LEUTERT™

SINCE 1941

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Digital Pressure Indicator DPI

Operating Instructions

Cylinder pressure monitoring

The DPI Digital Pressure Indicator measures dynamic pressures. It is designed to analyze the internal combustion curve of large two and four stroke diesel engines. The measurement is performed via an indicator valve.

Content

General

The operating instructions serve to ensure that the product is used properly, effectively and safely. Please read all instructions and warnings carefully. Follow all safety precautions to avoid personal injury or property damage during the workflow. For damage or injuries caused by non-compliance with the requirements, the manufacturer assumes no liability. The manufacturer also takes over no liability if other than original manufacturer spare parts and consumables are used.

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 the manufacturer 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.

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

1   Safety instructions

The DPI may only be operated by trained personnel with the utmost caution and in compliance with the safety regulations for measuring large diesel and gas engines.

⚠ DANGER

Wear protective glasses during the measurement as hot gas or particles come out of the engine and could injure you. Wear hearing protection during the measuring process as it can get very loud in the engine room.

⚠ WARNING

Put on protective gloves before measuring because the surface of the indicator valve and the sensor can get very hot during the indication process.

Do not operate the DPI hand-held device and the pressure sensor above the allowed pressure and temperature ranges.

Remove the pressure sensor from the indicator connection immediately after each measurement to avoid overheating.
Use the hollow key provided.

ℹ NOTICE

Protect the DPI from moisture to prevent corrosion damage.

Do not insert any tools into the sensor bore.

Cooling the sensor with liquids is not permitted.

If the BAT indicator light on the handheld device is red this indicates a low battery charge. There remains a measuring time of about 20 minutes. End the measurement within this time and charge the batteries.

Charge the batteries via the USB connection of the handheld device by the PC or with the associated USB charger.

2 Product description

2.1 Application and function

The DPI (Digital Pressure Indicator) measures dynamic pressures. It serves for Analysis of combustion processes in 2- and 4-stroke large diesel engines. The measurement is carried out via an indicator valve. This electronic indicator is the consistent further development of the successful digital indicators of the DPI range and replaces all mechanical indicators.

In order to be able to measure pressure profiles with the DPI each cylinder of the engine must be equipped with a standard indicator valve. By means of the Thompson adapter the DPI pressure sensor is temporarily mounted to the corresponding indicator valve. The construction of the Thompson adapter minimizes the risk of overheating since the heat is dissipated quickly.

By using a high-resolution sensor and a very high query rate of the hand-held device the DPI can assign a crank angle performance and create a power calculation without the use of a TDC sensor.

The electronics of the battery-operated DPI handheld device is installed in a robust splash-proof plastic housing. The low mass display is not pulled out of its seat in the event of impacts as it is often the case with larger displays.

Menu texts and measurement data are shown on the LC display of the DPI hand-held device. The menu structure is easy to grasp and enables you to operate measuring system intuitively. The menu-driven control enables you to use the DPI effectively after a short time.

The DPI is operated with standard AA batteries which can be replaced by releasing a single screw.

The measurement results are displayed during the respective cylinder measurement on the display of the DPI handheld device and are saved on the device's internal SD card.

A data set consists of several measurements (cylinder numbers) that amongst other things contain the following values:

– Place of measurement (ship name)
– Engine name
– Date / time
– Number of measuring cycles (cycles)
– Highest cylinder pressure (Max. Press.)
– Average cylinder pressure (Avg. Press.)
– Lowest cylinder pressure (min. Press.)
– Engine speed (RPM)
– Boost pressure

All representations and mathematical calculations in the DPI software are based on this data.
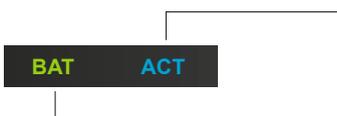
The saved measurement data can be transferred to a PC / laptop by the DPI software to be visualized, evaluated or to be sent electronically.

The measurement data evaluation using Windows-based software gives the ability to make complex diagnostic statements about the quality of the combustion processes.

Every product is manufactured according to the ISO 9001 quality standard, tested and shipped with a calibration certificate which guarantees a high device accuracy.

2.2 Handheld device

2.2.1 Design

4-pin connection socket for pressure sensor

LC display with backlight,
4 lines x 20 alphanumeric characters

LED for status display of the batteries
and of the measuring process

ON / OFF button

Control buttons

USB socket type B

ACT display:
– flashes blue during the measurement

BAT battery charge displays:
– lights up red: low battery charge
– flashes red: the automatic shutdown will take place shortly
– flashes green: active charging of the batteries
– glows green: batteries fully charged

Shoulder strap

Battery compartment for 4 x 1.5 V
rechargeble batteries

Type label with CE marking

Plastic housing

2.2.2 Technical data

|		
Storage capacity	:	50 engines with up to 24 cylinders each
Interface	:	USB 2.0
Power supply	:	rechargeable standard AA NiMH batteries 1.2 V / 2000 mAh
Battery life	:	> 8 h for sensor 0 to 300 bar
Battery charging	:	via USB
Display	:	20 x 4 alphanumeric characters, with backlight, high contrast
Degree of protection	:	IP 65
Temperature range	:	0 bis 55 °C
Dimensions	:	211 x 100 (81) x 45 (26) mm
Weight	:	430 g incl. batteries

2.3   Pressure sensor

2.3.1 Design

The DPI is supplied with a pressure sensor and connection cable. By the armored cable with plug the sensor is connected with the DPI hand-held device.

The pressure sensor is suitable for temporary measurements on indicator valves only (gas pressure measurements on internal combustion engines). Measurements on hydraulic systems must not be carried out.

The quartz sensor is characterized by high accuracy, robust construction and durability. Its calibration interval is 8000 operating hours. The calibration check can only be carried out by the manufacturer. In this regard please contact the manufacturer.

Connection cable

Piezoelectric sensor (inside)

Connection thread W27 x 1/10 ″
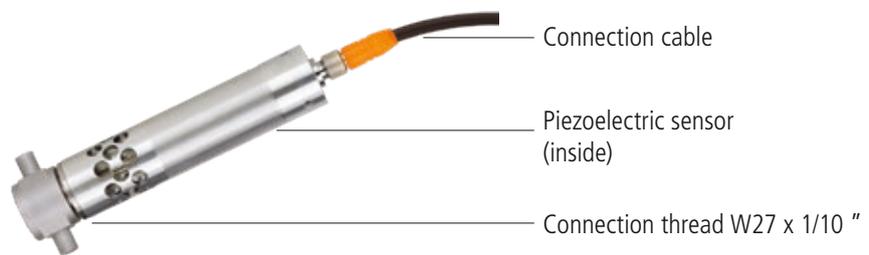
ℹ️ NOTE
The screw of the pressure sensor is sealed to prevent improper use or handling. Breaking the seal will lead to loss of warranty.
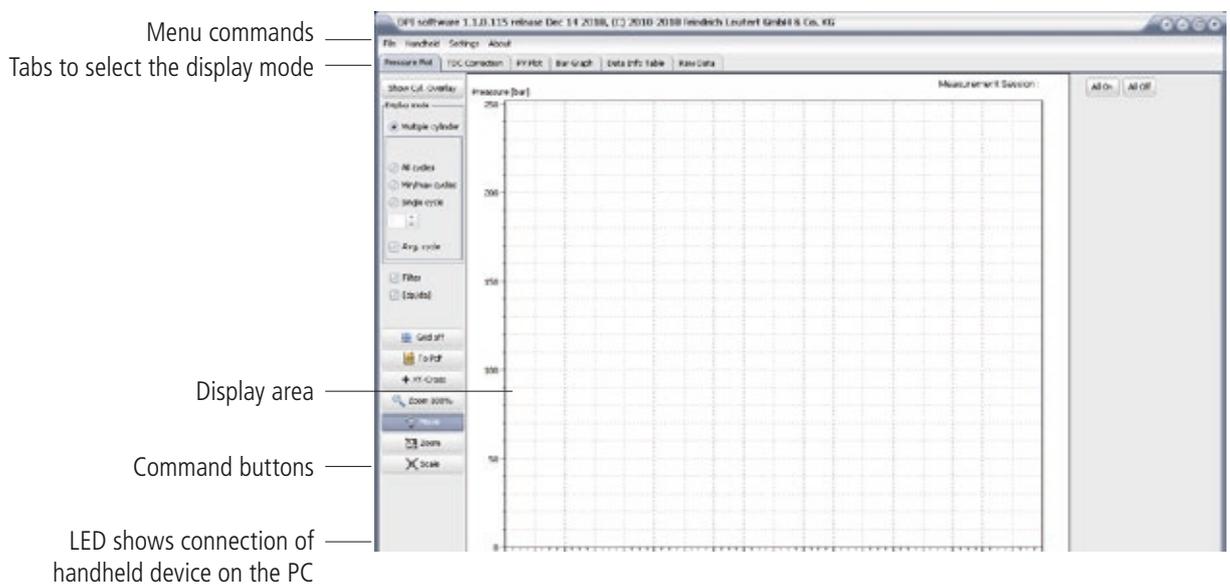
2.3.2 Technical data

Pressure range	:	0 to 300 bar
Speed range	:	50 to 5000 rpm
Accuracy	:	< 0.5%
A/D resolution	:	16 bit (0,0092 bar/sample)
Degree of protection	:	IP 65
Connection thread	:	W 27 x 1/10″
Temperature range	:	0 to 350 °C
Dimensions	:	Ø = 60 mm, L = 180 mm
Weight	:	approx. 490 g

2.4   Software

2.4.1 Description

After measuring the engine the measuring values saved in the handheld device are transferred to the PC and can be displayed with the DPI software and evaluated in detail. To analyze the engine data different visualization modes are available (pressure diagram, PV diagram, bar graphs, tabular information).

To operate the DPI software you can use the commands in the menu bar, the four tabs for selecting the display mode and various buttons.

Menu commands

Tabs to select the display mode

Display area

Command buttons

LED shows connection of handheld device on the PC

The software enables data export, report generation or sending of the data by email with just a few clicks.

In addition the software is used for comfortable configuration of the handheld device.

Since the software is in English language basic knowledge of English is favorable but not a requirement. In the manual you get a detailed description for each command which enables you to work with the program without any foreign language skills.
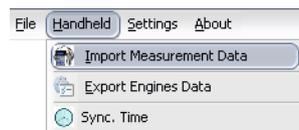
Menu commands

Menu "File"
Opens a data record from the PC's hard drive
Data export as a dpz file on a PC or by email Imports a dpz file from the PC hard drive
Exports the opened data record to an xls file Create a report for printing or as a PDF file
Exit the program, also with Alt + F4

*)   A dpz file is a measurement data record in DPI format and to be read with the DPI software only.

Menu „Handheld"
Imports a data record from the handheld device into the PC
Exports the engine data
Synchronize the date/time of the handheld device with the PC

Menu „Settings"
Selection of the display colors for the 24 cylinders
Enter the company name, address and logo for the report

Menu „About"
Display of software version and manufacturer
Find and install updates available online
Link to the manufacturer's homepage

2.4.2 Requirements for the PC

In order to be able to run the DPI software, your PC should meet the following requirements:

– A free USB port for data transfer between the handheld device
– and PC
– approx. 15 MB free space for the installation of the software and the
– documentation
– Windows 7 and higher
– minimum screen resolution 1024 x 768, recommended 1280 x 1024
– Color 16 bit or higher
– Printer, color printer recommended

This manual was created for software users who have basic knowledge of computer skills. You should be familiar with the typical Windows features like menus and command buttons since these elements are not explained here.

# 3 Preparation of the DPI system for use

3.1 Software installation

The software is stored in the handheld device's memory upon delivery and must be copied and installed on the PC before use.

1) Connect the DPI handheld device with a Windows PC using the supplied USB cable. The DPI automatically turns on and is recognized by the computer as a drive. Additional device drivers do not need to be installed.

2) Open the newly recognized drive 'DPI'. Select the file 'Installer DPI (version no.). Exe' and copy it to the PC, for example on the desktop.

> **i** NOTICE
> DO NOT start the installation directly from the DPI drive!
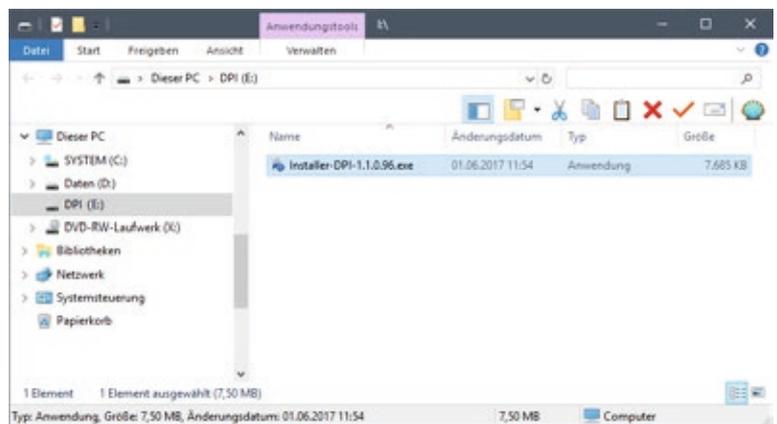
3) Start the software installation on the PC by double-clicking to the file 'Installer DPI (version no.). exe'.

4) Confirm the license conditions and continue with [Next>].
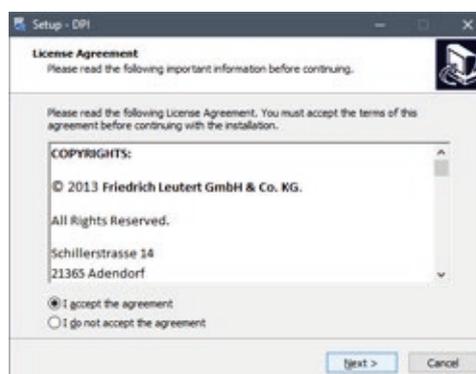
5) Follow the further installation instructions. Finally the DPI and a program group appears in the Windows start menu and Desktop icon for the DPI software.

If a previous version of the DPI software is already set up on your PC, you can update it. You will receive updates e.g. electronically..

Start the installation of the new software as described above. Here the installation program searches for existing versions and automatically selects their installation path.

During the update the program files are updated as well.
The directory with the measurement data remains unaffected.

NOTICE
The measurement data and program settings are saved on the System drive C under your user name \ My Documents \ DPI. Please back up this data regularly. Please be aware that a reinstallation of Windows will overwrite the directory `My Documents` and the data could be lost.

3.2 Prepare the handheld device for the measurement

3.2.1 Enter engine parameters

At first use of the device you have to enter the engine parameters once for each engine.

ℹ NOTICE
Pay attention to correct entries so that the DPI gives you correct measurement results.

1) Start the DPI software on the PC. Open the command [Open Database] in the menu [File].
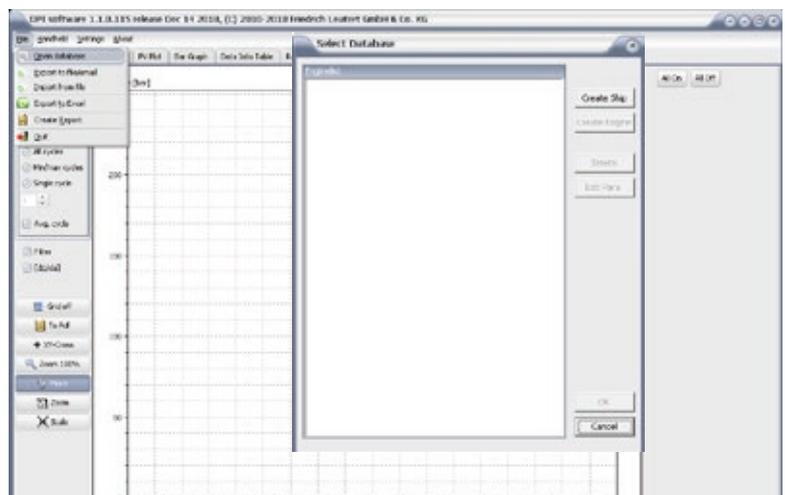
2) Select [Create Ship]. Place the mouse pointer on the line 'ANewShip' and enter the name of the ship / power plant or similar. Under 'Description' you can write down additional information. Save the entries with [Save].

3) Mark the ship's name and click on [Create Engine] to set up an engine for this ship.

4) Enter the engine-specific parameters in the 'Create new Engine' window.

Engine name	: Name of the engine
Stroke length	: Stroke length of the engine
Connection rod length	: Connecting rod length of the engine (see notice below)
Piston diameter / Bore	: Piston diameter of the engine
Engines	: Select engine type with preset settings from database
Default boost pressure	: Scavenging air pressure of the engine*
Default meas. cycles	: Number of complete engine cycles you want to measure*
Default meas. cylinder	: Number of cylinders of the engine
Default stroke	: 2- or 4-stroke engine
NOx	: Check when engine type has premature combustion
V-Engine (A/B Bank)	: Check in case engine is V-type
Tdc sensor enable	: Check in case you are using (optional) pick-up sensors
Config TDC Sensor	: Set firing order of the engine
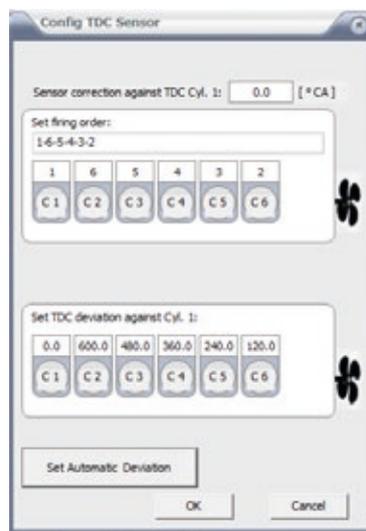
*these values can still be changed in the handheld unit before starting the measurement.

i NOTICE
When determining the length of the connecting rod the distance between the large end and the small end has to be considered and not the total length of the connecting rod.
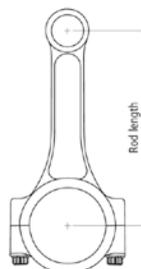
The DPI is able to measure the TDC based on the pressure curve showing the course of combustion. This is the basis of the power calculation. For engines with premature combustion for reduction of nitrogen oxide emissions some peculiarities result regarding the automatic detection of the TDC. In these cases the check box [NOx] can be ticked to determine the TDC.

Use the DPI's ability to prevent interfering influences on the measurement result by selecting certain measurement settings, e.g. the number of measurement cycles as basis for averaging. This gives you results which enable you to compare the measurement data of the individual cylinders to each other.

5) Save the entries with [OK]. Repeat this step for more engines if necessary.

During the indication process the DPI uses the current measuring settings for each engine. These will be saved until they are redefined.

3.2.2 Transfer engine parameters to the handheld device

1) Connect the handheld device to the PC by means of the USB cable. The handheld device switches on automatically and the battery charging process begins.

2) A green LED symbol in the status bar of the DPI software indicates that the handheld device is connected to the PC.

> **i** NOTICE
> If the handheld device is connected to the PC or the battery charger via USB button operation is not possible.

3) Open the [Export Engines Data] command in the [Handheld] menu.

In the upper 'Setup' area the datasets are displayed which are already stored in the handheld device. If you mark an engine with the mouse you will see the assigned "parameters" in the lower window area. If no engine data has been saved yet in the handheld device the following window would be empty.
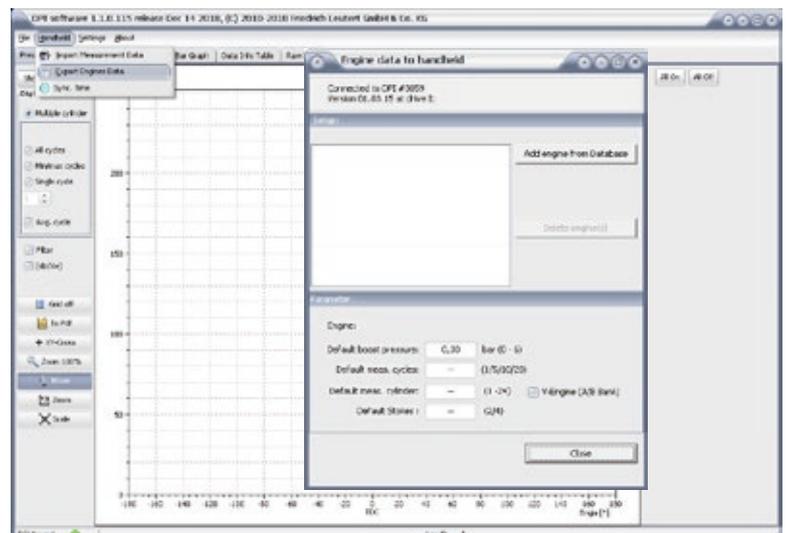
4) Click the [Add Engine from Database] button.

5) Mark the desired engine and click on [To Handheld]. After success-fully transferring the engine parameters to the connected hand-held device the new engine appears in the list. The handheld device is now ready for the measurement.
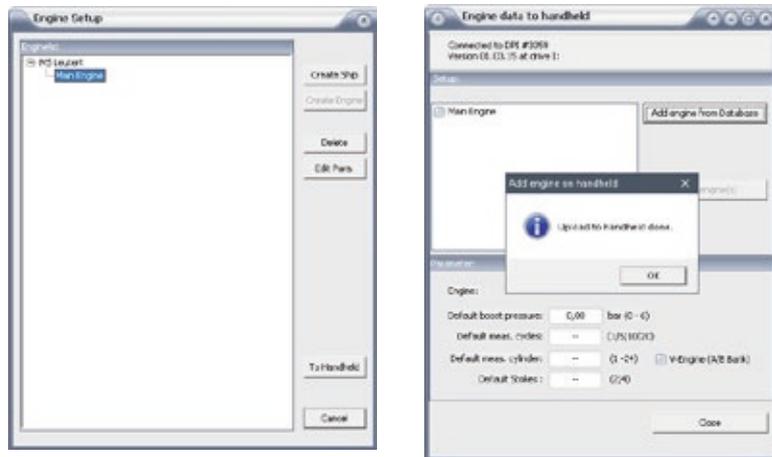
ℹ **NOTICE**
You can enter and save the parameters of a maximum of 50 engines in the DPI.

6) Close the window with [Close] and disconnect the handheld device from the PC.

3.3 Set the date and time of the handheld device

The correct value of time and date is necessary to ensure an exact temporal assignment of the measurement results.

The date format is month / day / year, the time is displayed in hours:Minutes:seconds.

The date / time setting of the handheld device is done in the DPI software by synchronization with the PC settings, provided the PC is set up correctly.
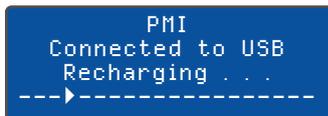
1) Connect the handheld device to the PC using the USB cable. The handheld device switches on automatically and the battery charging process begins.

2) Start the DPI software on the PC.

3) Open the menu [Handheld] and [Sync. Time].

4) Click the button [Synchronize Time to Handheld] button. The date and time settings of the PC are transferred to in the handheld device and saved there.

5) If necessary, disconnect the handheld device and PC. The handheld device switches off automatically.

4   Perform measurement on the engine

⚠️ DANGER

Wear protective glasses during the measurement as hot gas or particles come out of the engine and could injure you.

Wear hearing protection during the indication process as it can get very loud in the engine room.

⚠️ WARNING

Put on protective gloves before indicating because the surface temperature of the indicator valve and the sensor can get very high during the indication process.

Do not operate the DPI handheld device and the pressure sensor above the allowed pressure and temperature ranges.

ℹ️ NOTICE
Ensure that the load and the speed is as constant as possible during the measurement in order to get comparable results.

If the sensor cable is not connected to the sensor, insert the orange contact into the pressure sensor and secure the contact by screwing on the knurled nut. Pull it hand tight. The plugs of the connection cable have a "nose / slot" connection identifier. Please pay attention to correct insertion.
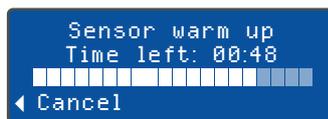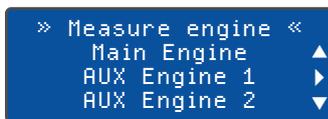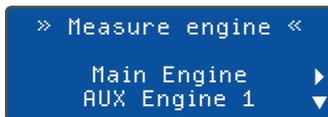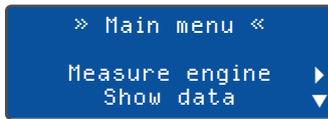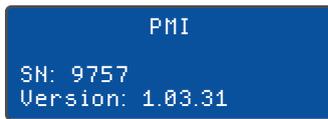
Plug the sensor cable into the 4-pin connection socket of the handheld device. Please make sure that the red marking point shows towards the display of the handheld device and the plug is not turned.

1)   Before installing the pressure sensor, clean the relevant indication channel by fully opening the indicator valve briefly while the engine is running in order to blow out the channel. You thus avoid the sensor membrane being contaminated or damaged.

2)   After blowing out close the indicator valve completely.

3)   Then attach the pressure sensor to the indicator connection of the Engine.

ℹ️ NOTICE
First hand-tighten the cold sensor to prevent it from seizing.

```
         PMI

SN: 9757
Version: 1.03.31
```

```
   » Main menu «

  Measure engine    ▶
    Show data       ▼
```

```
  » Measure engine «

   Main Engine       ▶
   AUX Engine 1      ▼
```

```
  » Measure engine «
   Main Engine        ▲
   AUX Engine 1       ▶
   AUX Engine 2       ▼
```
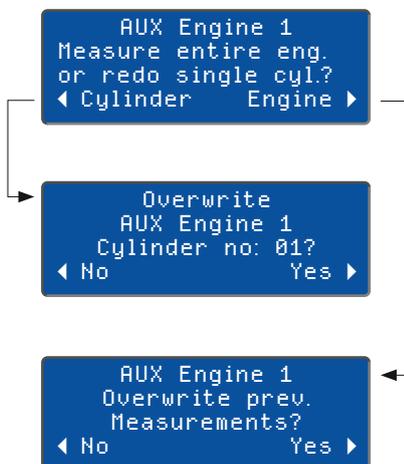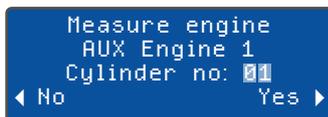
4)   Press the button ⏻ for 1 second to switch on the handheld device. The serial number and the firmware version appear on the display for a short time.

5)   In the main menu you can now use the arrow keys ⏶ or ⏷ to change the lines. Confirm with the button ❯ if the line `Measure engine` is marked by the ▶ arrow.

6)   Scroll with the vertical arrow keys ⏶ or ⏷, until the motor to be measured is marked on the display with the ▶ arrow.

7)   Open the indicator valve completely.

```
   Sensor warm up
   Time left: 00:48
 ▓▓▓▓▓▓▓▓▓▓▓░░░
 ◀ Cancel
```

8)   Start with ❯. The sensor warm-up phase begins. A cancellation is possible with the button ❮ , the display changes back to the main menu.

   ℹ️   NOTICE: Do not turn off the DPI before the measurement is terminated otherwise you would have to wait for the pressure sensor to warm up again before each measurement.

```
  Measure engine
   AUX Engine 1
  Cylinder no: 01
 ◀ No          Yes ▶
```

9)   The engine to be measured appears after the warm-up phase. Below that the cylinder number appears as a flashing digit. If necessary change the cylinder number with the arrow keys ⏶ or ⏷. Confirm by ❯.

   ℹ️   NOTICE: The series of measurements automatically starts with cylinder 1 at the beginning of a new measurement. Otherwise the system is counting up starting from the last measurement.

```
   AUX Engine 1
 Measure entire eng.
 or redo single cyl.?
 ◀ Cylinder   Engine ▶
```

10)   If data for this cylinder is already stored in the handheld device, decide here whether you want to repeat the complete measurement series of the engine by ❯ or only that of the cylinder by ❮.

```
     Overwrite
   AUX Engine 1
  Cylinder no: 01?
 ◀ No          Yes ▶
```

10.1)   If the existing cylinder data should be overwritten please confirm with Button ❯ and go to step 11. If canceled with button ❮ the display changes back to the main menu.

```
   AUX Engine 1
  Overwrite prev.
   Measurements?
 ◀ No          Yes ▶
```

10.2)   Use the arrow key ❯ to confirm overwriting the existing engine data and go to step 11. If canceled with button ❮ the display changes back to the main menu.

```
Measure engine
  AUX Engine 1
Cylinder no: 01
    Cycles: 010
```

```
Measure engine
  AUX Engine 1
Cylinder no: 01
    Boost: 0.50
```

```
  Measure engine
Start measurement?

◄ No          Yes ►
```

```
Measuring engine …
   AUX Engine 1

◄ Cancel
```

```
Measuring engine …
   AUX Engine 1
     RPM: 240
◄ Cancel
```

```
Measuring engine …
   AUX Engine 1

  Calculating …
```

```
Measurement finished
1.Close valve!
2.Disconnect sensor!
3.Hit key to confirm
```

11) The number of measuring cycles can be adjusted with the arrow keys ⌃ or ⌄. Confirm the value by ⟩.

12) In the following display the boost pressure can be adjusted with the ⌃ or ⌄ button. Confirm with the key ⟩.

13) Start the measurement with the key ⟩. During the measurement the **ACT** display flashes blue.

After the measurement is finished the results are calculated.

14) Close the indicator valve completely.

15) Unscrew the pressure sensor. Due to expansion of the sealing cone in the pressure sensor the hollow key may be required for unscrewing.

⚠ CAUTION
After completion of the measuring series, remove the pressure sensor from the indication bore in order to avoid overheating.

ℹ NOTICE
If the pressure sensor does not come loose, open the indicator valve for a short time to achieve a loosening through the combustion pressure. Close this valve immediately after removing the pressure sensor from the indicator valve.

16) For security reasons confirm the correct performance of steps 14 and 15 by the key ✓.

```
  » Cylinder : 01 «
  Avg. press.: 45       ▲
  Max. press.: 46       ▶
  Min. press.: 47       ▼
```

```
   » Cylinder: 01 «
   Store results        ▲
        Redo            ▶
       Cancel           ▼
```

```
   » Cylinder: 01 «
  ----------------      ▲
   Store results        ▶
        Redo            ▼
```

```


  Saving results ...


```

```
   Measure engine
    AUX Engine 1
   Cylinder no: 02
```
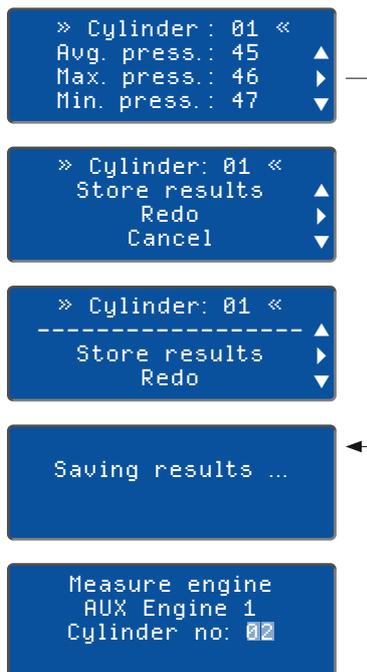
17) The display shows the measured data which you can watch and scroll by use of the arrow keys ⏶ or ⏷. With key ▶ switch to data storage immediately, see step 20.

18) Press the key ⏷, until you are asked what should be done with this series of measurements: store results, repeat measurement (redo) or cancel process.

19) To save scroll with the vertical arrow keys ⏶ or ⏷, until the option 'Store results' is marked on the display by the arrow ▶. Confirm with ▶.

20) The data of the measured cylinder is saved.

The DPI handheld device automatically leads to the measurement of the next cylinder.

Repeat steps 1 through 3 and 5 through 19 until the last cylinder has been measured according to the configuration (dataset).

ℹ️ NOTICE
Carry out the series of measurements quickly in order to ensure the same conditions for each cylinder.

```
         PMI

    Switch off ...
    ... x sec. left
```

```
         PMI

    Switch off ...
       Bye-bye!
```
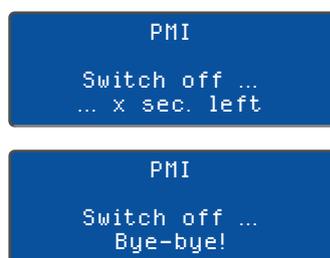
Switch off the DPI handheld device by pressing the button ⏻ for approx. 2 seconds.

ℹ️ NOTICE
After 5 minutes of inactivity - i.e. without pressing a button - the handheld device switches off automatically as long as it is not connected to a power supply via USB. The saved entries are retained. The handheld device must be switched on again for further operations and the last edited menu must be called up again.

Unplug the sensor cable from the DPI handheld device. The connection will be detached by pulling the knurled collar away from the handheld device, it should not be unscrewed. Store the system components in the measuring case.

⚠️ NOTICE
Never put the pressure sensor back in the transport case when it is still hot. Wait until the sensor has cooled down.

5 Display measurement results

5.1 Transferring data from the handheld device to the PC

For analysis and interpretation of the recorded cylinder pressure curve use the DPI software belonging to the system. For this purpose it is necessary to transfer the saved measurement data from the DPI handheld device to the PC.

1)   Connect the handheld device to the PC using the USB cable.

2)   Start the DPI software.
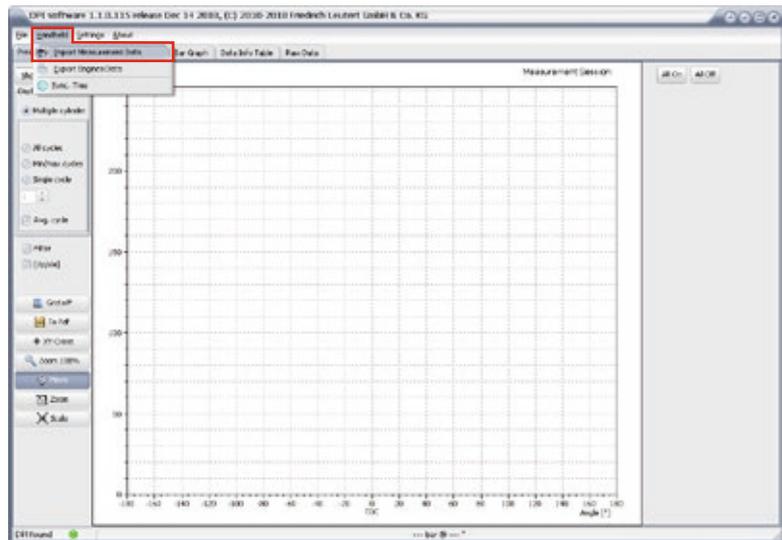
3)   In the menu [Handheld] open the command [Import measurement data]. A window with the measurements saved in the handheld device appears.

4) Select the measurement to be imported by clicking on the Check-box. The following options are activated:

[Import measurements] imports the data set into the DPI software. If the checkbox (Delete measurements from handheld after import] is marked with a cross the data set will be automatically deleted from the handheld device.

ℹ️ NOTICE

If you select this option the data will be irrevocably deleted from the handheld device.

Alternatively you can delete the measurement data manually at a later time. To do this press [Delete measurements from handheld].

[Save as …] assigns the measurements to be imported to an existing engine.

Under 'Parameters:' you can see the engine parameters of the marked data set applying during the measurement.

5)   Click on [Import measurement]. The 'Select ship' window appears.
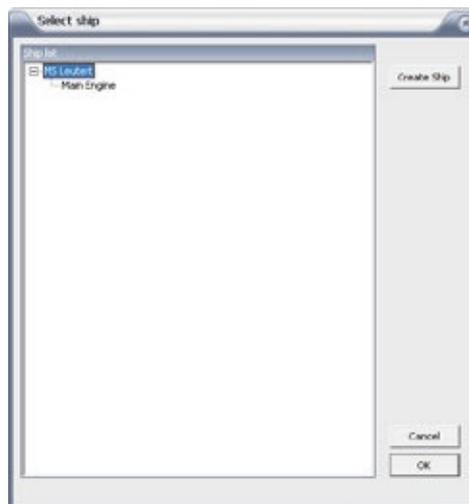
6)   Select the target directory into which the data record is to be imported and confirm with [OK].

7)   The following message shows how many cylinder measurements are included in the imported data set.

Close the window with [OK].

8)   With the next query decide whether the imported data should be shown now or not. Click accordingly to [Yes] or [No].
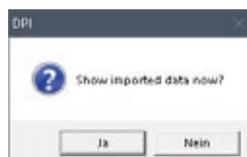
If [Yes] the data is preset in the menu [Pressure Plot].

5.2   Analyze measurement data with the DPI software

Various display modes are available for analyzing the measured values which are described in the following sections.

1)   Start the DPI software on the PC. Open in the menu (File] the Command [Open Database].

2)   Mark the data set to be opened in the list and click on OK].

The measurement data is displayed in the mode [Pressure Plot].

5.2.1 Pressure Plot

The curve progression shown in the [Pressure Plot] display mode shows the cylinder pressure [bar] for each cylinder measured at the indicator valve depending on the crankshaft angle [° CA].
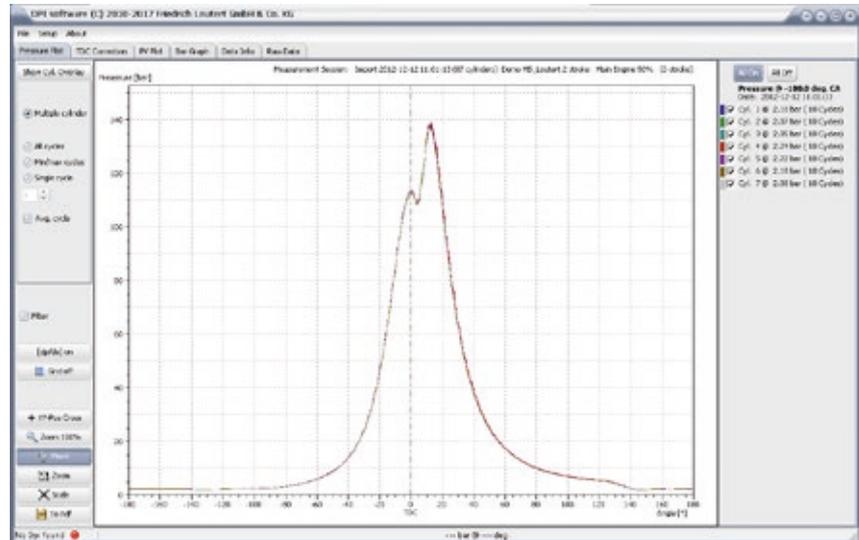
Select from the right window area the cylinders to be displayed:

– Checkboxes for individual cylinders (multiple selection possible)
– [All On] shows all cylinders
– [All Off] hides all cylinders

The button [Show Cyl. Overlay] also serves to select cylinders in a separate window. This function also offers the possibility to select a new dataset and to display an additional measurement (overlay).
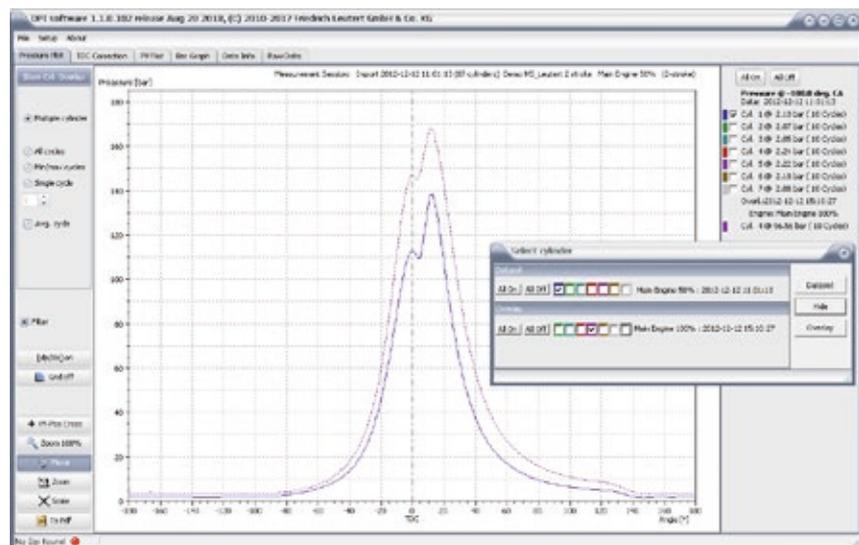
In the left window the following display options are available:
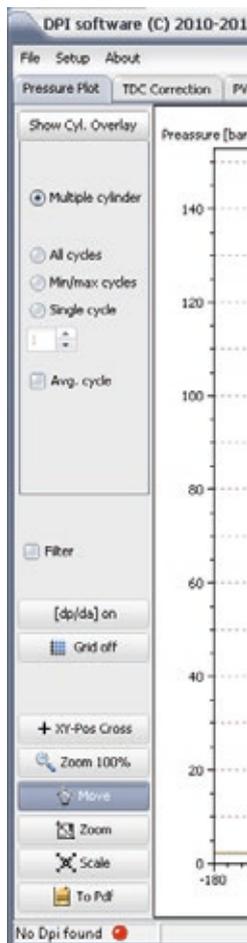
– Multiple cylinder: selection of all cylinders
– All cycles: display of all measured cycles of a cylinder
– Min / max cycles: shows the minimum and the maximum cycle of a cylinder
– Single cycle: display of a specific cycle of a cylinder, selection by using the arrow keys in the box below.

You can use checkboxes to influence the display as follows:
– Avg. cycle:
– Filter:
– [dp/da]: the first derivative of the pressure curve can be switched on / off

Available buttons:
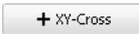
Button	Description
Grid off	Toggle Grid - switch grid on / off
To Pdf	Export to pdf - open the current view for printing or saving as pdf file
XY-Cross	XY-Cross - crosshair for reading the pressure values over the crankshaft angle
Zoom 100%	Zoom 100% - reset graphics after zooming, scaling or moving
Move	Move - Move the graphic section with the mouse
Zoom	Zoom - enlarge an area marked with the mouse
Scale	Scale - scale the graphic horizontally and / or vertically
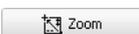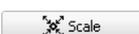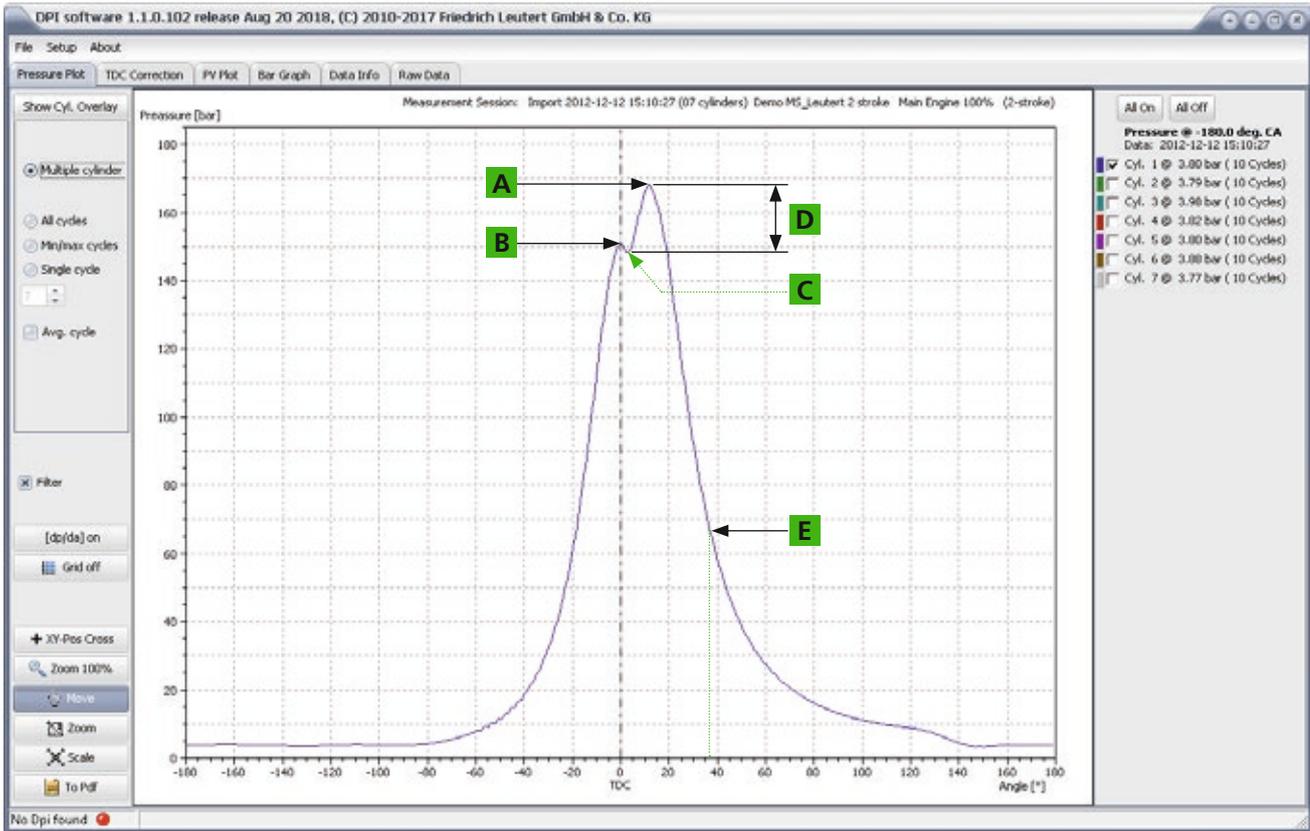
Some important pressure values to be read from the cylinder pressure curve are plotted in the graphic above.

A: Peak pressure
   Shows the maximum pressure value of the measurement curve, also known as ignition pressure.

B: Compression pressure
   Pressure measured at the top dead center of the respective cylinder.

C: Start of combustion

D: Differential pressure
   Peak pressure minus the pressure at the start of combustion.
   If the value is 0 the beginning of the combustion of the engine cannot be clearly assigned. This can also be the case with engines with a very early injection or engines having a combustion with linear beginning.

E: Expansion pressure
   Pressure at a particular point in the expansion phase, e.g. 36 ° CA (crankshaft angle) after top dead center.
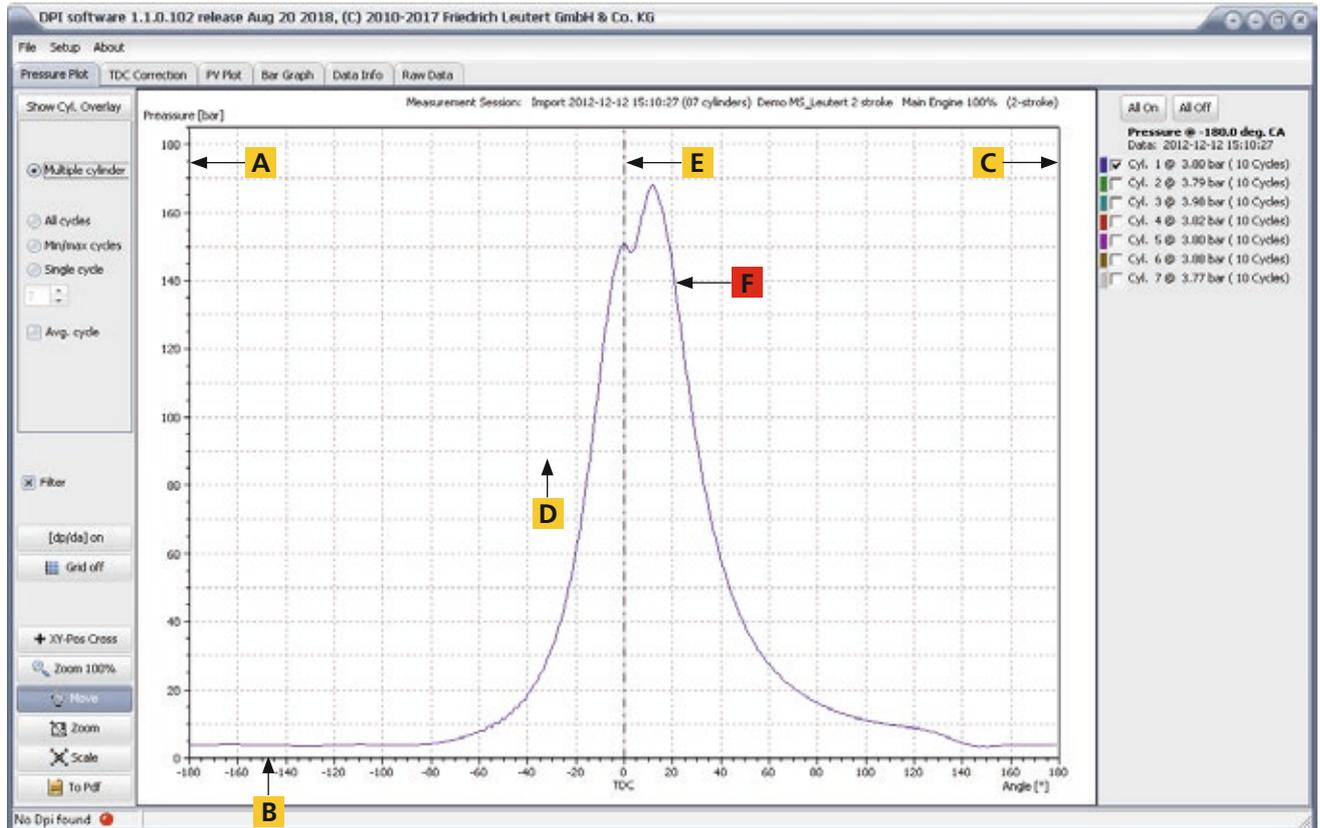
[Pressure plot] shows the cylinder pressure at the respective indicator valve depending on the crankshaft angle, at the top with activated first derivative.

A: Axis for the cylinder pressure, scaling in bar
This axis is automatically adjusted to the max. cylinder pressure of the current measurement.

B: Crankshaft angle, scaling in °
This axis shows the position of the crank angle for the measured Cylinder.

C: axis for the curve of the first derivative (dp / da)

D: 0 bar - line for the curve of the 1st derivative

E: TDC (top dead center) line

F: This cylinder pressure curve shows the pressure (rising / falling) depending on the crank angle of the measured cylinders.

5.2.2 TDC Correction

In the display mode [TDC Correction] the position of the top dead center can be determined which is necessary for the performance calculation.
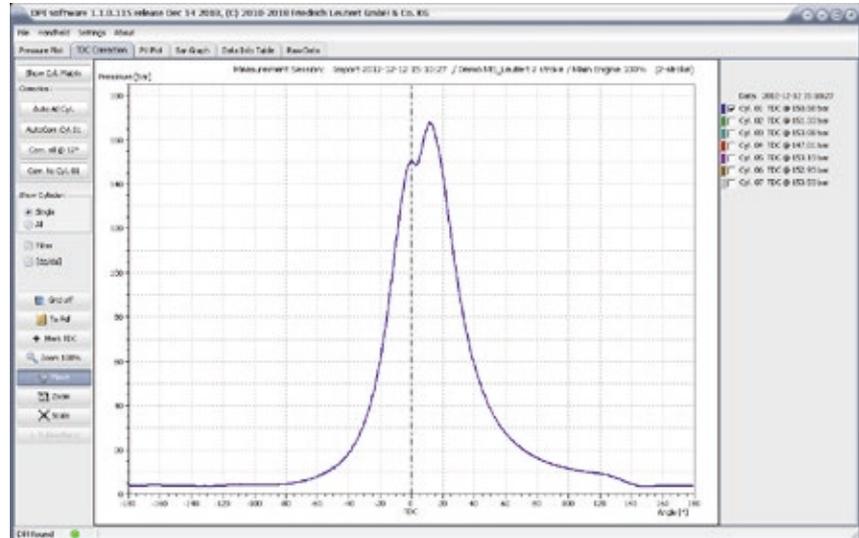
The cylinder to be displayed is selected in the right window are.
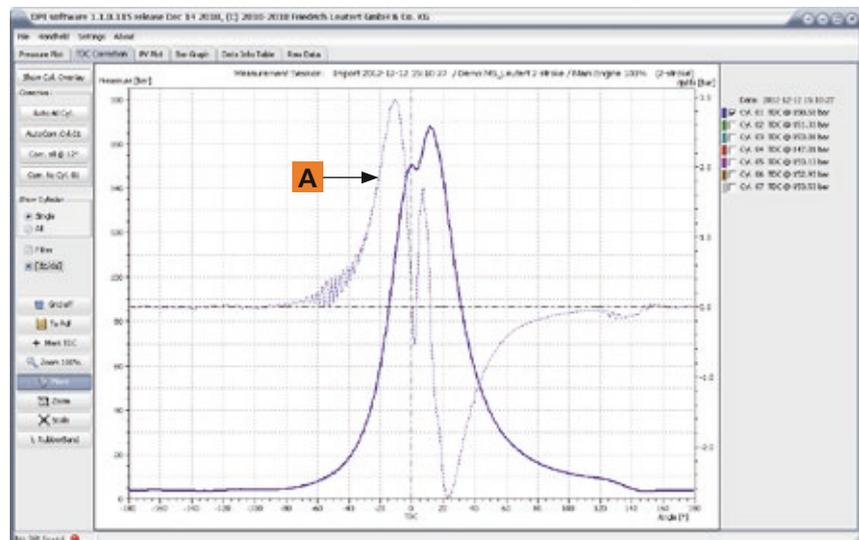
A: Derived pressure curve, scaling in bar / ° crank angle shift; The dp / da pressure line represents the rise / fall for 1 ° Change of crank angle. This should not exceed 6 bar / ° to avoid mechanical strain on the machine parts. This line also allows the position of the TDC to be calculated. TDC is the position where the pressure does not rise or fall (except engines with premature combustion).

Optionally the TDC can also be determined using software or it can be determined manually.

To correct the top dead center TDC there are various opportunities under „Correction:":

– [Auto All Cyl.]
– [AutoCorr.Cyl.01]
– [Corr. all @ 12°]
– [Corr. to Cyl 1]

Choose under „Show Cylinder:" between single (single) and all (all).

You can use checkboxes to influence the display as follows::
– Filter:
– [dp/da]: Switch on / off the first derivative of the pressure curve

Available buttons:

| Button	Description
Grid off	Toggle Grid - switch grid on / off
To Pdf	Export to pdf - open the current view for printing or saving as pdf file
+ Mark TDC	+ Mark TDC - manual TDC determination by placing the Mark TDC cross
Zoom 100%	Zoom 100% - reset graphics after zooming, scaling or moving
Move	Move - Move the graphic section with the mouse
Zoom	Zoom - enlarge an area marked with the mouse
Scale	Scale - scale the graphic horizontally and / or vertically
\ RubberBand	\ RubberBand - The rubber band function can be used to extend the derivation of the pressure curve (dp / da) in the downward movement to get to the point where the derivative would cross the zero line..

5.2.3 PV Plot

The display mode [PV Plot] illustrates the cylinder pressure in relation to the volume curve.
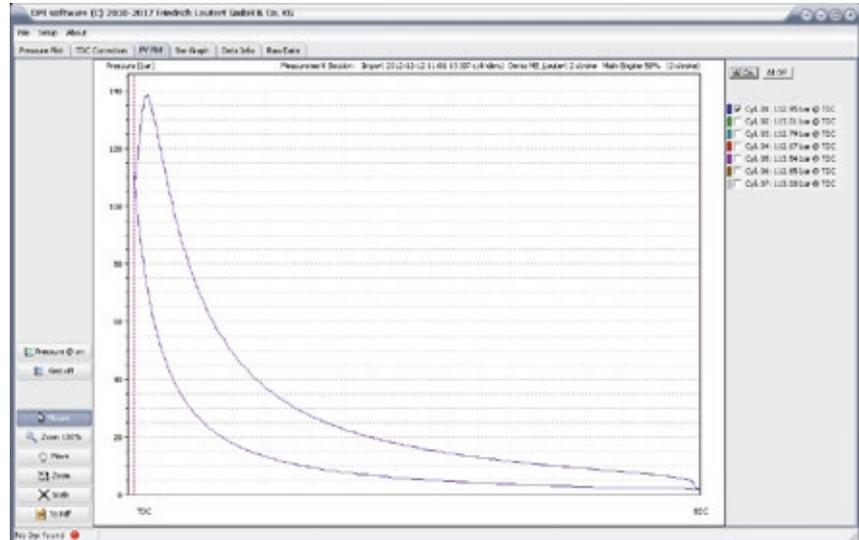
The cylinders to be displayed are selected in the right window area.

Available buttons:

 Toggle Crosshair - switch on / off horizontal line for reading the pressure values

 Toggle Grid - switch on / off grid

 Export to pdf - aopen the current view for printing or saving as pdf file

 Zoom 100% - reset graphics after zooming, scaling or moving

 Move - Move the graphic section with the mouse
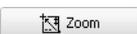
 Zoom - enlarge an area marked with the mouse
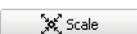
 Scale - scale the graphic horizontally and / or vertically
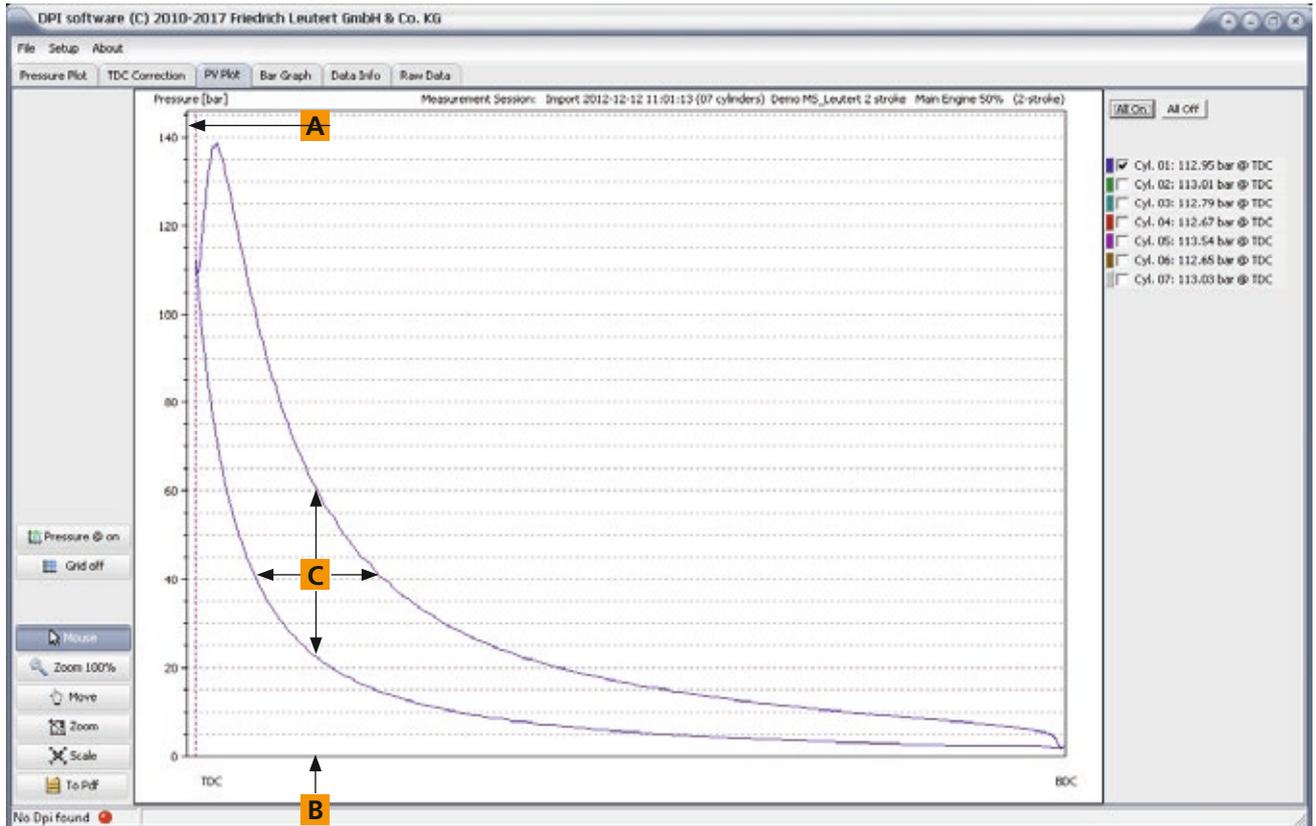
The PV diagram [PV Plot] shows the course of the cylinder pressure between top dead center (TDC) and bottom dead center (BDC) during a working cycle.

A: Axis for the pressure in bar

B: axis for volume change from BDC to TDC

C: The inner area represents the "gain of work".

In the past the PV diagram, also known as the banana curve, has been applied to measure the work area and to determine the indicated performance by use of a planimeter. Today this procedure is no longer necessary because the electronic indicator carries out this calculation automatically.

5.2.4 Bar Graph

In the [Bar Graph] mode the selected measurement data is displayed in form of a bar graph. This view allows you to easily compare the individual cylinders with each other.

The bar chart below shows a sample data set that shows the maximum of the combustion pressures for all cylinders with automatic scaling. The optimum is achieved once the deviation between the cylinders is as small as possible.
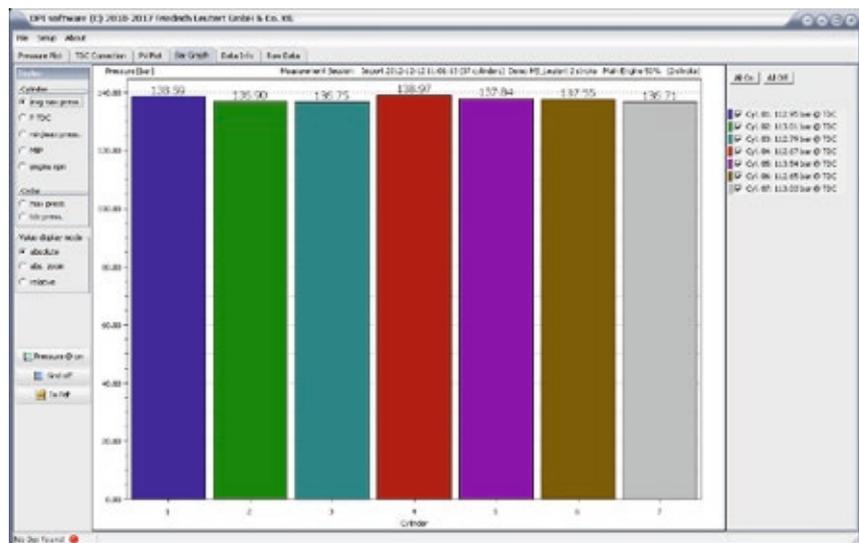
The cylinders to be displayed are selected in the right window area.

In the left window area the following display options are available:

„Cylinder:"
– avg. max press .: Average value of the maximum ignition pressure
– P TDC: pressure at top dead center
– min / max press .: minimum and maximum pressure
– MIP: mean indicated pressure
– engine rpm: engine speed

„Cycle:"
– max press .: maximum pressure per cycle and cylinder
– tdc press .: pressure at top dead center per cycle and cylinder

„Value display mode"
– absolute: display of the absolute values
– abs. zoom: graphic enlarged to the maximum values
– relative: display of the relative deviations

Available buttons:

Grid off	Toggle Grid - switch grid on / off
To Pdf	Export to pdf - open the current view for printing or saving as a pdf file
Pressure @ on	Toggle Crosshair - switch on / off horizontal line for reading the pressure values

5.2.5 Data Info

The table [Data Info] shows the measuring data determined for each cylinder in numerical order. All presentations and mathematical calculations of the DPI software are based on these measurements.


– Date, Time: Date and time of the measurement
– Average cycles: number of measured cycles (number of averages)
– Pmax_av: average peak pressure value of all measuring cycles
– Pmax_max: highest peak pressure value of all measuring cycles
– Pmax_low: lowest peak pressure value of all measuring cycles
– MIP: mean indicated pressure
– Deviation: standard deviation related to the mean value of all peak pressures of a series of measurements.
– Ptdc: pressure value at top dead center
– RPM: engine speed
– Max dp / da: 1. derivation of the pressure curve
– Ind. Power: indicated cylinder power
– Boost pressure: boost pressure of the engine
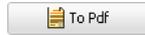– Ambient temp .: ambient temperature

The following values are not measured but can be optionally entered later to complete the data record.

– Exhaust gas temp .: exhaust gas temperature
– Fuel rack setting: position of the injection linkage
– VIT setting: variable injection time
– Additional information: space for entering additional information
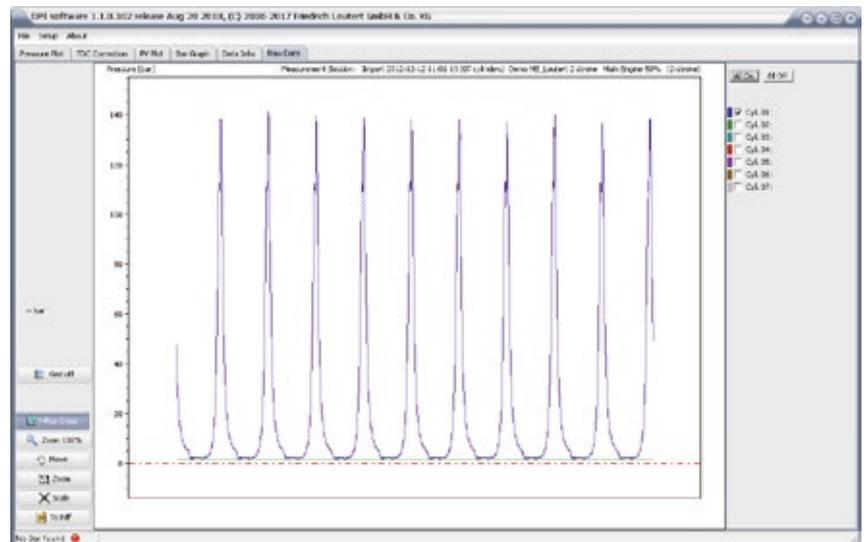
Available buttons:
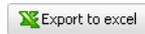
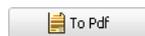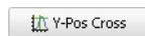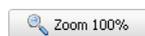|	
Export to excel	Export to Excel - Save and open the DataInfo table as an Excel file
To Pdf	Export to pdf - open the current view for printing or saving as a pdf file

5.2.6 Raw Data

Available buttons:

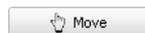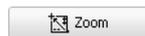|	
Grid off	Toggle Grid - switch on / off grid
To Pdf	Export to pdf - open the current view for printing or saving as a pdf file
Y-Pos Cross	Y-PosCross - help line for reading the exact pressure values on the y-axis
Zoom 100%	Zoom 100% - reset graphics after zooming, scaling or moving
Move	Move - Move the graphic section with the mouse
Zoom	Zoom - enlarge an area marked with the mouse
Scale	Scale - scale the graphic horizontally and / or vertically
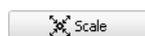
5.3   Send and receive measurement data by email

Sometimes it is necessary to send measurement data electronically.
You start this function in the DPI software with the menu command [File] and [Export to file / email].
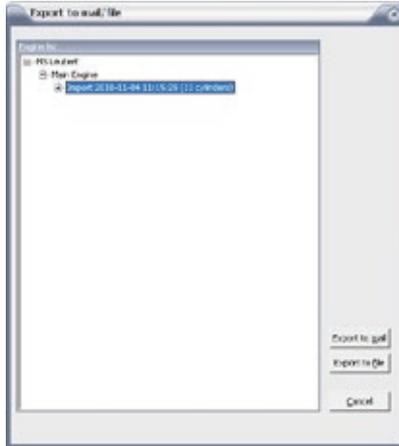
If you want to send the data record which is currently opened in the DPI software, this is already marked in the list. Otherwise select the record which you would like to send by email in the window above.

Click the button [Export to mail] button. The email program opens and the file appears in a prefabricated mail as an attachment.
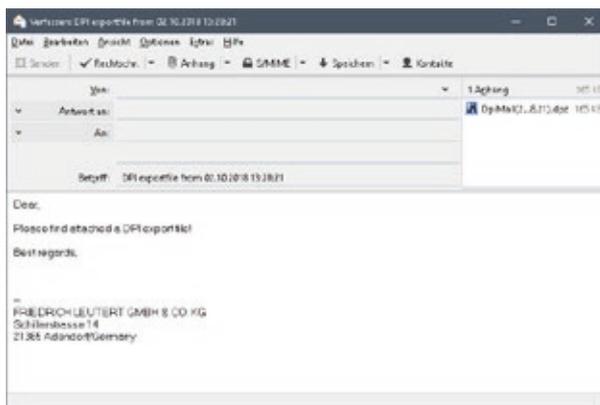
Fill in the appropriate address lines (From :, To :), complete the names and, if necessary, the text and send the mail.
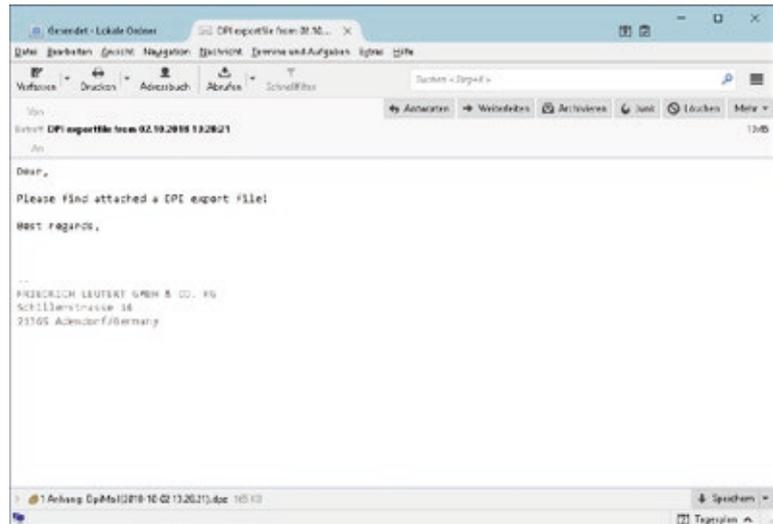
6 Organize measurement data in the handheld device

6.1 View data records on the handheld device

While the measured value is being recorded you can see on the DPI display some of the determined data such as speed, peak and differential pressure. After completing the series of measurements you can view the complete data sets on the DPI handheld.

```
» Main menu «

Measure engine    ▶
  Show data       ▼
```

1) Press the button ⏻ for approx. 1 second to switch on the handheld device. The main menu appears after the start screen. Use the buttons ⋀ or ⋁ to switch between the lines.

```
» Main menu «
Measure engine    ▲
  Show data       ▶
 Delete data      ▼
```

2) Confirm with ▷ if the line 'Show data' is marked with the ▶ arrow.

```
» Show data «

 Main Engine      ▶
 AUX Engine 1     ▼
```

3) The saved motors are displayed. Scroll down this list with the vertical arrow keys ⋀ or ⋁.

```
» Measure engine «
 Main Engine      ▲
 AUX Engine 1     ▶
 AUX Engine 2     ▼
```

4) If the chosen engine is marked with the arrow in the display, confirm the selection with button ▷.

```
» Select Cylinder «

Cylinder no: 01   ▶
Cylinder no: 02   ▼
```

5) The measured cylinders are displayed. Scroll with the keys ⋀ or ⋁, until the chosen cylinder is marked with the ▶ arrow. Confirm with the key ▷.

The saved measuring values of the selected cylinder are displayed.

```
» Cylinder : 01 «
Avg. press.: 45   ▲
Max. press.: 46   ▶
Min. press.: 47   ▼
```

```
» Cylinder : 01 «
  Boost: 4.00     ▲
  Cycles: 020     ▶
  @RPM: 360       ▼
```

6) Scroll with ⋀ or ⋁ to view the single measured values.

```
» Cylinder : 02 «
Avg. press.: 45   ▲
Max. press.: 46   ▶
Min. press.: 47   ▼
```

7) Use the key ▷ to switch to the next cylinder or leave the 'Show data' menu by pressing the ◁ button to return to the superordinate menu.

```
» Main menu «
Measure engine    ▲
  Show data       ▶
 Delete data      ▼
```

Switch off the DPI handset by pressing the button ⏻ for approx. 2 seconds.

6.2 Delete data records in the handheld device

During the measurement, the DPI saves the measured values as data re-
cords which can be assigned to each individual cylinder. If you start a new
measurement, this data is overwritten. So it is not mandatory to delete old
measurement results before a new measurement is started. If you wish to
delete old results though, proceed as follows:

i NOTE

Make sure that you have already downloaded and saved the mea-
surement data to the PC or that you no longer need the data.

```
   » Main menu «

Measure engine    ▶
  Show data        ▼
```
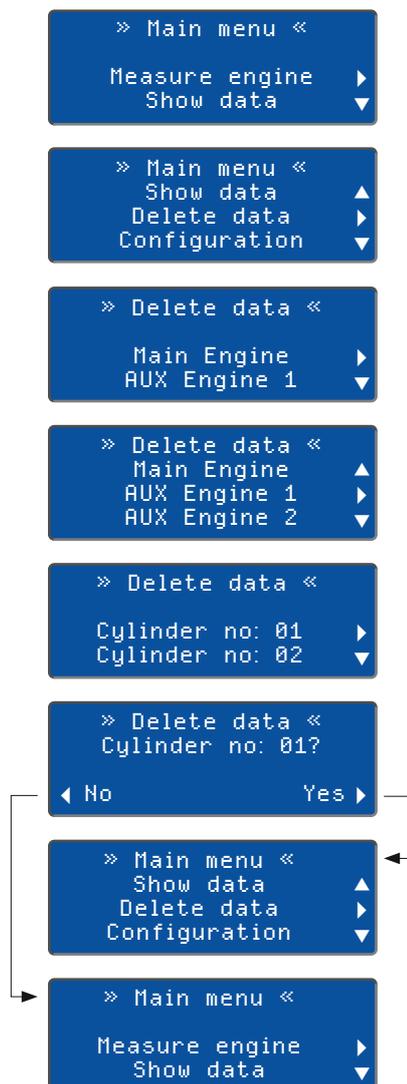
1) Press the ⏻ button for approx. 1 second to switch on the handheld
device. Use the buttons ⋀ or ⋁ to switch between the lines.

```
   » Main menu «
    Show data       ▲
   Delete data      ▶
  Configuration     ▼
```

2) If the 'Delete data' line is marked with the ▶ arrow, press the but-
ton ⊳.

```
   » Delete data «

 Main Engine        ▶
 AUX Engine 1       ▼
```

3) The saved engines are displayed. Scroll down this list with the verti-
cal arrow keys ⋀ or ⋁.

```
   » Delete data «
  Main Engine       ▲
  AUX Engine 1      ▶
  AUX Engine 2      ▼
```

4) If the chosen engine is marked on the display with the ▶ arrow, con-
firm the selection with button ⊳.

```
   » Delete data «

 Cylinder no: 01    ▶
 Cylinder no: 02    ▼
```

5) The measured cylinders are displayed. Scroll with the keys ⋀ or ⋁
until the cylinder to be deleted appears on the display or the selec-
tion 'All cylinders' is marked with the ▶ arrow.

```
   » Delete data «
 Cylinder no: 01?

◀ No          Yes ▶
```

6) Delete the process with key ⊳ [Yes] or cancel with ◁ [No] ab.

```
   » Main menu «
    Show data       ▲
   Delete data      ▶
  Configuration     ▼
```

6.1) [Yes] The display changes back to the main menu. 'Delete data' ist
is marked with the ▶ arrow.

```
   » Main menu «

Measure engine    ▶
  Show data        ▼
```

6.2) [No] ends the deletion process

Switch off the DPI handset by pressing the button ⏻ for approx. 2 sec-
onds.

7   Maintenance

7.1   Maintenance of the pressure sensor

The DPI handheld device requires little maintenance. Make sure that the device and the associated pressure sensor is returned to the manufacturer after approx. 100 operating hours or after 3 years to check the calibration data.

ℹ️   NOTE
While the calibration settings are controlled by the manufacturer, the pressure sensor will be cleaned simultaneously.

7.2   Cleaning of the pressure sensor

Remove regularly any soot or carbon deposits from the pressure sensor since they might interfere with the measuring operation. The contamination rate depends on the indicated engine and its operating conditions. The cleaning intervals given below should, thus, be considered as a rough guide::

– after approx. 5 operating hours for a diesel engine running on heavy oil
– after approx. 30 hours of operation for a diesel engine running on diesel oil
– No cleaning is required for gas engines.

No warranty claims will be accepted for damage or destruction of the pressure sensor due to non-respect of the following safety instruction.

⚠️   CAUTION
Before cleaning, allow the sensor to cool down to less than 50 °C.
Use commercial cleaning agent.
Do not introduce any tools into the sensor bore.
Do not disassemble the sensor unit.
Wear safety glasses when blowing out the sensor bore.

For cleaning the pressure sensor proceed as follows:

1)   Fix the sensor unit in upright position, with the sensor access bore-pointing upwards.

2)   Pour the cleaning liquid in a mixture ratio of 1:10 into the sensor bore and allow to react for about 30 min. to 1 hour.

3)   Remove the introduced cleaning agent by turning the device upside down.

4)   Afterwards, blow out the sensor bore by means of compressed air (max. 4 bar).

5) Any remaining cleaning agent may be removed with clear water by repeating steps 3 and 4.

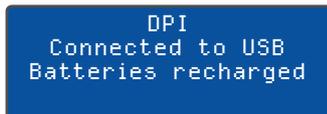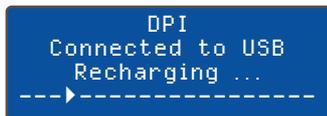If the sensor is heavily stained repeat the cleaning procedure.

7.3 Charge the batteries of the handheld device

ℹ️ NOTICE
Charge the batteries when the BAT indicator on the handheld device flashes red or lights up or the message 'charge battery' appears.

The battery must be charged after 9 months of storage at the latest.

```
       DPI
Connected to USB
   Recharging ...
---▶---------------
```

```
       DPI
Connected to USB
Batteries recharged
```

1) Connect the handheld device to the PC by using the USB cable Or the included charger. It is now automatically in the battery charge level and cannot be operated using the buttons. The BAT signal flashes green.

If the batteries are fully charged, the message 'batteries recharged' appears on the display. Depending on the remaining battery charge this procedure may take up to 12 hours.

The BAT signal lights up green. The charger turns off automatically and electricity no longer flows.

2) Finally remove the USB cable from the handheld device, it switches off automatically..

ℹ️ NOTICE
The charging process can be easily interrupted by disconnecting the USB cable.

7.4   Changing the batteries

⚠️ WARNING

Use rechargeable batteries only. Charging non-rechargeable batteries may result in a fire or explosion. Batteries are charged when the hand-held device is connected to a power source (e.g. wall outlet or computer).

⚠️ CAUTION

Switch off the DPI hand-held device and disconnect the charger before beginning the procedure.
Do not dispose in fire.
Do not mix diferent types of batteries.
Avoid short circuit.
Respect polarity of batteries.

ℹ️ NOTICE

Make sure that you have already downloaded and saved the measurement data to the PC or that you no longer need the data.

If the battery is to be replaced or removed from the DPI, please proceed as follows:

1)   Use a flat-blade screwdriver to screw off the cover of the battery compartment. The fastening screw is captive and the shoulder strap is on the cap.
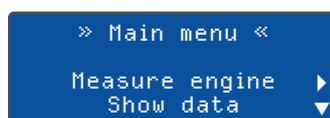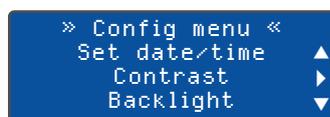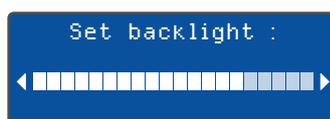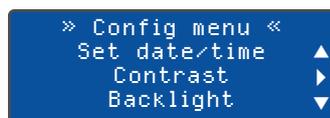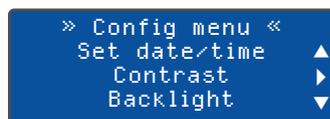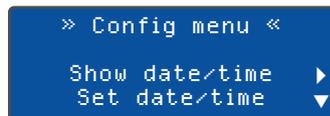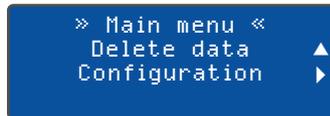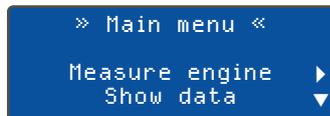

2)   Remove the old ones and insert the new ones. Take notice of the polarity.

3)   Put the cover cap back on and screw it on.

Environmental information

🗑️❌ Please note the RoHS directive 2011/65 / EU (RoHS-II) and BattG and do not dispose the batteries in the household waste for the sake of the environment.

7.5 Adjusting the contrast and the backlight of the handheld device.

```
» Main menu «

Measure engine    ▶
  Show data       ▼
```

```
» Main menu «
  Delete data     ▲
Configuration     ▶
```

```
» Config menu «

Show date/time    ▶
Set date/time     ▼
```

```
» Config menu «
Set date/time     ▲
  Contrast        ▶
  Backlight       ▼
```

```
Set contrast :

◀▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▯▯▯▶
```

```
» Config menu «
Set date/time     ▲
  Contrast        ▶
  Backlight       ▼
```

```
» Config menu «
  Contrast        ▲
  Backlight       ▶
```

```
Set backlight :

◀▮▮▮▮▮▮▮▮▮▮▮▮▮▯▯▯▯▶
```

```
» Config menu «
Set date/time     ▲
  Contrast        ▶
  Backlight       ▼
```

```
» Main menu «

Measure engine    ▶
  Show data       ▼
```

1) Press the button ⏻ for approx. 1 second to switch on the handheld device. The main menu appears after the start screen. Use the buttons ⋀ or ⋁ to switch between the lines.

2) When the 'Configuration' line is marked with the ▶ arrow, press the button ▷.

The display changes to the configuration menu.

3) Scroll with the vertical arrow keys ⋀ or ⋁, until 'Contrast' is marked on the display with the ▶. Confirm with ▷.

4) The display changes to the setting window 'Set contrast'. Change the set value with ◁ or ▷ and confirm with button ✔.

The configuration menu appears in the display, see step 3.

5) Switch with the or buttons ⋀ or ⋁ until 'Backlight' is marked with an ▶ arrow. Confirm with ▷.

6) The display changes to the 'Set backlight' setting window. Change the set value by ◁ or ▷ and confirm with button ▷.

The configuration menu appears in the display, see step 3.

7) You can now switch back to the main menu with ◁ or turn off the handheld device.