DIETZ automation

ValveExpert

Automatic test stand for servovalves and proportional valves

Introduction

ValveExpert was developed for testing servo- and proportional valves using advanced computer technology. Any 4-way flow control valves with flow up to 80 L/min and pressure up to 210 bar can be tested. The tests are performed quickly and with low energy usage. Graphic on-screen assistance guides the user through the entire testing procedure. The test results can then be saved to file and printed out as well.

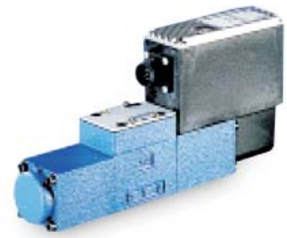
What is new and different?

Older, traditional test equipment usually had to be connected to an existing hydraulic power supply, and required power of 40 kW for testing a servovalve with a nominal flow of 80 L/min and a pressure of 210 bar. All this power for testing was lost and converted into heat and cooling by either be strong ventilation or complex water-cooling was necessary.

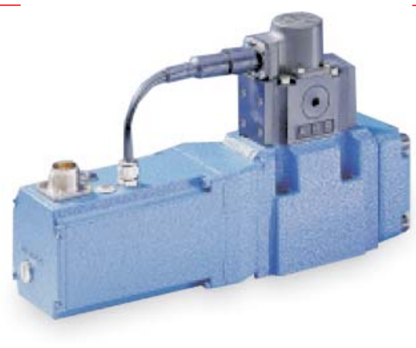
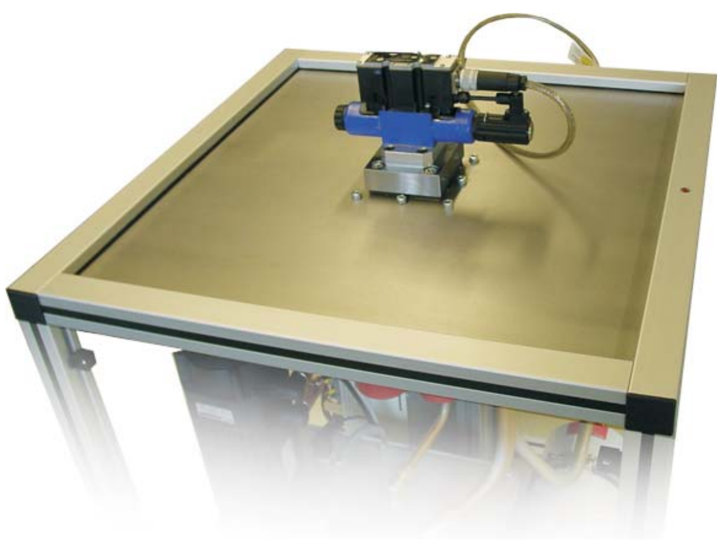
This is quite different with the ValveExpert technology. The valve characteristics are captured in fast mode. For this short test process, the energy is taken out of an accumulator. An installed power supply of 6 kW is sufficient where often 40 kW was necessary. Due to the short testing time, only little energy will be converted to heat and additional cooling is not necessary. Also, because a small oil tank is sufficient, the entire hydraulic power supply is small enough to be built into the test stand.

If you need to test servo- or proportional valves; the ValveExpert test-rig offers you the functionality of a full laboratory in a small space and at lowest cost.





Features

Plug and Play
The user simply switches on the electric power and mounts the servovalve to be tested. Then, a few minutes after starting the test sequence, the test results are available for printing or saving to file.

Mobility
The hydraulic power supply is built into the test rig itself and therefore no external piping is required. And since cooling is not necessary, no water connection is required either. Consequently, the test stand can easily be moved and installed at different places.

Fully automatic test
Besides being able to manually test valves, the operator can perform a fully automatic test by simply entering the model number of the valve to be tested and pushing the “run” button Only few minutes later 3 to 4 pages of test results are available, that can be saved to file or printed out.

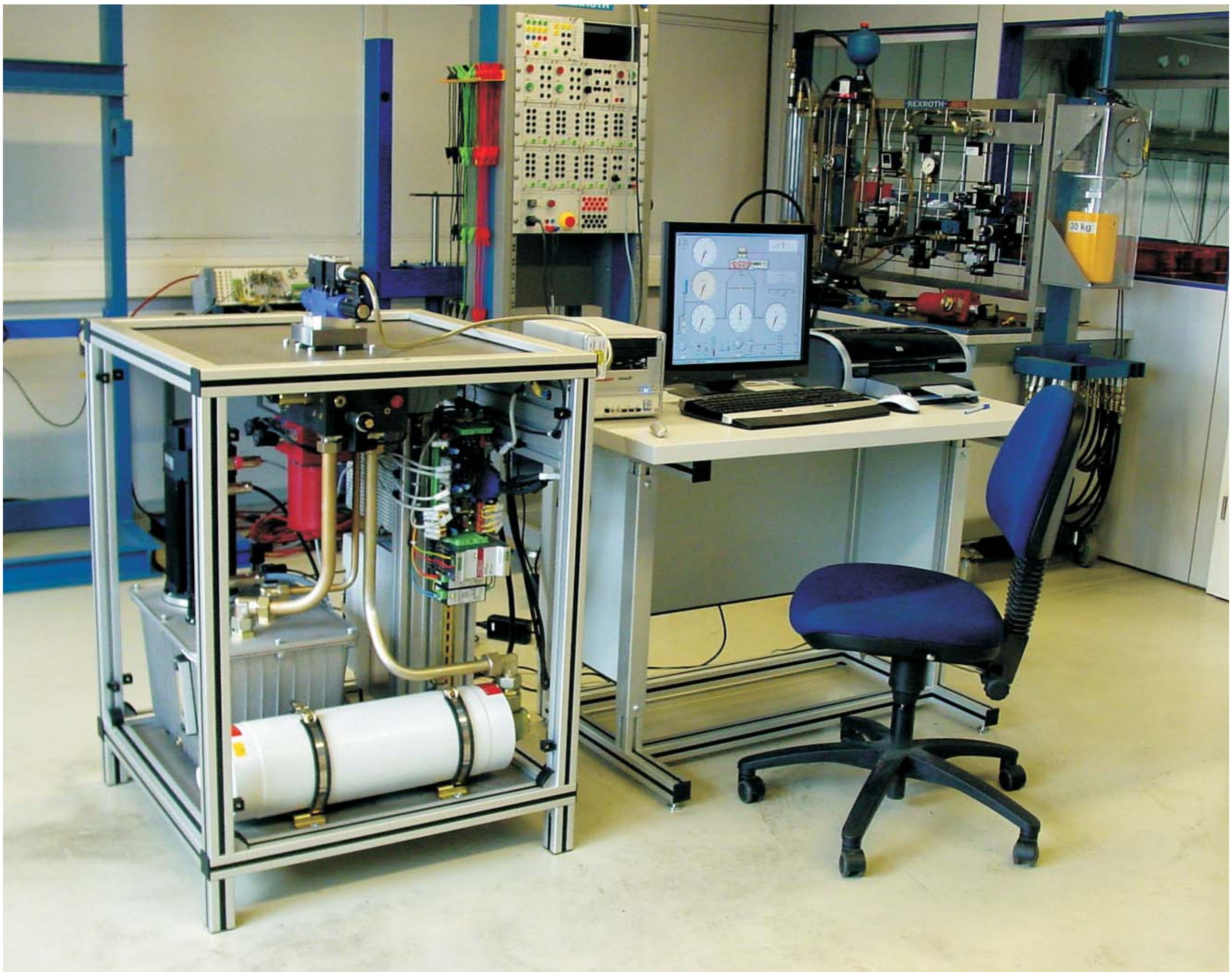
No skills
The user is guided through the testing sequence by graphic displays. No sophisticated skills are required. The operator is only required to have basic knowledge on how to use a computer running Windows, as well as the knowledge on how a servovalve works.

Efficiency
Because of the closed-loop pressure control on the hydraulic pump, the test stand uses no more energy than absolutely necessary. An electric motor drives a pump with fixed displacement and high efficiency. When the servovalve is without flow, the motor rotates economically slowly. As only little energy is converted into heat, cooling is not necessary.

Silent
“The pump is the most silent gear pump on the world market”, the supplier of this pump claims. We believed it and then installed it into the oil tank for even less noise!

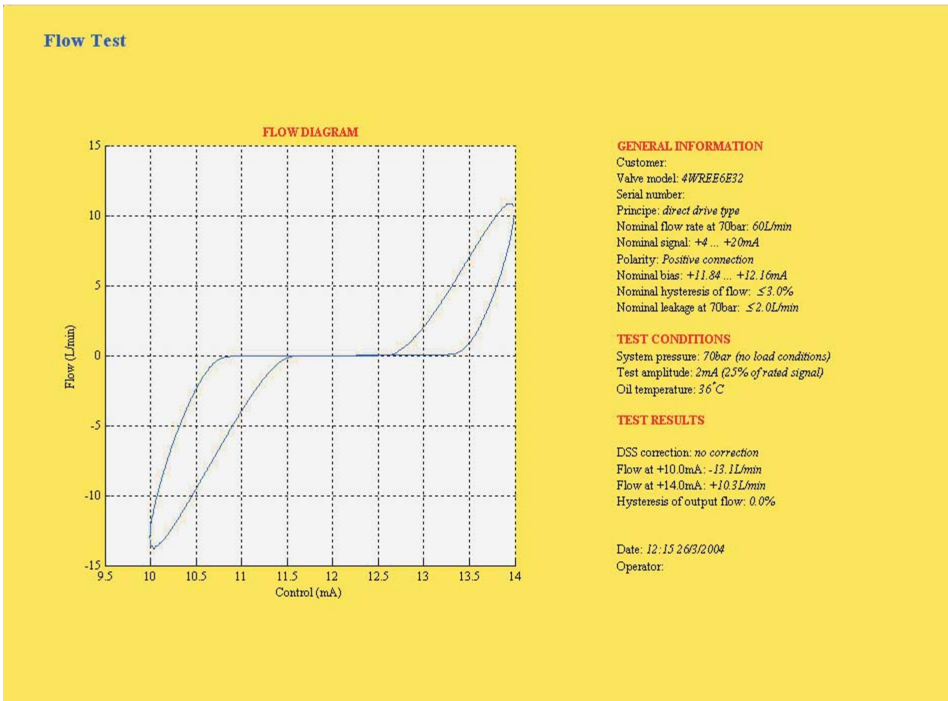
Reliability
The gear pump is oversized in its pressure rating and usually works at medium pressure in short cycles. Further, the oil is very clean - as required for the servovalves - and pump wear is minimal.
The electric servo motor is brushless and does not require any maintenance.
The switching valves, transducers and filters are mounted on a manifold. Having only a few fittings greatly decreases the probability of any leakage.

Low cost
Simple installation: Plug in to the three phase network. That's it.
Small footprint
Thanks to the smart pressure-control loop and a short test time, energy costs are minimal.
ValveExpert is a low-cost device.

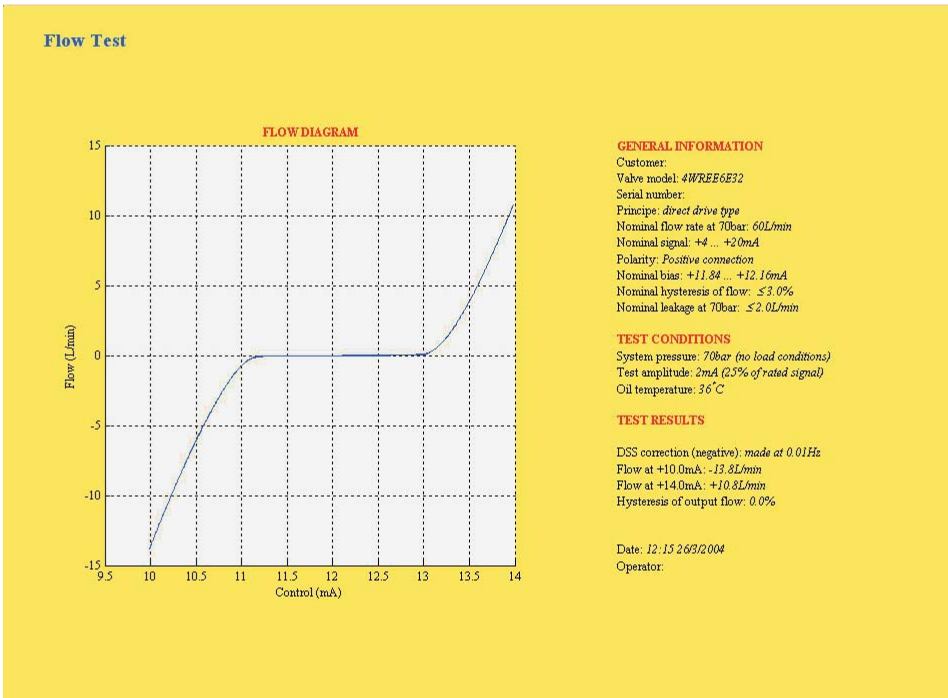


Measurement Principle

One of the outstanding features of this test rig is its integrated hydraulic power supply. The question then arises: “How is it possible to generate a flow up to 80 l/min with such a small device?” The answer is that the flow is measured rapidly; the necessary energy is taken out of the large accumulator. However, the resulting flow curve will be virtually “blown up” by a dynamic effect because the valve spool cannot move as quickly as the valve control signal is commanding it to move. This dynamic effect is then eliminated by applying an advanced mathematical algorithm to correct the phase lag between the in and output signals. This procedure is demonstrated in the two diagrams given below.



This diagram shows the flow curve of a REXROTH proportional valve. This valve is equipped with a ramp function. The ramp objective is to slow down the command signal of the valve, which therefore has an intentionally slower dynamic response. As can be seen, the curve is “blown up” and it is difficult to recognize the hysteresis, the overlap or the curvilinear form of the valve. (The curve was sampled with a control signal of 25% of the nominal signal and a frequency of 0,01 Hz.)



After the dynamic correction, we obtain the new diagram. Now it can be seen that the valve has no hysteresis, which was to be expected because of the valves closed-loop position control of the spool. Moreover, the overlap and form of the flow-curve can be seen clearly. An additional advantage of this method is that the valve can be tested without changing the adjusted ramp. Indeed, such a ramp is usually optimized for a specific application and after testing the adjustment does not have to be repeated.

Hydraulics

Brushless servomotor and internal gear pump
A brushless servomotor drives an internal gear pump which is mounted inside the oil tank. The internal gear ring of the pump is supported by a hydrodynamic/hydrostatic lubricating film, which allows operating at low and high speeds. The servomotor, which operates in a closed-loop velocity mode, superimposes a closed-loop pressure control that regulates the system pressure of the test rig. The pressure gauge of this loop is mounted close to the pressure port of the valve to be tested. As soon as the pressure is reached, the servomotor slows down and rotates just enough slowly to compensate the leakage flow. With closed load ports, there is no noise. A red lamp has been installed to indicate the presence of high pressure. Even with flow the pump has a low noise level and it has been installed inside the oil tank for additional insulation. As water-cooling is unnecessary, the test rig could even be installed in an office environment without causing any major disturbances.

Filter
The larger filter with a 3-micron high-pressure element does the main oil-cleaning job. An additional “last chance” filter with a 12-micron high-pressure element is installed in-line and at the pressure port of the valve to be tested.

Hydraulic distribution manifold
All control valves, pressure gauges, the flow meter and the filters are mounted on a single manifold requiring only a minimum of pipes and fittings to be used and thereby greatly reducing the probability of any external leakage.

Maintenance and survey
All maintenance work on the hydraulic equipment can be performed from one side of the test rig as shown in the picture, and all elements are easily accessible to allow verification of the oil level, the accumulator pressure and loading, verification of various pressures via miniature fittings, and exchange of the filter units.

Accumulator
A large piston accumulator with a capacity of 6 litres and a preload pressure of 35 bars provides the test rig with the necessary energy when flow peaks are demanded.

Oil tank
The oil tank has a capacity of 40 litres. While using the test rig under normal conditions, the oil temperature will increase from ambient temperature to an average value of 40 °C. When using the test rig very intensively (in a production line), the temperature may rise further and on reaching 60 °C the test stand will be automatically stopped until the temperature declines again. We recommend using hydraulic oil with flat viscosity characteristics (for example Shell Tellus Arctic). As the useful flow of servovalves is turbulent, the influence of temperature on flow measurements is negligible and on leakage flow measurements, the temperature has only little effect.

Electronics

SMD technology
Using „surface mounted“ technology enabled the small size of the electronics, which are mounted in a Plastic housing. The cover of the housing is made of transparent Plexiglass so the LEDs, which show the status of the various functions of the test process, can easily be seen.

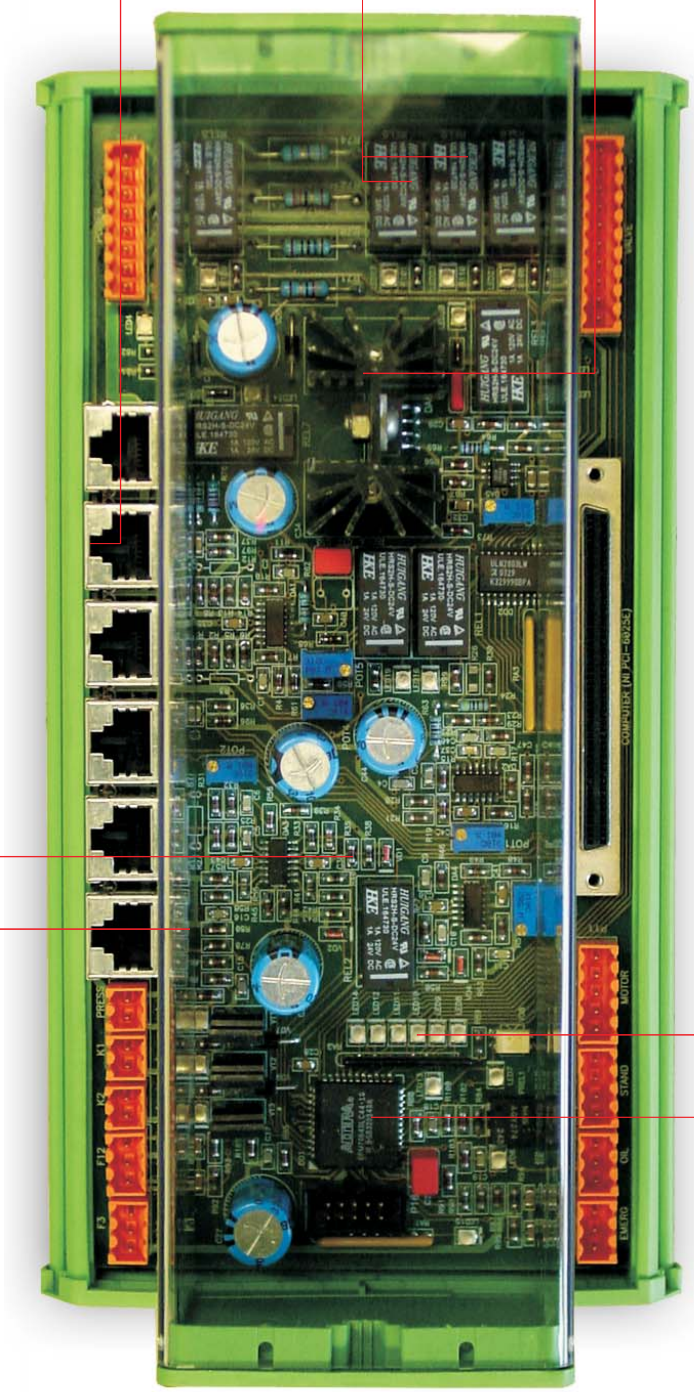
Connectors
All the connectors and cables to measurement and signal processing devices are shielded. A 100-pin connector assures a high and reliable data transfer rate to the computer.

Relays
The different configurations for the servovalve control signal for series, parallel or individual configuration are realized with relay switches. This feature saves the operator time, as only one single cable is required and the desired connections are selected by a simple mouse click.

Current amplifier
The current amplifier for the servovalve control signal can supply an output current of 500mA and is mounted on a generously dimensioned radiator, which, but for safety purposes the output current is limited to 120 mA.

LED indicators
All the important states of the test rig, such as the state of the valves, functionality of filters and power supplies, the oil level, the pulses from the flow-meter, the positive or negative servovalve control signal, the relay configurations, etc. are indicated by LEDs. This allows easy trouble shooting in case of a malfunction.

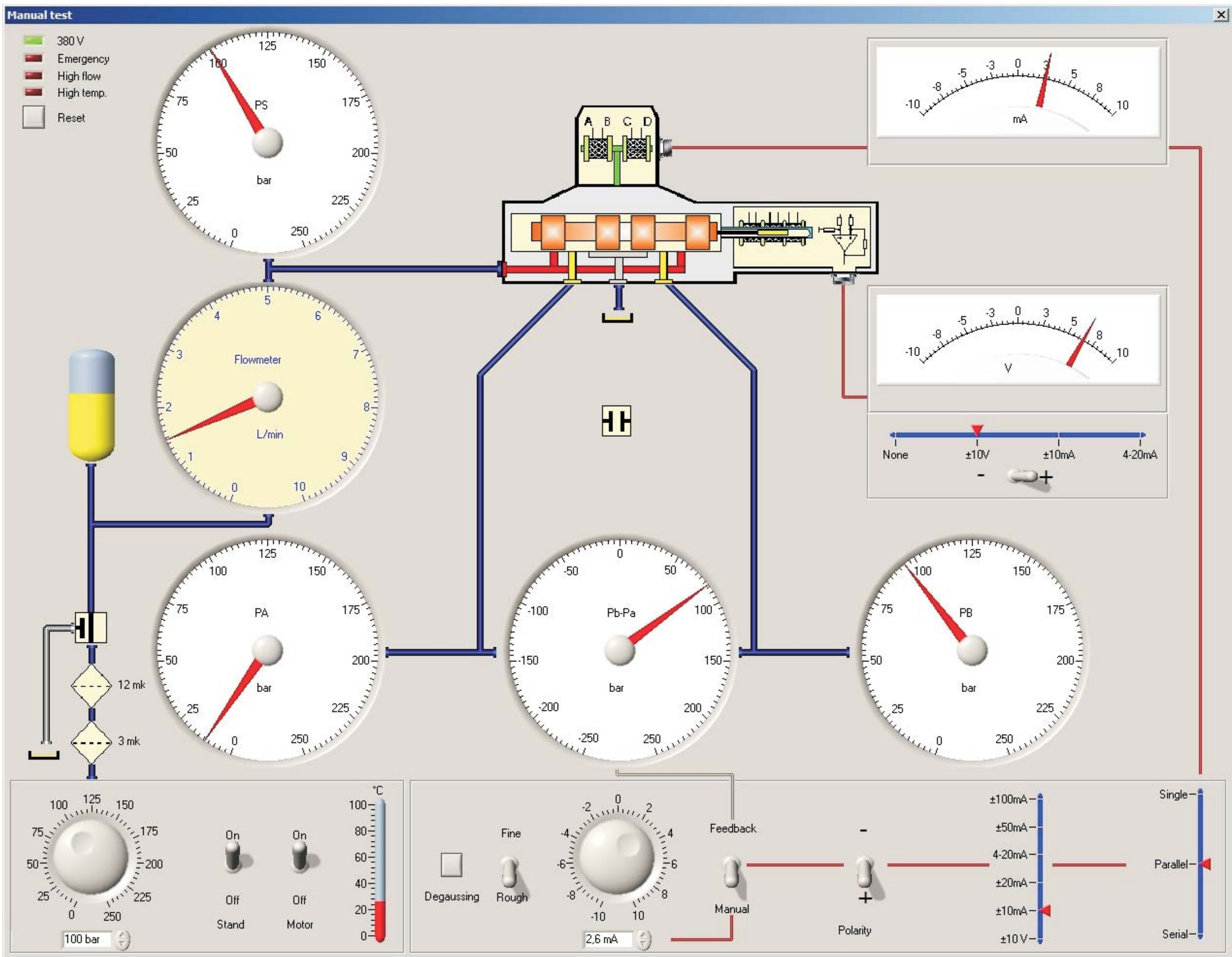
Programmable circuitry ALTERA
All digital circuits are implemented on a programmable chip, Altera, which allows modifying the digital circuits simply by programming with an external connector which has been provided for.



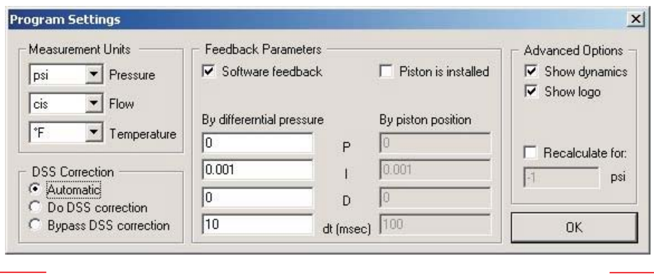
Manual test

When the test-stand is in the manual test mode, you virtually have a full laboratory at your disposal: (See the picture of the 19” screen in manual mode below.)

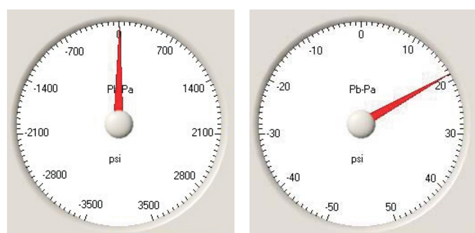
- Four simulated manometers (which therefore cannot leak and cannot be destroyed by hydraulic shocks) can be individually changed to a different scale (250 bar, 100 bar or 20 bar), or even to different units as psi or Pa. By clicking on the manometer the actual pressure value is displayed in numerical format for several seconds.
- A simulated instrument for flow measurement, which can also be configured to have a different sensitivity or display different units as L/min, cis or gal/min simply by clicking.
- Two volt/ampere meters; one for the servovalve control signal and the other for the spool position signal of valves with electric feedback. (Click feature for numerical readout.)
- Oil-temperature gauge: analogue and digital.
- Accumulator charge level display.
- Switch or direction valve control by mouse click.
- The control panel allows setting the system pressure and the servovalve control signal either analogue via “potentiometer” or numerically by keyboard. Selection of the servovalve connection configuration for series, parallel or individual configuration. Selection of the sensitivity of the servovalve spool position signal.
- Particular attention should be paid to “Feedback” control. The adjustment of the null position of servovalves with conventional test equipment is often difficult. Not so with ValveExpert: by clicking on “Feedback”, the servovalve being tested, automatically searches its hydraulic null in a closed-loop mode. Now, the null position can be adjusted to zero control signal or to any other predefined value while the feedback function keeps the servovalve at hydraulic null.



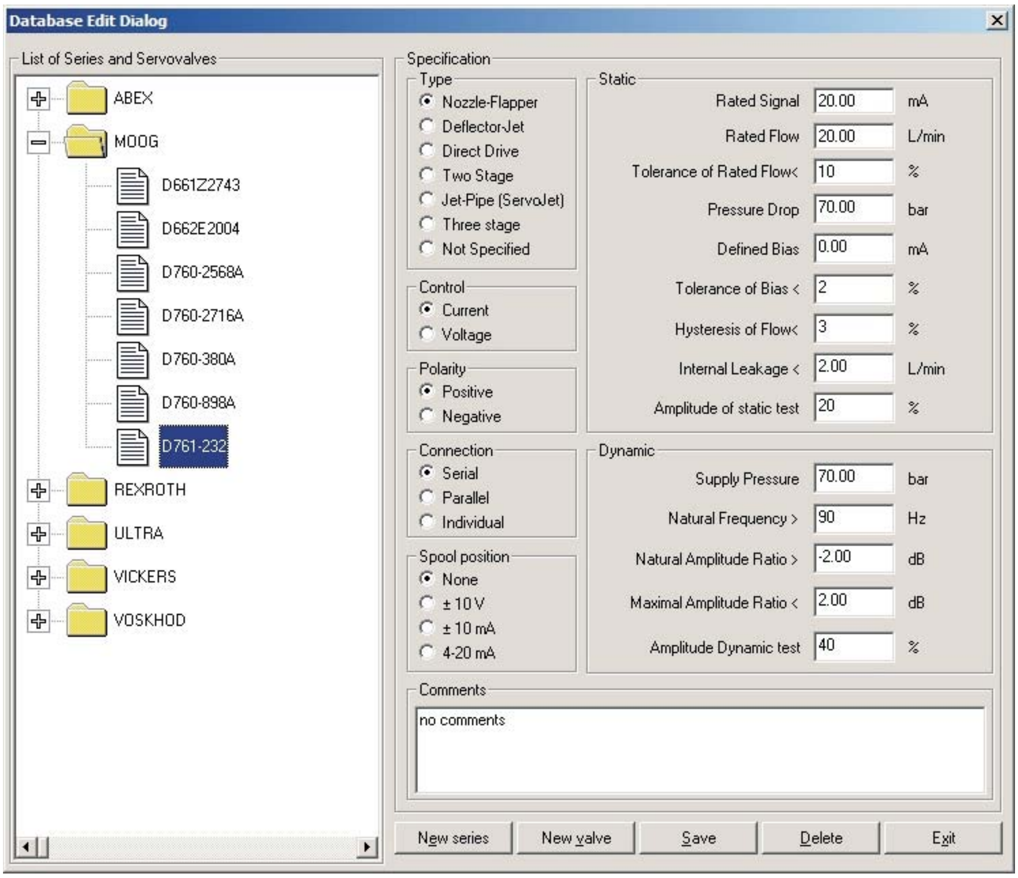
In the menu “Settings”, the desired units can be defined.



The sensitivity can be freely defined by clicking on any of the measurement instruments.

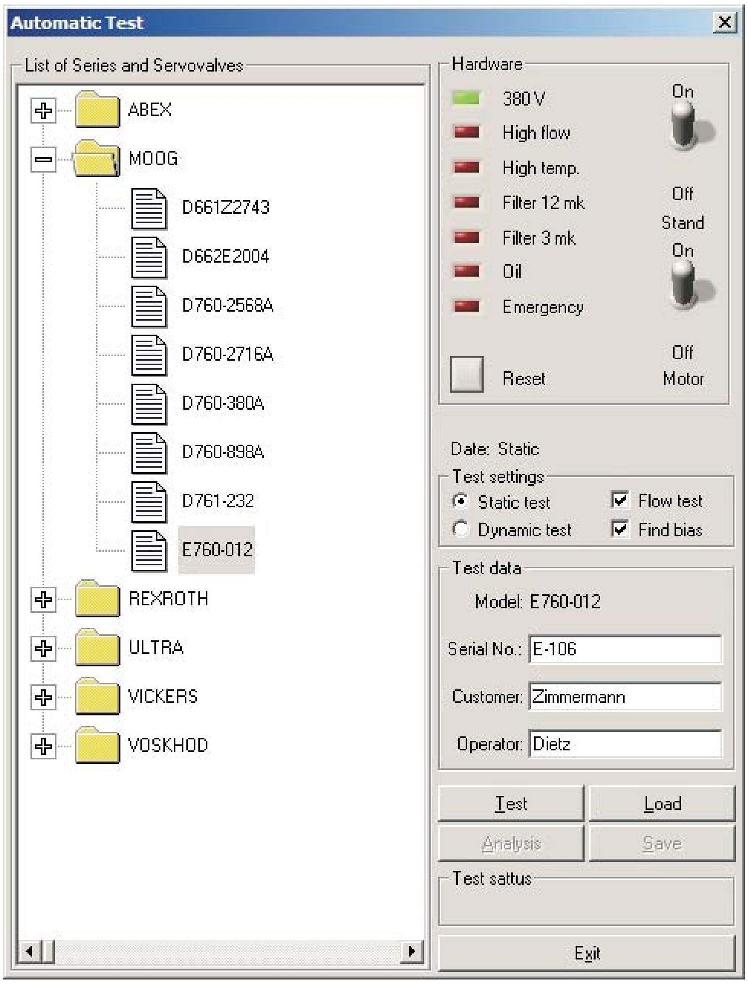


Automatic test



The Database
Servovalve test specifications are stored in a database which is similar in function to the Windows Explorer. The test specifications for newer servo- or proportional valves can be retrieved by simply entering the valve label, or if the specifications are not in the database, the user can supply these parameters by entering the information from the product catalogue of the valve supplier in the database configuration page.

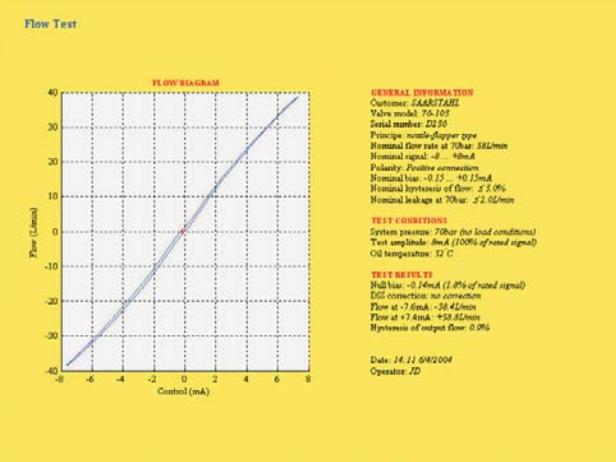
The test rig is equipped with only one flow meter that is located in the pressure line of the servovalve under test. Consequently, the servovalve pressure drop equals the system pressure. As the measurement principle is to take a greater part of the energy out of an accumulator, which has a preload of 35 bars, tests can only be performed above system pressure of 40 bars. It is recommended to test the valves with a pressure of 70 bars (or 1000 psi), which is the nominal pressure drop of most servovalves.



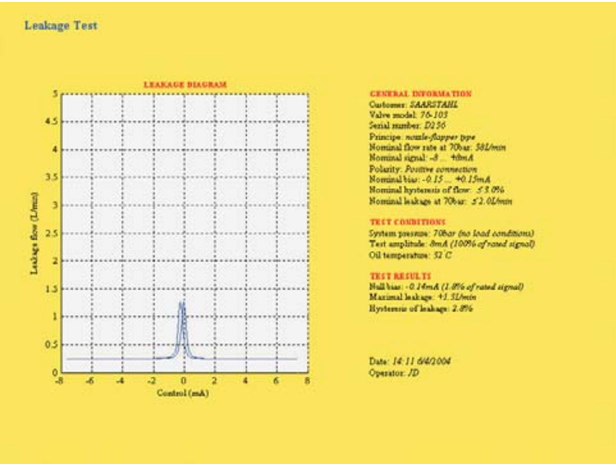
Program for fully automatic test
After starting the fully automatic test program, the operator enters the model number of the valve to be tested, the valve serial number, the customer name and his own name. Then the operator has the option of choosing various test modes, for example the static test without flow testing or the dynamic test, etc. After issuing the “Test “command, the test proceeds automatically, and after a couple of minutes the program finishes and the operator can analyse the test results. Now the operator has various options of analyses and can define whether he wants the dynamic correction, the evaluation of pressure gain, flow linearity, etc. But more importantly, he can still define what units he wants the results to be in: l/min, cis, gal/min, bar, psi, Pa ,etc. One of the main features is that the test results can be saved to file and retrieved at any time, and then be evaluated in the desired units.

In addition, the results for the flow diagram can be evaluated for a different valve pressure drop as the one used for the actual test. This is done by recalculating the values according to the Bernoulli relation, which states that flow is proportional to the square root of the pressure drop. This means that a proportional valve for which the flow was defined at a pressure drop of 10 bar, will effectively be tested at a pressure drop of 70 bar and the results recalculated for the defined 10 bar.

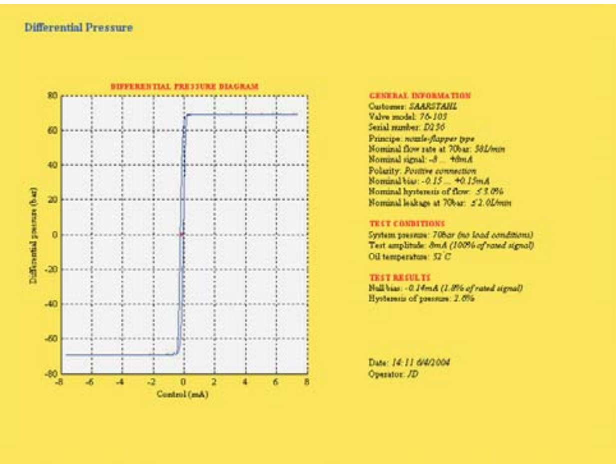
Diagnose (printout of the test results)



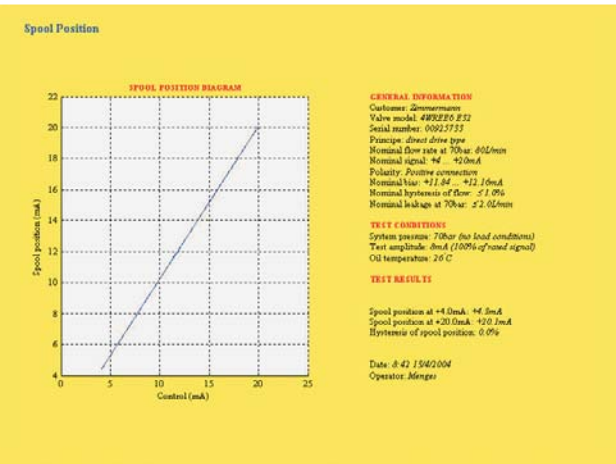
Flow test
This diagram shows the results of the flow measurement. This curve allows identifying some servovalve malfunctions, such as nonlinearity, high hysteresis due to contamination, or abnormal wear of the feedback ball (a.k.a ball glitch).



Leakage test
This diagram shows the leakage flow of the servovalve in relation to the input signal. The augmentation of the leakage around zero corresponds to the leakage of the valve spool. A higher value of this increased leakage flow gives indication of wear of the spool edges. The low values on the right and left correspond to the leakage flow of the pilot stage. Any non-symmetry of the first stage leakage is an indication of a damaged seal.

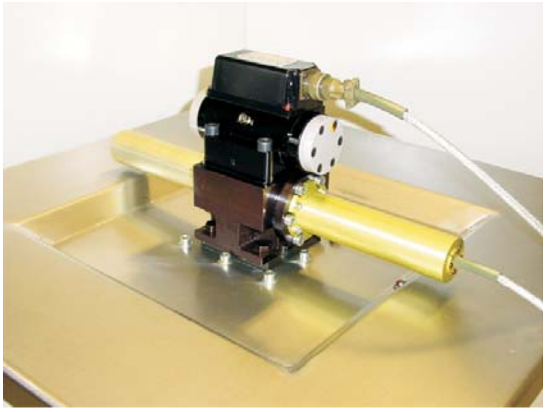


Differential pressure
This diagram shows the pressure gain of the servovalve. This information is seldom used, and if required, then usually only the curve around zero.



Spool position
This diagram shows the spool position of a valve with electric feedback. This is an important diagram. For larger servovalves or proportional valves the spool position of the valve is often controlled in a closed-loop position mode. A position transducer is used whose output signal is available on the connector of the valve. As large valves usually have a very high flow, and therefore would require very high hydraulic energy to be tested, it is sufficient to verify accurate spool positioning, and therefore the flow on these valves will only be checked around zero (up to 80 L/min with ValveExpert).

Evaluation of the dynamic performances (optional)



To evaluate the dynamic performances of a mechanical feedback servovalve, a frequency response piston has to be mounted below the valve being tested. The piston is equipped with a position transducer which allows controlling the piston in its mid-position and a velocity transducer for the flow measurement. For electric feedback valves such a frequency response piston is not necessary as the signal of the spool position can be used for the dynamic evaluation.

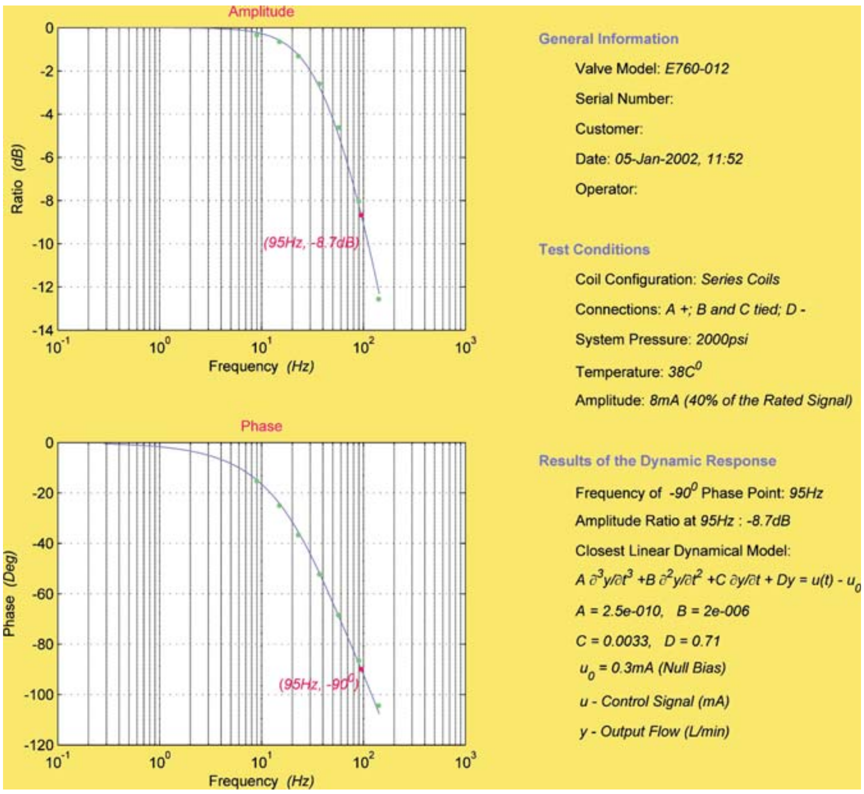
The dynamic performances of a servovalve may be described by linear differential equations (so called linear models) and therefore suppliers of servovalves usually indicate the natural frequency (phase lag at 90° and amplitude at this frequency) of the servovalve to describe the dynamic response. In ValveExpert we try to find the best linear system that describes the dynamic performances of the valve. To determine the dynamic properties we use following equation with three parameters:

$$A\frac{\partial^3 y}{\partial t^3} + B\frac{\partial^2 y}{\partial t^2} + C\frac{\partial y}{\partial t} + Dy = u(t) - u_0$$

and following starting conditions:

$$\left.\frac{\partial^2 y}{\partial t^2}\right|_{t=0} = \left.\frac{\partial y}{\partial t}\right|_{t=0} = \left.y\right|_{t=0} = 0$$

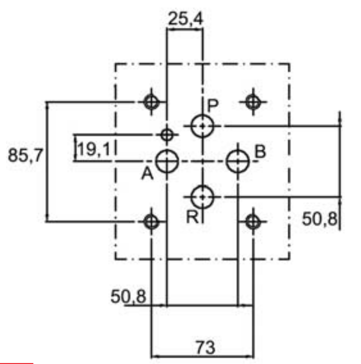
Where *u(t)* is the input signal of the servovalve and y*(t)* the output flow of the servovalve (u_0 is the bias signal). Under the assumption that the servovalve can be described with such an equation, we conduct the test with a defined function *u(t).* Then, we set up the output function y*(t)* and produce the matching process to determine the parameters A, B and C. Knowing the equation, we can determine all dynamic properties of the servovalve, such as phase lag and amplitude.



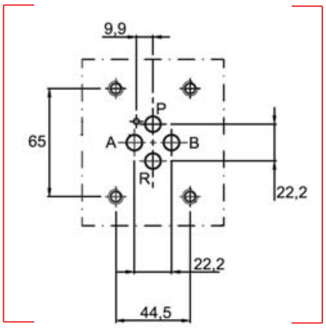
The results of the dynamic tests are imprinted as a Bode diagram as is common for servovalve manufacturers. The green points in the diagram show the actual measured values. The blue line represents the evaluation of the differential equation which best represents the dynamics of this valve.

Standard version and accessories

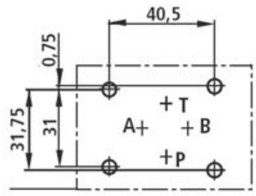
Basic version:
The basic version will be delivered with following adapter manifolds:



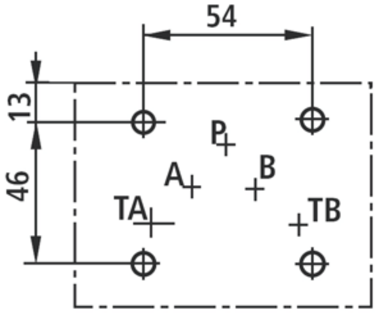
Norm ISO 10372-06-05-0-92
This corresponds to the basic port pattern on which can be mounted additional adapter manifolds.
The base port pattern is compatible for following servovalves:
MOOG X072,
MTS 252,3x,
STAR 8XX
ULTRA 4550
(with internal pilot)



Norm ISO 10372-04-04-0-092
For following servovalves :
ATCHLEY 209,
MOOG X062,
MOOG X073,
MOOG X076,
MOOG X760,
MOOG X761,
MOOG X765,
MTS 252.2x,
PEGASUS 122A,
REXROTH 4WSE2EM10A-45
STAR 5XX
ULTRA 4653,
VICKERSS M4-20,
VOSKHOD UG176
(with internal pilot)

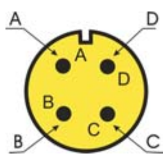


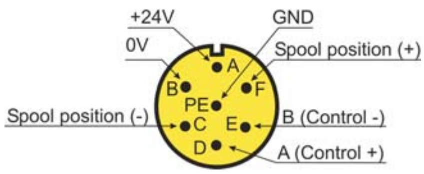
Norm ISO 4401-03-03-0-94
Norm NG6
For following servovalves :
MOOG D633
REXROTH 4WRAE
REXROTH 4WREE
REXROTH 4WRSE
REXROTH 4WRSEH
VOSKHOD 133

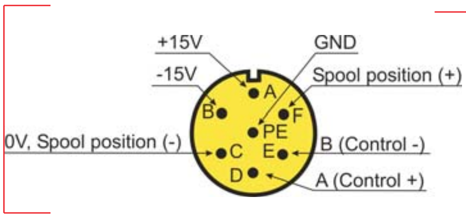


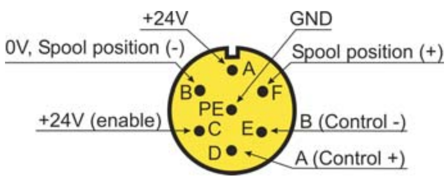
Norm ISO 4401-05-05-0-94
Norm NG10
For following servovalves :
MOOG D634
MOOG D661
REXROTH 4WRAE
REXROTH 4WRDE
REXROTH 4WREE
REXROTH 4WRGE
REXROTH 4WRKE
REXROTH 4WRSE
REXROTH 4WRSEH
REXROTH 4WRTE
REXROTH 4WRZE
STAR 1652R

For the control signals for above valves, four cables are supplied:

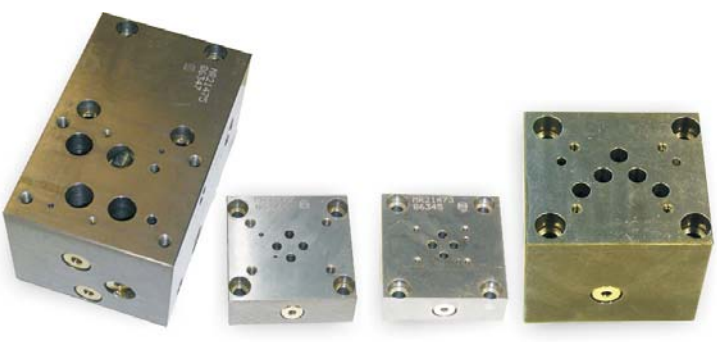








Accessories:
Other adapter manifolds are available on request.



A cover is available as accessory