

# ValveExpert

Automatic Teststand  
for Checking, Maintenance, and  
Adjustment of Servovalves



User Manual

# Contents

ValveExpert.....	1
Contents.....	2
Introduction.....	4
Review of Specifications.....	5
Application.....	5
Control Signal for Servovalve.....	5
Spool Position Signal (Feedback).....	5
Power Supply for Servovalve.....	5
Hydraulic Fluid.....	5
External Power Supply for ValveExpert.....	5
Hydraulics.....	6
Accessories.....	7
Measurement Piston.....	7
Standard Cables.....	7
Adapter Manifolds.....	8
Cover Cap.....	8
Universal Control Board.....	9
Servovalve Connector (Stand View).....	10
Software “ValveExpert”.....	11
Software Installation.....	11
Main Dialog.....	12
Menu Description.....	12
File.....	12
Load.....	12
Save.....	13
Analysis.....	13
Exit.....	16
Tests.....	16
Automatic Test.....	16
Manual Test.....	18
Manual Test Sequence (Example).....	21
Special futures of the Manual Test Dialog Box.....	22
Database.....	23
Settings.....	24
Help.....	25
Contents.....	25
DIETZ automation (Web).....	25
About.....	25
Menu Description Shortcuts.....	25
Definitions.....	26
Electrohydraulic Flow Control Servovalve.....	26
Rated Control Interval.....	26
Rated Minimum and Maximum of Control.....	26
Predefined Bias.....	26
Rated Signal.....	26
Four-Way Servovalve.....	26
Supply Pressure.....	26
Return Pressure.....	26
Load Pressure Drop.....	26
Valve Pressure Drop.....	27
Pressure curve.....	27
Pressure Hysteresis.....	27
Pressure Gain.....	27

Control Flow (Load Flow or Flow Output).....	27
Polarity .....	27
Null Bias.....	27
Null Shift.....	27
Rated Flow .....	27
Flow Curve.....	28
Hysteresis (Flow Hysteresis).....	28
Normal Flow Curve.....	28
Flow Gain.....	28
DSS Method .....	28
Internal Leakage.....	28
Null Leakage .....	28
Leakage Curve.....	29
Leakage Hysteresis.....	29
Total Valve Flow.....	29
Spool Position Signal .....	29
Spool Position Diagram.....	30
Spool Position Hysteresis.....	30
Dynamical Model of Servovalve.....	30
Frequency response .....	30
Natural Frequency .....	30
Degaussing Control .....	30
Address .....	32

# Introduction

ValveExpert is an automatic teststand for checking, maintenance, and adjustment of servovalves. It is a high performance test equipment based on the latest achievements in hydraulic servocontrol systems. ValveExpert was designed, mainly, to provide complete analysis of four-way flow control servovalves with flow up to 80 L/min and pressure up to 210 bar. Nevertheless we must note that ValveExpert can be used successfully also to test some other types of servovalves, proportional valves and other hydraulic devices.

ValveExpert is a completely autonomous teststand with hydraulic power inside and with a computer subsystem for control and powerful mathematical analysis. To start measurement with ValveExpert you just need the electric power supply 380 V. Small dimensions of the stand and the fact that ValveExpert does not require an external hydraulic power supply and cooling water allows using it as a portable high performance test equipment. Note that the computer subsystem allows to print or save all results and test data. You can immediately send out the results using a computer network connection.

The stand allows testing the most standard static and dynamic parameters. In addition to such traditional characteristics as static flow curve and frequency response, ValveExpert allows to obtain a mathematical model of a servovalve under test. The knowledge of the dynamical system which describes the servovalve, obviously, opens new possibilities for designers and developers of control systems. They can use the obtained model for fast computer simulations as well as for complex mathematical analysis. We believe ValveExpert will give you best possibilities for checking, maintenance and adjustment of your servovalves. The developers and designers will find ValveExpert as a good tool to construct excellent control systems.

General Manager of DIETZ automation GmbH



/Joachim Dietz/

# Review of Specifications

## Application

The teststand is developed for checking, maintenance and adjustment of four way servovalves with rated flow up to 80 L/min and supply pressure from 60 to 210 bar.

## Control Signal for Servovalve

Using ValveExpert you can check servovalves controlled by current as well as voltage. There are four ranges with 12 bit resolution for current control:  $\pm 10$ ,  $\pm 20$ ,  $\pm 50$  and  $\pm 100$  mA. We must note that, in reality, the electronics covers about 120% of these ranges, i.e., for instance, maximal control current for  $\pm 100$  mA range is about 120 mA. This extension is made for 20% possibility to correct the null bias of the servovalve, i.e. teststand is able to produce tests with amplitude 100 mA and control shift 20 mA. Note also that  $\pm 20$  mA range is used for the popular standard control 4 – 20 mA. There is one range Voltage control signal  $\pm 10$  V. The real output signal can be also 20% more, i.e.  $\pm 12$  V. Note that ValveExpert has build in switches to change polarity of control and coil configurations (series, parallel or single coil).

## Spool Position Signal (Feedback)

Many modern servovalves have build in electronics. These valves are usually equipped with position transducers used for internal feedback of the spool position. ValveExpert can check a signal from the spool position transducer. The standard signal ranges ( $\pm 10$  V,  $\pm 10$  mA, 4 – 20 mA) are supported.

## Power Supply for Servovalve

Servovalves with build in electronics require external power supplies. In most cases it is  $\pm 15$  V DC or 24 V DC with current 1 – 2 A. Such power suppliers are built in the teststand.

## Hydraulic Fluid

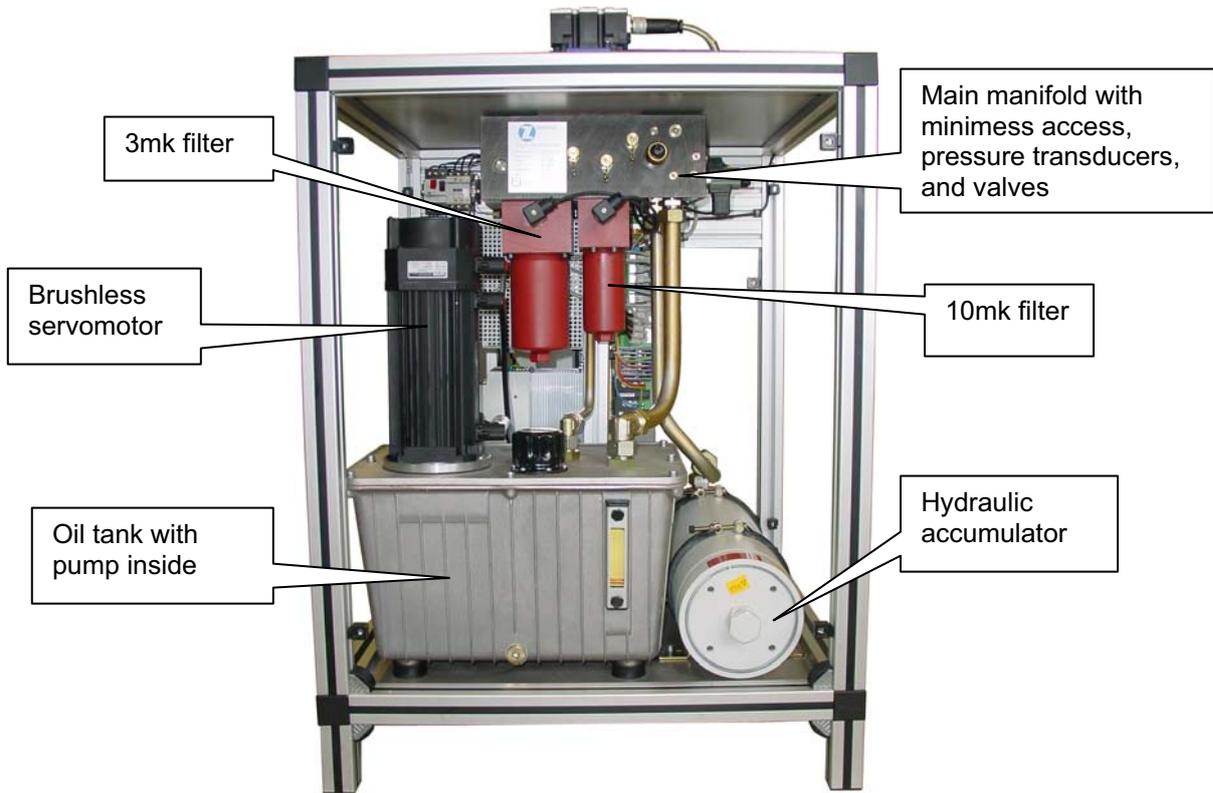
The teststand ValveExpert was developed and tested for a mineral oil with viscosity about 30. We recommend you to use Mobil DTE24, Shell Tellus 29, MIL-H-5606 or oil with the similar parameters. We must note that these requirements are needed basically to satisfy the requirements of a pump and a flowmeter which are built in the teststand. So, you should ask the producers of the pump and flowmeter before using another hydraulic fluid.

The integrated filtration system achieves a cleanliness level 5 of NAS1638 (level 14/11 of ISO4406) or better. The filtration is controlled by an operator of the stand and depends evidently on the contamination level of the servovalves been tested.

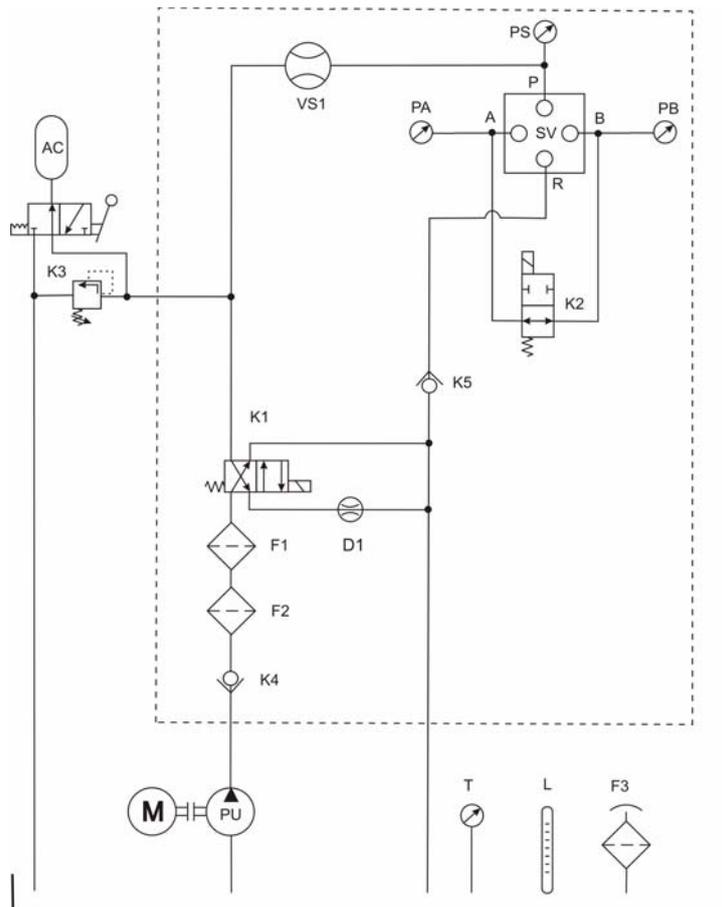
## External Power Supply for ValveExpert

The teststand does not require an external hydraulic power supply because it is inside. ValveExpert does not need a water connection for cooling because it does not take much energy. The only three-phase  $\sim 380$  Volt, 50 Hz power supply is required to start measurements with ValveExper.

# Hydraulics



Picture 1. Inside ValveExpert.

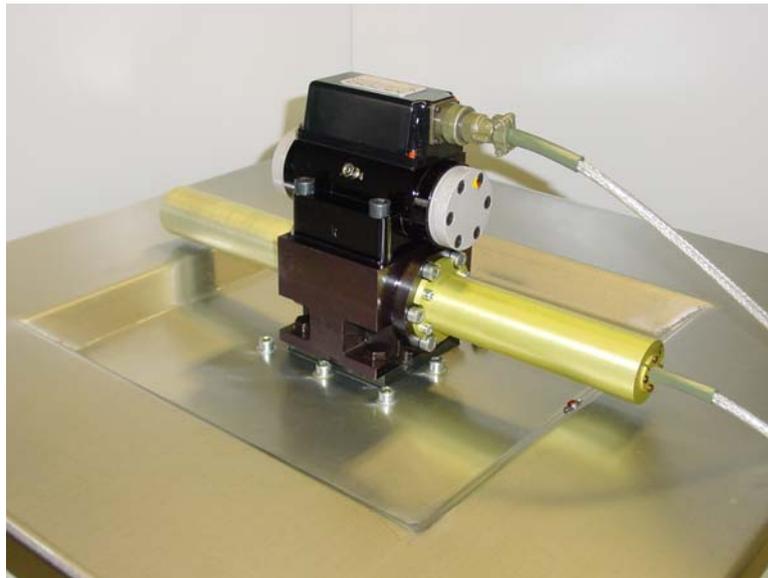


Picture 2. Hydraulic schema for automatic teststand ValveExpert. M – brushless servomotor, PU – gear pump, T – temperature transducer, L – oil level sensor, F1 – 10µ oil filter, F2 – 3µ oil filter, F3 – air filter, PA, PB, PS – pressure transducers for 0-250bar, AC – 4L hydraulic accumulator, VS1 – high precision gear-principle flowmeter, K1 – pressure/filtration valve, K2 – load valve, K3 – security valve, SV – manifold for servovalve, D1 – throttle to restrict return flow from accumulator AC. All components inside of the dotted box are mounted on the main manifold.

# Accessories

## Measurement Piston

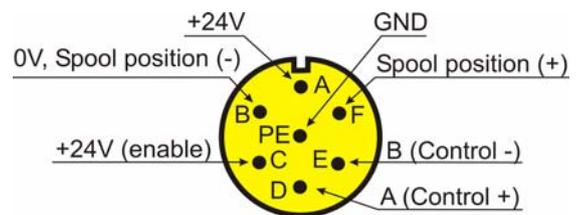
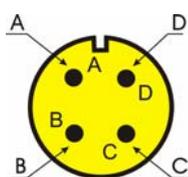
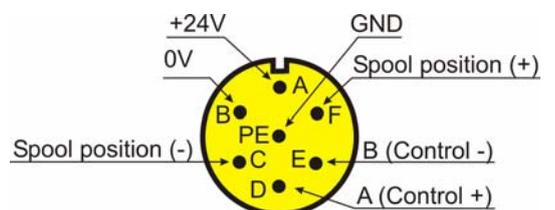
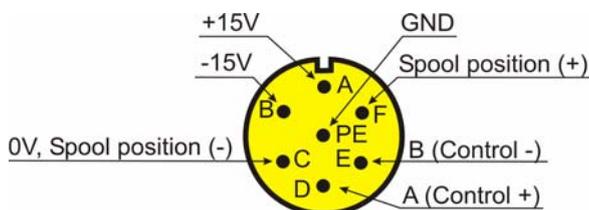
Most of industrial applications do not require the knowledge of the exact dynamical properties of servovalves. Nevertheless, they are absolutely necessary to know for most of military, science and other high precision and high frequency applications. Our firm has developed a special, so called, Measurement Piston (see Picture 3) which, in combine with teststand, is a powerful test equipment for dynamical response. The Measurement Piston allows to obtain the complete knowledge on dynamics of your servovalve. We must note that in addition to traditional frequency response curves, you will obtain the best liner dynamical model of your servovalve (see Picture 41).

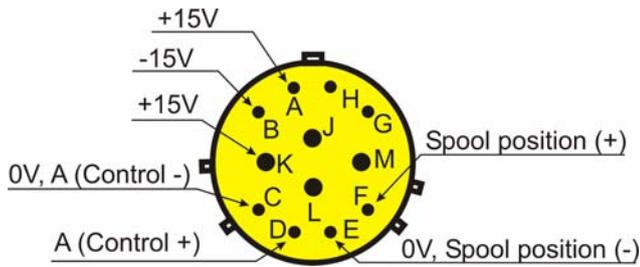


Picture 3. The Measurement Piston and a servovalve are installed on the teststand.

## Standard Cables

In order to connect servovalves with ValveExpert a number of cables can be delivered on your request. Each of the cables contains two connectors. One is for the teststand and the other one is for the servovalve. Schema of the teststand connector is shown on Picture 6 (teststand side view). Below we show the most popular connectors for servovalves (cable side view).





## Adapter Manifolds

With the standard equipment come two of the most popular mounting plates.

1. Norm ISO 10372-06-05-0-92 (for Moog series 72, MTS 252.3x, Ultra 4550).
2. Norm ISO 10372-04-04-0-92 (for Alpha series B0020010, Atchley 209, Moog 62, Moog 73, Moog 76, Moog 760, Moog 761, Moog 765, MTS 252.2x, Pegasus 122A, Ultra 4653, Vickers SM4-20, Voskhod UG-176).

Additional adapter plates can be delivered on request.



Picture 4. Adapter Manifolds.

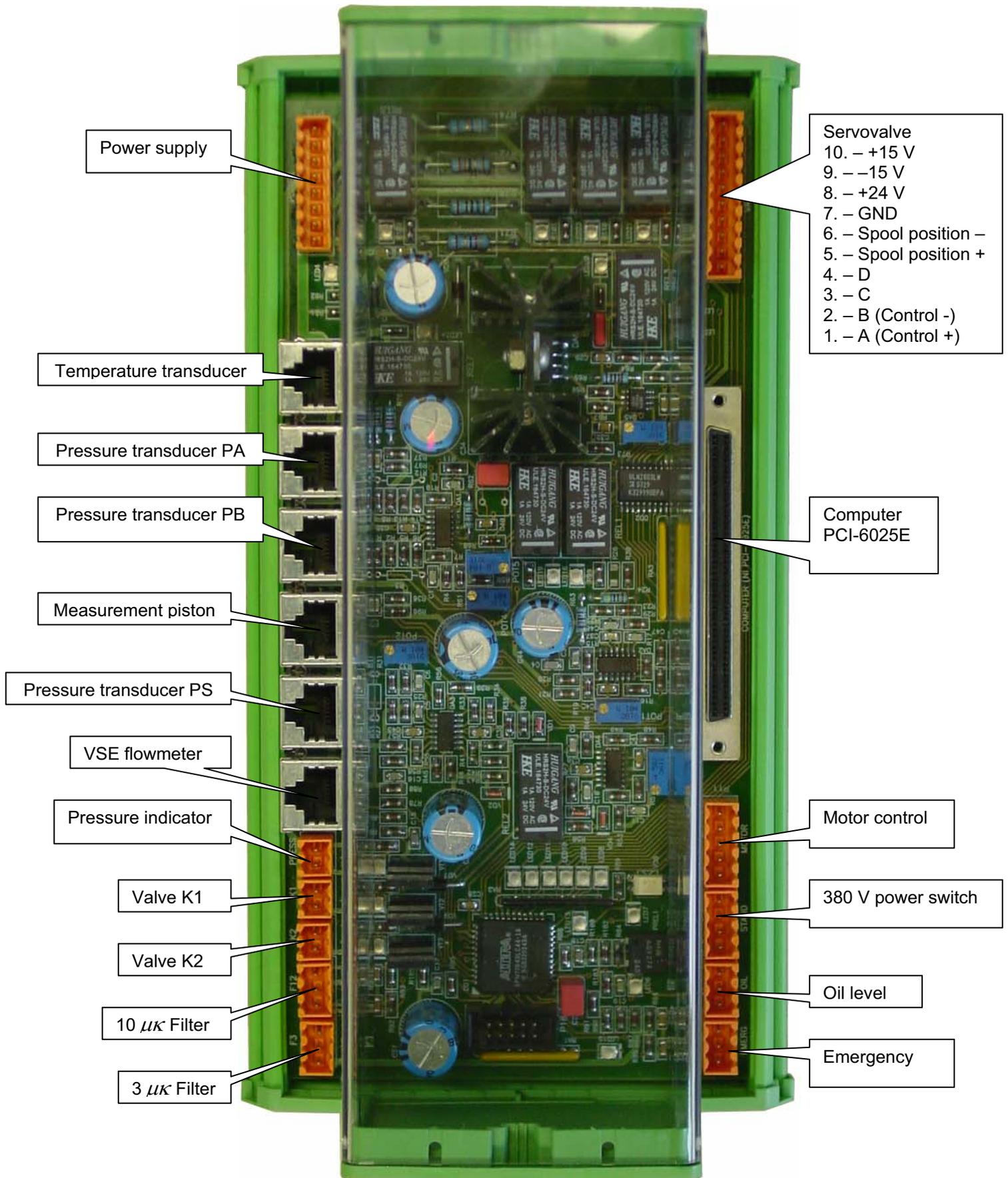
## Cover Cap

A cover cap shown on Picture 5 can be delivered with ValveExpert. Unfortunately nobody can guarantee that there will not be external leakage from a valve during a test. A lot of oil can be outside in such a situation. The cover cap will save you and your room from the “oil shower”.

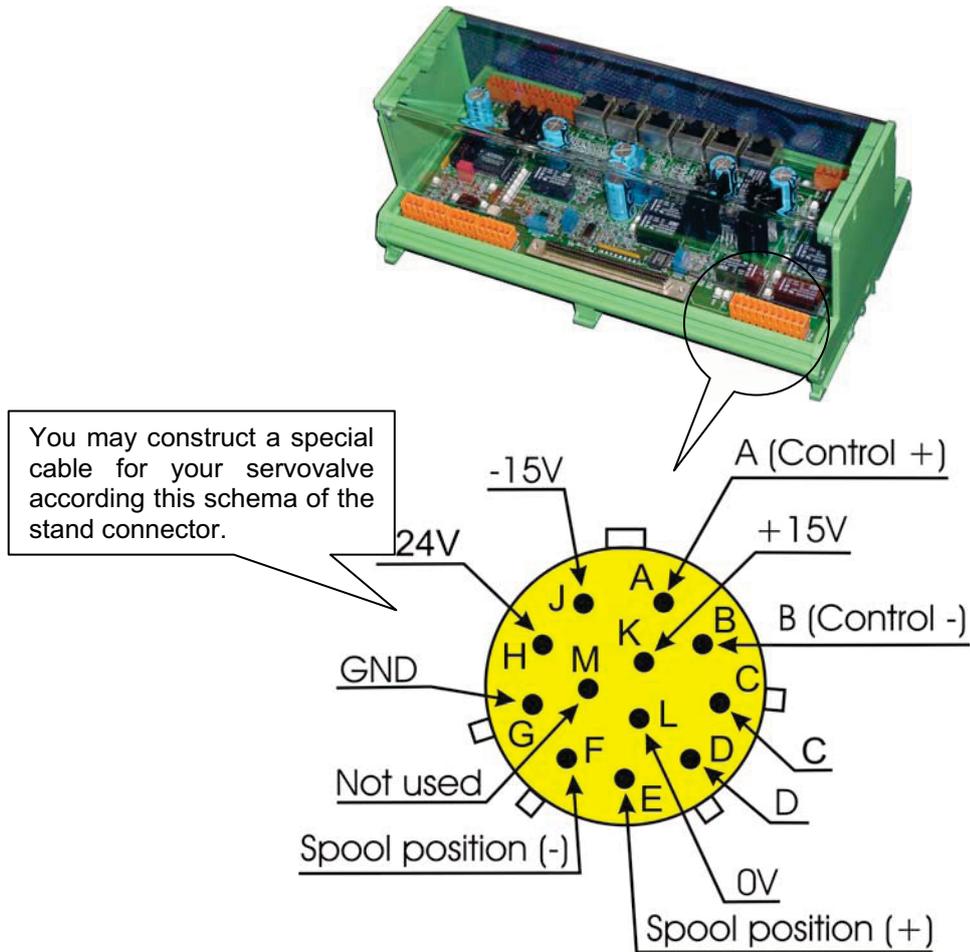


Picture 5. Cover cap.

# Universal Control Board



# Servo Valve Connector



Picture 6. Servo valve connector

# Software “ValveExpert”

## Software Installation

1. Insert the DIETZ automation disk with ValveExpert software in your CD ROM. This CD is supplied also by National Instruments software. “Autorun.exe” will start the NI Device Drivers installation program (Picture 7). Please follow the program instructions and NI documentation to install the drivers for PCI-6025E card inserted in the computer of your teststand.<sup>1</sup>



Picture 7. NI Device Drivers installation program.

2. Please execute the Measurement & Automation Explorer (Start → Program → National Instruments → Measurement & Automation) and check that your NI PCI-6025E card works properly (see Picture 8). Note, by default Measurement & Automation Explorer is located in "C:\Program Files\National Instruments\MAX\NIMax.exe"



Picture 8. Measurement & Automation Explorer

3. Start “CD:\ValveExpert\Setup.exe” program to begin setup the DIETZ automation software for ValveExpert.<sup>2</sup> Follow the program instructions to complete the installation.<sup>3</sup>
4. Copy your private configuration file “ValveExpert.cfg” with installation-specific settings to directory with MS Windows (usually c:\windows\).

<sup>1</sup> The installation program must be run under a valid administrative account.

<sup>2</sup> Here CD is the drive letter of your CD ROM.

<sup>3</sup> Please note that you can use ValveExpert software on a separate computer. This can be useful to analyze saved test data or correct your database file “DBAccess.mdb”. By default this file is located in “C:\Program Files\DIETZ Automation GmbH\ValveExpert”. In any case the NI Device Drivers must be installed.

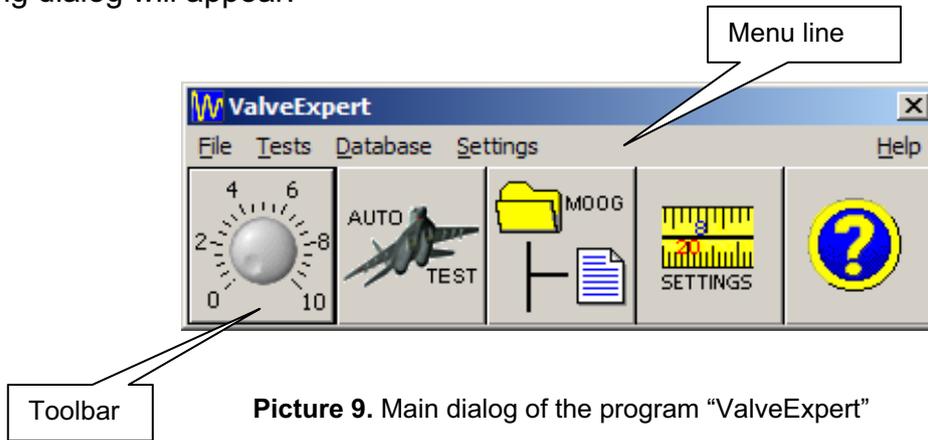
# Main Dialog

By default, the program ValveExpert is installed in:  
C:\Program Files\DIETZ Automation GmbH\ValveExpert\ValveExpert.exe.

You can execute it using the following icon  from start menu:

Start Program → DIETZ automation → ValveExpert → ValveExpert

The following dialog will appear.

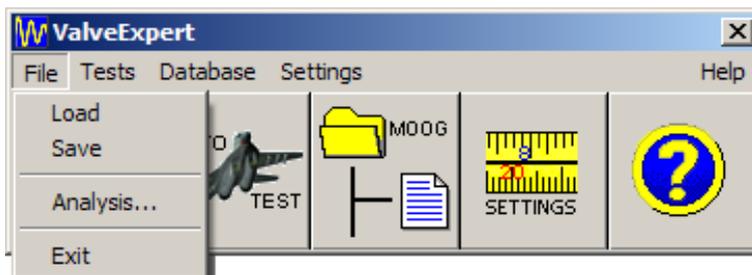


This dialog includes menu line and toolbar. Menu is used for access to all dialogs of the program. Toolbar contains five buttons for fast call of the main functions.

# Menu Description

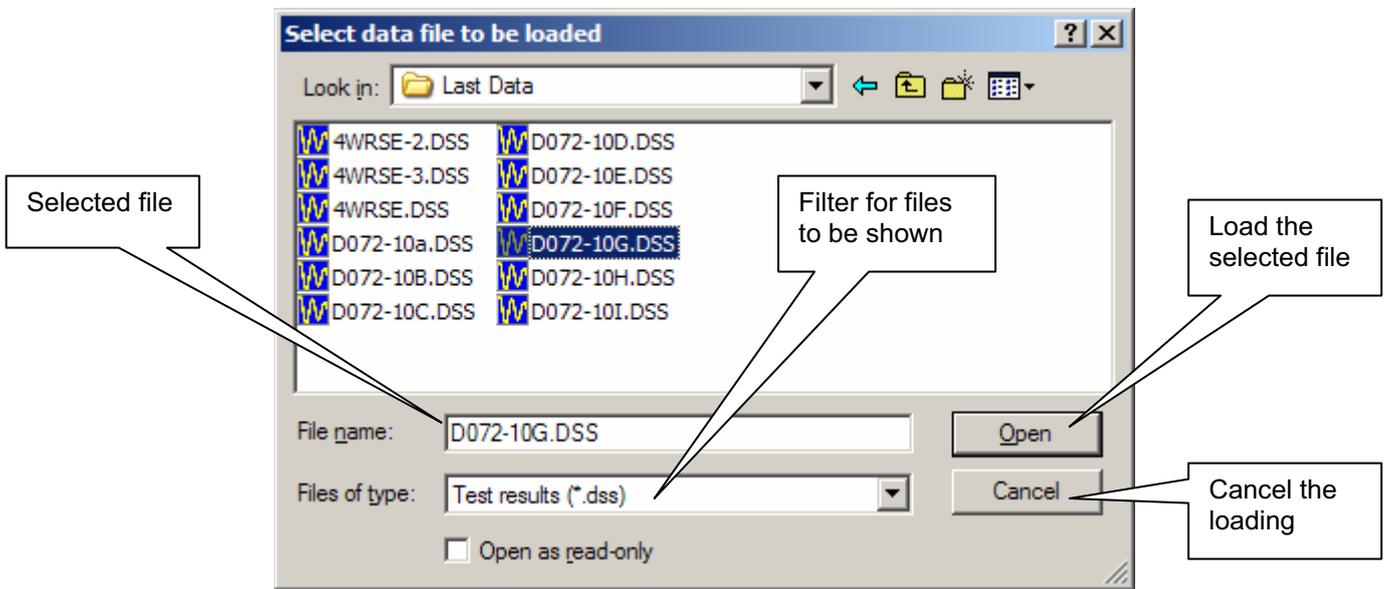
## File

This submenu (see Picture 10) allows to work with data which were obtained at the testing process. It can be used also to close the program.



## Load

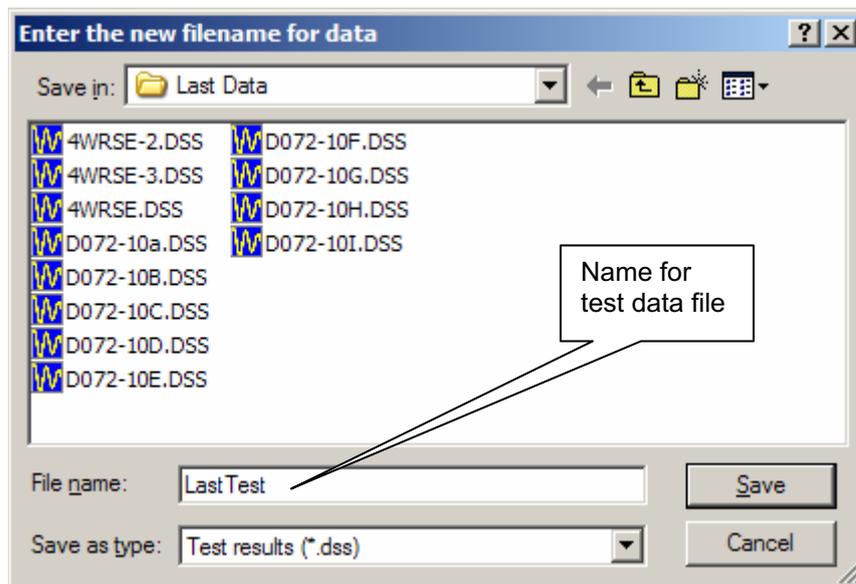
Select this item to execute a standard Windows open file dialog (see Picture 11). By this dialog you can load the saved test data for analysis and printing results.



**Picture 11.** Windows open file dialog. The filter \*.DSS is used by default for data files.

### Save

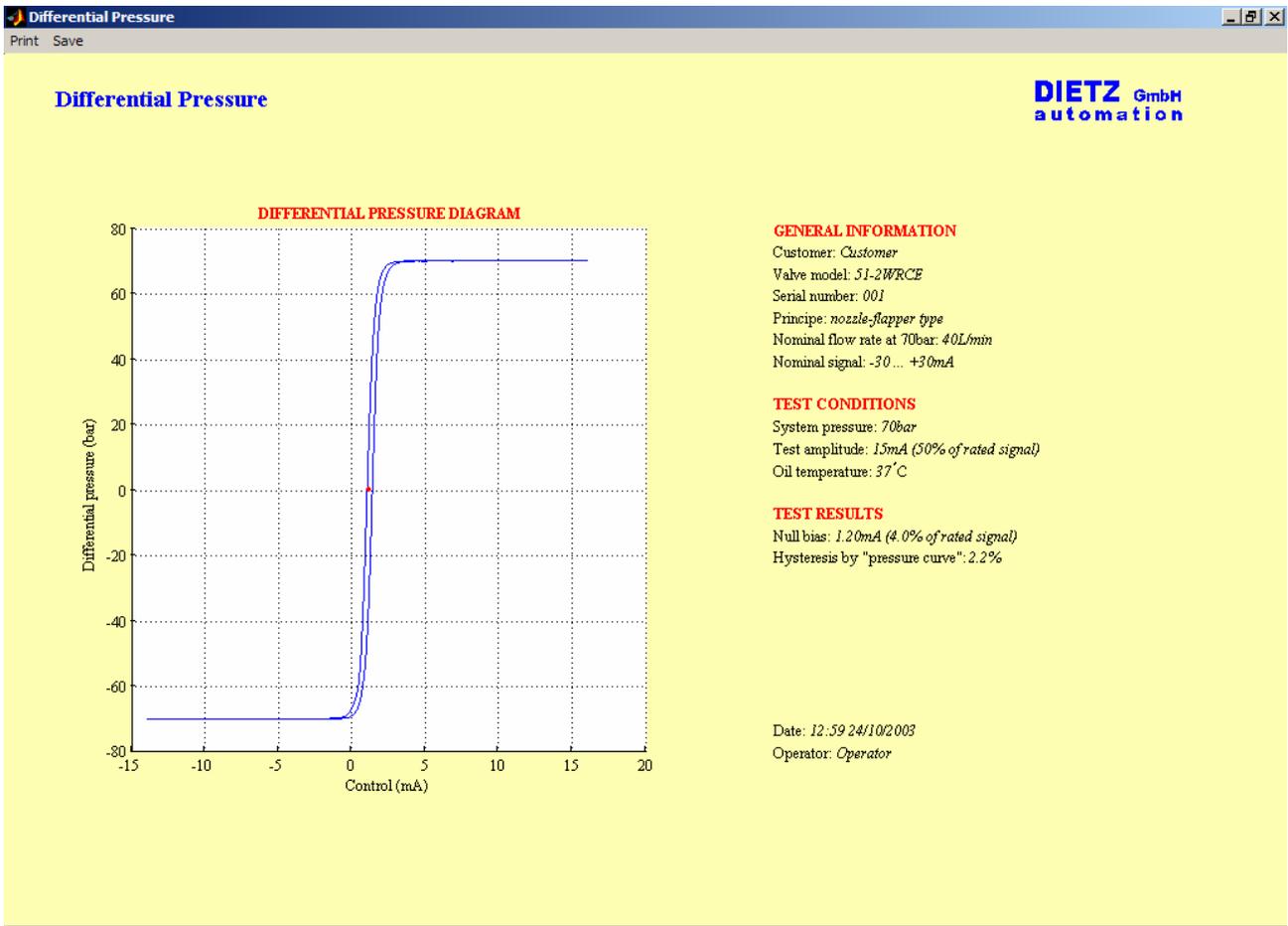
Select this item to save data of a test in a file. A standard Windows file dialog will be open (see Picture 12). If test data are saved, you are able to load the data and produce the analysis.



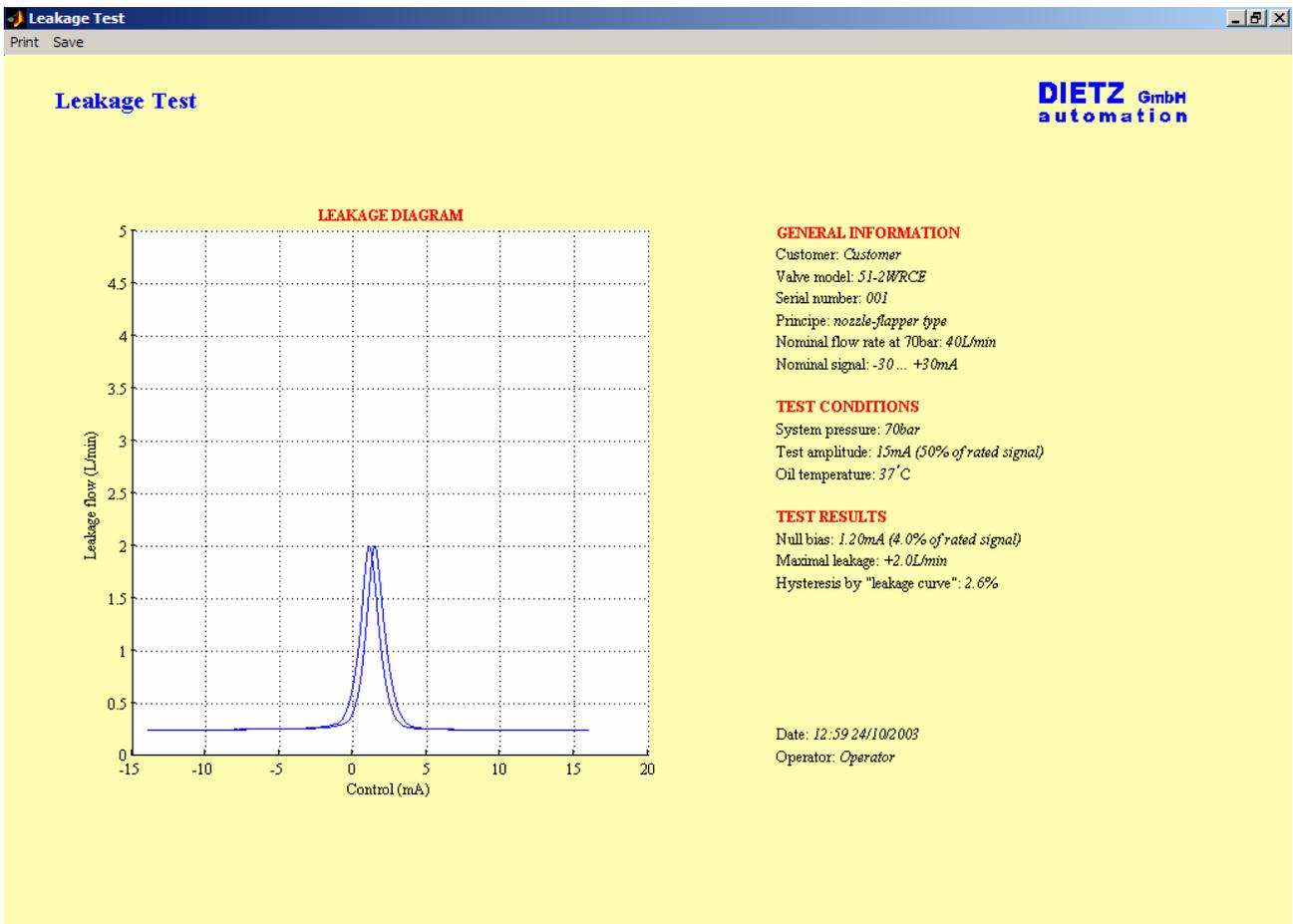
**Picture 12.** Windows save file dialog. Note the DSS extension is used by default to save the data.

### Analysis

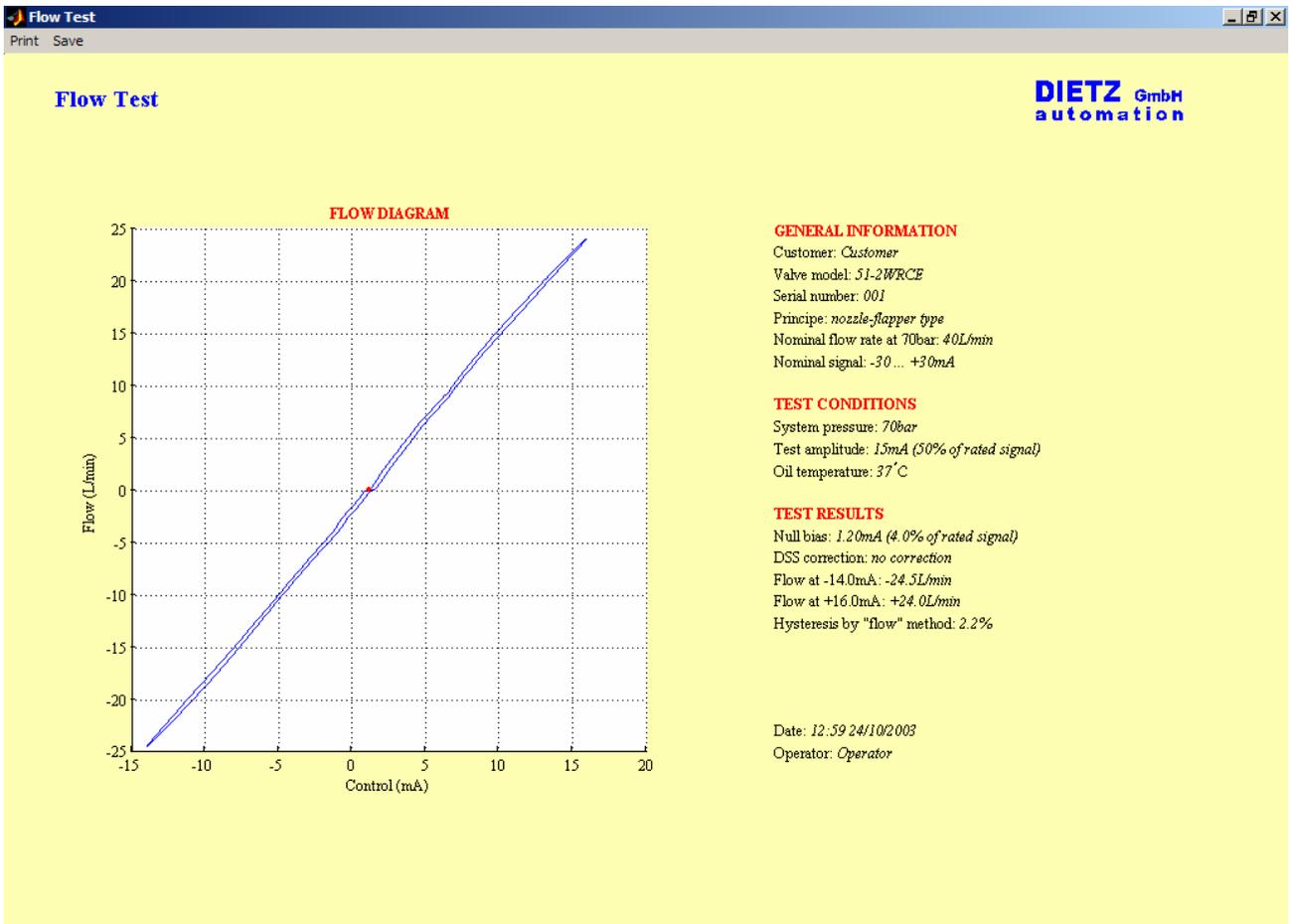
If the automatic test is done or test data are loaded you can select item "Analysis" to show results of the test. Note that you can execute the analysis also from "Automatic Test Dialog Box" (see Picture 19 below). We must note that standard modification of the test stand allows checking most of the static characteristics of servovalves, i.e.: pressure curve, flow curve, leakage curve, spool position diagram and some other parameters. The pictures (Picture 13 – Picture 16) below give an example of the analysis. In order to print or save pictures operator shall use the corresponded items of the picture menu. The item "Save" involves saving of the picture on the Desk Top of the computer. The item "Print" opens a standard Windows dialog (see Picture 17). In order to check the dynamic characteristics, the so called "Measurement Piston" must be installed. This option allows to obtain the frequency response and find the best linear dynamical model (see Picture 41).



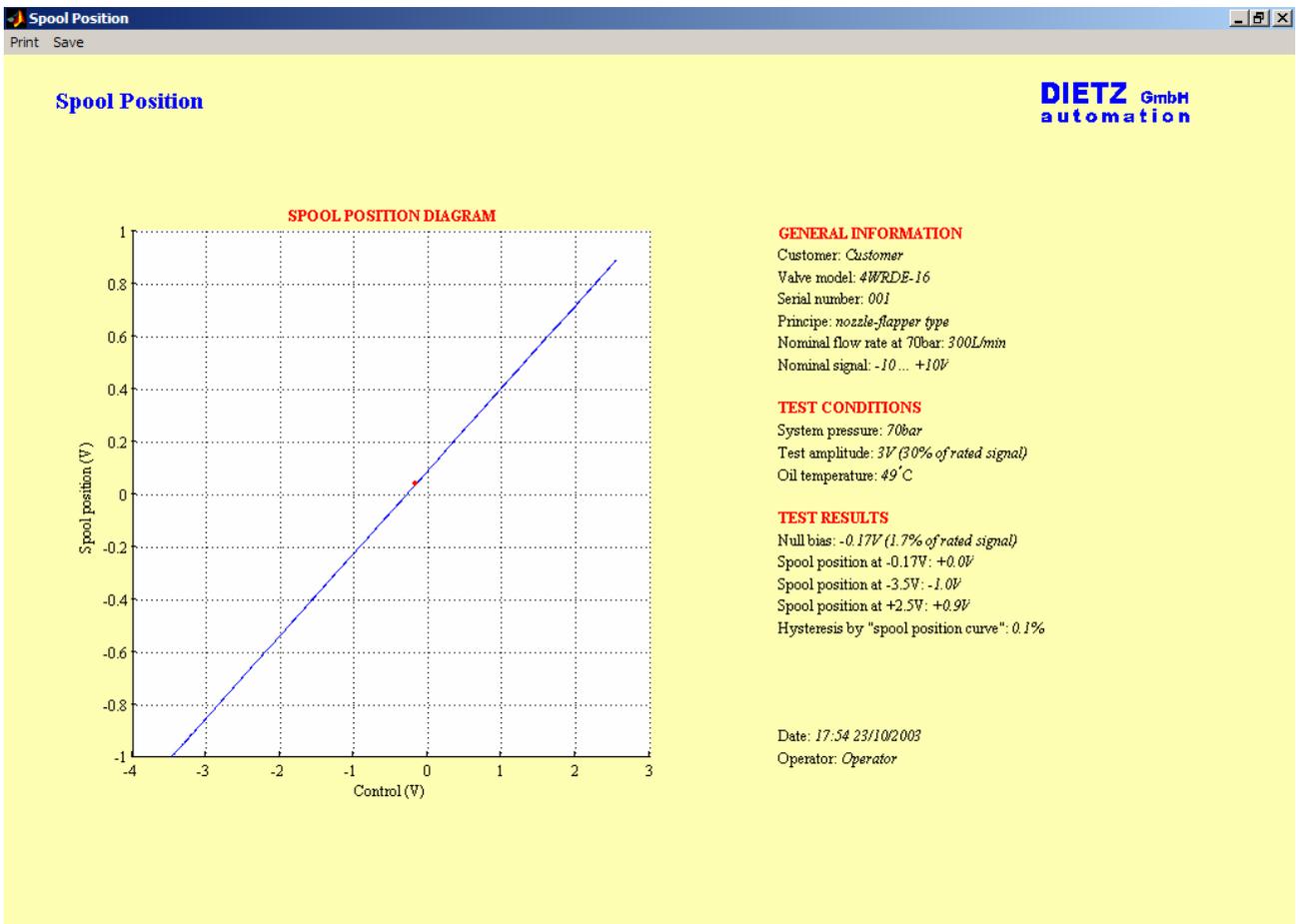
Picture 13. Pressure curve.



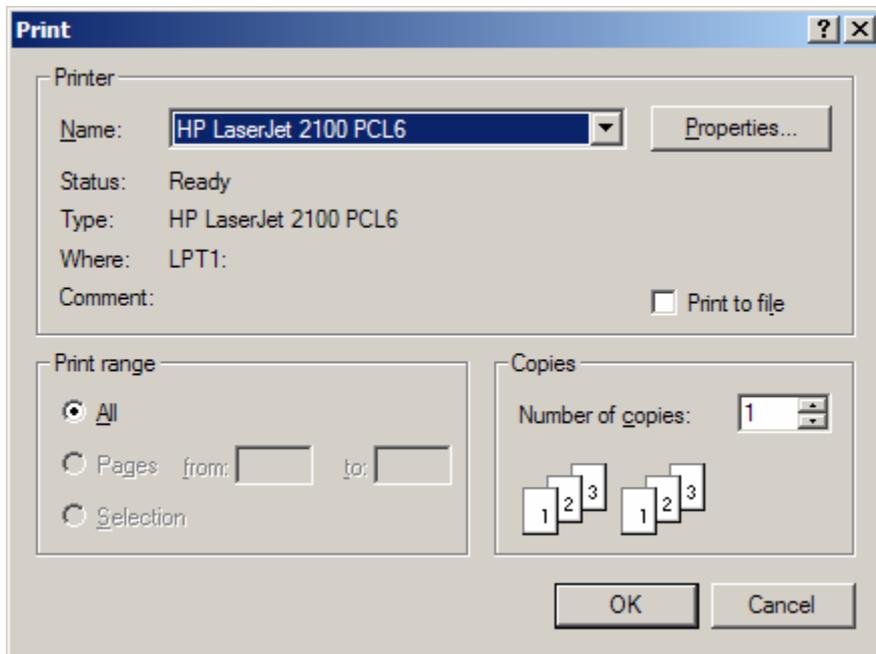
Picture 14. Leakage curve.



Picture 15. Flow curve.



Picture 16. Spool position diagram.



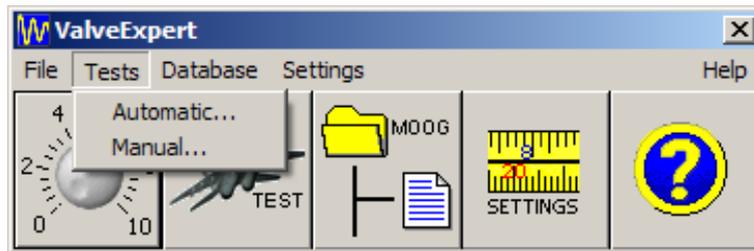
Picture 17. Standard Windows print dialog.

### Exit

Select this menu item to cancel the program.

### Tests

This submenu allows to select the “Automatic Test” and “Manual Test” (see Picture 18 below).



Picture 18. Submenu “Tests”.

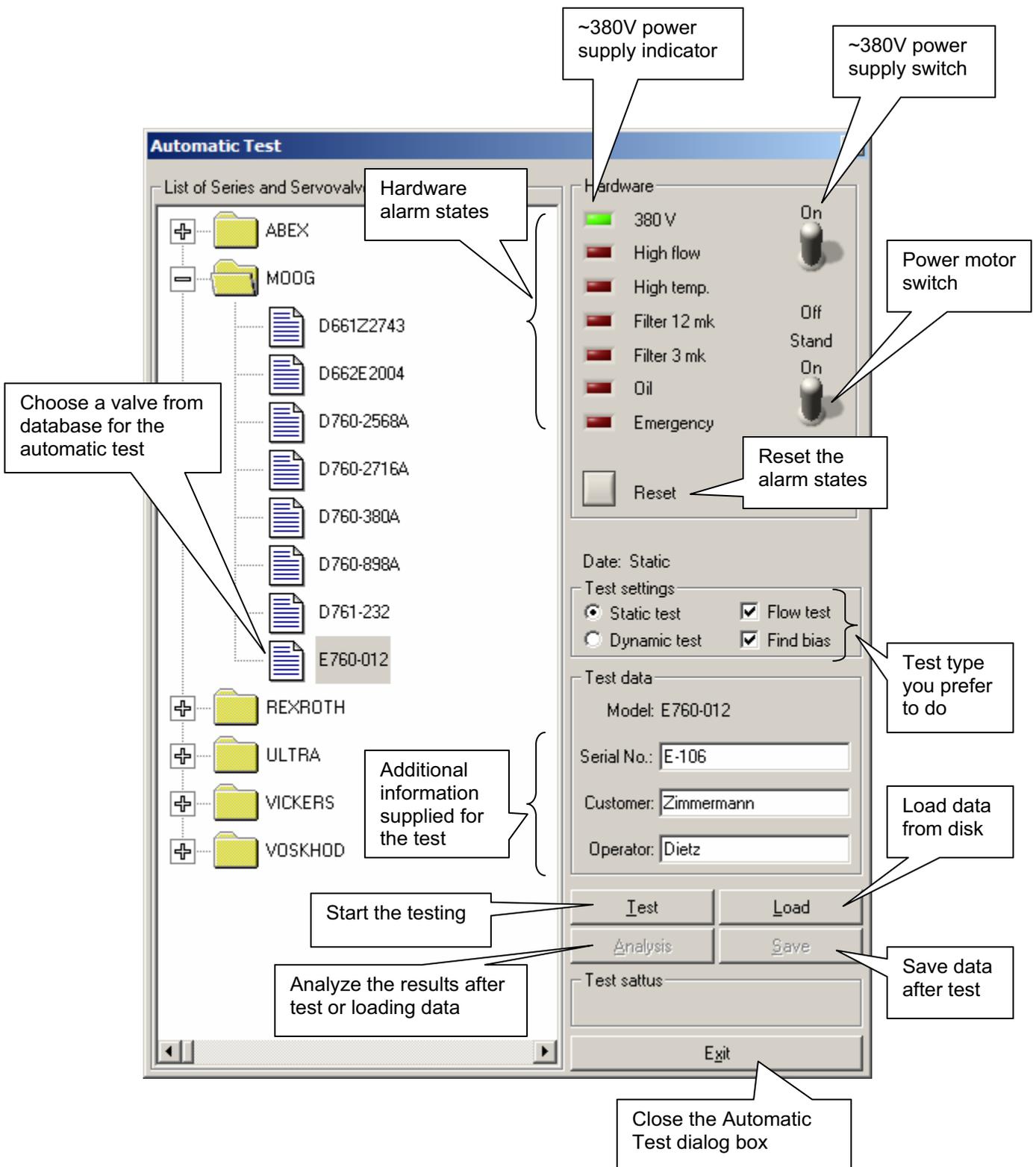
### Automatic Test

Select this item to execute “Automatic Test Dialog Box” (see Picture 19 below). Data for the future analysis will be accumulated during namely this automatic test process. Before starting the “Automatic Test Dialog Box” you have to be sure that a servovalve is installed, electrically connected with the test stand and which works properly. Therefore, we strongly recommend you to execute the “Manual Test Dialog Box” (see below) and check the type and value of rated signal, polarity, rated flow, type of spool position signal, null bias and maximum value of leakage. After the checking please verify that the valve parameters in your database are close to these which you found (see “Database Dialog Box”). Note: if the database parameters are very far from reality, the automatic test program will not work correctly.

In order to start the automatic test we recommend the following sequence:

1. Select a servovalve model you plan to test from your database.
2. Fill “Serial No.”, “Customer” and “Operator”. These edit boxes are optional. Fill them if you need this information on the output forms of the “Analysis”.
3. Select the type of test using tests settings. Notes, there are three types of tests: “Static with Flow Test”, “Static without Flow Test”, “Dynamic Test”.
4. Switch on the power supply ~380V.
5. Switch on the motor.

Start the testing using the “Test” button.

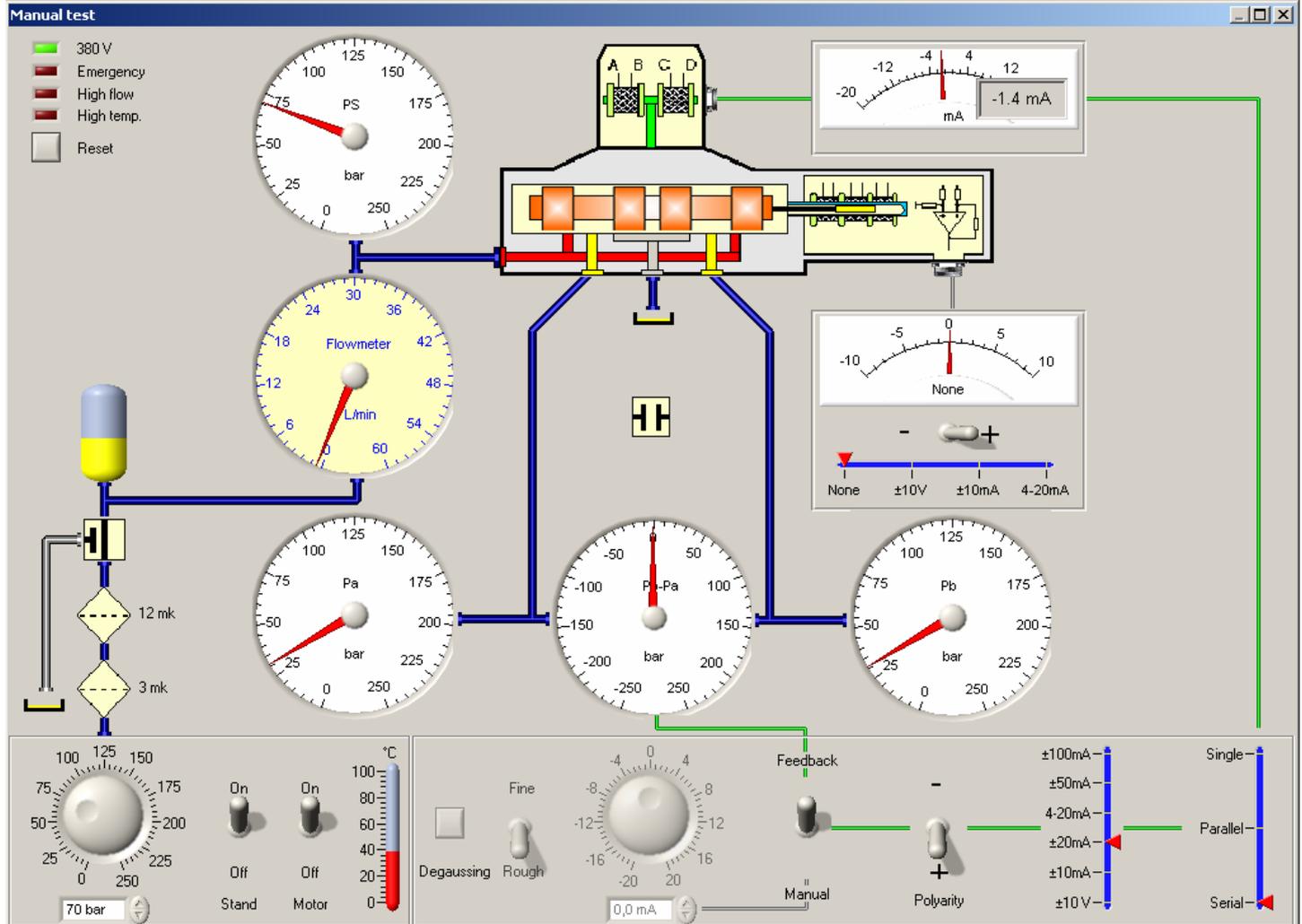


**Picture 19.** Automatic test dialog box.

The test process usually takes some minutes. After that you will be able to produce the analysis or save the data using the corresponded buttons of the "Automatic Dialog Box". Note that "Load", "Save", and "Analysis" buttons exactly duplicate the functions of the corresponded items from "File" submenu of the main dialog menu (see above). Note also that you will not be able to switch on the motor if an alarm is indicated or power supply ~380V is absent. In such a situation you have to fix the problem and reset the alarm states using the button "Reset".

## Manual Test

The item "Manual Test" of submenu "Tests" (see Picture 18) calls "Manual Test Dialog Box" (see Picture 20). Namely this dialog box should be the starting point of your test process. The intuitively understandable interface of "Manual Test Dialog Box" shows a structural schema of the teststand and gives a possibility to manually check your valve. We strongly recommend you to check type and value of rated signal, polarity, maximal total flow, type of spool position signal, value of null bias and maximal leakage before starting the automatic test for your valve. Notes, the "Manual Test Dialog Box" contains also indicators of power supply ~380V and alarm states of the stand. Below we describe the basic control elements of the dialog.



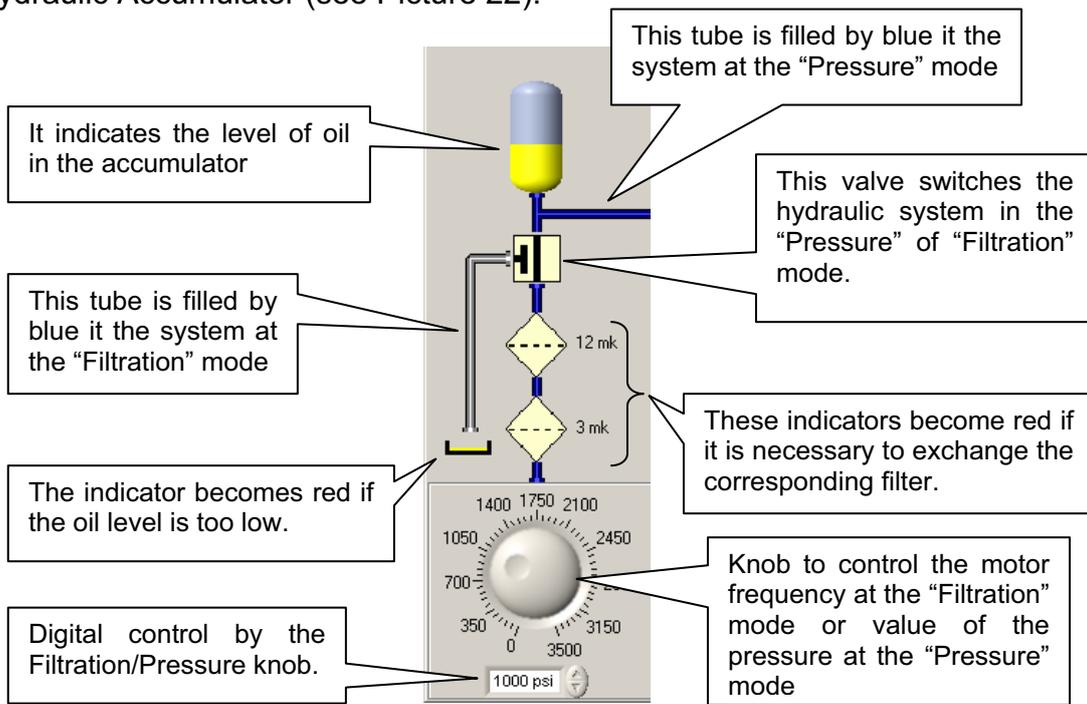
**Picture 20.** Manual Test Dialog Box. An example how to check null bias is shown. Supply pressure is installed 70bar, Rated Control Interval is -20mA ... 20mA, polarity is positive, coil connection is serial. Valve is controlled by feedback signal from the valve pressure drop transducer at control ports blocked, i.e. at zero control flow. Flowmeter shows a small leakage. Milliampere meter shows 1.4 mA null bias.

1. Power Supply, Motor Switch, Frequency/Pressure Knob and Temperature Indicator (Picture 21).



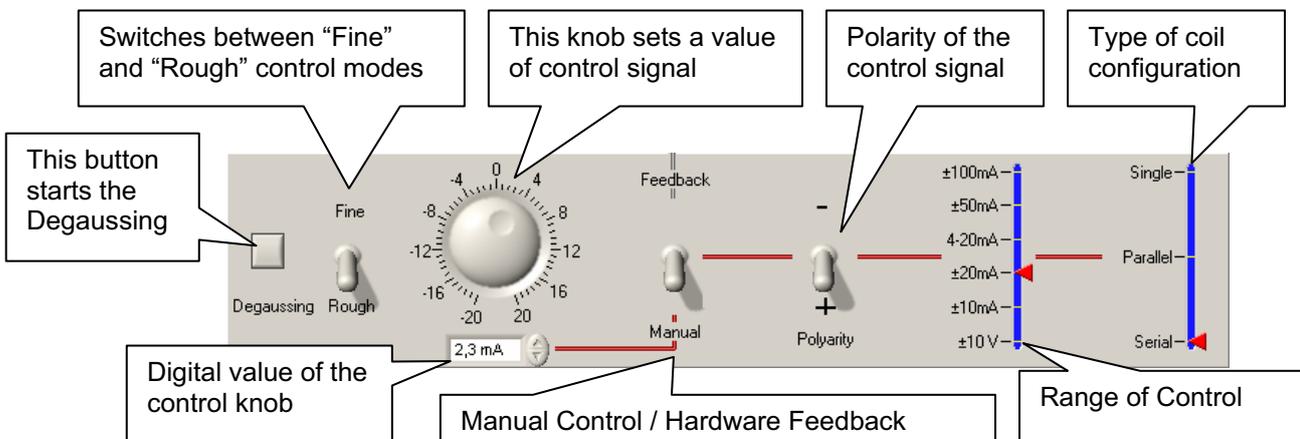
**Picture 21.** The main hydraulic station controls. Note that you are not able to switch the motor until ~380V is not switched on. Note also that high temperature will immediately stop the motor.

2. Frequency/Pressure Knob, Oil Level Indicator, 3mk and 12mk Filters, Filtration/Pressure Valve and Hydraulic Accumulator (see Picture 22).



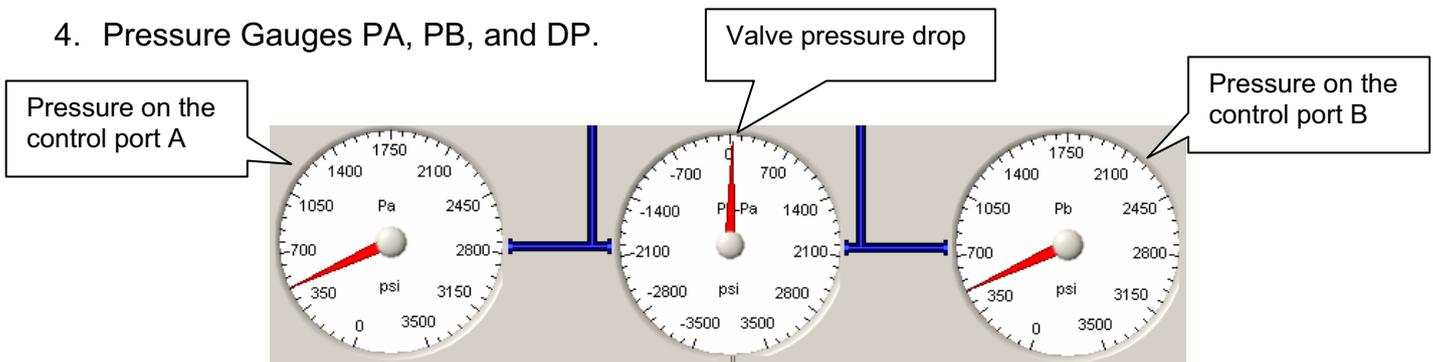
**Picture 22.** The system is in the "Pressure" mode. Pressure 1000 psi is installed. Filters and oil level are OK. The accumulator is about 50% loaded. Note that you will not be able to switch on the motor if the oil level indicator or filters indicate an alarm. In such a situation you have to fix the problem and reset the alarm states using the button "Reset" (see Picture 26 below).

3. Control Signal Knob, Degaussing Button, Rough/Fine, Feedback/Manual, Polarity, Control Range and Coil Configuration Switches (see Picture 23).



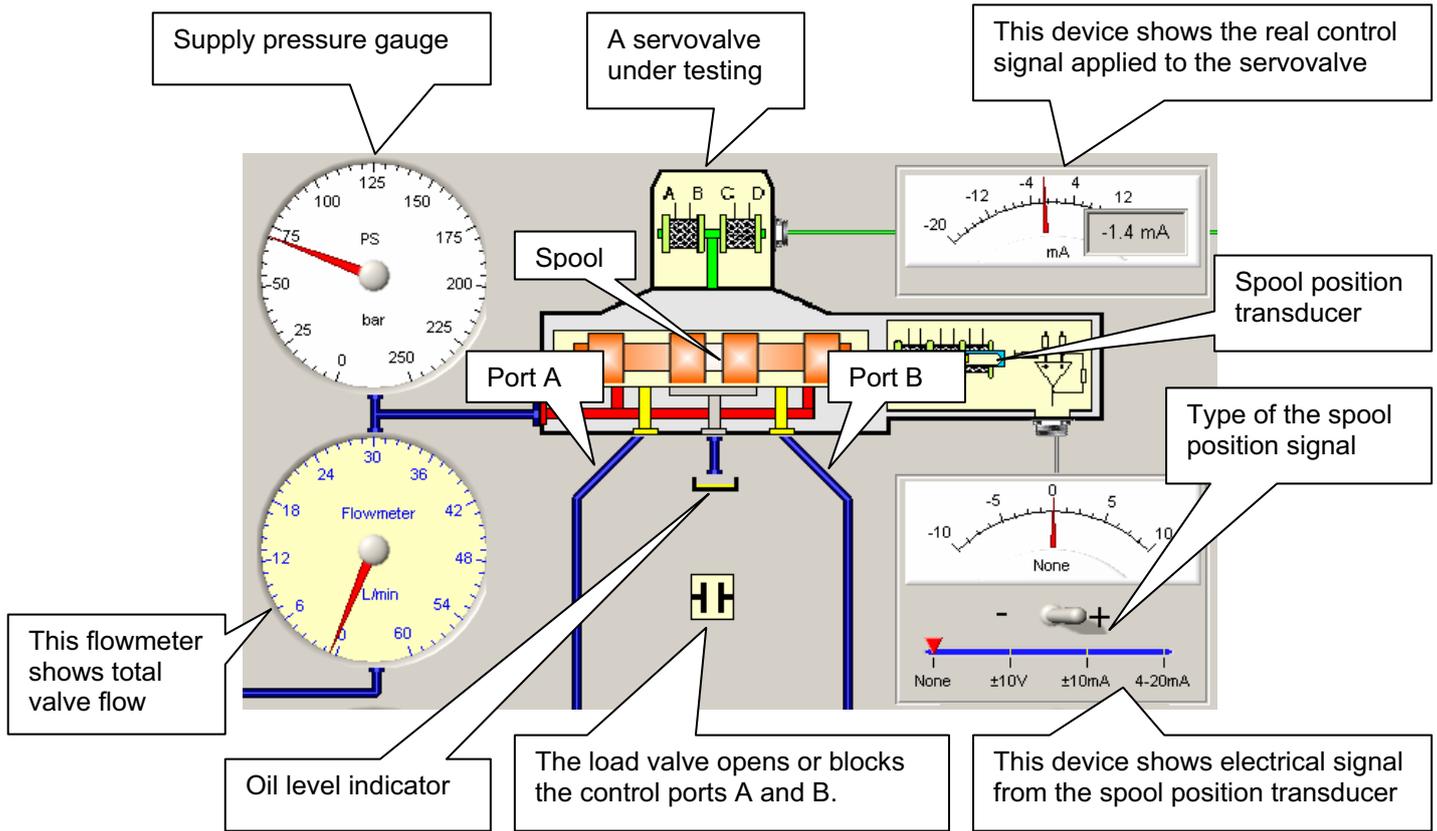
**Picture 23.** Valve control panel is shown.

4. Pressure Gauges PA, PB, and DP.



**Picture 24.** The gauges show pressure on the control ports of a servovalve under testing. Valve pressure drop is close to zero, i.e. the control signal is near the null bias if control ports blocked and control flow is zero.

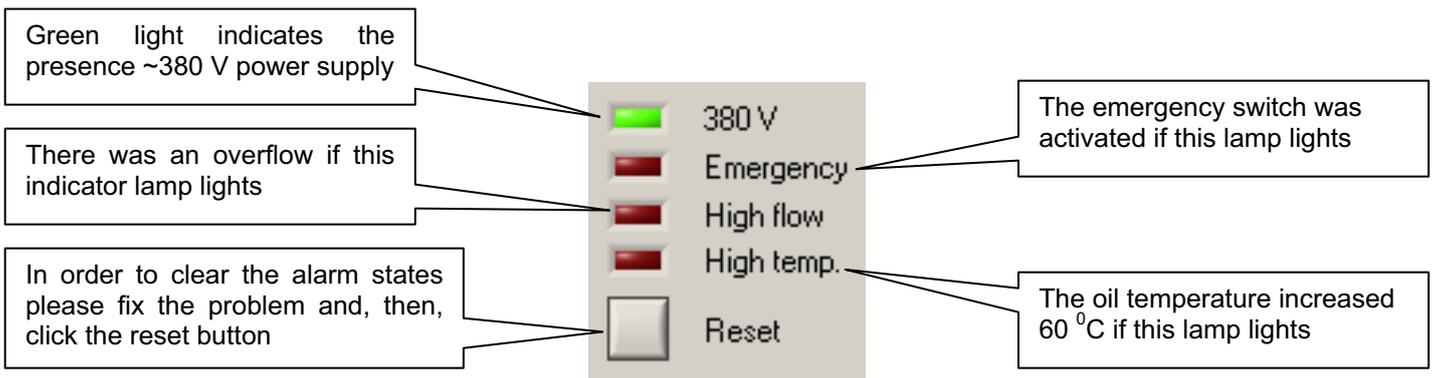
5. Supply Pressure Gauge, Flowmeter, Servovale, Control Signal and Spool Position Measuring Instruments, Oil Level Indicator, Load Valve (see Picture 25).



**Picture 25.** The main attachments of servovale are shown. Please do not forget to close the load valve before starting the test. This will restrict the total valve flow and, therefore, speed up the pressure installation process, and save the hydraulic energy. In opposite case the energy of the control flow will heat oil of the teststand. Moreover, the motor will not be able to install a pressure if the total valve flow will be grater 15 L/min

6. Power Supply Indicator, Reset Button and Alarms from Emergency Switch, High Flow and High Temperature Sensors (see

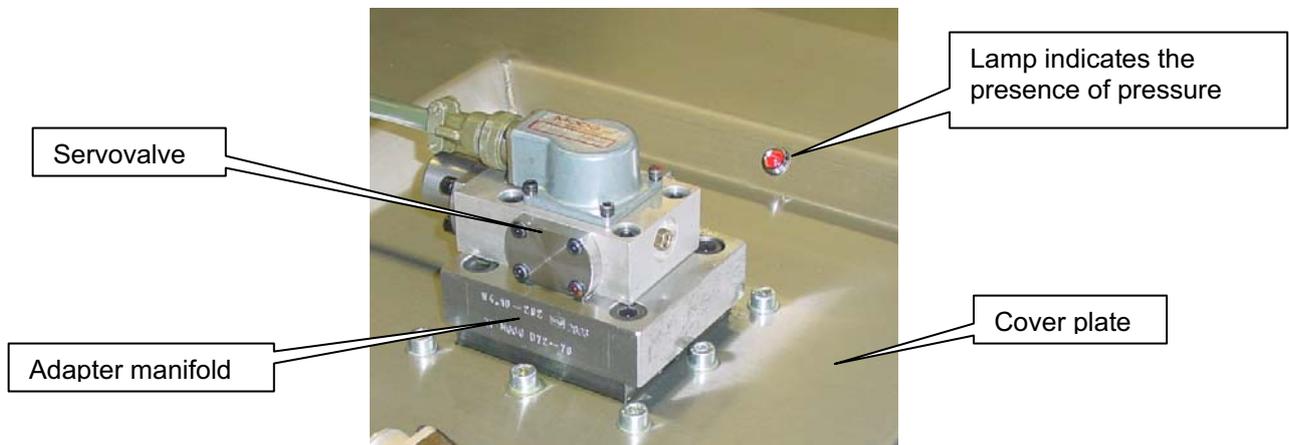
7. Picture 26).



**Picture 26.** Power supply indicator, reset button, and alarm indicators are shown. Note also that you will not be able to switch on the motor if an alarm is indicated or power supply ~380 V is absent.

## Manual Test Sequence (Example)

1. First of all you have to be sure that a servovalve you want to test is installed properly and the corresponded electrical cable connects the servovalve and teststand.
2. Check the alarm indicators (Picture 26, Picture 22, Picture 25) and the Emergency switch (see Picture 6). They should not be activated. If an indicator is light you have to correct the corresponded problem and, then, reset the indicator using the reset button (Picture 26)
3. Switch on the power supply (Picture 21). After that, the green lamp 380V (Picture 26) should indicate the presence of power supply. In the opposite case please verify that your teststand is properly connected to ~380V.
4. Install the Manual Control / Hardware Feedback switch in the manual mode and choose the proper values for polarity, control range and type of coil configuration (Picture 23). Note: you should use the parallel mode of the coil configuration switch for servovalves with build in electronics.
5. Set up the type of spool position signal (see Picture 25).
6. Switch on the motor (Picture 21).
7. Switch the Pressure/Filtration valve (Picture 22) in the filtration mode if you have to produce a preliminary clearing of the oil and, after that, install the knob in a middle position. Note: to save your servovalve as well as the teststand you should regularly filter the oil. Please do it every time when you add new oil in the tank. We recommend 40 minutes filtration for new oil.
8. Switch the Pressure/Filtration valve (Picture 22) in the pressure mode.
9. Close the load valve (Picture 25).
10. Install pressure using the knob or edit box (Picture 22). The lamp on the top cover of the stand will indicate the presence of pressure (). Please do it by small steps and verify absence of the external leakage from the servovalve. Note: in order to remove the pressure you can switch off the power supply, switch off the motor, switch the Pressure/Filtration valve in the filtration mode, set the zero pressure, close the program or activate the emergency switch (Picture 6) on the teststand.
11. The real pressure will be indicated on the supply pressure gauge PS (see Picture 25). The flowmeter will indicate internal leakage.
12. The gauges DP, PA and PB (Picture 24) will indicate load pressure drop and pressures at the control ports A and B correspondingly.
13. Use the control knob (Picture 23) to control the servovalve. A reaction of the valve will be reflected by the gauges (Picture 24, Picture 25). Note: you will see motion of the spool (Picture 25) if your valve has a spool transducer.
14. For accurate tuning of the control you can switch the control knob in "Fine" mode (Picture 23).
15. The button "Degaussing" (Picture 23) is used to start and stop the degaussing process with zero shift. The valve control knob sets the amplitude of the degaussing.
16. Switch on the "Feedback" mode (Picture 23) if you want to find the null bias. In this case a special electronic will try to find the null bias, i.e. a control signal which corresponds to zero load pressure drop. The null bias control signal will be shown on the control signal measurement instrument (see Picture 25). An example of settings to find null bias is shown on Picture 20. We must note that our electronic uses a special adaptive control schema to find the null bias. Nevertheless we are not able to guarantee the 100% efficiency of the electronics. First of all problems can arise if you test a proportional valve with extra slow dynamics. In such a case please use the manual control knob to find the null bias. Note also that there exist valves which do not have null bias points as well as such valves which have two or more null bias points. In the last situation the electronics, obviously, can not identify the proper choice.
17. You can use the left mouse click to open or close the load valve (Picture 25). Note: the flowmeter will always show the total valve flow, i.e. the sum of the control flow and the internal leakage flow. We strongly recommend you do not open the load valve for longer time because the energy of the control flow will heat the oil fast. Therefore, use the right mouse click to open this valve for a short interval of time. In this case a blue arrow on the flowmeter will indicate the maximal flow during this short subtest (see the Express Flow Test of the next section).

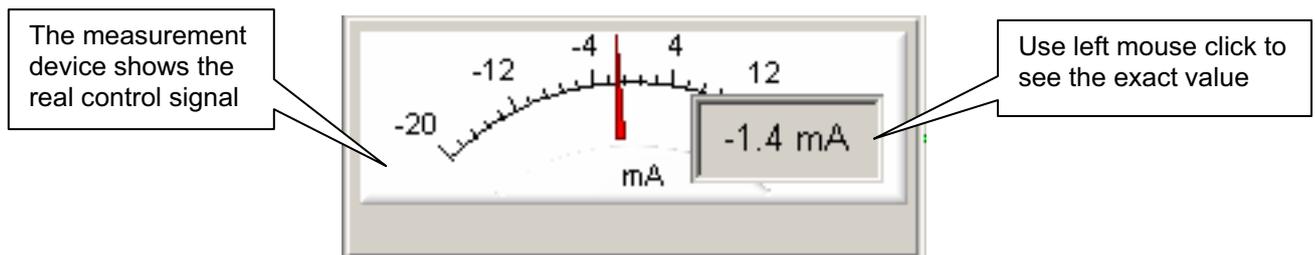


Picture 27. Top view of ValveExpert.

### Special features of the Manual Test Dialog Box

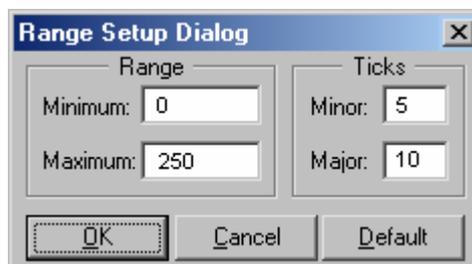
The Test Dialog Box is powered by the following abilities.

1. *Exact Value.* This ability allows to read the exact value from any analog device (see Picture 21, Picture 22, Picture 24, Picture 25) of the system. Use the mouse to point out a device and left click it. The exact value will be shown in a small window (see Picture 28 for an example).



Picture 28. Left mouse click shows the exact value.

2. *Range settings.* You can choose the range settings of the gauges and other analog devices yourself. In order to modify it point out a device and right click it. The range setup dialog will appear (see Picture 29). Please specify the values of ranges and ticks and click OK. The device range settings will be changed according your request. Note that you can use the Default button to reset the range settings by default. The Cancel button cancels the changes.



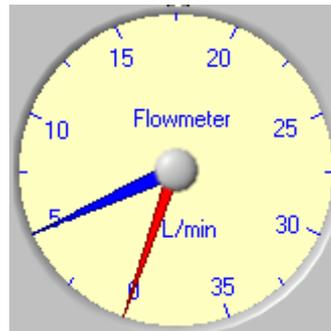
Picture 29. Range Setup Dialog.

3. *Accumulator Settings*. This ability is used to check the load pressure of the hydraulic accumulator and correct the corresponding software parameter. The right mouse click on the accumulator executes the corresponding dialog (see Picture 30). The button "Auto" executes the test program which starts the motor for a short time. This implies a small loading of the accumulator and, in this case, the supply pressure will be very close to the initial load pressure of the accumulator. Namely this value will appear in the edit box after the testing. Of course this value can be corrected manually. We must note that the pressure must be installed to zero before the test. Please regular check the load accumulator pressure. It should be about 30 – 40 bar. Too small or big load pressure may be a reason of mistakes.



**Picture 30.** Accumulator Settings Dialog.

4. *Impuls Flow Test*. This feature gives a possibility to find the total valve flow for any fixed control signal. The right mouse click on the load valve (Picture 25) opens it for a short time (about 0.2 sec). This time is enough to identify the flow. The blue arrow will point out the found value (see Picture 31).

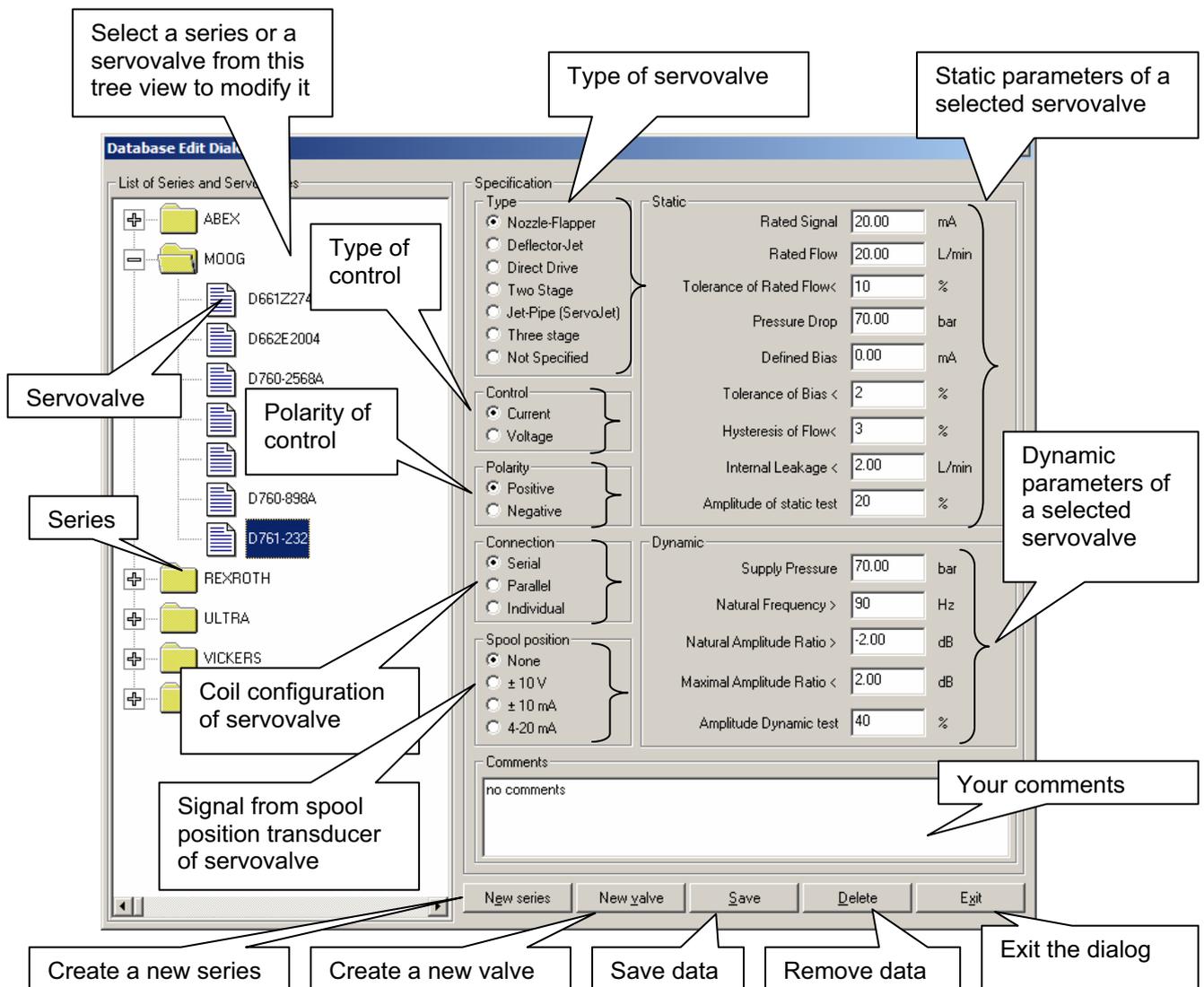


**Picture 31.** Expressed Flow Test is produced. Read arrow shows the total valve flow if the control ports are blocked. The blue arrow fixed the maximal flow during the expressed flow test.

5. *Valve Absence Checking*. The teststand checks the installation pressure process every time you install the pressure. The stand will be switched off after 0.2 sec. if you forgot to install a valve on the test stand. Only a little amount of oil will be spread outside. Nevertheless, our recommendation is to avoid using this feature.

## Database

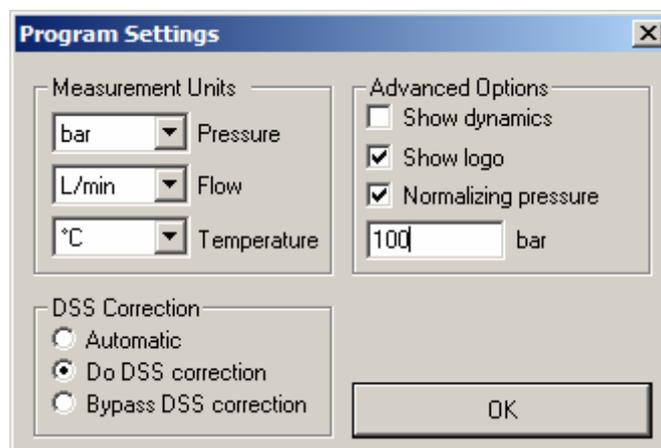
This item of the main menu (see Picture 10) opens the Database Dialog Box (Picture 32). This dialog is intended for visual modification of test parameters of servovalves. Currently the database consists of two tables: series table and valve table. The dialog shows this database structured in the tree control on the left side. This tree is very similar to a tree of Windows Explorer. The folders are series and the files are valves. The right side of Database Dialog Box shows parameters of a selected item of the tree. You can modify them using the keyboard and mouse. Please do not forget to save your parameters using the corresponding button after any changes of database records. In the opposite case the changes will be lost. Note that most of parameters will be disabled if you select a series (they are for valves only). Notes also, parameters from the dynamic group will be hidden if the corresponded box for the settings dialog (see below) is unchecked. Use "New Series" and "New Valve" buttons to create a new item of the database and "Delete" button to erase it. You can create a new valve with the same parameters you already have. In order to do that, just point out a servovalve with parameters you need and press "New Valve". You can use technology "Drag & Drop" to change series of servovalve.



Picture 32. Database Dialog Box.

## Settings

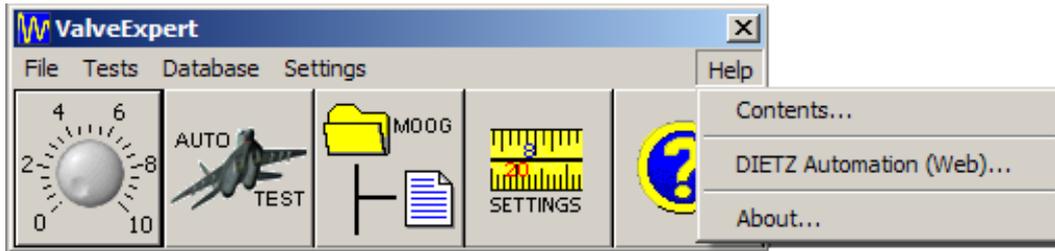
This item of the main menu (see Picture 10) opens the "Program Settings" dialog box (see Picture 33). The dialog allows to change settings for measurement units, DSS correction at the static analysis, and some other options of the program. Option "Show dynamics" gives access to the settings dynamical parameters in the "Database" dialog box and gives a possibility to produce dynamical testing. Mark "Show logo" implies appearance of your logo on the output forms. The setting "Normalizing pressure" predicts the results for the system pressure entered below.



Picture 33. Program Settings Dialog Box

## Help

This submenu (see Picture 34) gives you access to the help system.



Picture 34 Submenu "Help"

## Contents

Select this item to show contents of the help system.

## DIETZ automation (Web)

This item directs you to the main page of DIETZ automation GmbH site in the internet.<sup>4</sup>

## About

This dialog contains information about authors, version of the program and so on.

## Menu Description Shortcuts

There are three ways to call most of dialog boxes which were described above.

1. Select an item from menu.
2. Click a toolbar button.
3. Use a shortcut combination of keyboard keys.

The following table summarizes all these possibilities.

Toolbar	Keyboard	Menu (Description)
	{Alt-T+M}	Test → Manual (Manual Test Dialog Box)
	{Alt-T+A}	Test → Automatic (Automatic Test Dialog Box)
	{Alt-D}	Database (Database Dialog Box)
	{Alt-S}	Settings (Settings Dialog Box)
	{Alt-H+C}	Help → Contents (Help Dialog Box)
	{Alt-F+L}	File → Load (Load a File with Test Data)
	{Alt-F+S}	File → Save (Save Test Data to a File)
	{Alt-F+A}	File → Analysis (Produce Analysis of a Test Data)
	{Alt-H+A}	Help → About (Display About Box)
	{Alt-H+D}	Help → Dietz Automation (Web) (Open the Home Page in Internet)

Picture 35. Three possibilities to call the subsystems of the program are shown.

<sup>4</sup>The computer must have access to internet.

# Definitions

**Electrohydraulic Flow Control Servovalve** – A device designed to produce hydraulic flow output continuously depending from electrical input signal.<sup>5</sup> Usually the dependence is close to proportional one but there are kinds of servovalves where the output flow is not linear function of control.

**Rated Control Interval** – The interval of possible input electrical signals which specified by a producer of the valve as a nominal control.

**Rated Minimum and Maximum of Control** – The minimum and maximum of the rated control interval.

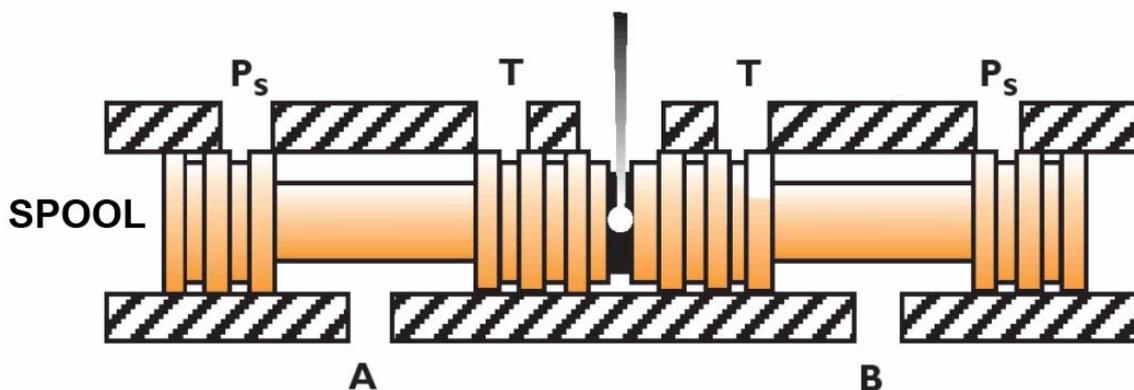
**Predefined Bias** – The mean of the rated maximum and minimum. It is expressed as half of sum of rated maximum and rated minimum of control signal.

**Rated Signal** – The amplitude of the input control signal which is expressed as half of difference between rated maximum and minimum of control signal.

Let us consider an example. Assume that rated control interval is [4mA ... 20mA], i.e. rated minimum and maximum of control are equal to 4mA and 20mA correspondingly. In this case the predefined bias will be  $(4+20)/2=12\text{mA}$ . Rated signal is  $(20-4)/2=8\text{mA}$ .

It is necessary to note that maximal and minimal signals, predefined bias, and rated signal depend of mode you use to control a servovalve. For instance, for servovalves with two or more lead coils the rated current must be associated with a specific coil connection (series, single, or parallel).

**Four-Way Servovalve** – A servovalve with supply port  $P_s$ , return port  $T$  and two control ports  $A$  and  $B$ . The ports are arranged so that valve action in one direction simultaneously opens control port  $A$  to supply port  $P_s$  and control port  $B$  to return port  $T$ . Reversed valve action opens control port  $A$  to return port  $T$  and control port  $B$  to supply port  $P_s$ . Schematically such a valve is shown on Picture 36 below.



**Picture 36.** Control signal implies moving the spool from left to right and back. At the left position, the port  $A$  is connected to  $P_s$  and  $B$  to  $T$ . If the spool is on the right side,  $A$  is connected to return  $T$  and  $B$  is connected to supply  $P_s$ .

**Supply Pressure** – Pressure on the port  $P_s$ .<sup>6</sup>

**Return Pressure** – Pressure on the port  $T$ .

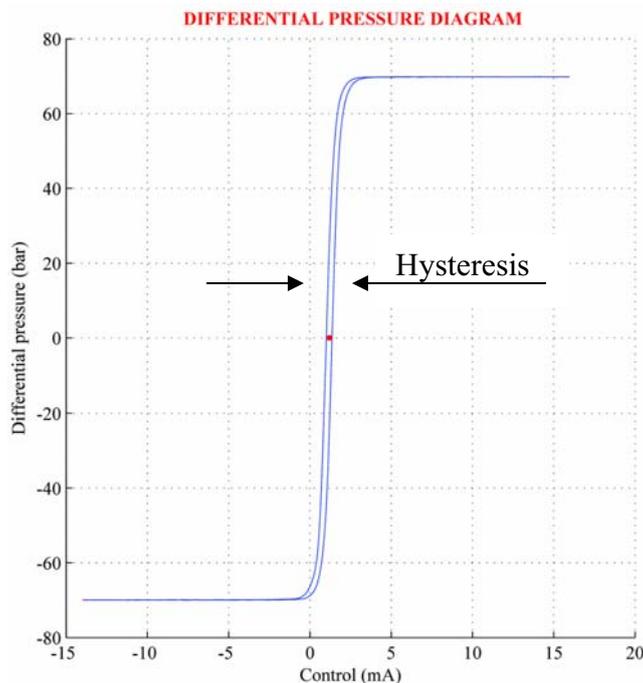
**Load Pressure Drop** – The differential pressure between the control ports  $A$  and  $B$ .

<sup>5</sup> Normally, the control is expressed in milliamperes (mA) or volts (V).

<sup>6</sup> The pressure usually expressed in  $\text{kg/cm}^2$  (bar) or  $\text{lb/in}^2$  (psi).

**Valve Pressure Drop** – The sum of the differential pressures across the control orifices of the servovalve. Valve pressure drop will equal the supply pressure minus the return pressure and minus the load pressure drop.

**Pressure curve** – A graph which represents dependence of the load pressure drop from control signal at zero control flow, i.e. with control ports blocked. An example of such a curve is shown on Picture 37.



**Picture 37.** Pressure curve for a real servovalve. Red point shows the null bias of the valve.

**Pressure Hysteresis** – The difference in the valve input signals required to produce the same load pressure drop at zero control flow, i.e. with control ports blocked. Pressure hysteresis is normally specified as the maximum difference occurring in a region between  $\pm 40\%$  of maximum load pressure drop. It is expressed as percent of rated signal.

**Pressure Gain** – The change in load pressure drop per unit of control with zero control flow (control ports blocked). Pressure gain is usually specified as the average slope of the curve of load pressure drop versus input current in the region between  $\pm 40\%$  of maximum load pressure drop.

**Control Flow (Load Flow or Flow Output)** – The fluid flow passing through the valve control ports A and B.<sup>7</sup>

**Polarity** – The relationship between the direction of control flow and the direction of the input signal. It can be positive and negative. Usually it is assumed that polarity is positive if positive (in some sense) control signal opens port A to supply port Ps and control port B to return port T.

**Null Bias** – The input control signal where the valve supplies zero control flow at zero load pressure drop. Note null bias may depend of operating conditions and environment. Due to the hysteresis effect null bias depends also on initial state of servovalve.

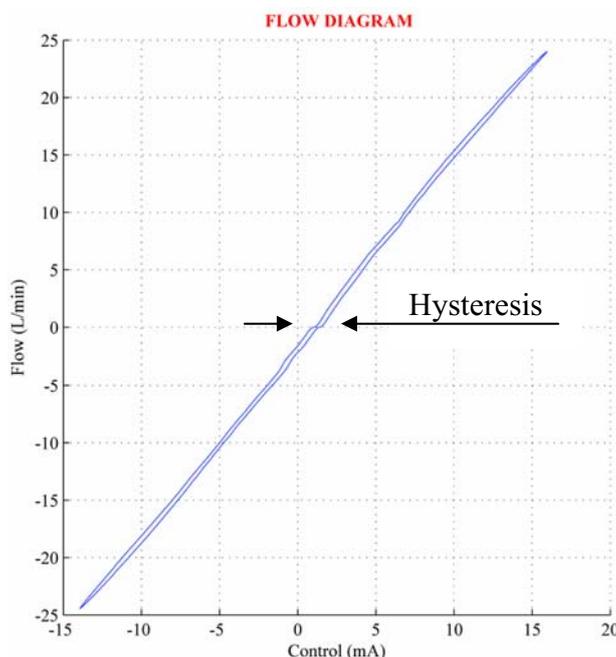
**Null Shift** – The maximal change in null bias resulting from changes in operating conditions or environment. It is usually expressed in percents of rated signal.

**Rated Flow** – The specified maximum of control flow for input signals from the rated control interval.

<sup>7</sup> The flow usually expressed in L/min (lpm), in<sup>3</sup>/sec (cis) or gal/min (gpm).

This value corresponds to specified valve and load pressure conditions. Normally it is assumed that the load pressure drop is zero. Note, usually rated flow corresponds to rated minimum and maximum of control.

**Flow Curve** – The graph of a function which represents dependence of control flow from control signal. Note, due to the hysteresis effect, the function usually is not uniquely defined. An example of a flow curve is shown on Picture 38.



**Picture 38.** Flow curve for a real servovalve. Rated signal is 15mA, null bias is about 1.2mA and rated flow is about 24L/min.

**Hysteresis (Flow Hysteresis)** – The difference in the valve input signals required to produce the same control flow. Flow hysteresis is normally specified as the maximum difference occurring in a region of rated control interval. It is expressed as percent of rated signal.

**Normal Flow Curve** – The locus of the mid-points of the complete cycle flow curve. This locus is the zero hysteresis flow curve. However, valve hysteresis is usually quite low such that one side of the flow curve can be used for the normal flow curve.

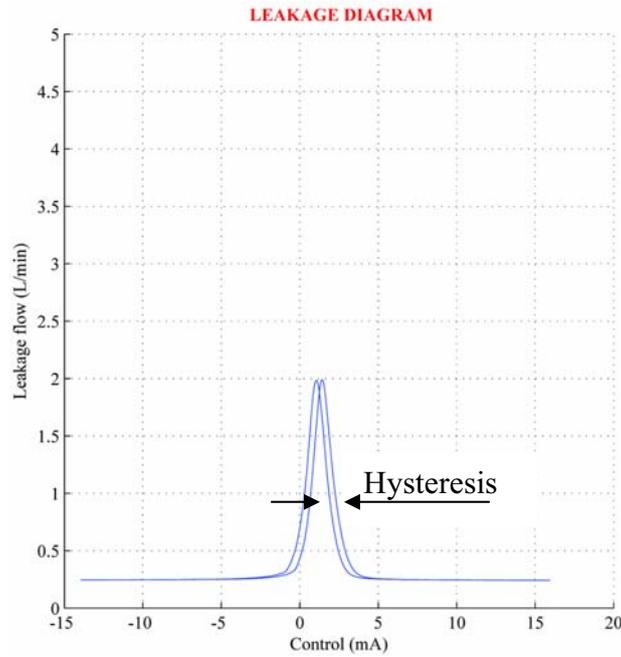
**Flow Gain** – The slope of the control flow versus input current curve at any specific point or in any specific operating region. The incremental flow gain may vary from point to point due to valve nonlinearities. The nominal flow gain will generally show three operating regions: (1) the null region, (2) the region of normal flow control, and (3) the region where flow saturation effects occur. When this term is used without qualification it is assumed to mean normal flow gain.

**DSS Method** – A method which allow to identify the flow curve by a short-time experiment. The main idea of the DSS method is based on the identification of nonlinear dynamical model of servovalve. Knowledge of the model allows to exclude the dynamical effect which certainly arise at fast measurements. For more details see or <http://arxiv.org/abs/math.DS/0202070>.

**Internal Leakage** – The total internal flow from supply port Ps to return port T with zero control flow. Normally it is measured with control ports blocked.

**Null Leakage** – The leakage at the null bias control signal. Usually this is a maximal value of the internal leakage.

**Leakage Curve** – The graphical representation of the dependence of an internal leakage from the control signal. An example of such a plot is shown on Picture 39.

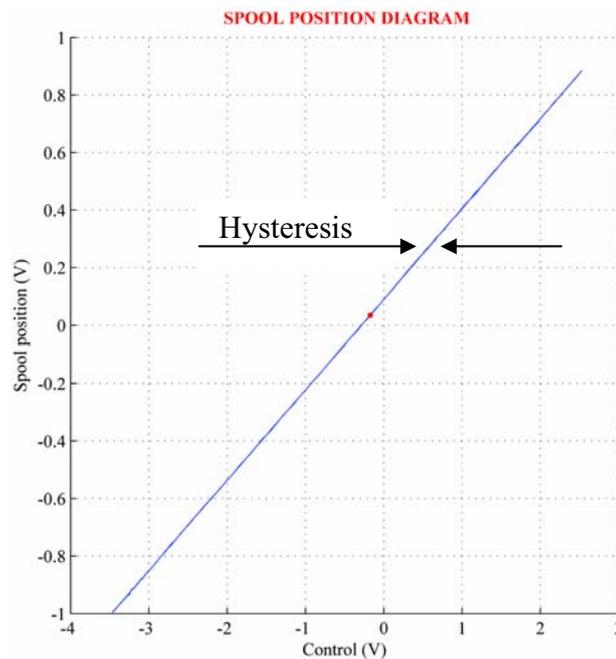


**Picture 39.** Leakage diagram for a real servovalve. Maximum of the leakage flow is about 2L/min.

**Leakage Hysteresis** – The difference in the valve input signals required to produce the same internal leakage during a single cycle of control signal inside the rated control interval. Leakage hysteresis is normally specified as maximum difference. It is expressed as percent of rated signal.

**Total Valve Flow** – The sum of the control flow and internal leakage flow.

**Spool Position Signal** – An electrical signal from a spool position transducer of servovalve. Normally this signal is proportional to the mechanical position of the spool. Note, the most popular servovalves use transducers with output signal  $\pm 10V$ ,  $\pm 10mA$  and 4-20mA.



**Picture 40.** Spool position diagram of a real servovalve. The red point shows the null bias which does not coincide with the zero of the spool position transducer.

**Spool Position Diagram** – The graph of a function which represents dependence of the spool position signal from control signal. Servovalves with spool transducers, normally, have very small hysteresis. Nevertheless, the spool position diagram can be not uniquely defined. An example of a spool position diagram is shown on Picture 40.

**Spool Position Hysteresis** – The difference in the valve input signals required to produce the same spool position signal. Spool position hysteresis is normally specified as the maximum difference occurring in a region of rated control interval. It is expressed as percent of rated signal.

**Dynamical Model of Servovalve** – A differential equation or system of differential equations which describe basic dynamical properties. In practice people usually use linear dynamical models, i.e. they assume that dynamical behavior of valve can be well described by a linear differential equation or system. In this case (and only in this case) the dynamical model can be represented by a transfer function. This is a complex function  $K(p)$  from a complex argument  $p$ . The transfer function gives the equivalent dynamical description and can be obtained from the linear differential equation by the Laplace transformation. An example of a linear dynamical model and the corresponding transfer function are shown below.

$$A\ddot{x} + B\dot{x} + Cx = u(t)$$

$$K(p) = \frac{1}{Ap^2 + Bp + C}$$

Here  $u(t)$  – control signal,  $x(t)$  – output flow,  $A$ ,  $B$ , and  $C$  – are some constants.

**Frequency response** – The relationship between no-load control flow and harmonic (sinus-type) input signal. Frequency response expressed by the amplitude ratio and phase angle which are constructed for harmonic signals from a specific frequency range.

Below we give definition of the amplitude ratio and phase lag more precise. Let  $x(t)$  be the control flow corresponding to input signal  $u(t) = A\sin(\omega t)$ . Here  $\omega = 2\pi f$  – frequency of the test signal. After some transition time  $\Delta t$  the output signal  $x(t)$  will be a periodic function with the same frequency  $\omega$ . In this case  $x(t)$  can be represented by the following Fourier series

$$x(t) = \sum_{k=0}^{\infty} R_k(\omega) \sin(k\omega t + \varphi_k(\omega)).$$

For any  $k$ , the amplitude  $R_k(\omega)$  and initial phase  $\varphi_k(\omega)$  expressed by the formulas

$$R_k(\omega) = |K_k(i\omega)|, \quad \varphi_k(\omega) = \arg(K_k(i\omega)),$$

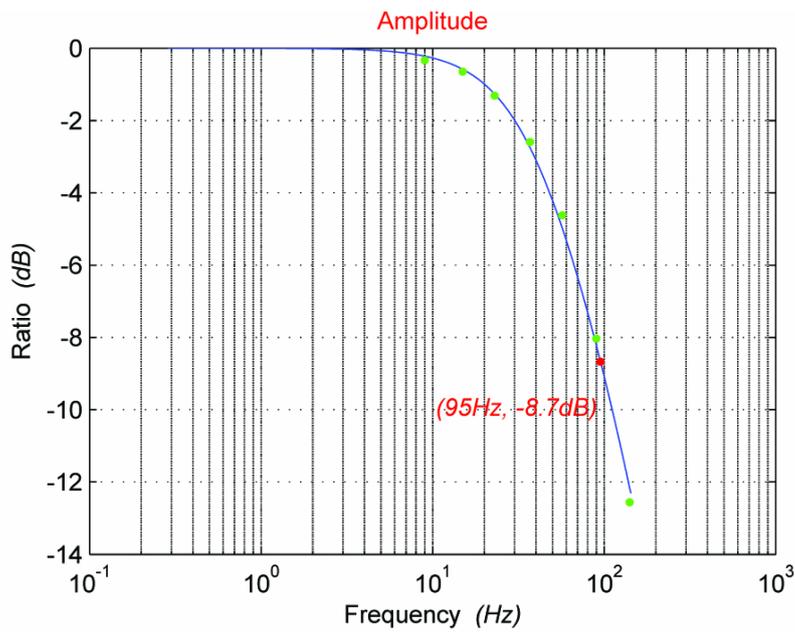
$$K_k(i\omega) = \frac{\omega}{2\pi} \int_{\Delta t}^{\Delta t + 2\pi/\omega} x(t) e^{-ik\omega t} dt.$$

The graph of the function  $R_1(\omega)/R_1(0)$  represents the amplitude ratio of the valve.<sup>8</sup> The graphical representation of the function  $\varphi_1(\omega)$  is the phase lag. Examples of phase lag and amplitude ration is shown below on Picture 41. We must note that valve frequency response may vary with the input amplitude, temperature, supply pressure, and other operating conditions. Note also, that for linear systems  $K_1(i\omega) \equiv K(i\omega)$  and  $K_k(i\omega) \equiv 0$ ,  $k = 2, 3, \dots, \infty$ .

**Natural Frequency** – Such frequency  $\omega$  that  $\varphi_1(\omega) = \pi/2$ .

**Degaussing Control** – The input control signal like  $u = \frac{A(T-t)}{T} \sin(\omega t) + u_0$ . Here  $A$  - amplitude,  $T$  - duration,  $\omega$  - frequency of the degaussing. Degaussing is used, mainly, before checking of average parameters of servovale for the control  $u_0$ . Below a degaussing curve is shown (Picture 42).

<sup>8</sup>  $R_1(0)$  is a formal notation for  $R_1(\omega_0)$  where  $\omega_0$  is small enough. Usually  $\omega_0$  is less 5Hz.



### General Information

Valve Model: E760-012

Serial Number:

Customer:

Date: 05-Jan-2002, 11:52

Operator:

### Test Conditions

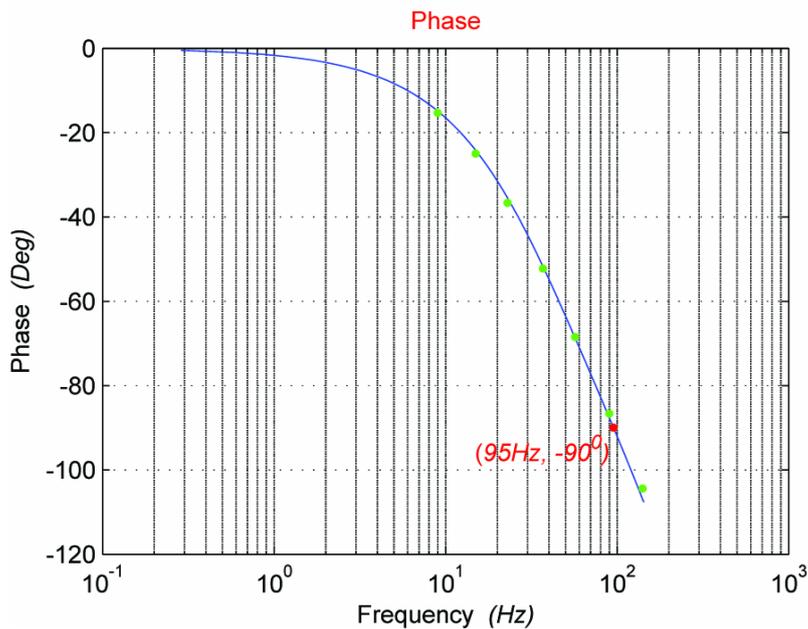
Coil Configuration: Series Coils

Connections: A +; B and C tied; D -

System Pressure: 2000psi

Temperature: 38C<sup>0</sup>

Amplitude: 8mA (40% of the Rated Signal)



### Results of the Dynamic Response

Frequency of -90<sup>0</sup> Phase Point: 95Hz

Amplitude Ratio at 95Hz : -8.7dB

Closest Linear Dynamical Model:

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

$$A = 2.5e-010, \quad B = 2e-006$$

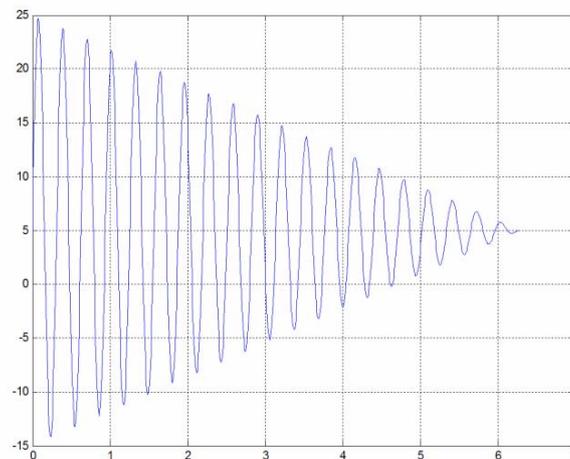
$$C = 0.0033, \quad D = 0.71$$

$$u_0 = 0.3mA \text{ (Null Bias)}$$

$u$  - Control Signal (mA)

$y$  - Output Flow (L/min)

**Picture 41.** Frequency response of a real servovalve. Green points on the graphics show the real data obtained by the Fourier analysis. Blue lines are phase lag and amplitude ration of the closest linear dynamical model of servovalve. Red point shows the natural frequency.



**Picture 42.** An example of the control to produce degaussing.