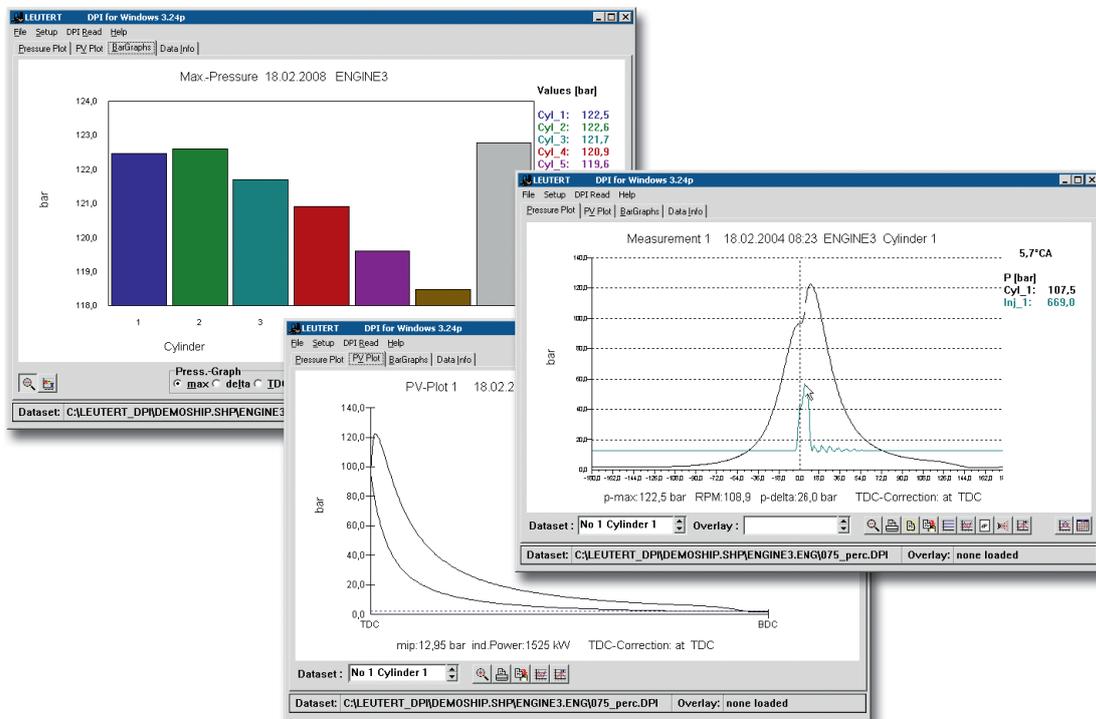


DPI-2 Digital Pressure Indicator

Operating Instructions



DPI software, version 3.24 for Windows

Introduction



This operating manual provides instructions on how to use this product correctly, effectively and safely for the intended purpose. Please, do read all instructions, notes on danger and warning, attentively. Please follow all safety instructions and precautionary notes in order to avoid damage to people or property during operation. LEUTERT can not be held responsible for damage or injury resulting from improper product use, incorrect operation or lack of maintenance.

This operating manual is directed mainly at technically trained personnel. In case of doubt regarding safety or operational aspects, please do not hesitate to contact LEUTERT for assistance. Should you notice a faulty description or depiction or if you would like to suggest points for improvement, we are looking forward to hearing from you.

Please keep the operating manual near the product to have it available if needed. Make sure that the manual is protected from dirt and moisture.

Explanation of symbols:



DANGER

Immediate danger is possible causing severe injury or death if you do not follow the instructions given.



WARNING

If you do not heed the warning, dangerous situations may occur leading to severe injury or death.



CAUTION

Follow the instructions carefully, otherwise dangerous situations may occur leading to injury or damage to property.



NOTICE

Please follow the recommendations and instructions for a correct and flawless operation of the device or measuring system.

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1 Product description

1.1 Application of the DPI software

The software serves to evaluate the data measured by means of the portable DPI. On completion of the measurement series, these data may be transferred via the serial or USB interface from the DPI to the PC and stored there as a *.dpi text file.

The DPI software is available either as a basic version called „DPI 3.24“ or in its extended version „DPI 3.24 Pro“. Compared to the basic version, the extended version contains additional functions allowing to calculate performance parameters.

Since the following descriptions and images refer exclusively to the extended version „DPI 3.24 Pro“, users of the basic version will notice differences as to the availability of certain menu and parameter features. Such differences are not explicitly highlighted in this manual.

For the generation of images, the DPI software was installed under the Windows XP operating system. A PC provided with other versions of the windows operating system will be subject to minor visual, but not to functional differences compared to the images shown in this manual.

1.2 Hardware requirements

In order to run the DPI software, your PC should be provided with the following features:

Computer

Pentium PC (min. 500 MHz)

Interface

1 free serial interface RS 232 or 1 free USB port for data transmission from the DPI hand-held unit to the PC

Approx. 30 MByte of free disc space are required for the installation of the software and the documentation.

RAM

depending on the operating system

Operating system

Windows 9x/ME/NT4/2000/XP/Vista

Monitor display settings

Minimum screen resolution 1024 x 768 pixel
(recommended: 1280 x 1024 pixel), color quality 16 bit or more

Printer

Color printer required

This manual has been compiled for software users who have basic computer knowledge. You should be familiar with typical Windows features like menus and command buttons since those elements are not explained in detail in this manual.

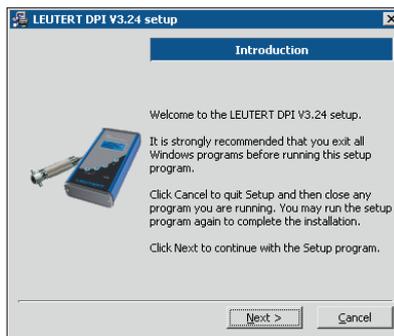
With the detailed information on each command that is given in this manual you will be able to handle the program.

1.3 Installing the DPI software

For the first installation of the DPI software, please proceed according to the following steps. Several messages displayed during the installation procedure will prompt you to the required action.

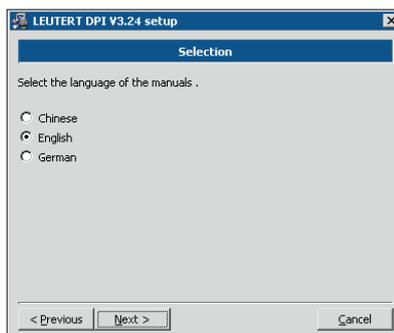
If you would like to substitute an older version of the DPI software with the current program, please refer first to the end of this chapter and read the information given there.

- 1) Close all active Windows applications and insert the installation CD into the CD ROM drive. The installation routine will start automatically. If autostart is deactivated, run the SETUP.EXE program from the installation CD.

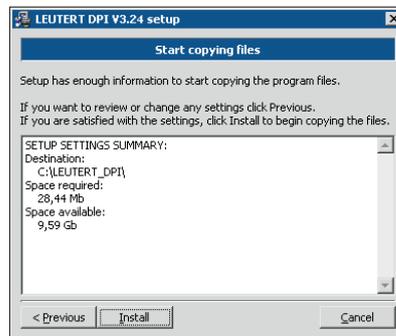


Click the <Next>-button.

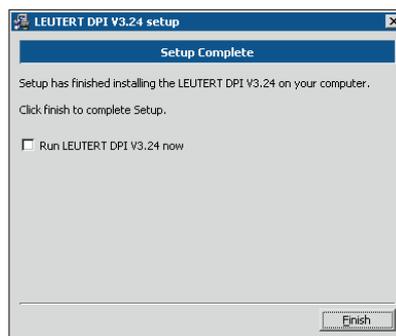
- 2) Select the „Pro“ version as „Setup Type“ and proceed with <Next>.
- 3) The preset path for the installation, „Destination folder“, is displayed in the input field. If necessary, select a different destination path. Run the installation program by clicking on <Next>. To cancel the procedure, select <Cancel>.
- 4) Select your preferred language for the manuals, which will then be used as the basic setting within the DPI software. Continue the installation by clicking on <Next>.



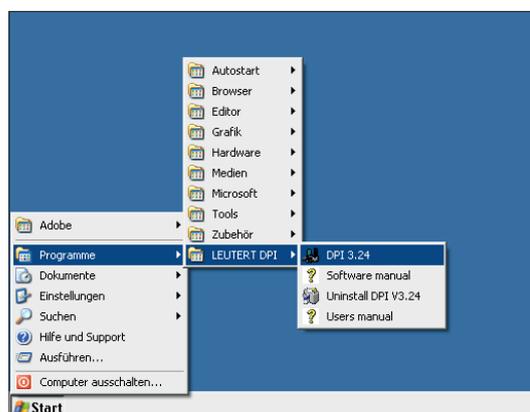
- 5) The next message designates the program group the DPI software will be assigned to. Click *<Next>* to continue.
- 6) Subsequently, the installation information will be displayed. Click *<Install>* to start the installation procedure.



- 7) Finally, the message shown below will be displayed. If desired, you may start the DPI software immediately. Click *<Finish>* to complete the installation.



The program group "LEUTERT DPI" with the application „DPI 3.24" will appear in the Windows start menu.



- 8) Remove the installation CD from the drive.

If a former version of the DPI software is installed on your PC, you may update your program. An update concerns only the program files and leaves the directory containing the measurement files untouched.

However, we advise you to regularly make backup copies of the datasets stored in the DPI program directory, either by copying them into a different PC or onto a disk or CD.

Run the update installation from the new program CD as described above. The installation program will detect any software versions already existing and enter the installation path in the box, see step 3.

For the success of the update and in order to preserve the links to the startup menu, it is absolutely necessary to maintain the proposed pathname.



If you install the DPI software 3.24 in a separate program directory parallel to an earlier version, you have to observe the following: When displaying the existing measurement data with an earlier software version, the individual cylinders will be shown in a different color-coding than before.

1.4 Installing the USB drivers (optional)

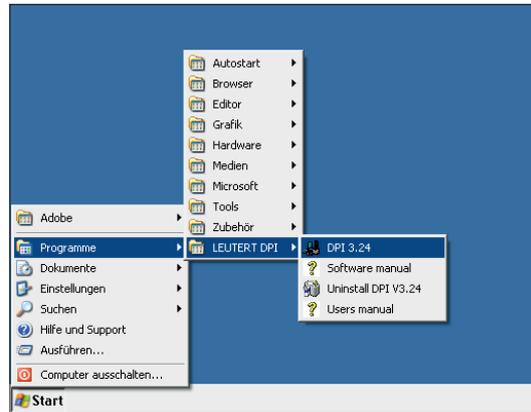
If no or no unoccupied RS232 port is available, the connection between the DPI hand-held unit and the PC can also be established by means of a USB connection.

For this purpose, it is imperative to install the corresponding driver from the installation CD. Go to the directory matching your operating system on the mini CD, and start SETUP.EXE. Follow the instructions of the installation routine.

2 Operating the software

2.1 Starting the software

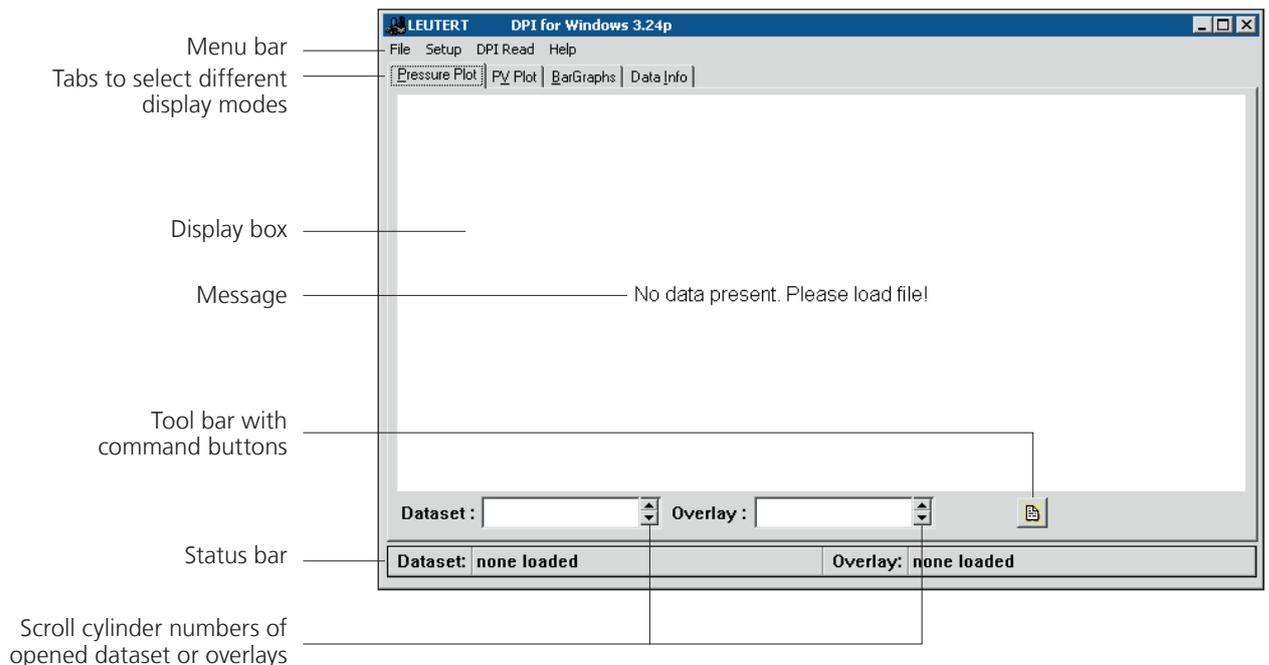
Run the software by selecting the application „DPI 3.24 Pro“ from the Windows startup menu.



An experienced Windows user may also create a link onto the desktop and run the program from there.

The software will start with a splash screen. After clicking on the <OK>-button the display will show the program window of the DPI software.

To change the size of that window, left-click the DPI program symbol in the top left corner and select the desired option.



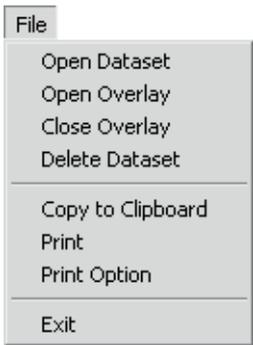
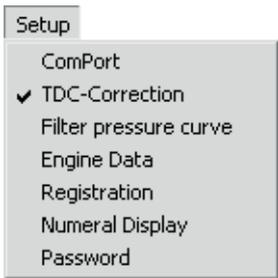
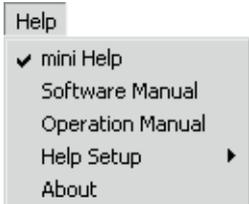
2.2 Control elements

To operate the DPI software, you can use the menu bar commands, four tabs for the selection of different file display modes and a number of command buttons.

The different elements will be briefly explained in the following so that you are able to familiarize yourself with their use. From chapter 6 onwards, you will get detailed information on the options of the different display modes for analysis and evaluation purposes.

2.2.1 Menu commands

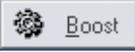
Each command of the menu bar is allocated to a hotkey which you can use alternatively to selecting a command with the mouse. First press the ALT key, and then the underlined letter.

| Command | Description |
|---|--|
|  <p>File</p> <ul style="list-style-type: none"> Open Dataset Open Overlay Close Overlay Delete Dataset Copy to Clipboard Print Print Option Exit | <p>File menu</p> <ul style="list-style-type: none"> Open a *.dpi file on the PC hard disk Open a second additional *.dpi file Close the second file Delete a *.dpi file from the PC hard disk Copy the current graph display to the clipboard Print the current display Set printer option Quit program, also with Alt + F4 |
|  <p>Setup</p> <ul style="list-style-type: none"> ComPort ✓ TDC-Correction Filter pressure curve Engine Data Registration Numeral Display Password | <p>Setup menu</p> <ul style="list-style-type: none"> Select serial port for connection of hand-held unit Turn on or off automatic TDC-Correction Filter cylinder pressure curve Enter engine parameters Register DPI software Selection of data series to be displayed in Data Info Enter the password for locking the engine parameters, and enter the measurement settings |
|  <p>DPI Read</p> | <p>DPI Read</p> <ul style="list-style-type: none"> Starts the menu for data transfer from the hand-held unit to the PC |
|  <p>Help</p> <ul style="list-style-type: none"> ✓ mini Help Software Manual Operation Manual Help Setup ▶ About | <p>Help menu</p> <ul style="list-style-type: none"> Switch on or off help files Open software instructions Open the DPI hand-held unit operating manual Language selection for the instructions Display product information |

2.2.2 Command buttons

Depending on the selected display mode, different buttons allow you to quickly execute certain commands.

| Symbol | Description |
|---|--|
|  | Zoom out - scale down, set graphic display back to default |
|  | Print graph - print displayed measurement curve, for printing other views select „Print“ from the menu bar |
|  | File open - open a new file, also by clicking into the empty „Dataset“ box |
|  | Copy to clipboard - copies present graph display to clipboard |
|  | Show grid - activates grid of pressure axis |
|  | Display all - shows simultaneously all measuring curves of a dataset |
|  | Show derivative plot - creates the first derivation of the pressure curve |
|  | Fuel injection curve - displays the injection pressure above the crankshaft angle when using the corresponding sensor |
|  | Filter pressure curve - Filtering of the cylinder pressure curve |
|  | Show numeric data - shows the numeric measured values which are marked when the mouse is moved across the diagram (Pressure Plot) |
|  | Show variation of values - shows the variation relative to the mean value as percentage |
|  | Zoom in - enlarge scale |
|  | Open dialog for additional entries - allows the input of additional measurement data |
|  | Select firing sequence - selection of the firing sequence |
|  | Enter VEE-angle - Input of the offset angle of the cylinder banks for VEE type engines |
|  | Set reference cylinder - determines the reference cylinder for TDC correction |
|  | TDC Correction - centers the measuring curves in accordance with the procedure selected under Setup – Engine Data |

| Symbol | Description |
|--|---|
|  Send | transfer engine data to the DPI |
|  Copy | copy engine data to the clipboard |
|  Boost | adoption of the boost pressure corrected for dataset 1 for all datasets |
|  Reset | reset the scavenging air pressure to the original values |
|  INI-Files | opens the menu for the selection of various engine parameter files |

2.2.3 Display modes

The measured data may be presented in different display modes by selecting one of the following tabs.

| Mode | Description |
|--|--|
|  Pressure Plot | display cylinder pressure in relation to crankshaft angle |
|  Pv Plot | depict cylinder pressure in relation to volume evolution, only possible for measurement series with TDC sensor |
|  BarGraphs | display several selectable parameters as bar diagram |
|  Data Info | table of all measuring data determined within one dataset |

3 Entering the basic settings

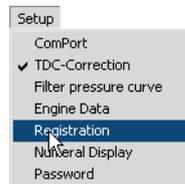
3.1 Software registration

The software contains a registration function in order to protect it against unauthorized copies.

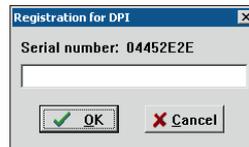
Prior to registration it is not possible to enter the required engine data for performance calculation under menu item „*Setup / Engine data*“. A corresponding message will be shown. The input fields are enabled upon completion of the following steps.

 The standard version of the DPI software does not include performance calculation, and therefore need not be registered.

- 1) Open the menu item „*Setup / Registration*“.



The following window will appear.



- 2) Please note down the serial number and phone the LEUTERT company at +49-4131-959-0 or send an e-mail to sales.maritime@leutert.com. The corresponding registration code will be delivered to you.
- 3) Enter this code into the box and acknowledge with <OK>.



The feature to enter the engine data „*Setup / Engine data*“ is now accessible.

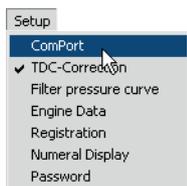
Put the registration number in a safe place. You will need it again if a re-installation of the DPI software should be necessary.

3.2 Select interface

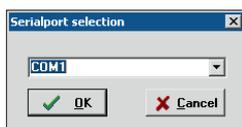
Please check at the start of the program if the PC's serial interface, to which the portable DPI is supposed to be connected for measuring data transfer, is activated. Refer also to chapter 5.

i The operating system must provide a free COM port in area 1 to 9. If this condition is not fulfilled, please contact your system administrator.

- 1) Select the „Setup / ComPort“ command from the menu of the DPI software.



- 2) Mark the desired COM port and confirm with <OK>.



Make sure to connect the portable DPI to this same port.

If no or no free serial interface is available on your PC, plug the USB–RS232 adapter into a free USB port. Install the appropriate driver, see chapter 1.4. The adapter appears as another COM port in the Setup menu of the DPI software. Select this new port.

i Make sure that after the adapter has been plugged in, the associated USB port is selected in the software (see step 2).

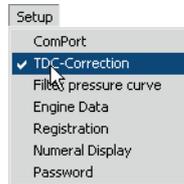
3.3 Automatic TDC correction

TDC correction eliminates both the effects of static and dynamic deviations in the crankshaft drive and additional measuring inaccuracies with regard to the TDC position which may occur with fluctuating speeds.

You may turn on or off the automatic TDC correction, however.

i We recommend having the automatic TDC CORRECTION generally ENABLED.

- 1) Select the „*Setup / TDC-Correction*“ command from the menu of the DPI software. The TDC correction is activated if, as shown in the illustration, the tick appears in front of it.



- 2) In the „*Pressure Plot*“ or „*PV Plot*“ display mode, automatic TDC correction may also be switched on or off by the button  „TDC Correction: OFF“ or the selected correction method are shown in the lower graphic area.

TDC correction at the top dead center “center at TDC”

This correction procedure is to be used in general for 2-STROKE ENGINES. Centering occurs at the top dead center of the respective cylinder determined from the measured curve.

EXCEPTION: If correction is not possible due to an atypical pressure pattern, a corresponding error message will appear. In this case, select TDC correction “center at -55 °CA”. However, in this case you must expect a reduced accuracy of TDC correction and of the calculated performance.



When using the TDC correction „center at TDC“ (only for 2-stroke-engines), entering the „TDC correction angle [°CA]“ and the reference cylinder has no effect on the calculated performance, but on the calculation of crankshaft torsion (see „Data Info - delta TDC“).

TDC correction in the beginning of compression “center at -55 °CA”

This is the only procedure available for 4-STROKE ENGINES. Here, the individual measuring curves are centered in the beginning of compression (-55 °CA) in relation to the entered reference cylinder.



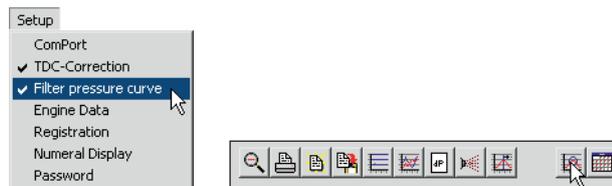
With the TDC correction method „center at -55 °CA“, both entering the „TDC correction angle [°CA]“ and the reference cylinder has a direct influence on the calculated engine performance.

AN ANGLE ERROR OF ONLY ± 1 °CA RESULTS IN A PERFORMANCE CALCULATION ERROR OF APPROX. $\pm 8\%$.

3.4 Filtering the cylinder pressure curve

This filter function (software filter) enables you to subsequently eliminate possible disturbances in the cylinder pressure pattern. If this function was already enabled in the DPI hand-held unit (Filter 2) during the measuring process, no more filtering will occur the software.

For enabling/disabling the function, use either the „*Setup / Filter pressure curve*“ command in the menu of the DPI software, or click on the corresponding function button in the „*Pressure Plot*“ display mode.



In the „Data Info“ display mode, you will find information on which filter was enabled during the measurement with regard to the currently opened file. For this purpose, the „Filter“ parameter must be selected under „*Setup / Numeral Display*“, and the filter function must be disabled by means of „*Setup / Filter pressure curve*“. The following parameters are available:

- 0 - no filtering
- 1 - slight filtering
- 2 - strong filtering

see also the instruction manual of the DPI hand-held unit, chapter 5.5. The enabled „*Filter pressure curve*“ function is documented in the „Data Info“ by „ON“.

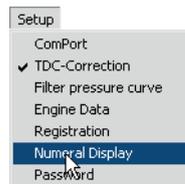


We recommend that you disable the filter function in the DPI hand-held unit by setting it to **Filter 0**. This will enable detailed, unfiltered data to be stored. You can decide subsequently in the DPI software, based on the curve shape, whether you wish the data to be displayed with or without filter on the monitor.

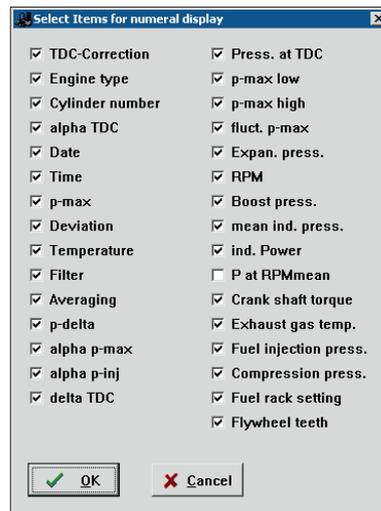
3.5 Select numeral display

In the file display mode „Data Info“, the measuring data are shown as a table. The parameters to be displayed can be determined by the following settings.

- 1) Select the „Setup / Numeral Display“ command from the menu of the DPI software.



- 2) Click to the corresponding check boxes to activate or deactivate the data series. The respective marked parameters are displayed in the „Data Info“ display mode.



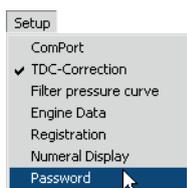
- 3) Confirm your selection with <OK>.

3.6 Defining a password

Starting from version 3.24, the DPI software contains an option for protecting the engine parameters and measurement settings against unauthorized manipulation. The password challenge appears when new settings are stored in the software, and when parameters are transmitted to the hand-held unit.

How to change the password:

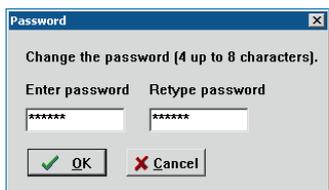
- 1) Select „Setup / Password“ in the menu.



- 2) In the next window you are prompted to enter the current password. In as-delivered condition, the password is „leutert“. Please note that the password is case sensitive.



- 3) Enter your own password on the left, and repeat it in the field on the right. It should be 4 to 8 characters in length. A message window will confirm the change.



-  Make a note of the new password, and keep the information in a safe place. In the event of loss of the password, please contact the company Leutert.

4 Enter engine and measuring parameters

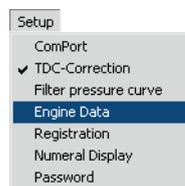
4.1 Creating a new engine



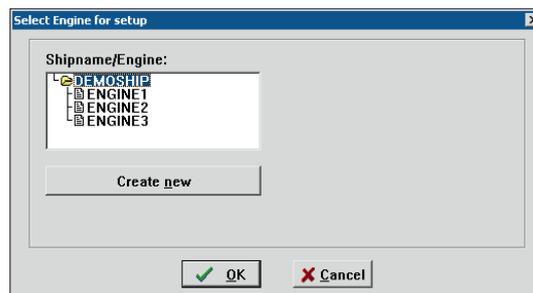
It is only possible to create a new engine if no measuring file is open, i. e. directly after the program start.

In order to add a new engine to the DPI measuring system, it must initially be entered in the software. For this purpose, set the engine data and parameters required for performance calculation.

- 1) Select the „*Setup / Engine Data*“ command in the menu of the DPI software immediately upon program start-up and before loading a measuring file.



- 2) Click on the <Create new>-button in the window „Select Engine for setup“ to create the directory structure for a new engine. This selection box will not appear if another measuring file is already open.



The image shows the directory structure with the demo datasets that will be offered to you.

- 3) Enter the name of the ship in the following window in the field „Shipname“ and after „Enginename“ the name of an engine. The engine name may contain maximally 8 characters. Close this window with <OK>.

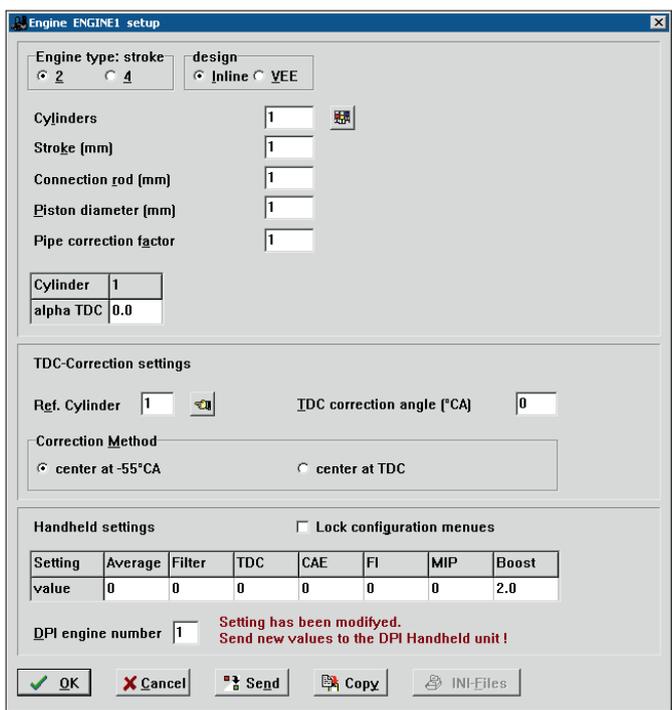


i The engine name is transferred to the DPI hand-held unit when the engine parameters (see chapter 4.3) are transmitted and serves for unambiguous assignment of the measuring files.

The selected „Shipname“ creates a folder of the same name with the ending „shp“ which is added to the directory list of the DPI software. Your entry after „Enginename“ generates in this path a directory with the ending „eng“ into which the *.dpi datasets will be stored. The directory structure will be referred to again in more detail in chapter 6.1.

- 4) Every time a new engine has been entered, the following dialog box will be displayed where all relevant engine parameters must be entered. We will explain the individual parameters in the next paragraph illustrated by an already registered engine.

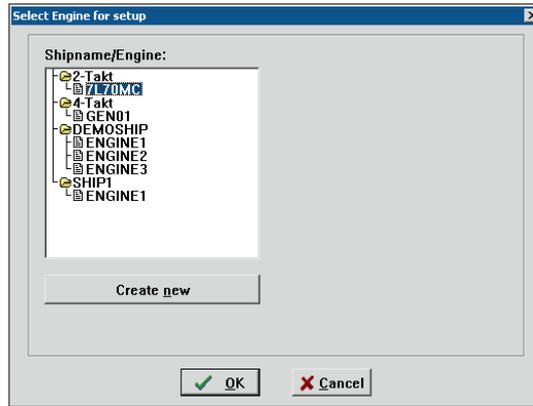
i The engine parameters can only be entered after registration of the DPI software (see chapter 3.1).



i If you generally indicate the engines without TDC sensor, only the engine type and the TDC correction method need to be set.

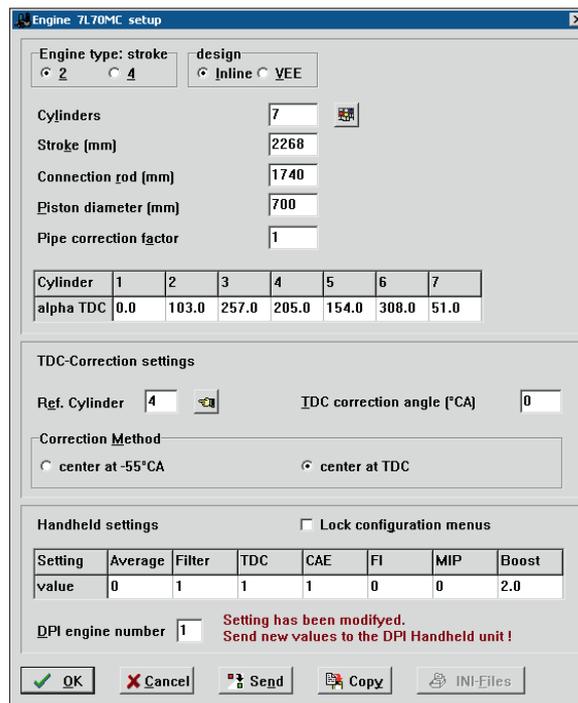
4.2 Settings for an already created engine

- 1) Select the „Setup / Engine Data“ command from the menu of the DPI software. If a measuring file has already been opened, no engine may be selected. Continue with step 3.
- 2) In the next window you must select the ship and the engine which you want to be measured using power calculation.



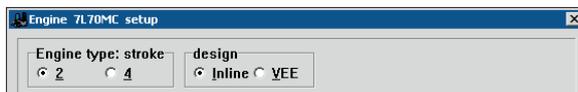
The settings are password-protected. Changes may only be made by authorized persons. Please have the required password ready.

- 3) Enter the pertaining engine parameters in the following dialog box. Please, avoid false entries in order to get correct performance evaluation results.

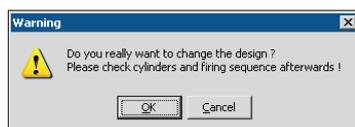


3a) Engine parameters

Click on the appropriate engine type (2- or 4-stroke engine) under „Engine type: stroke“.

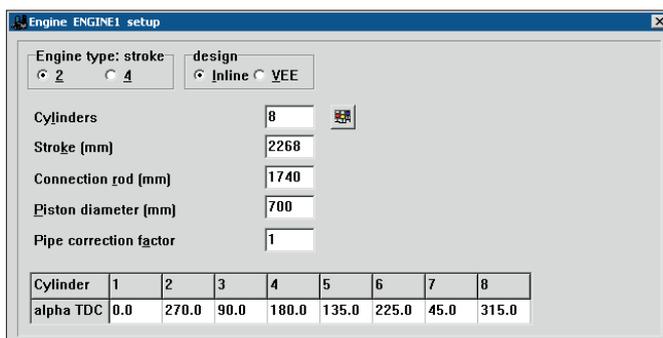


Select the „design“ of the engine (straight-type or VEE type). When changing, a warning will be displayed: You are requested to check the firing order of the cylinders (see below).



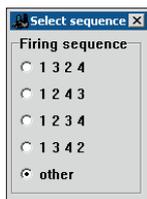
Inline engine

Enter the engine data (number of cylinders, stroke, con-rod length and bore) in the appropriate fields.



The calculated performance is corrupted by pressure measurement remote from the combustion chamber. At the same time, the design and the condition of the indication channels and the indication valves exert great influence. This may be adjusted by means of the „Pipe correction factor“. Usually the factor is „1“ but it may range between 0.85 and 1.15. In any case, the limits of the input value for the pipe correction factor are 0.75 and 1.25.

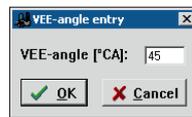
A click on the icon  will lead you to a window showing possible sequences.



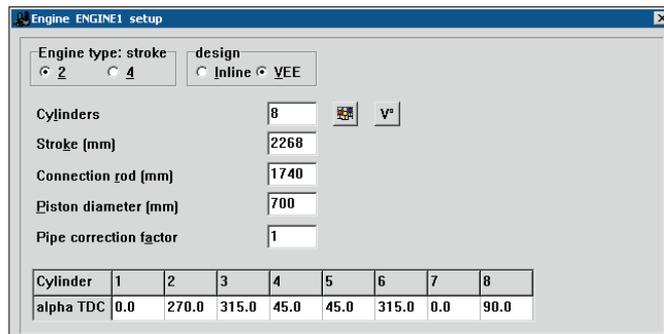
If you select one of the predefined sequences, the angles for the list will be calculated automatically.

VEE type engine

If a VEE type engine is selected, an additional enquiry for offset appears. Enter the angle between banks A and B.



After entering this value, the software automatically calculates the TDC angles of bank B in correlation to bank A. This is displayed in reference line „alpha TDC“.



Click on the  button to change the VEE angle between bank A and B. This button is only available upon selection of a VEE type engine.

For VEE type engines:

After clicking the icon , only the cylinders of bank A are displayed, because the firing order of bank B is identically.

If no matching sequence for your engine is available, click to „other“ and enter the TDC angle for each cylinder related to cylinder 1 manually into the table cell „alpha TDC“.

Usually, the cylinders are measured bank by bank, so you should start with cylinder $A_1, A_2 \dots A_n$ followed by $B_1, B_2 \dots B_n$.

For bank B you must add the VEE angle between the two banks to the angle within the bank B. Instead of 0°CA , B_1 has f. ex. the corresponding VEE angle between A_1 and B_1 .

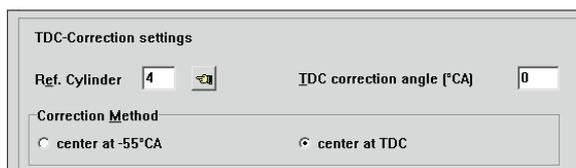
The VEE angle must be added or subtracted depending on the turning direction of the engine. That means if B_1 is at TDC about the VEE angle BEFORE A_1 the angle of TDC for B_1 is 360°CA MINUS the VEE angle, otherwise it is equal to the VEE angle.

Example for a 16 cylinder engine, angle VEE = 60 °CA:

| Cylinder | TDC | Cylinder | TDC | Cylinder | TDC |
|----------------|-----|-----------------|-----|-----------------------|-----|
| | | $B_n = A_n + V$ | | $B_n = A_n + 360 - V$ | |
| A ₁ | 0 | B ₁ | 60 | B ₁ | 300 |
| A ₂ | 90 | B ₂ | 150 | B ₂ | 30 |
| A ₃ | 270 | B ₃ | 330 | B ₃ | 210 |
| A ₄ | 180 | B ₄ | 240 | B ₄ | 120 |
| A ₅ | 180 | B ₅ | 240 | B ₅ | 120 |
| A ₆ | 270 | B ₆ | 330 | B ₆ | 210 |
| A ₇ | 90 | B ₇ | 150 | B ₇ | 30 |
| A ₈ | 0 | B ₈ | 60 | B ₈ | 300 |

The angle of TDC is the remainder of the value in parentheses divided by 360.

3b) TDC correction settings



In the „Ref. Cylinder“ field you can enter the number of the reference cylinder for the automatic TDC correction (for correction method „center at -55 °CA“ only). The standard setting is the automatically calculated cylinder. Alternatively, the cylinder located next to the flywheel may be selected with 2-stroke engines. With 4-stroke engines, the preset value should be used.

When clicking on the button , the reference cylinder will automatically be newly calculated.

 The entry of the TDC correction angle is optional and allows you to compensate a wrong magnet position or a phase displacement of the measurement signal caused by the indication channel. Be aware of the fact that a deviation of 0.1 °CA causes a performance evaluation error of about 0.8%, a 1 °CA deviation creating, thus, an error of 8%!

The TDC correction angle can be determined dynamically, with 2-STROKE ENGINES directly from the curve. For this purpose, the mouse cursor is pointed to the combustion pressure of the reference cylinder in the „Pressure Plot“ display mode, using the zoom function with automatic TDC correction switched off (see chapter 6.2). With the „Show numeric data“ function enabled, the corresponding alpha angle will appear in the upper part of the plot. Enter this value in „Setup / Engine data“ as „TDC correction angle“.

With 4-STROKE ENGINES, record a measuring curve of the reference cylinder without injection (tractrix) with deactivated averaging and proceed as described above.



In order to deactivate injection of individual cylinders, the engine output may have to be reduced in accordance with the manufacturer's instructions, if applicable. The manufacturer's instructions must be observed by all means in order to avoid damages to the engine.

3c) Handheld settings

| Handheld settings | | | | | | | |
|--|---------|--------|-----|-----|----|-----|--|
| | | | | | | | <input type="checkbox"/> Lock configuration menus |
| Setting | Average | Filter | TDC | CAE | FI | MIP | Boost |
| value | 0 | 1 | 1 | 1 | 0 | 0 | 2.0 |
| DPI engine number <input type="text" value="1"/> | | | | | | | Setting has been modified. Send new values to the DPI Handheld unit ! |

Select in the table „Handheld settings“ the following settings:

Average : 0 – 1 - Averaging OFF, record individual measuring curve
2 – 16 - Averaging enabled during n measurements:
n = max. 16 for 4-stroke engines,
n = max. 8 for 2-stroke engines

Filter : 0 - OFF, no signal smoothing
1 - slight smoothing, basic setting
2 - strong smoothing, at whistling vibrations

TDC : 0 - TDC sensor not available
1 - TDC sensor installed

CAE : 0 - CAE sensor not available
1 - CAE sensor installed

FI : 0 - Fuel injection sensor not available
1 - Fuel injection sensor installed

MIP : 0 - mip calculation in the hand-held unit disabled
1 - calculation in the hand-held unit enabled

Boost : Boost pressure head,
with several turbochargers, mean boost pressure



If you are using an incremental encoder instead of the TDC or CAE sensor, respectively, enter 1 for both the TDC and the CAE sensor.

The meaning and the effects of the settings are described in chapter 5.5 to 5.8 in the Users Manual for the DPI hand-held unit.

The „DPI engine number“ is used to define the storage place in the hand-held unit. Storage places 1 to 9 are available. As verification the storage place will be checked during the transmission of the settings to the DPI hand-held unit, refer to chapter 4.3. If the number is used for a different engine, you will get a warning.

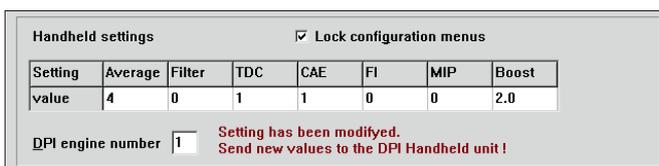


The „DPI engine number“ **MUST NOT BE CHANGED** subsequently, otherwise you will obtain error messages when evaluating the measuring file.

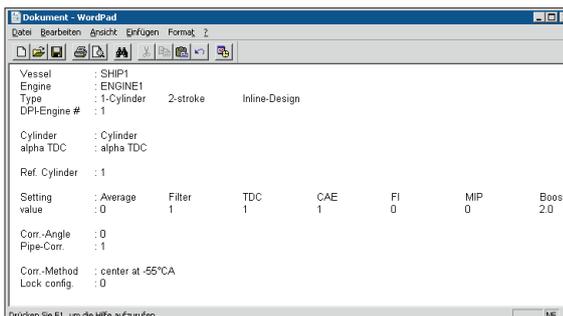
The following table is a suggestion for the assignment of the engines to the DPI engine numbers. The engine names selected for the individual engines result automatically from the entry in the list of engines (see chapter 4.1).

| | Engine name | Engine number | |
|--------------|-------------|---------------|---|
| Generators | AUX1 | 1 | 1 |
| | AUX2 | 2 | 2 |
| | AUX3 | 3 | 3 |
| | AUX4 | 4 | - |
| Main machine | MAIN1 | 5 | 4 |
| | MAIN2 | 6 | - |

- The „Lock configuration menus“ option protects the values entered in chapter 4.2 against unauthorized manipulation in the DPI hand-held unit, i. e. the corresponding menu items are not enabled in the DPI hand-held unit. When saving with <OK> or transferring data to the hand-held unit by <Send>, respectively, you will be prompted to enter the password.

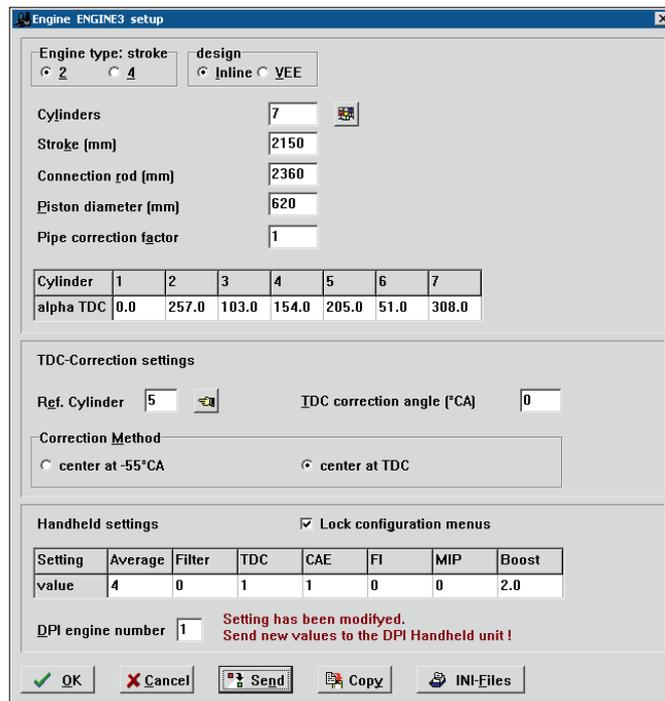


- Clicking on the  icon stores all entries in the clipboard and can then be inserted into a text file.

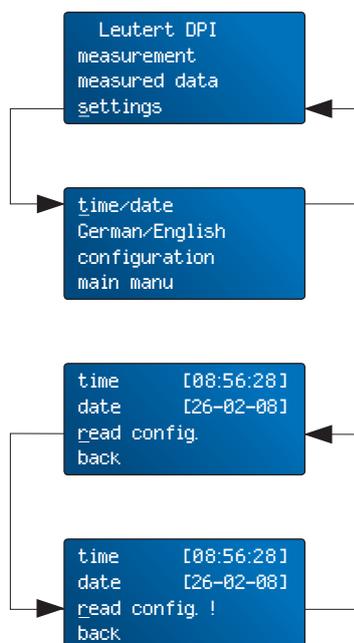


4.3 Transfer engine and measuring parameters to the DPI hand-held unit

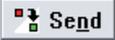
When all settings are done, you can transfer this configuration to the DPI hand-held unit. The box with the engine parameters in the DPI software is open.

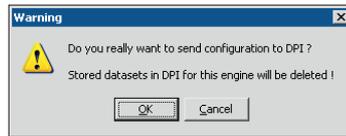


- 1) The DPI hand-held unit is switched off. Connect the serial interfaces of the DPI hand-held unit and the PC using the supplied serial interface cable. Make sure the correct ComPort is selected (see chapter 3.2).
- 2) Switch on the DPI and switch into the ‚settings‘ menu.
- 3) Move the cursor to ‚date/time‘ and confirm the opening of the settings menu using **P**.
- 4) Select the function ‚read config.‘ and confirm with the **P** key.



The DPI hand-held unit shows that it is ready to receive the data from the PC with the line changing to ‚read config !‘ until the transmission has ended. If the error message ‚no connection‘ appears, something is wrong with the communication between the DPI hand-held unit and the PC.

- 5) Press  in the „Engine ... setup“ window. The following warning will appear after entering the password:



After pressing the <OK> button, the transmission of the settings to the DPI hand-held unit will start. When sending the configuration file to the DPI hand-held unit, it verifies whether the selected engine number („DPI engine number“) is still available. If it has already been assigned to a different engine, a warning will be displayed.

In addition, the date/time on the DPI hand-held unit and the system time on the PC will be adjusted during data transmission.

After transmission, the DPI hand-held unit will take over the name of the engine entered under “Enginename” (see chapter 4.1). The latter will then be displayed instead of the engine number, facilitating the assignment to the engine.

- 6) When the transmission is finished you may return to the main menu and turn off the DPI hand-held unit. The settings are stored in nonvolatile memory and will remain there until you overwrite them.
- 7) By closing the box, the display will return to the „Engine ... setup“ engine parameters.
- 8) To leave the engine setup press the <OK> button.

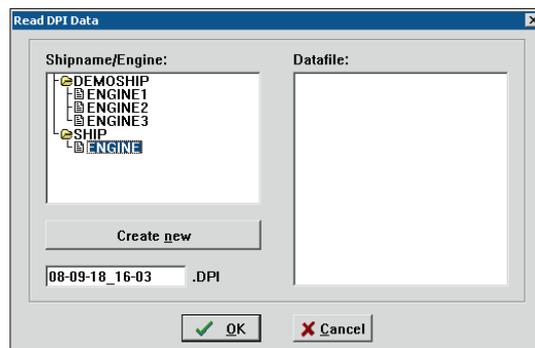
5 Transfer datasets to PC

In order to display the measuring data by means of the DPI software they must first be transferred from the DPI hand-held unit to your computer's hard disk.



Transfer all measuring series of one particular engine to the same directory. Make sure that measuring data of different engines are not stored in the same directory. Before transferring data of an engine to the PC for the first time, the engine must initially be newly generated in the software (see chapter 4.1).

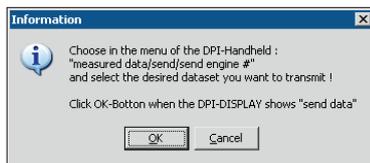
- 1) The DPI hand-held unit is switched off. Connect the serial interfaces of the DPI and the PC using the supplied serial interface cable. Make sure the correct ComPort is selected (see chapter 3.2).
- 2) Run the DPI software on your computer under Windows.
- 3) Click on the command „DPI Read“ in the main menu.
- 4) Mark the directory into which you want to transfer the datasets and click the <OK> button.



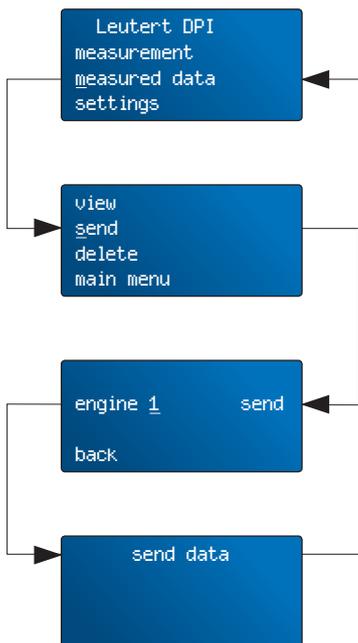
With the directory you allocate the dataset to a ship and to an engine.

The file name is automatically generated from the current date and time, but you can determine it anew by overwriting.

The PC monitors displays the following message:



DO NOT select anything yet on the PC, but move on first to step 5 to carry out the operations mentioned there.



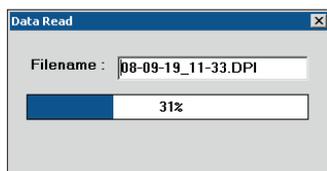
- 5) Switch on the DPI and move to the 'measured data' menu.

Select the function 'send'.

Under the first menu item, select the engine the measuring data of which you have recorded. When the configuration data have been transferred from the PC to the hand-held unit (see chapter 4.3), the engine designation defined by you will appear here. Execute this command in order to send all datasets allocated to this engine to the PC. This is the normal procedure.

If the message 'send data' appears on the DPI display, start receiving data at the PC (see step 6).

- 6) Start the data transfer from the PC by clicking the <OK> button inside the current program window (see step 4).
- 7) A progress bar keeps you informed about the state of data transfer. After the data transfer has been completed (i.e. if the bar has reached 100 %) close the PC's menu window by clicking the <Close> button.



- 8) Switch off the DPI hand-held unit again. The measured data are now available on the PC for further analysis.

6 Displaying measured data

Now that you have familiarized yourself with the operations provided by the software, let us proceed to the actual application of the DPI software: Display and analysis of the measured data.

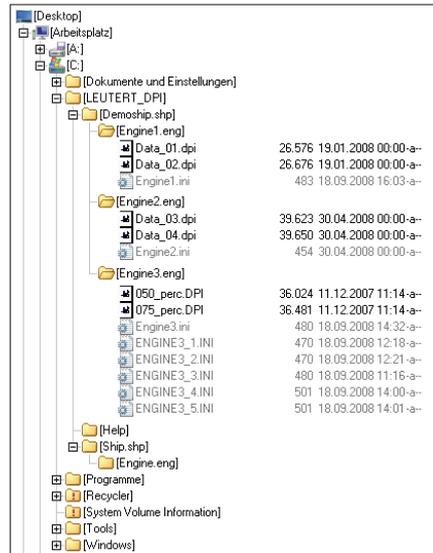
One set of data usually consists of several measurements (cylinder numbers) which contain the following values in each case:

- Time and date
- Number of engine and cylinder
- Type of engine
- Type of filter
- Number of averaging
- Starting angle of the pressure curves with installed TDC sensor
- Boost pressure, manually entered value
- Engine Speed
- Course of cylinder pressure
- Peak pressure
- Differential pressure
- Mean indicated pressure
- Injection pressure process with installed fuel injection sensor
- Starting angle of the injection pressure curves
- Peak pressure fluctuations with active averaging
- Number of flywheel teeth with activated CAE sensor

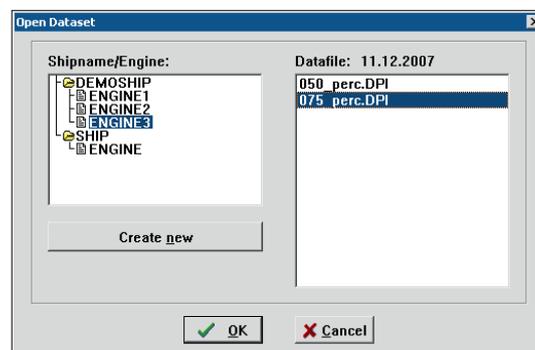
All displays and mathematical calculations in the DPI software are based on these measured quantities.

6.1 Managing datasets

We would like to demonstrate to you the functions of the software using sample data which were stored in the folder „Demoship“ of the program directory of the DPI software during installation. The figure below shows you this in schematic form.



The same structure is reflected in the selection box „Open dataset“ which is presented to you in order to open a file.



You should get in the habit of making backup copies of your data. Use Windows tools such as the Explorer for copying the files. Please note the advice given below.



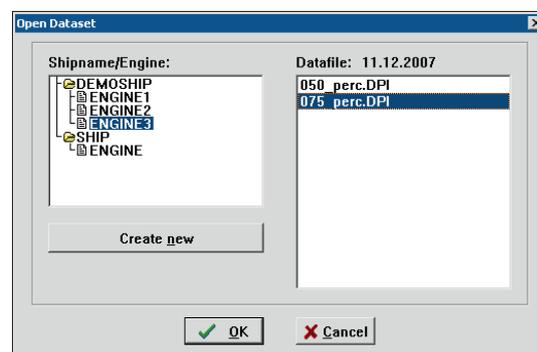
Please ensure that the „dpi“ files to be displayed are located in a directory of the DPI program folder. If you move them into another directory, they cannot be accessed within the DPI software.

6.1.1 Selecting a measuring file

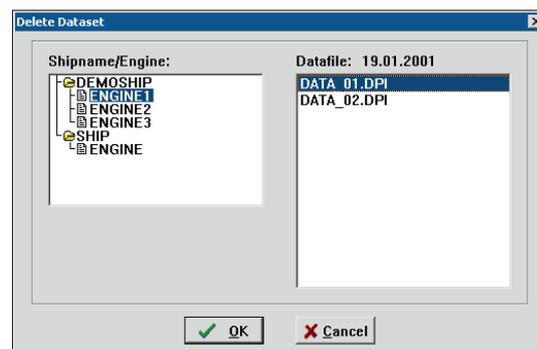
The DPI software offers several variants for LOADING a dataset. You may use

- the menu command „File / Open Dataset“
- the function button „File open“  oder
- click into the empty field „Dataset“ .

Then you will be offered the directory structure with the already existing datasets. Mark one *.dpi data file and click on <OK>. The file always opens at default in display mode „Pressure Plot“ (see chapter 6.2).



We would like to add at this point that you may DELETE a dataset with the menu command „File / Delete Dataset“. To do this, select the dpi-file that you want to remove from the hard disk in the lower window and confirm with <OK>. Use this command very carefully.



6.1.2 Selecting the engine parameter file

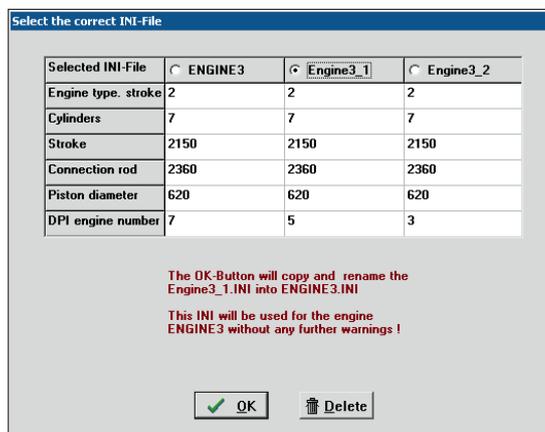
The engine parameter file contains the engine parameters and measurement settings entered under „*Setup / Engine data*“. It is automatically saved as an *.ini file in the directory of the engine, e. g. „C:/LEUTERT_DPI/Demoship.shp/Engine3.eng/Engine3.ini“ (see diagram of the directory structure in chapter 6.1).

The selection of an engine parameter file is ONLY POSSIBLE if there are several parameter files (*.ini) for one engine. This may occur if an engine directory with Windows system programs has been renamed, or if measuring files are transmitted and stored together with the assigned engine parameter file in the DPI program directory.

 The selection of an engine parameter file is REQUIRED if there are discrepancies in the representation of a measuring file, because the engine parameter file has an impact on the performance values calculated in the software.

If a measuring file is open, use the „*Setup / Engine data*“ command. The parameters and settings which are the basis of the displayed diagrams will be shown (see illustration in chapter 4.3).

Click on the enabled <INI-Files> button. After entering the password, you may select a different file for this engine in the subsequent window.

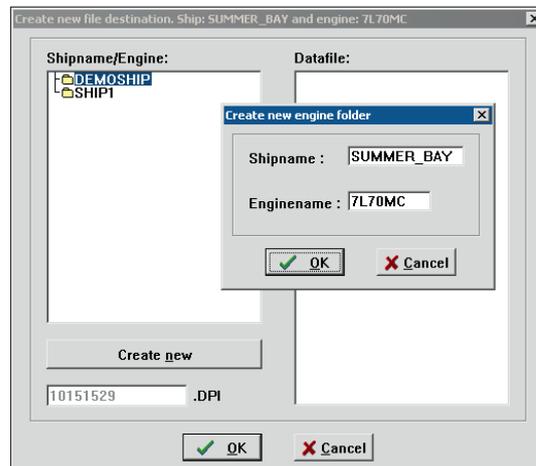


Click on <OK> to confirm the selection of the engine parameter file. The display of the currently opened measuring file is adjusted on the basis of the parameters from this *.ini file.

6.1.3 Opening a measuring file from an email

Starting from DPI software version 3.24, it is possible to automatically copy a measuring file from an email to the corresponding engine folder. To do so, click on the DPI file attached to the email. The DPI software will launch automatically.

- a) The engine has already been created in the DPI software:
A message will appear announcing that the measuring file is being saved in the corresponding engine directory on the PC. Subsequently, the file will be displayed in the „*Pressure Plot*“ display mode.
- b) The measuring file belongs to an engine which has not been registered in the DPI software, yet:
A new ship and engine directory will be generated, and the file will be copied to the same.



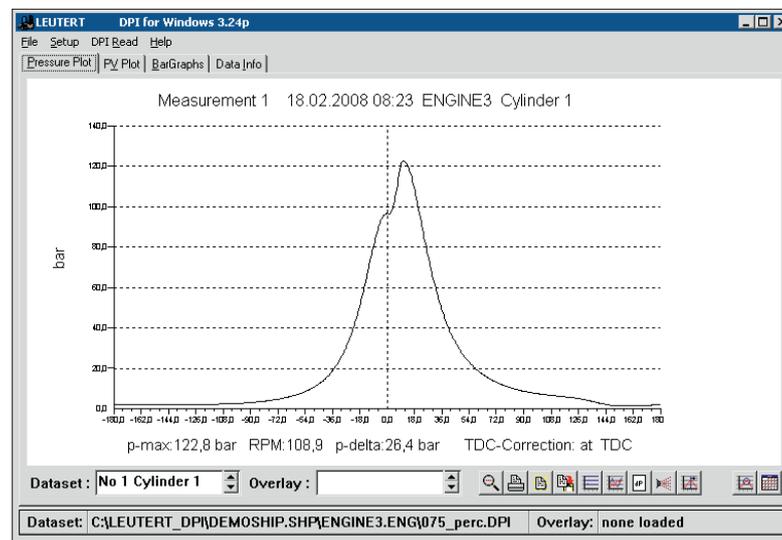
Subsequently, you will see the engine parameters of this new measuring file in the “Engine ... setup” window. Click on <OK>, and after entering the password, the *.dpi data file will be displayed in the „*Pressure Plot*“ display mode.

6.2 Viewing „Pressure Plot“



The course of the curve depicted in the display mode „*Pressure Plot*“ shows the cylinder pressure measured at the indicator valve [bar] depending on the crankshaft angle [°CA]. When using an injection pressure sensor, the pressure curve [bar] determined at the injection pump is shown in dependence on the crankshaft angle [°CA].

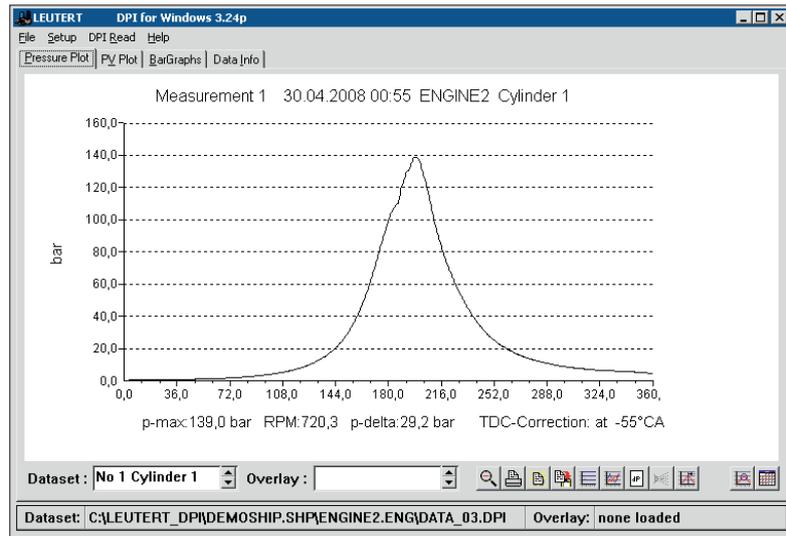
The curve depicted in the example was recorded using a TDC sensor. Measurements WITH A TDC SENSOR may be recognized by the fact that the top dead center of the relevant cylinder determined is marked by a vertical line at 0 °CA. The measured values in front of and after the upper dead center are plotted relative to this in the range from -180 °CA to +180 °CA on the X-axis.



Alternatively, you will find on the next page a second example with measured data from an engine that was indicated WITHOUT A TDC SENSOR. At first glance, you will see the difference: the scaling of the X-axis starts at 0 °CA. This value, however, does not correspond to the top dead center depicted in the previous example.



When loading a 2-stroke engine measuring file for the first time and with TDC correction enabled, initially „center at TDC“ will ALWAYS be attempted, even if „center at 55°CA“ was selected under „*Setup / Engine data*“. This serves to prevent incorrect operation.



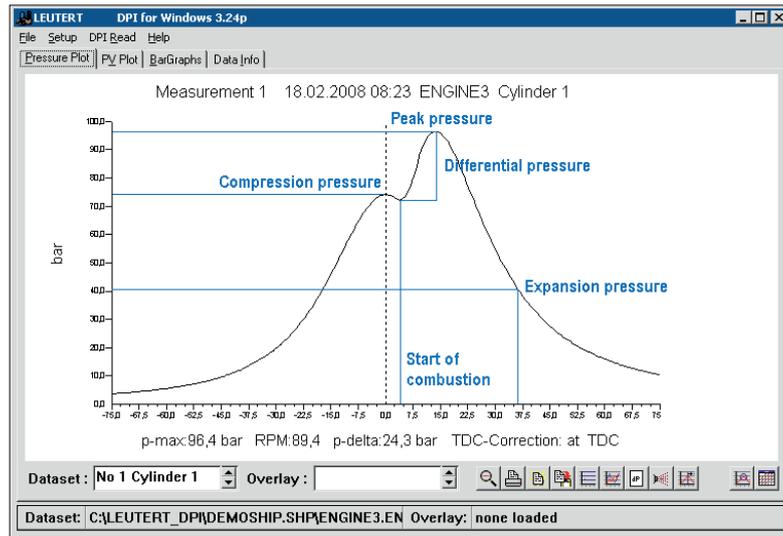
The advisory text above the pressure curve includes information on the dataset displayed:

- Measurement : Consecutive numbering of the individual measurements; If indication began with cylinder 1, the measuring number corresponds to the cylinder number.
Date and time of the measurement
- Engine : Number to distinguish several engines (1–9) respectively engine name, refer to chapter 4
- Cylinder : Cylinder number (1–24)

There is more information about the current measurement curve below the graph:

- p-max : Peak pressure [bar]
- RPM : Engine speed [rpm]
- p-delta : Differential pressure [bar]
- TDC Correction : selected TDC correction method

The complete path name of the dataset currently open may be found in the status bar.

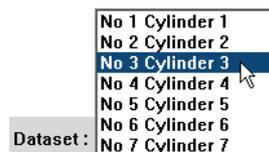


In the graph above we have entered some important pressure values for you which you may read from the cylinder pressure curve.

- Peak pressure : Depicts the maximum pressure value of the measurement curve, also known as ignition pressure.
- Compression press. : Pressure at the upper dead center of the relevant cylinder measured.
- Expansion pressure : Pressure value at a specific point of the expansion phase, i.e. 36 °CA (crankshaft angle) after the upper dead center.
- Differential press. : Peak pressure minus the pressure value at beginning of combustion.
When the value 0 is displayed, the beginning of combustion of the machine cannot be determined clearly.
This may also be the case when indicating having activated filter 2, or with machines having a very early injection beginning or a combustion with a linear beginning.

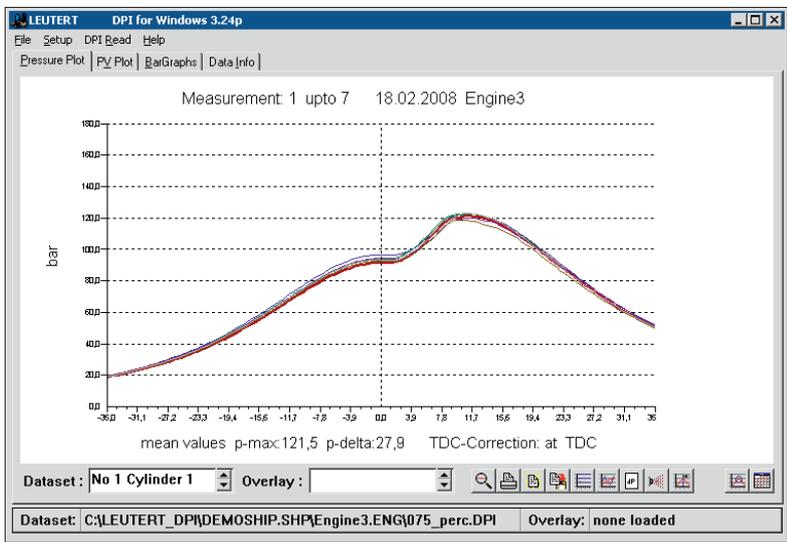
Next, we would like to explain the options provided in the „*Pressure Plot*“ mode for detailed data analysis.

- 1) Enlarge important sections of the graph by marking the area of the curve that you are interested in while keeping the left mouse button pressed. When you release the mouse button, you will have an enlargement of the section selected on the display space of the software.
- 1a) After ZOOMING, scroll bars will appear on the right side of the screen with which you can move the pressure curve.
- 1b) By clicking the command button  you will get the original full screen view again.
- 2) Use the command button  you will get the original full screen view again.
- 3) As necessary, copy the curve currently displayed into the Windows clipboard by clicking on  with the mouse which enables you to paste it as an image into another application.
- 4) Clicking the button  starts printing the displayed measuring curve.
- 5) Actuate the function switch  in order to center the measuring curves in accordance with the method selected under „Engine data“ (see chapter 4).
- 6) The  button serves to switch the software filter on and off, see chapter 3.4.
- 7) A dataset generally includes several measurements (cylinders) that you can select with various commands.
- 7a) In order to view the measurement curves of all cylinders of one dataset one after the other, you may use the scroll arrows in the „Dataset“ box .
- 7b) If you click in the box „Dataset“ with the mouse, you will see a list of the cylinder data available in which you mark the desired line.



Then the display changes to the pressure curve of the selected cylinder.

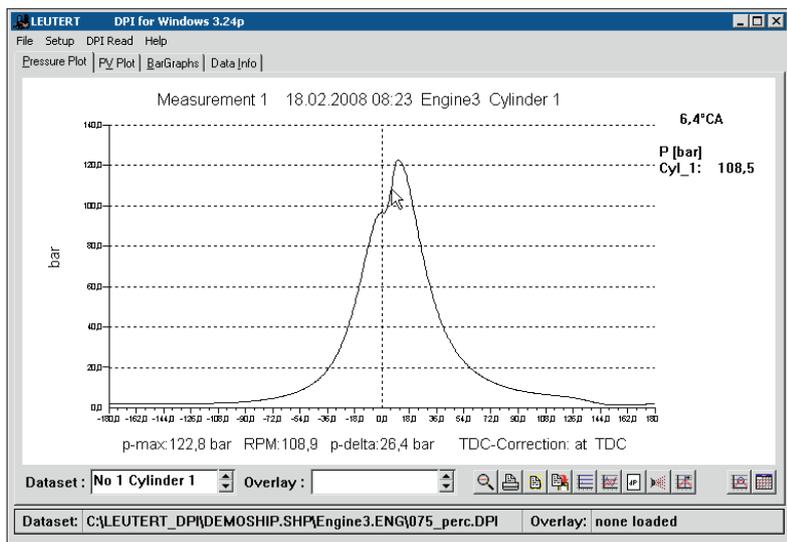
7c) Another display mode is provided by the command „Display all“, which is activated using the  button. This permits all cylinder pressure curves of an engine to be displayed overlapping in order to compare them with each other. This function is inactive if an „overlay“ was loaded.



When switching between the cylinders by means of the arrow buttons next to the „Dataset“ field, the respective selected measuring curve will be displayed in bold. This simplifies identification of the individual curves.

Clicking on  again restores the view of the individual cylinder selected previously.

8) The function button  serves to show or hide the numerical measured values marked by the mouse when moving across the diagram (Pressure Plot). When clicking on this button, the mouse cursor will jump to the center of the screen, and the respective data will appear in the upper right part of the graphic area.

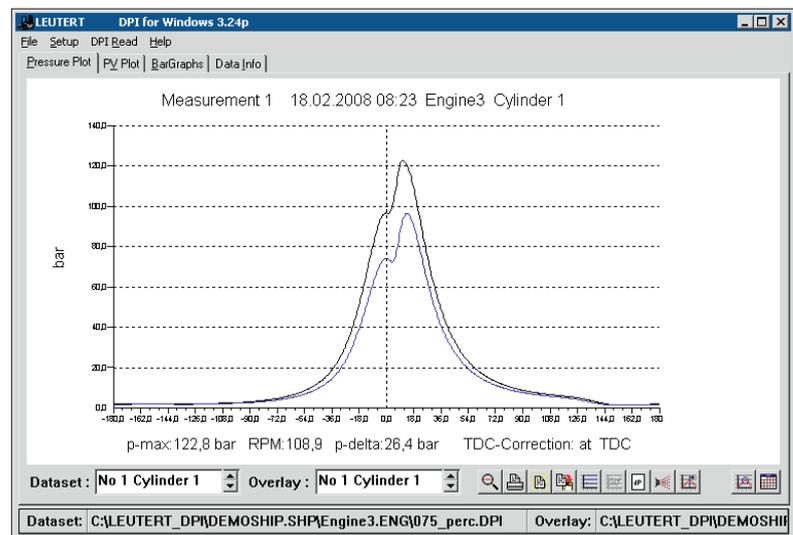


9) Another way of comparing the curves is additionally opening a dataset as an „overlay“. You could use a reference curve for example as an overlay in order to depict changes in comparison to a defined standard state. This method is also interesting if you would like to compare measuring series of the same engine after changing settings, exchanging sub-assemblies or engine overhauls with the previous data.

9a) In order to open an overlay file, either use the menu command „File / Open Overlay“ or click in the empty „Overlay“ box

Overlay: No 1 Cylinder 1

9b) Select the file which you would like to have displayed in addition to the active dataset in the window „Open Overlay“. The overlay curve is subsequently visible in the graph as a blue line. In order to make the deviations clearer you may zoom the relevant area.

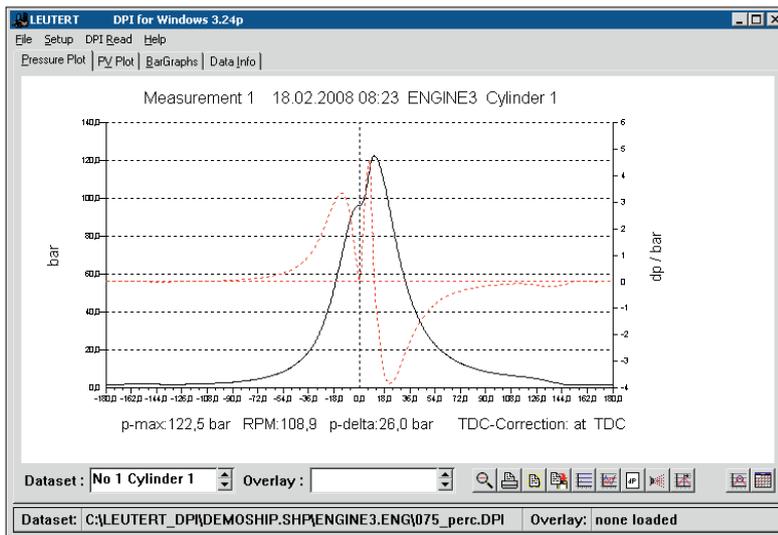


9c) Switching between the individual measuring series of the overlay is carried out in the same way as in the dataset, see step 7.

9d) To close the overlaid dataset use the menu command „File / Close Overlay“.

10) The „Show derivative plot“ command  of the toolbar provides you with the opportunity of displaying the first derivative of the relevant cylinder in addition to its pressure curve. A further axis appears on the right side of the graph on which dp (corresponds to Δp) is plotted in bar. This differential depicts the increase in pressure per °CA in relation to the crankshaft angle.

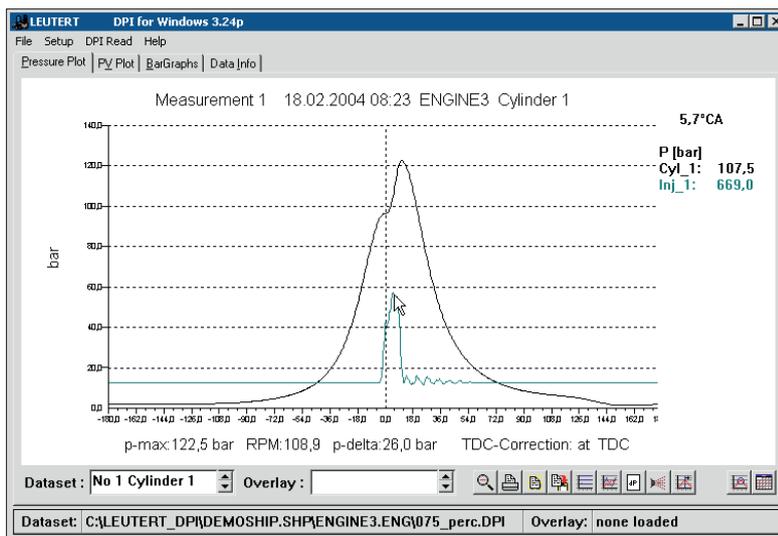
In this manner you can determine a possible overload of the engine due to an excessively steep pressure rise.



Note: Switch off the software filter by means of the  button, or under „Setup / Filter pressure curve“ and disable the existing filters in the DPI hand-held unit before measuring in order to obtain the actual pressure increase (see also chapter 3.4).

Pressing the  button again switches off the curve of the first derivative again.

- 11) With this button  the plot of the fuel injection appears. The fuel injection pressure is indicated without scaling, i.e. without correlation to the y-axis. The button is only enabled if you have recorded the values for the injection pressure by means of the DPI hand-held unit. When the function „Fuel injection curve“ is selected, the function „Show numeric data“ is called automatically.



Pressing the  button again switches off the plot of the fuel injection.

6.3 Viewing „PV Plot“



The „*PV Plot*“ display mode illustrates the course of the cylinder pressure in relation to the volume.

Entering the precise engine parameters is absolutely necessary to carry out the performance calculations which may be viewed in the display mode „*PV Plot*“. Check whether the entered engine parameters are correctly registered in the software program, refer to chapter 4.

It may only be selected for measurement series which have been registered by using a TDC sensor since this is a prerequisite for the calculation of the volume rating.

If you choose „*PV Plot*“ for a dataset that was registered without the use of a TDC sensor, the message „Not available for measurements without TDC sensor“ will appear on the screen, which means that no curve may be displayed.

The line above the curve provides information about the displayed dataset:

PV Plot : Consecutive numbering of the individual measurements. If the indication was started with cylinder 1, the PV Plot number corresponds to the cylinder number.

Date and time of the measurement

Engine : Number to distinguish several engines (1–9) respectively engine name, refer to chapter 4

Cylinder : Cylinder number (1–24)

The line below the graph contains the following important performance parameters of the respective cylinder:

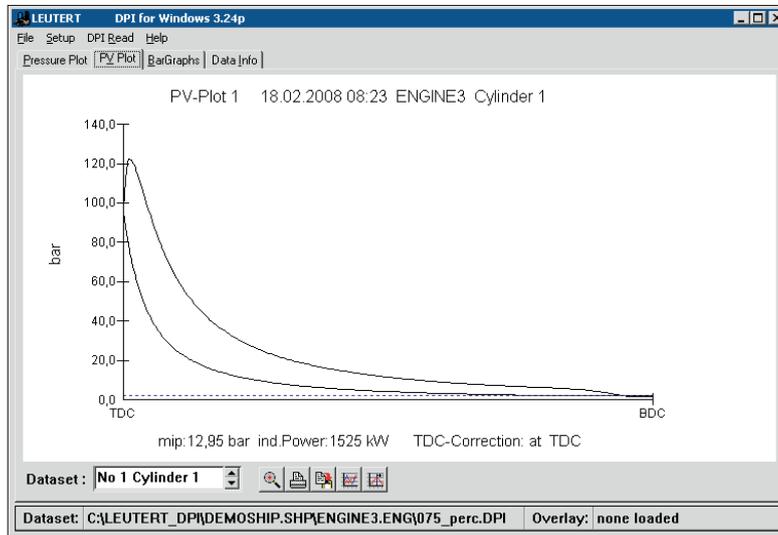
mip : Mean indicated pressure (average pressure) [bar]

ind. Power : Cylinder power [kW]

TDC-Correction : selected TDC correction method

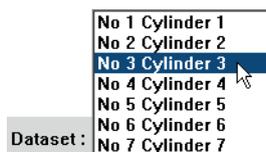
If the message „Setup engine data for correct calculations“ appears after you selected „*PV Plot*“, this means that engine parameters are missing or incorrect. In this case, proceed according to chapter 4.

The following curve depicts the course of the cylinder pressure during a working cycle between the top dead center (TDC) and the bottom dead center (BDC). In addition, the scavenging air pressure (Boost pressure) set on the portable unit is shown as a broken line.



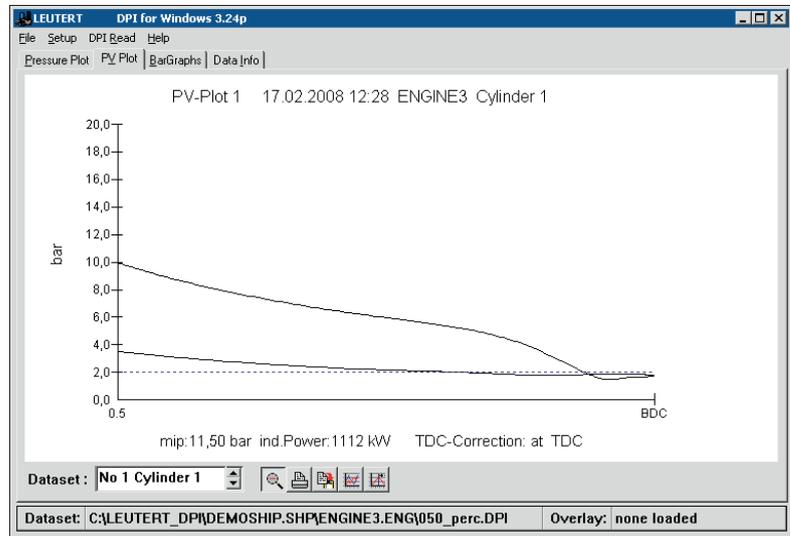
If an error occurs with automatic TDC correction, no performance values will be displayed here.

- 1) You have different options in order to display the individual measurement series of an opened dataset:
 - 1a) Use the scroll arrows of the „Dataset“ field **Dataset : No 1 Cylinder 1** to view the measurement curves of all cylinders one after the other.
 - 1b) On clicking the „Dataset“ field, a list of the measured data available will be displayed, allowing you to mark the desired line.



The curve graph of the selected cylinder will appear on the screen.

- 2) The zoom button  newly implemented in the „PV Plot“ enables an improved analysis of the charge changing process (gas exchange) for 2-stroke engines.



With a mouse click on , the original display is restored. Only one zoom process at a time (in/out) is possible.

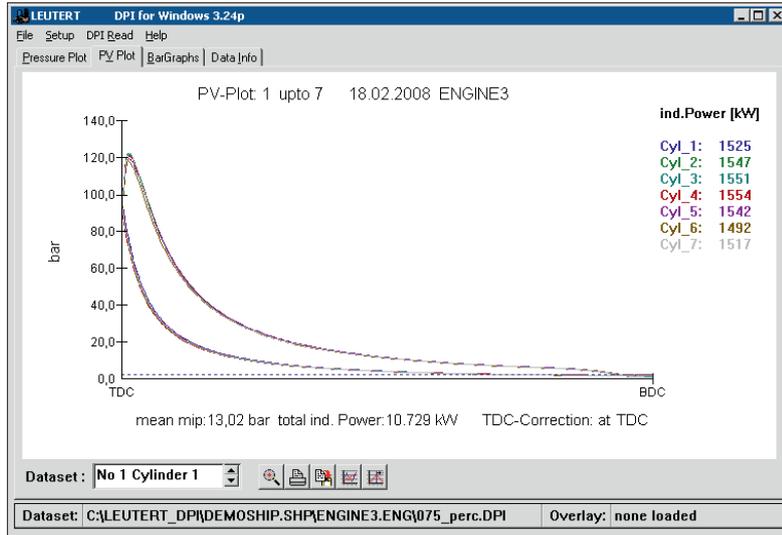
- 3) Another display option is provided by the „Display all“ command which you can select by clicking the  button. This allows you to display simultaneously all performance curves pertaining to the measured cylinders of an engine.

The information given in the line below the graph refers to the following parameters:

mean mip : Average of mean indicated pressures of all cylinders [bar]

total ind. Power : Total engine power [kW]

TDC-Correction : selected TDC correction method



In order to return to the individual display of the previously selected cylinder, click .

- 4) If you want to copy the currently displayed curve to the Windows clipboard, click the  command button.
- 5) Clicking the button  starts printing the displayed measuring curve.
- 6) Actuate the function switch , in order to center the measuring curves in accordance with the method selected under „Engine data“ (see chapter 4).

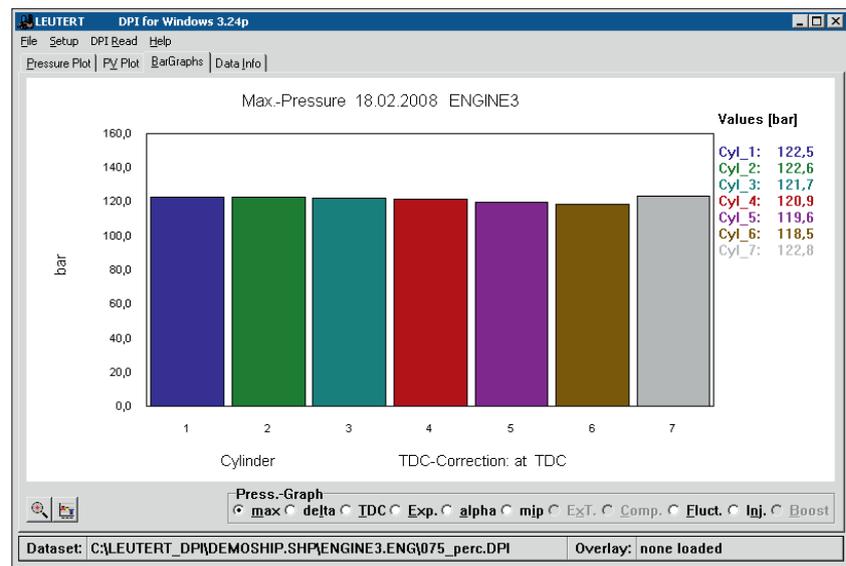
6.4 Viewing „BarGraphs“



In the „BarGraphs“ mode, the selected measured data are displayed as a bar diagram.

This picture allows you to compare the individual cylinders with each other at one glance.

The window below shows an example dataset depicting the maximum pressures of all cylinders which were registered with a TDC sensor and active averaging feature. The latter setting is necessary for displaying maximum pressure fluctuations (Fluct).



The line above the bar diagram gives information about the display mode selected for the Y-axis under „Press.-Graph“, as well as about the date and the time of the measurement series and about the engine number. The X-axis indicates the cylinder number.

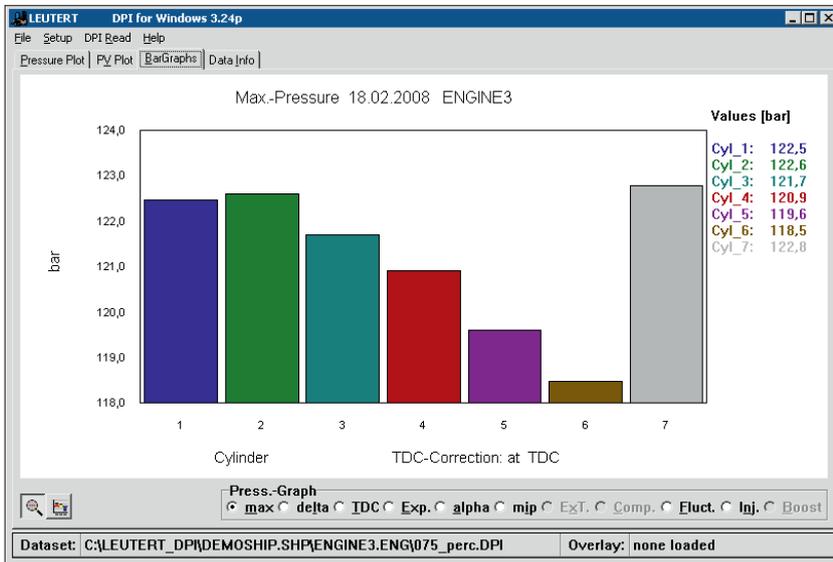
On the right side of the graphic area, you can read the numerical values of the peak pressures of the respective cylinders.



If you observe major differences between the individual cylinders appearing in the bar diagrams, you should compare the measured parameters to the standard ratings defined by the engine manufacturer.

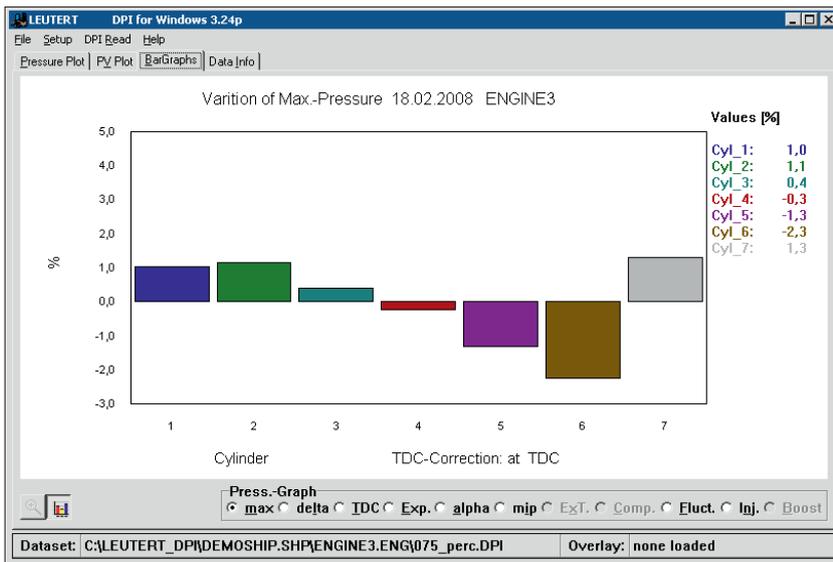
1) Here you can choose the mode you want the data to be displayed.

1a) Zoom in the displayed graph by clicking the zoom button . This view will allow you to distinguish more easily any differences occurring among the cylinders.



In order to return to the previous view, click the  command button again. Only one zooming operation (in/out) is possible at a time.

1b) With the  button you may display the percentage of the difference from each value to the mean value. By clicking again on this button the display will return to the absolute mode.



- 2) Use the following „Press. Graph“ field to select the parameter which you want to view as a bar diagram:



- 2a) The following parameters are available for all datasets:

- max : Peak pressure (p-max), maximum pressures measured on all cylinders of a specific engine
- delta : Differential pressure (p-delta), determined from the pressure at ignition point and the peak pressure

- 2b) If the measurement series were recorded by using a TDC sensor, the following additional parameters will be available:

- TDC : Indicated pressure (pressure at TDC), measured at top dead center
- Exp. : Expansion pressure on all cylinders of a 36 °CA engine after the top dead center
- alpha : Peak pressure position (alpha p-max) in relation to the top dead center
- mip : mean indicated pressure

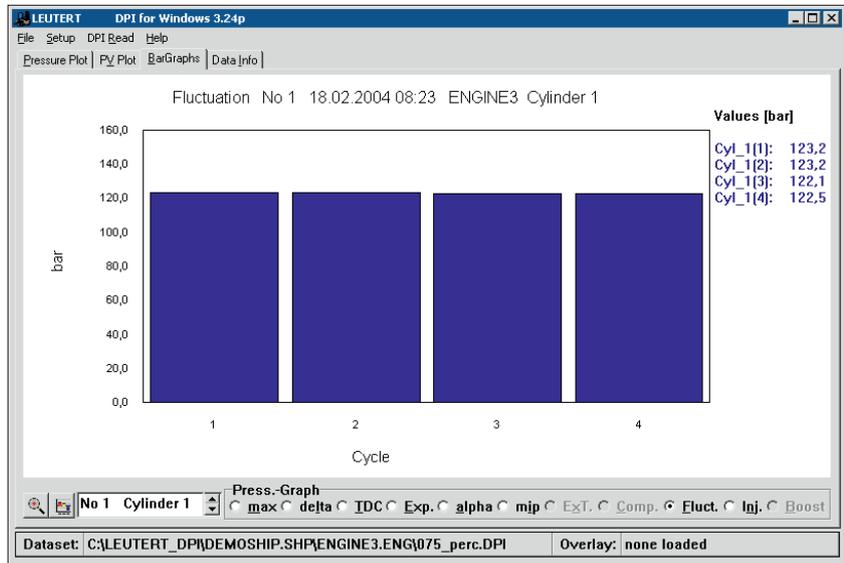
- 2c) If the following parameters are selected in „*Setup / Numeral Display*“ (see chapter 3.5) and the corresponding values are typed in as described in chapter 6.5, they can also be displayed as Bargraph:

- Ext. : Exhaust temperature
- Comp. : Compression pressure

- 2d) For measurements with active averaging option, an additional parameter will be displayed:

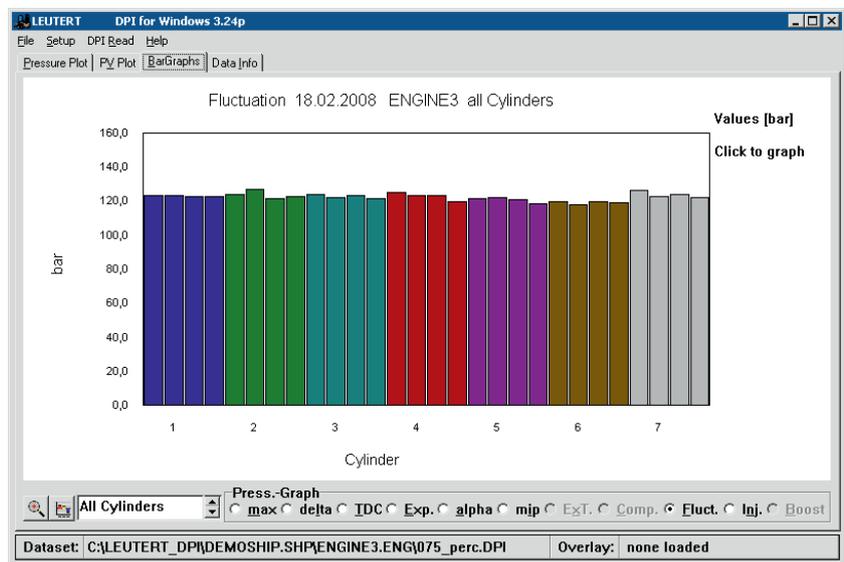
- Fluct. : Peak pressure fluctuations within the averaged working cycles of a cylinder. For a description, see next page.

The corresponding graph is different from the pictures in step 2a and 2b since it depicts the maximum pressures of ONE cylinder in relation to the number of averaged cycles.

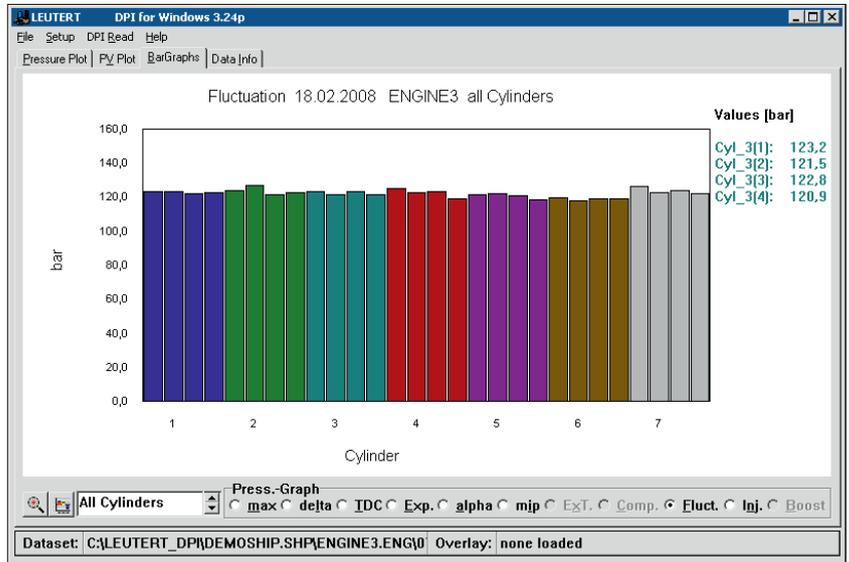


Scroll the field **Dataset: No 1 Cylinder 1** in the usual way in order to select the desired cylinder number.

If you choose **All Cylinders**, the peak pressure fluctuations of ALL cylinders will be displayed simultaneously.

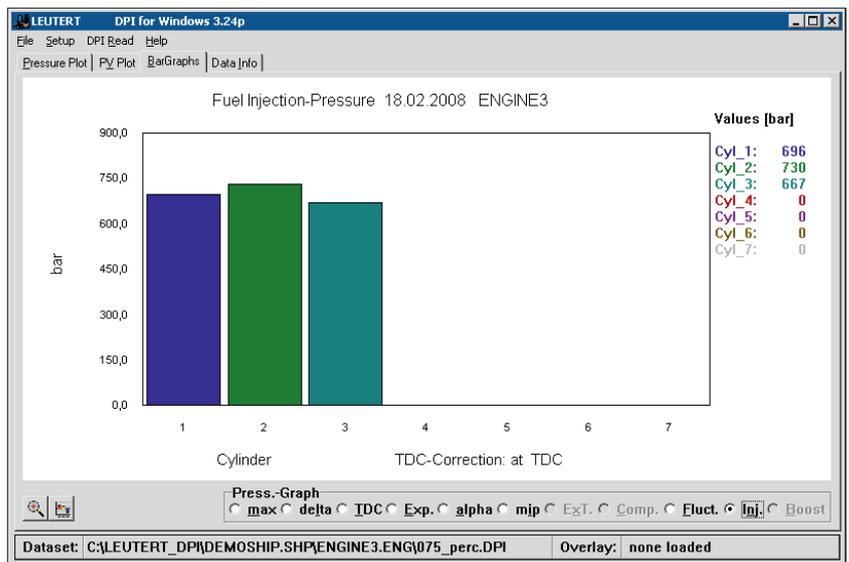


When mouse-clicking on a bar, the numerical values of the peak pressure fluctuations of the MARKED cylinder will appear in the upper right graphic area above the number of averaged cycles. The example shows the configuration of the average of 4 cylinders.



2e) The following parameter appears for measurements with injection pressure sensor:

Inj. : Injection pressure



2f) Additional system components are required in order to display the boost pressure, making it possible to continuously display the boost pressure. If required, please contact the company Leutert.

Boost. : Boost pressure

6.5 Viewing „Data Info“



The „Data Info“ graph shows a numerical display of the measured parameters of a dataset.

| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | mean | total |
|--------------------|------------|------------|------------|------------|------------|------------|------------|-------|-------|
| Engine | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -- | -- |
| Cylinder | 1 | 2 | 3 | 4 | 5 | 6 | 7 | -- | -- |
| alpha TDC [°] | 0 | 257 | 103 | 154 | 205 | 51 | 308 | -- | -- |
| Date | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | -- | -- |
| Time | 08:23:11 | 08:26:01 | 08:27:43 | 08:30:36 | 08:31:48 | 08:32:39 | 08:33:29 | -- | -- |
| Filter | ON | -- | -- |
| Averaging | ON | -- | -- |
| TDC-Correction | at TDC | -- | -- |
| Boost-Press. [bar] | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | -- |
| p-fuel-inj. [bar] | 695,8 | 730,1 | 666,8 | 0,0 | 0,0 | 0,0 | 0,0 | 299,0 | -- |
| p-max [bar] | 122,5 | 122,6 | 121,7 | 120,9 | 119,6 | 118,5 | 122,8 | 121,2 | -- |
| p-max low [bar] | 122,1 | 121,5 | 121,1 | 119,2 | 118,5 | 117,9 | 122,0 | 120,3 | -- |
| p-max high [bar] | 123,2 | 126,8 | 123,4 | 125,0 | 122,1 | 119,6 | 126,2 | 123,8 | -- |
| Fluct. p-max [bar] | 1,1 | 5,3 | 2,3 | 5,7 | 3,7 | 1,6 | 4,3 | 3,4 | -- |
| p-delta [bar] | 26,0 | 28,6 | 28,2 | 29,5 | 25,3 | 26,1 | 29,3 | 27,6 | -- |
| alpha p-max. [°] | 10,5 | 10,8 | 10,6 | 11,0 | 11,1 | 10,3 | 11,0 | 10,8 | -- |
| alpha p-inj. [°] | 0,0 | -0,2 | 0,0 | -0,1 | 0,1 | 0,0 | 0,0 | 0,0 | -- |
| delta TDC [°] | 0,2 | -0,5 | -0,5 | -0,2 | -0,2 | -0,3 | -0,1 | 0,3 | -- |

On clicking the „Data Info“ tab, you will view the table depicted above. It contains all data measured by means of the DPI hand-held unit during indication of the engine and calculated afterwards with the DPI software program.

Next to the cylinder numbers is the „mean“ column which contains the calculated average value for all cylinders of the respective parameter. The „total“ column gives the overall value of the respective line.

The completeness of this table depends on the availability of a TDC sensor and on whether the averaging feature was used on the DPI hand-held unit during the measurements.



Click on the button if you wish to supplement the table by engine data which you have received e. g. from other measuring instruments. The corresponding dialog will be opened then.

| Dataset No. 1, 2, 3, ... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|--------------------------|------|------|------|------|------|------|------|--|
| Boost-Press. [bar] | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | 2,20 | |
| Crank shaft torque [kN] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Exhaust gas temp. [°C] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Fuel inj. pres. [bar] | 696 | 730 | 667 | 0 | 0 | 0 | 0 | |
| Compression pres. [bar] | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | |
| Fuel rack setting | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | |

Type in the separately measured data. Only in „Setup / Numeral Display“ selected parameters are visible in this dialog.

The boost pressure can also be modified here.



Make sure that the actual boost pressure of the engine during indexing is entered under „Boost-Press.“

If it is the same for all cylinders, change only the value in the first field and then click on the <Boost> button to adopt the value for the other columns. The <Reset> button will restore the original values of the boost pressure.

| Dataset No. 1, 2, 3, ... | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|--------------------------|-------|-------|-------|-----|-----|-----|-------|
| Boost-Press. [bar] | 2,1 | 2,1 | 2,1 | 2,1 | 2,1 | 2,1 | 2,1 |
| Crank shaft torque [kN] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exhaust gas temp. [°C] | 420 | 430 | 410 | 415 | 440 | 435 | 395 |
| Fuel inj. pres. [bar] | 695,8 | 730,1 | 666,8 | 0 | 0 | 0 | 299,0 |
| Compression pres. [bar] | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| Fuel rack setting | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |

Buttons: Boost, Reset, OK, Cancel

The other parameters have informative character only and do not have any influence on performance calculation in the software.

When you accept the new entries by clicking on the <OK>. button the values will appear in the „Data Info“ table.

| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | mean | total |
|---------------------|------------|------------|------------|------------|------------|------------|------------|-------|--------|
| Engine | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -- | -- |
| Type (stroke) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | -- | -- |
| Cylinder | 1 | 2 | 3 | 4 | 5 | 6 | 7 | -- | -- |
| alpha TDC [°] | 0 | 257 | 103 | 154 | 205 | 51 | 308 | -- | -- |
| Date | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | 18.02.2004 | -- | -- |
| Time | 08:23:11 | 08:26:01 | 08:27:43 | 08:30:36 | 08:31:48 | 08:32:39 | 08:33:29 | -- | -- |
| Filter | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -- | -- |
| Averaging | ON | -- | -- |
| TDC-Correction | at TDC | -- | -- |
| Boost-Press. [bar] | 2,10 | 2,10 | 2,10 | 2,10 | 2,10 | 2,10 | 2,10 | 2,10 | -- |
| Exhaust temp. [°C] | 420 | 430 | 410 | 415 | 440 | 435 | 395 | 421 | -- |
| p-fuel-inj. [bar] | 695,8 | 730,1 | 666,8 | 0,0 | 0,0 | 0,0 | 299,0 | 341,7 | -- |
| p-max [bar] | 122,7 | 122,7 | 122,0 | 121,0 | 119,7 | 118,6 | 123,0 | 121,4 | -- |
| p-max low [bar] | 122,4 | 121,6 | 121,4 | 119,3 | 118,6 | 118,1 | 122,2 | 120,5 | -- |
| p-max high [bar] | 123,5 | 126,9 | 123,7 | 125,0 | 122,2 | 119,7 | 126,5 | 123,9 | -- |
| Fluct. p-max [bar] | 1,1 | 5,3 | 2,3 | 5,7 | 3,7 | 1,6 | 4,3 | 3,4 | -- |
| Deviation [bar] | 1,3 | 1,3 | 0,6 | -0,4 | -1,7 | -2,8 | 1,6 | 1,7 | -- |
| p-delta [bar] | 26,4 | 28,8 | 28,7 | 29,7 | 25,7 | 26,5 | 29,8 | 27,9 | -- |
| alpha p-max [°] | 10,9 | 10,8 | 10,6 | 11,1 | 11,4 | 10,0 | 11,3 | 10,9 | -- |
| alpha p-inj. [°] | 1,1 | 0,2 | 0,1 | 0,2 | 1,3 | 0,8 | 0,9 | 0,7 | -- |
| delta TDC [°] | -0,2 | -0,5 | -0,5 | -0,3 | -0,4 | -0,6 | -0,4 | 0,4 | -- |
| Press. at TDC [bar] | 96,5 | 93,9 | 93,4 | 91,3 | 94,2 | 92,3 | 93,4 | 93,6 | -- |
| Expan.-Press [bar] | 49,2 | 47,9 | 48,0 | 48,0 | 48,9 | 47,4 | 47,9 | 48,2 | -- |
| RPM [1/min] | 108,9 | 108,8 | 108,8 | 108,8 | 108,8 | 108,9 | 108,7 | 108,8 | -- |
| Flywheel Teeth | 82 | 82 | 82 | 82 | 82 | 82 | 82 | -- | -- |
| Temperature [°C] | 25 | 25 | 25 | 25 | 25 | 25 | 25 | -- | -- |
| mip [bar] | 13,38 | 13,15 | 13,18 | 13,34 | 13,38 | 12,94 | 13,18 | 13,22 | -- |
| ind. Power [kW] | 1.576 | 1.547 | 1.552 | 1.570 | 1.575 | 1.524 | 1.550 | 1.556 | 10.893 |
| P at RPMmean [kW] | 1.575 | 1.547 | 1.552 | 1.571 | 1.575 | 1.523 | 1.551 | 1.556 | 10.893 |

Dataset: C:\LEUTERT_DPI\DEMOSHIP.SHPIENGINE3.ENG\075_perc.DPI Overlay: none loaded

The abbreviations used in the different lines are explained in the following survey:

| | | |
|--------------------------|---|--|
| Engine | : | Number of indicated engine |
| Type (stroke) | : | 2 or 4 stroke engine |
| Cylinder | : | Number of cylinder |
| alpha TDC [°] | : | Top Dead Center of the cylinders related to TDC of cylinder no. 1 |
| Date | : | Date of measurement |
| Time | : | Time of measurement |
| Filter | : | Type of filter activated on DPI hand-held unit during measurement series: filter function (0, 1, 2), ON - software filter enabled |
| Averaging | : | Selected option on DPI hand-held unit during measurement series, ON - averaging over several measurements OFF - averaging not active, individual meas. |
| TDC-Correction | : | Selection of TDC correction method |
| Boost-Press. [bar] | : | Boost pressure of engine |
| Crank shaft torque [kN] | : | Crank shaft torque |
| Exhaust temp. [°] | : | Exhaust gas temperature |
| Fuel rack setting | : | Position of the fuel injection rack |
| Compression press. [bar] | : | Compression pressure |
| p-fuel-inj. [bar] | : | Fuel injection pressure |
| p-max [bar] | : | Peak pressure |
| p-max low [bar] | : | Minimum peak pressure of all meas. cycles ²⁾ |
| p-max high [bar] | : | Maximum peak pressure of all meas. cycles ²⁾ |
| Fluct. p-max [bar] | : | Difference between minimum and maximum peak pressure ²⁾ |
| Deviation [bar] | : | Standard deviation in relation to the average of all peak pressures of a measurement series |

| | | |
|---------------------|---|---|
| p-delta [bar] | : | Differential pressure |
| alpha p-max [°] | : | Peak pressure position in relation to TDC ¹⁾ |
| alpha p-inj [°] | : | Injection-angle calculated of the measured curve |
| delta TDC [°] | : | Correction of the TDC when automatic TDC correction is active |
| Press. at TDC [bar] | : | Pressure value at top dead center ¹⁾ |
| Expan.-Press. [bar] | : | Expansion pressure, value at 36°CA (crankshaft angle) after TDC ¹⁾ |
| RPM [1/min.] | : | Engine speed |
| Flywheel Teeth | : | Number of flywheel teeth ³⁾ |
| Temperature | : | Sensor temperature (only for DPI-1) |
| mip [bar] | : | Mean indicated pressure ¹⁾ |
| ind. Power [kW] | : | Indicated cylinder power ¹⁾ |
| P at RPMmean [kW] | : | Indicated power at mean RPM ¹⁾ |

¹⁾ stands for: only for measurements with TDC sensor

²⁾ stands for: only for active averaging function

³⁾ stands for: only for measurements with CAE sensor

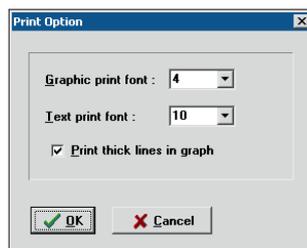
6.6 Printing measured data

The following commands contained in the DPI software program allow you to print any selected curve graphs or tables:

- 1) Use the „Print graph“ command button  if it is available in the tool bar. Alternatively, you may use the „File / Print“ command which is accessible in the menu of each display mode. Select the print parameters in the following window and start printing by clicking <OK>.

The printout will always correspond to the graph currently shown on the screen which is either a curve or bar diagram or a table.

- 2) In certain cases, it is more useful to print in the landscape format. For this purpose, click on the <Setup...> button in step 1 and change the printer settings according to your requirements.
- 3) If you are not satisfied with the printout, select the „File / Print Option“ menu command which will allow you to change the settings for character and line size inside a dialog box.



„Graphic print font“
adjusts the font size in the graphic printout

„Text print font“
is used to adjust the font size for the printout of „Data Info“ and, thus, the size of the printed table

„Print thick lines in Graph“
activates the usage of thick lines in the printout of „Pressure Plot“ and the „PV Plot“. This may give better results on some printers. Usually thin lines give a better resolution.

7 Notes, warnings and error messages

7.1 Notes



Engine type (2/4-stroke) are not the same, comparison is not useful!

Event:

- Opening of a measuring file and of an overlay file

Meaning:

- a 2-stroke engine is compared to a 4-stroke engine
- Comparing data of different engine types is not useful

Different engines are being compared!

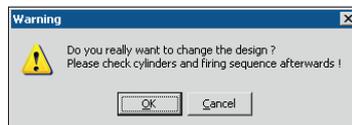
Event:

- Opening of a measuring file and of an overlay file

Meaning:

- Different engines are compared to each other
- Measuring file and overlay file are not from the same engine

7.2 Warnings



Do you really want to change the design? Please check the firing sequence then!

Event:

- For input/change of the engine design, see „*Setup / Engine Data*“

Meaning:

- Please check the firing order after entry or change of the engine design (in-line engine or VEE type engine).

**Do you really want to send configuration to DPI?
Stored datasets in DPI for this engine will be deleted!**

Event:

- Transmission of a configuration file with new parameters from PC to DPI hand-held unit

Meaning:

- Please save the measuring data stored on the DPI hand-held unit to the PC before loading the new configuration file into the DPI hand-held unit. Otherwise, the measuring data will be lost, since they are deleted when re-configuring the DPI-2.

You are going to change the DPI engine number! It is not permitted if there are already measurements stored with the previous number!

Event:

- Change of the "DPI engine number" (see „*Setup / Engine Data*“) after measuring data have already been saved

Meaning:

- Measuring data have already been saved under the previous "DPI engine number". The engines on board are assigned unique consecutive numbers. In this process, no number must be assigned twice, nor must this number be changed subsequently.

Do you really want to delete Dataset?

Event:

- Deletion of a measuring file

Meaning:

- Abort the deletion process or delete file, respectively

**Creating new engine is not allowed with opened datafile!
Please close the application and restart it without opening any datafile in order to create a new engine!**

Event:

- Clicking on <Create new> in the "Read DPI data" menu after execution of the "DPI read" command while the measuring file is open

Meaning:

- It is not possible to create a new engine during communication with the DPI hand-held unit, if one measuring file has already been opened.
- Close and restart the DPI software. Carry out the „*DPI Read*“ command and create a new engine by means of <Create new>, without opening a measuring file.

There was a manual copy or renaming of the INI-File or the subdirectory! Please do not rename any INI-Files of the DPI, because this may lead into trouble to get the correct engine data as it has been setup before!

Event:

- Opening a measuring file of an engine the *.eng directory of which was renamed outside of the DPI software
- Opening a measuring file the *.ini engine parameter file of which was renamed outside of the DPI software

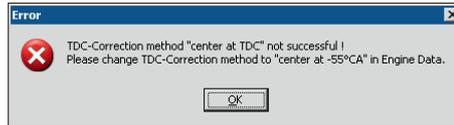
Meaning:

- The software cannot find the *.ini engine parameter file required to display the measuring file.
- Select the correct "INI file" from the list offered.

7.3 Error messages

Error messages appear either in the program window beneath the graph or in a separate box.

7.3.1 Error messages in a separate box



Correction method „center at TDC“ not successful! Please change TDC-Correction method to „center at -55°C“ in Engine Data.

Meaning:

- Automatic TDC correction “center at TDC” could not be performed correctly.

Cause:

- The curve shape does not allow centering in the area of the TDC position.

Recommended measure:

- If this error message appears only with individual cylinders, check injection, if applicable. If this error message appears predominantly with old cylinders, please select the TDC correction method “center at -55 °CA”.

Cause:

- The alpha angle set in the engine parameters is incorrect

Recommended measure:

- Correct the alpha angle in the DPI software under „*Setup / Engine Data*“ and/or in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing an alpha angle in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

Cause:

- The engine type set in the engine parameters is incorrect.

Recommended measure:

- Correct the engine type in the DPI software under „*Setup / Engine Data*“ and/or in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing an engine type in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

Please check DPI-Handheld settings for alpha TDC, or update Engine Data!

Cause:

- The alpha angles stored in the DPI software do not match the alpha angles stored in the measuring file.

Recommended measure:

- Make sure that the alpha angles in the DPI software under „*Setup - Engine Data*“ match those in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing an alpha angle in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

Boost-Press. exceeds limits 0 to 5 [bar] are allowed only!

Cause:

- The boost pressure (Boost-Press.) under „*Data Info*“ in the „*Additional entries*“ dialog window has been entered incorrectly!

Recommended measure:

- Enter a boost pressure in the range between 0 and 5 bar.

These are old measurements. Please use DPI Version 3.21

Cause:

- These measuring data cannot be processed with the current DPI software.

Recommended measure:

- Please use DPI software version 3.21 or below for this file.

Setting for engine type in this Datafile does not fit with setting in Engine Data! Please check DPI-Handheld settings for engine type (stroke), or update Engine Data !

Cause:

- The engine type stored in the DPI software does not match the engine type stored in the measuring file.

Recommended measure:

- Set the correct engine type in the DPI software under „*Setup / Engine Data*“ and in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing the engine type in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

Datafile does not match with the selected engine! Please transfer this datafile into the correct engine-folder.

Cause:

- The engine name stored in the DPI software and the engine number do not match the values stored in the measuring file.

Recommended measure:

- Copy the measuring file to the related folder or transfer it once more to the correct folder.

Cause:

- Engine number and engine name were changed after indexing of the engine.

Recommended measure:

- The engine numbers assigned by the software to the individual engines on board (DPI engine number, see „*Setup / Engine Data*“) must not be changed in any case!

Please check CAE-Sensor!

Cause:

- The number of teeth on the flywheel detected during the measurement is not constant.

Recommended measure:

- Check the CAE sensor and clean or adjust the sensor, if required.

DPI datafile is corrupted. Please delete this file!

Cause:

- The measuring file is defective or incomplete and cannot be opened.

Recommended measure:

- Delete or overwrite the measuring file and repeat the measurement

Select a valid ComPort first!

Cause:

- Due to a missing interface definition, a connection to the DPI hand-held unit cannot be established.

Recommended measure:

- Select an available serial interface from the „Serialport selection“ window (see also chapter 3.2).

Timeout in communication**Please check ComPort settings, serial connections and DPI status!**

Cause:

- No communication with the DPI hand-held unit could be established within a "Timeout" period.

Recommended measure:

- Check the ComPort definition, the correct contacting of the interface connection, and verify whether the DPI hand-held unit is ready for operation.

Settings were not transferred correctly!

Cause:

- The engine data have not been transmitted to the DPI hand-held unit.

Recommended measure:

- Establish a correct connection between the PC and the DPI hand-held unit. Repeat sending the engine data.

7.3.2 Error messages in the program window**ERROR: Setup Engine Data for correct calculations!**

Mode: PV Plot

Cause:

- The engine parameters required for performance calculation have not been entered yet.

Recommended measure:

- If applicable, register the DPI software (see chapter 3.1).
- Enter the engine parameters under „*Setup / Engine Data*“.

ERROR: TDC-Correction „center at -55°CA“ out of range!

Mode: PV Plot, BarGraphs

Meaning:

- Automatic TDC correction "center at TDC" could not be performed correctly.

Cause:

- The alpha angle set in the engine parameters is incorrect.

Recommended measure:

- Correct the alpha angle in the DPI software under „*Setup / Engine Data*“ and/or in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing an alpha angle in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

ERROR: Check measurement conditions and settings for correct calculations!

Mode: PV Plot, BarGraphs

ERROR: Check measurement conditions and settings!

Mode: Pressure Plot

Meaning:

- The cylinder pressure curve is not within the standard range.

Cause:

- The alpha angle set in the engine parameters is incorrect.

Recommended measure:

- Correct the alpha angle in the DPI software under „*Setup / Engine Data*“ and/or in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing an alpha angle in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

Cause:

- The measured cylinder did not match the cylinder number displayed in the DPI hand-held unit during measurement.

Recommended measure:

- Set the correct cylinder number for the measurement and make sure that the cylinder number displayed in the DPI hand-held unit matches the cylinder to be measured.
- Delete the defective measuring file and repeat the measurement.

Cause:

- The pressure curve was corrupted by a defective indication valve.

Recommended measure:

- Replace the indication valve.
- Delete the defective measuring file and repeat the measurement.

Cause:

- The boost pressure set in the DPI hand-held unit is incorrect.

Recommended measure:

- Correct the boost pressure in the DPI software under „*Setup / Engine Data*“ and in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- The boost pressure may also be adjusted subsequently in the DPI software (see „*Data Info*“ display mode, „additional entries“ button).

Cause:

- The cylinder pressure was measured without injection, what you see is a so-called tractrix.

ERROR: Power calculation!

Mode: PV Plot

ERROR: Calculation of Mean indicated Pressure!

Mode: BarGraphs

Meaning:

- The calculation of performance or of the indicated mean pressure did not result in usable values.

Cause:

- The alpha angle set in the engine parameters is incorrect.

Recommended measure:

- Correct the alpha angle in the DPI software under „*Setup / Engine Data*“ and/or in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).
- After changing an alpha angle in the DPI hand-held unit, please delete the defective measuring file and repeat the measurement.

Cause:

- The „TDC correction angle [°CA]“ set in the DPI software under „*Setup / Engine Data*“ is incorrect.

Recommended measure:

- Enter the correct correction angle.

Cause:

- The engine data set in the DPI software are incorrect.

Recommended measure:

- Correct the engine data in the DPI software under „*Setup / Engine Data*“ and in the DPI hand-held unit (see operating manual of the DPI-2 hand-held unit chapter 5.3.3).

Not available for measurements without TDC sensor!

Mode: PV Plot

Meaning:

- The „*PV Plot*“ display mode illustrates the cylinder pressure in relation to the progression of the volume. It can only be used for measuring series recorded by means of a TDC sensor, since only in this case, the volume curve can be calculated.

Cause:

- The measuring series have been recorded without TCD sensor.

Recommended measure:

- Repeat the measurement with a TDC sensor, if required.

7.4 Typical error plots

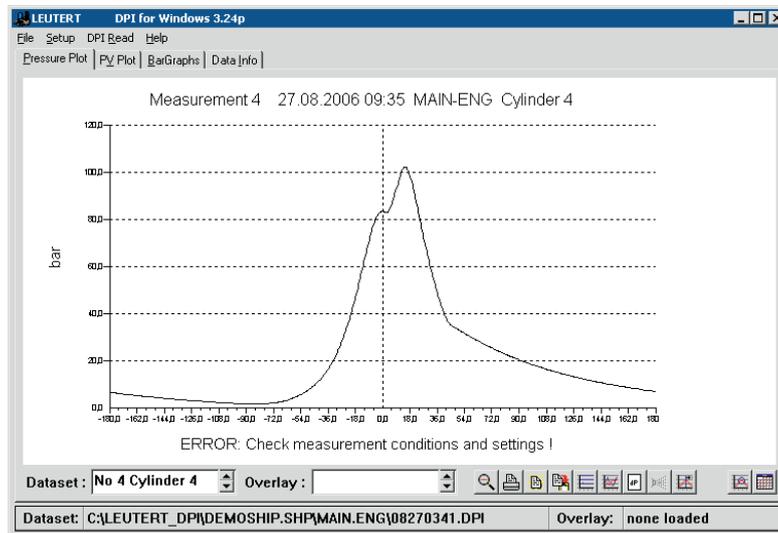
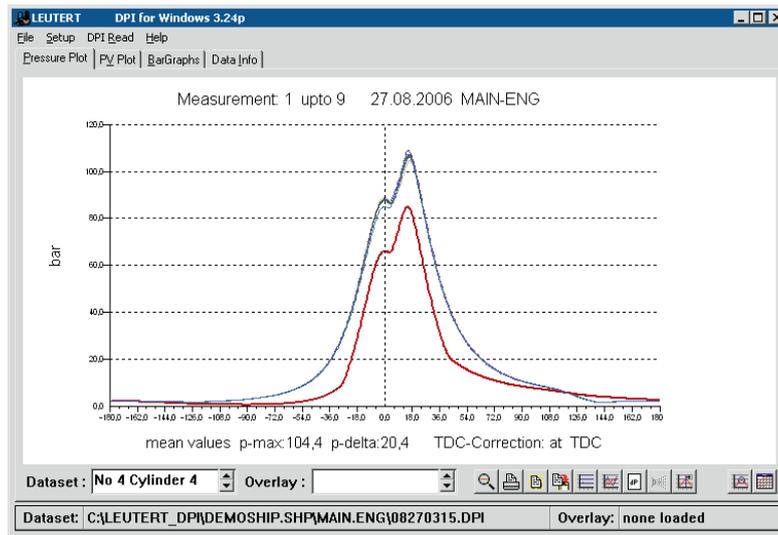
Mode: Pressure Plot

Cause:

- Defective indicator valve of cylinder no. 4

Recommended measure:

- Check the defective valve and replace it, if required.



Mode: Pressure Plot

Cause:

- Incorrect alpha angle, except cylinder no. 6

Recommended measure:

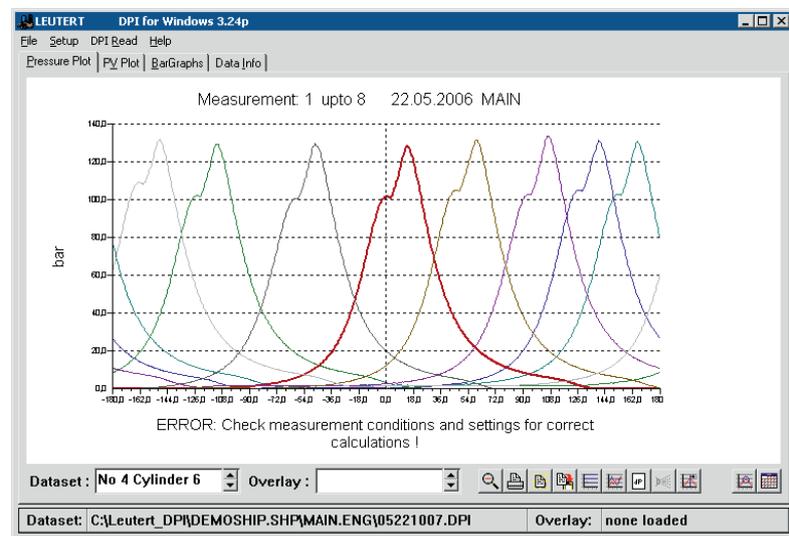
- Enter the correct values for the alpha angles under „*Setup / Engine Data*“ and transmit these settings to the DPI hand-held unit. Repeat the measurement.

Cause:

- Incorrect cylinder numbers were used during indexing.

Recommended measure:

- Make sure that the measured cylinder matches the one entered in the DPI hand-held unit.



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