positions:	Approx 50
Click position 0:	Fully clockwise at maximum force (spring max preloaded).

* As it is a through rod damper, the compression and rebound pressure areas are the same. The pressure area multiplied with the piston velocity give you the flow (volume per time unit) of oil that passes through the valves.

** During year 2005, an internal 3 mm hex replaced a screwdriver slot.

*** The 12 mm hex has previous been 13 mm.

**** The external high speed adjuster can be eliminated by replacing the needle housing with the one way adjuster needle housing, part no. 5953-03. See ”*Revalving - End piece disassembly and assembly*” in chapter ”*Work Section*”).

As can be seen in the figure, the cylinder head is market “C” and “R” together with “+” and “-”. This will help the first time users to separate Compression from Rebound and tells what direction the adjusters should be turned to increase (+) or reduce (-) damping.

NOTE:

All external adjusters are ”fully hard” when turned clockwise until they stop. The clicker positions, including the high speed adjusters, is always counted from ”fully hard”.

The reason is ”full hard” is always an absolute position. ”Fully soft” will vary more depending on the tolerances, so the matching wouldn’t be as good if the clicker positions were counted from full soft.

The first click and/or detent is counted as ”zero” position.

To match damping curves of a pair of dampers in the dynamometer, sometimes the clicker numbers will end up a couple of clicks from each other. Often they match within ± 1-2 clicks, but sometimes you can see ± 3 clicks.

Just remember maximum clockwise is “full hard” for all adjusters and the adjusters are counted from full hard.

Low speed adjusters

The TTX follows the tradition from the TT44/40 with two fully independent low speed adjusters adjusting the main piston oil flow. For a specific damping force, the internal pressures can be kept low, giving a minimum of delay in the damping force build up.

The two low speed adjusters (bleeds) LSC and LSR are identical and are designed so that in the normal operating range each click of the adjusters will change the damping in close to equal steps. They are tapered needles working in fixed orifices, but due to a double coned nose of the needle, the damping force doesn’t increase progressively per click as the needle is closed. The adjusters are powerful over the whole range making it easier to find the optimum settings.

Both adjusters have a range of approximately 40 clicks. Normally they match within ± 2 clicks.

The bleeds are adjusted with a 3 mm Allen key. During year 2005, an internal 3 mm hex in the needle replaced a screwdriver slot. Do not use too much torque when closing the bleeds completely.

Generally it is better to start with the adjusters a little more open and gradually close them off. See chapter *Damping guidelines* for more information.

Low speed adjusters effect on damping curve

Assuming the LSC and the LSR have the same clicker setting, the piston velocity is the same and that there is no oil flowing through the high speed valves (including the nose shims of the poppet valves), exactly the same amount of oil will flow through both valves. The LSR has exactly the same affect on the nose of the rebound damping curve as the LSC has on the nose of the compression damping curve.

The different curves in the figure are achieved by adjusting only the LSC/LSR. The numbers above the curves represent low speed adjuster clicker settings. The dotted curves pointing upwards indicate the theoretical shape of the curves if there was only a low speed valve and no high speed valve to open. The poppet used here to produce the curves is special made with a flat nose instead of the standard triangular shaped nose to ensure that no oil goes through the nose shim stack. See chapter *Adjustment and valving charts* or the VRP (Valving Reference Program) for real values when the low speed valve is used in combination with different nose shim stacks.

If the adjuster is turned counter clockwise the clicker numbers get higher. As the bleed is opened more and more, the damping is reduced and the speed at which the knee starts increases and the

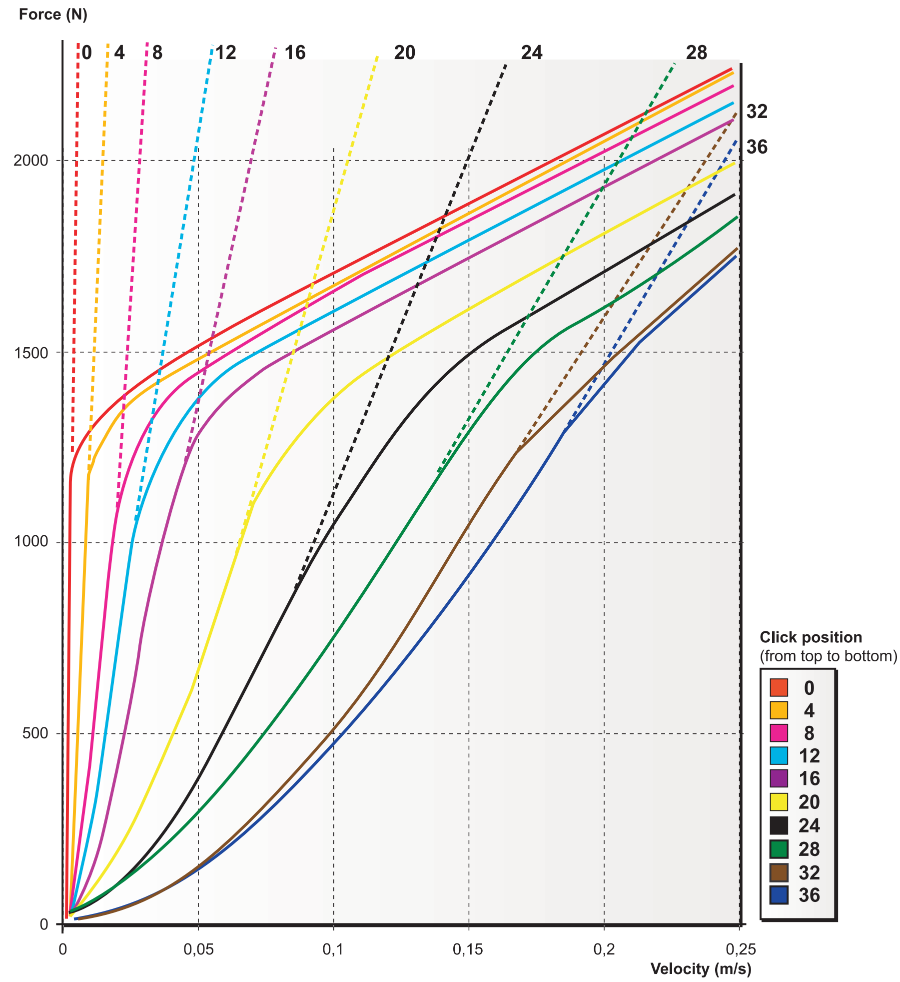


Figure 7.1 *Influence of the low speed adjusters. The graph represents both the LSC and the LSR.*

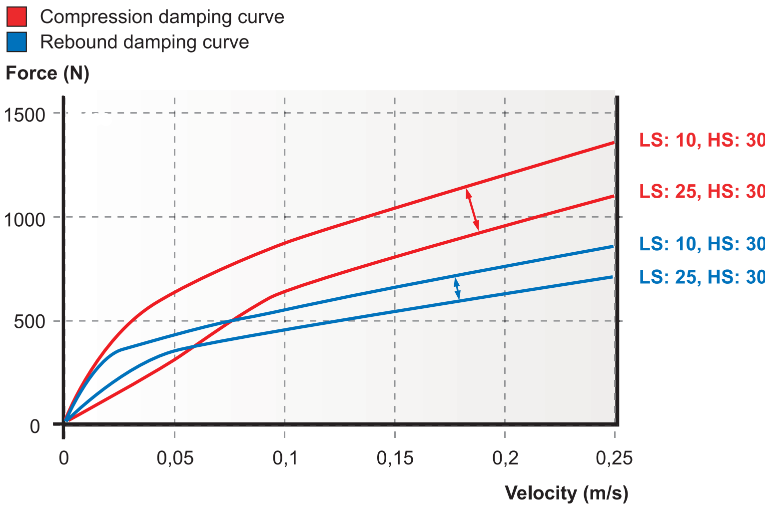


Figure 7.2 *The low speed adjusters affect on the high speed at different high speed slopes. See chapter "Adjustment and valving charts" or the VRP) for real values.*

nose is stretched longer and longer. Also, the force of the knee and the slope angle will remain the same. This is because only the high speed valve determines the knee height and the slope.

This means that even the high speed damping will drop as the low speed adjuster is opened. The more slope there is, the more the high speed will drop. Conversely, if you wish to keep the knee force constant, the poppet preload has to be increased every time the low speed adjuster is opened.

If the low speed adjuster instead is turned clockwise, the opposite from above will be true.

High speed adjusters

The TTX has two hight speed adjusters; one for compression and one for rebound. A damper like the TTX is often called fully adjustable. This provides race engineers and technicians with more external control over the damping. Anything that can make an adjustment quicker and thereby gain time during practice and qualifying is important.

Just as the low speed adjusters, the high speed adjusters HSC and HSR are identical (only the colour of the needle housing is different), fully independent and adjust the main piston flow. They are delivered with the same valving.

Both high speed adjusters consist of a poppet valve preloaded by a coil spring. The coil spring pushes the poppet against its seat. The preload of the spring determines the pressure differential needed to make the poppet lift from its seat. The adjusters change the amount of preload. A preload change will change the height of the knee. Each click of the adjusters changes the damping in almost equal steps.

A poppet valve works like a shim stack. Both are pressure regulators that control oil flow by opening at a pre-determined pressure and thereby providing a path for the oil to flow.

In the nose of the poppet valves, shims make it possible to adjust the sharpness of the knee. An alternative poppet valve is available with a corresponding valve seat. Also there are three other springs available. See Internal adjustments for more information about the alternative hardware in the valves.

Each high speed valve consists of the following parts that can be changed

- 04104-02 Valve seat ⌀12
- 04103-06 Poppet valve
- 04107-04 Spring c=40 N/mm, t = 2.20 mm
- 01415-14 x 3 Nose shim, 0.15x14

In the first generation of TTX dampers the poppet valves and springs were different. These dampers are marked TTX NE020 and TTX NE040. In these dampers, the parts used are

- 04103-04 Poppet valve
- 04134-04 Spring, c = 40 N/mm, t = 2.40 mm

These parts generate the same forces. The new 04107-04 Spring is 1 mm shorter (15.5 mm instead of 16.5 mm), but on the other hand the 04103-06 Poppet valve is 1 mm higher (3.5 mm from the surface of the triangle to where the spring stands instead of 2.5 mm). The same thing is true for the new alternative poppet valve 04103-07 compared to the old 04103-05. The reason fo r the change is that the new combination keeps the high speed less progressive at high velocities (about 1.5 m/s).

For information about the alternative valve hardware, see Internal adjustments.

Both high speed compression and rebound adjusters have a range of approximately 50 clicks. Normally they match within ± 2 clicks. The thickness of the nose shim stack affects the number of clicks. An increased thickness of the stack reduces the number of clicks. For example, if the shim stack thickness is increased by 0.25 mm, there will be about 4 clicks less and vice versa.

The preload is adjusted with a 12 mm wrench. A 13 mm wrench has previous been used.

Note: It is no problem to run the high speed adjusters at clicker position 0, as it is the needle housing that bottoms against a circlip and not the spring that is coil binding.

High speed adjusters effect on damping curve

If the high speed compression and rebound valves have identical hardware and the adjusters are set the same, the damping forces will turn out the same.
The height of the knee is changed and the steps are about the same over the whole adjustment range.
The low speed isn't affected at all and the slope remains unchanged.
To change the slope, the hardware

has to be changed.

As mentioned before, there is one alternative poppet valve (part no. 04103-07) and three other springs (04107-01 (10 N/mm), -02 (20 N/mm) and –08 (80 N/mm)) available. The figures below illustrate how these parts will change the adjustment range. For information about the alternative hardware, see Internal adjustments.

The alternative poppet valve 04103-07 increases the adjustment range and raises the slope. This poppet valve can of course also be combined with the alternative springs.

Figure. The alternative valve springs affect the adjustment range compared to the standard spring 04107-04 (40 N/mm) if the other valve parts are kept standard and the low speed adjuster is set at clicker position 20.

What can be noticed is that the adjustment range changes a lot depending on the spring used, but the influence on the slope is fairly small. The window of adjustment starts at about the same level for each spring, but reaches different maximum limits. The difference in the maximum force is proportional to the difference in spring rate. The same is true for the change in force per click adjustment.

Shaping the high speed

The height of the knee depends on the stiffness and preload of the spring together with the pressure area of the poppet. If the area is small it takes a higher pressure to overcome the force that is acting on the poppet. The spring rate and the pressure area also control the slope of the graph by restricting the maximum size of the fluid path past the poppet.. This is why the alternative poppet (part no. 04103-07), that is smaller, lifts the knee higher and increases the slope.

Note: The spring rate is not a very powerful tool when it comes to changing the slope. For example if the spring rate is increased by a factor 10, the slope will only rise about 60%, but the adjustment range is increased about ten times.

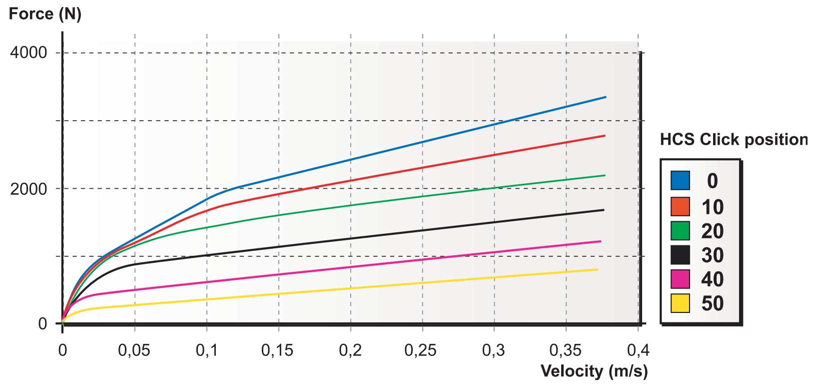


Figure 7.3 *The influence of the high speed adjusters. Here the standard valving is used and the low speed adjuster is set at clicker position 0. The graph represents both the HSC and the HSR.*

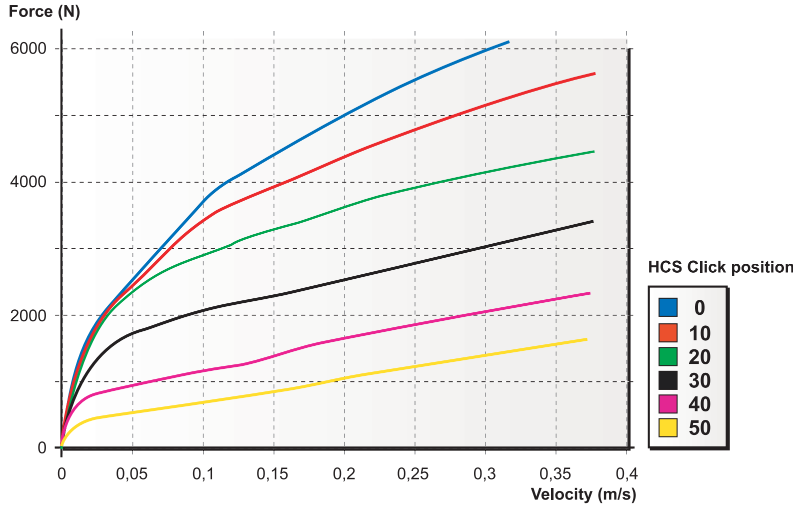


Figure 7.3 *The alternative poppet valve 04103-07 affects on the adjustment range compared to the standard poppet valve 04103-06 if the other valve parts are kept standard and the low speed adjuster is set at clicker position 0.*

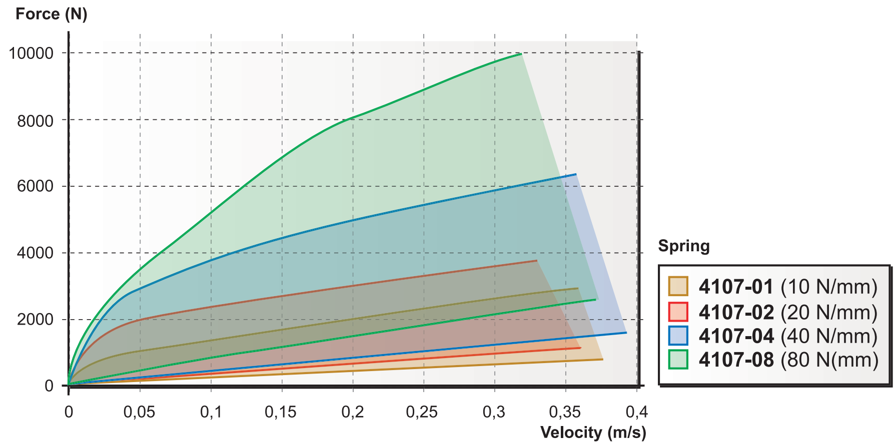


Figure 7.4 *The alternative valve springs affect the adjustment range compared to the standard spring 04107-04 (40 N/mm) if the other valve parts are kept standard and the low speed adjuster is set at clicker position 0.*

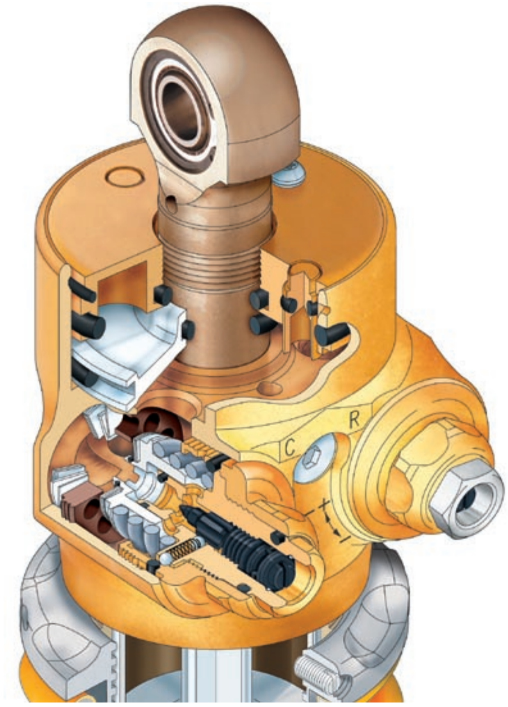


Figure 8.0 *Internal Adjustments*

8 Internal Adjustments

Now we have just learned about the external adjusters. We now need to look inside to see what tools are available to influence the damping.

Unlike the TT44/40 damper, there are no valves on the main piston. The high speed valves instead consists of two identical poppet valves. This gives more freedom to use the same poppet for either compression curves and rebound curves.

Poppet valves

There are two different poppet valves available. They are

- 04103-06 Poppet valve (standard)
- 04103-07 Poppet valve

The optional poppet valve has a smaller nose and goes with smaller valve seat (∅10 mm hole). The two available valve seats are

- 04104-02 Valve seat (∅12, goes with poppet 04103-06)
- 04104-01 Valve seat (∅10, goes with poppet 04103-07)

NOTE:
Do not use other combinations of poppet valve and valve seat.

In the first batch of TTX dampers the poppet valves and springs were different. See section High speed adjusters for more information.

The standard poppet valve (04103-06) has a triangular plateau on the nose, while the smaller poppet (04103-07) has a rectangular shaped nose. The reason for these shapes is to allow the nose shims to lift away from the seat. With the high speed coil spring pushing the poppet from behind, it clamps the stack against the seat. The standard poppet clamps the shims at the corners of the triangle. This means that the nose shims can lift in the three areas outside the triangle. The optional poppet does the same thing except the shims are allowed only to bend in two areas opposite from each other along the rectangular plateau. This shim action is comparable to the difference between the shim movement on a conventional 3 port piston versus a 2 port piston.

If the poppet together with the hole of the valve seat is smaller, the forces from the nose shim stack increase and due to the physical reduction in the shim area allowed to bend (leverage), changes in shim thickness will do very little to lower the stack stiffness. To get the leverage back, and thus the adjustability of the shims the nose on the smaller poppet has gone from a triangular shape to rectangular.

Each poppet valve is guided by its needle housing. On each needle housing there is an o-ring that both seals and damps the poppet. Without the o-ring, the poppet would oscillate on the undamped spring.

See the previous chapter External adjusters for information about how the adjustment range will be affected by a poppet valve change.

Valve springs

There are four different valve springs available. They are

- 04107-01 Spring c=10 N/mm, t = 1.70 mm
- 04107-02 Spring c=20 N/mm, t = 1.80 mm
- 04107-04 Spring c=40 N/mm, t = 2.20 mm (standard)
- 04107-08 Spring c=80 N/mm, t = 2.75 mm

In the first batch of TTX dampers the poppet valves and springs were different. See section High speed adjusters for more information.

See the previous chapter External adjusters for information about how the adjustment range will be affected by a poppet valve change.

Nose shims

A poppet valve generally gives a very sharp knee due to the abrupt opening/closing characteristic. However, it's possible to design a poppet valve that opens smoothly. To do this with the poppet alone you would need many different designs each with there own knee characteristics. Instead of doing this, the TTX uses shim stacks to manipulate the opening characteristic of the poppet. Before the poppet has lifted from the seat, the shims are clamped between the poppet and the valve seat. As the shim stack gradually starts to open before the poppet does, the oil is released gradually creating a smooth transition from closed to open. Using nose shims gives more freedom of adjustment and keeps the cost down for the customers as they don't need a lot of different poppet valves.

When the poppet has lifted from the seat, the pressure and oil flow will keep the shims towards the poppet. So the damper can actually be used without the circlip in the nose of the poppet, but this is not recommended.

The shim stack continuously interacts with the poppet valve. Even after the poppet has lifted from the seat the shims in the stack continue to move. This makes it hard to predict the shape of the damping curve without testing the particular poppet, spring and shim stack combination.

By using these shims, it is also possible to run steep slopes at high speed by just using the shim stack as the high speed valve. This is achieved by using a fairly stiff shim stack in combination with a high preloaded poppet valve so the poppet doesn't open. The highest opening pressure is achieved with the small poppet (part no. 04103-07) in combination with the stiffest spring (part no. 04107-08) used at clicker position 0. However, this eliminates the external high speed adjustment.

The internal diameter of all shims is 6 mm. For each poppet, only one outer diameter is used.

The available shims for the standard poppet valve 04103-06 has outer diameter 14 mm and are

- 01410-14 Shim t = 0.10 mm
- 01415-14 Shim t = 0.15 mm
- 01420-14 Shim t = 0.20 mm
- 01425-14 Shim t = 0.25 mm
- 01430-14 Shim t = 0.30 mm

The available shims for the alternative poppet valve 04103-07 has outer diameter 12 mm and are

- 01410-12 Shim t = 0.10 mm
- 01415-12 Shim t = 0.15 mm
- 01420-12 Shim t = 0.20 mm
- 01425-12 Shim t = 0.25 mm

The number of combinations is huge.

The combinations used in the Valving Reference Program (VRP) for the standard poppet 04103-06 are:

- 2x 0.15-14
- 2x 0.15-14 + 1x 0.10-14
- 3x 0.15-14
- 2x 0.20-14
- 4x 0.15-14
- 2x 0.20-14 + 1x 0.15-14

The combinations used in the Valving Reference Program (VRP) for the alternative poppet 04103-07 are:

- 2x 0.15-12
- 3x 0.15-12
- 4x 0.15-12

These stacks are listed softest to stiffest.

Note: *Keep in mind that a thickness change of the shim stack changes the preload of the poppet. A height change of 0.0625 mm corresponds to 1 click.*

Nose shims effect on damping curve

If the low speed adjuster is set to a closed position, the nose shim stack knee can be studied.

As the bleed is fully closed here, all flow goes through the shim stack until the poppet lifts from the seat. The slope between the two knees is depending on the rate of the shim stack. The slope raises as the stiffness of the shim stack increases.

Note: The nose shim stacks can be compared with non preloaded main piston shim stacks, as the load from the poppet on the shims doesn't preload the shims, but just clamps them.

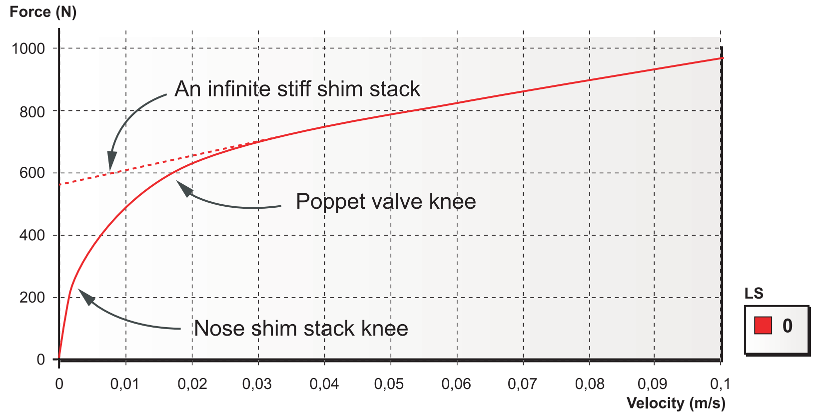
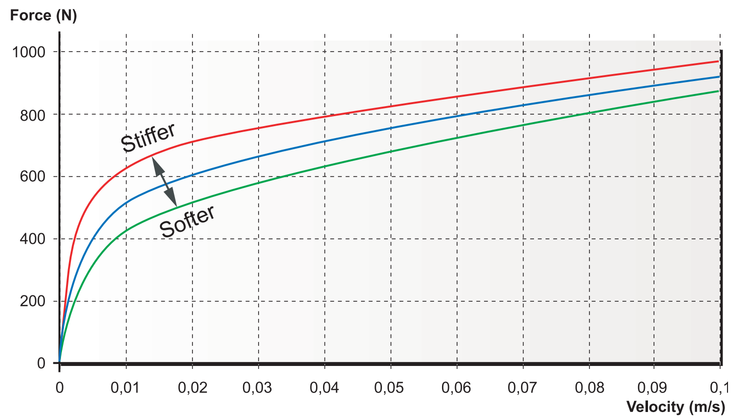


Figure 8.2 *The shim stack knee and the poppet valve knee.*



Using the damper without the external high-speed adjuster.

The external high-speed adjuster can be eliminated by replacing the needle housing (5953-01 or 5953-02) with the one way adjuster needle housing 5953-03 (including a cylinder pin) preventing the needle housing from rotating.

You can still preload the spring (high-speed damping) by adding shims in top or underneath the spring. Preferably add shims between the spring and the needle housing (max shim stack thickness: 1.2 mm). To increase the preload more than the 1.2 mm produced by this 1:st stack, add extra shims at the 2:nd stack (max shim stack thickness: 2 mm) between the spring and the poppet valve (See figure 8.3).

See table in Figure 8.4 for shims to be used, shim thickness and the number of clicks the thickness corresponds to.

For instruction see "*Revalving*" in chapter 18, "*Work Section*".

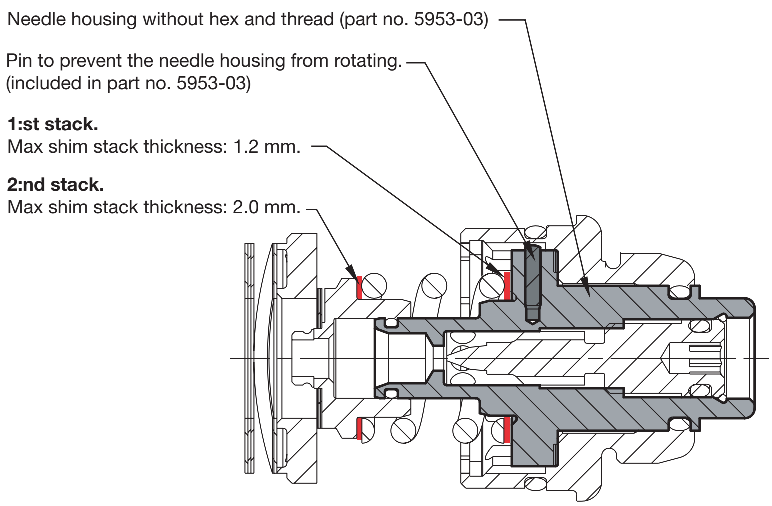


Figure 8.3 *Instruction for the one way adjuster, Part No. 5953-03*

Part No.	Shim thickness	Corresponding number of clicks
00610-16	0.10	1.6
01115-16	0.15	2.4
00520-16	0.20	3.2
00525-16	0.25	4.0
00530-16	0.30	4.8

Figure 8.4 *Shims to be used.*

9 Limits in Force and Velocity

The TTX is designed for pretty low damper velocities. It is hard to give a definitive limit in velocity, but peak velocities from 1 to 1.5 m/s (40 to 60 inch/s)are no problem.

When it comes to the limit in damping force, it is important to know that the peak forces are not normally the problem, fatigue is. Be aware that increased temperature reduces the strength of the materials. Peek loads at 90ºC (250ºF) reaching 8000 N (1800 lbs.) can be handled by the TTX with no problem.

10 Matching of Damping Force

Even with tight tolerances, the types of high speed valves used in the TTX are hard to get to match compared to main piston shim stack valves. This is the drawback of this type of valves. The adjusters can on the other hand be made extremely powerful and if a dynamometer is available, the graphs can be spot on if the adjusters are changed a few clicks.

Dampers set at the same clicker positions should match within ±10%, but many times they match within ±5%.

All TTX dampers are dynamometer tested at Öhlins Racing before they are delivered.

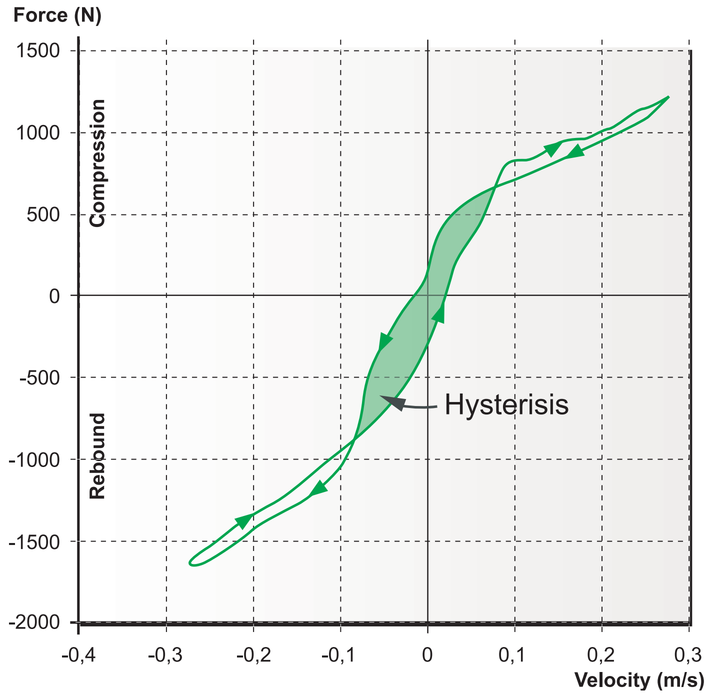


Figure 11.0 *Damping force during a complete sine-wave cycle illustrating hysteresis. Due to the low hysteresis of the TTX, some oil has been replaced with air to get a better illustration of hysteresis.*

11 Hysteresis

Start by studying chapter *Damping force measurement*.

Among teams, the experience of hysteresis mainly comes from continuous measurement of damping force during sine wave runs in a dynamometer. On those damper graphs, there is always a difference in ascending (acceleration) and descending (deceleration) parts of the curve around zero velocity. We normally refer to this area as *hysteresis*. At constant velocity or peak force measurements, the hysteresis can't be detected. Technically, the term hysteresis is related to energy losses, but here we are actually storing energy as the damper acts like a spring.

Hysteresis is actually flex in the damper system. The flex delays pressure rise and pressure drop. Hysteresis affects the performance of the damper. Generally, a minimum of flex is desired. Especially where there are very short damper movements. For example in single seaters, with very short strokes, you are dependent on quick damping force build up and if there is any delay, the damper might changes direction before there is any damping at all. Because of this, hysteresis needs to be kept to a minimum.

How much the delay affects the damping curve is very much related to the stroke and frequency in the test. When keeping the maximum velocity constant and varying the frequency and stroke, it is very obvious that with a short stroke and a high frequency the hysteresis deforms the damping curve more than long stroke and low frequency.

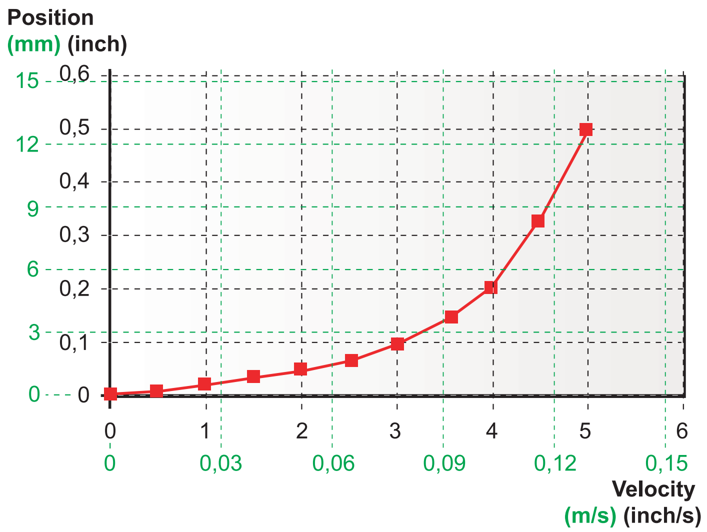


***Figure 11.1** Stroke-velocity relation in a typical dynamometer run. Peak velocity 5 ips (0.127 m/s) and frequency 2 Hz.*

In the graph (figure 11.1), the relation between displacement and velocity is shown for a peak velocity of 5 ips (0.127 m/s) and a frequency of 2 Hz.

NOTE:
The displacement at lower velocities is very small. Because of this, still with very little flex in the damper, the hysteresis in a dynamometer graph can easily be seen.

In a graph illustrating damping forces, the hysteresis changes the damping curve in a similar way as a more open bleed would do – both delay the damping force build up when using a sine input. The force drop from a more open bleed depends on the actual velocity, while the force drop due to increased hysteresis depends on the stoke. The setting and the hysteresis affect each other. The hysteresis increases at increased damping.

If only the compression acceleration and the rebound deceleration are illustrated, you don't see the amount of hysteresis. Therefore, it is easy to believe the bleed is more open when it actually is due to the hysteresis. There have been situations when teams have used the dampers with a low speed adjuster set to almost fully closed position. As the damping curve nose at continuously measurement still doesn't go vertical, the teams have asked for a different adjustment range of the low speed adjusters to put the actual clicker setting more in the middle of the range. Here, they have been misled by the hysteresis. Due to the low amount of hysteresis of the TTX compared to other dampers, this should be less of a problem.

Damper flex can be classified into three different groups: flex of damper parts, flex due to damper oil compressibility, and flex of gas present in the oil (dissolved or bubbles). The flex of the damper parts is fully elastic and linear. The compressibility of the oil itself is not linear. Some hysteresis comes from the compression and expansion of gases in the oil. Gas bubbles in the oil will be compressed in a very progressive way and will act almost like a slack in the system. Dissolved gas in the oil is a result of different factors. Air enters the damper during the filling procedure and some air is already dissolved in the oil when it is delivered. By using a vacuum filling machine, the amount of air in the oil can be minimised. With a vacuum machine there is no risk of trapping air in the damper. The oil used for filling the damper has been under low pressure for some time before it enters the damper. This removes air dissolved in the oil. But even without air, there will be gas bubbles at low pressures. Oil contains different additives that boil at different pressures/temperatures. At low pressure, those additives change to a gaseous form which creates bubbles. See chapter *Cavitation* for more information.

The amount of hysteresis for a certain damping force can be very different depending on the size of the piston (pressure area) and the volume of oil that is pressurised. The larger the piston is, the easier it will be to reduce the hysteresis. This is explained by the formula $F = p \bullet A$. F is the force, p is the pressure and A is the pressurised area. For a specified damping force (F) a smaller area (A) will lead to a higher pressure (p). The higher pressure will make the damper flex more. This will cause more hysteresis. On conventional dampers (the gas reservoir is connected to the compression side), not on the TTX, the piston rod acts as a small diameter piston sending oil to the valve in the reservoir. Because the effective pressure area is very small and the total oil volume is large, there will be a lot of hysteresis from this portion of the damping force compared to the damping force produced by the main piston.

On all dampers where the internal pressure of the damper pushes the piston rod out of the damper body, a "hysteresis effect" might be seen on the dynamometer graph. This is not the case with the TTX. How much of this "hysteresis effect" that will be seen depends on how well the dynamometer compensates for the gas force. The reason for this is that on a conventional damper the static piston rod force varies depending on the position of the piston rod. The more compressed the damper is, the higher the internal pressure will become due to the gas volume being compressed. For example, if the gas force compensation only reduces the compression damping and increases the rebound damping with the static piston rod force measured when the damper is at maximum length in the dynamometer, the compensation will not be enough when the damper is more compressed. This difference can be mistaken for hysteresis. Good gas force compensation will avoid this problem.

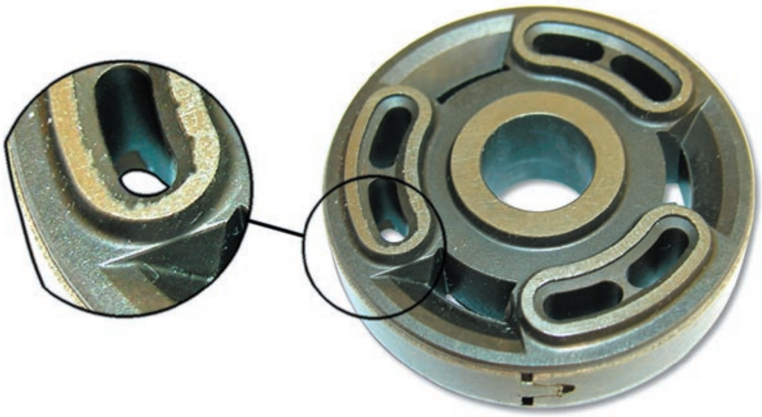


Figure 12.0 *Example of cavitation pitting on a shimmed piston.*

12 Cavitation

Cavitation is a word used a lot in the pump and damper industry for describing the phenomenon when gas bubbles are produced in fluids at pressure drops. The gas comes from both the fluid that has changed its state from fluid to gas and from air that had been dissolved in the fluid. Cavitation also includes the collapse of the gas bubbles when the pressure increases and the gas returns to liquid form.

In conventional dampers, cavitation very often occurs on the rebound side of the piston. If no reservoir valve is used the damping force mainly comes from a pressure drop on the rebound side. Here the set gas pressure has to be high enough to allow a pressure drop on the rebound side without letting it get too low. By using a reservoir valve the pressure doesn't have to drop as much on the rebound side as there also will be some increased pressure on the compression side due to the reservoir valve. However, if the piston rod is extended near full rebound, the volume on the rebound side will be small and the pressure will drop very quickly, so some cavitation will still occur.

Cavitation in dampers should always be prevented. Cavitation can cause serious malfunction, reduced performance and damage the damper.

Absolute pressure, temperature and type of fluid are factors that affect the risk of cavitation. Normally, an absolute pressure drop below 0.7-0.8 bar (10-12 psi) cause cavitation. For your information: The absolute pressure in the atmosphere is close to 1 bar (15 psi) at sea level altitude. High piston accelerations will increase the risk of cavitation as pressure changes do not immediately effect the entire volume of oil due to delays in the pressure distribution in the fluid. These different pressures in the same volume of oil are sometimes called “dynamic pressures”.

As cavitation is a state change from fluid to gas, compare boiling of water, an increased temperature increases the risk for cavitation. However in damper applications the influence from temperature variations is normally relatively small compared to the influence from pressure variations.

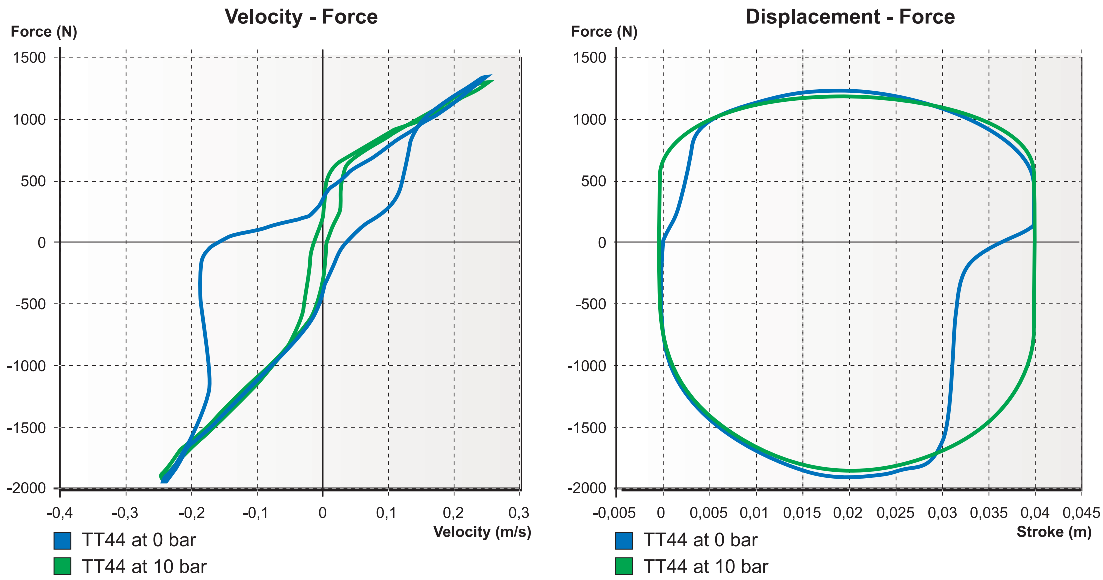


Figure 12.1 *Example of cavitation in a TT44 tested at 0 bar of reservoir gas pressure. The curves are produced at continuously force measurement at a sine wave cycle with peak velocity 0.25 m/s.*

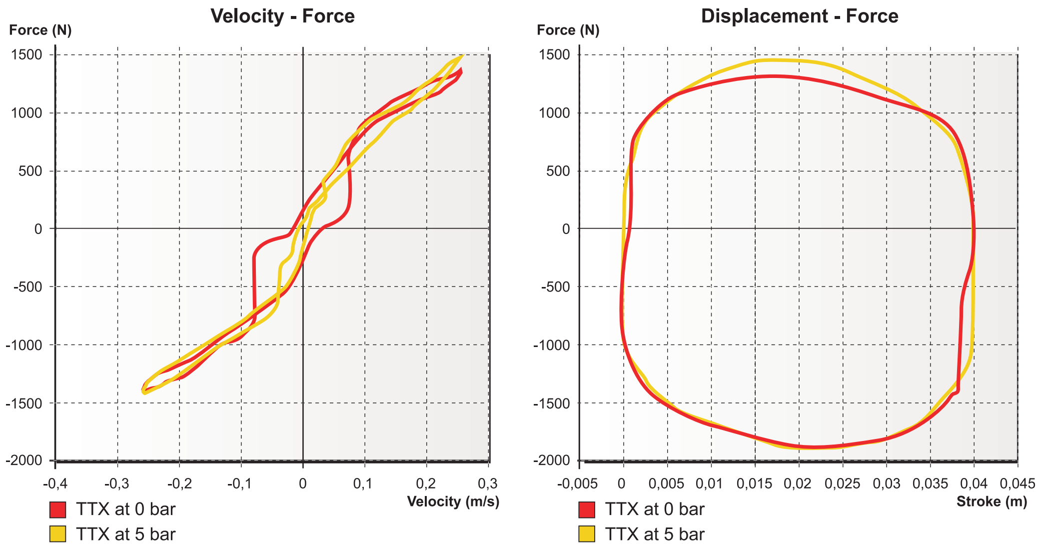


Figure 12.2 *Example of cavitation in a TTX tested at 0 bar of reservoir gas pressure. The curves are produced at continuously force measurement at a sine wave cycle with peak velocity 0.25 m/s.*

In non-TTX type dampers, pressure drops are found at the backside of the main piston and at the outlet of the valves. If the volume of fluid where the pressure drop happens is pressurised high enough, the produced gas bubbles caused by delays in the pressure distribution will disappear right away. As these small bubbles only occur very locally in direct proximity of the piston/valves this phenomenon is sometimes called “local cavitation”. However, cavitation normally refers to conditions where the pressure is low enough to make the small gas bubbles combine to large volumes of gas. If these volumes of gas pass through the valves instead of damper fluid, the damping will go away.

When the gas bubbles are exposed to higher pressure, they will implode. These implosions could cause damage to damper, so called *cavitation pitting*. Often sounds from the implosions can be noticed as a hissing or gurgling sound. As most dampers use shimmed main pistons, damage from cavitation is normally found at the outlet ports of the pistons. The damage is very dependent on the geometry of the piston.

In a conventional damper, the cavitation starts during the compression strokes. If the absolute pressure (see below) on the rebound side drops too much during a compression stroke, gas bubbles will occur. This leads to a stop in pressure drop on the rebound side. The volume increases as the oil changes from fluid to gas and oil from the compression side is dumped into the reservoir. Any additional damping force will come from increased pressure on the compression side. On the following rebound stroke, there will be a lack of oil on the rebound side and this will lead to a delay in the rebound damping force build up.

Most conventional dampers have some type of reservoir valve. This valve is often referred to as a compression valve, but the main purpose of this valve is to improve damper response and reduce the risk of cavitation. By adding a restriction in the reservoir, the absolute pressure on the compression side will be higher for a specific compression damping force. This means that the pressure on the rebound side does not have to drop as far to achieve the same pressure differential across the valve. This shortened pressure drop allows that differential to happen in less time, which equals response time, and also keeps the rebound pressure away from the cavitation limits. This may decrease the risk of cavitation, but it adds hysteresis to the damper.

In a conventional damper with no reservoir valves, the available damping force before cavitation can be estimated from the formula below.

$$F_{max\ comp} = p_{reservoir} \bullet A_{rebound}$$

$p_{reservoir}$ = reservoir gas pressure (not absolute pressure)

$A_{rebound}$ = area of the rebound side of the main piston (piston area minus rod area).

Always try to stay with the recommended gas pressure and keep the extra margin against cavitation by adding reservoir damping.

In the TTX, the risk of cavitation is always minimised. Check valves prevent the pressure from dropping below the set gas pressure. This results in always having the same good margin for cavitation, no matter how high the damping forces are. Cavitation in the TTX can only occur if the oil isn't pressurised. Even a tiny pressurisation of 1-2 bar (15–30 psi) is enough. There will be no pressurisation of the oil if

- The reservoir isn't pressurised
- There is too little oil in the damper.

If the oil level is to low, the separating piston won't be pushing on the fluid and can't add any pressure to the damper fluid. The reason why some pressure has to be added to the damper fluid to avoid cavitation in the TTX is that there will always be small areas with pressure drops in channels and check valves.

The easiest way to study cavitation in a dynamometer is to reduce the reservoir gas pressure. Continuous measurement is the best way to identify cavitation, as the acceleration and deceleration part of the damping curve separates due to the delayed damping force build up. In a conventional damper the delay will mainly be noticed on the rebound side. While in a TTX the delay will very much less. In a TTX there will be about the same delay on compression and rebound. Even with constant velocity or peak velocity measurement, cavitation can sometimes be observed. However it will be more difficult to know if the loss in damping force actually is due to cavitation or some other factor.

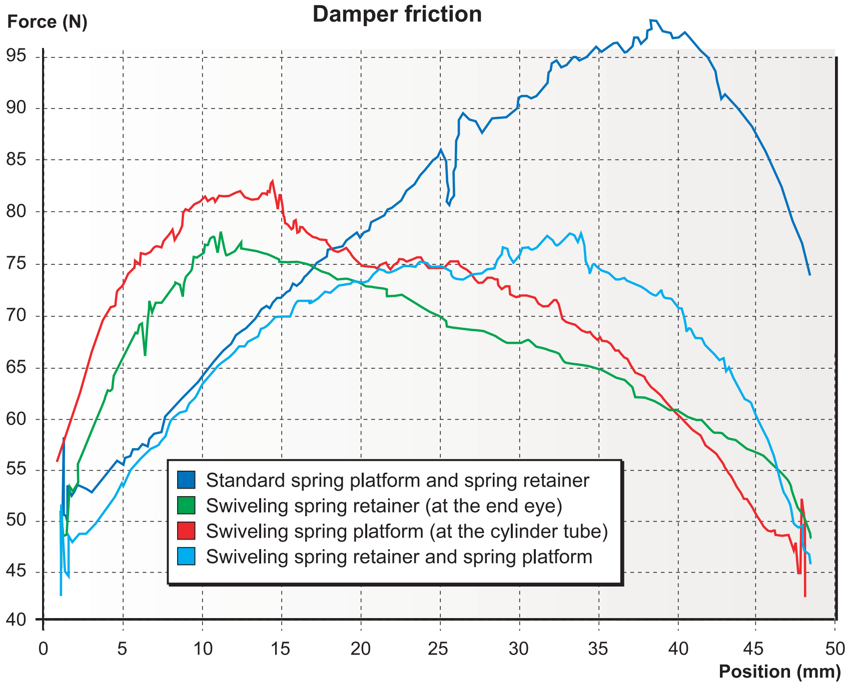


Figure 13.0 *Damper friction verses stroke in a TT44. The higher the position number is, the more compressed the damper is.*

13 Friction Levels

For some period in history, damping came mainly from friction. For example, leaf spring friction on trucks gives damping. As the damping characteristics of friction are maximum force at the start of the movement and normally with little or no relation between friction force and velocity. Friction doesn't result in a desired damping characteristic for a vehicle. The level of friction is also hard to control. As racing teams always try to optimise everything to gain performance, the levels of friction can not be neglected.

It is normally hard to quantify the level of friction in the suspension as it depends on the loads. When it comes to the dampers, the spring element used is a determining factor. Coil over springs always cause bending forces to the dampers, as the springs are not perfect. Here the main friction comes from the bushings. The design of the TTX will guarantee minimum friction forces when subjected to side loads (See section *Piston rod guide/seal*).

There are always some variations in friction between individual dampers. After the dampers have been run in, the friction will be reduced.

Without side loads, the friction levels of a TTX could be expected to be in the region of about 15 - 17 N in sliding friction and about 22 - 24 N in starting friction. One reason for these low values is the low gas pressure. Another reason is that the separating piston doesn't move as the piston rod displaces oil. Therefore, there is no friction from the separating piston.

If side loads are added, it is hard to give some exact numbers of how the TTX perform friction wise compared to for example a TT40, as is very much depends on the spring used and the position of the piston rod, but a reduction of friction with about 50% can easily be found.

Many times but not always, a swivelling spring retainer and/or spring platform reduce the friction from side loads caused by coil springs. In the figure below shows how the friction force varies over the stroke in a TT44 with different combinations of spring retainers and spring platforms. The best combination depends on the position of the piston.

NOTE:

The figure here is only for illustrating the trends for a non through rod damper. The numbers are only true for this particular hard ware combination.

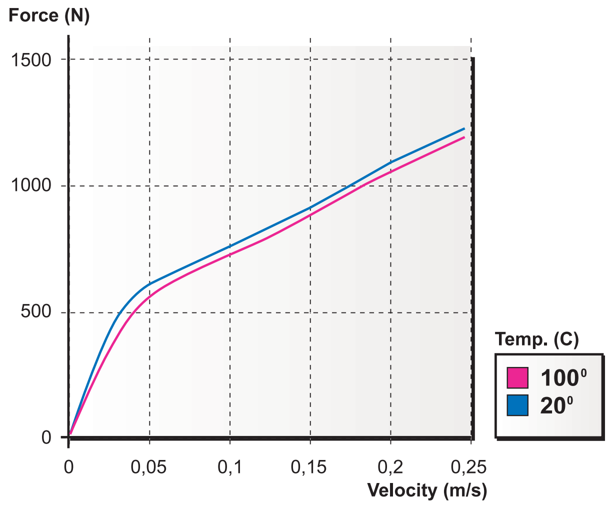


Figure 14.0 *Example on how the damping force can drop in a TTX if the temperate raised from 20° C to 100° C.*

14 Temperature Stability

In all dampers, the damping force changes due to temperature variations. As the viscosity drops when the temperature rises, the damping force will drop unless there is some "compensation". The word *fading* is often used for this loss of damping. The compensation is normally done by using materials in the bleed needle and housing, so the opening of the bleed path is reduced as the temperature goes up. An enclosed volume of fluid can also be used to push the needle closer to the seat. The lengths of the two parts have to be correct to get an acceptable compensation. However the compensation can never be perfect and any overcompensation is objectionable.

How much focus there is on fading varies. On most applications, the temperature rapidly reaches a constant operating temperature. In single seaters, there is generally a fairly low amount of energy absorbed by the dampers. Therefore, the temperatures are normally very stable – in the front they stay low and in the rear they are kept high by the engine. See the chapter *Temperature range* for recommended temperatures. In applications were a lot of energy is absorbed by the dampers, fading might be more of a concern.

The amount of fade will depend on the type of flow through a valve. Flows are divided in to two different categories – laminar and turbulent. In general, laminar flow occurs where the area change is gradual and the restriction is extended in length. Turbulent flow results from an abrupt area change. Also, the velocity of the fluid moving through the valve has an influence on the type of flow. Increased velocity increases the amount of turbulent flow. At laminar flow, the restriction depends on the viscosity, while turbulent flow is not as sensitive to viscosity changes.

The drop in damping force is not linear with respect to temperature and depends on the fluid used. The Öhlins 309 oil for instance drops little in viscosity above 50°C.

It is very hard to give correct values on how much fading there is in a damper as there are huge variations, both in force and in percentage of force, due to settings and velocity. The settings include both hardware and how the adjusters are set. Expressed as percentage of drop in damping force, fading will always go down as the velocity increases. In general, compared to a TT44, the TTX fades more at lower damper velocities while the TT44 drops more at higher velocities.

NOTE:

For simulations, keep in mind that the actual damping force you have on the car might be lower than what the dynamometer testing at room temperature indicates. For this reason dynamometer testing for this purpose should be done at operating temperature. When only comparing settings, dynamometer testing can be made at room temperature if it is always done this way.

Figure 15.1 *Jason Bright, Ford Performance Racing.*

15 Damper Functions

by Bruce Burness

Historically, dampers were asked only to provide a comfortable ride. If you were lucky, driver controllability was enhanced at the same time. With the advent of ground effect aerodynamics in the late seventies, racing engineers discovered that damper settings are a valuable tool for optimising "aero" effects. At the same time, the tire companies found they needed to redesign their tires to take advantage of the downforce created by the new ground effect aerodynamics. The mechanical grip of these new tires also turned out to be extremely sensitive to damper settings. These developments doubled the number of duties required of dampers of today. The priority list today for racing damper functions is "areo" management, mechanical grip, tire wear, driver controllability and ride comfort. Dampers have a powerful influence on the performance of your car.

These five damper functions are all interrelated but at the same time optimising one of these functions can sabotage another. A compromise between function goals is many times unavoidable. Finding the most effective compromise is the overall goal and will pay dividends on the racetrack.

Comfort, grip and control

These five goals are so tightly interwoven that most of the time it is very difficult to make a damping change and then properly assign the performance gain or loss to the correct category. For example, let us say you have added some extra compression damping to the front dampers and now the front tires have gained grip. The question is did we create pure mechanical grip from the tires or is the gain from improved aerodynamics or from better dynamic fore/aft pitch control or possibly a higher dynamic ride height or centre of gravity which could also change dynamic roll centres. It is not essential to know the exact cause and effect, but it is possible through a cleverly planned sequence of subsequent tests to better isolate the gain and assign it to the correct category. If this is achieved, the focus of further testing will be more on target and the possibility of a wayward theory will be minimised.

All this may sound too hypothetical but rest assured if you optimise the aerodynamic potential without compromising the grip and then find the mechanical balance by adjusting the springs, sway-bars, etc. the driver controllability will most likely be there automatically. The ride comfort may be compromised but do not be too concerned. Even though Öhlins dampers generally produce an improved ride quality, we have found that damper settings that give too much comfort cannot provide optimum grip or controllability.

Aerodynamic management

In this ground effect age, dampers can maximise the amount of downforce generated by the underside of the car by assisting in maintaining a constant air gap between the underside and the ground. Today we have basically two types of formula car ground effect configurations, *tunnels* and *flat bottoms*. With both types the clearance between the underside and the ground is very critical. Generally there is a ride height ”sweet spot” that is favourable for generating high downforce with a minimum of ”aero” drag. The problem is that this ”sweet spot” is very close to the ground. Good damper settings will keep the car at this ideal ride height a higher percentage of the time through most dynamic conditions without allowing the underside to contact the ground (bottoming).

With both tunnel and flat bottom cars the centre of the downforce is found where the geometry of the underside comes closest to the ground. With either type of car the centre of downforce migrates with any change in pitch angle in relation to the ground caused by braking, cornering or acceleration. This migration of the centre of downforce alters the handling balance by increasing the downforce towards the direction of migration and reducing the downforce away from the migration. Therefore, added tire grip will occur at the end of the car that moves closer to the ground.

Tunnel cars have far less downforce migration than flat bottom cars because the contour of the tunnel is curved in the shape of a venturi with a raised entry that curves down to a short flat area followed by a long, slowly enlarging exit. Tunnels are generally positioned near the vehicle centre of gravity. The tunnel flat part is in the closest proximity to the ground and that is where the centre of downforce occurs. When the car pitches fore or aft this part of the tunnel primarily rocks back and forth and does not raise or lower significantly. Tunnels minimise downforce migration.

Flat bottom with diffusers

On the other hand, flat bottom cars with diffusers can have the downforce migrate from just ahead of the diffuser at the back all the way to the tip of the nose under braking. For cars with raised noses the migration will essentially stop where the underside begins to move away from the ground. Flat bottom cars are much more sensitive to static and dynamic pitch changes than ground effect cars. Damper settings for flat bottom cars therefore need to be biased more towards pitch control than the settings for tunnel cars.

Both tunnel and flat bottom cars can also benefit by keeping the underside parallel to the ground, side to side, while cornering. In this case, the downforce migrates from side to side but also will diminish substantially if the inside of the car raises away from the ground. For cars that turn only one direction as on an oval, sometimes higher corner speed can be achieved by increasing the compression damping and reducing the rebound on the right side (outside) and the opposite on the left side (inside).

Mechanical grip

Compared to aerodynamics, understanding the dynamics of tire grip is more elusive and the perceived rules change from one type of tire to another. It seems tire grip is created when the tire is pressed into the track surface enough to cause the rubber to interlock with the grain of the pavement. Not enough compression damping allows the tire to move freer and ride up on top of the pavement grain, metaphorically similar to “dry aquaplaning”. As the compression damping is increased, the tire will interlock with the pavement and grip will increase. If the damping is further increased incrementally, eventually the grip will stop improving and begin to go down. This is mainly caused by too much pressure from the suspension that overheats the tire or compresses it too much, giving unduly high tire load variations. Keep in mind that the suspension pressure the tire feels is the sum of the compression damping, the spring rate, the sway-bar rate and possibly the torsional rigidity of the chassis. If the pressure sum seems to be optimised for grip but for other reasons it is indicated that one component of the sum needs to be increased, another component may need to be reduced. For instance, a higher spring rate may be necessary to reduce fore and aft pitching. In order to make the stiffer spring work properly, the compression damping may need to be reduced. In another case, one car might have less torsional stiffness in its chassis than another. To compensate for this, the car with lower chassis stiffness will require more compression damping to make the suspension pressure sum high enough. An indicator of too much suspension pressure is controllable sliding at all speeds and all phases throughout the turns (flat sliding).

Grip and rebound damping

Grip in relation to rebound damping works in a slightly different manner. Rebound damping only occurs after there has been some compression of the damper and spring. The pavement grain constantly causes small wheel movements of the suspension system. The rebound damping controls the expansion in these small displacements. If the rebound damping is excessive, the expansion will be too slow leading to a loss of grip. This type of grip loss will be particularly noticeable in rear tire forward traction with the application of power. Cornering grip will not be as dramatically effected as forward traction.

If a lot of rebound damping is used the suspension will be dynamically pumped down which can improve the aerodynamic downforce. If there is enough ”aero” gain it can more than offset any loss of grip due to slow rebound recovery. When this approach is used compression damping is generally reduced at the same time to help the pumping down. We have seen success with this approach, but today most teams are pursuing the high compression, low rebound technique with even better results. Both philosophies have their place. It seems that in the classes where the downforce potential is much less, the proportion between compression and rebound damping leans towards less compression and more rebound damping.

Driver controllability

In most cases vehicle stability will be quite acceptable when the damper has been adjusted for optimum "aero" and grip management. Sometimes "aero" and grip need to be slightly compromised in order to adapt to the style of different drivers. In the final analysis a car that is more driver friendly will prevail over a car with ultimate grip that is also nervous.

Tire wear

Sometimes settings that are good for qualifying can be too hard on tires after a lot of laps. Our experience suggests slightly more compliant damper settings for the race than those used during qualifying.

Ride comfort

One final word about ride comfort. Harshness is either from a suspension that is too stiff to comply with bumps or from a suspension that shakes because of inadequate damping. Deciding which condition exists in your car plus a review of your damper settings can guide you in solving harshness problems.

Figure 16.0 *Öhlins Racing AB, Upplands Väsby, Sweden.*

16 Factory Damper Setting

Racecar set-ups as well as track conditions can vary in an endless number of ways. There is no information available about the optimum damper set-up for just your car. However, to help you, Öhlins has installed a valve configuration that seems to be one of the most useful and results in a huge adjustment range.

The valve components, the same on both compression and rebound, consists of

- 04104-02 Valve seat ∅12
- 04103-06 Poppet valve
- 04107-04 Spring c=40 N/mm, t = 2.20 mm
- 01415-14 x 3 Nose shim, 0.15x14

In the first batch of dampers, the poppet valves and springs were different. These dampers are marked TTX NE02**0** and TTX NE04**0**. In these dampers, the parts used are

- 04103-04 Poppet valve
- 04134-04 Spring, c = 40 N/mm, t = 2.40 mm

See section *High speed adjusters* for more information.

For quality control, all Öhlins TTX dampers are dynamometer tested at least once before they are delivered to the customer. They are first tested at the Öhlins factory in Sweden. At the test at the factory, all dampers are set the same. The clicker positions are set to

LSC/HSC: 10/30
LSR/HSR: 10/30

NOTE:

As the compression and rebound valving are the same, the compression and rebound forces turn out the same.

Figure 17.0 *K-Mart Racing in the V8 SCCS was one of the first touring car teams to test the TTX.*

17 Damping Guidelines

It is not our intention in this chapter to cover all questions about how to find a good damper set-up. However, we offer some basic rules to help you set up the car.

The first time the TTX is installed on the vehicle our recommendation is to match the damping curves previously used. However, as the TTX will have at least as quick damping force build up as the damper you are replacing, you might have to lower the damping force on the TTX to find a better set-up.

If there is no history when it comes to damping forces, some calculations, simulations or shake rig testing might be needed to find the correct amount of damping. If "aero" isn't taken in account, there will be no information about the distribution compression to rebound damping. Also, the damping curves may need to be reshaped from the maximum grip level to achieve an acceptable vehicle handling. Here experience is extremely useful.

In general, our recommendation is to start with linear damping curves and add knee if necessary.

When comparing damping curves, keep in mind that the motion ratio must be the same. The damping forces at a different motion ratio could be estimated by scaling the forces with the square of the quotient of the motion ratios. If the damping curves are not very linear, you have to do a more proper calculation by scaling both the forces and velocity with the quotient. One of them should be multiplied with the quotient the other divided. See the end of this chapter for some more detailed information. Having intimate knowledge of your damper mounting geometry is the key to predicting the proper amount of damping forces.

If your racecar has handling problems, determine first if it is damper related or not. Because dampers have proved to have such a profound influence on handling, some race engineers are in the habit of tuning the dampers before making "aero" or mechanical adjustments. As damper manufacturers, we are flattered, but there are limits to the problems that can be solved by damping adjustments. If a problem can be improved by "aero" or mechanical changes, it is wise to make those changes first.

To make improvements, it is important to understand the function of the dampers. Then through testing, learn how the dampers influence the handling of your car. When making adjustments, keep notes, make adjustments one at a time and in small steps. Always pay attention to changes in conditions like tire wear, track temperatures, time of day, etc. At the end of the test session, go back, if possible, to the starting set-up to double check that an improvement has actually been achieved.

We recommend limiting changing of the low speed adjusters to steps of no more than 6 to 7 clicks at the time. Too large a change can jump right over the optimum setting and sometimes result in similar handling as the original setting. We normally recommend changes of 3 to 4 clicks. When you are near the optimum setting the driver can notice such a little change as 1 or 2 clicks. When both compression and rebound are near optimum a final adjustment might require a trade of one less rebound click for one more compression click or the reverse.

A logical reason for opening only the compression low speed adjuster could be a desire to reduce harshness, to slow down turn-in, or to search for more mechanical grip. The limits to how far the low speed adjusters can be opened are instability, bottoming, lazy turn-in, not enough roll support, braking problems or loss of grip.

Opening the low speed rebound adjuster usually results in more grip especially in the rear during power-down conditions.

As the low speed adjusters are changed, the knee will occur at a different velocity. This affects the high speed forces. The more slope there is on the high speed, the more the high speed will be affected. This can be compensated by changing the high speed adjusters to raise or lower the knee.

Raising the knee (mainly on compression) can result in more support. Raising the knee can also be an effective way to control the underside rake angle, in either the front or rear. Lowering the knee can reduce harshness.

The more pronounced knee you have the more feedback the driver will get. There is often a trade off between feedback and grip/traction. With the TTX the nose shim stack is the main parameter for reshaping the knee without changing low or high speed.

Reducing the compression slope might be called for on bumpy street courses if your car has difficulty absorbing bumps causing harshness. You might want to increase the compression slope if the car bottoms easily or if roll support seems inadequate. This could also be advantageous on bumpy circuits where bumps cause big chassis movements.

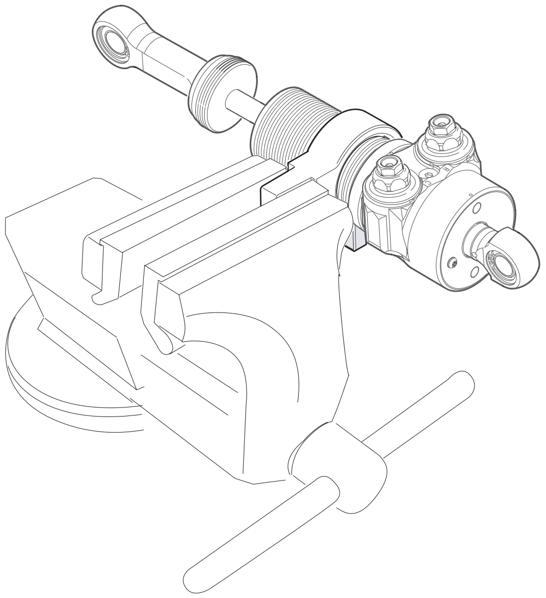
Also, if you determine the knee needs to be reduced, increasing the slope at the same time is sometimes a good idea. The converse is also true.

To compensate for motion ratio changes, both high and low speed have to be changed.

It is not easy to have some general rules about in what range the adjusters should be set, as the needs can be very different depending on the vehicle. However for race cars with damper/wheel bell crank (rocker) ratios of around 1.0/1.0, the low speed compression (LSC) very often ends up at a clicker position in the range of 6 to 14. The corresponding range for the low speed rebound (LSR) is 15 to 25.

If your bell crank ratio moves the damper slower than the wheel, the clickers will need to be set to lower numbers to give more low speed damping. The reason is the wheel has mechanical leverage over the damper and the forces from the damper will end up less effective at the wheel. In addition, the leverage also causes the damper piston speed to be lower. Thus the original damping must be multiplied by the change factor and then the new damping force must be moved to a lower piston speed this time dividing the speed by the same factor. To compensate for the leverage changes, tighten the low speed adjuster and add preload with the high speed adjuster.

Conversely, if your bell crank ratio moves the damper faster than the wheel the adjusters need to be set to higher numbers to give less damping and the damping change factor now needs to divide the original damping and multiply the piston speed.



18 Work Section

General information

This chapter describes how to work with the TTX damper. For areas not described here, we recommend you to contact Öhlins or an Öhlins distributor.

Information about torque, Loctite etc. is also found in chapter Spare parts.

Öhlins has tried to make it as easy as possible to work on the TTX. Below are a couple of examples of details described that can make the work easier.

The cylinder head is designed with two flat sides to enable clamping it in a vise with soft jaws.

CAUTION!
If the flat sides of the cylinder head are used to hold the damper, clamp the damper gently to not damage the cylinder head. With a valve end cap removed the cylinder head will be even more sensitive so always do this with the adjuster housing installed.

In operations when one end cap of the valves are removed, this method should only be seen as a temporary solution instead of using Öhlins damper holder (part no. 01878-01). The force that can be used in these situations are very limited. The damper can easily come lose and get damaged.

To simplify positioning the spring platforms, a detent for positioning a caliper is made in the cylinder head.

NOTE!
Always before starting operations where the damper is opened, it is of the utmost importance that the work area be free from dust and dirt. Contamination is the primary enemy of dampers. Do not use any shop rags around internal damper parts because lint will find its way inside the assembled damper. Öhlins recommends lint-free paper only.

NOTE!
Always use the recommended tools.

NOTE!
All threads are right handed, so you will always go counter clock wise when disassembling.

NOTE!
Every time the piston rod assembly needs to be moved in an oil filled damper, you are free to reduce the force needed by opening the low speed adjusters. Therefore always keep the tool needed for changing the low speed adjusters available. This tool is a 3 mm Allen key or a small screw driver (the screw driver was used until 2005).

NOTE!
Also, always make sure you have some lint free paper available.

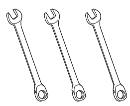


Figure 18.1 *Classification symbols*

In the following chapters, there is a classification that indicates how difficult the task is to do. The classification made here can not be compared to classifications made in other mechanic handbooks. As even operations marked with many symbols are still relatively simple.

In some of the illustrations a spring platform is mounted on the damper, on some it is not. It is up to you if you prefer to remove it or not.

Safety signals

Important information concerning safety is distinguished in this chapter by the following notations:

⚠ WARNING!
Failure to follow warning instructions could result in severe or fatal injury to anyone working with, inspecting or using the suspension, or to bystanders.

CAUTION!
Caution indicates that special precautions must be taken to avoid damage to the suspension.

NOTE!
This indicates information that is of importance with regard to procedures.

Öhlins Racing AB can not be held responsible for any damage whatsoever to damper or vehicle, or injury to persons, if the instructions for how to use and maintain the product are not followed exactly. Similarly, the warranty will become null and void if the instructions are not adhered to.

⚠ WARNING!
Changing damper/dampers may affect the stability of your vehicle. Öhlins Racing AB cannot be held responsible for any personal injury or damage whatsoever that may occur after fitting the suspension. Contact an Öhlins dealer or other qualified person for advice.

NOTE!
Öhlins products are subject to continual improvement and development. Consequently, although these instructions include the most up-to-date information available at the time of printing, there may be minor differences between your suspension and this manual. Please consult your Öhlins dealer if you have any questions with regard to the contents of the manual.

Reclocking top eye

The top eye of the TTX damper can be reclocked to any angle. Normally the top eyes are reclocked only when the dampers are fitted to the car for the first time.

Degree of difficulty: 

Tools needed:
00146-01 Red grease
01761-03 Peg spanner
01779-02 Gas needle housing**
01781-01 Gas filling device **
2 Screwdrivers*
Adjustable wrench with flat large jaws
Nitrogen gas **
Vise with soft jaws
Torx T20

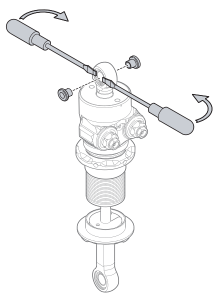
** Only needed if there are spacers (”top hats”) installed in the spherical bearing of the top eye.*

*** As it is possible to reclock the top eye without depressurising the damper, these tools are not critical. However, a depressurisation of the damper is always recommended.*

The described working method assumes a fully assembled damper.

SEE SECTION:
Using the gas filling device

S1



S1.

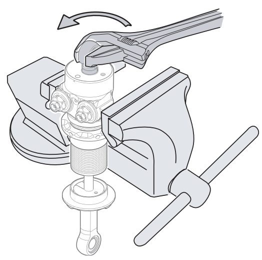
- Release the gas pressure from the damper. See section *Using the gas filling device*.
- Remove the spacers of the spherical bearings in the top eye if installed. Use two screwdrivers to remove the spacers.

S2.

- Mount the flat sides of the cylinder head in a vise with soft jaws. Plastic jaws are recommended.

CAUTION!
Use a minimum of force, just enough to ensure the damper doesn’t fall down as you are working with it.

S2

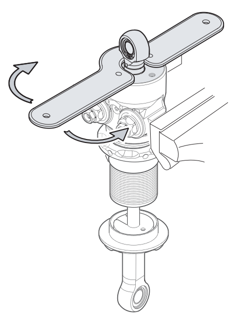


- Apply the adjustable wrench at the centre of the bearing and loosen the top eye by turning the wrench counter clockwise.

CAUTION!
Make sure the jaws of the wrench are long enough to reach across the hole for the bearing and engaging the top eye on both sides of the bearing.

S3.

S3

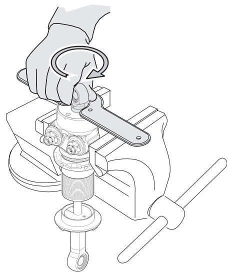


- Install the peg spanner (part no. 01761-03) in the reservoir end cap. The pins will go in the holes of the pressure indicators.

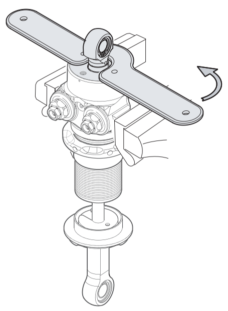
NOTE!
If the damper was not depressurised, the peg spanner has to be pushed down to overcome the force from the pressurised gas acting on the pressure indicators.

- Rotate the reservoir end cap in any direction just enough to make sure the top eye follow the end cap. If it doesn’t, loosen the top eye a little bit more.

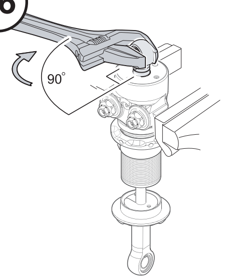
S4



S5



S6



SEE SECTION:
Using the gas filling device

S4.

- Turn the top eye by hand clockwise until it stops. If you find it hard to do this operation by hand, you can use the adjustable wrench together with a minimum of force. This allows you to feel when the end of the top eye touches the cylinder head.

S5.

- Turn the reservoir end cap with the peg spanner counter clockwise so the top eye points in a 90° angle from the where you like to have it. Turning the end cap counter clockwise ensures that the reservoir end cap and the top eye turn together.

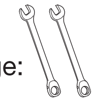
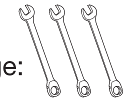
S6.

- Remove the peg spanner and apply the adjustable wrench on the top eye. Turn the wrench 90°. Again make sure the spanner covers both sides of the bearing hole.

- Remove the adjustable wrench and pressurise the damper. See section *Using the gas filling device.*

Revalving

Even though the external adjustability of the TTX is huge, there still might be situations when revalving is necessary.

Degree of difficulty: Spring change:  Nose shim change:  Valve and valve seat change: 

Tools needed:
00146-01 Red grease
00773-01 Vise / Standard vise with soft jaws
01306-01 Shock absorber fluid 309
01499-04 Circlip*
01779-02 Gas needle housing
01781-01 Gas filling device
01875-02 Circlip installation tool **
01876-XX Separating piston positioning tool ***
01878-01 Damper holder
04106-03 Valve seat tool
12 mm wrench *****
17 mm wrench / torque wrench
19 mm wrench / torque wrench
Caliper
Nitrogen gas
Pin (max ∅3.5 mm, to check the check valve function)
Small circlip pliers
Small pliers
Torx T20

* If the nose shims of the poppet are changed, new circlips are recommended.

** Not necessary, but will make installing the circlip easier.

*** This tool is needed only to check the position of the separating piston. It is available in two different ver sions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

***** The 12 mm hex has previous been 13 mm.

Extra circlips for the poppet valves are good to have if shim stack changes will be made.

If the oil level is found incorrect, see section *Adjusting the oil level* for the tools needed.

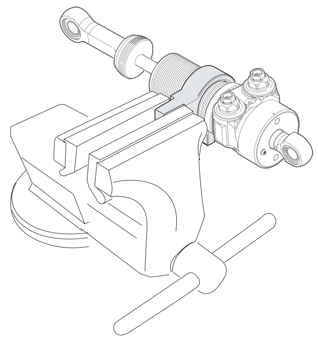
No vacuum filling machine is needed.

The described working method assumes a fully assembled damper.

Information about how to disassemble/assemble the valve end piece (end cap, needle housing, needle etc.) is not given in detail in this manual. The method is pretty straight forward, but some steps can be pretty tricky. See the end of this section.

Disassembly:

D1



SEE SECTION: General information

SEE SECTION: Using the gas filling device

D1.

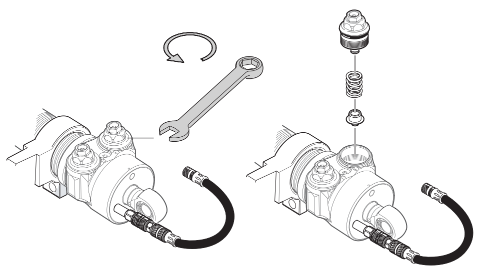
- First of all clean the damper. In particular the area around the valves has to be cleaned carefully.

- Install Öhlins damper holder (part no. 01878-01) in a vise (part no. 00773-01 can be used) and mount the damper in the damper holder with the adjusters pointing upwards. The damper holder clamps the damper around the outer tube.
  As an alternative the flat sides of the cylinder head can be used to hold the damper in a vise with soft jaws. However for revalving, this should only be seen as a temporary solution. See section *General information* for more details.

NOTE:
The clicker positions will normally not change during a revalving. It is recommended to set the preload of the poppet valve to minimum as this simplifies the revalving, but it is not necessary. However, plenty of preload will make the reinstallation of the end piece a bit more difficult.

- Depressurise the damper. See section *Using the gas filling device*. The gas needle housing together with the quick-connect hose can be left installed during the revalving procedure.

D2



D2.

- With a 19 mm wrench remove the end piece of the valve that is being changed.

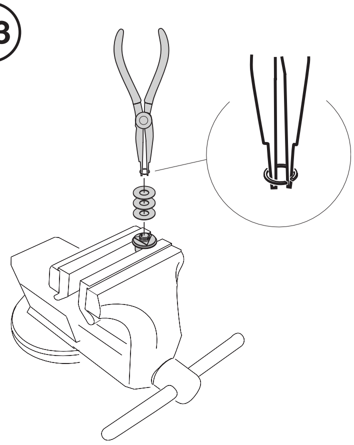
NOTE:
Depending on the amount of preload of the poppet, the poppet together with the spring might come up with the end piece or not. At a low amount of preload, they will stick to the end piece. Even if both valves are being changed, just do one at the time.

- If the spring and poppet doesn't come up with the end piece, pick up the spring and poppet with a pair of small pliers.

CAUTION:
Grab the poppet valve gentle, so the pliers don't make any marks on the poppet.

If only the spring is changed go to *A7* in *Assembly.*

D3



D3.

- If the same poppet will be used but the nose shims need to be changed, install the poppet in a vise with soft jaws. Plastic jaws are recommended.

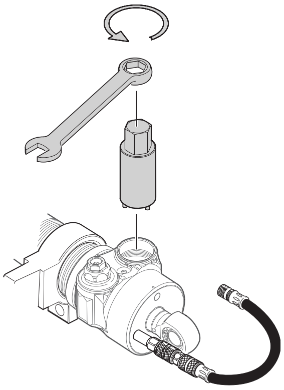
CAUTION:
Use a minimum of force to hold the poppet valve in the vise. Otherwise, it will be deformed and hurt the performance of the damper.

- Remove the circlip in the nose of the poppet by using a pair of small circlip pliers.

NOTE:
As it is hard to remove the circlip without deforming it, use a new circlip when putting it back together.

If only the nose shims are being changed go to *A4* in *Assembly*.

D4



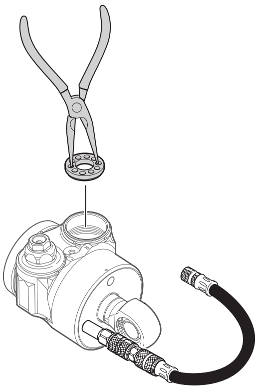
D4.

- To change the valve seat, install the valve seat tool (part no. 04106-03).
- Apply a 17 mm wrench to the valve seat tool and unscrew the valve seat.

NOTE:

Removing the valve seat is usually not necessary for normal revalves. If this is not necessary, proceed to Assembly: A4.

D5



D5.

- Add oil to the cavity to make sure some will overflow when the end piece is installed.
- Pick up the valve seat with a pair of small pliers.

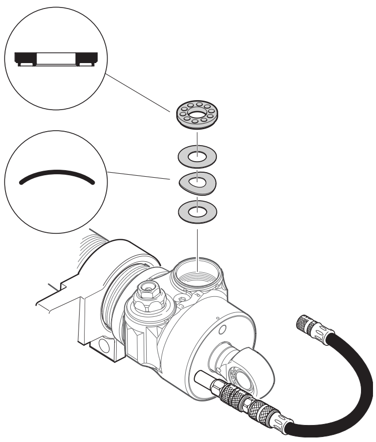
CAUTION:

Avoid grabbing the valve seat by the centre hole. Damage in this area could cause a leakage between the nose shims and the valve seat.

Make sure the oil level never gets below the ports inside the valve cavities to avoid any air bubbles getting trapped in the damper.

Assembly:

A1



A1.

- Try to centre the shims in the bottom of the valve cavity.

NOTE:

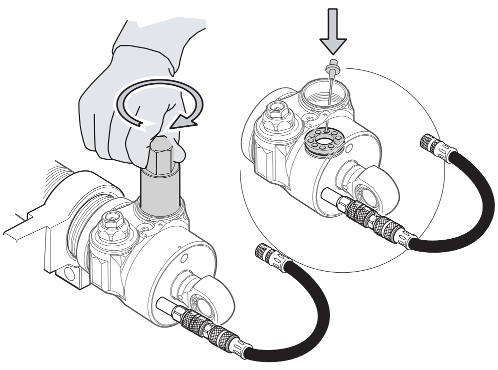
If the shims for some reason are removed, see Spare parts for type and position. The wave washer should be positioned with the concave side pointing down.

- Place the new valve seat on top of the shims in the cylinder head.

NOTE:

The side with the groove should point downwards.

A2



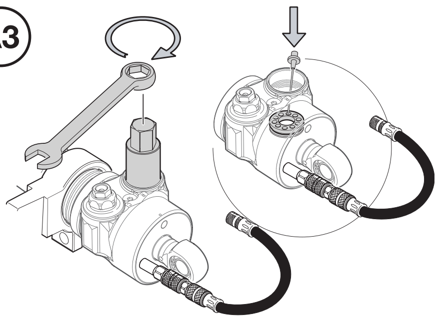
A2.

- Fit the valve seat tool and thread the valve seat by hand until it bottoms.
- Make sure the check valve shim moves freely away form the valve seat by pushing a pin (max ∅3.5 mm) into 3 or 4 of the holes in the check valve seat.

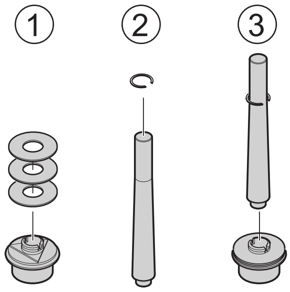
NOTE:

You should be able to open the check valve from any hole and feel the force from the wave washer wanting to close the check valve. If the check valve is stuck closed on one side or scrapes the side wall of the cylinder head, loosen the valve seat until the check valve can be opened as described above. Now tighten it again. Make sure the check valve is now free to move. If the valve seat is tightened when the check valve is misaligned underneath it, the check valve will be damaged and needs to be replaced.

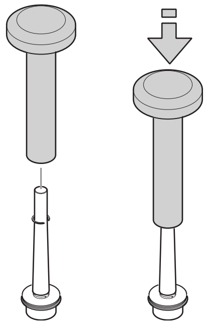
A3



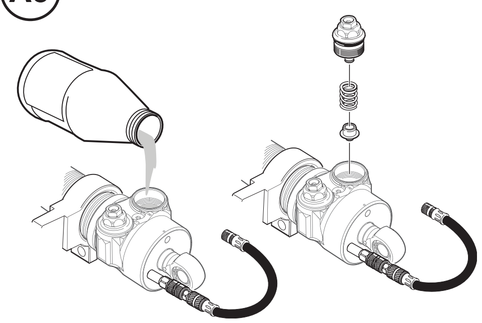
A4



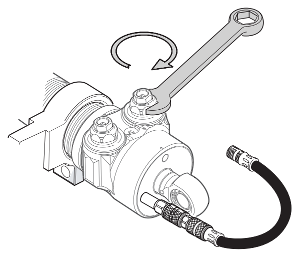
A5



A6



A7



SEE SECTION:
Checking the oil level

SEE SECTION:
Using the gas filling device

A3.

- Tighten the valve seat with the valve seat tool and a 17 mm torque wrench. Torque: 18 Nm (13 lbs. ft.).
- Once again ensure the function of the check valve.

A4.

- Install the desired nose shims on the poppet valve.
- Place the poppet on a flat surface with the nose upwards or install the poppet with the nose upward in vise with soft jaws. Be careful not to damage the poppet. If Öhlins vise 00773-01 is available, clamp the poppet on the backside of the jaw. Use a very low torque.
- Put the circlip on the cone of the circlip installation tool pin (part no. 01872-02). Push it up on the cone to prevent the circlip from sticking between the two parts of the tool.
- Centre the tool pin to the valve by putting the ∅3.8 mm tap into the centre hole of the poppet.

A5.

- Put the ”female part” of the tool (part no. 01871-01) on the pin until it stops against the circlip.
- Now hold the ”female part” in line with the poppet and push the circlip on to the poppet.

NOTE:

This operation is easier if the circlip is pushed quickly onto the valve.

A6.

- If not already done, add some oil to the valve cavity to guarantee oil overflow to purge trapped air.
- Install the desired spring and poppet on the needle housing inside the end piece.

NOTE:

If the preload of the spring is low enough and the assembled unit is handled with care, the friction from the o-ring at the end of the needle housing will keep the poppet and therefore the spring in place during assembly. The position of the needle housing has only a marginal effect of the amount of air trapped in the end piece, so don’t worry about that.

- Put the valve assembly back into the valve cavity.

A7.

- Thread in the end piece and tighten it with a 19 mm torque wrench. Torque: 12 Nm (9 lbs. ft.).
- Install the separating piston positioning tool (part no. 01876-XX) to check the position of the separating piston. See section *Checking the oil level* for more information.
- Inflate the gas reservoir with nitrogen. See section *Using the gas filling device* for more information.

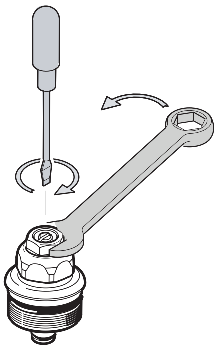
End piece disassembly and assembly

Here is a very brief instruction for disassembling/assembling a valve end piece. The method is quite straight forward, but some steps are tricky.

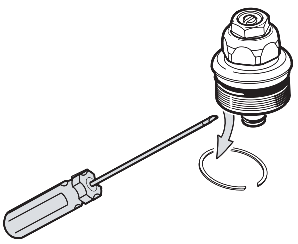
Make sure you have some spare detent balls and springs available before you start the job. They are easy to drop during disassembly and assembly.

For information about how to use the One-way adjustable needle housing (part no. 5953-03) see See chapter 8, "*Internal Adjustments*".

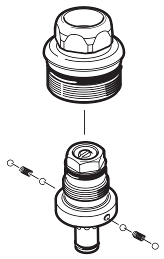
D1



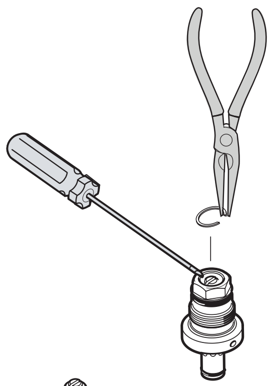
D2



D3



D4



D5

D1.

- To disassemble the valve piece, turn the low speed adjuster to fully closed position and the high speed adjuster to minimal preload.

D2.

- Remove the large circlip in the end cap underneath the needle housing. A screwdriver with one side of the tip rounded or something similar is needed. Without the right technique, this can be quite hard to do.

D3.

- Once the circlip is removed, screw out the needle housing. Be prepared to catch the detent balls and springs that will pop out.

D4.

- The next step is to remove the little circlip above the needle. Push the centre of the circlip down with a little screwdriver and then grab it with a pair of small pliers and pull it out.

D5.

- Screw out the needle valve.

The assembly is done in the opposite order.

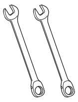
Rebuilding the Damper

In this section, the methods for adding or changing internal spacers, and how to change piston rod, cylinder tube and top eye is described.

Clean the damper as all the work described here involves opening the damper. The risk of getting contamination inside the damper must be minimised.

The described method for rebuilding the damper assumes a fully assembled damper without spring platform and spring retainer unless otherwise specified.

Adding/Changing internal spacers

Degree of difficulty: 

Tools needed:
00146-01 Red grease
00727-02 Jaws for piston rod
00773-01 Vise*
01306-01 Shock absorber fluid 309
01761-01 Peg spanner for cylinder cap
01772-03 Wrench 21 mm
01779-02 Gas needle housing
01781-01 Gas filling device
01861-01 Mounting sleeve for piston**
01876-XX Separating piston positioning tool ***
Adjustable wrench with flat large jaws
Calliper
Nitrogen gas
Small pliers ****
Torx T20
Vise with soft jaws

The oil retaining cup, part no. 01776-03, is nice to have, but not necessary.

* A vise with soft jaws can be used instead, but this tool is recommended.

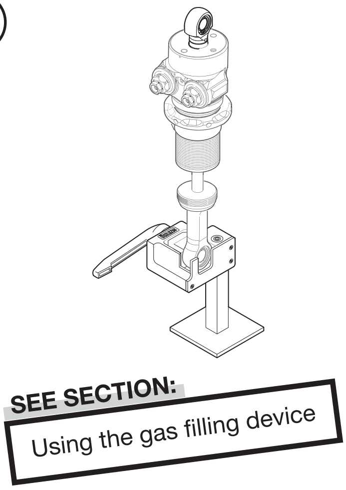
** Only needed if the piston rod assembly is removed from the cylinder tube.

*** This tool is needed only to check the position of the separating piston. It is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

**** Only needed if some internal spacers have to be removed and no vacuum filling machine being used.
If using the vacuum filling machine, see section *Using Öhlins filling machine* for information about the extra tools needed. If the manual method described is used, and the oil level is incorrect, see *Adjusting the oil level* for tools needed.

NOTE:
In this example, the spacers are placed only on the rebound side. However, it is also possible to use internal spacers around the internal piston rod.

D1



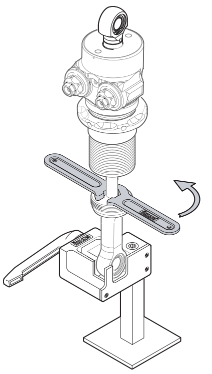
D1.

- To remove the end eye, pull the piston rod to fully extended position and install the end eye of the damper in a vise (part no. 00773-01 or a standard vise with soft jaws).

- Depressurise the damper by installing the gas needle unit and attach the quick-connect hose. See section *Using the gas filling device* for more details.

NOTE:
The gas needle unit has to be removed to later be able to install the separating piston positioning spacer.

D2



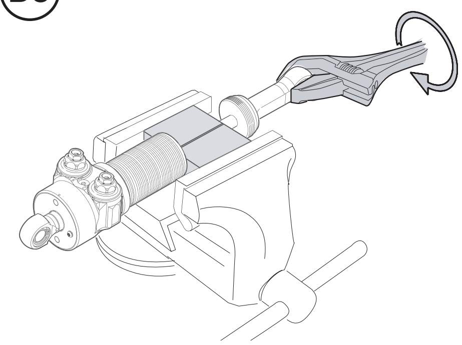
D2.

- Loosen the lock nut at the end eye by using Öhlins 21 mm wrench (part no. 01772-03).

D3.

- Unscrew the end eye. If the piston rod rotates with the eye, clamp the piston rod in a vise using the jaws for ∅12 piston rods (part no. 00727-03). Firmly tighten. Apply a large adjustable wrench with flat jaws around the end eye and loosen the eye from the piston rod. Only little torque should be needed, as the eye should have been threaded to the piston rod by hand.

D3

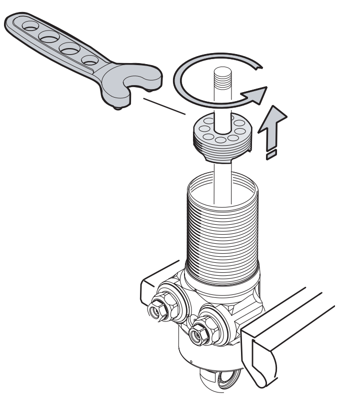


CAUTION:
The tool 00727-03 is made both for ∅12 mm and ∅10 mm rods, so ensure the correct end (for ∅12 mm) is used.

NOTE:
By cleaning the piston rod of oil, the vise doesn't have to be tightened as hard to prevent the rod from rotating. Spray some degreaser (brake clean) on the piston rod for a better grip in the jaws. Do not get break brake clean into the rod seal.

- Remove the lock nut and any external spacers.

D4



D4.

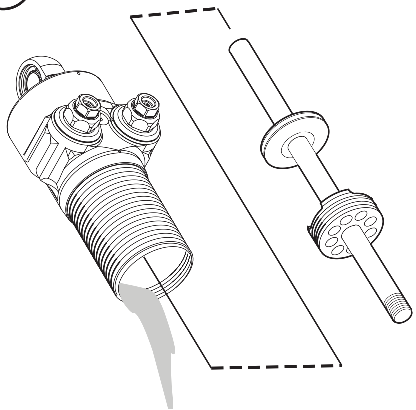
- Place the damper in a vise with soft jaws so the piston rod is pointing upwards. Clamp the damper gently at the flat sides of the cylinder head.

NOTE:
If the manual method is to be used, oil will later flow out between the end cap and the tube, so place the damper where you easily can collect the oil. By wrapping some paper around the cylinder tube, some oil can be collected. An oil fill cup is available (part no. 1776-03).

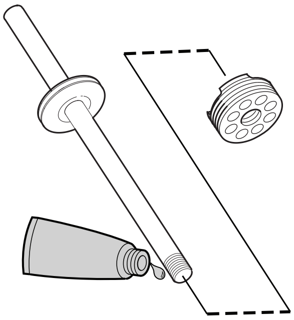
- Compress the damper some distance to increase the margin for the internal piston rod leaving the seal in the cylinder head. If the top eye leaves the seal, oil will leak out into the top eye cavity before it comes out through the holes of the top eye.

- Unthread the cylinder end cap by using Öhlins peg spanner (part no. 01761-01).

D5V



D6V



Depending on if there is a vacuum filling machine available or not, there are two different procedures to use.

Using a vacuum filling machine:

D5V.

- Loosen the damper from the vise and turn it up side down. Pull out the piston rod assembly and drain the oil from the damper.

- Place the damper body in a standing upright position (the damper is standing on the end of the tube) as you continue to work with the piston rod assembly. This will prevent oil from entering the top eye.

D6V.

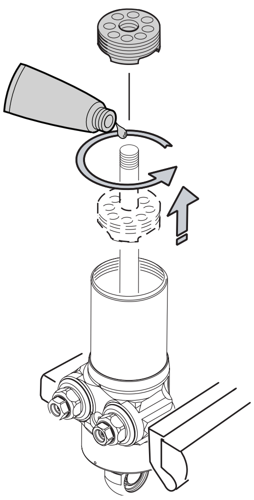
- Put some red grease on the end eye thread of the piston rod. Rotate the cylinder end cap to prevent sticking as you slide it up the piston rod. Carefully pull it over the thread.

CAUTION:

When pulling the x-ring over the thread, there is always some risk to damage the x-ring, so be careful.

- Remove internal spacers if needed.

D5M



Manual method without emptying the damper:

D5M.

- Put some red grease on the end eye thread of the piston rod. Rotate the cylinder end cap to prevent sticking as you slide it up the piston rod. Carefully pull it over the thread.

CAUTION:

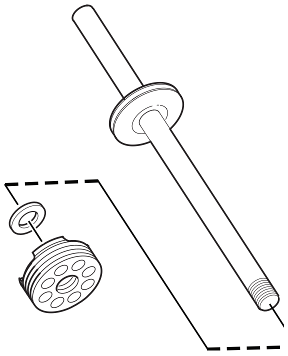
Be careful not to move the piston rod assembly upwards. The internal piston rod can come outside the seal in the cylinder head causing oil to leak out through the top eye. When pulling the x-ring over the thread, there is always some risk to damage the x-ring, so be careful.

- Remove internal spacers if needed. You might need a pair of small pliers to do it.

Assembly:

Using a vacuum filling machine:

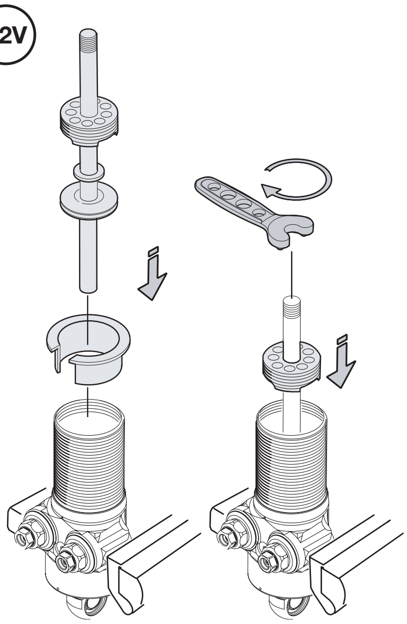
A1V



A1V.

- Add internal spacers if needed.
- Carefully reinstall the cylinder end cap on the piston rod assembly. Pull it carefully over the piston rod thread to prevent damage of the end cap seal.

A2V

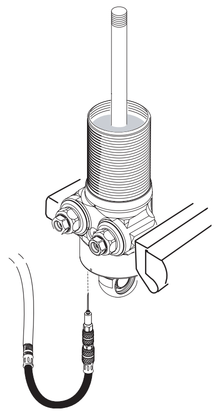


A2V.

- Put the cylinder head back into the vise as before with the cylinder tube pointing upwards. It is hard to avoid some small amount of oil entering the volume inside the top eye. This will not create any problems other than a mess.
- Apply Öhlins mounting sleeve (part no. 01861-01) in the cylinder tube. Push the piston rod assembly into the cylinder tube until the piston seal enters the inner tube. Remove the mounting sleeve. Push the piston rod assembly in all the way and engage the thread for the end cap.

Manual method without emptying the damper:

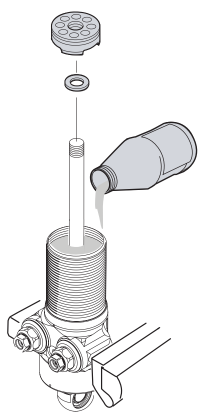
A1M



A1M.

- If the separating piston is positioned at maximum gas volume before the end cap is installed, the position of the separating piston will be close to correct after the cylinder end cap has been installed.
- To move the separating piston to the bottom of the cylinder head (maximum gas volume), pressurise the reservoir temporary. This can be done by connecting the gauge to the quick-connect hose and add Nitrogen or by just putting an air gun to the quick-connect hose and blow air into the reservoir. Pay attention to the oil level of the cylinder tube. You should notice how the level of oil rises as the separating piston is moved due to the increased pressure in the reservoir.
- Depressurise the reservoir.

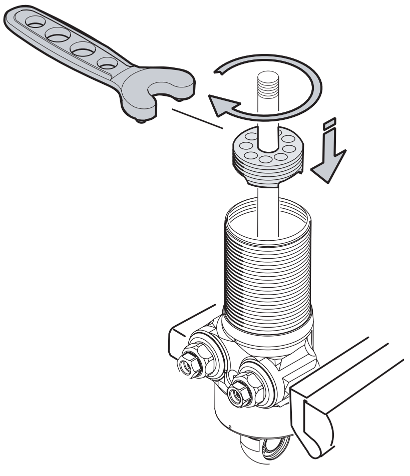
A2M



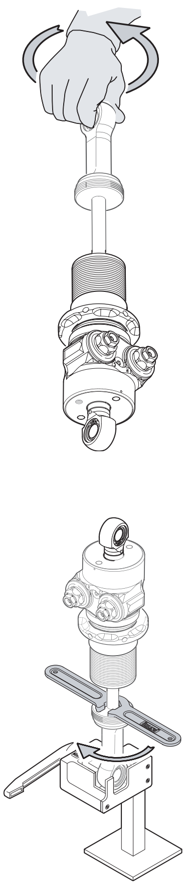
A2M.

- Add some oil to the cylinder to guarantee an oil overflow. An oil level covering the beginning of the thread should be enough.
- Add internal spacers if needed.
- Carefully reinstall the cylinder end cap on the piston rod assembly while it is still placed in the cylinder tube. Pull the cylinder end cap over the piston rod thread. Rotate the end cap as it slides down the rod to prevent stick slip.

A3



A4



For both methods

A3.

- Screw the end cap into the tube and tighten it.

  Torque: 50 Nm (36 lbs.ft.).

  As the torque can't be measured, it has to be estimated.

- If no oil overflows before the end cap is pushed down, step A1M and A2M have to be repeated.

A4.

- Reinstall the external spacers on the piston rod and thread the lock nut to the inner end of the thread.

- Install the end eye on the piston rod. Thread it in until it stops.

- Turn the damper up side down and clamp the end eye in the vise 00773-01 or use a normal vise.

- Tighten the lock nut to the end eye.

  Torque: 25 Nm (18 lbs.ft.)

  As the torque can't be measured, it has to be estimated.

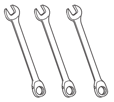
CAUTION:
The torque used is half of the torque used on the TT44/TT40 dampers.

If the vacuum filling machine is used, see *Using Öhlins filling machine*. If the manual method above has been used, check the position of the separating piston. See sections *Checking the oil level* and *Adjusting the oil level*. Finally, pressurise the damper. See *Using the gas filling device*.

SEE SECTION:
Using Öhlins filling machine
or
Checking the oil level + Adjusting the oil level

SEE SECTION:
Using the gas filling device

Changing piston rods

Degree of difficulty: 

Tools needed:
00146-01 Red grease
00727-02 Jaws for piston rod
00773-01 Vise*
01306-01 Shock absorber fluid 309
01761-01 Peg spanner for cylinder cap
01772-03 Wrench 21 mm
01779-02 Gas needle housing
01781-01 Gas filling device
01861-01 Mounting sleeve for piston
6 mm Allen key
6 mm Allen bit to fit the torque wrench
Heat gun**
Loctite 243
Nitrogen gas
Torque wrench
Torx T20
Vise with soft jaws

* A vise with soft jaws can be used instead, but this tool is recommended.

** If needed.

If the vacuum filling machine is used to fill the damper, see section Using Öhlins filling machine for information about the extra tools needed. If the damper is filled by hand, see sections Manual oil filling and Adjusting the oil level for tools needed.

In the example below, both piston rods are changed. However if only the internal piston rod (part no. 06112-XX) is to be changed, the end eye and the cylinder end cap do not need to be removed from the external piston rod.

Disassembly:

D1.

- Follow the steps D1 to D5V in section *Adding/Changing internal spacers*.

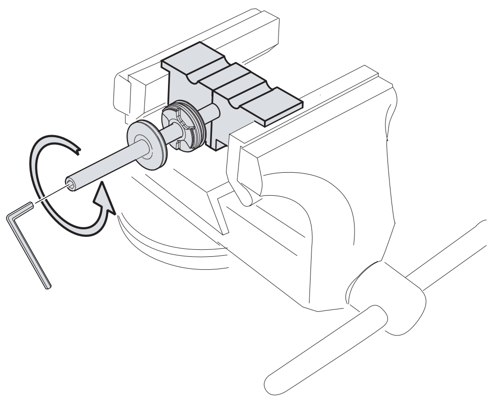
NOTE:
As the two piston rods will be separated here, the recommendation is to take the cap off in the opposite direction to minimise x-ring damage.

- Clamp the external piston rod in a vise with Öhlins jaws (part no. 00727-02). Use the 12 mm jaws. Tighten firmly.

NOTE:
To reduce the force needed to keep the piston rod from rotating, clean the rod carefully. Spray some degreaser (brake clean) on the piston rod to get it to grip better in the jaws. Avoid getting break clean into the piston rod seal.

D1

SEE SECTION:
Adding/Changing internal spacers: D1-D5V



- Install the 6 mm Allen key in the internal piston rod and loosen the thread.

CAUTION:
Do not use to much torque as this can damage the piston rod.

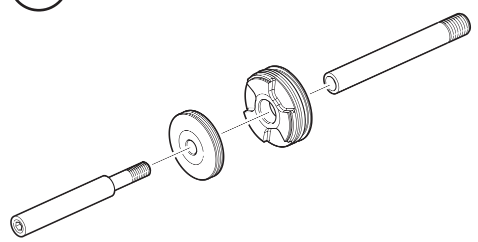
If it doesn't come loose, use a heat gun.

- Heat the external rod, but try to protect the piston from the heat as the width of the piston would increase. Add heat all around.

- Separate the rods and remove the piston.

WARNING:
Be careful not to get burned on hot parts when using the heat gun.

D2



D2.

- If there are some internal spacers, remove these.

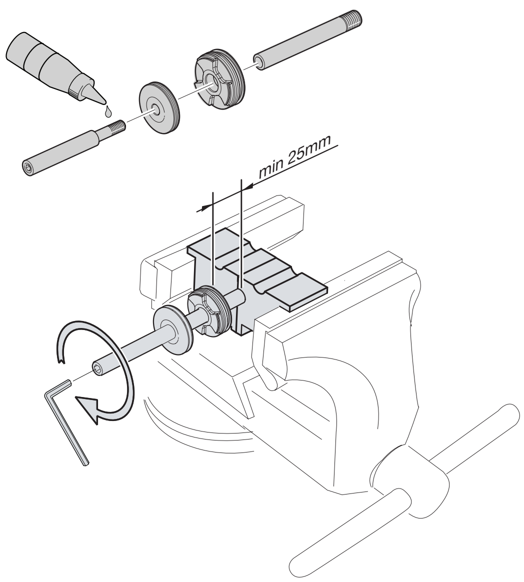
- Take the cylinder end cap of the piston rod.

- Remove the piston rod from the vise.

Assembly:

A1.

A1



- Clamp the new external piston rod in the vise with Öhlins 12 mm jaws.

NOTE:
Don't clamp the external piston rod closer than 25 mm (1 inch) from where the piston will be positioned.

To minimise x-ring damage, install the cylinder end cap from the other side. If a rod is to be reused, clean Loctite from the threads.

- Add some red grease on the piston rod. Install the end cap carefully from the side where the piston is installed.

- Add internal spacers if needed.

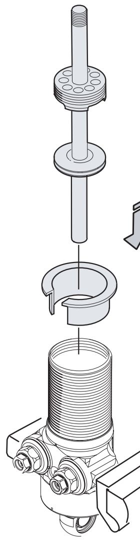
- Put the piston on the new internal piston rod.

NOTE:
The piston is symmetrical.

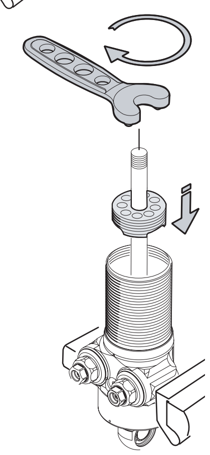
- Add 2-3 drops of Loctite 243 on the M8x1 thread of the internal piston rod and screw the two rods together. Use a torque wrench.

Torque: 22 Nm (16 lbs. ft.).

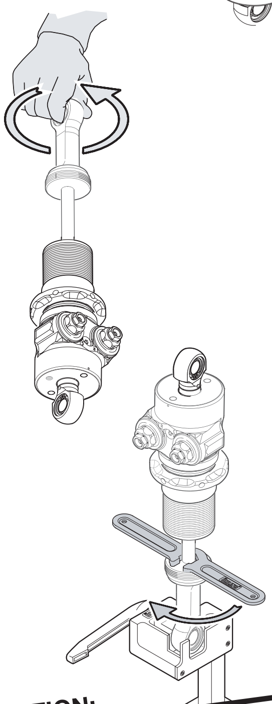
A2



A3



A4



SEE SECTION:

Using Öhlins filling machine
or
Manual oil filling

SEE SECTION:

Using the gas filling device

A2.

- Put the cylinder head back into the vise as before with the cylinder tube pointing upwards.
- Reinstall the piston rod assembly in the cylinder tube. Use Öhlins mounting sleeve (part no. 01861-01) for the operation.

A3.

- Screw the end cap into the tube and tighten it.

Torque: 50 Nm (36 lbs.ft.).
As the torque can't be measured, it has to be estimated.

A4.

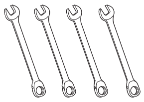
- Put the external spacers back on the piston rod and thread the lock nut to the end of the thread.
- Install the end eye on the piston rod. Thread it in until it stops.
- Remove the cylinder head from the vise and turn the damper so the cylinder head is pointing upwards. Clamp the end eye in the vise instead.
- Tighten the lock nut to the end eye.

Torque: 25 Nm (18 lbs.ft.)
As the torque can't be measured, it has to be estimated.

CAUTION:
The torque used is half of the torque used on the TT44/TT40 dampers.

- If the vacuum filling machine is used, see *Using Öhlins filling machine*. If the manual oil filling method is used, see *Manual oil filling method*. Finally pressurise the damper. See *Using the gas filling device*.

Changing cylinder tubes

Degree of difficulty: 

Tools needed:
00146-01 Red grease
00438-17 O-ring*
00737-05 Sleeve 49 mm
00738-01 Spanner for reservoir
01306-01 Shock absorber fluid 309
01761-01 Peg spanner for cylinder cap
01779-02 Gas needle housing
01781-01 Gas filling device
01861-01 Mounting sleeve for piston
Heat gun**
Loctite 243
Nitrogen gas
Torx T20
Vise with soft jaws

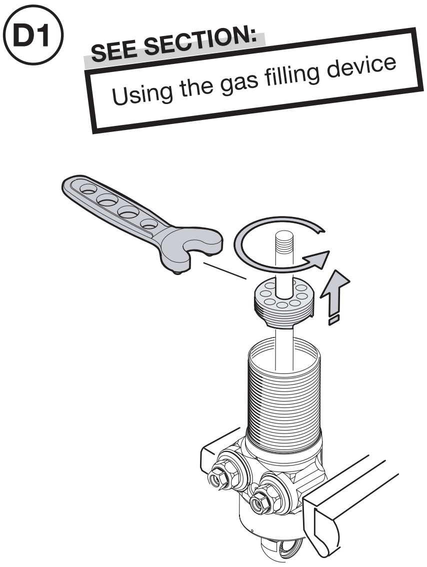
* Only needs to be replaced if a heat gun is used.

** Almost never needed, but can sometimes be a good help to loosen the outer tube from the cylinder head if it is stuck.

If the vacuum filling machine is used to fill the damper, see section Using Öhlins filling machine for information about the extra tools needed. Or if the damper is filled by hand, see Manual oil filling and Adjusting the oil level for tools needed.

NOTE:
Make sure the internal piston rod length corresponds to the length of the tubes. If only the inner tube has to be changed, the outer tube doesn't have to be removed. See below.

To only replace the inner tube, follow the first five steps in D1 and pull out the inner tube. This can be done by hand if you can get enough friction between the tube and your fingers. By moving the inner tube a little side to side, less force will be needed. Install the new tube and go to the final step in A4.



Disassembly:

D1.

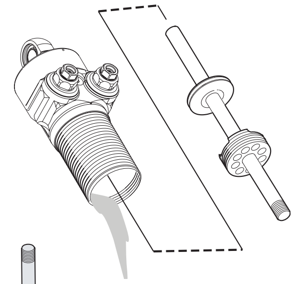
- Depressurise the damper by installing the gas needle unit and attach the quick-connect hose. See section *Using the gas filling device* for more details.

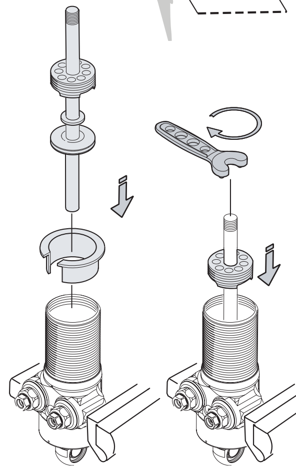
NOTE:
The gas needle unit has to be removed to later be able to install the separating piston positioning spacer.

- Place the damper in a vise with soft jaws so the piston rod is pointing up. Clamp the damper the flat sides of the cylinder head gently.

- Unthread the cylinder end cap using Öhlins peg spanner (part no. 01761-01).

- Loosen the damper from the vise and turn it upside down. Pull out the piston rod assembly and drain the oil from the damper.



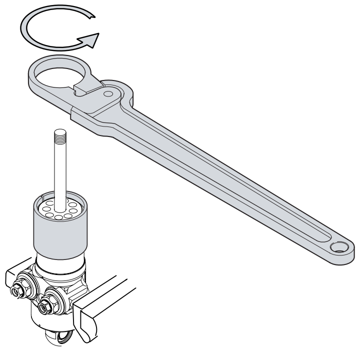


- Put the cylinder head and cylinder tube unit back into the vise by clamping the cylinder head gently at the flat sides.
- Reinstall the piston rod and end cap assembly temporary in the damper. Use the mounting sleeve (part no. 01861-01) for the operation.

CAUTION:

Always have the cylinder end cap installed when using the spanner 00738-01 to avoid damage to the outer tube

- Screw the end cap into the tube until it stops. From here, loosen just enough to ensure that the end cap can easily be removed by hand later on.
- Install the ∅49 mm sleeve (part no. 00737-05) to the outer tube. Put the top of the sleeve at about the same level as the end of the outer tube.
- Install the spanner (part no. 00738-01) on the sleeve and position it so that it grabs the area around the cylinder end cap.

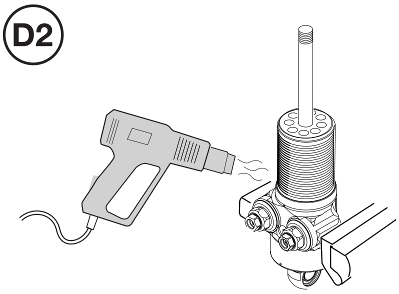


NOTE:

The spanner has to be installed in a direction that locks it around the sleeve when the handle of the spanner is turned counter clockwise. Sometimes, the spanner must be held until it starts to clamp to prevent it from rotating on the sleeve.

- Now, loosen the outer tube from the cylinder head. Quite a bit of force will be needed. If the tube doesn't come loose, go to *D2*.

D2



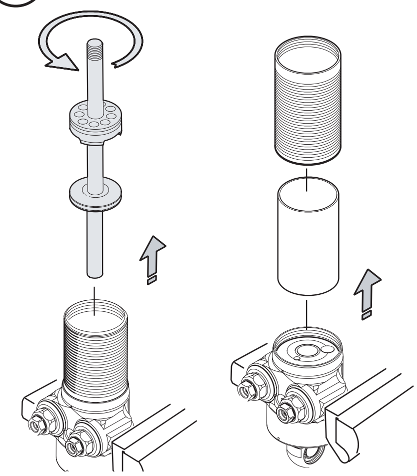
D2.

- Heat the cylinder head in the area where the tube is installed. Add heat evenly around the tube. Try to protect the adjusters from the heat to avoid damage to the o-rings in the valve units.
- Loosen the tube.

⚠ WARNING:

Be careful not to get burned on hot parts when using the heat gun.

D3



D3.

- Remove the sleeve and the spanner.
- Before removing the outer tube unscrew the cylinder end cap and pull out the piston rod assembly.
- Unscrew the outer tube.

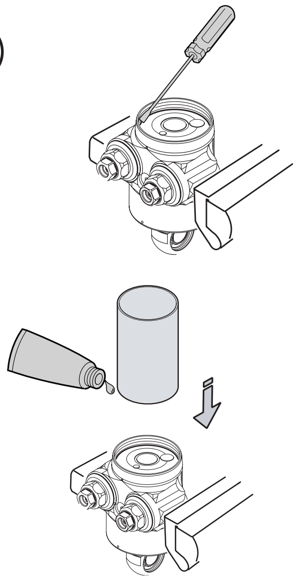
NOTE:

If the heat gun has been used, always replace the o-ring that seals between the cylinder head and the outer tube (part no. 00438-17).

- Pull out the inner tube. This is done by hand. By moving the inner tube a little side to side, less force will be needed.

Assembly:

A1



A1.

- Clean old Loctite from the thread of the cylinder head.

NOTE:
Be careful not to get old Loctite inside the damper.

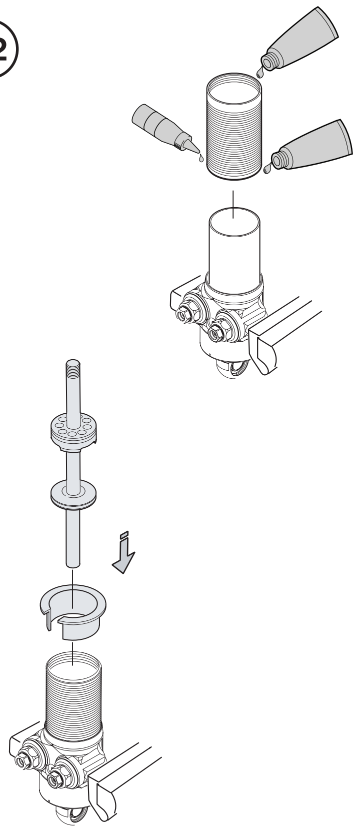
- For information about how to remove the separating plate, see section *Replacing seals and bushings*.

- Add some red grease inside one of the ends of the new inner tube to reduce the risk of damaging the o-ring at the separating plate.

NOTE:
The inner tube is symmetrical.

- Push the new inner tube on to the separating plate installed at the cylinder head. The side with grease should face the separating plate.

A2



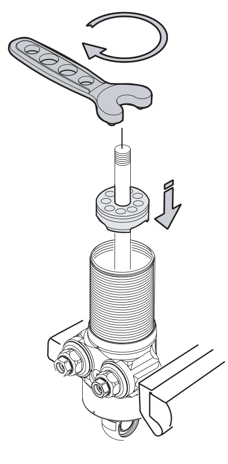
A2.

- Put 3 drops of Loctite 243 on the thread of the new outer tube. Apply a thin layer of red grease to the surface meeting the o-ring of the cylinder head. At the same time, apply some red grease inside the other end of the outer tube on the thread and the surface that will meet the end cap o-ring.

- Screw the new outer tube in place by hand.

- Install the piston rod and end cap assembly in the damper. Use the mounting sleeve (part no. 01861-01) for this operation.

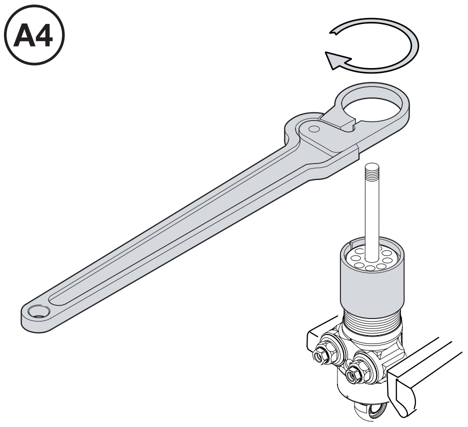
A3



A3.

- Screw in the cylinder end cap enough to support the outer tube when tightening the outer tube in the cylinder head. The end cap recommended position is about 1 to 2 mm above the end of the outer tube.

CAUTION:
Never have the end cap flush with the outer tube when the outer tube is installed on the cylinder head. The high torque used to install the outer tube could damage the cylinder end cap if it has been threaded in to far.



A4.

- Apply the ∅49 mm sleeve on the outer tube. Put the top of the sleeve at about the same level as the end of the outer tube.

- Install the spanner on the sleeve and place it in the same area as the cylinder end cap.

- Tighten the outer tube to the cylinder head.

Torque: 90 Nm (66 lbs.ft.)

As the torque can't be measured, it has to be estimated.

- Follow the steps A3 to A4 in section *Changing piston rods*.

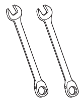
If the vacuum filling machine is used, see *Using Öhlins filling machine*. If the manual oil filling method is used, see *Manual oil filling method*. Finally, pressurise the damper. See *Using the gas filling device*.

SEE SECTION:
Changing piston rods: A3-A4

SEE SECTION:
Using Öhlins filling machine
or
Manual oil filling

SEE SECTION:
Using the gas filling device

Changing top eye

Degree of difficulty: 

Tools needed:
00146-01 Red grease
00778-01 Gas needle
01761-03 Peg spanner
01779-02 Gas needle housing
01781-01 Gas filling device
2 Screwdrivers*
Adjustable wrench with flat large jaws
Nitrogen gas
Soft mallet
Torx T20
Vise with soft jaws

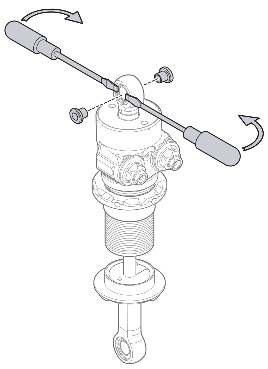
* Two are needed if there are spacers (“top hats”) installed in the spherical bearing of the top eye. Otherwise only one is needed.

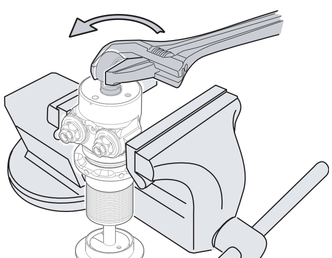
NOTE:
Make sure the top eye length corresponds to the internal piston rod length.

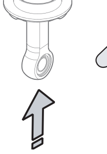
Top eye 06126-04 and longer versions are used together with a large reservoir end cap (part no. 06121-02).

D1

SEE SECTION:
Using the gas filling device





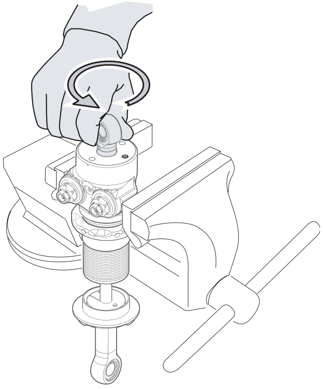


Disassembly:

D1.

- Depressurise the damper. See *Using the gas filling device*. Leave the gas needle together with the quick-connect hose installed.
- Remove the spacers from the spherical bearings in the top eye if installed.
- Gently clamp the flat sides of the cylinder head in a vise with soft jaws. The top eye must be pointing up.
- Push the piston rod to the fully compressed position. This will minimise the amount of oil getting into the new top eye.
- Apply the adjustable wrench at the centre of the bearing. Loosen the top eye by turning the wrench counter clockwise.

CAUTION:
Make sure the jaws of the wrench are long enough to reach across the hole for the bearing and engage the top eye on both sides of the bearing.



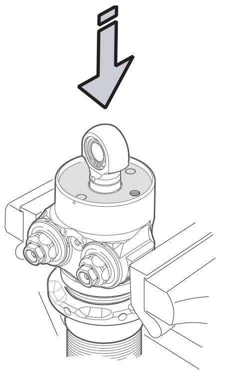
- Continue to screw the top eye counter clockwise by hand 3 to 5 turns. The top eye will thread out of the damper while the reservoir end cap stays stationary.

NOTE:

Do not unthread the top eye too far as it can come loose from the reservoir end cap. Later on, the top eye will be used to pull the end cap out of the cylinder head. It should take at least 7 turns until that happens.

- To avoid getting oil into the gas reservoir or air into the oil volume, it is important to keep the damper in an upright position.

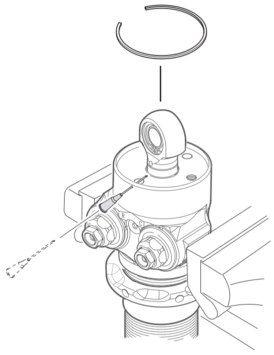
D2



D2.

- Push the reservoir end cap down with your fingers. Quite some force is needed. The top eye will follow the reservoir end cap back into the damper. If the end cap is stuck, tap on the top eye with a soft mallet. Be careful so the damper doesn't come loose from the vise as you are tapping.

D3

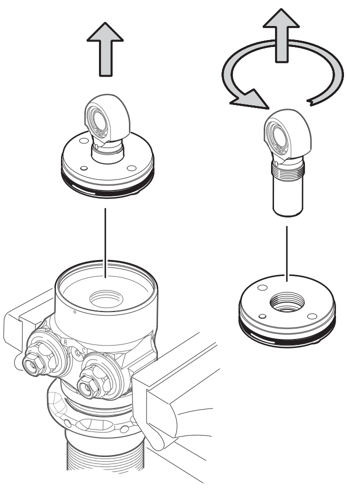


D3.

- Insert a gas-filling needle (part no. 00778-01) or a small Allen key into the small hole of the cylinder head with the chamfer of the needle pointing up. Try to get the needle underneath the circlip. If there isn't room enough to install the needle and push the circlip out of it's groove, screw out the top eye a little bit more and push the cap further in.

- If the circlip doesn't come out by itself, insert a small screwdriver underneath the circlip and help it out.

D4



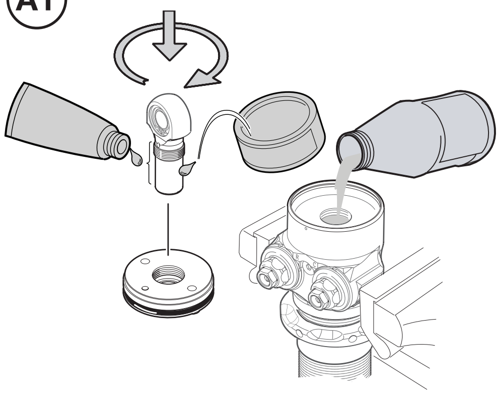
D4.

- Pull the top eye and the reservoir end cap out of the cylinder head. By moving the top eye side to side, less force will be needed.

- Thread the top eye out of the reservoir end cap.

Assembly

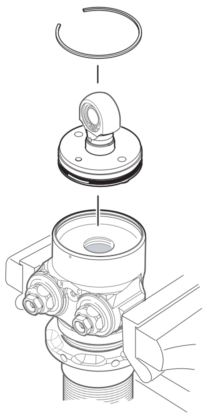
A1



A1.

- Put a thin layer of white grease on the new top eye where the separating piston moves.
- Add some red grease on the thread of the new top eye.
- Thread the new top eye a couple of turns into the reservoir end cap.
- If the damper is filled with oil, the following steps have to be done.
- Add oil into the centre hole of the separating piston, so the oil level reaches just above the centre of the o-ring in the separating piston.
- Remove any oil on top of the separating piston with a syringe or some lint free paper.

A2



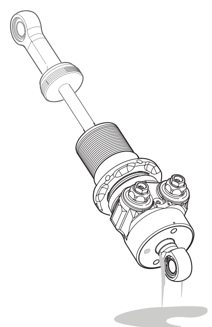
A2.

NOTE:
If the cylinder head of some reason is replaced, add a thin layer of white grease followed by a layer of red grease on the inside of the new cylinder head reservoir tube.

- Install the top eye and reservoir end cap unit into the cylinder head.
- Install the circlip.

NOTE:
Make sure the opening of the circlip isn't in front of the hole that is used to remove the circlip.

SEE SECTION:
Reclocking the top eye: S3-S6



- Set the clocking of the top eye by following step S3 to S6 in section *Reclocking top eye*.
- Drain any oil from the holes of the top eye. (Only needed on a filled damper.) Some brake clean can be used, but be careful so it doesn't come in contact with the piston rod seal.
- Check and adjust the oil level.
- Pressurise the damper.

SEE SECTION:
Pressurise the damper

Replacing seals, bushings, bearings and membrane

In total there are almost 20 seals in the TTX. The method to change these is very similar when you finally reach the seal after disassembling the damper. Tools and degree of difficulty varies. Here are some general ideas to keep in mind when doing seal changes and some detailed information about the seals and bushings for the two piston rods. See the chapter *Rebuilding the damper* and *Manual oil filling* for information about how to disassemble and assemble the damper.

Disassembly

Except for the piston rod seals, all seals consist of o-rings placed in grooves. If the o-ring is hard to remove by hand, a tool has to be used. A small screwdriver is often very useful. It is recommended to use a special screwdriver for this operation where the edges have been rounded off to reduce the risk of damaging the sealing surfaces.

CAUTION:
Always be careful not to scratch the surface of the groove.

The easiest way to remove small o-rings can be to use a gas needle (part no. 00778-01) to put underneath the o-ring or to even spear the o-ring on the needle.

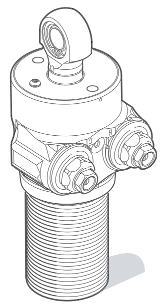
A method to find out if the rubber membrane in the reservoir end cap is leaking is to pressurise the damper and put some soapy water on top of the membrane and look for bubbles. This method can also be used to check the end cap o-ring. The membrane can be replaced if needed. Remove the reservoir end cap and remove the circlip holding the membrane. Pull the membrane out by using a small screwdriver, but be careful not to damage the surface of the end cap. For installation, see *Assembly* below.

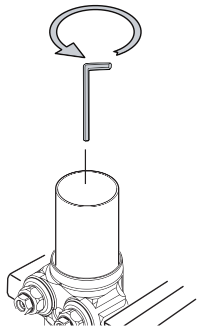
The piston seal consists of an o-ring with a soft ring outside of it to reduce friction. After removing the piston and rod assembly from the damper, the ring is easily removed by hand.

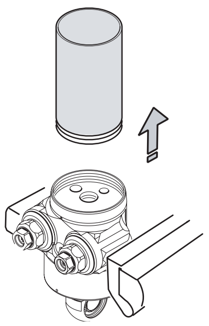
To reach the piston rod seal and bushing in the end cap, the end cap has to be removed. See section *Adding/Changing internal spacers*. The seal consist of an x-ring. One way to remove it is to spear it on a gas needle and pull it out. Outside the x-ring is a back-up ring that can be removed with a small screwdriver. The bushing is hard to remove without some special tools even though it is just pressed in place. Specific tools for this purpose are not available from Öhlins. A punch placed on one side of the split in the bushing works well. Gently tap the punch with a ballpien hammer until the bushing slides apart and is pushed out of the end cap. For further information contact Öhlins or an Öhlins distributor.

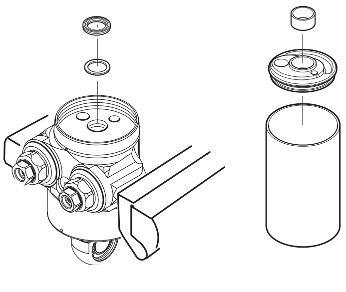
CAUTION:
When using a punch be very careful not to hit the material of the end cap.

The bushing for the internal piston rod is installed in the separating plate. If the outer tube is to be removed anyway, start by doing this. See section *Changing cylinder tubes*. If the outer tube doesn't need to be replaced, drain the damper of oil and remove the piston rod and end cap assembly. See section *Changing piston rods*. Continue by following the steps below.

D1


D2


D3


D4


D1.

- Let the damper stand for some time with the cylinder head pointing up and use some lint-free paper to remove as much oil as possible from the inside of the inner tube.

NOTE:
It is important that the damper is carefully drained of oil. If there is any oil residue, Loctite will be ineffective on the screw that positions the separating plate.

D2.

- Use a 3 mm Allen key to remove the screw of the separating plate.

D3.

- Lift up the inner tube using your fingers inside the inner tube. The separating plate should follow the inner tube up.

- As the separating plate only sticks to the inner tube due to the friction from an o-ring, just push out the separating plate. Use the handle of a hammer or something similar for this operation.

D4.

- If the bushing is to be replaced, press the bushing out of the separating plate. The bushing can be pressed out in both directions. Öhlins doesn’t supply tools for this operation. For further information contact Öhlins or an Öhlins distributor.

CAUTION:
Be careful not to damage the surface of the separating plate that will sit against the cylinder head as this surface must be perfectly flat and smooth to seal against the cylinder head.

- Remove the x-ring and back-up ring from the hole in the cylinder head with a suitable tool.

If the spherical bearing of the top eye or end eye has to be changed, remove the circlips with a pair of circlip pliers and push the bearing out.

NOTE:
Press on the outer race of the bearing.

Öhlins doesn’t sell tools for this operation. You have to make your own tool or order it from a bearing manufacturer. The bearing used has

Öhlins part no. 05536-05. The outer diameter is 22.2 mm (0.875 inch), the ball hole diameter is 12.7 mm (0.5 inch) and the ball width is 11.1 mm (0.437 inch).

With 36 mm (1.5 inch) spring configuration, the end eye uses a bearing with Öhlins part no. 05536-01. The outer diameter is 20.6 mm (0.8125 inch), the ball hole diameter is 9.5 mm (0.375 inch) and the ball width is 12.7 mm (0.5 inch).

Assembly

Always apply red grease on the new o-rings before installing them. Also, put a thin layer of red grease on the surfaces that will slide against the o-rings during installation.

Install the membrane of the reservoir end cap by pushing it into the hole after adding some red grease to the surface of the membrane. Then, install the circlip.

NOTE:

Put the “eyes” of the circlip on the side of the grove that is closest to the centre of the end cap. This reduces the risk of hitting the “eyes” when the gas needle is installed.

The piston ring can be installed in any direction as it is symmetrical.

When installing the seal and bushing of the end cap, the following procedure is recommended. If the bushing has been removed, install the back-up ring and x-ring from the inside of the end cap, otherwise do the installation from outside. Start to install the back up ring. Cover the x-ring with a thin layer of white grease followed by a layer of red grease. Then, install the x-ring into the groove. A rounded screwdriver is a perfect tool for this operation.

CAUTION:

The x-ring can easily twist 90? and is hard to notice. Be sure to verify the x-ring is installed correctly.

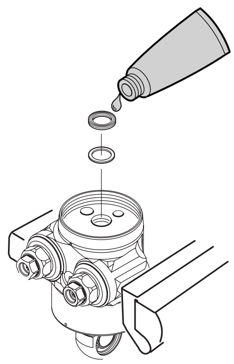
Finally press in the bushing so it is flush with the inside of the cylinder end cap.

CAUTION:

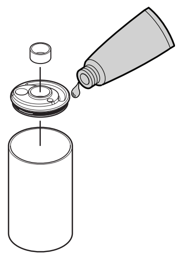
It is important that the bushing is correctly aligned with the end cap during installation.

To install the seal and the bushing for the internal piston rod follow the steps below.

A1



A2



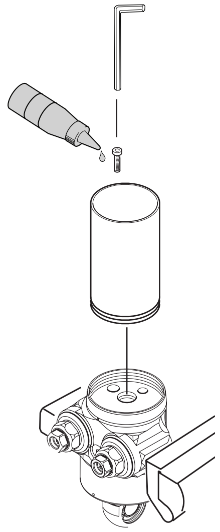
A1.

- Put the back-up ring back into the hole of the cylinder head.
- Apply a thin layer of white grease followed by a layer of red grease on the x-ring. Then, place it on top of the back-up ring. A rounded screwdriver is a good tool for this operation.

A2.

- Press a bushing into the separating plate if it has been removed. Remember to be careful with the sealing surface of the separating plate and to have the bushing aligned correctly in the hole.
- Add some red grease to the o-ring of the separating plate and put the inner tube back on the separating plate. This is done by hand.

A3



A3.

- Install the separating plate and inner tube assembly. The separating plate centres in the hole of the cylinder head.

- Clock the separating plate to the correct position by putting the screw hole in the plate in line with the hole of the cylinder head.

- Apply one drop of Loctite 222 on the screw and install it.

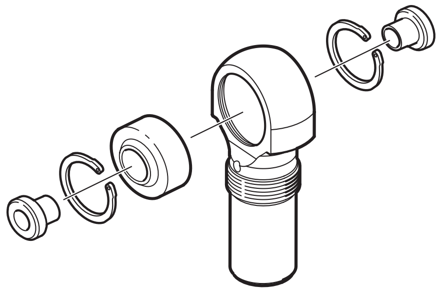
- Tighten the screw with a torque wrench.

Torque: 3 Nm (2 lbs. ft.)

When installing a spherical bearing, follow the steps below.

A1.

- Even if the outer ring of the bearing is chamfered, the edges are quite sharp. If possible round of the edges on one of the sides on the new bearing.



A2.

- Install one of the circlips in the groove opposite the side with the small chamfer. Use a pair of small circlip pliers for the operation.

- Clean the outer ring of the bearing and the hole of the eye and add 1-2 drops of Loctite 603 to the bearing. Spread the Loctite to a thin layer.

A3.

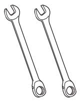
- Install the bearing. A manual arbor press is recommended. Press until the bearing contacts the installed circlip.

NOTE:

If you are making the installation tool yourself, you can design the tool so that it will bottom against the eye when the bearing is in the correct position.

- Install the other circlip.

Using Öhlins filling machine

Degree of difficulty: 

00146-01 Red grease
00773-01 Vise * / Standard vise with soft jaws*
01306-01 Shock absorber fluid 309
01779-02 Gas needle housing
01781-01 Gas filling device
01825-01 Cord for 230 V European standard /
01825-02 Cord for 115 V US standard
01840-01 Vacuum filling machine
01876-XX Separating piston positioning tool**
01877-XX Spacer, separating piston positioning tool***
01878-01 Damper holder*
3 mm Allen key ***
19 mm wrench / torque wrench
Nitrogen gas
Pressurised air with pressure 2.5 bar (approx. 40 psi.)*****
Small screwdriver (for the low speed adjusters)****
Torx T20
Torx T25

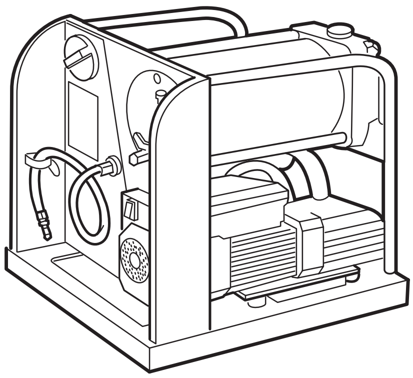
* Not necessary, but will make draining the oil from damper easier.

** 1876-XX is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

*** For each length of the top eye there is a corresponding length of the spacer tool in the 01877 series. The last digit of the spacer part number matches the last digit of the top eye part number. For example a 06126-02 top eye uses a 01877-02 spacer tool.

**** The low speed adjusters have a 3 mm internal hex, but until 2005 they had a screw driver slot.

***** If pressurised air isn't available, the nitrogen can be used to add pressure to the oil when filling the damper as long as the pressure can be limited to 2.5 bar.



The Öhlins filling machine is a device specially designed for filling dampers with fluid without allowing air into the damper.

The main components are reservoirs for fresh and waste oil, a motor driven vacuum pump, control valves and a pressure regulator. Everything is mounted in a compact steel frame.

The vacuum filling machine speeds up and makes the filling procedure of the TTX damper easier, it also gives a better result. Vacuum filling the damper effectively removes air from the damper body and reduces the amount of air dissolved in the damper oil. This is so important because even a small amount of air will result in damper flex. See chapter Hysteresis.

A kit of tools is included with the vacuum filling machine. The enclosed tools make it possible to use the vacuum filling machine on all Öhlins standard dampers. An owners manual (part no. 07221-01) is included with the machine.

The vacuum machine requires an electrical cord be added. Chose between

- 01825-01 Cord for 230 V European standard
- 01825-02 Cord for 115 V US standard

See Owners Manual 07221-01 for information about how to install and use the vacuum filling machine 01811-01.

The following unique TTX tools are required to position the separating piston.

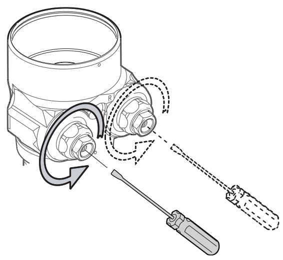
- 01876-XX Separating piston positioning tool
- 01877-XX Spacer, separating piston positioning tool

NOTE:
If special made spherical bearing spacers ("top hats") is used, ensure they fit together with the 01877-XX spacers. As long as the maximum diameter of the spherical bearing spacers is below 16 mm, there will not be a problem.

Here follows a description of how to vacuum fill the TTX damper step by step. The described method assumes a fully assembled damper partially filled with oil and an installed filling machine.

S1

SEE SECTION:
Using the gas filling device



S1.

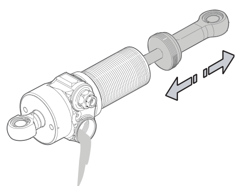
- Depressurise the damper by installing the gas needle unit and attach the quick-connect hose. See section *Using the gas filling device* for more details.

NOTE:
The gas needle unit has to be removed to later be able to install the separating piston positioning spacer.

- Open the low speed adjusters completely.

S2

SEE SECTION:
Revalving



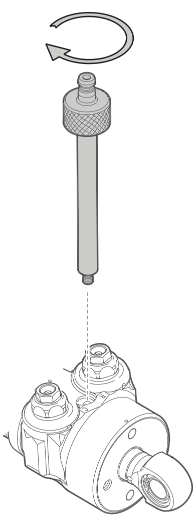
S2.

- Drain the oil from the damper before starting vacuum filling. One way to do this is to remove one of the valve end pieces (part no. 05942-01) and just pour the oil out at the same time as the piston rod is moved back and forth. When the damper is empty, put the end cap back. See section *Revalving* for more details on how to do the disassembly/assembly.

It is possible to vacuum fill a damper already filled with oil, but it has the following drawbacks.

- Increased risk of damper oil entering the vacuum pump.
- The waste oil reservoir will soon be full of oil.
- The time needed to suck the oil and air out of the damper must be extended for a good result.

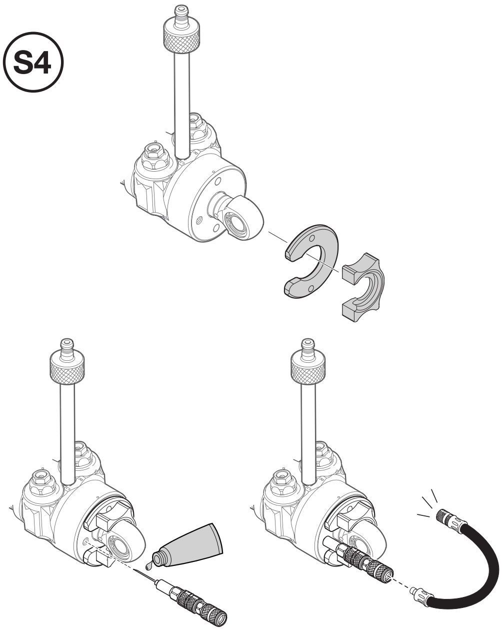
S3



S3.

- Remove the oil filling screw on the cylinder head with a Torx T25 screwdriver. Keep the o-ring in place on the cylinder head. Screw the M5 adapter (part no. 1820-01, included with the vacuum filling machine) in place by hand.

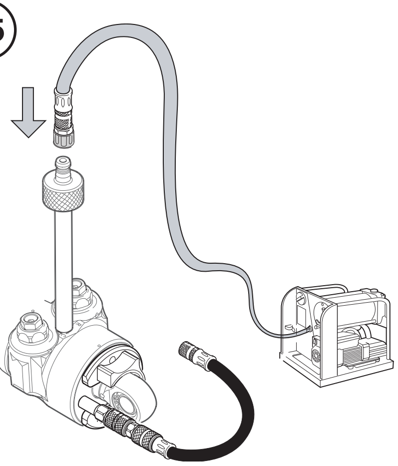
S4



S4.

- Put the separating piston positioning tool (part no. 01876-XX) in place. There should be no force pushing the pressure indicators back out as the damper is depressurised.
- Install the separating piston positioning spacer (part no. 01877-XX). For the correct part number see the text above. The side with the chamfer should go against the top eye. Clock the spacer so it rests as much as possible on the two shoulders of the top eye.
- Reinstall the gas needle unit and the quick-connect hose to keep atmosphere pressure inside the reservoir during the filling process to ensure the position of the separating piston doesn't move due to different pressurises on both sides of the separating piston.

S5



S5.

- Connect the installed adapter to the vacuum filling machine.

CAUTION:

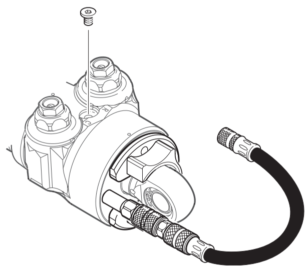
Lower the filling pressure (air pressure) of the machine to 2.5±0.5 bar (approx. 40 psi) when filling TTX dampers.

At 2.5 bar, there will about 550 N (122 lbs.) of load on the thin separating piston.

- Follow the instructions on how to operate the machine by studying the sections Empty procedures and Filling procedures in the owners manual (part no. 07221-01).

Note:
Be careful the spacer 1877-XX doesn't move from its position under the top eye during the filling procedure.

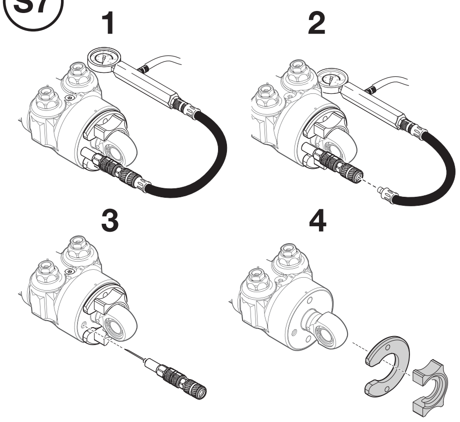
S6



S6.

- Disconnect the damper from the machine.
- Replace the M5 adapter with the filling screw.

S7



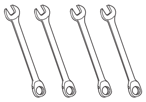
S7.

- Pressurise the damper. See Using the gas filling device.
- Remove the quick connect hose at the needle housing and unscrew the needle housing.
- Remove the separating piston positioning tools. This is done by twisting the 01877-XX spacer tool and pulling it out.

NOTE:

If you find it hard to remove the separating positioning tools if the damper is pressurised, you can first remove the separating piston positioning tools after removing the gas needle unit, then reinstall the needle unit and pressurise the damper.

Manual Oil Filling

Degree of difficulty: 

00146-01 Red grease
00778-01 Gas needle
01306-01 Shock absorber fluid 309
01761-01 Peg spanner for cylinder cap
01761-03 Peg spanner
01779-02 Gas needle housing
01781-01 Gas filling device
01876-XX Separating piston positioning tool
01881-01 Syringe kit
2 Screwdrivers***
Adjustable wrench with flat large jaws
Caliper
Nitrogen gas
Soft mallet
Torx T20
Torx T25
Vise with soft jaws

The oil retaining cup, part no. 01776-03, is nice to have, but not necessary.

** 1876-XX is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

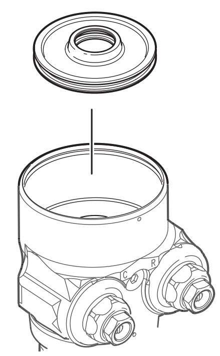
*** Two are needed if there are spacers (“top hats”) installed in the spherical bearing of the top eye. Otherwise, only one is needed to help remove the circlip of the reservoir end cap and to open the low speed adjusters if needed.

If the oil level is found too low, see Adjusting the oil level for tools needed.

Compared to using a vacuum filling machine, you will find the manual oil filling method quite time consuming. Every team should put that in relation to the cost of investing in a vacuum filling machine.

S1

SEE SECTION:
Changing top eye: D1-D4



The following is a step by step description of how to fill the TTX damper without a vacuum filling machine. The described method assumes a fully assembled damper without spring retainer with no or just some oil inside.

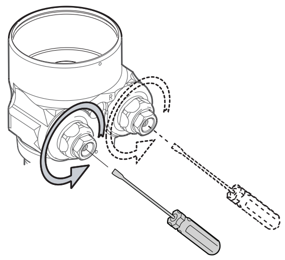
It is also possible to fill the damper through one of the valve cavities after the valve end piece has been removed. However, it can be hard to remove all trapped air inside the damper as the damper is horizontal in this case. This method doesn’t perform as good as the method described below. Therefore, it is not recommended.

S1.

- Follow step D1 to D4 in *Changing top eye*.

- Remove the separating piston. This is done by hand. Put in a finger in the centre hole and lift it up.

S2



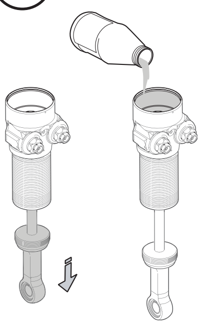
S2.

- Set the low speed adjusters to minimum force positions (fully open).

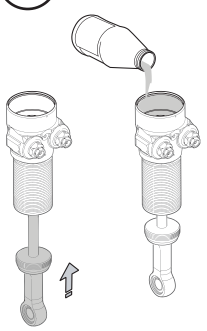
S3.

- Pull the piston rod to fully extended position.
- Fill the cylinder head with oil to the circlip groove.

S3



S4



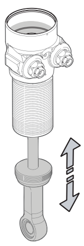
S4.

- Push the piston rod slowly into fully compressed position. If the damper is empty on oil, the oil level in the cylinder head will drop. Take care that no air is drawn into the damper.
- Again add oil to the cylinder head up to the circlip groove.

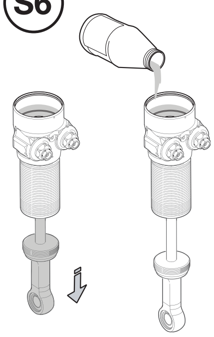
S5.

- Continue to stroke the damper until all the air is removed. After using full stroke movements, additional air can be removed by using short, fast strokes. Be mindful of the air bubbles.

S5



S6



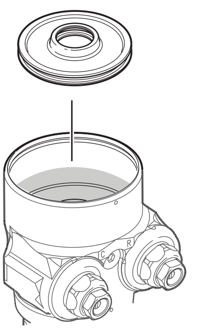
S6.

- Pull the piston rod to the fully extended position and if needed add oil enough to cover the separating piston after it has been installed.

S7.

- Install the separating piston and push it towards to the bottom. Be sure the o-ring is well coated with red grease to help ease the installation. The conical side should face towards the damper. Make sure it is parallel to the bottom of the cylinder head to ensure that no gas bubbles are trapped underneath the piston. Oil will now cover both sides of the separating piston.

S7



CAUTION:

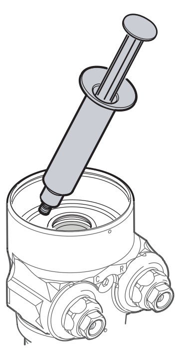
It is hard to avoid stick slip, so it is very likely that some oil will splash out. One way to avoid this problem is to place a rag above your hands and the damper while you install the separating piston.

NOTE:

The further down you push the separating piston, the less oil there will be in the damper. You could try to position the piston about 2 mm from the bottom, which is in the middle of the accepted window. A 2 mm gap between the separating piston and the cylinder head will give the desired 1 mm gap between the 01876-XX tool and the reservoir end cap.

- If there are internal spacers on the rebound side, push the separating piston all the way down. It will move back later on when oil is added at the end cap during the evacuation of trapped air underneath the piston.

S8



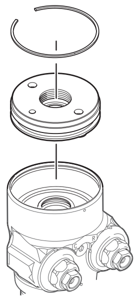
S8.

- Remove the oil above the separating piston. The level of oil should reach the centre of the o-ring in the hole of the separating piston. The syringe kit (part no. 01881-01) is very useful for this operation.

- The last amount of oil can be dried up with some lint-free paper.

NOTE:
The gas volume doesn't have to be completely free of oil.

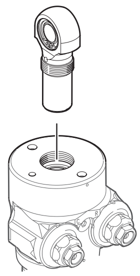
S9



S9.

- Install the reservoir end cap and the circlip.

S10

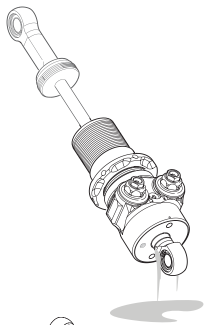


SEE SECTION: Reclocking the top eye

S10.

- Put the top eye into the hole of the reservoir end cap and thread it into the reservoir end cap.
- Clock the top eye to the desired angle by following the instructions in section *Reclocking the top eye*.

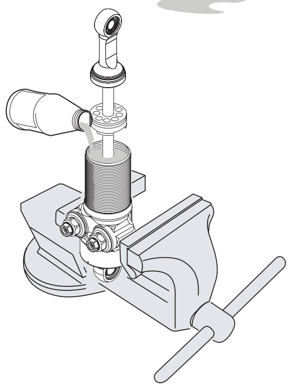
S11



S11.

- Loosen the damper from the vise and turn it upside down so any oil trapped in the top eye can come out through the two holes in the top eye.
- If the damper has internal spacers on the rebound side, go to S12, otherwise check the oil level and if necessary adjust it. See sections Checking the oil level and Adjusting the oil level. When the oil level is correct, pressurise the damper. See Using the gas filling device.

S12



S12.

- Place the damper upside down in a vise, so the piston rod is pointing upwards by clamping the damper gently at the flat sides of the cylinder head.

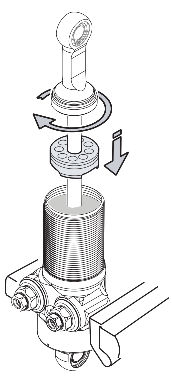
NOTE:
As the oil later on will flow out between the end cap and the tube, place the damper where you easily can collect the oil. By wrapping some paper around the cylinder tube, some oil can be collected. An oil fill cup is available (part no. 1776-03).

- Unscrew the cylinder end cap from the outer tube and pull it up enough to make it possible to add oil to the damper.

NOTE:
Don't move the piston and rod unit too far out from the cylinder tube as oil then would start to leak out through the top eye.

- Add some oil to the cylinder to guarantee an oil overflow. An oil level covering the beginning of the thread should be enough.

S13



S13.

- Rotate the end cap to prevent stick slip as it slides down the piston rod and thread it back into the outer tube.
- If no oil is flowing over before the end cap is pushed down all the way, steps S12 and S13 have to be repeated.

SEE SECTION:
Checking the oil level

SEE SECTION:
Adjusting the oil level

SEE SECTION:
Using the gas filling device

- Check the oil level. There should be a little bit too much oil in the damper. See sections *Checking the oil level* and *Adjusting the oil level*. When the oil level is correct, pressurise the damper. See *Using the gas filling device*.

Checking Oil Level and Pressurisation

Degree of difficulty:

Tools Needed:
01876-XX Separating piston positioning tool*
Caliper

* 1876-XX is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

With no other damper on the market is it as easy to check the oil level as the TTX. Along with verifying the oil level you will check if the damper is pressurised or not.

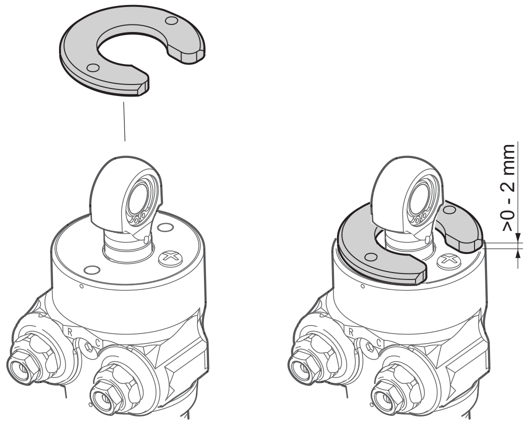
Before you have enough experience to know how the position of the separating piston varies due to heat on your particular car, you should make checking the floating piston part of your regular routine. It would be advised to do this not only before you install the dampers on the car, but also when they are hot, This will give you a feel for how much the floating piston will move and you can adjust the starting oil level accordingly

NOTE:
The TTX doesn't change separating piston position due to shaft position.

How much the separating piston moves due to temperature changes depends on the size of the damper. The larger the damper is, the more the separating piston will move for a specific temperature change because of the larger volume of oil. The volume change of the gas can be significant. If you set the position of the separating piston early in the morning when it is cold outside, the oil level might have increased significantly in the afternoon.

Step by step instructions on how to check the oil level and to check if the damper is pressurised follow. The described method assumes a fully assembled damper.

S1



S1.

- Install the separating piston positioning tool (part no. 01876-XX) in the reservoir end cap by pushing down the pressure indicators with the two pins of the tool. If a force is pushing the tool back up, the damper is pressurised.

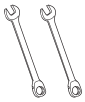
- Push the tool so that it is parallel to the end cap and measure the distance between the tool and the end cap.

- The distance should be >0 to 2 mm at room temperature. As the temperature rises, the distance will increase. However, at operating temperature the distance should never extend more than 4.5 mm if the short reservoir end cap (part no. 06121-01) is used and no more than 7 mm if the long reservoir end cap (part no. 06121-02) is used.

NOTE:

When installing the separating piston positioning tool, you might find that the separating piston isn't parallel with the cylinder head (up to 3 mm). This is not a problem. If the tool is in contact with the reservoir end cap, you don't know the actual oil level. There must be some air between the tool and the end cap hence the lower limit is set to >0. If the tool is touching the end cap add oil. (When the tool is hitting the reservoir end cap, the separating piston can still move 1 mm more inside the damper before it bottoms against the cylinder head.) When the separating piston positioning spacer (part no. 01877-XX) is installed and oil is pressed into the damper, for example in the vacuum filling machine, the distance between the tool and the end cap will be approximately 1 mm. If the damper is properly filled with oil, you will not notice any movement of the separating piston when the damper is getting pressurised. If the separating piston moves further in, there is air in the oil.

Adjusting oil level - Adding oil

Degree of difficulty: 

Tools Needed:
00146-01 Red grease
00773-01 Vise / Standard vise with soft jaws
01306-01 Shock absorber fluid 309
01779-02 Gas needle housing
01781-01 Gas filling device
01876-XX Separating piston positioning tool*
01877-XX**
01881-01 Syringe kit
Nitrogen gas
Torx T20
Torx T25

* 1876-XX is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

** For each length of the top eye there is a corresponding length of the spacer tool in the 01877 series. The last digit of the spacer part number matches the last digit of the top eye part number. For example a 06126-02 top eye uses a 01877-02 spacer tool.

If the oil level in the damper is too low, oil has to be added. Except for the described method below, oil can be added by

- Using a vacuum filling machine

- Opening up the cylinder end cap and adding oil.

The vacuum filling method is not recommended unless there is air in the oil, as you must first empty the damper of oil.

The following is a description of how oil can be added to the damper. The description assumes a fully assembled damper.

S1

SEE SECTION:
Using the gas filling device

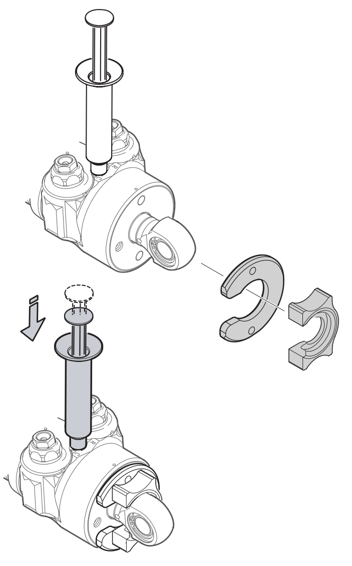
SEE SECTION:
Using the oil syringe

S1.

- Depressurise the damper by installing the gas needle unit and attaching the quick-connect hose. Leave it installed. See section *Using the gas filling device* for more details.

- Position the damper with the oil filling screw pointing up and remove the oil filling screw on the cylinder head. The vise 00773-01 along with 1878-01 is recommended. Keep the o-ring on the damper and screw the oil syringe (kit part no. 01881-01) filled with oil in place by hand. See section *Using the oil syringe* for more information.

S2



S2.

- Put the separating piston positioning tool (part no. 01876-XX) in place.

- Install the separating piston positioning spacer (part no. 01877-XX). For the correct part number, see the text above. The side with the chamfer should face the top eye. Clock the spacer so it rests as much as possible on the two shoulders of the top eye.

- Press oil from the syringe into the reservoir until the piston of the syringe gets solid. The separating piston has now bottomed out towards the pressure indicators positioned by the separating piston positioning tools.

S3

SEE SECTION:
Using the gas filling device

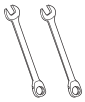
S3.

- Unthread the syringe and reinstall the screw.

- Remove the separating piston positioning tools.

- Pressurise the damper. See *Using the gas filling device*.

Adjusting oil level - Removing oil

Degree of difficulty: 

Tools Needed:
00146-01 Red grease
00773-01 Vise / Standard vise with soft jaws
01779-02 Gas needle housing
01781-01 Gas filling device
01876-XX Separating piston positioning tool*
1 mm shim stack / washer (2 pcs)**
Caliper
Nitrogen gas
Torx T20
Torx T25

* 1876-XX is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

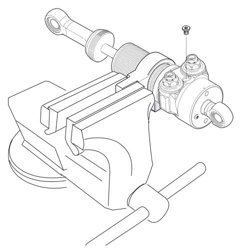
** Not necessary, but makes the job a lot easier.

If the oil level in the damper is too high, oil can be removed by using the following method.

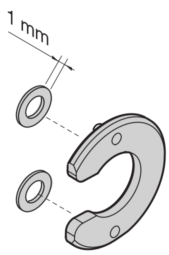
The following is a description of how oil can be removed from the damper. The description assumes a fully assembled damper.

S1

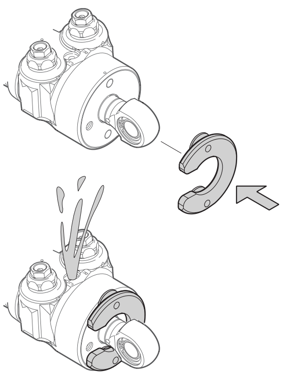
SEE SECTION:
Using the gas filling device



S2



S3



S1.

- Depressurise the damper by installing the gas needle unit and attaching the quick-connect hose. Leave it installed. See section *Using the gas filling device* for more details.
- Position the damper so the oil filling screw is pointing upwards and remove the oil filling screw on the cylinder head. It is recommended to use the vise 00773-01 and 1878-01.

NOTE:
As oil later will flow out through the screw hole, place the damper where you can easily collect the oil.

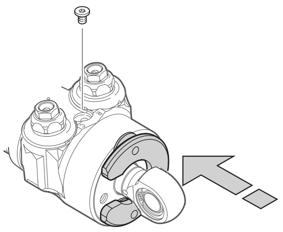
S2.

- Put 1 mm thick shim stacks or washers around each of the two pins of the separating piston positioning tool.
- This will help to set the separating piston in the correct position and remove the risk of the separating piston being pushed in too far.

S3.

- Install the separating piston positioning tool (part no. 01876-XX) and push it in slowly until the shim stacks / washers hit the reservoir end cap. Oil will now flow out through the screw hole.

S4



SEE SECTION:
Using the gas filling device

S4.

- Keep the pressure on the tool and install the screw. This prevents air from being sucked in when the tension of the o-rings of the separating piston is removed. The elasticity of the o-rings would otherwise move the separating piston back slightly.

- Remove the separating piston positioning tool and pressurise the damper. See *Using the gas filling device*.

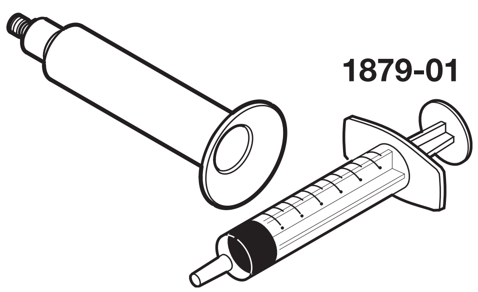
Using the oil syringe

The oil syringe is used both to add oil into the damper if the oil level is found too low and to remove oil above the separating piston when the damper is filled manually.

The syringe kit part no. 01881-01 consists of

- 01880-01 Syringe casing 1 pcs
- 01879-01 Syringe piston 5 pcs

The 01879-01 Syringe piston is actually an ordinary medical 5 ml syringe. The syringe is ready for use by following the steps below.



S1.

- Pull out the piston with the rubber seal from the plastic casing.

S2.

- Put some red grease or damper oil on the rubber seal and install it into the steel casing (part no. 01880-01).

S3.

- Fill oil into a cup (the Öhlins oil bottle cap can be used) and put the tip of the syringe under the surface of the oil and suck oil into the syringe by pulling the piston outwards.

NOTE:
There is no stop, so pay attention to the position of the plunger, so you don't pull it out of the casing.

S4.

- Turn the syringe up and push piston in just enough to evacuate the air.

- The syringe is ready to be used.

NOTE:
The rubber of the plunger will swell from damper oil. This process, which takes some time, can be annoying so always remove the piston from the casing after it has been used. If the rubber seal is removed from the piston and carefully cleaned, it can be reused, but the low price of this piston makes a frequent change the best solution. The separating piston moves 0.44 mm per millilitre of oil.

Using the gas filling device - Preparing the gas filling device

The TTX uses the same system for pressurising dampers as Öhlins uses on all their other products: Nitrogen gas separated by a piston. The gas is filled through a needle pushed through a rubber membrane connected to the gas reservoir.

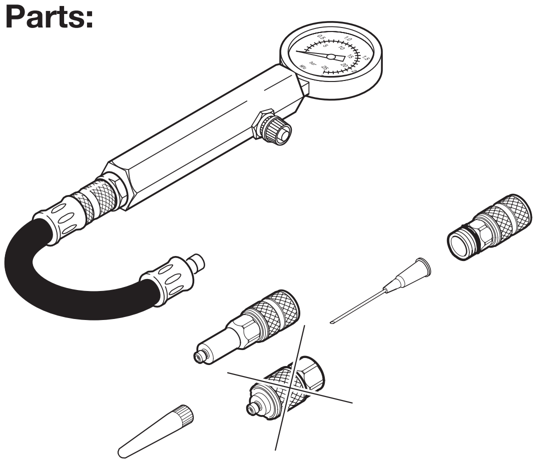
To pressurise the TTX damper, Öhlins standard gas filling device 01781-01 is needed. Always make sure to have some spare gas needles (part no. 0778-01).

The following special tool for the TTX is also needed.
- 01779-02 Gas needle housing

To be able to use the gas filling device on the TTX it has to be modified: Replace the needle housing (part no. 01781-01) included in standard gas filling device with needle housing 01779-02. 01779-02 can be used on most Öhlins product.

To do this modification the following tools are needed:
- 10 mm wrench
- 11 mm wrench
- 14 mm wrench

Parts:



S1.

- Loosen the old needle housing from the gas filling device. A 11 mm and 14 mm wrench are needed.

S2.

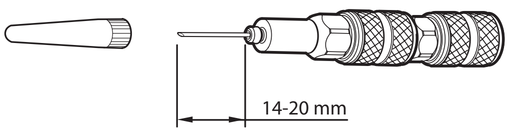
- Push out the installed needle. The easiest way is to push the needle towards some surface that doesn't damage the tip of the needle (some wood or plastic material is recommended).

S3.

- Put the needle into the new needle housing and screw it back on the gas filling device. A 10 mm and 11 mm wrench are needed.

NOTE:
Use a low torque.

S4



S4.

- Check the length of the needle. The visible length of the needle should be 14 -20 mm (measured to the tip of the needle).

If the length is shorter, there is a risk the needle will not reach all the way through the rubber membrane. If the needle is longer, the risk is that it will hit the separating piston.

NOTE:
If the damper is warm, the risk that the needle hits the separating piston is increased as the gas volume gets smaller at higher temperatures. Always make sure the needle is undamaged. Change the needle if you find burrs around the tip. A bad needle can cause damage to the rubber membrane.

Using the gas filling device - Depressurising the damper

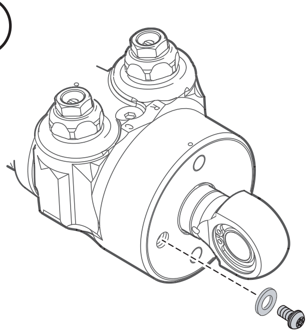
Degree of difficulty: 

Tools Needed:
Red grease
00773-01 Vise* / Standard vise with soft jaws*
01779-02 Gas needle housing
01781-01 Gas filling device
Torx T20

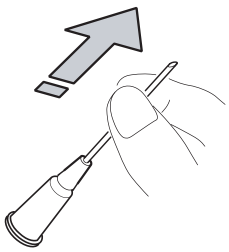
* Not necessary.

The description assumes a fully assembled damper.

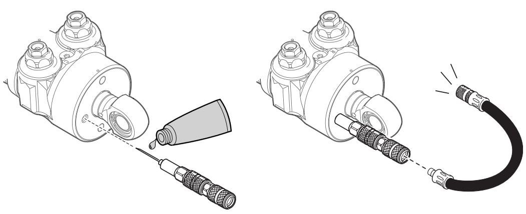
S1



S2



S3



S1.

- Remove the screw together with the washer covering the membrane at the reservoir end cap with a Torx T20 screwdriver.

S2.

- Make sure the needle is undamaged by checking for burrs around the sharp tip. If you are careful you can easy find burrs with your fingers tips by grabbing the needle between two fingers and move them along the needle to the tip.

⚠ WARNING:
Never move the fingers towards the tip.

S3.

- Apply some red grease (part no. 00146-01) to the tip before inserting it into the rubber membrane in the reservoir end cap.

- When the needle is successfully inserted, thread the needle housing into the reservoir end cap.

- Attach the quick-connect hose without the gauge to depressurise the damper.

Using the gas filling device - Pressurising the damper

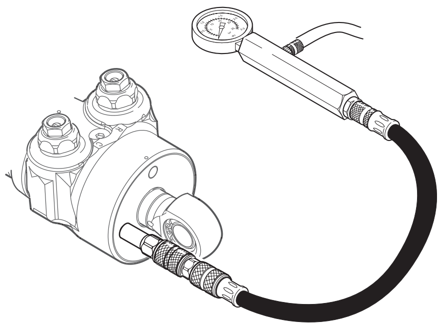
Degree of difficulty:

Tools Needed:
00773-01 Vise* / Standard vise with soft jaws*
01779-02 Gas needle housing
01781-01 Gas filling device
Nitrogen gas
Torx T20

* Not necessary.

The description assumes a depressurised damper with the quick-connect hose installed.

S1

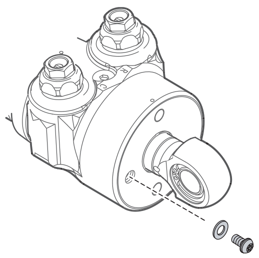


S1.

- Attach the quick connect gauge to the quick-connect hose and charge the damper to the specified pressure, standard is 5 bar (75 psi).

⚠ WARNING:
Only use Nitrogen gas (N2) to pressurise the damper. Nitrogen is an inflammable gas that has no affect on the materials in the gas reservoir.

S2



S2.

- Reinstall the screw and washer in the reservoir end cap to protect the thread from dirt.

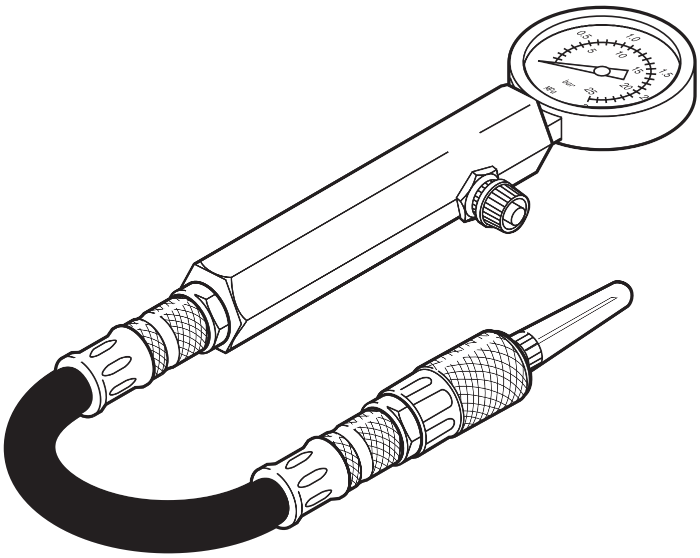


Figure 19.0 *Gas filling device*

19 Gas Pressure

A good rule is to stay with the recommended pressure. For the TTX this pressure is 5 bar (75 psi).

In the TTX, different gas pressures have no influence of the damper characteristics. For instance a range of 2 to 10 bar can be used with no influence on the characteristics. Even going higher than 10 bar will not effect the damping characteristics but it will exert unnecessary forces on the damper parts. Be aware that at 0 bar, there will be cavitation.

⚠ WARNING:
Never run the TTX damper at higher gas pressure than 10 bar.

Always pressurise the damper at room temperature.

Use nitrogen gas only. It is an inflammable gas with no effect on the material in the gas reservoir.

See section Using the gas filling device in chapter Work section for how to pressurise and depressurise the damper. If there are any doubts, please contact your Öhlins distributor.

Figure 20.1 *Paul Tracy, Forsythe Championship Racing.*

20 Temperature Range

The working environment for the damper is important to its function and life You should always pay attention to the damper temperature. Low temperature is normally not a problem with the TTX damper. The problem is high temperatures.

Some heat is generated by the damping energy, but most of the heat comes from being in close proximity to engine or brake parts. Try to keep the temperature b low 90°C (approx. 200°F). If the damper runs hotter than 120°C (approx. 250°F), try to vent some fresh air to the damper. Heat shields may be necessary. Naca ducts in the engine cover also help cooling. If your vehicle has the exhaust system on one side only, a larger naca duct on that side can equalise the temperature of both dampers.

The gas volume is not stroke dependant, but remember that the gas volume will decrease as the oil expands from the temperature change.

NOTE:
Many times the temperature variation is the problem, not the temperature itself.

⚠ WARNING:
Always pay attention to the position of the separating piston.

See section *Revalving* in chapter *Work section* for information.

To cool down the dampers, when they come of the car, some teams put them in a can of cold water. This is not recommended. However if this happens, put the shock in with the cylinder head down. Trapped air will help prevent water from reaching the internal piston rod. Also, spray some WD40 or similar into the holes of the top eye to protect the piston rod. Otherwise, the end of the piston rod will rust. Make sure the rust preventive being used doesn't cause damage to rubber.

21 Routine Maintenance

It is hard to give recommendations about servicing dampers as the conditions vary a lot. For example, during hot and dirty conditions the maintenance has to be done more frequently.

An example of a recommended inspection and maintenance schedule for a Champ car team starting to run TTX dampers is as follows.

NOTE:
Depending on the results of the inspections below, the time between the inspections can be changed.

Every race weekend

- Measure the position of the separating piston. This should be done several times during a race weekend. On the TTX this is a very quick operation. See section Adjusting the oil level in chapter Work section.
- Look for oil leakage. By keeping the damper clean and dry, any leakage will be easy to detect. If oil is leaking from the X-ring seal repeatedly, replace X-ring and inspect the piston rod for imperfections on its surface.
- Inspect the dampers for external wear or damage.
- Check the spherical bearings regularly for excessive play. On installations where the spring is not of coil over type, a gap is more critical as the bearings will see loads in both directions.

Every third to fifth race weekend

- Inspect the piston ring for wear occasionally by measuring the height and width of the piston ring.

NOTE:
The piston ring of the TTX is a seal and not a bushing and it does not take any side loads so ware should be minimal.

See the figure below for smallest accepted dimensions of the piston ring. Replace if necessary. See section Rebuilding the damper in Work section for information about how to remove the piston ring.

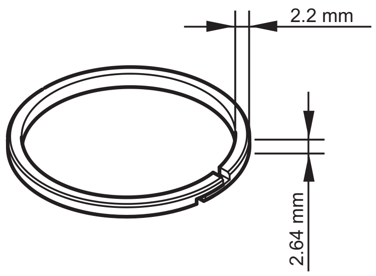


***Figure 21.1** Smallest accepted dimensions of the TTX damper piston band.*

- Check the condition of the inside of the inner tubes. See section Rebuilding the damper in Work section for information about how to remove the inner tube.

- Examine the sealing surfaces of the poppet valves and the check valves. These consist of the valves, the seats and the nose shims. The sealing surface of the nose shims will become polished, but as long as no significant wear is noticed, they won't have to be replaced. The same thing is true for the check valve shims. See section Revalving in Work section.

- Examine the surface of the needle housing (part no.05953-01/-02) where the coil springs is seated.

It is hard to give some general recommendations when to change the oil as the conditions vary greatly. If the oil has changed colour and smells bad the oil should be changed. In hot conditions, in the region of 90°C (approx. 200°F) begin to inspect the oil after about 1500 km (approx. 1000 miles). Only use Öhlins damper fluid 309.

If any o-rings need to be replaced, always apply Öhlins red grease (part no. 00146-01) to the new o-rings. The same thing applies to the threads where no Loctite is used.

A dynamometer is a good tool to find failures in the damper. Therefore, we recommend doing regular dynamometer testing. For example leakage, check valve problems, etc, can be detected. See chapter Damping force measurement for more information.

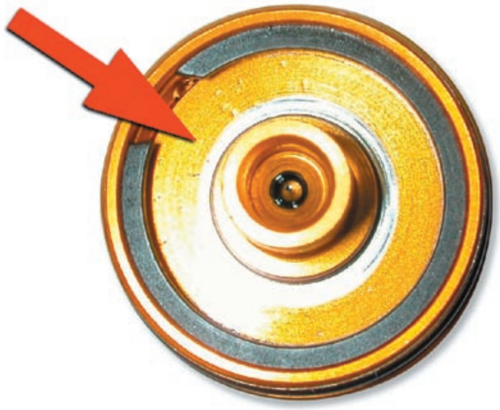


Figure 21.2 *Area to inspect at the needle housings.*

Every tenth to fifteenth race weekend

- Inspect the condition of the two piston rod bushings. Even if some of the PTFE (grey colour) covering the surface of the bushings is gone, they still perform fine. If all of the PTFE is gone, the bushings should be replaced. No Loctite is needed. If assistance is needed, contact Öhlins distributors.

At least once every season, we recommend complete disassembly of the damper for visual examination. Ask your Öhlins distributor for help or advice if needed.

In chapter Spare parts information about torque, Loctite and grease are listed.

⚠ WARNING:

Make sure the chemical substance used for cleaning the dampers doesn't harm rubber and plastic.

Figure 22.0 *Michel Jourdain becomes airborne in Turn 1 at the start of the race.*

22 Actions After a Crash or Fire

The damage to a car involved in a crash very often gives a good idea if the dampers are intact or not. If you suspect that there is a risk that something has happened to a damper, you should remove the damper from the car for closer inspection.

First, check for leakage and new external marks or cuts on the damper you haven't seen before. If you find something, you have to inspect the damper carefully to determine what is damaged.

Slowly compress the damper by hand and pay attention for variations in friction. Increased friction is often an indication of a bent piston rod. The straightness of the piston rod should always be checked and be within 0.05 mm (0.002 inch).

If possible, make a dynamometer test to ensure that the damping forces reproduce correctly.

A crash sometimes results in cracks in the damper materials. The cracks may be hard to detect with the bare eyes, so Öhlins always recommends making a magnaflux inspection on the parts that could be damaged. If no special indications of damage can be seen, these parts should always be checked: top eye, cylinder head, outer tube, piston rod and end eye.

If the dampers have been in an area of fire, the heat might have had an effect on the material. The rubber seals are the most sensitive parts and should always be replaced. Also, check the plastic parts like spacers, bushings etc.

When opening a damper that has been in a fire, ensure the ventilation is good and avoid getting the oil on your skin as it might be harmful.

NOTE:

Glued parts can come loose. In the TTX, Loctite is used between the outer tube and the cylinder head, between the piston rods and on the screw for clocking the separating plate.

See *Spare parts* for information where Loctite has been used.

Even with no visible damage to the metal parts, the heat might have affected them and the strength of the materials can be reduced. By measuring the hardness of the materials, you can find out. If the hardness has gone down, the parts should be replaced.

If the dampers have been at a very high temperature, not only in a fire but anything that may cause unusually high temperatures, there is a risk that the separating piston will bottom out. If so, the cylinder head could start to deform at the circlip holding the reservoir end cap. Therefore inspect the top of the cylinder head carefully.

If in doubt, always replace the parts.

23 Adjustment and Valving Charts

By using the TTX VRP, no charts illustrating damping forces, with respect to clicker adjustments and valving changes are needed. However, as you might not have the possibility to use the VRP or a dynamometer, we will illustrate some damping force graphs here.

NOTE:
As the compression and rebound damping are identical if the settings are the same, all forces here will be illustrated as compression damping forces only.

As the number of combinations of both hardware and external adjustments are huge, only some examples will be illustrated here. In all examples, both with the small and large poppet valve, the nose shims are 0.15 x 3. The position of the low and high speed adjusters, together with poppet valve and spring is changed.

The damping graphs illustrated are from the VRP. The data in the VRP have been measured at constant velocity in an Instron dynamometer at Öhlins Laboratory.

NOTE:
If these forces are compared with forces produced in a dynamometer measuring the forces continuously, there will some differences. See chapter Damping force measurement.

NOTE:
Compression and rebound damping forces are identical if the same setting is used.

NOTE:
The scale differs in the graphs.

In figures 23.1 and 23.2 the standard valving is used. The standard valving uses the following valve parts.

Poppet valve:	04103-06
Nose shims:	01415-14 x 3
Spring:	04107-04 (40 N/mm)

In figures 23.1 and 23.2 the standard valving is used. The standard valving uses the following valve parts.

Poppet valve: 04103-06
Nose shims: 01415-14 x 3
Spring: 04107-04 (40 N/mm)

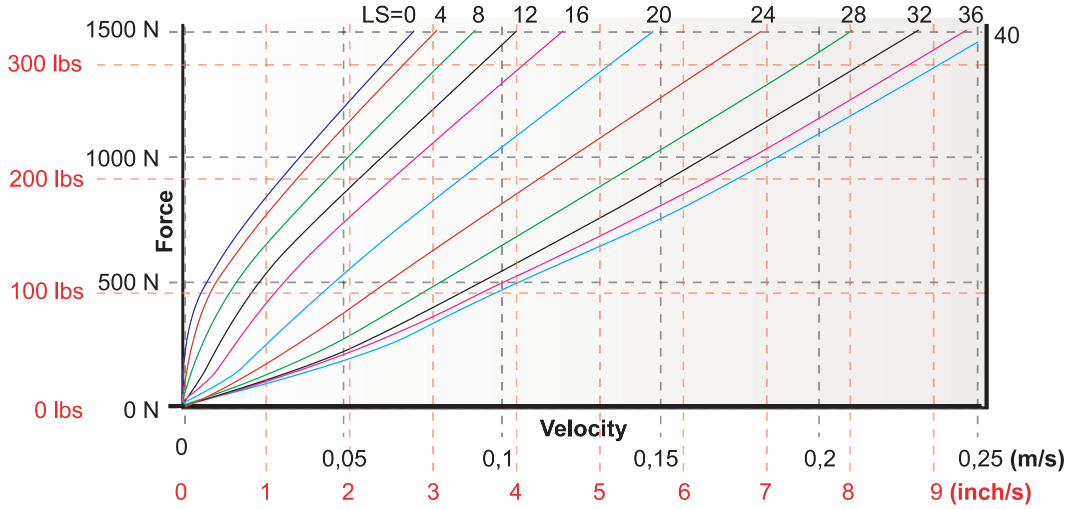


Figure 23.1 *Adjustment range of the low speed adjusters. The high speed adjuster is set to clicker position 0.*

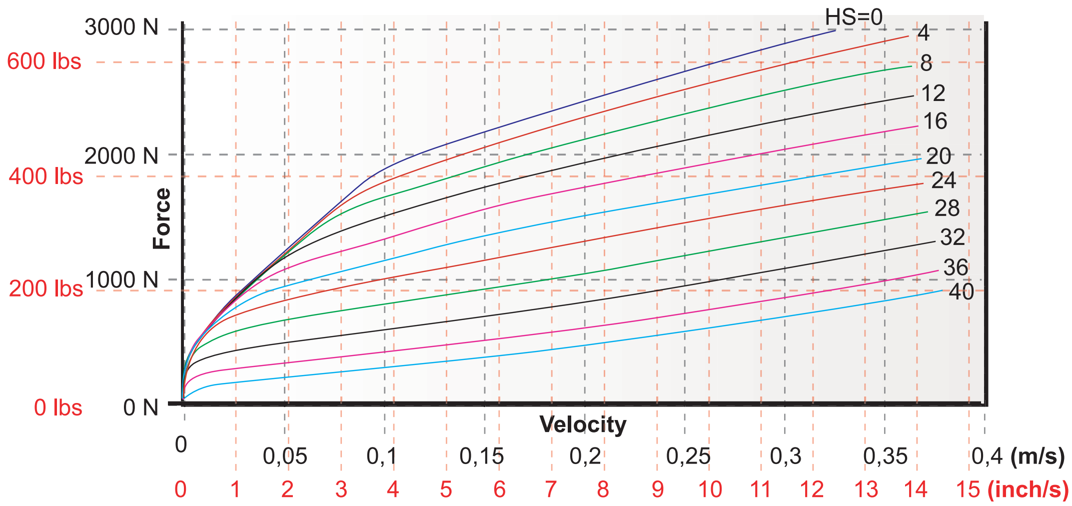


Figure 23.2 *Adjustment range of the high speed adjusters. The low speed adjuster is set to clicker position 0.*

By changing valve springs the following spectrums can be achieved. In figures 23.3, 23.4 and 23.5 the standard poppet valve (04103-06) and nose shims (01415-14x3) are used.

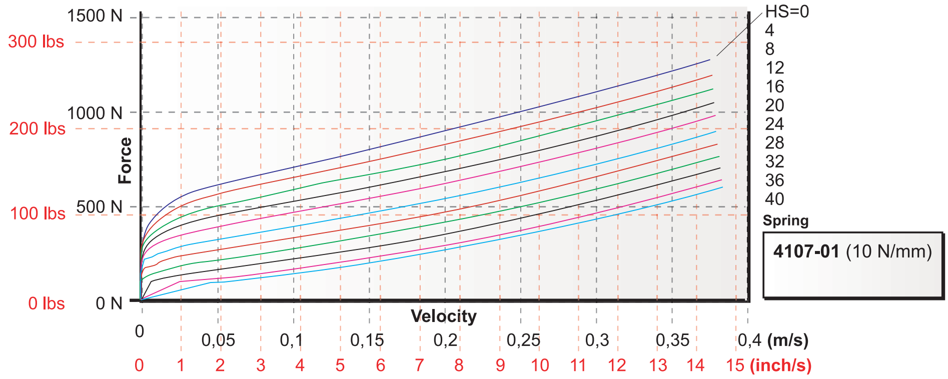


Figure 23.3 *Adjustment range of the high speed adjusters with 10 N/mm spring (part no. 04107-01). The low speed adjuster is set to clicker position 0.*

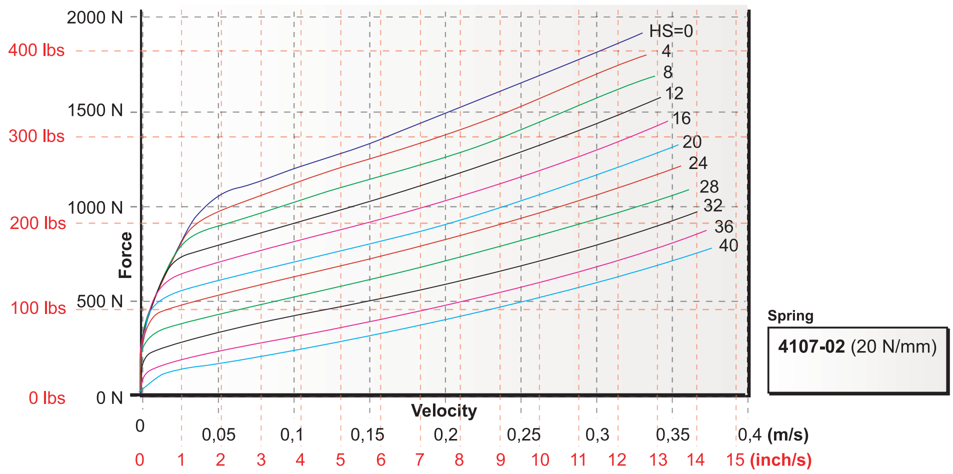


Figure 23.4 *Adjustment range of the high speed adjusters with 20 N/mm spring (part no. 04107-02). The low speed adjuster is set to clicker position 0.*

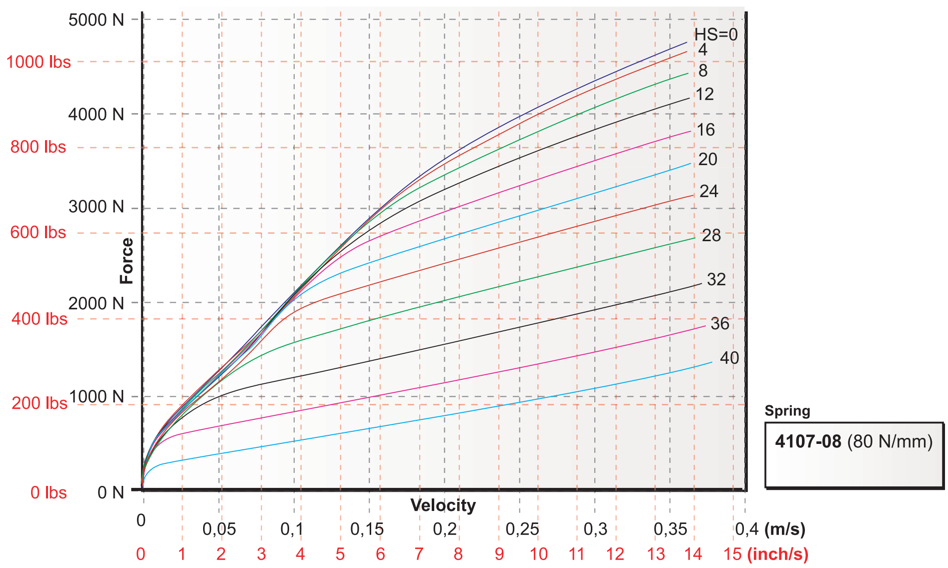


Figure 23.5 *Adjustment range of the high speed adjusters with 80 N/mm spring (part no. 04107-08). The low speed adjuster is set to clicker position 0.*

In figures 23.6 to 23.9 the different valve springs used together with the smaller poppet valve 04103-07. Nose shims 3x01415-12 are used.

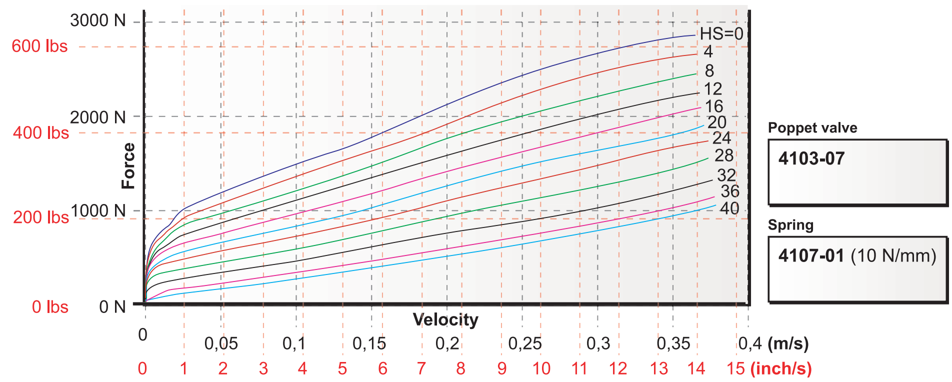


Figure 23.6 *Adjustment range of the high speed adjusters with poppet valve 04103-07 and 10 N/mm spring. The low speed adjuster is set to clicker position 0.*

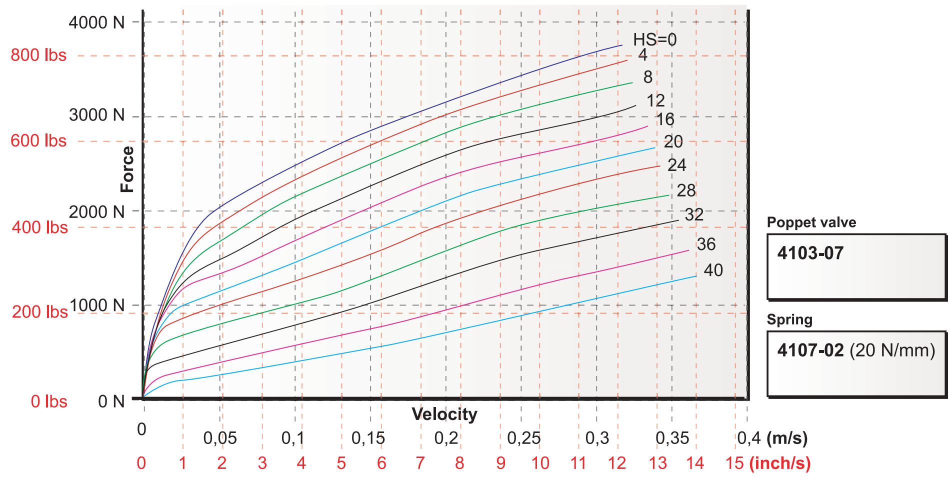


Figure 23.7 *Adjustment range of the high speed adjusters with poppet valve 04103-07 and 20 N/mm spring. The low speed adjuster is set to clicker position 0.*

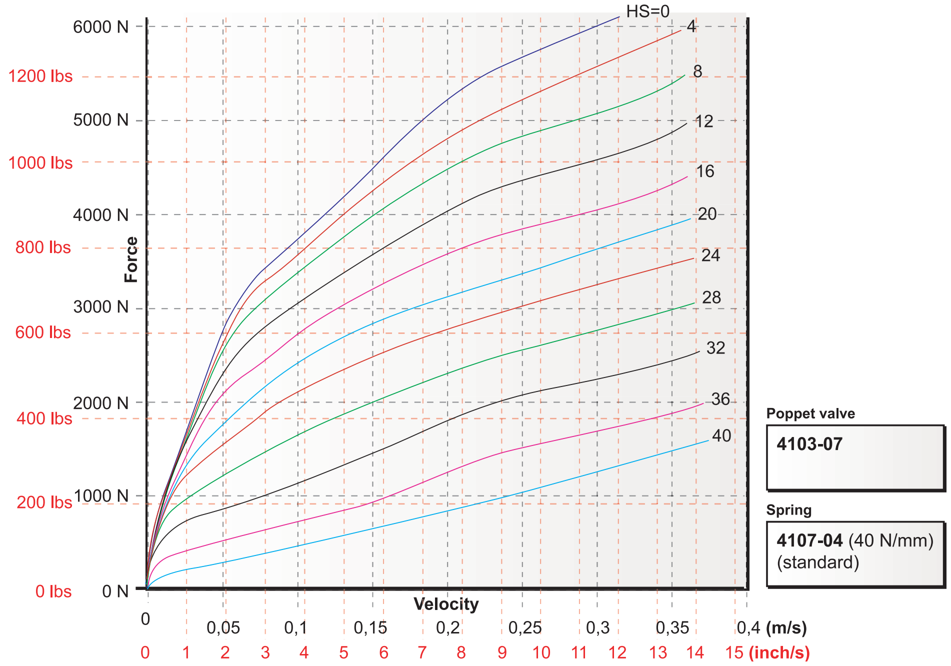


Figure 23.8 *Adjustment range of the high speed adjusters with poppet valve 04103-07 and the standard 40 N/mm spring. The low speed adjuster is set to clicker position 0.*

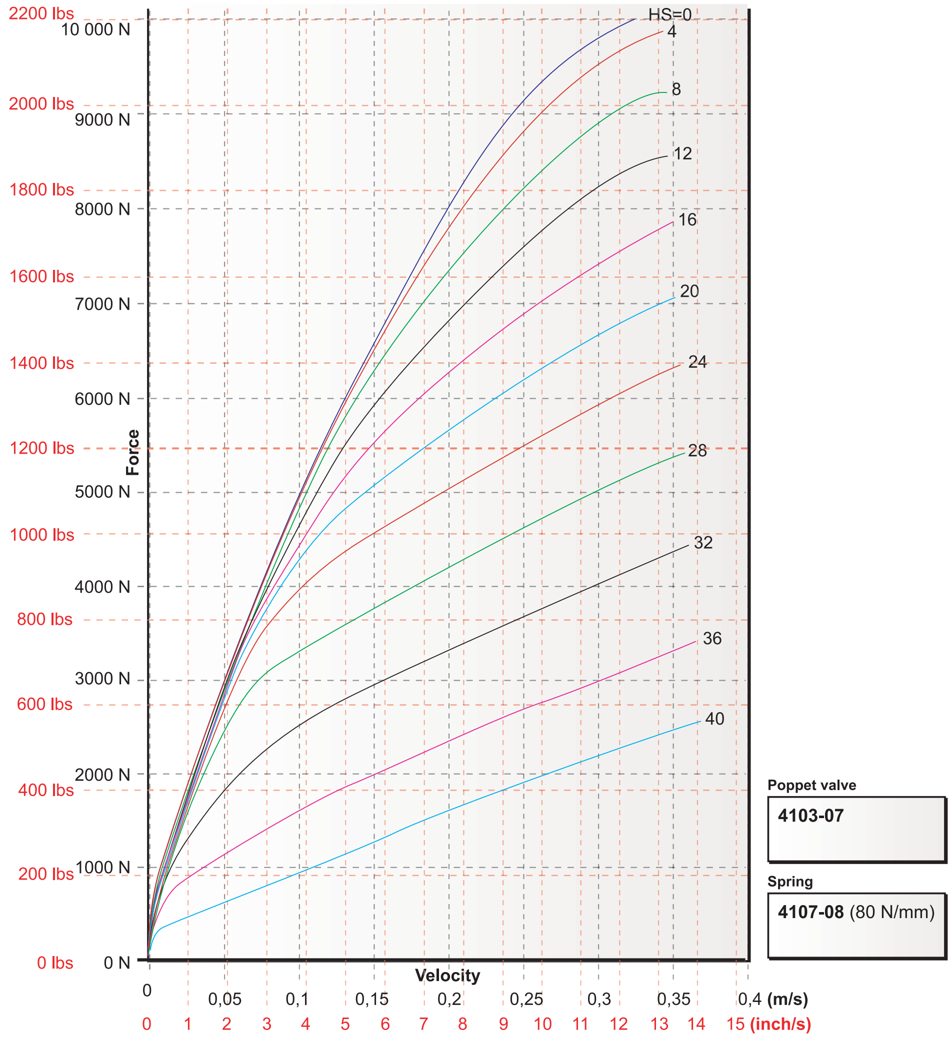


Figure 23.9 *Adjustment range of the high speed adjusters with poppet valve. 04103-07 and 80 N/mm spring. The low speed adjuster is set to clicker position 0.*

In figures 23.10 and 23.11 graphs from different nose shim stack configurations are illustrated with standard poppet valve and poppet valve 04103-07.

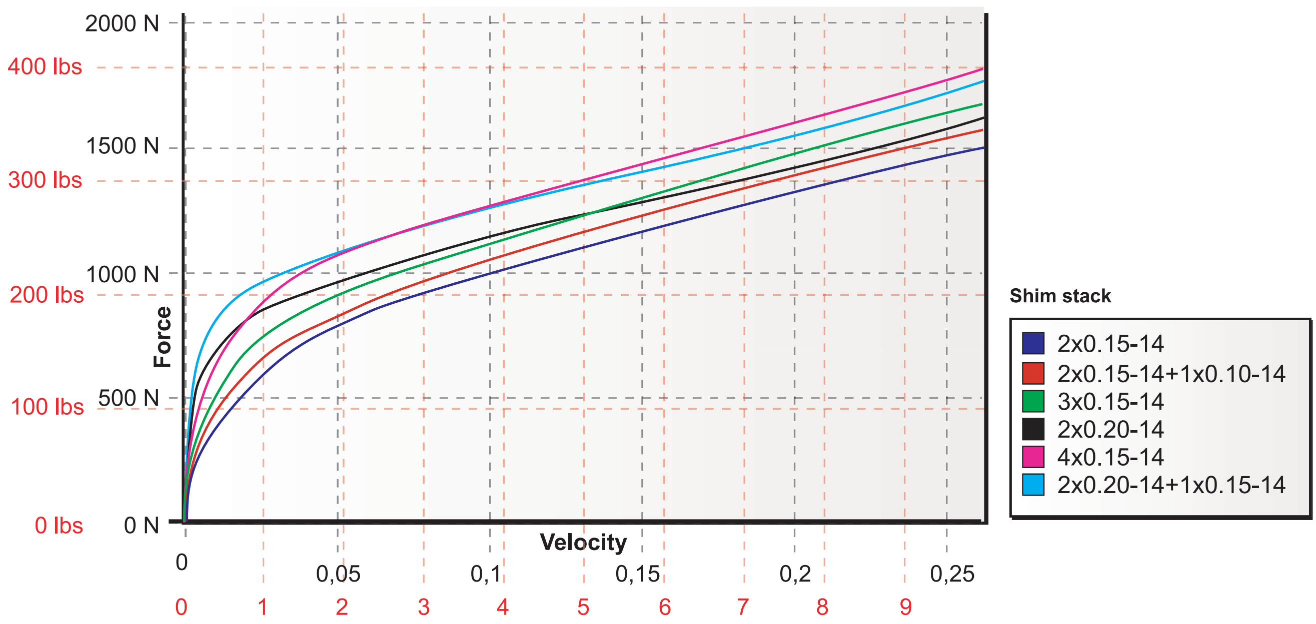


Figure 23.10 *Different nose shim stacks on the standard valve. The low speed adjuster is set to clicker position 0 and the high speed adjuster to clicker position 25 (in the middle of the range).*

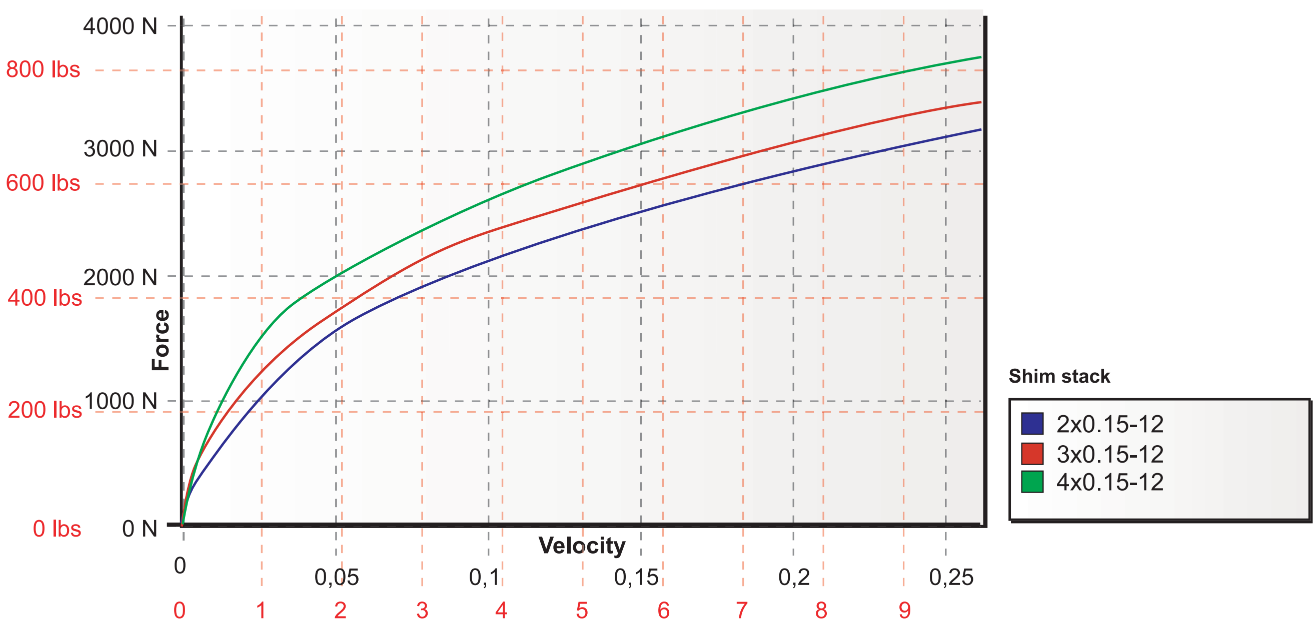


Figure 23.11 *Different nose shim stacks on poppet valve 04103-07. The low speed adjuster is set to clicker position 0 and the high speed adjuster to clicker position 25 (in the middle of the range).*

Figure 24.0 *VRP desktop shortcut.*

24 Valving Reference Program

One of the advantages with the TTX is the ability to use the VRP (Valving Reference Program). It enables you to research the damping forces without dynamometer testing. You virtually build your damper in the computer using different combinations of clicker settings, valves, nose shims and valve springs. The program will then present the Compression and Rebound dynamometer curve for your specific setting. This will make the work easier and quicker for both mechanics and engineers. No manual today with valving charts can cover as big range of combinations of adjustments and settings as the Öhlins VRP does. Normally, a lot of dynamometer testing is necessary to find the setting that produces the desired damping curve. This results in a lot of work since usually the hardware has to be changed several times during this process. With the VRP this is not necessary.

The VRP should be seen as a complement to the dynamometer, not as a replacement. The dynamometer is still needed to ensure that the correct damping forces are achieved. This work will be made much easier by using the VRP, since comparing the dynamometer forces with the VRP forces can be done with any combination of valves and clicker settings desired.

The damping forces illustrated in the VRP have been measured in an Instron dynamometer at constant velocity.

NOTE:

If these forces are compared to forces from a dynamometer measuring the forces continuously (crank dynamometer), there will be some differences. For best results, use peak velocity measurements on a crank dynamometer. See chapter Damping force measurement.

Of course it is possible to use nose shim stacks not covered by the program, but there should be no need for this.

The TTX VRP is free of charge on the Internet at www.ohlins.com. The TTX VRP is basically self-instructed, but there is also instructional text available in the program.

25 Damper Configuration

The TTX damper is available with different strokes. To minimise the damper length needed for a given stroke, the external and the internal stroke is the same. A small difference ensures a well defined external bottoming. The external stroke is approx. 0.5 mm shorter than the internal stoke. There is also approx. 0.5 mm in distance between the internal piston rod and the bottom of the top eye at fully compressed position except for the TTX NE01, where the distance is 3.5 mm.

To ensure a correct assembly of the dampers including dynamometer testing and still give the customers freedom to configure their dampers, the dampers are sold without end eyes, spacers or spring platforms. We call this unit the “damper unit”.

The TTX damper is designed to fit 2 inch i.d. springs. Platforms for 2.25 inch i.d. springs are also available. There are also possible to run 36 mm (1.5 inch) i.d. springs. If so, the spring platform is placed on the end cap of the cylinder body.

To get your desired damper configuration pick

- Damper unit
- End eye
- Spacers for spherical bearings (“top hats”) to top eye and end eye
- Spring platform
- Spring retainer (spring platform at end eye)
- Internal spacers
- External spacers
- Packers
- Rubber caps (for protecting the adjusters)
- Sleeve (for tube protecting)

The rubber caps (part no. 05925-01) can be fitted to the valve end caps to protect the adjusters from dirt.

The cylinder tube protecting sleeve (part no. 06140-01) is useful when 2 inch i.d. springs are used as there is a risk of the spring contacting the outer tube. When long springs are used, this risk increases. The protecting sleeve is installed with spanner part no. 00738-01 together with mounting sleeve part no. 00737-04. Torque: 30 Nm (22 lbs.ft.). As the torque can’t be measured, it has to be estimated.

NOTE:

The lock nut for the end eye (part no. 06117-01) together with the plastic spacer (part no. 05449-03) covering this nut are installed on the damper unit. A set screw (part no. 05410-01) for the spring platform also comes with the damper unit. If bump rubbers will be used, an external spacer must be used to prevent bump rubber damage caused by the holes in the end cap.

See Spare parts and illustrations in next chapter for identification of parts.

Damper unit / Stroke [mm]	End eye	Bearing spacers	Spring platform	Spring retainer	Internal spacers	External spacers	Packers	Rubber cap (2x)
TTX NE01 / 48	06136-01*	06119-XX	05964-01 (2”)	05411-01 (2.25”)	06132-01 (1 mm)	06130-01 (1 mm)	06131-02 (2 mm)	05925-01
TTX NE02 / 56	06136-02*	05425-XX	05964-02 (2.25”)	05411-02 (2”)	06132-02 (2 mm)	06130-02 (2 mm)	06131-03 (3 mm)	
TTX NE03 / 68	06136-03*	05518-XX	05972-01 (1.5”)***	05412-01 (2.25”)	06132-05 (5 mm)	06130-05 (5 mm)		
TTX NE04 / 80	06136-04*			05965-01 (2”)	06132-10 (10 mm)	06130-10 (10 mm)		
TTX NE06 / 110	06136-05*			05441-01 (1.5”)				
TTX NE08 / 140	06136-06*							
	06136-07*							
	06133-01**							

* Bearing 05536-05 and circlips 05057-04 (2x) have to be included.
** Bearing 05536-01 and circlips 05057-02 (2x) have to be included.
*** O-ring 00438-60 has to be included.

Figure 25.1 *Table with parts needed to complete a TTX damper.*

NOTE:
If bump rubber is to be used on a 36 mm (1.5 inch) spring configuration, spacer 05449-03 can be machined down to fit inside the spring. The internal spacers in the 06132 series can be used as external spacers.

The parts in the table above are not the only ones that can be ordered, see the chapter Spare parts for a complete list. This result in total freedom to build the damper you need.

Even if none of the damper units can be used without modifications, Öhlins recommendation is to always order a complete damper unit and modify it instead of ordering all included parts. Pick the unit with the correct tube length and change top eye and/or external piston rod if needed. As the internal piston rod matches the tube length, it never has to be changed unless the tubes are changed.

There could be several different reasons why some parts in a damper unit have to be changed. For instance, a longer top eye might be needed to move the cylinder head away from some interference near the top mount. Another example is, a team optimising the stroke when using bump rubbers. As a bump rubber will take some of the external stroke away, a longer piston rod might be needed. When doing this, the length of the piston rod can be calculated by taking into account the type of bump rubber being used and the highest acceptable force from the installed bump rubber. The height of the bump rubber at specified force can be found from a force-position graph.

All damper units except TTX NE02 and TTX NE04 come without external spacers on the piston rod. The external piston rod is optimised to match the internal stokes. TTX NE02 and TTX NE04 come with a piston rod that would give longer external strokes than internal if there are no external spacers used. This allows the ability to run bump rubbers without losing any stroke, and results in more room for the spring. If the last two digits of the external piston rod part number match the numbers of the damper unit, the external piston rod is optimised to the stoke of the damper unit. For example, the TTX NE02 needs a 06127-02 piston rod to have an external stroke matching the internal stoke.

Except for the external piston rods of TTX NE02 (06127-12) and TTX NE04 (06127-14), all top eyes (06126-XX), internal and external tubes (06110-XX and 06109-XX), internal and external piston rods (06112-XX and 06127-XX) have numbers that matches their damper unit.

For damper units TTX NE04, TTX NE06 and TTX NE08 (the damper units with the longest strokes and therefore the largest volumes of oil), a reservoir end cap 06121-02 with a larger gas volume is used instead of 06121-01. The stroke of the separating piston will increase by 4.5 mm. If the separating piston is set so there is 1 mm between the tool 01876-XX and the reservoir end cap, the stroke of the separating piston is 5.5 mm with end cap 06121-01 and 10 mm with end cap 06121-02. However the useable stroke is less. The internal pressure will otherwise be too high. See Checking oil level and pressurisation for more information.

NOTE:
Top eye 06126-01, -02 and -03 can only be used with reservoir end cap 06121-01 and top eye 06126-04, -05 and -06 can only be used together with the reservoir end cap 06121-02. Reservoir end cap 06121-01 uses pressure indicator 06105-01 (2x) and end cap 06121-02 uses pressure indicator 06105-02 (2x).

The tool 01876-XX needed to check to position of the separating piston is available in two different versions: 01876-01 and 01876-02. The 01876-01 is used together with top eye 06126-01, -02 and -03. 01876-02 is used together with the top eye 06126-04, -06 and -08.

To position the separating piston, an additional tool of the 01877-XX series is needed. For each length of the top eye, a corresponding length of the spacer tool in the 01877 series is required. The last digit of the spacer part number matches the last digit of the top eye part number. For example a 06126-02 top eye uses a 01877-02 spacer tool.

External and internal spacers together with the available lengths of top eyes, cylinder tubes, piston rods and a large number of different end eyes, gives plenty of freedom to get the damper that you are looking for.

Öhlins has an Excel program, TTX Length Calculation Program, LCP, free of charge to help you configure your own TTX damper.

26 Damper Dimensions

In the figures below are some external dimensions of the TTX-damper.

NOTE:
The top eye can be rotated and positioned in any angle to the cylinder head.

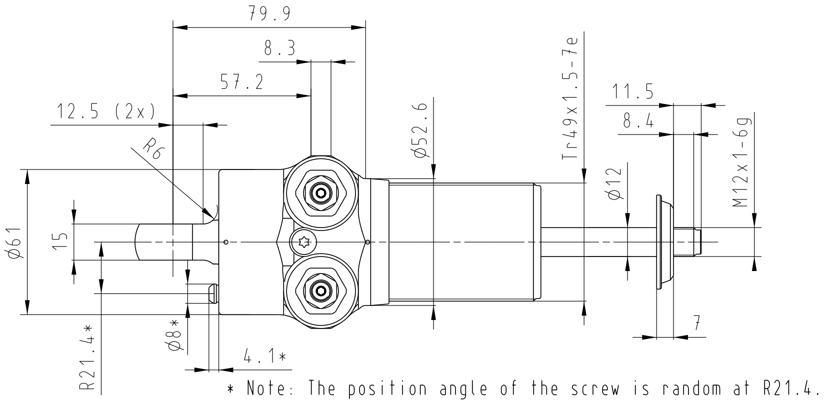
See Reclocking the top eye for information about how to reclock the top eye.

There is also a cross section of the damper, where parameters needed to do length calculations are defined. A table gives the different parameter values available.

In chapter Dimensions of some parts some parts are illustrated with dimensions to simplify identification and to help the customers that may need to make these parts themselves, i.e. a custom made end eye.

NOTE:
All dimensions in drawings, tables and formulas are in millimetres.

TTX NE01, TTX NE02, TTX NE03.



TTX NE04, TTX NE06, TTX NE08.

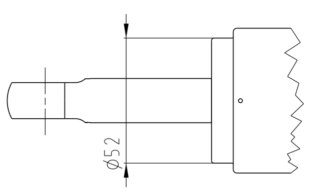


Figure 25.1 *Front view of a TTX damper unit.*

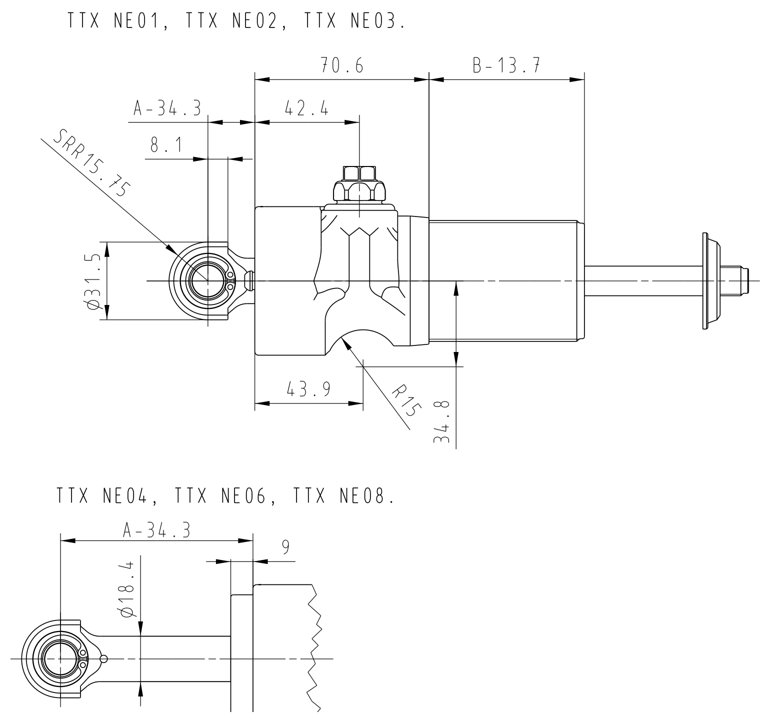


__Figure 25.2__ Side view of a TTX damper unit. See the cross section view below for definition of A and B.

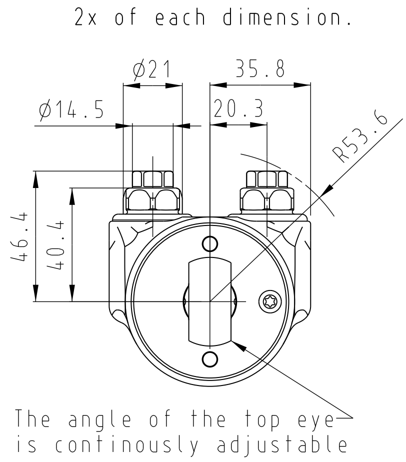


__Figure 25.3__ Top view of a TTX damper unit.

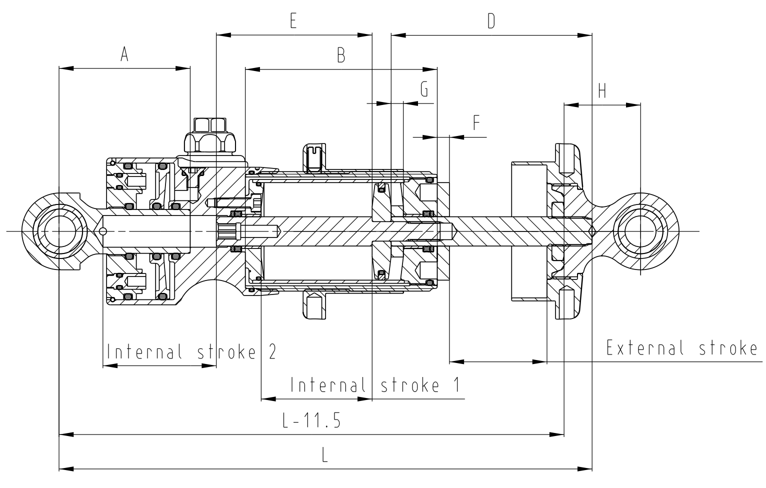


__Figure 25.4__ Cross section view of a TTX damper unit.

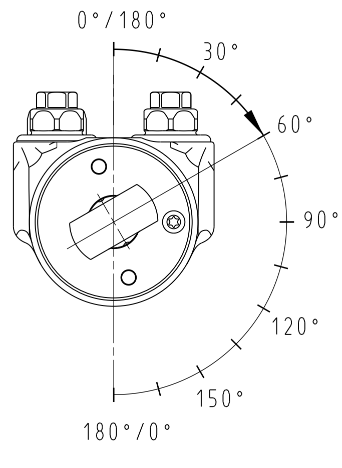


__Figure 25.5__ Definition of clocking angle of TTX.

	External stroke	Internal stroke 1	Internal stroke 2	L - 11.5
TTX NE01	48	48.5	**51.5**	207.6
TTX NE02	56	56.5	56.5	243.6
TTX NE03	68	68.5	68.5	264.6
TTX NE04	80	80.5	80.5	321.6
TTX NE06	110	110.5	110.5	390.6
TTX NE08	140	140.5	140.5	480.6

Figure 25.6 *Table 1 with TTX damper unit information.*

	A	06126	B	06109	D	06127	E	06112	F	06130
TTX NE01	53.3	-01	76.7	-01	80.4	-01	89.8	-01	0	-
TTX NE02	58.3	-02	84.7	-02	103.4	**-12**	97.8	-02	15	-05x1 -10x1
TTX NE03	70.3	-03	96.7	-03	100.4	-03	109.8	-03	0	-
TTX NE04	82.3	-04	108.7	-04	133.4	**-14**	121.8	-04	21	-01x1 -10x2
TTX NE06	112.3	-06	138.7	-06	142.4	-06	151.8	-06	0	-
TTX NE08	142.3	-08	168.7	-08	172.4	-08	181.8	-08	0	-

Figure 25.7 *Table 2 with TTX damper unit information. Dimensions in millimetre.*

A	06126	B	06109	D	06127	E	06112	F	06130	G	06132	H	06136
53.3	-01	76.7	-01	80.4	-01	89.8	-01	1	-01	1	-01	31.4	-01
58.3	-02	84.7	-02	88.4	-02	97.8	-02	2	-02	2	-02	40.4	-02
70.3	-03	96.7	-03	100.4	-03	109.8	-03	5	-05	5	-05	49.4	-03
82.3	-04	108.7	-04	103.4	-12	121.8	-04	10	-10	10	-10	58.4	-04
112.3	-06	138.7	-06	112.4	-04	151.8	-06					67.4	-05
142.3	-08	168.7	-08	133.4	-14	181.8	-08					76.4	-06
				142.4	-06							85.4	-07
				172.4	-08								

Figure 25.8 *Table of the different lengths available of the parts in the formulas.*

The end eyes are made with 9 mm increments in length.

NOTE:
The inner tubes are not listed here as they will always have the same number in the last two digits of the part number as the corresponding outer tuber. For example inner tube 06110-03 is always used together with outer tube 06109-03. The inner tubes are always 16.5 mm shorter than the corresponding outer tubes.

Formulas to calculate stroke and length follows:

FEL* = A + B + H + D - G - 2.8

**FEL = Fully Extended Length*

NOTE
H in the formula above only refers to end eyes of the 06136 series. The fully extended length should be within ± 1 mm.

Internal stroke 1 = B - G - 28.2
Internal stroke 2 = A + B - E - G + 11.3
External stroke = D - F - G - 32.4

NOTE:
The internal piston rod has to be long enough to seal against the X-ring.

Formula to calculate the minimum length of the internal piston rod:

ML* = B - G + 13.1

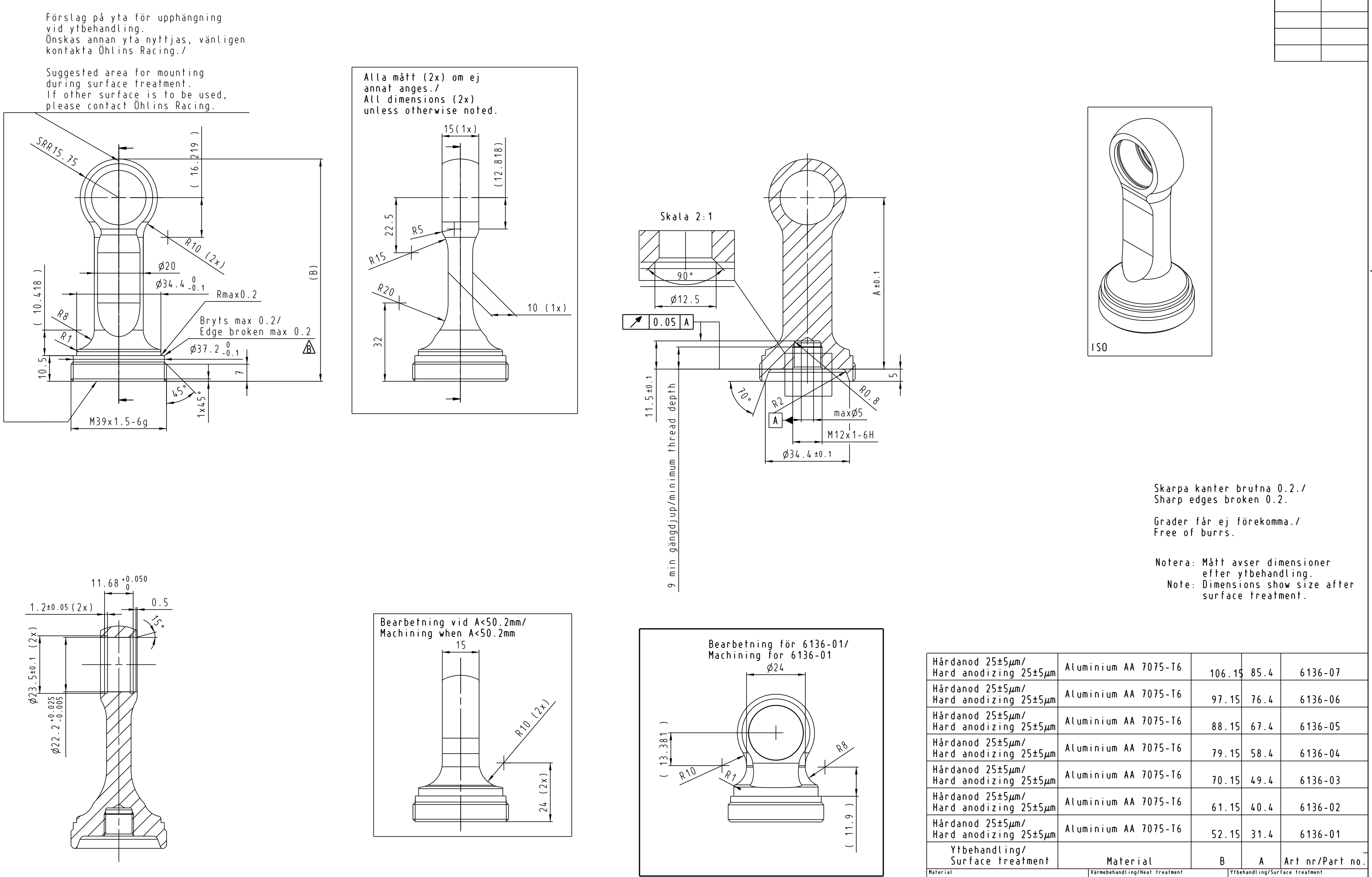
**ML = Minimum length of internal piston rod*

To simplify the job of doing the calculations use Öhlins LCP (Length Calculation Program). This program also helps to calculate how much room there is available for the spring.

Dimensions of some parts

As some teams might want to make custom end eyes and spring retainers themselves, some key dimensions in the drawings will make this easier.

NOTE:
The thread of the spring platforms 05964-01/-02 is Tr49x1.5-7H and the thread of the set screw is M6x1-6H. Please contact Öhlins if you need more information about these parts.



Skarpa kanter brutna 0.2./
Sharp edges broken 0.2.

Grader får ej förekomma./
Free of burrs.

Notera: Mått avser dimensioner efter ytbehandling.
Note: Dimensions show size after surface treatment.

Mått Measurement	Avmått Tolerance

Ytbehandling/ Surface treatment	Material	B	A	Art nr/Part no.
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	106.15	85.4	6136-07
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	97.15	76.4	6136-06
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	88.15	67.4	6136-05
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	79.15	58.4	6136-04
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	70.15	49.4	6136-03
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	61.15	40.4	6136-02
Hårdanod 25±5µm/ Hard anodizing 25±5µm	Aluminium AA 7075-T6	52.15	31.4	6136-01

Material	Värmebehandling/Heat treatment	Ytbehandling/Surface treatment
Se ovan./ See above.		Se ovan./ See above.

Datum/Date	Ritad/Drawn	Godkänd/Approved	Format-Skala/Scale	Lösa grader får ej förekomma / No loose burrs allowed	Jämför/Compare	Artikelkod/Parts code
04-09-23	CL	md	A2 1:1		6116	2800

ÖHLINS

Benämning/Designation: End eye

Ritning nr/Drawing number: 6136

Revision: B

Rev.	Ändringens art/Type of change	Sign	Datum/Date	Än Revision n:r
B	Ø37.2 var Ø37,"bryts max 0.2" tillk.	CL	041130	7807
A	Ø22.2 +0.025/-0.005 var Ø22.2 +0.02/0.	CL	041125	7797
	Mått flyttades från 6116, vy med bearb. för -01 tillk			7782

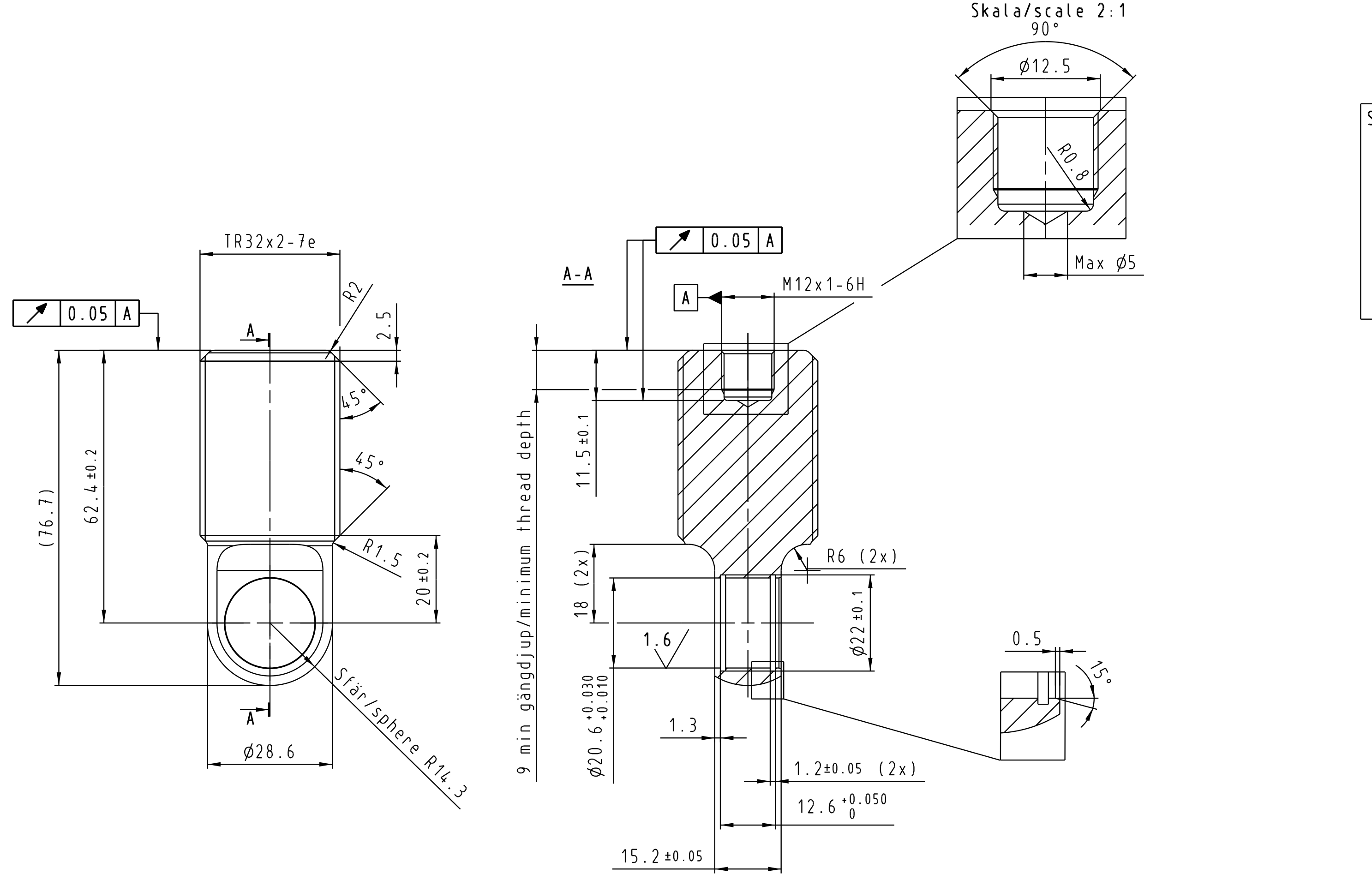
ISO-Toleranser
ISO-Tolerances

Ytjämnhet Ra/
Surface roughness Ra

Får ej tolerans-satta mått gäller/For meas-urements without tolerances applies: SS-ISO 2768-0fm

Basmått (mm)	Tol. (mm)
- 6	±0.1
(6)- 30	±0.2
(30)- 120	±0.3
(120)- 400	±0.5
(400)-1000	±0.8

Mått Measurement	Avmått Tolerance



3.2 (1.6)

Om annat ej anges skall skarpa hörn brytas 0.2./
I no other information, sharp edges should be broken 0.2.

ISO-Toleranser
ISO-Tolerances

Ytjämnhet Ra/
Surface roughness Ra

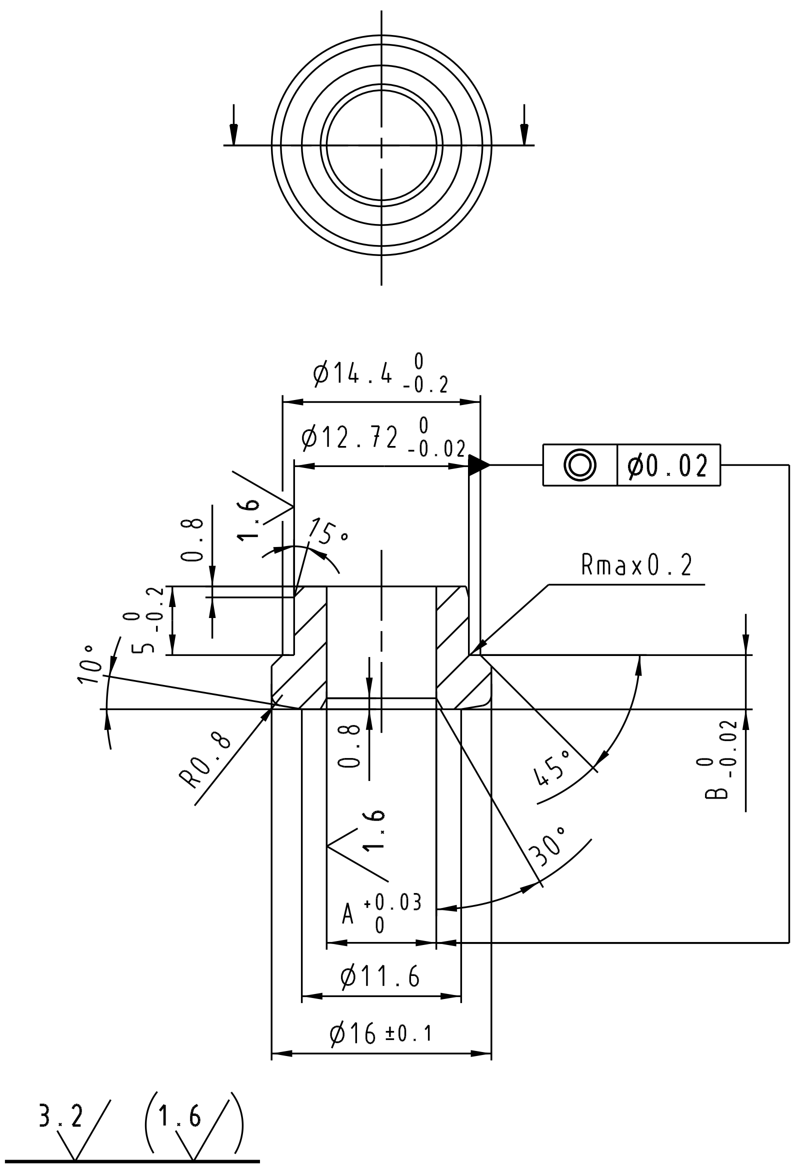
För ej toleranssatta mått gäller/For measurements without tolerances applies: SS-ISO 2768-01m

Basmått (mm)	Tol. (mm)
- 6	±0.1
(6)- 30	±0.2
(30)- 120	±0.3
(120)- 400	±0.5
(400)-1000	±0.8

Rev.	Ändringens art/Type of change	Sign	Datum/Date	Am Revision n:r

Material: Aluminium AA 7075 T6			Värmebehandling/Heat treatment		Ytbehandling/Surface treatment: Hårdanod 25±5μm/ Hard anodizing 25±5μm	
Datum/Date: 040623	Ritad/Drawn: CL	Godkänd/Approved: md	Format-Skala/Scale: A3 1:1	Lösa grader får ej förekomma / No loose burrs allowed	Jämför/Compare: 5931-01	Artikelkod/Parts code: 9000
ÖHLINS	Benämning/Designation: Ändögla End eye				Ritning nr/Drawing number: 6133-01	Revision

Rev.	Ändringens art/Type of change	Sign	Datum/Date	Äm Revision n:r	Mått Measurement	Avmått Tolerance



ISO-Toleranser
ISO-Tolerances

Ytjämnhet Ra/
Surface
roughness Ra

8 (5/16")	20	4.45	06119-02
8 (5/16")	18.98	3.94	06119-01
A	FTF (med/with 05536-05)	B	Art. nr/no.

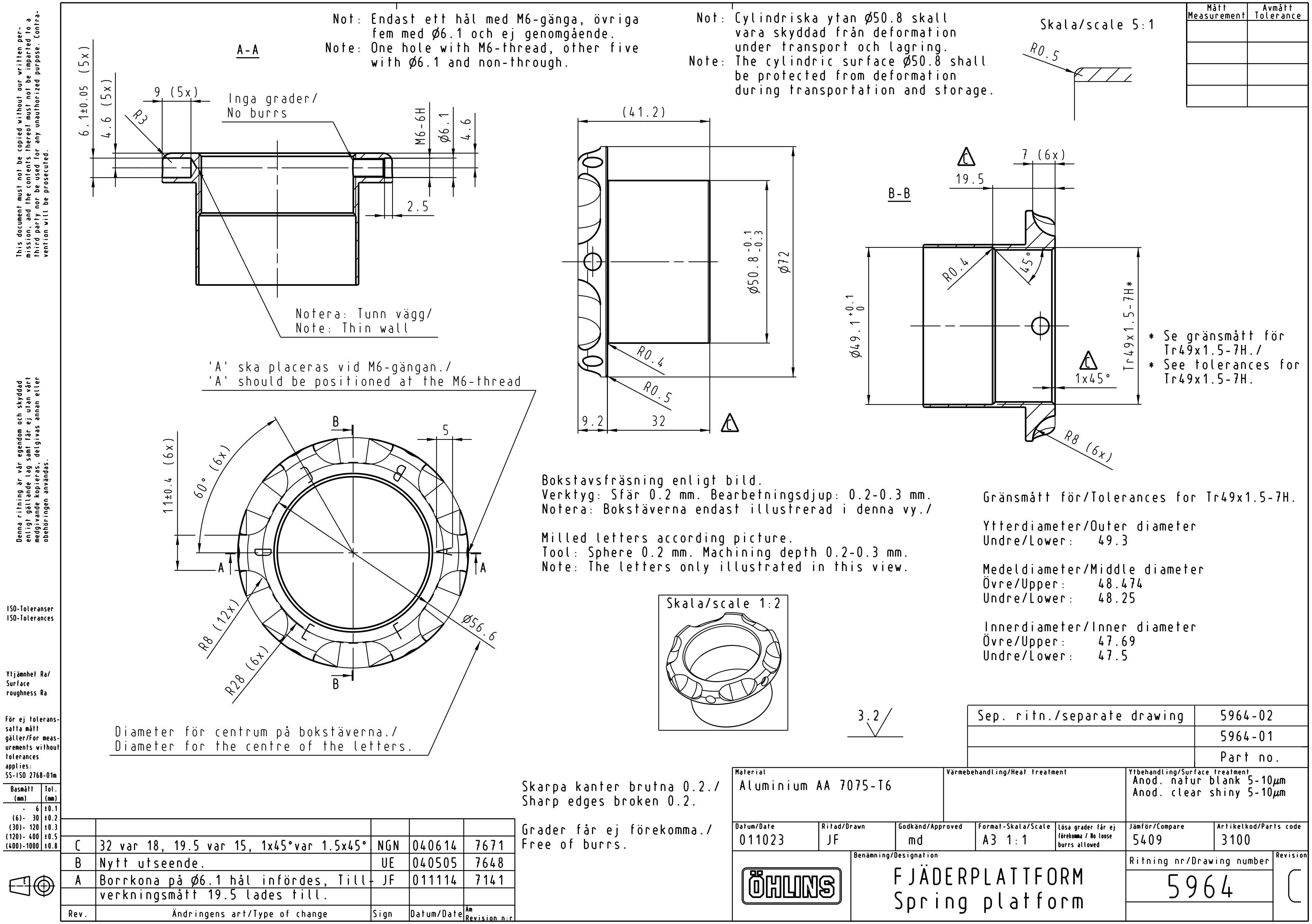
För ej tolerans-satta mått gäller/For measurements without tolerances applies: SS-ISO 2768-01m

Basmått (mm)	Tol. (mm)
- 6	±0.1
(6)- 30	±0.2
(30)- 120	±0.3
(120)- 400	±0.5
(400)-1000	±0.8

Material	Värmebehandling/Heat treatment	Ytbehandling/Surface treatment
Stål/Steel SS 1914		Svartoxiderad 5-10µm Black oxide 5-10µm

Datum/Date	Ritad/Drawn	Godkänd/Approved	Format-Skala/Scale	Lösa grader får ej förekomma / No loose burrs allowed	Jämför/Compare	Artikelkod/Parts code
04-11-10	NGN	md	A4 2:1		5425	4000

	Benämning/Designation	Ritning nr/Drawing number	Revision
ÖHLINS	Spacer spherical bearing	6119	


Not: Endast ett hål med M6-gänga, övriga fem med Ø6.1 och ej genomgående.
Note: One hole with M6-thread, other five with Ø6.1 and non-through.
Not: Cylindriska ytan Ø50.8 skall vara skyddad från deformation under transport och lagring.
Note: The cylindric surface Ø50.8 shall be protected from deformation during transportation and storage.
Skala/scale 5:1
R0.5
A-A
6.1±0.05 (5x)
4.6 (5x)
9 (5x)
R3
Inga grader/
No burrs
M6-6H
Ø6.1
4.6
2.5
Notera: Tunn vägg/
Note: Thin wall
'A' ska placeras vid M6-gängan./
'A' should be positioned at the M6-thread
(41.2)
Ø50.8 -0.1 -0.3
Ø72
R0.4
R0.5
9.2
32
B-B
19.5
7 (6x)
R0.4
45°
Ø49.1 +0.1 0
Tr49x1.5-7H*
1x45°
R8 (6x)
* Se gränsmått för Tr49x1.5-7H./
* See tolerances for Tr49x1.5-7H.
11±0.4 (6x)
60° (6x)
5
Ø56.6
R8 (12x)
R28 (6x)
Diameter för centrum på bokstäverna./
Diameter for the centre of the letters.
Bokstavsfräsning enligt bild.
Verktyg: Sfär 0.2 mm. Bearbetningsdjup: 0.2-0.3 mm.
Notera: Bokstäverna endast illustrerad i denna vy./
Milled letters according picture.
Tool: Sphere 0.2 mm. Machining depth 0.2-0.3 mm.
Note: The letters only illustrated in this view.
Skala/scale 1:2
Gränsmått för/Tolerances for Tr49x1.5-7H.
Ytterdiameter/Outer diameter
Undre/Lower: 49.3
Medeldiameter/Middle diameter
Övre/Upper: 48.474
Undre/Lower: 48.25
Innerdiameter/Inner diameter
Övre/Upper: 47.69
Undre/Lower: 47.5
3.2
Skarpa kanter brutna 0.2./
Sharp edges broken 0.2.
Grader får ej förekomma./
Free of burrs.
Mått Measurement
Avmått Tolerance
Sep. ritn./separate drawing 5964-02
5964-01
Part no.
Material: Aluminium AA 7075-T6
Värmebehandling/Heat treatment
Ytbehandling/Surface treatment: Anod. natur blank 5-10µm / Anod. clear shiny 5-10µm
Datum/Date: 011023
Ritad/Drawn: JF
Godkänd/Approved: md
Format-Skala/Scale: A3 1:1
Lösa grader får ej förekomma / No loose burrs allowed
Jämför/Compare: 5409
Artikelkod/Parts code: 3100
ÖHLINS
Benämning/Designation: FJÄDERPLATTFORM Spring platform
Ritning nr/Drawing number: 5964
Revision: C
C | 32 var 18, 19.5 var 15, 1x45°var 1.5x45° | NGN | 040614 | 7671
B | Nytt utseende. | UE | 040505 | 7648
A | Borrkona på Ø6.1 hål infördes, Tillverkningsmått 19.5 lades till. | JF | 011114 | 7141
Rev. | Ändringens art/Type of change | Sign | Datum/Date | Ärende Revision n:r
ISO-Toleranser
ISO-Tolerances
Ytjämnhet Ra/
Surface roughness Ra
För ej toleranssatta mått gäller/For measurements without tolerances applies: SS-ISO 2768-01m
Basmått (mm) | Tol. (mm)
- 6 | ±0.1
(6)- 30 | ±0.2
(30)- 120 | ±0.3
(120)- 400 | ±0.5
(400)-1000 | ±0.8
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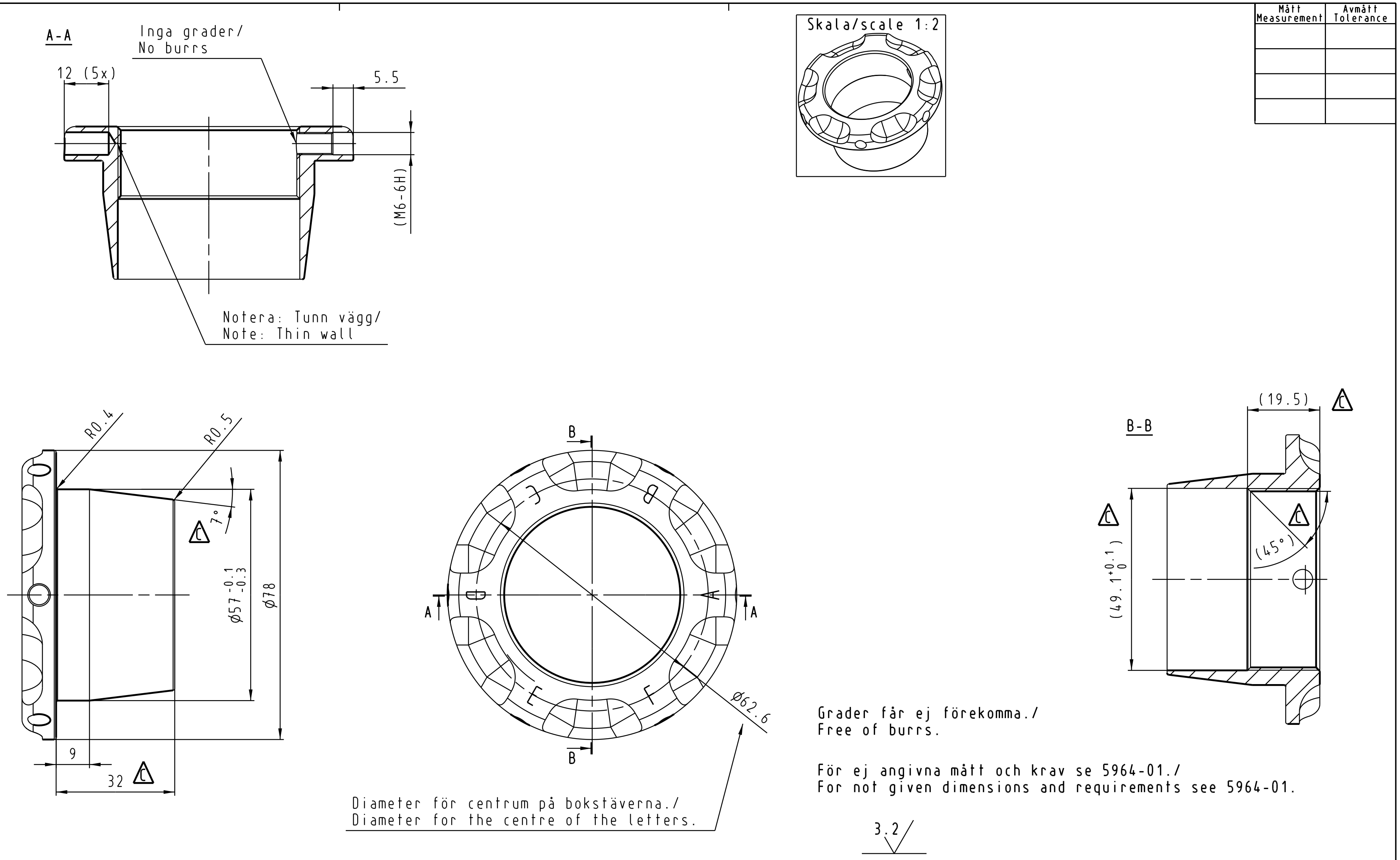


Mått Measurement	Avmått Tolerance

ISO-Toleranser
ISO-Tolerances

Ytjämnhet Ra/
Surface
roughness Ra

För ej toleranssatta mått gäller/For measurements without tolerances applies: SS-ISO 2768-01m

Basmått (mm)	Tol. (mm)
- 6	±0.1
(6)- 30	±0.2
(30)- 120	±0.3
(120)- 400	±0.5
(400)-1000	±0.8

Rev.	Ändringens art/Type of change	Sign	Datum/Date	Än Revision n:r
C	Ø49.1 +0.1/0 var 53, 19.5 var 15, 45° var 1.5x45°, 32 var 18, 7°var 5°.	UE	040505	7672
B	Nytt utseende.	UE	040505	7648
A	Borrkona på Ø6.1 hål infördes. Tillverkningsmått 19.5 tillkom.	JF	011114	7141

5964-02

Material	Värmebehandling/Heat treatment	Ytbehandling/Surface treatment
Aluminium AA 7075-T6		Anod. natur blank 5-10µm Anod. clear shiny 5-10µm

Datum/Date	Ritad/Drawn	Godkänd/Approved	Format-Skala/Scale	Lösa grader får ej förekomma / No loose burrs allowed	Jämför/Compare	Artikelkod/Parts code
011023	JF	md	A3 1:1		5409	3100

ÖHLINS

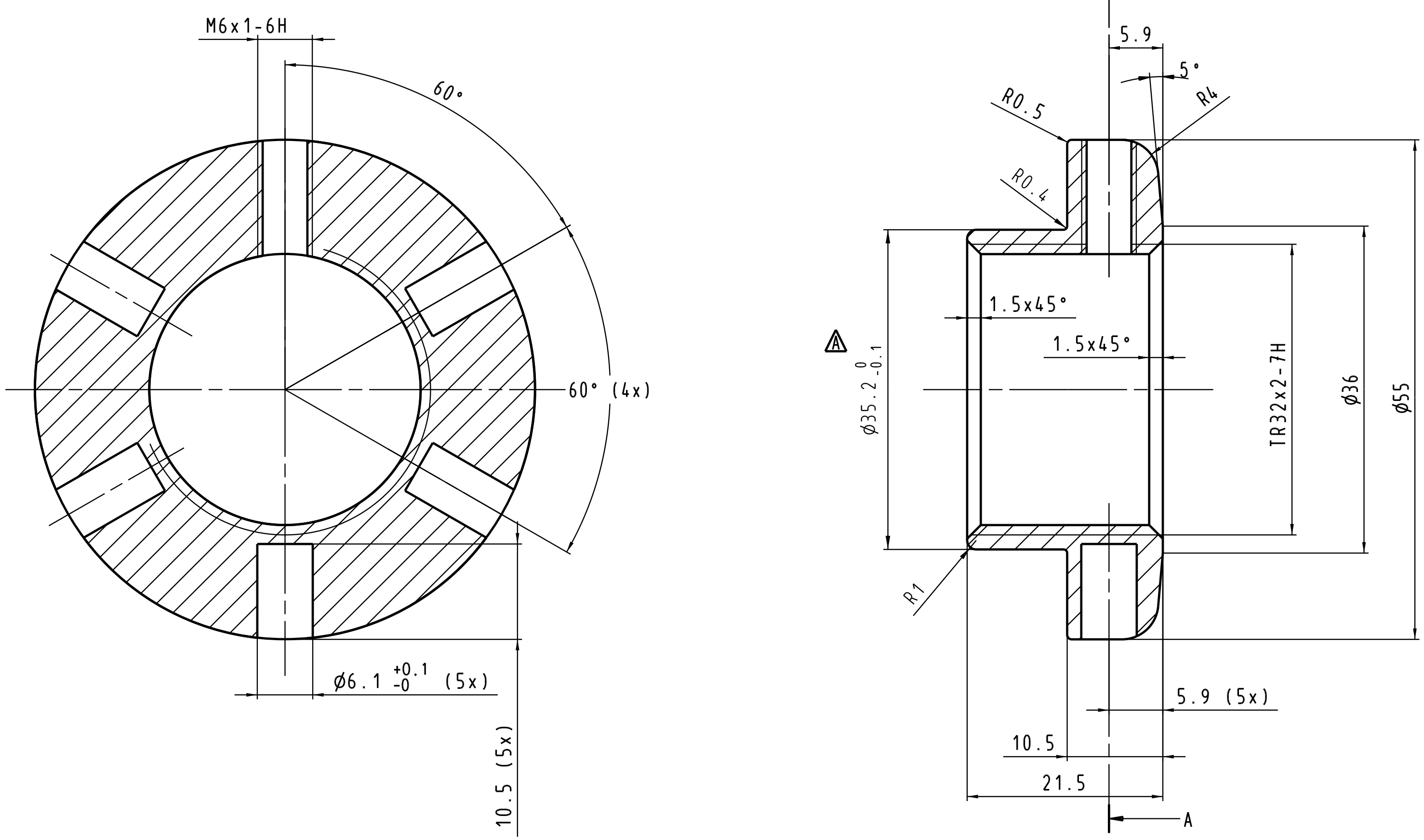
Benämning/Designation: FJÄDERPLATTFORM
Spring platform

Ritning nr/Drawing number: 5964-02

Revision: C

Mått Measurement	Avmått Tolerance

Snitt A-A
View A-A



3.2

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ISO-Toleranser
ISO-Tolerances

Ytjämnhet Ra/
Surface
roughness Ra

För ej toleranssatta mått gäller/For measurements without tolerances applies:
SS-ISO 2768-01m

Basmått (mm)	Tol. (mm)
- 6	±0.1
(6)- 30	±0.2
(30)- 120	±0.3
(120)- 400	±0.5
(400)-1000	±0.8

Rev.	Ändringens art/Type of change	Sign	Datum/Date	Ä.m Revision n:r
A	Ø35.2 0/-0.1 var Ø35.85 0/-0.05, vinkeln 10°utgick.	NGN	040916	7719

5441-01
Detalj nr

Material	Värmebehandling/Heat treatment	Ytbehandling/Surface treatment
Aluminium AA 7075-T6		Elox.Natur 5-10µm Ej betad

Datum/Date	Ritad/Drawn	Godkänd/Approved	Format-Skala/Scale	Lösa grader får ej förekomma / No loose burrs allowed	Jämför/Compare	Artikelkod/Parts code
961016	NGN	md	A3 2:1			3100

ÖHLINS

Benämning/Designation
FJÄDERSTÖD
Spring retainer

Ritning nr/Drawing number: 5441-01
Revision: A

27 Damper Weight

The weights of the standard TTX damper units are

TTX NE01	810 g
TTX NE02	880 g
TTX NE03	910 g
TTX NE04	1025 g
TTX NE06	1145 g
TTX NE08	1345 g

NOTE:
The weight of the end eye and the spring platforms has to be added.

For weight calculations of other damper configurations and complete dampers, use the LCP.

Figure 28.0 *Damper identification.*

28 Damper Identification

All Öhlins dampers are marked with the damper article number and the production order number. On the TTX damper, these numbers are placed on the side of the cylinder head.

The marked article number has one digit added to the number. This digit signifies the revision number.

Keep in mind that as some of the customers rebuild dampers themselves, the hardware configuration can be changed from the time when the damper was produced. As a result these article numbers are not a definite indication of the installed hardware on that particular damper.

Figure 29.0 *Hydraulic spring preload adjuster knob.*

29 Optional Parts

There are some optional Öhlins parts available for the TTX damper. These parts are not always specifically made for the TTX damper and can be used together with different Öhlins products. These parts have to be bought separately.

- **Bump rubbers**
  Bump rubbers are used both as spring elements, very often in combination with coil springs or torsion springs to achieve increased resistance to compress the damper further into the stroke. The bump rubbers are normally engaged only when the damper is compressed some distance from static ride height position. If the bump rubber is used only when the damper is almost fully compressed to prevent the damper from bottoming metal to metal, the rubber is used more as a bump stop. However, very often, the bump rubber is an active part of the suspension. In particular, in applications with a lot of downforce. The force produced by bump rubbers is largely position dependant, but compared to steel coil springs, there is also quite a bit of damping, “hysteresis”, from the bump rubbers. Increased frequency (velocity) at given amplitude will increase the force produced both under the loading and the unloading phase. The hysteresis will also increase. Because of this and the non-linearity when engaging the bump rubber, simulations including bump rubbers are quite complicated without simplifications.

Bump rubbers are just as the name indicates, made out of rubber. Öhlins mainly uses bump rubbers made out of polyurethane, a material made with small closed cells filled with gas. Different densities are used to produce varying spring rates.

The spring rate always increases when the rubber is compressed. By making bump rubbers with different shapes, different characteristics can be achieved.

Öhlins has many different bump rubbers available, but there are two specially made to be used as spring elements and not just bump stops. These bump rubbers are:

Part no.	**Colour**	**Density**
05375-15	Black	550±50 g/cm³
05375-16	Nature	650±50 g/cm³

To increase the number of combinations these bump rubbers are made short, so you can achieve different characteristics by stacking them differently. This is done by changing the number and type of rubber and also by playing with separately plastic washers. Adding a separating washer between two rubbers will increase the stiffness slightly. Below you can find some examples of how the force changes due to displacement.

Always use a plastic washer of type 06130-XX between the rubber and the cylinder cap (part no. 06114-01) to avoid damaging the bump rubber by the holes of the cylinder cap. The thinnest washer 06130-01 (1 mm) is enough to handle the loads of the rubber.

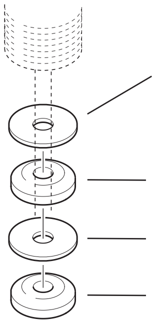


__Figure 29.2__ Example of a bump rubber stack.

The maximum load to use from bump rubbers on the TTX damper is 8000 N (approx. 1800 lbs).

For information about the specific bump rubbers, please contact an Öhlins distributor.

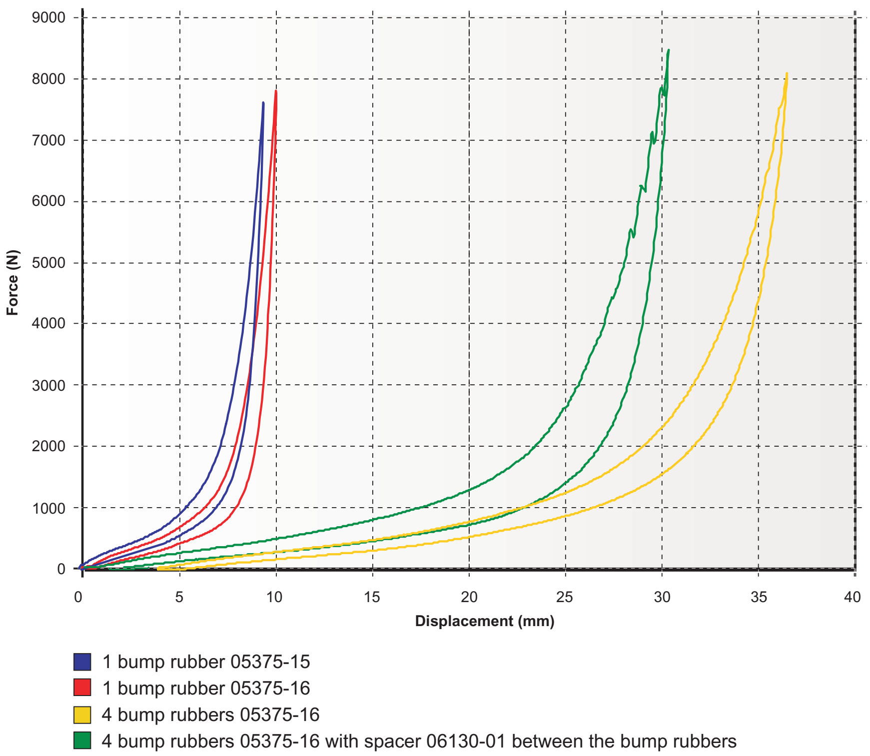


__Figure 29.1__ Examples of different bump rubber stiffness. The measurement took place at low frequency.

- **Weight jacker 05490-01**

Weight jackers are used to change the balance of the car by changing the position of one of the spring platforms. Often, the adjustment is made directly from the cockpit. Weight jackers are especially useful in oval racing.

For the TTX damper, Öhlins offers the hydraulic spring preloader (weight jacker) 05490-01. It consists of a master cylinder and a slave cylinder connected by a hose. By turning the adjuster wheel of the master cylinder, the piston of the slave cylinder will move.

The spring preloader is designed for 2¼ inch inner diameter (i.d.) springs and comes with a 1500 mm long hose.

The rate is 0.5 mm/turn and the stroke is 6.5 mm.

The spring preloader can be adjusted by hand to approx. 5500 N (1200 lbs) of load. Maximum load to use is 11 000 N (2500 lbs).

By changing some parts in the master cylinder, the spring preloader can be rebuilt so you get a rate of 0.75 mm per turn. However, this will increase the torque needed for a specific load.

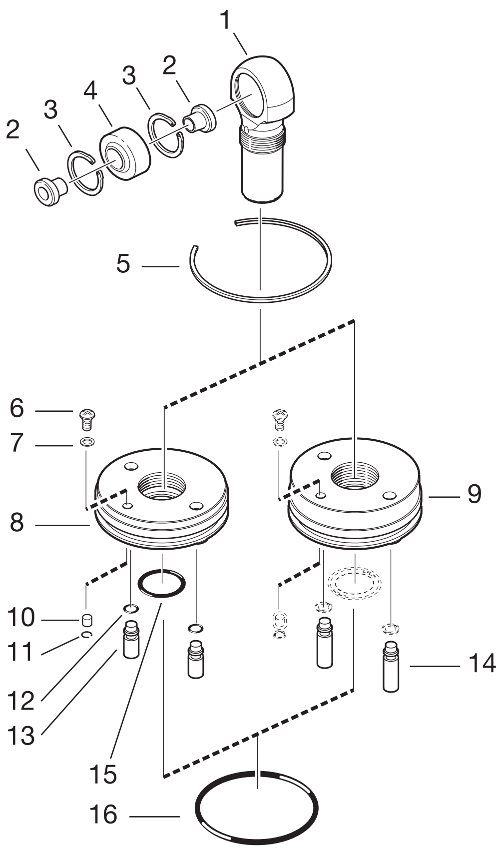
If the spring preloader needs to be taken apart for whatever reason, it is very important to get all the air out of the system when it is assembled. If not, the stroke will be reduced and flex in the system will increase. For the best result, use a vacuum filling machine.

High loads on the spring preloader will compress the oil and the spring preloader, causing some flex in the system. At maximum load, the stroke of the slave cylinder can be expected to drop about 1 mm to 5.5 mm.

For further information regarding Öhlins hydraulic spring preloader, please contact Öhlins factory or Öhlins distributors.

30 Spare Parts List

Top eye and reservoir



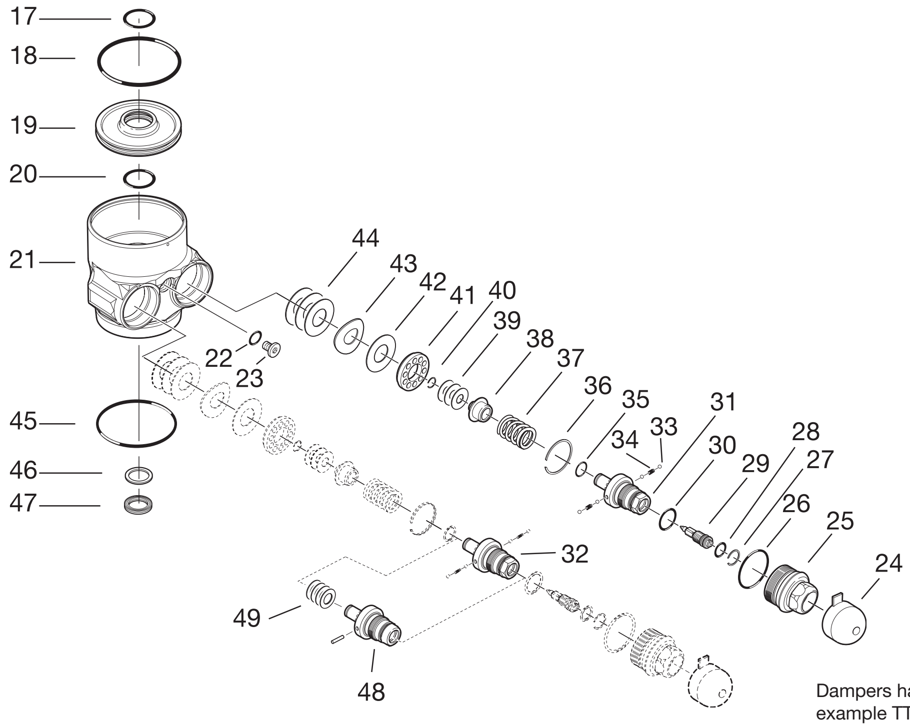
Pos.	Part No.	Pcs.	Description	Assembly Information
1	06126-01	1	Top eye 53.3	Turn 90^{0} from stop
	06126-02	1	Top eye 58.3	Turn 90^{0} from stop
	06126-03	1	Top eye 70.3	Turn 90^{0} from stop
	06126-04	1	Top eye 82.3	Turn 90^{0} from stop
	06126-06	1	Top eye 112.3	Turn 90^{0} from stop
	06126-08	1	Top eye 142.3	Turn 90^{0} from stop
2	06119-XX	2	Spacer	
3	05057-04	2	Circlip	
4	05536-05	1	Spherical bearing	Loctite 603
5	00329-11	1	Circlip	
6	01050-01	1	Screw	3 Nm (2 lbs.ft.)
7	00586-02	1	Seal washer	
8	06121-01	1	Reservoir end cap	
9	06121-02	1	Reservoir end cap	
10	00604-01	1	Inflation membrane	
11	01152-05	1	Circlip	
12	00438-90	2	O-ring	
13	06105-01	2	Pressure indicator	
14	06105-02	2	Pressure indicator	
15	00438-91	1	O-ring	
16	00579-01	1	O-ring	

***** in the end of a description indicates that the part not will be availble in the future.

Dampers having 0 as the last digit of the article number, for example TTX NE020, have the following unique parts.

Pos.	Part No.	Pcs.	Description
1	06106-02	1	Top eye 58.3*****
	06106-04	1	Top eye 82.3*****
2	05425-XX	2	Spacer
	05518-XX	2	Spacer
3	05057-02	2	Circlip
4	05536-01	1	Spherical bearing
8	06104-01	1	Reservoir end cap*****

Cylinder head and Valve



Pos.	Part No.	Pcs.	Description	Assembly Information
17	00438-91	1	O-ring	
18	00579-01	1	O-ring	
19	06102-01	1	Separting piston	
20	00438-91	1	O-ring	
21	06120-01	1	Cylinder head	
22	00438-33	1	O-ring	
23	00382-07	1	Screw	
24	05925-01	2	Rubber cap	
25	05942-01	2	End piece	12 Nm (8 lbs.ft.)
26	00338-27	2	O-ring	
27	01473-01	2	Circlip	
28	00577-01	2	O-ring	
29	05954-03	2	Bleed valve internal hex	
	05954-02º	2	Bleed valve screw driver slot*****	
30	00338-69	2	O-ring	
31	05953-01	1	Needle housing (silver)	
32	05953-02	1	Needle housing (gold)	
33	00884-02	8	Ball	
34	05945-02	4	Spring	
35	00438-52	2	O-ring	
36	00575-13	2	Circlip	
37	04107-01	-	Spring c=10 N/mm, t= 1.70 mm	
	04107-02	-	Spring c=20 N/mm, t= 1.80 mm	
	04107-04	2	Spring c=40 N/mm, t= 2.20 mm	
	04107-08	-	Spring c=80 N/mm, t= 2.75 mm	
38	04103-06	2	Poppet valve (for Ø12 seat)	
	04103-07	-	Poppet valve (for Ø10 seat)	
39	01410-12	-	Shim t=0.10 mm (for Ø10 seat)	
	01415-12	-	Shim t=0.15 mm (for Ø10 seat)	
	01420-12	-	Shim t=0.20 mm (for Ø10 seat)	
	01425-12	-	Shim t=0.25 mm (for Ø10 seat)	
	01410-14	-	Shim t=0.10 mm (for Ø12 seat)	
	01415-14	6	Shim t=0.15 mm (for Ø12 seat)	
	01420-14	-	Shim t=0.20 mm (for Ø12 seat)	
	01425-14	-	Shim t=0.25 mm (for Ø12 seat)	
	01430-14	-	Shim t=0.30 mm (for Ø12 seat)	
40	01499-04	1	Circlip	
41	04104-01	-	Valve seat Ø10	18 Nm (12 lbs.ft.)
	04104-02	2	Valve seat Ø12	18 Nm (12 lbs.ft.)
42	00530-23	2	Shim	
43	04105-01	2	Wave washer	See *Revalving* for direction
44	00530-23	6	Shim	
45	00438-17	1	O-ring	
46	01032-05	1	Back-up ring	
47	01027-05	1	X-ring	
48	05953-03	1	One-way adjustable Needle housing including Pin	
49	00610-16	-	Shim t=0.10 mm (for One-way adj. Needle housing)	
	01115-16	-	Shim t=0.15 mm (for One-way adj. Needle housing)	
	00520-16	-	Shim t=0.20 mm (for One-way adj. Needle housing)	
	00525-16	-	Shim t=0.25 mm (for One-way adj. Needle housing)	
	00530-16	-	Shim t=0.30 mm (for One-way adj. Needle housing)	

Dampers having 0 as the last digit of the article number, for example TTX NE020, have the following unique parts.

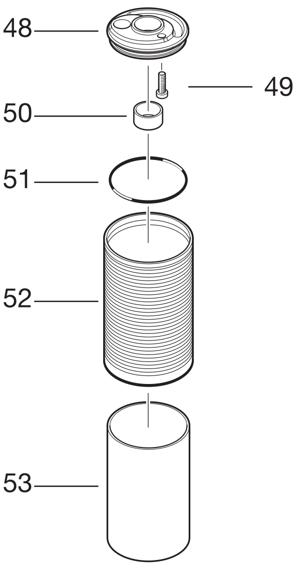
Pos.	Part No.	Pcs.	Description
21	06100-01	1	Cylinder head*****
34	05945-01	4	Spring
37	04102-31³	-	Spring c=10 N/mm, t=1.80 mm*****
	04102-32³	-	Spring c=20 N/mm, t=2.10 mm*****
	04102-34	2	Spring c=40 N/mm, t=2.40 mm*****
	04102-38³	-	Spring c=80 N/mm, t=2.80 mm*****
38	04103-04	2	Poppet valve (for Ø12 seat)*****
	04103-05	-	Poppet valve (for Ø10 seat)*****

***** will not be availble in the future.

º 05954-02 (screwdriver groove) will be replaced by 05954-03 (3 mm Allen key).

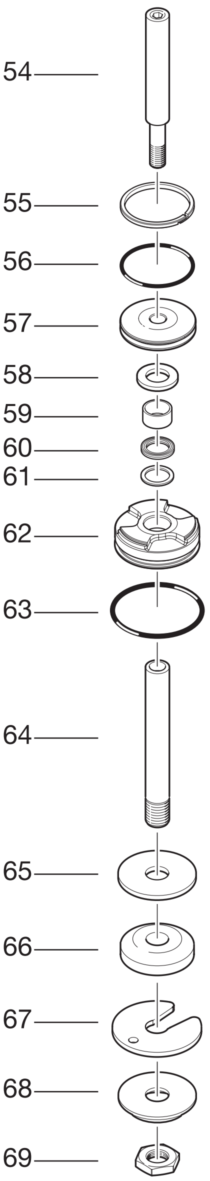
³ These parts have not been included in the damper part number TTX NE … but they where sold during the same period.

Separating plate and tubes



Pos.	Part No.	Pcs.	Description	Assembly Information
48	06101-01	1	Separating plate	
49	01046-43	1	Screw	Loctite 222, 3 Nm (2 lbs.ft.)
50	00110-05	1	Bushing	
51	00438-18	1	O-ring	
52	06109-01	1	Outer tube 76.7 mm	Loctite 243, 90 Nm (66 lbs.ft.)
	06109-02	1	Outer tube 84.7 mm	Loctite 243, 90 Nm (66 lbs.ft.)
	06109-03	1	Outer tube 96.7 mm	Loctite 243, 90 Nm (66 lbs.ft.)
	06109-04	1	Outer tube 108.7 mm	Loctite 243, 90 Nm (66 lbs.ft.)
	06109-06	1	Outer tube 136.7 mm	Loctite 243, 90 Nm (66 lbs.ft.)
	06109-08	1	Outer tube 168.7 mm	
53	06110-01	1	Inner tube 60.2 mm	
	06110-02	1	Inner tube 68.2 mm	
	06110-03	1	Inner tube 80.2 mm	
	06110-04	1	Inner tube 92.2 mm	
	06110-06	1	Inner tube 122.2 mm	
	06110-08	1	Inner tube 152.2 mm	

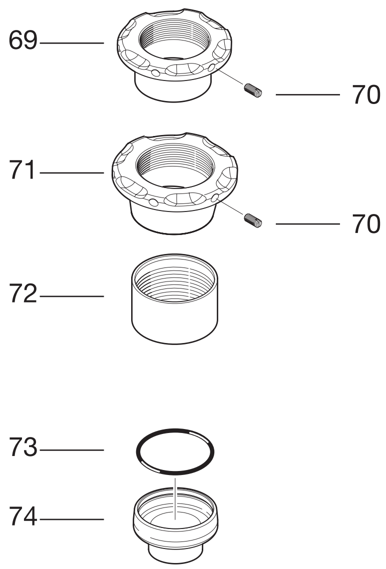
Piston rod assembly



Pos.	Part No.	Pcs.	Description	Assembly Information
54	06112-01	1	Piston rod, internal 12/89.8	Loctite 243 22 Nm (16 lbs.ft.)
	06112-02	1	Piston rod, internal 12/97.8	Loctite 243 22 Nm (16 lbs.ft.)
	06112-03	1	Piston rod, internal 12/109.8	Loctite 243 22 Nm (16 lbs.ft.)
	06112-04	1	Piston rod, internal 12/121.8	Loctite 243 22 Nm (16 lbs.ft.)
	06112-06	1	Piston rod, internal 12/151.8	Loctite 243 22 Nm (16 lbs.ft.)
	06112-08	1	Piston rod, internal 12/181.8	Loctite 243 22 Nm (16 lbs.ft.)
55	06118-01	1	Piston seal	
56	00438-24	1	O-ring	
57	06113-01	1	Piston	
58	06132-01	-	Spacer 1 mm	
	06132-02	-	Spacer 2 mm	
	06132-05	-	Spacer 5 mm	
	06132-10	-	Spacer 10 mm	
59	00110-05	1	Bushing	
60	01027-05	1	X-ring	
61	01032-05	1	Back-up ring	
62	06114-01	1	Cylinder cap	50 Nm (36 lbs.ft.)
63	00338-02	1	O-ring	
64	06127-01	1	Piston shaft, external 80.4 mm	
	06127-02	1	Piston shaft, external 88.4 mm	
	06127-03	1	Piston shaft, external 100.4 mm	
	06127-12[1]	1	Piston shaft, external 103.4 mm	
	06127-04	1	Piston shaft, external 112.4 mm	
	06127-14[2]	1	Piston shaft, external 133.4 mm	
	06127-06	1	Piston shaft, external 142.4 mm	
	06127-08	1	Piston shaft, external 172.4 mm	
65	06130-01	-	Spacer 1 mm	
	06130-02	-	Spacer 2 mm	
	06130-05	-	Spacer 5 mm	
	06130-10	-	Spacer 10 mm	
66	05375-15	-	Bump rubber, colour: black, 550 g/cm^3	
	05375-16	-	Bump rubber, colour: nature, 650 g/cm^3	
67	06131-02	-	Packer 2 mm	
	06131-03	-	Packer 3 mm	
68	05449-03	-	Support washer	
69	06117-01	1	Lock nut	25 Nm (18 lbs.ft.)

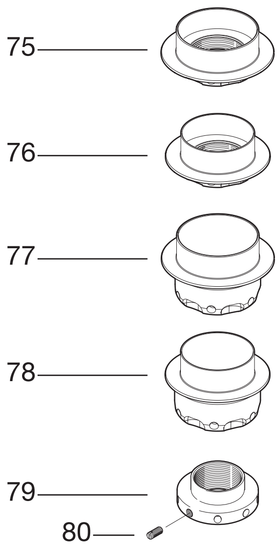
[1] 06127-12 was earlier named 06111-03.
[2] 06127-14 was earlier named 06111-05.

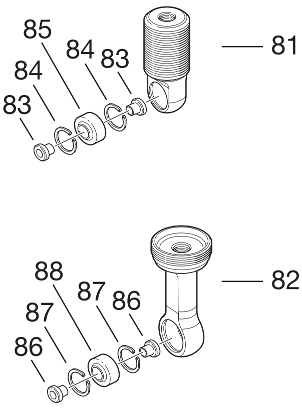
Spring platforms



Pos.	Part No.	Pcs.	Description	Assembly Information
69	05964-01	1	Spring platform Ø50.8 mm (2”)	
70	05410-01	1	Set screw	
71	05964-02	1	Spring platform Ø57 mm (2.25”)	
72	06140-01	1	Sleeve	30 Nm (22 lbs.ft.)
73	00438-60	1	O-ring	
74	05972-01	1	Spring platform Ø35.2 mm (1.5”)	

End eyes and spring retainers





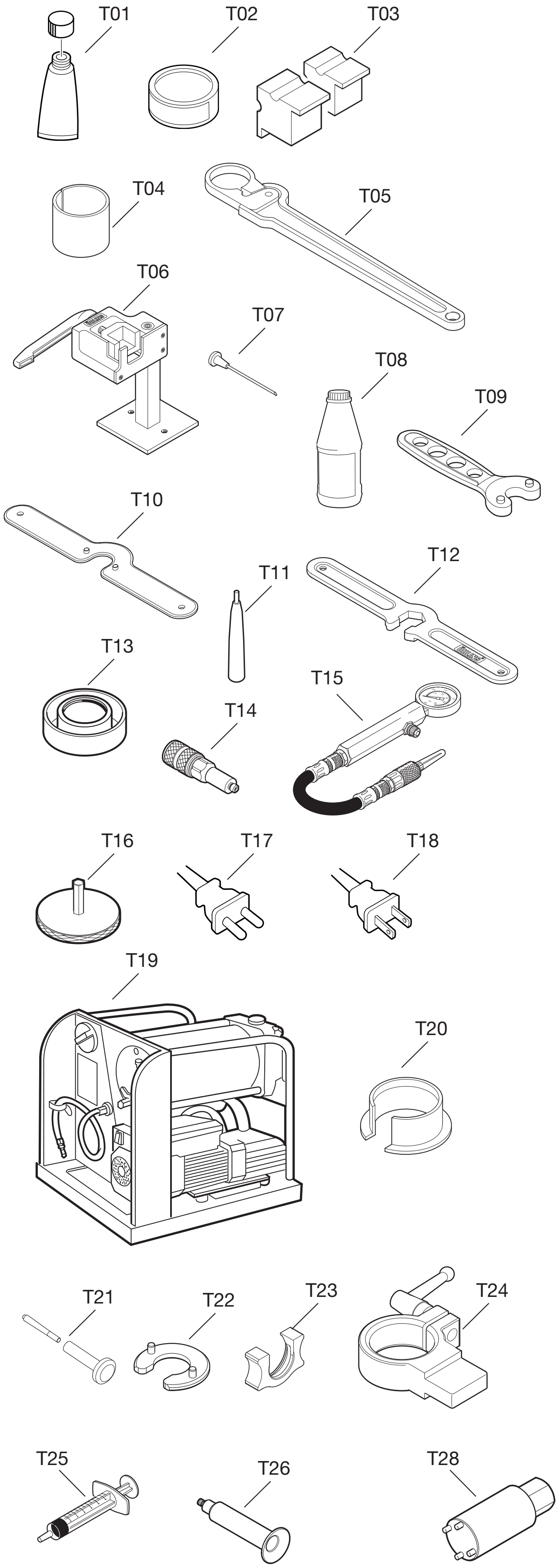
Pos.	Part No.	Pcs.	Description	Assembly Information
75	05411-01	1	Spring retainer Ø57 mm (2.25”)	
76	05411-02	1	Spring retainer Ø50.8 mm (2”)	
77	05412-01	1	Spring retainer Ø57 mm (2.25”)	
78	05965-01	1	Spring retainer Ø50.8 mm (2”)	
79	05441-01	1	Spring retainer Ø35.2 mm (1.5”)	
80	05410-01	1	Set screw	
81	06133-01	1	End eye 62.4 mm	
82	06136-01	1	End eye 31.4 mm	
	06136-02	1	End eye 40.4 mm	
	06136-03	1	End eye 49.4 mm	
	06136-04	1	End eye 58.4 mm	
	06136-05	1	End eye 67.4 mm	
	06136-06	1	End eye 76.4 mm	
	06136-07	1	End eye 85.4 mm	
83	05425-XX	2	Spacer	
	05518-XX	2	Spacer	
84	05057-02	2	Circlip	
85	05536-01	1	Spherical bearing	Loctite 603
86	06119-XX	2	Spacer	
87	05057-04	2	Circlip	
88	05536-05	1	Spherical bearing	Loctite 603

Dampers having 0 as the last digit of the article number, for example TTX NE020, have the following unique parts:

Pos.	Part No.	Pcs.	Description
82	06116-01[3]	1	End eye 31.4 mm*****
	06116-02[3]	1	End eye 40.4 mm*****
	06116-03[3]	1	End eye 49.4 mm*****
	06116-04[3]	1	End eye 58.4 mm*****
86	05425-XX[3]	2	
	05518-XX[3]	2	
87	05057-02[3]	2	
88	05536-01[3]	1	Loctite 603

***** will not be availble in the future.
[3] These parts have not been included in the damper part number TTX NE … but they where sold during the same period.

Tools



Pos.	Part No.	Pcs.	Description
T01	00146-01		Red grease 100 g
T02	00147-01		White grease 100 g
T03	00727-02		Jaws for piston shaft
T04	00737-04		Sleeve for 06140-01
	00737-05		Sleeve for outer tube
T05	00738-01		Spanner for cylinder tube
T06	00773-01		Vise
T07	00778-01		Gas needle
T08	01306-01		Shock absorber fluid 309 1 litre
T09	01761-01		Peg spanner for cylinder end cap
T10	01761-03		Peg spanner dia. 41
T11	01762-01		Spring preloader
T12	01772-03		Wrench for end eye lock nut
T13	01776-03		Oil retaining cup
T14	01779-02		Gas needle housing
T15	01781-01		Gas filling device
T16	01822-02		Adjustment tool, hex 3 mm
T17	01825-01		Cord for 230 V European standard
T18	01825-02		Cord for 115 V US standard
T19	01840-01		Vacuum filling machine
T20	01861-01		Mounting sleeve for main piston
T21	01875-02		Circlip installation tool:
			01871-01 Sleeve + 01872-02 Cone pin
T22	01876-01		Separating piston pos. tool for 6121-01
	01876-02		Separating piston pos. tool for 6121-02
T23	01877-01		Spacer sep. piston pos. tool 5.4 mm
	01877-02		Spacer sep. piston pos. tool 10.4 mm
	01877-03		Spacer sep. piston pos. tool 22.4 mm
	01877-04		Spacer sep. piston pos. tool 25.4 mm
	01877-06		Spacer sep. piston pos. tool 55.4 mm
	01877-08		Spacer sep. piston pos. tool 85.4 mm
T24	01878-01		Damper holder
T25	01879-01		Syringe piston
T26	01880-01		Syringe casing
T27	01881-01		Syringe kit:
			01879-01 Syringe piston x 5 + 01880-01 Syringe casing
T28	04106-03		Peg spanner for valve seat
	07430-01		Technical manual TTX40
	07431-01		CD TTX40
	07432-01		CD TTX40 10 pcs

NOTE:

The scale of the tools varies.

31 Technical Data

The data only refers to the standard damper units.

	Stroke [mm]	Length* [mm]	Weight [g]:
TTX NE01	48	207.6	810
TTX NE02	56	243.6	880
TTX NE03	68	264.6	910
TTX NE04	80	321.6	1025
TTX NE06	110	390.6	1145
TTX NE08	140	480.6	1345

External adjusters	4
Number of click positions:	
Low Speed Compression	40
High Speed Compression	50
Low Speed Rebound	40
High Speed Rebound	50

Max recommended velocity	1.5 m/s (60 inch/sec.)
Max damping peak force	8000 N (1800 lbs.)
Max bump rubber force	8000 N (1800 lbs.)
Max operating temperature	120°C (approx. 250°F)
Oil	Öhlins damper fluid 309
Spherical bearing hole diameter**	12.7 mm (0.5 inch)
Spherical bearing ball width**	11.1 mm (0.437 inch)
Recommended gas pressure	5 bar (75 psi)

* The length is measured from the spherical bearing centre of the top eye to where the lock nut on the piston rod sits against the end eye. By adding the given length of the end eye in chapter Spare parts you get the total length centre to centre of the bearings.

** End eyes for 36 mm (1.5”) springs uses a bearing with hole diameter 9.5 mm (0.375 inch) and the ball width is 12.7 mm (0.5 inch).

Öhlins knows that it takes more than just a unique product to fill the customer's expectations. One of them is a complete manual. This manual will follow the Öhlins tradition to set the state of art for damper manuals, just as the TTX damper does when it comes to dampers.

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Part no. 07430-01A