NHT-6 Opacimeter

Operation Manual

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1. Summary

NHT-6 Opacimeter is a portable intellectual instrument used to test the visible contaminants in emissions (exhaust smoke) from the compression combustion (diesel) engine. With advanced test technology and excellent parts and components from abroad, it is applicable for environmental protection departments, vehicle test stations, automotive manufactures and workshops.

This instrument has the following main functions and characteristics:

- Sampling (split) test. With the "air curtain" protection technology, it prevents the optical system from being polluted by exhaust smoke. The test chamber is controlled under constant temperature, there is no moisture condensation formed in the emissions, which may affect the test result.

- Full-English interactive menu display. It can display two readouts of the opacity and the light absorption coefficient by easy, direct and convenient operation.

- With separate control unit and measurement unit, it prevents the exhaust smoke from polluting the LCD display, and makes it convenient to get the readings during testing.

- Carrying out free acceleration test in accordance with China standard # GB3847-2005: Limit Measurement Method for Exhaust Smoke from C.I.E. (Compression Ignition Engines) and Vehicles Equipped with C.I.E". Under the programmed test mode, it processes the test data automatically and displays the peak values from each test, automatically judges whether the test complies with the national standard. The complicated test procedure can be done quickly.

- With the function of real-time test and display of instantaneous values, it tests visible contaminants in vehicle emissions under loaded mode and at stable revolving speed.

- With the function of engine revolving speed measurement, piezoelectric, photocell or battery sensor are available. Piezoelectric sensor is standard configuration. The other two ones are optional.

- Oil temperature of the engine can be tested.

- Large LCD display, adjustable LCD brightness.

- Equipped with micro printer.

- Equipped with RS232 serial port for communication with external computer.
- 500 groups of free acceleration test data can be saved and sent to external PC via RS232 port. It is suitable for roadside test.

2. Specifications and Technical Parameters.

2.1 Operational Condition:

Temperature: 5℃～40℃

Relative Humidity: ≤ 95%

Power Supply: 220VAC±10%, 50Hz ± 10%

2.2 Test Range:

Opacity (N): 0～99.9%

Light absorption Coefficient (k): 0～16.0 m^{-1}

Revolving Speed: 300～8000 rpm

Oil Temperature: 0℃～120℃

2.3 Resolution:

Opacity: 0.1%

Light Absorption Coefficient: 0.01m^{-1}

Revolving Speed: 1 rpm

Oil Temperature: 1℃

2.4 Accuracy

Opacity (uncorrected): ±2.0% (absolute error)

Revolving Speed (piezoelectric): ±1.0% (relative error)

Oil Temperature: ±2℃ (absolute error)

2.5 Effective Length of Optical Path: 215mm

Equivalent Length of Optical Path: 430mm

2.6 Warm-up: 15 min.

2.7 Length of Sampling Probe: 2.5m

2.8 Power Consumption: 200W

2.9 Dimension:

Measurement Unit: 410×215×360mm

Control Unit: 370×280×220mm

2.10 Net Weight

Measurement Unit: 6.5kg

Control Unit: 5.5kg

3. Measurement principle.

Measurement principle of this instrument for pollution of exhaust smoke (mainly smoke soot particles): pass a light beam through the exhaust smoke for which a certain length is given, and determine pollution of the exhaust smoke to the environment by the its absorption of light.

As shown in Fig. 1, test chamber inside the control unit is a round tube divided into two halves, left half and right half. The exhaust smoke to be measured enters into the test chamber from the entrance in the middle, passes through the left tube and the right tube respectively, exhausts from the left exit and the right exit. There are two convex lens on the left side and the right side, with a green LED on the left and a photoelectric sensor on the right. Both the optical distances from the LED to the left lens and from the photoelectric sensor to the right lens are the focal distances of the lens. Thus, the light emitted from the LED becomes a parallel beam after passing the left lens, focuses on the photoelectric sensor after passing the right lens, and becomes an electric signal. The more the smoke in the exhaust gas, the greater the luminous attenuation of the parallel beam passing through the test chamber, and the weaker the electric signal converted by the photoelectric sensor.

There are a lot of smoke soot particles in exhaust gas. If the exhaust gas touches the surfaces of the left lens and the right lens directly, the smoke soot particles will deposit on the surfaces, absorb the luminous energy and affect the test result. In order to prevent the optical system from

being polluted by the smoke, "air curtain" protection technology is taken. The exhaust fans as shown in Fig. 1 sends external clean air into the channel between the left lens, the right lens and the exits of the test chamber, forms "air curtain" on the surfaces of the lens to avoid contamination of the smoke soot particles.
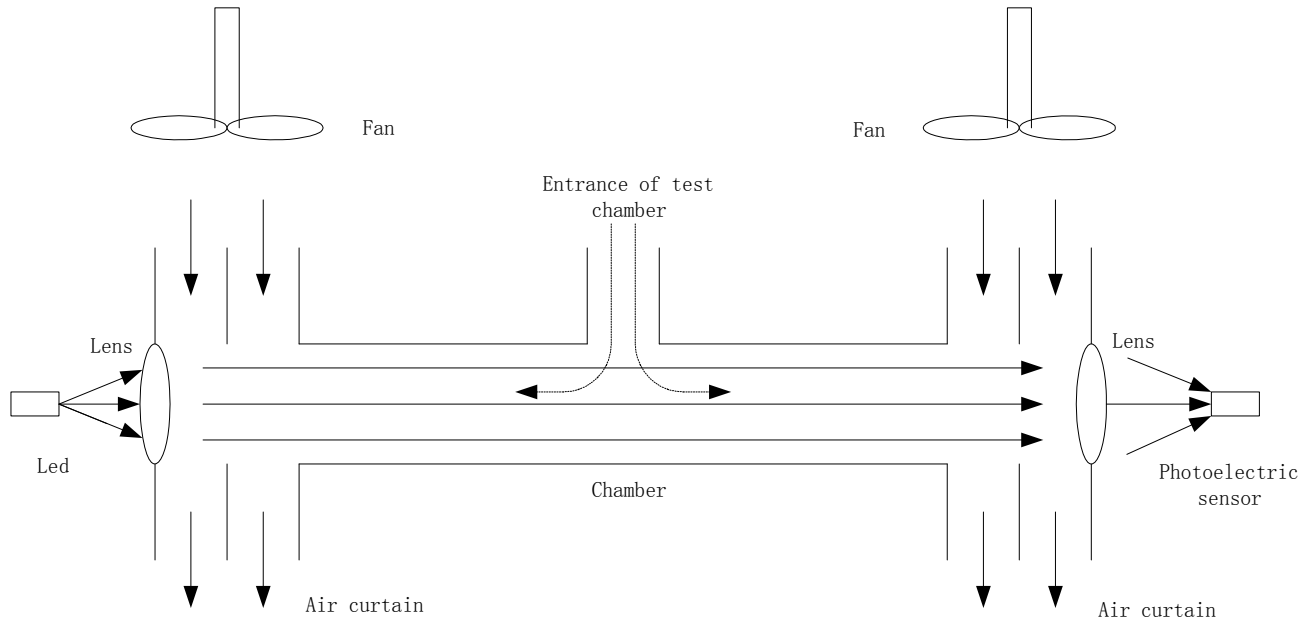
Fig. 1 Measurement Principle

There is water in vehicle emissions. Due to high temperature of exhaust gas, the water in emissions coming into the instrument remains gaseous state. If the temperature on the tube wall of the test chamber of this instrument is much lower, water vapor in the exhaust gas will condense and become atomized, which affects the test result. To prevent influence from such condensation, the temperature on tube wall of the test chamber should be kept at 70℃ or above. Due to this, the heating device and thermostat are equipped on the test chamber.

4. Instrument Composition
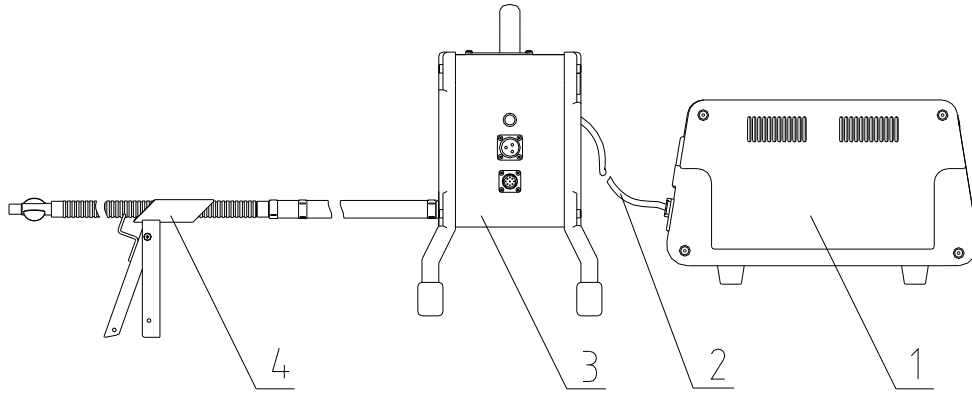
1.Control Unit;   2. Connection Cable;   3. Measurement Unit;   4. Sampling Probe;

Fig. 2   Composition of Instrument

As shown in Fig. 2, the instrument is mainly composed of measurement unit, control unit, sampling probe and connection cable.

4.1 Control Unit.

All parts on the front panel of control unit are shown in Fig. 3. All parts on the rear panel of control unit are shown in Fig. 4.
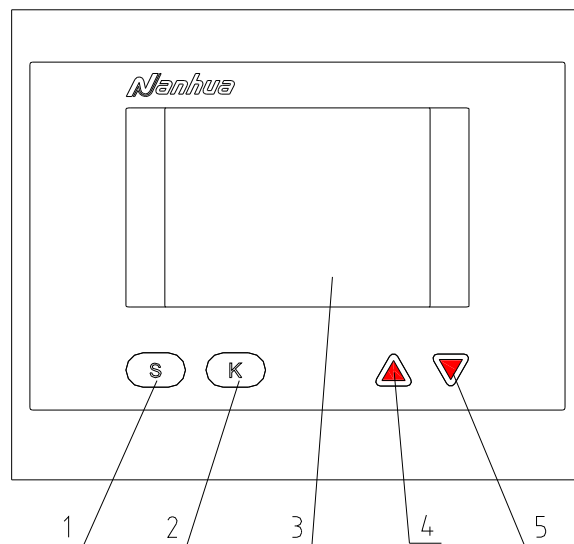
1. "S" key;   2. "K" key;   3. LCD;   4. "↑" key;   5. "↓" key

Fig. 3   Front Panel of Control Unit
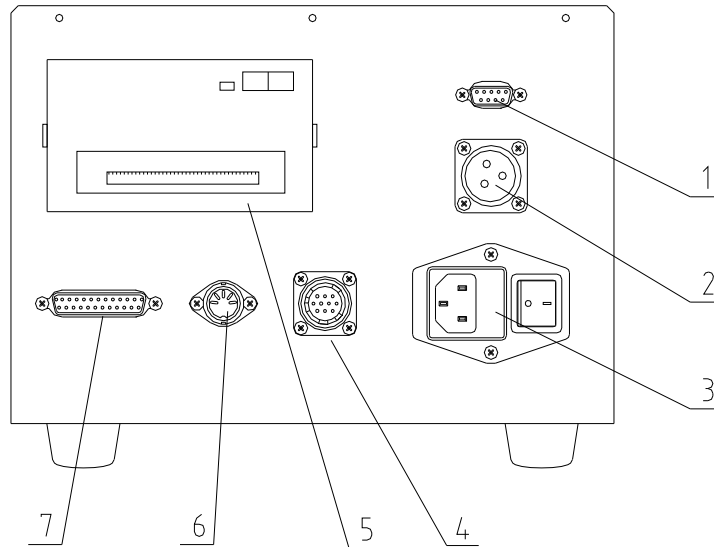
1. Measurement Interface;   2. 220VAC Output Socket;   3. Power Socket and Switch;
4. Measurement Interface for Revolving Speed.   5. Micro Printer;
6. Measurement Interface for Oil Temperature;   7. Communication Interface
Fig. 4   Rear Panel of Control Unit

Functions of all parts on the rear panel of control unit:

1. Measurement Interface: Connect the signal cable and receive test data signal from measurement unit.

2. 220VAC Output Socket: Connect the power cable and output 220V AC power supply to measurement unit.

3. Power Socket and Switch: Input 220V AC power supply. Use the switch with built-in 3A fuse and power supply noise filter to turn on/off of the power.

4. Measurement Interface for Revolving Speed: Input RPM signal.

5. Micro Printer: Print test data from each test.

6. Measurement Interface for Oil Temperature: Input measurement signal for oil temperature.

7. Communication Interface: RS232 serial port communicates with external computer.

4.2 Measurement Unit
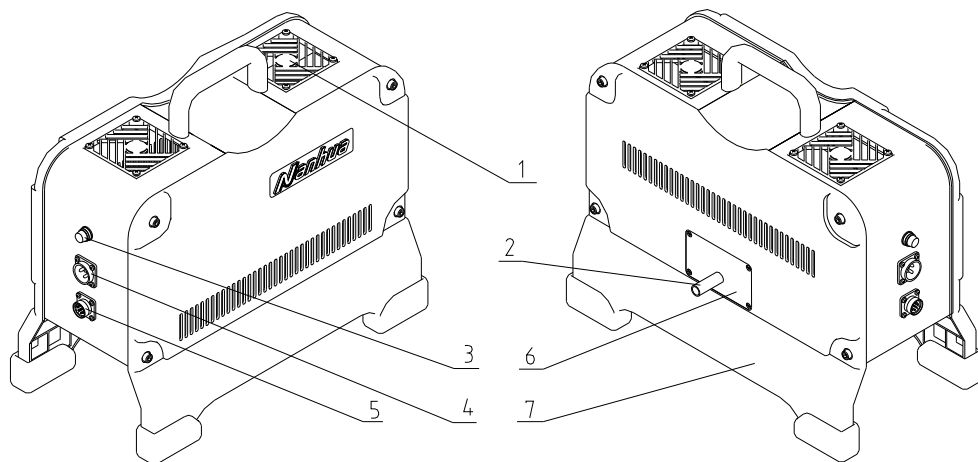
1. Fan;　2. Entrance of Test Chamber;　3. Fuse Box; 4. AC Supply Input Socket Signal;

5. Socket for Test;　6. Cover for Sensor;　7. Support

Fig. 5　　　Measurement Unit

All parts on the top and the rear side of measurement unit are shown in Fig. 5.

Functions of all parts of the measurement unit:

1) Fan: Clean air comes in through the fan and forms a protective air curtain.

2) Entrance of Test Chamber: Connected with the conduit of the sampling probe, exhaust gas from the vehicle to be tested comes in measurement unit through it

3) Fuse Box: Keep a 3A fuse for AC supply.

4) AC Supply Input Socket: Connect the supply cable and receive AC supply output from Control Unit.

5) Socket for Test Signal: Connect the signal cable and output test data signal to Control Unit.

6) Cover for Sensor: Open this cover for replacing the gas temperature sensor.

7) Supports: Keep the measurement unit above the ground for a certain height enabling the exhaust gas after being tested and the air of "air curtain" can be vented.

5. Operation Instruction

5.1 Preparation.

Install the instrument in the following steps before operation.

a) Plug the guide pipe of the sampling probe into the connector on the measurement unit, and fasten the screws on the clamp of the guide pipe to avoid leakage at the connections.

b) Connect the measurement signal interfaces on the measurement unit and the control unit with the measurement signal cable.

c) Connect the power supply socket of the measurement unit and 220VAC output socket of

the control unit with the power cable.

d) Connect the measurement interface for revolving speed to the revolving speed sensor with the cable.

e) Insert the cable plug of the oil temperature sensor to the measurement interface for oil temperature.

f) Insert the plugs of power wire into "Power Socket" of the control unit. The instrument must have good grounding and a reliable earth cable on the power socket for protecting the operator and the instrument.

Note: Don't turn or heel over the measurement unit when testing, otherwise the test values may be affected. Furthermore, use the handle on the measurement unit when moving it. Don't drag the connection cable or it will fall off from the socket. If the communication cable between the control unit and the measurement unit is not well connected, a prompt "Communication failed!" will be displayed on the status bar. At this time, user should check if the cable for measurement signal is connected well or not.

5.2 Warm-up

After installing the instrument according to Section 5.1, turn on the power supply. The model, description and version of the instrument are displayed as shown in Fig. 6. The lower part on the display is the status information. As the instrument enters this interface, "Testing, please wait" is displayed. Then, the instrument starts to warm-up, "Warming up" is displayed, followed by "Remaining time 15:00" by count-down. The warm-up takes 15 minutes in total. During warm-up, it is allowed to adjust the LCD brightness by "↑" key or "↓" key. At the end of countdown, the instrument calibrates automatically and enters the interface of "Main Menu".

NHT-6

OPACIMETER

Version 1.4

Status: Warming Up!　　　　　Remaining Time:　15:00

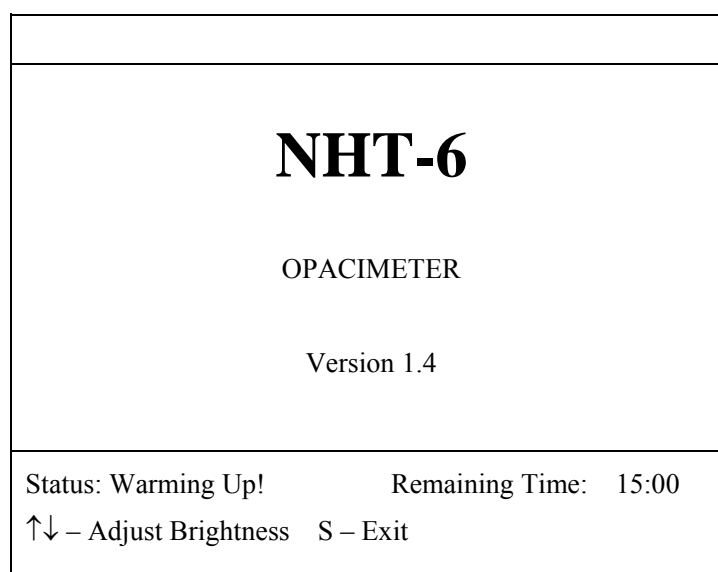↑↓ – Adjust Brightness　　S – Exit

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Fig. 7　　Interface of Warm-up

Note: During warm-up, never put the sampling probe in the exhaust pipe of the vehicle, but in clean air to ensure automatic calibration of the instrument after warm-up. If "S" key is pressed during warm-up, the instrument will stop warm-up and enter into operation status in advance. However, insufficient warm-up may cause excessive zero shift and inaccuracy of the instrument.

5.3 Real-time Test

Steps for real-time test:

1) After installing the instrument as described in Section 5.1 and warm-up in Section 5.2, the instrument enters the interface of Main Menu automatically (as shown in Fig. 8). Move the cursor "→" in front of "Real-time Test" by "↑" key or "↓" key (as shown in Fig. 8), press "K" key to enter the interface of Real-time Test. In this interface (as shown in Fig. 9), the transient value of opacity (N), light absorption coefficient (K), revolving speed, oil temperature, max. value of opacity (N), light absorption coefficient (K), revolving speed are displayed. Stable revolving speed test and single free acceleration test can be done in this interface.

2) The vehicle to be tested should be warmed up for some time unless it's running.

3) To test the revolving speed of the engine, refer to Section 5.10 below.

4) To test the oil temperature of the engine, refer to Section 5.11 below.

5) Before testing each vehicle, press "↓" key to calibrate the instrument automatically. During calibration, put the measurement unit and the sampling probe into clean air to ensure correct automatic calibration, otherwise, the test result may be affected. The instrument runs internal automatic calibration for zero (0%) point and full-range (99.9%) point for about 3 seconds. Zero calibration is to calibrate the value of the instrument under transparent condition, and full-range calibration is to calibrate the value of the instrument under full-shading (opaque) condition.

6) After calibration, put the measurement unit near the exhaust pipe of the vehicle. The measurement unit must bring in clean air as protective air curtain during testing. If any exhaust gas is absorbed, it may affect the test result. In view of this, it is not allowed to put the measurement unit in diffusion direction of the exhaust gas, but in the right angle with it (see Fig. 10).

7) Before inserting the sampling probe into the exhaust pipe of the vehicle, step down the accelerator of the vehicle continuously for 2-3 times to exit the smoke soot inside the engine. While inserting the sampling tube into the exhaust pipe, the sampling probe must be inserted into the exhaust pipe for a depth of about 30cm unless the straight-line length of the exhaust pipe is shorter. In such case, try to insert the sampling probe to this depth as far as possible. The bending of the exhaust pipe should not block the entrance of the sampling probe so as to avoid influence to the test result. Make sure that the insertion direction of the probe is in the same direction of exhaust (see Fig. 11).

```
                        Main Menu
            ======================
            →1. Real-time Test
              2. Acceleration Test (Normal)
              3. Acceleration Test (Networking)
              4. Diagnosis
              5. Parameters Setting
              6. Alarm Information
              7. Version Information
              8. Data View

Status:
↑↓ – Select    K – Enter
```

Fig. 8   Interface of "Main Menu"

```
                  Active              Max.

  Speed            0                   0
  (rpm)

    N             0.0                 0.0
   (%)

    K             0.00                0.00
   (/m)

 Oil Temp.         28
   (℃)

Status:
↑ – Clear   ↓ – Calibrate   K – Print   S – Exit
```

Fig. 9   Interface of "Real-time Test"
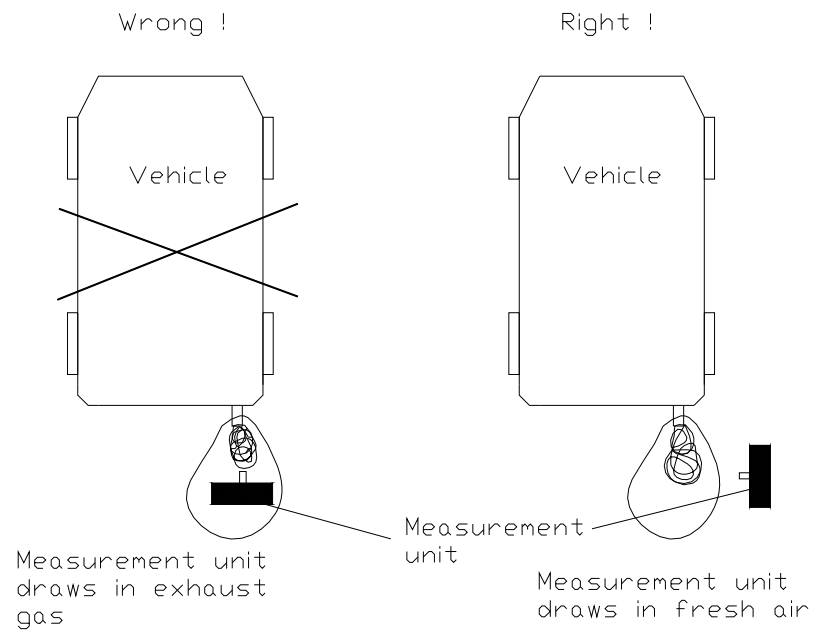
Fig. 10   Placement of Measurement Unit
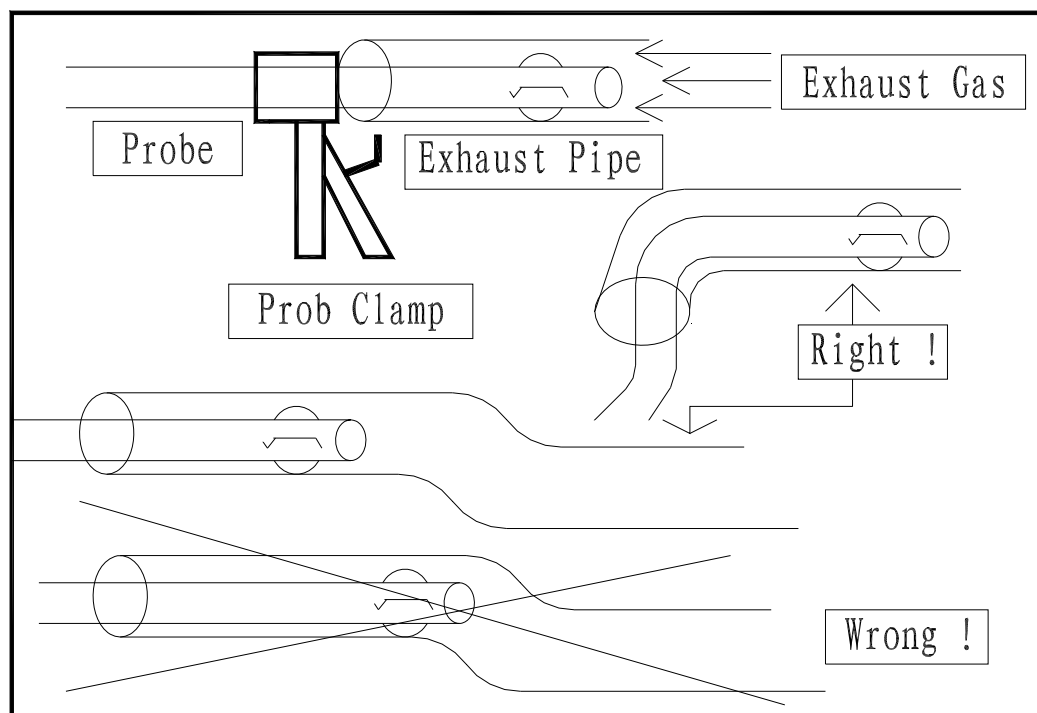
Fig. 11   Insertion Method of Sampling Probe

8)   After the above steps, real-time test or free acceleration test can be started. The real-time test value can be read as sampling data. The acceleration test should be done as follows: Step

down the accelerator quickly and accelerate the engine abruptly to the maximum rated revolving speed. Keep the speed for about 3 seconds and release the accelerator, the engine returns to idle. When the accelerator is stepped on, the exhaust smoke from the engine increases sharply. When the revolving speed becomes stable, the exhaust smoke drops rapidly. The instrument samples and compares the values constantly and the maximum value will be displayed on the left of the screen. During the test, press "K" key to print the real-time data and the maximum value. The maximum value is stored until it is cleared by "↑" key. After the test, take out the sampling probe from the exhaust pipe of the vehicle, and put the measurement unit back to a clean place. Repeat steps 2)～ 8) above to test another vehicle. Steps 3 and 4 can be omitted if no test required for oil temperature and revolving speed. Press "S" key to return to Main Menu from this interface.

5.4 Acceleration Test (Normal).

    1. The free acceleration test (normal) shall be done in the following steps:

    1) After installing the instrument as mentioned in Section 5.1 and warm-up in Section 5.2, the instrument enters the interface of Main Menu automatically (as shown in Fig. 12). Move the cursor "→" in front of "Acceleration Test (Normal)" by "↑" key or "↓" key (as shown in Fig. 12), press "K" key to enter the interface of Acceleration Test (Normal). Free acceleration tests can be done in this interface (as shown in Fig. 13) according to China Standard # GB3847-2005. With the test result displayed on the left of the screen, the transient value and test times displayed on the right, operator can observe the test status of the instrument dynamically.

```
                        Main Menu
            ======================

              1. Real-time Test
            →2. Acceleration Test (Normal)
              3. Acceleration Test (Networking)
              4. Diagnosis
              5. Parameters Setting
              6. Alarm Information
              7. Version Information
              8. Data View

 Status:
 ↑↓ – Select    K – Enter
```

Fig. 12   Interface of "Main Menu"

```
Acceleration Test (Normal) ———-————————————-————

  K-Peak Value (/m):                    Active:
     1)   — — — —        Speed        0      rpm
     2)   — — — —        N            0.0    %
     3)   — — — —        K            0.00   /m
     4)   — — — —        Oil Temp     28     ℃


  Average:   — — — —     Times        0

──────────────────────────────────────────────────
Status:
↑ – Start   ↓ – Save   K – Print   S – Exit
```

Fig. 13   Interface of "Acceleration Test (Normal)"

2) The vehicle to be tested should be warmed up for a certain time unless it's running.

3) To test the revolving speed of the engine, refer to Section 5.10 below.

4) To test the oil temperature of the engine, refer to Section 5.11 below.

5) After the above steps, start the free acceleration test (Normal). During testing, operator must follow the prompts on the lower part of the screen. The test should be done in the following steps.

a. Press "↑" key to start the test, "Put the probe in clean air" is displayed on the instrument. Automatic calibration begins after 4 seconds, a prompt "Calibrating, please wait" is displayed, indicating that the instrument is be calibrated. Before calibration, put the measurement unit and the sampling probe into clean air. The instrument runs internal automatic calibration for zero (0%) point and full-range (99.9%) point for about 3 second. The zero calibration is to calibrate the value of the instrument under transparent condition, and the full-range calibration is to calibrate the value of the instrument under full-shading (opaque) condition.

b. After calibration, a prompt "Please insert probe" is displayed. Operator should step down the accelerator continuously for 2-3 times to exhaust the smoke soot from the engine. Put the measurement unit near the exhaust pipe of the vehicle. The measurement unit must bring in clean air as protective air curtain during testing. If any exhaust gas is absorbed, it may affect the test result. In view of this, it is not allowed to put the measurement unit in diffusion direction of the exhaust gas, but in a right angle with it (see Fig. 10). After that, insert the sampling probe into the exhaust pipe of the vehicle. The sampling probe must be inserted into the exhaust pipe for a depth of about 30cm unless the straight-line length of the exhaust pipe is shorter. In such case, try to insert the sampling probe to this length as deep as possible. The bending of the exhaust pipe should not block the entrance of the sampling probe so as to avoid influence to the test result. Make sure that the insertion direction of the probe is in the same direction of exhaust (see Fig. 11). Then, keep the revolving speed of the vehicle engine in idle, press "K" key for confirmation. "Testing, please wait" is displayed, indicating that the instrument is testing at idle speed, and the starting threshold and the stopping threshold of the sampling data can be achieved.

c. After testing in idle, a prompt "Please accelerate" is displayed, operator may start the free acceleration test. Step down the accelerator quickly to accelerate the engine abruptly to the maximum rated revolving speed. Keep this speed until "Please resume to idle speed" is displayed (if operator is far away from the instrument and fails to read the prompt, keep on running at the max. speed for about 3 seconds). Then, release the accelerator, the engine returns to idle speed. When the accelerator is stepped on, the exhaust smoke from the engine increases sharply. If opacity of the exhaust smoke detected goes beyond the starting threshold, the instrument will start sampling the data continuously. When the accelerator is released, the exhaust smoke drops rapidly. So long as the opacity value drops to the stopping threshold or the sampling is more than 5 seconds, the instrument will stop sampling automatically, start to transfer the data, find out the maximum value from the sampling data as the test result of this time, and display it on the left of the screen.

d. After one test, a new test will be started automatically with "Please accelerate" displayed on the screen. Operator may repeat the operation in step c) and start another free acceleration test. The instrument can store and display the last four test data (peak values of the light absorption coefficient) by rolling order.

e. In accordance with the China standard # GB3847-2005, free acceleration test shall be repeated for at least six times. If the light absorption coefficients from the continuous four tests are within the bandwidth of $0.25m^{-1}$ without the tendency of continuous drop, the arithmetic average of the four values can be taken as the test result. After six free acceleration tests, the instrument will decide whether ending the test on the base of the above condition. Provided that the difference between the maximum value and the minimum value of the test results from the four continuous tests is lower than $0.25m^{-1}$, the data is displayed in "Average" line and the test will be stopped. The maximum times of the continuous tests are 15. If values are still not qualified after 15 tests, the test will be stopped automatically, the data and their average value of the last four times will be displayed with a prompt "Test stopped, data invalid". During this time，operator can press "↓" key to stop the test at any time. After the test, press "K" key to print the test result or press "↓" to save the test results and enter vehicle license number.

6) After the test, take out the sampling probe from the exhaust pipe of the vehicle, put the measurement unit to a clean place. Repeat steps 2) ～6) to test another vehicle. Steps 3 and 4 can be omitted if no test required for oil temperature and revolving speed. Press "S" key to return to Main Menu from this interface.

Note: During free acceleration test, press "↓" key to stop the test, then press "S" key to return to Main Menu or press "K" key to print the test results.

2. Save Test Results and Input Vehicle License Number

After free acceleration test（Normal）, press "↓"key to save the test result and input vehicle license number. After free acceleration test is completed, press "↓" key to enter the interface of Current Vehicle License Number (Fig. 14). Follow the prompts, input the current vehicle license number（the default setting is "----------"）. If it is not necessary to edit the current vehicle license number, press "S" key to save the test result and enter the vehicle license number. If it is necessary to edit the current vehicle license number, press "K" key to edit it, enter the interface

as shown in Fig. 15. After entering this interface, the cursor "▼" appears over the first character of vehicle license number, press "↑" "↓" for modification. There are three Input Methods，"Letter"、"Figure" and "Symbol". Press "K" key to modify the current input method. After the first character is modified，press "S" key to modify the next character. When the last character is modified, press "S" key to return to the interface as shown in Fig. 14. Press "S" to save the test result and vehicle license number, and "Completed" is prompted in "Status:" bar. If further modification is required, press "K" key for editing. The saved data can be enquired in the interface of "Data View" (see 5.10 for details).

      3. Print Test Result

After free acceleration test (Normal), press "K" key to print the test result which includes vehicle license number. Follow the prompt, input vehicle license number before printing. After free acceleration test (Normal), press "K" key to enter the interface of Current Vehicle License Number（Fig. 14）. Follow the prompts, input the current vehicle license number（the default setting is "----------"）. If it is not necessary to edit the current vehicle license number, press "S" key to save the test result and enter the vehicle license number. If it is necessary to edit the current vehicle license number, press "K" key to edit it, enter the interface as shown in Fig. 15. After entering this interface, the cursor "▼" appears over the first character of vehicle license number, press "↑" "↓" for modification. There are three Input Methods，"Letter"、"Figure" and "Symbol". Press "K" key to modify the current input method. After the first character is modified，press "S" key to modify the next character. When the last character is modified, press "S" key to return to the interface as shown in Fig. 14. Press "S" to print the test result. If further modification is required, press "K" key.

> Note：During vehicle license number modification，press "↑" key or "↓" key without releasing until the content for modification is changed to the required one.

Current vehicle license number:

            ABCDEF12345

Status:

K–Edit   S–Next

Fig. 14   Current Vehicle License Number

```
┌─────────────────────────────────────────────────┐
│                                                 │
│                                                 │
│   Input vehicle license number:                 │
│                        ▼                        │
│                  ABCDEF12345                    │
│                                                 │
│                                                 │
│   Input Method ：Letter                         │
│                                                 │
│                                                 │
│                                                 │
├─────────────────────────────────────────────────┤
│   Status:                                       │
│   ↑↓－Modify   S－Select   K－Change Input Method │
└─────────────────────────────────────────────────┘
```

Fig. 15　　　Edit Vehicle License Number

5.5 Acceleration test (Networking)

This function is specially designed for network testing. An external computer controls the instrument through RS-232 communication port to run free acceleration test. For detailed network communication, refer to "Communication with External Computer" below. In addition, operator may use this function to complete the multiple free acceleration tests in the following steps:

1)　　　After installing the instrument as mentioned in Section 5.1 and warm-up in Section 5.2, the instrument enters the interface Main Menu automatically (as shown in Fig. 14). Move the cursor "→" in front of "Acceleration Test (Networking)" by "↑" key or "↓" key (as shown in Fig. 16), press "K" key to enter the interface of Acceleration Test (Networking). Same as the interface of Acceleration Test (Normal), this interface (as shown in Fig. 17) displays the test result on the left of the screen, the transient value and times of test on the right, which enables operator to observe the test status dynamically.

```
┌─────────────────────────────────────────────────┐
│                   Main Menu                     │
│            =======================              │
│                                                 │
│             1. Real-time Test                   │
│                                                 │
│             2. Acceleration Test (Normal)       │
│                                                 │
│           →3. Acceleration Test (Networking)    │
│                                                 │
│             4. Diagnosis                        │
│                                                 │
│             5. Parameters Setting               │
│                                                 │
│             6. Alarm Information                │
│                                                 │
│             7. Version Information              │
│                                                 │
│             8. Data View                        │
│                                                 │
├─────────────────────────────────────────────────┤
│   Status:                                       │
│   ↑↓ – Select   K – Enter                       │
└─────────────────────────────────────────────────┘
```

Fig. 16   Interface of "Main Menu"

```
┌─────────────────────────────────────────────────┐
│ Acceleration Test (Networking) ───────────────── │
│                                                  │
│   K-Peak Value (/m):              Active:        │
│     1)   – – – –          Speed      0    rpm    │
│     2)   – – – –          N         0.0   %      │
│     3)   – – – –          K        0.00   /m     │
│     4)   – – – –          Oil Temp   28   ℃      │
│                                                  │
│                                                  │
│   Average :   – – – –     Times      0           │
│                                                  │
├──────────────────────────────────────────────────│
│ Status:                                          │
│ ↑ – Start   K – Print   S – Exit                 │
└─────────────────────────────────────────────────┘
```

Fig. 17   Interface of "Acceleration Test (Networking)"

2) Same with Step 2) of the Acceleration Test (Normal). Please refer to it.

3) Same with Step 3) of the Acceleration Test (Normal). Please refer to it.

4) Same with Step 4) of the Acceleration Test (Normal). Please refer to it.

5) After the above steps, run the vehicle for free acceleration test. During the test, operator must follow the prompts on the lower part of the screen. Testing should be done in the following steps.

a.   Press "↑" key to start the test, "Put the probe in clean air" is displayed. Automatic calibration begins after 4 seconds, "Calibrating, please wait" is displayed, indicating that the instrument is being calibrated. Before calibration, put the measurement unit and the sampling probe into clean air. The instrument runs internal automatic calibration for zero (0%) point and full-range (99.9%) point for about 3 second. Zero calibration is to calibrate the value of the instrument under transparent condition, and full-range calibration is to calibrate the value of the instrument under full-shading (opaque) condition.

b. After calibration, a prompt "Please insert probe." is displayed. Operator should step down the accelerator continuously for 2-3 times to exhaust the smoke soot in the engine to ensure accurate test. Put the measurement unit near the exhaust pipe of the vehicle. The measurement unit must bring in clean air as protective air curtain during testing. If any exhaust gas is absorbed, it may affect the test result. In view of this, it is not allowed to put the measurement unit in diffusion direction of the exhaust gas, but in a right angle with it (see Fig. 10). After that, insert the sampling probe into the exhaust pipe of the vehicle. The sampling probe must be inserted into the exhaust pipe for a depth of about 30cm unless the straight-line length of the exhaust pipe is shorter. In such case, try to insert the sampling probe to this depth as far as possible. The bending of the exhaust pipe should not block the entrance of the sampling probe so as to avoid influence to the test result. Make sure that the insertion direction of the probe is in the same direction of exhaust (see Fig. 11). Keep the revolving speed at idle speed, press "K" key for confirmation.

"Please accelerate!" is displayed. The instrument does not check the exhaust smoke in idle as mentioned in step 5) of Acceleration Test (Normal) for the starting threshold and stopping threshold, but start sampling directly.

c. After "Please accelerate" is displayed, operator should start free acceleration test. Step down the accelerator quickly and accelerate the engine abruptly to the maximum rated revolving speed. Keep this speed until "Please resume to idle speed" is displayed (If operator is far away from the instrument and fails to read the indication, keep on running at the max. speed for about 3 seconds). "Please accelerate!" and "Please resume to idle speed" are displayed for 5 seconds for each one. After 10 seconds, the instrument stops sampling automatically, starts data processing, calculates the maximum value from the sampling data, uses it as the test result displays it on the left of the screen.

d. After one test, a new test will be started automatically with "Please accelerate" displayed. Operator may repeat the operation in step c) and start another free acceleration test. The instrument can store and display the last four test data (peak values of the light absorption coefficient) by rolling order.

e. According to China standard # GB3847-1999, free acceleration test shall be repeated for at least six times. If the light absorption coefficients from the continuous four tests are within the bandwidth of $0.25m^{-1}$ without the tendency of continuous drop, the arithmetic average of the four values can be taken as the test result. After six free acceleration tests, the instrument will decide whether ending the test on the base of the above condition. Provided that the difference between the maximum value and the minimum value of the results from the four continuous tests is lower than $0.25m^{-1}$, the data is displayed in "Average" line and the test will be stopped. The maximum times of the continuous tests are 15. If values are still not qualified after 15 tests, the test will be stopped automatically, the data and the average value of the last four times will be displayed with a prompt "Test stopped, data invalid". Operator can press "↓" key to stop the test at any time. After the test, press "K" key to print the test result.

6) After the test, take out the sampling probe from the exhaust pipe of the vehicle, and put the measurement unit to a clean place. Repeat steps 2) ～6) to test another vehicle. Steps 3 and 4 can be omitted if oil temperature and revolving speed are not tested. Press "S" key to return to Main Menu.

5.6 Diagnosis and Accuracy Check.

```
                        Main Menu
            =====================

                1. Real-time Test

                2. Acceleration Test (Normal)

                3. Acceleration Test (Networking)

            →4. Diagnosis

                5. Parameters Setting

                6. Alarm Information

                7. Version Information

                8. Data View

Status:
↑↓ – Select    K – Enter
```

Fig. 18   Interface of "Main Menu"

```
            N (Raw) :          0.0      %

            K (Raw) :          0.00     /m

        Gas temperature :       35      ℃

        Tube temperature :      80      ℃

      Detector temperature :    45      ℃

        LED temperature :       45      ℃

       Board temperature :      30      ℃

        Left fan current :     400      mA

        Right fan current :    400      mA

         Power voltage :       14.6     V

        Received intensity :   3000

        Ambient intensity :     384

Status:
↓ – Calibrate    S – Exit
```

Fig. 19   Interface of "Diagnosis"

After installing the instrument as mentioned in Section 5.1 and warm-up in Section 5.2, the instrument enters the interface Main Menu automatically (as shown in Fig. 18). Move the cursor "→" to item "Diagnosis" by "↑" key or "↓" key (as shown in Fig. 18), press "K" key to enter the interface of Diagnosis (as shown in Fig. 19). The internal data of the measurement unit will be displayed and user can check the failure information in alarm status. Accuracy check and calibration can also be done in this interface.

As the instrument calibrates zero point and full-range point, the linearity between the two points must be guaranteed by electronic and optical components of the instrument. Accuracy check must be done after a period of service, because the polluted optical components or the aged electronic

components may cause error in testing. The opacity and light absorption coefficient displayed in the interface of "Diagnosis" are uncorrected values (effective length of the optical path is 215mm), and the values displayed in other interfaces are corrected value (effective length of the optical path is 430mm), it is necessary for user to check accuracy of the instrument in this interface periodically so as to ensure good performance of the instrument. Check the accuracy in the following two ways:

1) After entering the interface of "Diagnosis", press "↓" key to start an automatic calibration, "Calibrating, please wait" is displayed. Put the sampling probe and the measurement unit into clean air before calibration, otherwise the test result may be inaccurate. During calibration, the instrument automatically calibrates zero (0%) point and full range (99.9%) point for about 3 seconds. Calibration for zero point is to calibrate the value of the instrument under transparent condition, and calibration for full-range point is to calibrate the value of the instrument under full-shading (opaque) condition. After calibration is completed, "Calibration over." is displayed.

2) Check accuracy with the optical filter supplied together with the instrument: Insert the optical filter into the lead-in channel (on the side of the detector) on the bottom of the measurement unit (refer to Fig. 25), observe the opacity (raw value) displayed on the screen. This opacity subtracts the standard value of the filter and the indication error is obtained. During accuracy check, never turn or heel over the measurement unit, otherwise the value will be affected. Put the optical filter back to the case immediately after the usage, otherwise it may be damaged by long exposure. The optical filter should be checked regularly to assure the accuracy. Clean the dirty optical filter (if any) by lens tissue each time before usage. No alcohol or other detergent is allowed for cleaning.

Maintain and repair the instrument immediately according to the following chapter once the accuracy is out of range. After accuracy check, press "S" key to return to Main Menu.

5.7 Parameters Setting.

After installing the instrument as mentioned in Section 5.1 and warm-up in Section 5.2, the instrument enters the interface of Main Menu automatically (as shown in Fig. 20). Move the cursor "→" to item "Parameters Setting" by "↑" key or "↓" key (as shown in Fig. 20), press "K" key to enter the interface of Parameters Setting (as shown in Fig. 21). In the interface, user may modify and store three internal parameters. All parameters of the instrument are set as default before delivery (as shown in Fig. 21), normally no modification shall be required. However, in special conditions, user can make suitable modifications based on the actual situation. Operator can not make any modification, this interface is available to professional service and management personnel only. All parameters are stored in the instrument and will not be lost even if power off.

```
                            Main Menu
                     =====================

                        1. Real-time Test

                        2. Acceleration Test (Normal)

                        3. Acceleration Test (Networking)

                        4. Diagnosis

                     →5. Parameters Setting

                        6. Alarm Information

                        7. Version Information

                        8. Data View

 ──────────────────────────────────────────────────────
 Status:
 ↑↓ – Select   K – Enter
```

Fig. 20   Interface of "Main Menu"

```
 Parameters setting ──────────────────────────────

    →1. Engine Stroke:                    4

       2. Speed Sensor:               Piezoelectric

       3. Gas Compensation:               Off

       4. Default Setup


 ──────────────────────────────────────────────────────
 Status:
 ↑↓ – Select K – Enter S – Exit.
```

Fig. 21   Interface of "Parameters Setting"

Enter the interface of "Parameters Setting", modify the parameters: Move the cursor "→" to the item to be modified by "↑" key or "↓" key, press "K" key for confirmation, the cursor "→" will be moved to the content of this parameter. Use "↑" key or "↓" key for modification. After

modification, press "K" key to confirm and validate the modification, and move the cursor "→" to this parameter again to complete the modification. Press "S" key to cancel the modification and return to the previous status. Repeat such steps to modify other parameters (if necessary). In case that the cursor is in front of the parameter item, press "S" key to return to Main Menu.

"Engine stroke": there are two options, "Two Stroke" and "Four Stroke". This parameter affects the accuracy of revolving speed test with piezoelectric sensor, but has no effect on the optical or battery sensor. User should set up this parameter correctly before RPM test.

"Speed sensor": there are three options, "piezoelectric", "optical" and "battery" sensor. User shall choose a correct one based on the test.

Two options, "On" and "Off" are available for "Gas Compensation". When "On" is selected, the instrument compensates the measurement data on the base of the gas temperature. When "Off" is selected, the instrument does not compensate the measurement data. User may set up this parameter in accordance with the requirement. The default setting is "Off".

In order to resume the default setting, select "Default setup" and press "K" key for confirmation.

5.8 Alarm Information.

```
                         Main Menu

             =======================

                1. Real-time Test

                2. Acceleration Test (Normal)

                3. Acceleration Test (Networking)

                4. Diagnosis

                5. Parameters Setting

             →6. Alarm Information

                7. Version Information

                8. Data View


    Status:

    ↑↓ – Select    K – Enter
```

Fig. 22   Interface of "Main Menu"

```
┌─────────────────────────────────────────────────────────┐
│ Alarm Information ─────────────────────────────          │
│       (   )    Board temperature out of range            │
│       (   )    Detector temperature out of range         │
│       (   )    Tube temperature out of range             │
│       (   )    Power voltage out of range                │
│       (   )    LED temperature out of range              │
│       (   )    Opacity out of range                      │
│       (   )    Fan current out of range                  │
│       (   )    Fan current imbalance                     │
│       (   )    Full light intensity out of range         │
│       (   )    Amb. Light intensity out of range         │
│       (   )    EEPROM data error                         │
├─────────────────────────────────────────────────────────┤
│ Status:                                                  │
│ S – Exit                                                 │
└─────────────────────────────────────────────────────────┘
```

Fig. 23   Interface of "Alarm Information"

The control unit monitors the internal status of measurement unit on real-time. In case of any internal failure in measurement unit, the control unit sends out an alarm to user immediately and display continuously flashing "Alarm" on the lower right corner of each interface. Once the alarm is noted, user may find out the failure reason by checking the interface of "Alarm Information" for further repair and maintenance. Check "Alarm Information" in the following way,

After installing the instrument as mentioned in Section 5.1 and warm-up in Section 5.2, the instrument enters into the interface of Main Menu automatically (as shown in Fig. 22). Move the cursor "→" to item "Alarm Information" by ↑ and ↓ (as shown in Fig. 20), press "K" and enter the interface of "Alarm information". In this interface (as shown in Fig. 23), if there is any failure, "*" will appear in the "(   )" in front of the corresponding failure information, and will disappear once the failure is eliminated. For any "*" in front of alarm information, "Alarm" will be displayed on the lower right corner of each interface, and will disappear once all "*" disappear. Press "S" key to return to Main Menu.

5.9 Version Information and LCD Brightness Adjustment

After installing the instrument as mentioned in Section 5.1 and warm-up in Section 5.2, the instrument enters the interface of Main Menu automatically (as shown in Fig. 24). Move the cursor "→" to item "Version Information" by "↑" key or "↓" key (as shown in Fig. 2), press "K" key to enter the interface of Version Information (as shown in Fig. 25). In this interface, model, description and version number of the instrument will be displayed, and the status information is displayed on the lower part of the screen. Use "↑" key or "↓" key to adjust the LCD brightness. Press "S" key to return to Main Menu.

```
                    Main Menu
          =======================

               1. Real-time Test

               2. Acceleration Test (Normal)

               3. Acceleration Test (Communicate)

               4. Diagnosis

               5. Parameters Setting

               6. Alarm Information

            →7. Version Information

               8. Data View

   Status:
   ↑↓ – Select   K – Enter
```

<p align="center">Fig. 24   Interface of "Main Menu"</p>

```
                    NHT-6

                   OPACIMETER


                   Version 1.4


   Status:
   ↑↓ – Adjust Brightness   S – Exit
```

<p align="center">Fig. 25   Interface of "Version Information"</p>

5.10 Data View

After assembly as per instructions in 5.1，power on the instrument for warm-up（see 5.2 for details），and the instrument enters Main Menu（see Fig. 8）. Use ↑、↓ to move the cursor → to option "Data View"（see Fig. 26）, press K for confirmation. The interface "Select Data Query Method" is entered（see Fig. 27）. There are 3 options in this interface: Query by Serial Number、Query by Vehicle License Number、Clear All the Saved Data. Use ↑、↓ key to move the cursor to the corresponding option, press "S" key to return to Main Menu.（see Fig. 26）.

```
                    Main Menu
          =====================

              1. Real-time Test

              2. Acceleration Test (Normal)

              3. Acceleration Test (Communicate)

              4. Diagnosis

              5. Parameters Setting

              6. Alarm Information

              7. Version Information

        → 8. Data View

  Status:
  ↑↓ – Select    K – Enter
```

Fig. 26   Interface of "Main Menu"

```
          → Query By Serial Number


             Query By License Number


             Clear All Saved Data




  Status:
  ↑↓ – Select    K – Enter    S– Exit
```

Fig. 27   Select Data Query Method

5.10.1 Query by Serial Number

In the interface of Select Data Query Method, use ↑、↓ key to move the cursor → to option "Query By Serial Number"（see Fig. 27），press "K" for confirmation，the interface "Input serial number" is entered（see Fig. 28），and the cursor is located at Hundreds, use ↑、↓ key to modify the figure. After modification, press "S" key to move the cursor to the Tens. After modification, press "S" key to Digits for modification. Then press "K" key to input the serial number for query. If the inputted serial number exists, the interface of Query By Serial Number is entered（see Fig. 29）. In this interface, use ↑↓ key to page up and page down. Press "↑" key for ascending query, press "↓" key for descending query. Query range is 0～quantity of saved data − 1. For example, if the saved quantity is 500 groups, the query range is 0～499. Press "K" key to print the current data, press

"S" to return to the interface as shown in 27.

```
                          ▼
        Input Serial Number : 000




                                                            
        Status:
        ↑↓ – Modify    K – Enter    S– Select
```

Fig. 28   Input Serial Number

```
        Serial Number:000               Saved Count: 020


        K-Peak Value(/m):               Date: 2010-8-10
            1)    0.93
            2)    0.95                   Time:    10:25
            3)    0.93
            4)    0.94                   License Number:
        Average(/m):                          ABCDEF01234
                0.94

        Status:
        ↑↓ –Page Up/Down    K – Print    S– Exit
```

Fig. 29   Query by Serial Number

5.10.2 Query by Vehicle License Number

In the interface of Select Query Method, use ↑、↓ key to move the cursor → to item "Query By License Number"（see Fig. 30），press K for confirmation, the interface of "Vehicle License Number Display" is entered（see Fig. 31）. In this interface, the current vehicle license number for query is displayed（the default setting is "----------"）. If the displayed vehicle license number is the one for query, press "S" key to start the query. If the displayed vehicle license number is not the one for query, press "K" to enter the interface as shown in Fig. 32 to edit the vehicle license number. In this interface, the cursor "▼" appears above the first character of the vehicle license

number, press "↑" "↓" for editing. There are three Input Methods，"Letter"、"Figure" and "Symbol". Press "K" key to modify the current input method. After the first character is modified，press "S" key to modify the next character. When the last character is modified, press "S" key to return to the interface as shown in Fig. 31. Press "S" to query vehicle license number, press "K" for further editing.

After the interface of Query By License Number is entered, if a saved vehicle license number is same as the one for query, enter the interface for the query result（Fig. 33）. In this interface, use ↑ ↓ for query by page up and page down. Press "↑" key for ascending query, display the next saved result of the identical vehicle license numbers; press "↓" key for descending query, display the previous saved result of the identical vehicle license numbers. Query range is 0～quantity of saved data − 1. For example, if the save quantity is 500 groups, the query range is 0～499. Press "K" key to print the current data, press "S" to return to the interface as shown in 27. In the interface of vehicle license query, if the vehicle license number for query is not available in the saved data, enter the interface as shown in Fig. 34, press "S" to exit and return to the interface of Select Data Query Method（Fig. 30）；Press "K" to re-edit the vehicle license number for query an d enter the interface as shown in Fig. 32.

<div style="border:1px solid">

Query By Serial Number

→ Query By License Number

Clear All Saved Data

Status:

↑↓ – Select   K – Enter   S– Exit
</div>

Fig. 30   Select Query Method

```
Current Vehicle License Number:


                    ABCDEF01234






Status:
K − Edit    S − Next
```

Fig. 31   Display Vehicle License Number

```
Input Vehicle License Number:
                    ▼
                ABCDEF01234



Input Method: Letter



Status:
↑↓−Modify    S−Select    K−Change Input Method
```

Fig. 32   Edit Vehicle License Number

```
┌─────────────────────────────────────────────────────┐
│  Serial Number:005           Saved Count:020        │
├─────────────────────────────────────────────────────┤
│                                                     │
│  K-Peak Value(/m):          Date: 2010-8-10         │
│      1)    0.93                                      │
│      2)    0.95             Time:    10:25          │
│      3)    0.93                                      │
│      4)    0.94             License Number:          │
│  Average(/m):                   ABCDEF01234         │
│              0.94                                    │
│                                                     │
│                                                     │
├─────────────────────────────────────────────────────┤
│ Status:                                             │
│ ↑↓ – Page Up/Down    K – Print    S– Exit           │
└─────────────────────────────────────────────────────┘
```

Fig. 33 Result of Query by Serial Number

```
┌─────────────────────────────────────────────────────┐
│                                                     │
│   Current Vehicle License Number:                   │
│                                                     │
│              ABCDEF01234                            │
│                                                     │
│                                                     │
│                                                     │
│                                                     │
│                                                     │
│                                                     │
│                                                     │
├─────────────────────────────────────────────────────┤
│ Status: No data is found                            │
│ K – Edit   S – Exit                                 │
└─────────────────────────────────────────────────────┘
```

Fig. 34 Display Vehicle License Number

5.10.3 Clear All Save Data

In the interface of Select Data Query Method（Fig. 27），use ↑、↓ key to move the cursor → to item "Clear All Saved Data"，press "K" and a prompt "Are you sure? " is displayed（Fig. 35），press "K" for confirmation, all the saved data will be cleared. Then "Completed" is displayed in "Status" bar, press "S" to cancel the operation of clearing all the data.

```
                    Query By Serial Number


                    Query By License Number


              → Clear All Saved Data




Status: Are you sure ?
K – OK    S – Cancel
```

Fig. 35 Select Query Method

5.11 Test of Revolving Speed.

Three speed sensors, piezoelectric, optical and battery sensors are available, which can be used in different situations. Piezoelectric sensor, with accurate test but complicated operation, is applicable for automotive manufacturers and workshops. Optical and battery sensors are applicable for vehicle test stations and environmental protection departments because of the easy operations. The standard configuration is piezoelectric sensor. The other two are optional.

The measurement principle of piezoelectric sensor is to test revolving speed of the engine indirectly by testing the pulse of the oil jet pipe on the diesel engine. Firstly, turn off the diesel engine of the vehicle to be tested, put the piezoelectric clamp on the oil jet pipe of the diesel engine in the following ways:

a. Before application, measure the diameter of the oil jet pipe on the diesel engine of the vehicle to be tested, use the piezoelectric clamp which is corresponding to the diameter measured. A piezoelectric clamp will be provided with the diameter of 6.0 mm, clamps with different diameters shall be purchased by user separately.

b. Check if there is any oily dirt, dust or paint on the oil jet pipe before testing. If any, remove it with a piece of fine sandpaper, and clean it with a piece of cloth to make sure of the conductivity. The position clipped on the oil jet pipe shall be round and straight without any scar or curve. The piezoelectric clamp shall be put near to the oil nozzle, and away from the cylinder.

c. Insert the terminal of the piezoelectric clamp into the cable connector, clip it on the oil jet pipe, and tighten the nut on the clamp by hand (Note: Tighten 1/4 circle more when the speed clip fully touches the oil jet pipe. Never use any mechanical tool for tightening, or the piezoelectric clamp may be damaged). Otherwise, it may cause the instable test data. Put the crocodile clip for cable connection on the nut of the oil jet pipe (Note that the nut shall be clean). Refer to Fig. 36.

d. The speed sensor and engine stroke must be set correctly. Otherwise, it may affect the accuracy of the speed testing. Refer to "Parameters Setting" for details.

Strictly follow the above steps a, b, c, d. Otherwise, it may cause inaccuracy or unstable test.
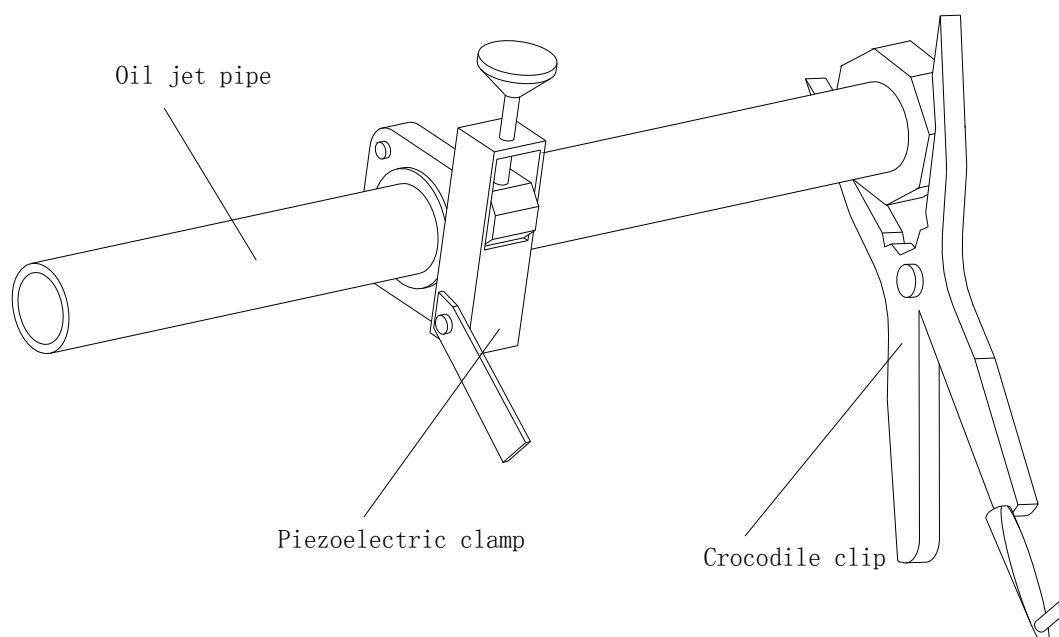
Fig. 36   Use of Piezoelectric Clamp

5.12 Test of Oil Temperature.

When oil temperature of the engine is tested, turn off the diesel engine of the vehicle to be tested, clean the plug-in part of the oil temperature sensor and insert it into the oil cylinder of the engine. The length of the sensor shall be same with that of the oil gauge (adjust it by the sealing rubber on the sensor), or the engine and the oil temperature sensor may be damaged. Block up the plug-in opening by the sealing rubber and avoid spillage of the engine oil. After the test, remove the oil on the sensor by cloth. The oil temperature sensor can not be folded or excessively bent or it may be damaged.

6. Maintenance and Repair

6.1 Maintenance.

The measurement unit must take periodical maintenance. The maintenance period depends on the usage. If the instrument is frequently used, weekly maintenance is recommended. Maintenance must be done with the following steps:

a) Carefully insert the cleaning brush provided by us into the tube of the test chamber (4 in Fig. 25) from the emission outlet (3 or 6 in Fig. 25), stretch forward while cleaning the smoke soot until it reaches the another emission outlet. During the operation, never touch nor damage the optical lens on the two sides. Do not insert the cleaning brush from the emission inlets (5 in Fig. 25), this may damage the gas temperature sensor.

b) Gently wipe the lens (1 and 7 in Fig. 37) on the two sides by a piece of soft and clean wet cloth (suitably wetted). Care must be taken for the lens. Don't turn on the instrument until the moist on the lens is vaporized.

c) Clean the inside and outside of the sampling probe and the guide pipe with cloth by clear

water.
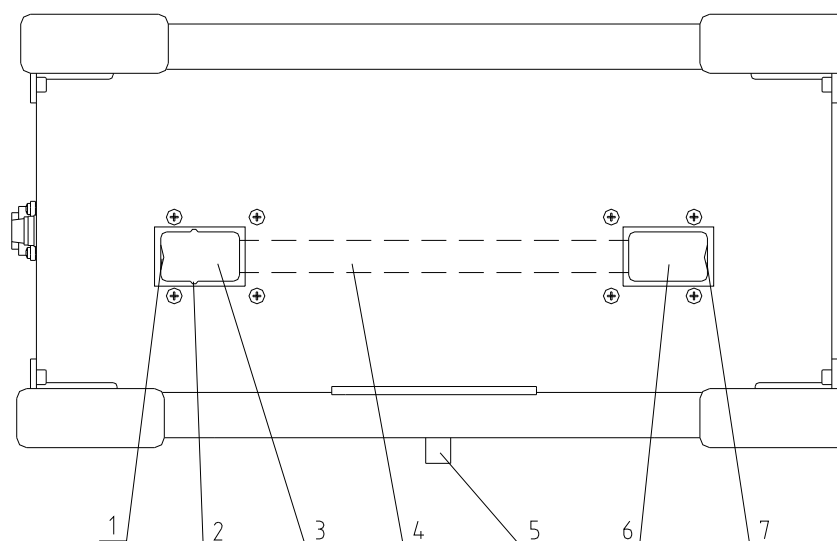
1. Lens;   2. Insert of Glass Filter;   3. Emission Outlet;   4. Test Chamber;
5. Emission Inlet;   6. Emission Outlet;   7. Lens;
Fig. 37   Bottom View of Measurement Unit

6.2 Simple Trouble-Shooting

　　a) If no display at power-on, check the connection of the power cable and the fuse.

　　b) If a prompt "Communication error!" is displayed, check the connections of communication cable and measurement signal cable between the measurement unit and the control unit.

　　c) Clean the measurement unit and make calibration in case of abnormal test value or inaccuracy.

　　d) If there are alarms "Board temperature out of range"(1~75℃), "Detector temperature out of range"(1~70℃), "Tube temperature out of range"(70~250℃) or "LED temperature out of range"(1~70℃), check the actual temperature and compare it with the temperature shown in the interface of "Diagnosis". If the temperature is out of range, check whether the internal components are defective or warm-up is insufficient or replace the temperature sensor.

　　e) If it alarms "Fan current out of range" or "Fan current imbalance", replace the fan.

　　f) If it alarms "Full light intensity out of range", clean and calibrate the measurement unit. If "Amb. light intensity out of range" is alarmed, the circuit must be repaired.

　　g) If it alarms "EEPROM data error", use "Default Setup" function in "Parameters Setting" interface and re-start the instrument.

　　h) Make calibration if the opacity value is out of the range.

　　i) Repair the power sensor in the measurement unit if it alarms "Power voltage out of the range".

Notes: Unprofessional people should never dismantle the optical bench inside the instrument.

Some of the trouble-shootings mentioned above must be done by server engineer from manufacturer. If repair or replacement is required, contact us.

6.3 Assembly and Disassembly of Gas Temperature Sensor

Unless verification test or replacement is required, do not disassembly the gas temperature sensor which is fixed at the tube about 50mm from the emission inlet (inside the measurement unit). During disassembly, turn off the power and open the cover for sensor (as shown in Fig. 5), the sensor can be seen fixed on the tube of the gas inlet. Screw the bolts with a screwdriver, then release the pressing sheet and take out the sensor carefully. Care must be taken to avoid breaking the sensor. Clean the sensor with dry cloth if it is dirty. Insert the sensor into the hole on the tube gently, then install the pressing sheet and screw down the bolt (not too tight) when re-installing it to the tube.

6.4 Installation of Print Paper

   a) Power-off the instrument and open the cover of printer.

   b) Take out the paper core and insert a new print paper roll into the guide groove.

   c) Cut the end of the paper roll into an obtuse angle, send the paper into the printer head.

   d) Power-on the instrument, press "SEL" key on the front panel of the printer to turn off the "SEL light". Press "LF" key to enable the printer head to rotate. Meanwhile send the end of the paper with hand to the paper inlet underneath the printer head, the print paper will go slowly into the printer head until it comes out from the front panel of the printer. When the print paper comes out for a certain length, press "LF" key or "SEL" key again to stop it from moving forward.

   e) Power off the instrument and re-mount the cover of printer.

7. Communication with External Computer.

Commands to communicate with external computer for network testing are available. There are two ways for networking test corresponding to the two interfaces of "Real-time Test" and "Acceleration Test (Networking)". External computer controls the instrument to run real-time test and acceleration test by using these two ways, and obtain test results. User can choose the test mode based on actual requirements.

7.1 Connection.

"Communication Interface" on the control unit is RS232 serial communication port connected with external computer, which is for sending test commands and data. Connect the port in the following way:

25-pin interface   TXD 2 —— RXD   RXD_ 3 —— TXD   GND 7 —— GND   External Computer

7.2 Communication Parameters.

　　Baud Rate: 9600 bps

Character Length: 1 starting bit, 8 data bits, and 1 stopping bit.

　　Parity: none

Note: It is necessary to set the "Print/communication" switch of the instrument to the position of "Communication" when communicating with external computer (see Fig. 4).

7.3 Command Format

Note: Unless specially indicated, all the command codes below are in hexadecimal mode.

7.3.1 Select test mode

　　From external computer: A0H + mode code (1 byte) + check code (1 byte)

　　Response of instrument: A0H + check code (1 byte)

7.3.2 Get current test mode.

　　From external computer: A1H + check code (1 byte)

　　Response of instrument: A1H + mode code (1 byte) + check code (1 byte)

7.3.3 Mandatory exit warm-up interface

　　From external computer: A2H + check code (1 byte)

　　Response of instrument: A2H + check code (1 byte)

(Note: After this command is used, it takes 5 seconds to quit the operation. Usually do not use this command, let the instrument quit warm-up interface automatically to ensure sufficient warm-up.)

7.3.4 Get alarm information

　　From external computer: A3H + check code (1 byte)

　　Response of instrument: A3H + alarm info code (2 bytes, high byte in front)

　　　　　　　　　　　　 + check code (1 byte)

7.3.5 Calibration (Real-time Test).

　　From external computer: A4H + check code (1 byte)

　　Response of instrument: A4H + check code (1 byte)

7.3.6 Get real-time data (Real-time Test).

　　From external computer: A5H + check code (1 byte)

　　Response of instrument: A5H + opacity (2 bytes, high byte in front) + light absorption

　　　　　　　　　　　　　　coefficient (2 bytes, high byte in front) + revolving speed (2 bytes,

　　　　　　　　　　　　　　high byte in front) + oil temperature (2 bytes, high byte in front)

　　　　　　　　　　　　　　+ check code (1 byte)

7.3.7 Get the maximum data (Real-time Test).

　　From external computer: A6H + check code (1 byte)

Response of instrument: A6H + opacity peak (2 bytes, high byte in front) + light absorption

co-efficient peak (2 bytes, high byte in front) + revolving speed

peak (2 bytes, high byte in front) + check code (1 byte)

7.3.8 Clear the maximum data (Real-time Test).

From external computer: A7H + check code (1 byte)

Response of instrument: A7H + check code (1 byte)

7.3.9 Start acceleration test (Acceleration Test (Networking)).

From external computer: A8H + maximum test times (1 byte) + check code (1 byte)

Response of instrument: A8H + check code (1 byte)

7.3.10 Get acceleration test status (Acceleration Test (Networking))

From external computer: A9H + check code (1 byte)

Response of instrument: A9H + status code (1 byte) + check code (1 byte)

7.3.11 Confirming the insertion of the probe (Acceleration Test (Networking))

From external computer: AAH + check code (1 byte)

Response of instrument: AAH + check code (1 byte)

7.3.12 Stop acceleration test (Acceleration Test (Networking)).

From external computer: ABH + check code (1 byte)

Response of instrument: ABH + check code (1 byte)

(Note: This command can be sent any time during free acceleration test to stop free acceleration test.)

7.3.13 Get acceleration test result (Acceleration Test (Networking)).

From external computer: ACH + check code (1 byte)

Response of instrument: ACH + light absorption Coefficient1 (2 bytes, high byte in front) +
light absorption Coefficient2 (2 bytes, high byte in front) + light
absorption Coefficient3 (2 bytes, high byte in front) + light
absorption Coefficient4 (2 bytes, high byte in front) + light
absorption Coefficient average (2 bytes, high byte in front) + check
code (1 byte)

(Note: This command gets the last 4 tests results and the average value of them.)

7.3.14 Get Count of Saved Data Groups

From external computer： B2H + Check Code（1 byte）

Response of instrument： B2H + Count of the saved data groups（2 bytes，high order first）
+ Check Code（1 byte）

7.3.15 Get Saved Test Data

From external computer： B3H + S/N of the first data group to be accessed（2 bytes，high
order first）+ Number of the data group to be got（2 bytes，high
order first） + Check Code（1 byte）

Response of instrument： B3H + Test data to be get（total bytes=data groups to be
got x 26） + Check Code（1 byte）

（B2、B3 commands are valid in the interface of main menu，refer to 7.4.6 for statements about B3H command.）

Note: External computer should immediately wait and receive response from the instrument as soon as the above commands are sent so as to confirm whether the instrument has received the command or not.

7.4 Codes Instruction

7.4.1 Mode Code

It indicates the current test mode of the instrument, with the length of 1 byte, and the numerical meaning as follows:

00H: The instrument is under warm-up. At this time, only A1H, A2H and A3H are valid commands. All other commands are invalid. After warm-up, the instrument will exit from this status automatically to mode FFH (see below).

01H: The instrument is under real-time test mode. At this time, only A0H, A1H, A3H, A4H, A5H, A6H and A7H are valid commands. All other commands are invalid. Under this mode, external computer can control the instrument to make real-time test and single free acceleration test. During free acceleration test, external computer can get the maximum data of each single test, and judge whether the test should be terminated automatically. Refer to the flow chart below (Fig. 27 and Fig. 28).

02H: The instrument is under acceleration test (Networking) mode. At this time, only A0H, A1H, A3H, A8H, A9H, AAH, ABH and ACH are valid commands. All other commands are invalid. External computer can control the instrument to make multiple free acceleration tests and get the final test result. Refer to the flow chart of acceleration test mode below. (Fig. 29)

03H：The instrument is at the status of data view（in the interface of main menu），onlyA0H、A1H、B2H and B3H commands are legal, all others are illegal. External computer can query the data groups saved in the instrument and obtain specific quantity of test data which are saved temporarily. Note：The quantity of test data which is obtained in this way must be less than the quantity of saved data. Otherwise, it is treated as illegal command, refer to the flow chart as shown in Fig. 42.

FFH: The instrument is under other operation mode. At this time, only A0H A1H and A3H are valid commands. All other commands are invalid.

Note: In case that external computer sends out invalid command, the following response will respond: 15H + check code (1 byte), which means the instrument can't run this command under the current mode.

7.4.2 Alarm Information Code

This code indicates all the alarm information of the instrument. It is composed of 2 byte (16 bit), each bit indicates an alarm information.

Each bit of high byte means as follows:

0 bit: Not used

1st bit: Full light intensity out of range

2nd bit: Ambient light intensity out of range

3rd bit: Not used

4th bit: Not used

5th bit: Not used

6th bit: Not used

7th bit: EEPROM error

Each bit of low byte means as follows:

0 bit: Broad temperature out of range

1st bit: Detector temperature out of range

2nd bit: Tube temperature out of range

3rd bit: Power voltage out of range

4th bit: LED temperature out of range

5th bit: Opacity out of range

6th bit: Fan current out of range

7th bit: Fan current imbalance

7.4.3 Status Code

This code indicates status of the instrument during free acceleration test. It is applicable for Free Acceleration Test (Networking) mode only, with the length of 1 byte, the numerical meaning follows:

01H: The instrument is ready for calibration. External computer prompts operator to put the probe into clean air before calibration.

02H: The instrument is being calibrated. External computer prompts that it is being calibrated.

03H: Calibration is completed. External computer prompts operator to insert the sampling probe into the exhaust pipe of the vehicle, press "K" key for confirmation or send AAH to enter the next status directly.

04H: The instrument is sampling data, external computer prompts the vehicle to be accelerated to maximum revolving speed and keep for 3~4seconds.

05H: The instrument has completed the test for peak value, and waiting the vehicle to be decelerated to idle speed. External computer prompts the vehicle to be decelerated.

06H: Free acceleration is completed and the test data complies with the requirements of termination, the data is valid. External computer sends ACH to obtain the test result and A8H to start a new test for another vehicle.

07H: Acceleration test has been stopped or completed, but the test data doesn't comply with the requirements of termination, the data is invalid. External computer sends ACH to obtain the test result and A8H to start a new test for another vehicle.

08H: During the test, the instrument encounters a failure or communication error and needs checking. External computer sends A8H to restart a new test.

Others: The instrument is in illegal status, external computer sends ABH to stop the test and A0H to re-select a test mode.

Under Acceleration Test (Networking) mode, external computer sends A9H and ABH at any time. A9H monitors the status of acceleration test, ABH stop the test at any time.

7.4.4 Maximum test times for free acceleration test

The value is an unsigned integer, with the data length of 1 byte and the valid range 6~15 times. 15 times or above will be processed as 15 times, less than 6 times will be processed as 6 times. If the test times is less than the max. times but more than 6 times, and the test data complies with the requirements of termination, the test will be stopped, the statue code of free acceleration test is 06H. If the test times have not reached the max. times and the test data doesn't comply with the requirements of termination, the test will be stopped, the statue code of free acceleration test is 07H.

7.4.5 Format of test data

The opacity value received is an unsigned integer, with the data length of 2 bytes, high byte in front. Take it divided by 10 as the actual value. The light absorption coefficient received is an unsigned integer, with the data length of 2 bytes, high byte in front. Take it divided by 100 as the actual value. The revolving speed received is an unsigned integer, with the data length of 2 bytes, high byte in front. The oil temperature received is an unsigned integer, with the data length of 2 bytes, high byte in front. The oil temperature is absolute temperature, it must be converted into the centigrade temperature by reducing 273. Moreover, if the oil temperature received is FFFFH, it means that there is no temperature sensor equipped.

7.4.6 Data Format of B3H Command

For example, 500 groups of test data are saved in the instrument, the serial number of these test data is 0 ~ 499. If 100 groups are taken out, the S/N of the first data group is 15，external computer sends the following commands：B3H、00H、0FH、00H、64H、DAH. The instrument returns these 100 test groups, the S/Ns of them are 15 ~ 114，each data group is composed of 26 bytes with the following definitions,
1st~11st byte：for vehicle license number, use English characters and figures in ASCII code.

12th~16th byte：for test data and time，these 5 bytes are for Year, Month, Day, Hour and Minute in turn, the data type is unsigned integer.

17th~26th byte：for 5 light absorption co-efficient values from free acceleration test, each data is composed of two bytes，high byte first, the data type is unsigned integer. The true value is got after it is divided by 100, the unit is m^{-1}, where the first 4 data is the test results from 4 continual free acceleration test, the final one the average value of the previous 4 test results.

7.4.7 Check Code

Check code is used for verifying safety of the data during transmission, with the length of 1 byte. This value equals to the sum of all the bytes before it, then takes the low 8 bits, and adds 1 on the reverse (i.e., complementary code).

7.4.8 Example of Command Format

If external computer requires to get real-time test data, command A5H can be sent out with its check code of 5BH. If the instrument is in valid status, the returned data from 1st byte is A5H. Assuming that the returned test data is: opacity (N) value = 50% and light absorption coefficient

(K) value =1.61m-1, revolving speed = 3000 rpm, oil temperature = 100℃, the returned data from 2nd ~9th bytes will be respectively 01H、F4H、00H、A1H、0BH、B8H、01H、75H. The check code returned from 10th byte is 8CH. If the instrument is in invalid status, the returned data from 1st byte is 15H with its check code of EBH.

Summing up the above conditions, the following is concluded:

External computer sends out: A5H、5BH

Response from the instrument in valid status:　　A5H、01H、F4H、00H、A1H、0BH、

B8H、01H、75H、8CH

Response from the instrument in invalid status: 15H、EBH

7.5 Flow charts for communication between external computer and the instrument.

Fig. 38, Fig. 39, Fig. 40, Fig. 41 and Fig. 42 are the flow charts available for reference by user when programming with external computer.

Note: "Send XXH command" in the flow charts below complies two meanings, i.e., Send out XXH command code and the correlative data code, check code and receive response of the instrument.
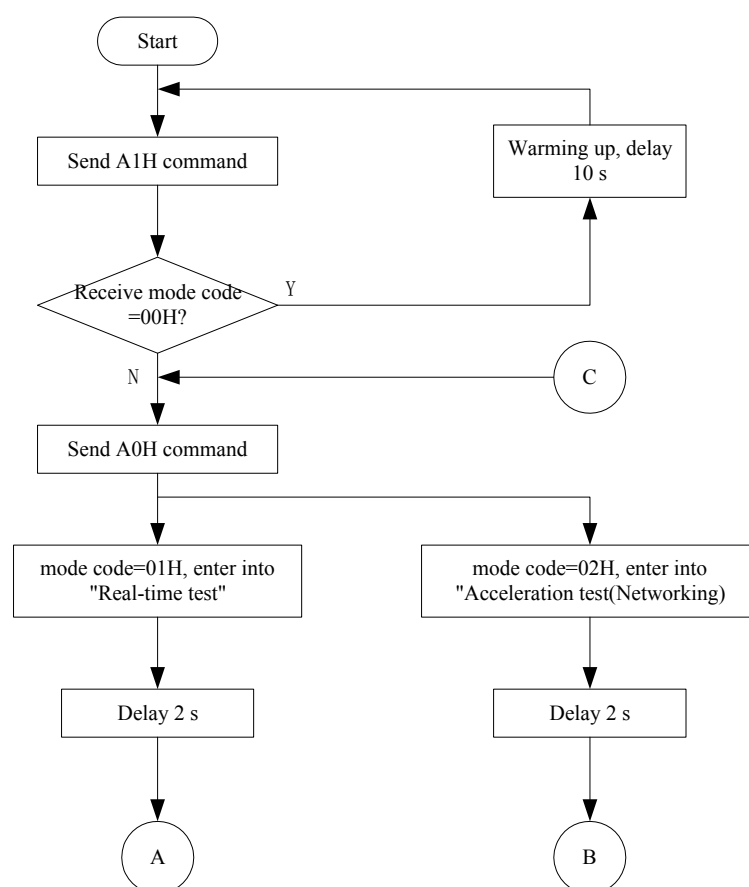
Fig. 38 Flow Chart of Selecting Test Mode.

Fig. 39 Flow Chart of "Real-time Test" Mode

```
                              ( A )
                                │
                                ▼
                  ┌──────────────────────────┐
              ┌──▶│  Prompt to put the probe │
              │   │     in clean air for     │
              │   │       calibration        │
              │   └──────────────────────────┘
              │                 │
              │                 ▼
              │   ┌──────────────────────────┐
              │   │   Send A4H command to    │
              │   │        calibrate         │
              │   └──────────────────────────┘
              │                 │
              │                 ▼
              │   ┌──────────────────────────┐
              │   │         Delay 3s         │
              │   └──────────────────────────┘
              │                 │
              │                 ▼
              │   ┌──────────────────────────┐
              │   │   Prompt to insert probe │
              │   │        and delay         │
              │   └──────────────────────────┘
              │                 │
              │        ┌────────┤
              │        │        ▼
              │        │  ┌──────────────────────────┐
              │        │  │   Send A7H comand to     │
              │        │  │    clear the max value   │
              │        │  └──────────────────────────┘
              │        │        │
              │        │        ▼
              │        │  ┌──────────────────────────┐
              │        │  │   Prompt to accelerate   │
              │        │  │     and delay >=5s       │
              │        │  └──────────────────────────┘
              │        │        │
              │        │        ▼
    ┌─────────────────┐│  ┌──────────────────────────┐
    │  delay>=100ms   ││  │   Prompt to decelerate   │
    └─────────────────┘│  │     and delay >=5s       │
              ▲        │  └──────────────────────────┘
              │        │        │
              │        │        ▼
              │        │  ┌──────────────────────────┐
              │        │  │   Send A6H command to    │
              │        │  │     get the max value    │
              │        │  └──────────────────────────┘
              │        │        │
              │        │        ▼
              │      Y ◇────────────────◇
              │        └─  Test again?  ─┘
              │                 │ N
              │                 ▼
              │   ┌──────────────────────────┐
              │   │   Prompt to take out     │
              │   │         probe            │
              │   └──────────────────────────┘
              │                 │
              │                 ▼
              │   Y ◇────────────────────────◇
              └───── Test another vehicle?  ──┘
                                │ N
                                ▼
                              ( C )
```
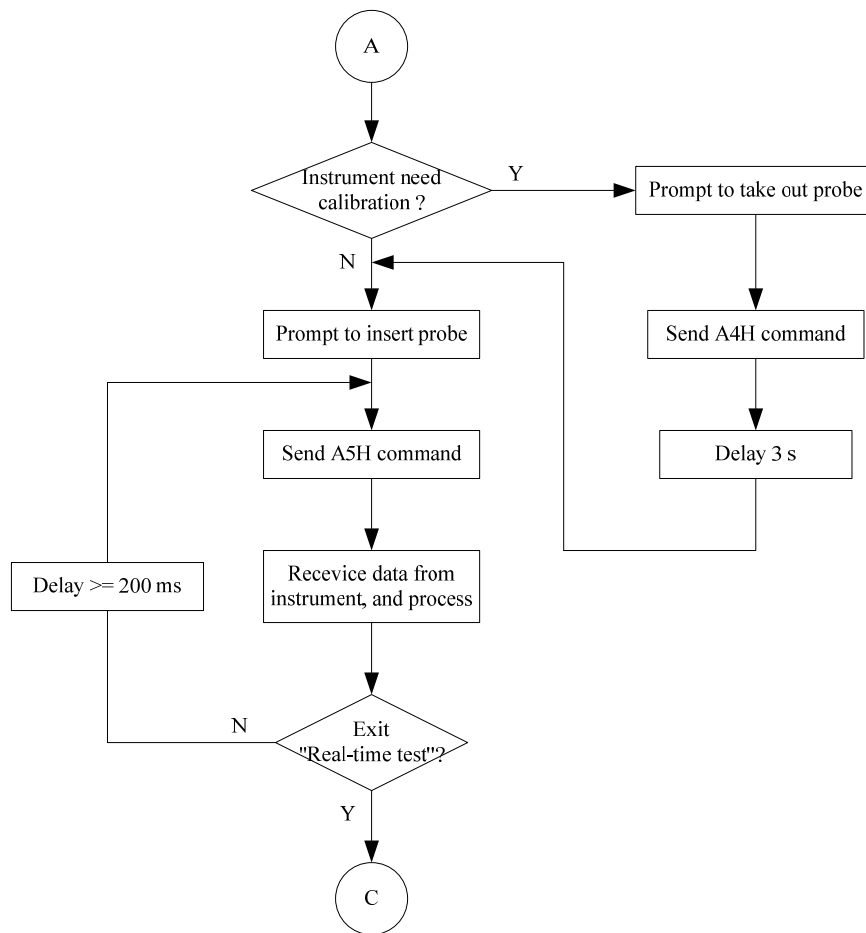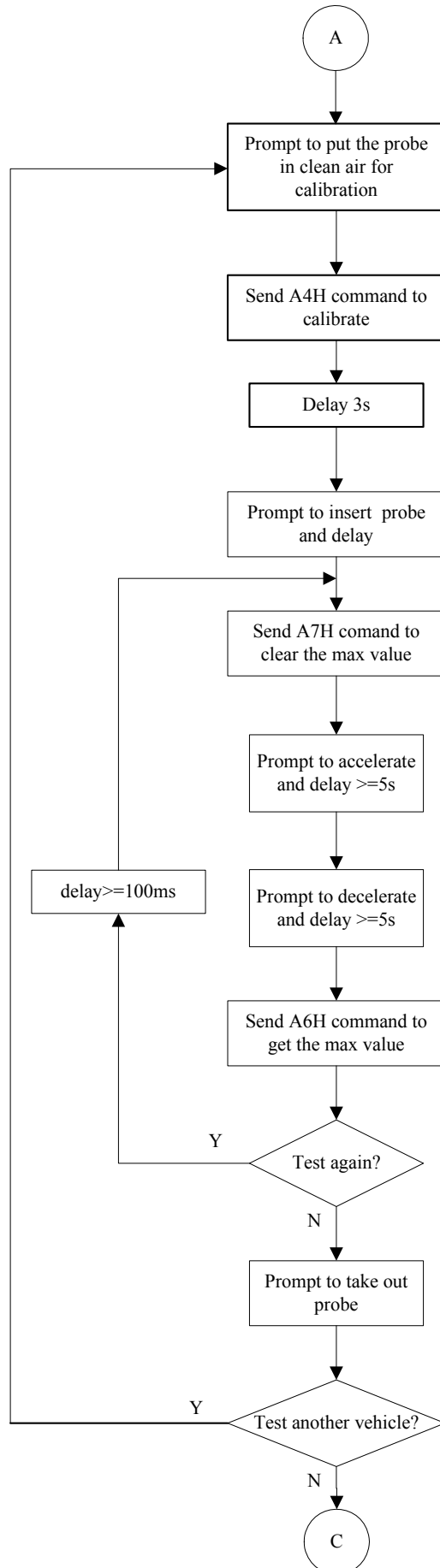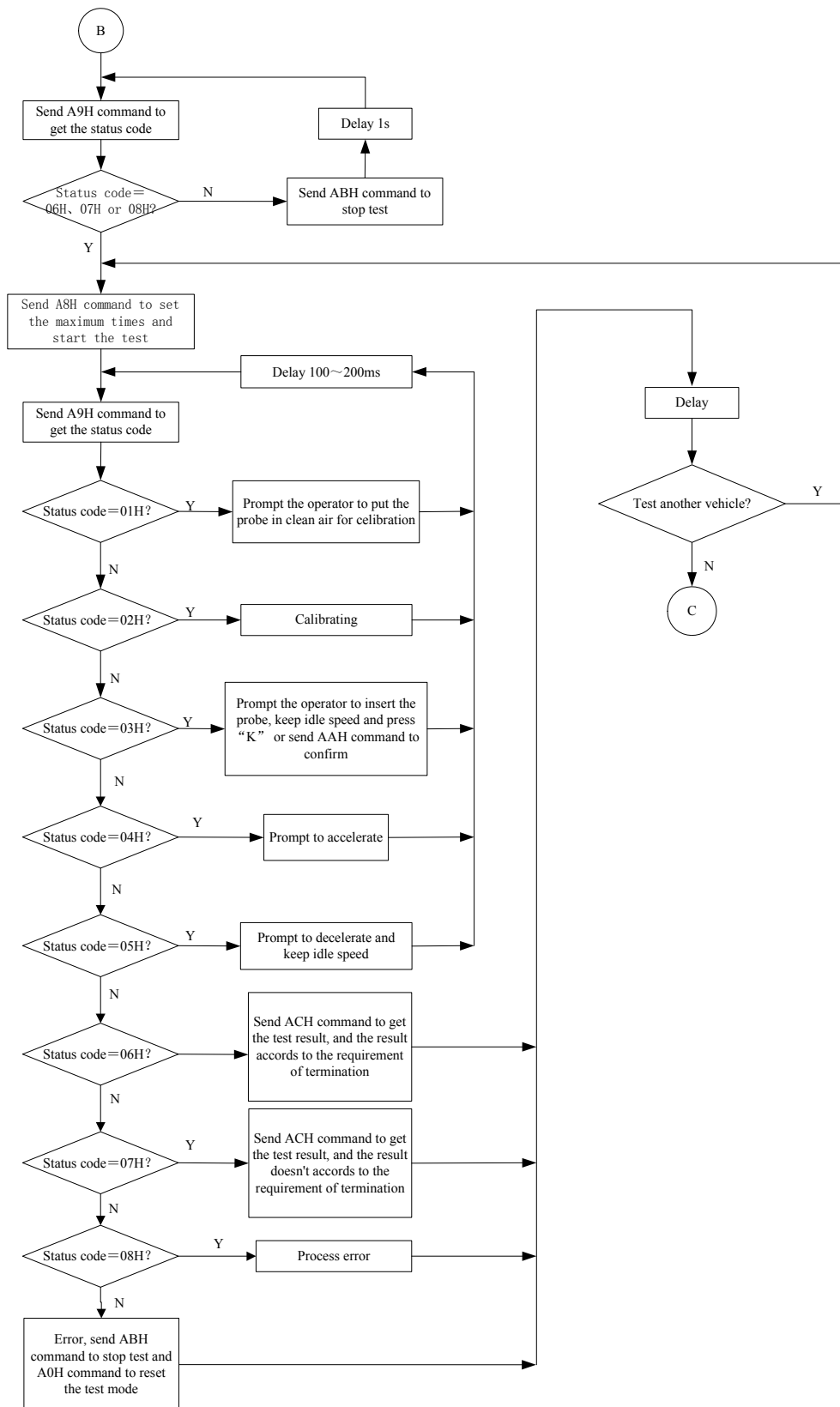
Fig. 40 Flow Chart of Acceleration Test Mode (method 1)

41

Fig. 41 Flow Chart of Acceleration Test Mode (method 2)

```
                    ┌─────────┐
                    │  Start  │
                    └────┬────┘
                         │
                         ▼
   ┌──────────────────────────────────────────┐
   │ Manually enter the interface of Main Menu │
   │  or send A0H command (code=03H) to        │
   │         enter this interface              │
   └────────────────────┬─────────────────────┘
                        │
                        ▼
              ┌──────────────────┐
              │    Delay 1 s     │
              └────────┬─────────┘
                       │
                       ▼
            ┌────────────────────────┐
            │ Send B2H command, get  │
            │  the group count of the│
            │      saved data        │
            └───────────┬────────────┘
                        │
                        ▼
              ┌──────────────────┐
              │    Delay 1 s     │
              └────────┬─────────┘
                       │
                       ▼
      ┌──────────────────────────────────────┐
      │ Send B3H command + S/N +group         │
      │              count                    │
      └─────────────────┬────────────────────┘
                        │
                        ▼
              ┌──────────────────┐
              │ Receive data and │
              │    verify it     │
              └────────┬─────────┘
                       │
                       ▼
                  ┌─────────┐
                  │   End   │
                  └─────────┘
```
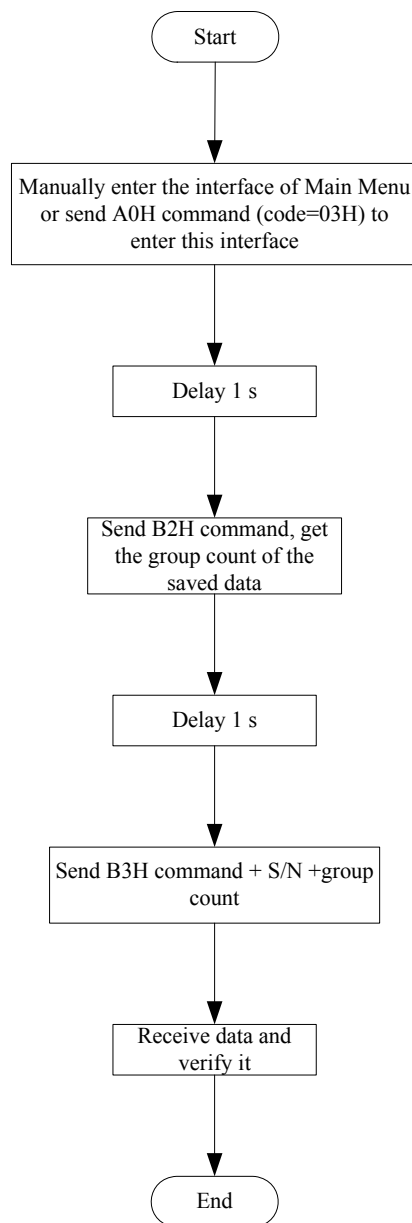
Fig. 42 Flow chart of Data View