Thermoluminescence System TL 200/PMT

Photon Systems Instruments

User's Guide for:

Standard version

High-Temperature version

Liquid Nitrogen Cooling version

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Thermoluminescence System TL 200/PMT consists of five major parts, which may include additional optional components.

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3. **Measuring Chamber**
    - *A. Light Source*
    - *B. Photomultiplier*
    - *C. A/D Converter*
    - *D. Sample Disc*
4. **TFPE1 Control System**
    - *A. AC-88 Unit*
    - *B. Liquid Nitrogen Unit*
    - *C. Additional Heating Unit*
    - *D. Sample Fan*
    - *E. Other TFPE1 Functions*
5. **Additional Cooling Unit**
    - *A. Water Cooling Unit AC-88*
    - *B. Liquid Nitrogen Cooling Unit*

II. How to Connect the System

1. **Plug in the Control Unit power source +12V into the wall socket (110-230V~ allowed); plug its output on the back side of the Control Unit. Let the instrument switched OFF.**

2. **Plug in the Thermoregulator power source +15V/150W into the wall socket (110-230V~ allowed); plug its output on the back side of the Thermoregulator TR 2000. Let the instrument switched OFF.**

3. **Let the TFPE1 Unit switched OFF.**

   For Liquid Nitrogen version:
   If your wall socket voltage is 110V~ (US), plug in the TFPE1 Unit into the wall socket (110V~ allowed only).

   If your wall socket voltage is 230V~ (Europe), plug in the TFPE1 Unit into the transformer 230V~/110V~ output socket. Plug in the input of the transformer into the wall socket 230V~.

   For Standard and High-Temperature version:
   Plug in the TFPE1 Unit into the wall socket (110-230V~ allowed).

4. ***For Standard and High-Temperature version:***
   AC-88 mains switch (placed on the back side of the AC-88) must be switched OFF.

   If your wall socket voltage is 110V~ (US), plug in the AC-88 Unit into the transformer 110V~/230V~ output socket. Plug in the input of the transformer into the wall socket 110V~.

   If your wall socket voltage is 230V~ (Europe), plug in the AC-88 unit into the wall socket (230V~ allowed here only!!!).

   Connect two plastic hoses between the AC-88 and Measuring Chamber. The two hoses are interchangeable. Fill the white tank inside the AC-88 with tap water to within 1cm below the tank lip. Switch the mains switch ON. The actual temperature of water in the water tank is displayed on the front panel as well as the pump operation (green LED below the temperature indicator). You can test the pump function by the PUMP switch = ON and the MODE switch = MANUAL mode. Let the PUMP switch in the ON state and the MODE switch in the REMOTE mode. Connect the AC-88 External Control - TFPE1 Pump cable.

5. **Connect the TR 2000 Cooling Unit – TFPE1 Thermoregulator cable (white).**
6. **Connect the TR 2000 OUTPUT – TFPE1 Control cable.**
7. **Connect the TR 2000 AUX/SERIAL – FL3500 Channel 2 cable.**
8. **Plug in the Measuring Chamber power source +19V into the wall socket (110-230V~ allowed); plug its output on the top side of the Measuring Chamber.**
9. **Connect the Measuring Chamber TL_DATA - FL3500 Channel 1 cable.**
10. **Connect the Measuring Chamber – TFPE1 Thermoluminescence cable (orange).**
11. **Connect the Measuring Chamber – TFPE1 Additional heating cable.**
12. **When the Sample Fan (12V/0.3A) is an attached option, make its connection into the TFPE1 Sample Fan connector.**

13. **Connect the serial cable between the PC and the FL 3500 back side. When there is no serial port on your PC, use the USB-RS232 converter.**
14. **Switch ON the FL 3500, Thermoregulator Power Supply, TR 2000 and TFPE1. Now, the actual temperature of the sample disc is displayed on the front screen of the Thermoregulator.**
15. **Your Thermoluminescence System is ready for experiments now. Use the FluorWin software package for controlling and running measurements.**

CAUTION:

- **Don't plug or unplug any cables when the instruments are switched ON.**
- **Switch OFF all instruments and power supplies before changing the wiring!!!**
- **The manufacturer is not responsible for any "faulty wiring" damage or for damage due to wiring when the instruments are connected to power!!!**

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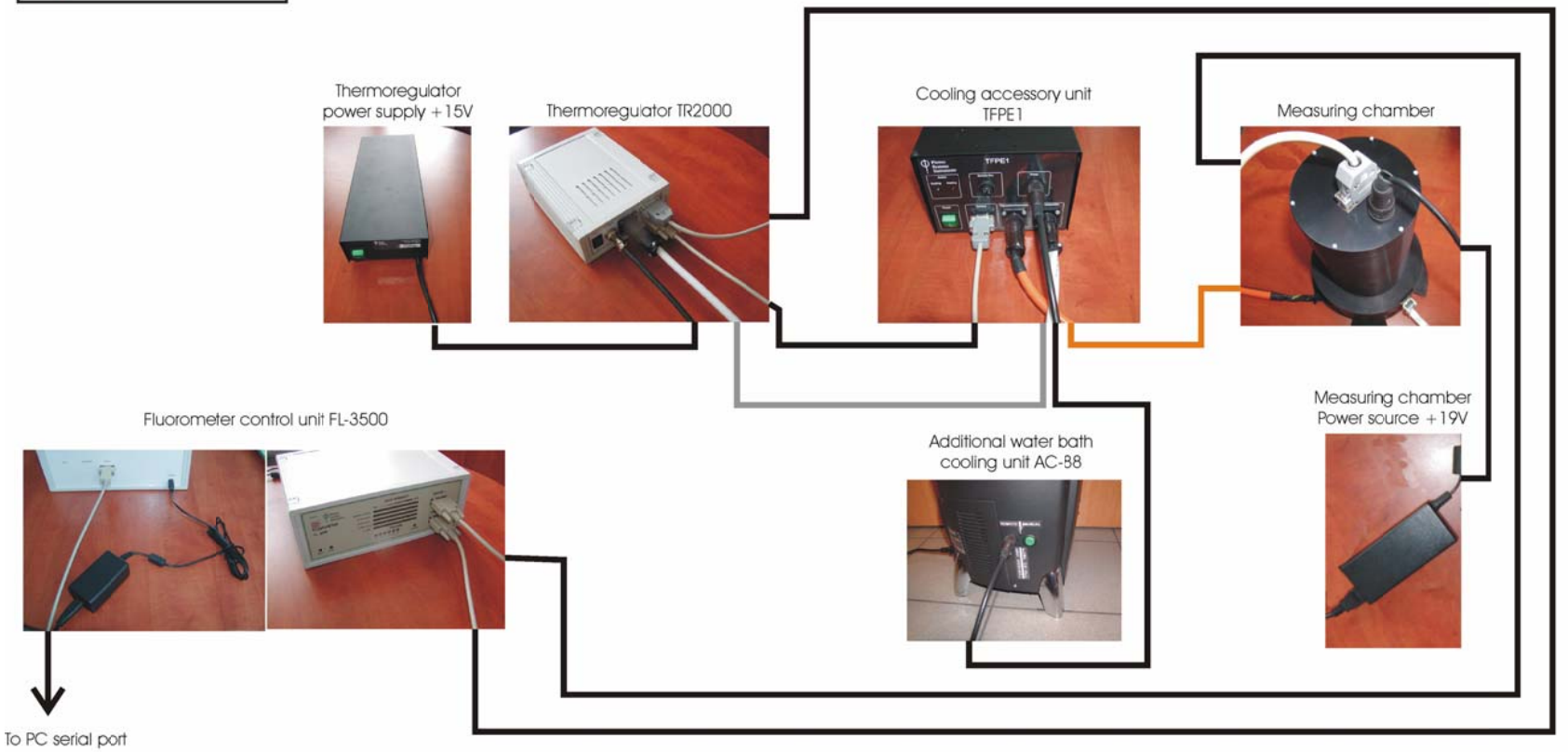
ELECTRICAL CONNECTION OF THE THERMOLUMINESCENCE TL-200 SYSTEM



III. Detailed Description of the Thermoluminescence System

Thermoluminescence System TL 200/PMT consists of five major units (1 – 5). Some of these units include additional components (A, B…).

1. **Fluorometer FL 3500 Control Unit**
2. **Thermoregulator TR 2000**
3. **Measuring Chamber**
    - *A. Light Source*
    - *B. Photomultiplier*
    - *C. A/D Converter*
    - *D. Sample Disc*
4. **TFPE1 Control System**
    - *A. AC-88 Unit*
    - *B. Liquid Nitrogen Unit*
    - *C. Additional Heating Unit*
    - *D. Sample Fan*
    - *E. Other TFPE1 Functions*
5. **Additional Cooling Unit**
    - *A. Water Cooling Unit AC-88*
    - *B. Liquid Nitrogen Cooling Unit*

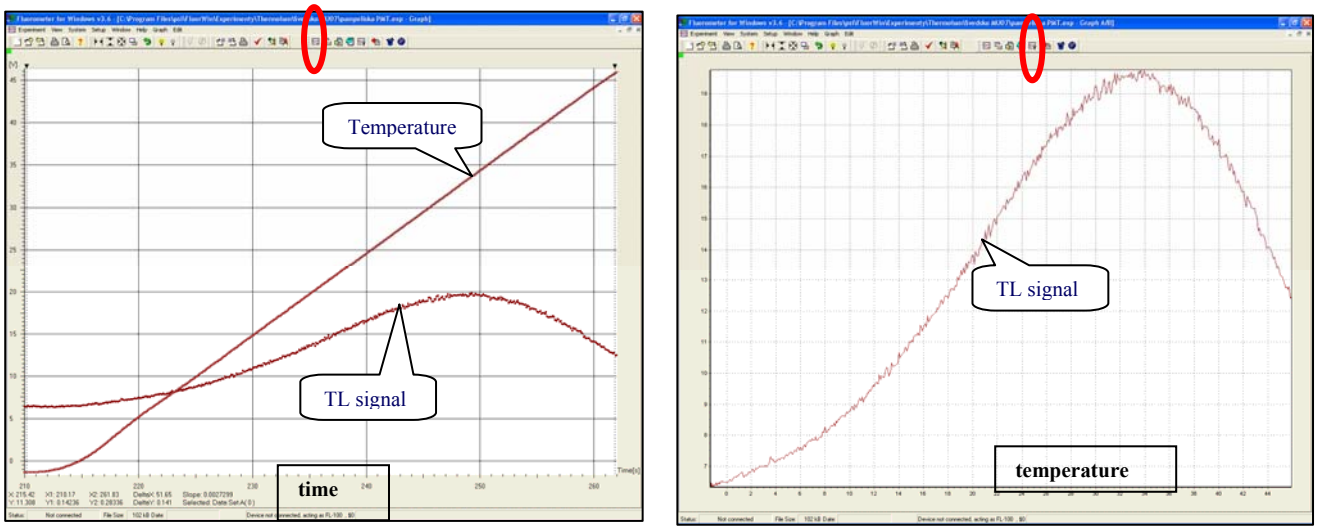
1. Fluorometer FL 3500 Control Unit

Fig.1: Fluorometer FL 3500 – front view

Fluorometer FL 3500 Control Unit executes the experiment according to protocols defined by the user in the FluorWin software. The protocols combine elemental commands, e.g., set temperature, set temperature ramp rate, adjust photomultiplier sensitivity, generate saturating pulse/pulses with defined duration, and specify timing of their execution. The Control Unit communicates with the PC via a serial port *(Fig.2)*. There are two Channel inputs in the Control Unit. Channel 1 is used for measurement of the thermoluminescence signal; Channel 2 serves for temperature measurement during the experiment *(Fig.1)*.

Fig.2: Fluorometer FL 3500 – rear view

The curves may be displayed in two formats: **Time/Temperature** (Dataset A) and **Time/TL** Signal (Dataset B; Graph icon) or **Temperature/TL Signal** (icon), *(Figs.3,4)*. The experimental data may be exported to a *.txt file for an analysis in other software packages.



Figs.3,4: Examples of data visualization

The Control Unit FL 3500 is powered by the +12V/2.5A Power Source. Both the 110V~(US) and 230V~(EU) are allowed on its input *(Fig.2)*.

2. Thermoregulator

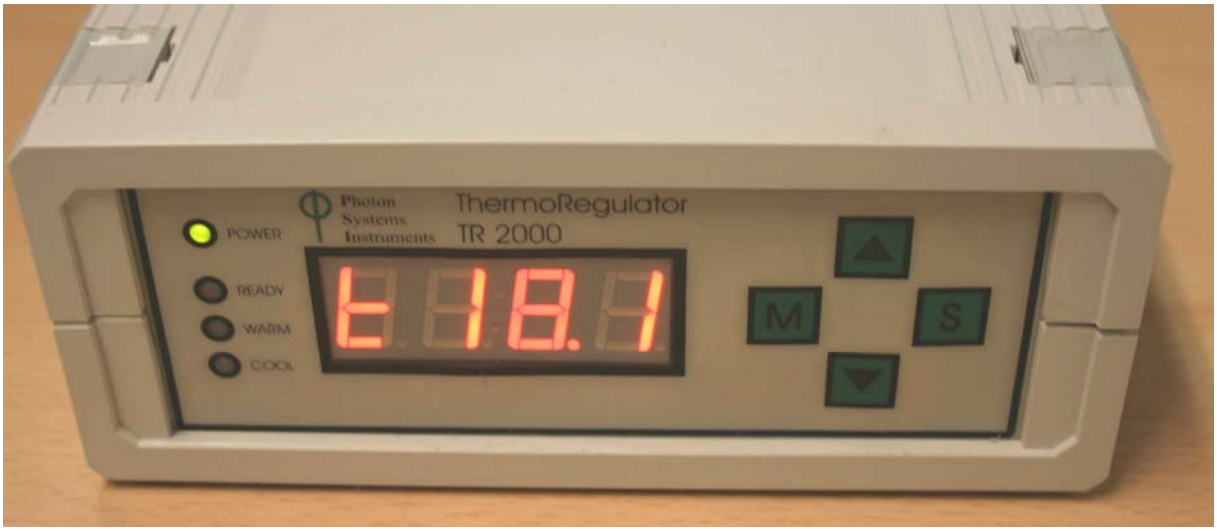


Fig.5: Thermoregulator TR 2000 – front view

The Thermoregulator controls the temperature of the sample disc. Controlled temperature range is -25°C - +70°C (-90°C - +70°C in the Liquid Nitrogen Option version; -25°C - +180°C in High-Temperature version). The temperature can be set either manually (in the menu) or by the protocol (software). The actual temperature of the sample disc is displayed on the front panel of the Thermoregulator.

The **"M"** key is used for listing in the menus.

The **"UP/DOWN"** keys (▲ ▼) are used to set the appropriate temperature.

The **"S"** key is used for confirmation of the selected temperature value.

THERMOREGULATOR FRONT PANEL EXPLANATION:

t - Temperature of the Sample pan (use UP/DOWN and "S" keys to set the temperature of the sample pan).

o- Temperature of the bottom cooler (use UP/DOWN and "S" keys to set the temperature of the sample pan) - functional in the Liquid Nitrogen version only).

r – Automatic Regulation State <On / Off>

P - Pump State <On / Off>

n – Liquid Nitrogen Regulation State <On / Off> (functional in the Liquid Nitrogen version only)

F - Sample Fan State <On / Off>

The temperature is read and recorded by the Control Unit.

In the temperature ramp mode, the Thermoregulator increases the temperature of the sample linearly with a rate ranging between 0.1°C/sec - 1°C/sec.

The temperature data as well as the temperature settings are sent to/from the Fluorometer Control Unit via a SERIAL/AUX ← → Channel 2 cable. The Thermoregulator communicates with the temperature sensors via an OUTPUT cable. Power for the TEC Unit is provided by a Cooling Unit Connector (connected via the TFPE1 Control Box).

The Thermoregulator TR 2000 is powered from the +15V/150W Power Source. Both the 110V~(US) and 230V~(EU) are allowed on its input.

COOLING WITH THE AC-88 UNIT:

An additional cooling water circuit is required for proper operation of the Thermoluminescence System For temperatures reaching down to -25 °C, the AC-88 additional water cooling circuit can be used. The AC-88 unit is a part of both the Standard version and the High Temperature version.

All the settings necessary for proper thermoluminescence measurements are sent by the PC during the protocol execution and they are stored with experiment data. The user doesn't have to control the Thermoregulator manually.

COOLING IN THE LIQUID NITROGEN VERSION:

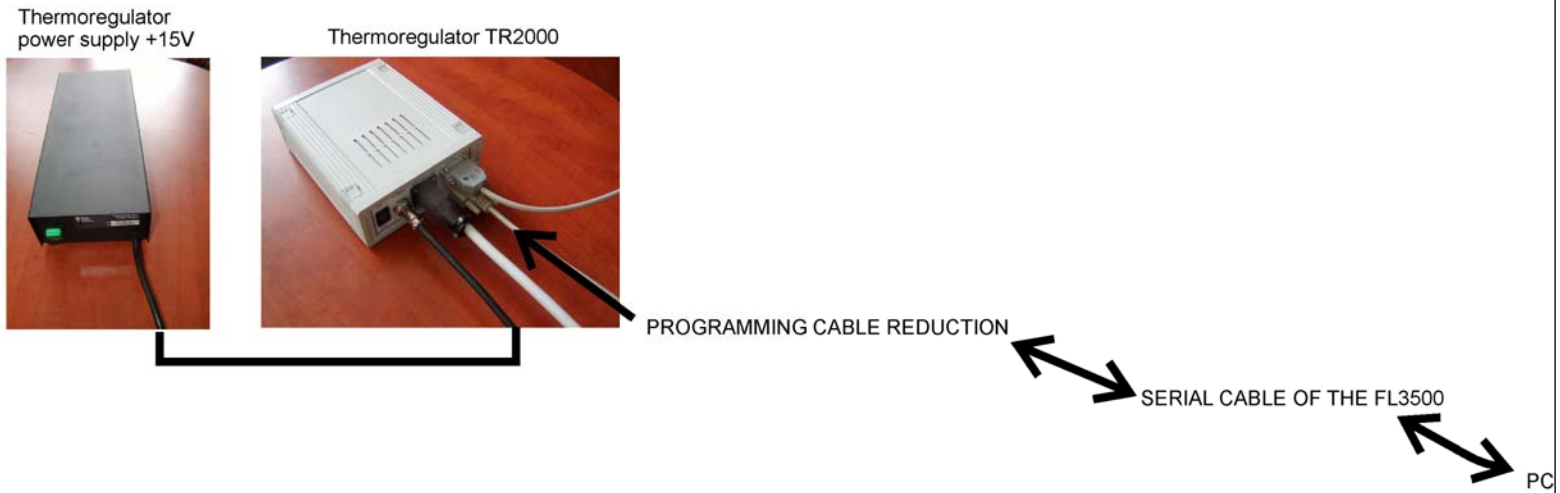
For temperatures reaching down to -70 °C, the Liquid Nitrogen Cooling Unit must be used. This option is a part of the Thermoluminescence Liquid Nitrogen version. The desired temperature of the bottom cooler can be set manually in the **"o"** menu (using **"UP/DOWN"** and **"S"** keys). Automatic regulation can be switched ON and OFF in the **"n"** menu. Protocol equivalent is:

<time>=>Nitro(State , Temperature)

,where *State* means the state of the Liquid Nitrogen automatic regulation (1=ON; 0 = OFF) and *Temperature* (in ºC) the desired temperature to reach at the bottom cooler. The default state when the Thermoregulator starts is: OFF and 0°C.

These settings are not functional in the Standard and High-Temperature versions.

ELECTRICAL CONNECTION FOR THERMOREGULATOR TR2000 REPROGRAMMING



* If the Thermoregulator TR2000 reprogramming is required, plug the programming reduction cable (VGA 15-CANON 9) in the OUTPUT connector on the backside of the TR2000. Use then the FL3500 serial cable to make a connection between this reduction and the PC serial port. Additional instructions are provided on a separate data sheet.

3. Measuring Chamber

The Measuring Chamber consists of four major parts:

- ***A. Light Source***
- ***B. Photomultiplier***
- ***C. A/D Converter***
- ***D. Sample Disc***

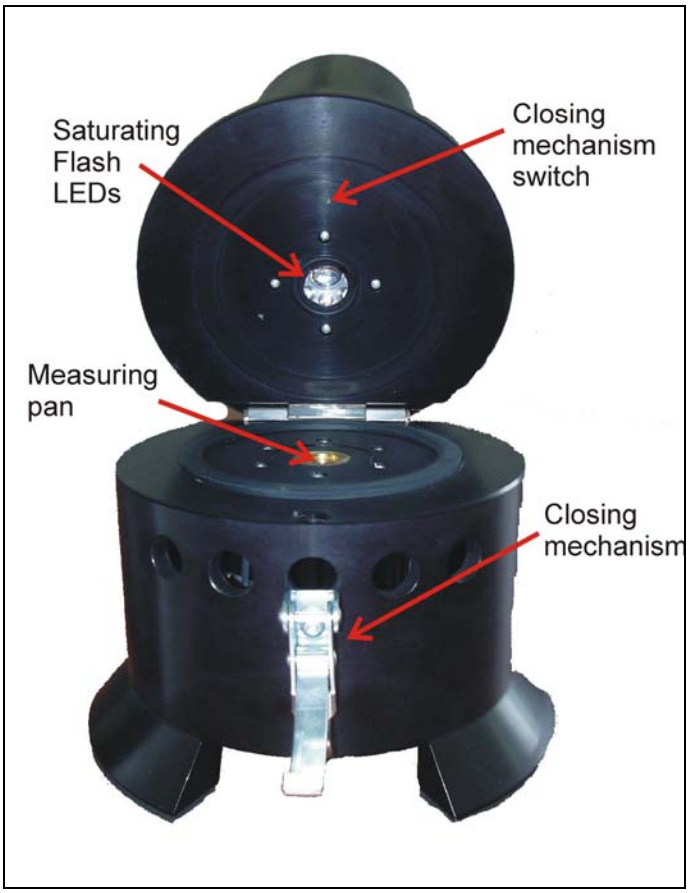


Fig.6: Measuring Chamber

A. Light Source

Installed LEDs offer single turnover saturating flashes focused on the ½" Sample pan. Flash duration and intensity can be defined in protocols. The maximum flash duration is 150 µs. Appropriate light signals are controlled by the Fluorometer Control Unit.

LIGHT IN THE STANDARD AND HIGH-TEMPERATURE VERSIONS:

There are 8 saturating flash LEDs (peak wavelength 625 nm) in the Measuring Chamber. The maximum intensity of a single turnover flash is around 200 000 µmol(photons).m^{-2}.s^{-1}.

LIGHT IN THE LIQUID NITROGEN VERSION:

There are 6 saturating flash LEDs + 2 actinic light LEDs (peak wavelength 625 nm) in the Measuring Chamber. The maximum intensity of a single turnover flash is around 130 000 µmol(photons).m^{-2}.s^{-1}. The maximum intensity of an actinic light is around 300 µmol(photons).m^{-2}.s^{-1}.

The proper light function can be tested by the following steps:

1) Set the Sensitivity 1 slider to 0% in System-System monitor menu

2) Open the Measuring Chamber

3) Go to Window-Test Keys

4) Set slider F_Voltage to 30 %

5) Press Actinic Flash key. You should be able to see a short flash coming out from the LEDs situated in the mid part of the Measuring Chamber lid.

6) Set slider F_Voltage back to 0 %

7) Set slider A_Voltage to 30 %

8) Press Aux 1 key. You should be able to see the light coming out from 2 LEDs placed in the mid part of the Measuring Chamber lid

9) Set slider A_Voltage back to 0 %

10) Close the Windows-Test Key window

CAUTION:

The Measuring Chamber must be OPEN when running the test!!!

Closed Measuring Chamber (during the test) can cause irreversible damage to the detector!!!

B. Photomultiplier with a Built-in Power Supply

The Measuring Chamber contains a high sensitivity detector with the photomultiplier. The photomultiplier detects photons in the wavelength range of 300 to 900 nm. When the Measuring Chamber opens, the photomultiplier shuts automatically down being thus protected from high ambient light. In only 100 ms after the light-flash, the photomultiplier switches on and is ready for the detection of delayed luminescence.

The detector is turned ON by the switch on the Fluorometer FL3500 Control Unit. It communicates with the detector via a communication cable TL DATA OUPUT ← → Channel 1.

There are two possibilities how to set the detector sensitivity:

1) **Protocol Control:**

<time>=>Sens1(Value)

where *Value* is sensitivity of the detector in 0-100% range. 0% value means that the detector is in a power-down mode.

2) **"System-System monitor" menu of the FluorWin software**, where the APD1 sensitivity slider provides sensitivity control. Maximum sensitivity is 100 %, minimum sensitivity is 1 %. Setting the slider to 0 % brings the detector to a power-down mode.

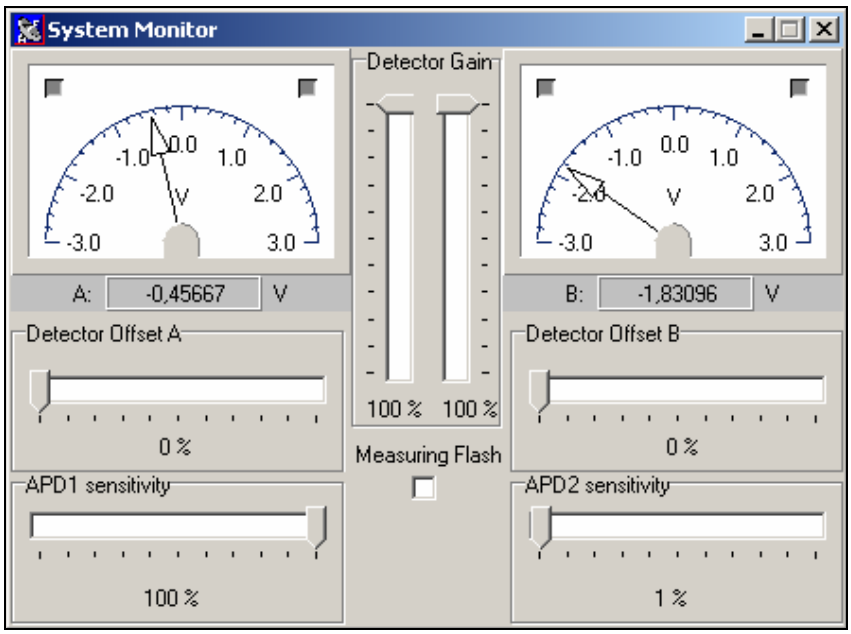


Fig.7: Photomultiplier Control Panel

The same menu provides setting of the detector electrical gain - again in the range 0 – 100 % (left slider). The gain can multiply the signal approximately 40x.

The Offset slider is not active in this instrument.

The manufacturer does not recommend any changes to be done in the default values (Gain = 100, Sensitivity = 0). If you still are considering such changes, consult them with the manufacturer first! Keep in mind that the Thermoluminescence Wizard contains default pre-settings that do not require any user's revision.

If you want to program your own protocol, consult it with the manufacturer (www.psi.cz) first. Be aware, that running a wrong protocol can cause irreversible damage to the detector!!!

CAUTION:

Use only the Thermoluminescence Wizard!!!

Don't use the other wizards of the FluorWin software!!!

The manufacturer is not responsible for any damages caused by using other than Thermoluminescence Wizard protocols!!!

The photomultiplier is supplied with a closing mechanism (switch), which prevents it from damage caused by incoming ambient or actinic light.

CAUTION:

Measuring chamber must be accurately closed by the closing mechanism during the measurements!!!

When the Measuring Chamber is open, the detector is automatically switched to a power-down mode (Sensitivity=0). Incorrect data can be measured in this case.

LIQUID NITROGEN VERSION:

Although the photomultiplier is in a power-down mode during the actinic light excitation, it must be protected by the electromechanical shutter during this period. When the shutter opens, a signal from the sample might be detected after the command:

<time>=>Shutter_On

Command

<time>=>Shutter_Off

closes the shutter and protects the photomultiplier against the light. This state is set as a default by the manufacturer.

C. A/D Converter

The electric current of the photomultiplier is amplified with a software controlled gain before digitization. The time response of the amplifier is fixed at 50 ms, determining the minimal sampling period to 100 ms. The signal is digitalized in the Measuring Chamber.

D. Sample Disc

The sample disc is made of gold-plated copper. The temperature sensor is situated right under the surface of the disc. The sensor is calibrated in the range of -90°C to +200°C with an absolute accuracy of 0.1°C (16bit digitalization). Teflon PTFE ring with an inner diameter of 12 mm must be used for fixing the sample on the sample pan.

Samples, e.g., suspensions of cells, chloroplasts or membranes, ought to be measured on a cellulose filter paper (>= 15mm diameter, 0.4-5um pore size) so that good thermal connection between the metal disc surface and the sample is maintained.

If measuring thermoluminescence in leafs, the sample volume should be as low as possible so as to minimize its heat capacity and the temperature difference between the top and bottom areas of measured leaves.

The sample disc is cooled and heated by a Peltier cell with a cooler (mounted on the disc bottom side). Circulating water flowing through this cooler dissipates heat from the bottom side of the Peltier cell. For temperatures below -25°C, an additional Liquid Nitrogen Unit is required.

The Measuring Chamber is powered by the +19V/4.7A Power Source. Both the 110V~(US) and 230V~(EU) are allowed on its input.

Fig.8: Gold-plated copper sample disc

4. TFPE1 Control System

CAUTION:

If using the Liquid Nitrogen version of the instrument, the TFPE1 Control System must be powered from the 110V~ (US) ONLY!!!

In case of 230V~ power, the liquid nitrogen output valve will burn out!!!

Fig.9: TFPE1 Control System – front panel with connectors

TFPE1 Control System provides automatic control of the additional cooling or heating units. These units are:

A. AC-88 Water Cooling Unit

The unit enables reaching temperatures down to -25°C. This unit must be connected to the "Pump" connector on the front side of the TFPE1.

B. Liquid Nitrogen Cooling Unit

The unit serves for temperatures reaching down to -70°C. TFPE1 supplies 110V~ for the nitrogen output valve on the backside output connector.

Be aware that automatic control for both the AC-88 and for Liquid Nitrogen Cooling Unit must be enabled in the protocol by the following syntax:

<time>=>ExtPowerEnable(1)

ExtPowerEnable(0) command disables controlling the additional devices. Default value, when the TR2000 starts, is Enabled (1).

The pump can be switched ON either manually in the Thermoregulator menu ("P"menu) or in the protocol command syntax:

<time>=>SetPump(1)

SetPump(0) switches the water pump off. Default value when the TR2000 starts is Off.

Automatic control is maintained via the liquid nitrogen valve (Liquid Nitrogen Cooling Unit) or via the pump (AC-88). Both systems use the comparison of the difference of temperatures on the cooler and on the sample disc. When the sample disc temperature is 5 °C lower than the bottom cooler temperature, the pump of the AC-88 starts working or the liquid nitrogen valve is opened. When the sample disc temperature is 5°C higher than the bottom cooler temperature, the pump is switched off or the valve is closed. The actual state of the pump is signaled on the front panel by the LED diode.

Fig.10: TFPE1 Control System – rear view

C. Additional Heating Unit

Additional Heating Unit is provided for the High-Temperature Thermoluminescence version only. The Heating Unit is controlled by the TFPE1 Control System and it is to be connected to the "Additional heating" connector at the back side of the TFPE1. Automatic heating control is signaled by the red "Heating" LED diode at the front side of the TFPE1. The Heating Unit provides temperature control up to +180°C.

The additional Heating Unit is supplied with the High-Temperature Thermoluminescence version only!

D. Sample Fan

To connect the Sample Fan, plug its output to one of the two plastic connectors on the Measuring Chamber (see Fig. 11). The second connector is used as an outlet from the Measuring Chamber. The connected Sample Fan can be independently switched ON/OFF in the protocol.

Fig.11: Sample Fan connectors

E. Other TFPE1 Functions

The „Control“connector (data input/output) creates a digital connection between the TFPE1 Control System Unit and the Thermoregulator TR 2000.

The “Thermoregulator“and the “Thermoluminescence” connectors provide power to the Peltier Cell (connection: Thermoregulator – TFPE1 – Measuring Unit).

5. Additional Cooling Units

An outer Water Cooling Unit AC-88 is used for temperatures reaching down to -25°C.
The Liquid Nitrogen Unit is required for temperatures between -25°C and -70°C.

A. AC-88 Water Cooling Unit

Fig.12: AC-88 Water Cooling Unit – front view

CAUTION:

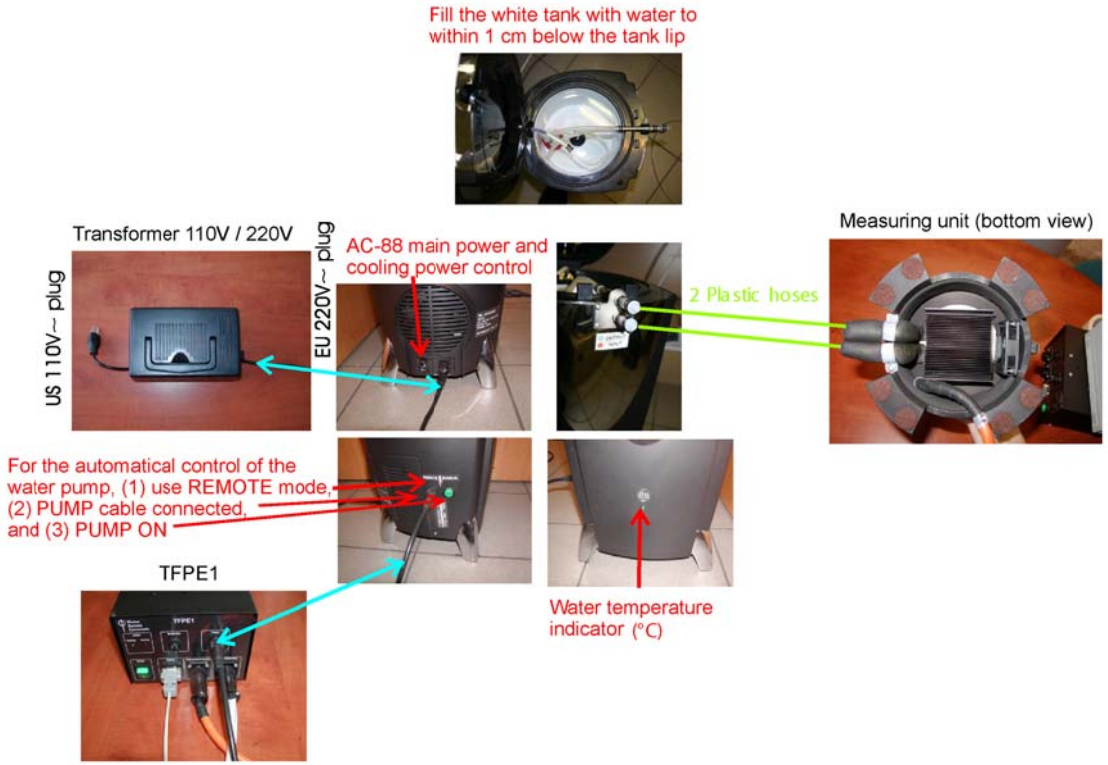
The AC-88 device must be powered from 230V~ (EU) only!!!

If your wall socket voltage is 110V~ (US), a voltage transformer 110V~/230V~ must be inserted in the power path!!!

This transformer provides 230V~/300W on its output. This is sufficient to supply all the Thermoluminescence System components (with multi-plug addition).

The only exception is the TFPE1 Control System. This system must be powered from 110V~ US plug or from the transformer 230V~/110V~.

WATER COOLING CIRCUIT CONNECTION



* NEVER switch ON the AC-88 with NO water inside!!!
* NEVER switch ON the PUMP when the plastic hoses are disconnected!!!
* When working in the MANUAL control mode, the PUMP is controlled by the PUMP switch ONLY.
* When working in the REMOTE control mode, the PUMP must be switched ON for providing TFPE1 automatic control.
* When the main switch is ON, water in the water tank is automatically cooled down with the preset power (backside of the potentiometer).

The AC-88 Unit includes an electrically controlled pump and an integrated refrigerator for cooling the water in the inner tank.

Operation instructions:

1) Fill the white tank inside the AC-88 with clean water to within 1 cm below the tank lip.

Fig.13: AC-88 tank filled with water

2) Connect plastic hoses coming out from the Measuring Chamber to the OUTPUT and INPUT ports at the front side of the AC-88. Input and output hoses can be altered; they do not have a specific position. The pump inside the water tank supplies water into the cooler of the Measuring Chamber.

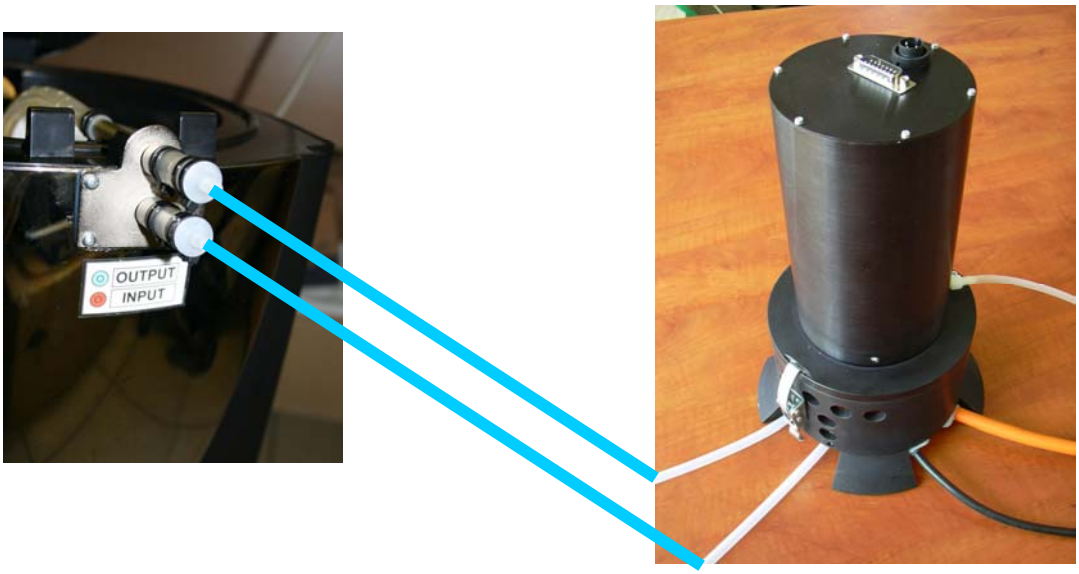


Fig.14: Hose connection between the AC-88 and the Measuring Chamber

3) Switch on the unit by the Mains power switch at the back side of the device.

Fig.15: AC-88 main switch

3) The refrigerator power is adjustable by the backside knob. Turning the knob clockwise lowers the tank water temperature. Be aware, that cooling down the tap water (15°C) to 5°C takes approximately 4-6 hours in the room temperature.

Top cover should stay closed during this time. The reservoir should be monthly refilled with clean water. Water temperature in °C is displayed on the front panel of the unit.

Fig.16: AC-88 temperature display

4) The pump can be controlled either manually or remotely.

For manual control: switch to manual control (right position of the switch) and press the green button (position 1) to start pumping (see Fig. 17).

Fig.17: Pump switch; remote / manual switch

For remote control (see Fig. 17): connect EXT.CONTROL cable to the TFPE1 Control System, switch to remote control (upper position of the switch), and press the green button (position 1). In the remote control mode, the pump is controlled by the Thermoregulator (in the Setting menu) or using a protocol command during the experiment:

<time>=>SetPump(State)

, where State means the state of the pump (0=OFF, 1=ON). Default value after the Thermoregulator starts working is OFF.

Important note:

If the pump is OFF and the automatic control of the AC-88 is enabled (default state when the Thermoregulator starts), the pump can be switched ON by the control loop.

B. Liquid Nitrogen Cooling Unit

The Liquid Nitrogen Cooling Unit is connected to the Measuring Unit by copper pipes. These pipes are connected to the CryoFab Liquid Nitrogen Tank with an electrically controlled cryogenic output valve. Detailed instructions on how to use the Liquid Nitrogen Unit are described on a separate datasheet.

Fig.18: CryoFab Liquid Nitrogen Tank

IV. Running Experiments

1) Switch all instruments ON.

2) Connect the device using the “System-Device ID”(Ctrl-I) menu in the FluorWin software.

3) Put a sample on the sample pan and close the Measuring Chamber by its closing mechanism. Use filter paper for sample suspensions. If using larger filters, make the appropriate cut of 15 mm diameter with a punch-hole tool.

4) Open a typical Thermoluminescence experiment (File-Open Experiment). This experiment is included on the attached CD.

5) Start the experiment by clicking the “red flash” on the icon bar.

6) Once the experiment is finished (message “Ready” appears in bottom left corner), you can check the measured data in T graph window. ( icon).

7) Open the Measuring Chamber and replace the sample.

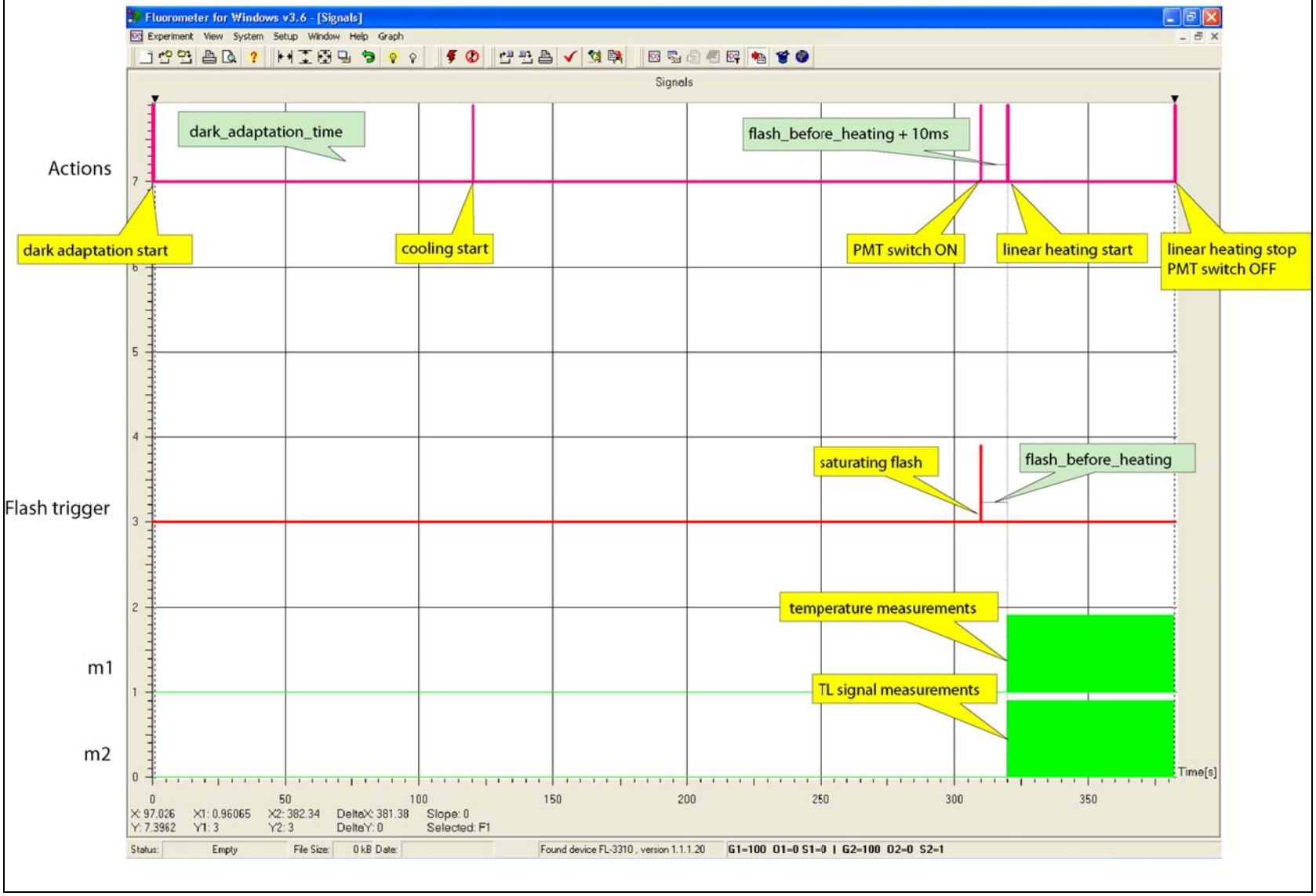
8) If needed, repeat the experiment starting from point 3.

IMPORTANT NOTES:

I) The Thermoluminescence System TL 200/PMT can also measure leaf segments. In this case, it is harder to maintain the dynamic thermal equilibrium between the sample metal disk and the leaf. Therefore, the thermometer reading must be calibrated by the user for this particular experimental setting.

II) The user should also consider potential temperature-reading errors that can be caused by the phase change in the sample (freezing, de-freezing). Because of the latent heat, the sample is arrested during the phase change at a constant temperature (the temperature rise is non-linear). This error will be small if the sample volume is low.

Typical Thermoluminescence experiment signals description



V. Technical Specification

Temperature Control:	
Temperature range	-90°C - +70°C Liquid Nitrogen version -25°C - +70°C Standard version -25°C - +190°C High-Temperature version
Modes of operation	Constant Linear change (0.1°C/sec – 1°C/sec)
Overheating protection	120°C (200°C for High-Temperature version)
Minimum sampling period	10 ms
Control regimes	Manual (constant temperature), Protocol defined temperature profiles
Sample:	
Sample diameter	½" disc
Sample disc material	Gold-plated copper
Typical sample	Algae, cyanobacteria suspension on a filter paper
Light source wavelength	λmax = 625 nm
Light source intensity	Up to 200 000 µmol(photons).m^{-2}.s^{-1}
Detection System:	
Sensor	Photomultiplier with sensitivity software control
Spectral response	300 nm-900 nm
Sampling period	100 ms
Time response	50 ms
Switch-on delay	100 ms
Ambient light protection	Mechanical switch, Electromechanical Shutter (Liquid Nitrogen version)
Control Unit:	
Custom defined protocols	Variable timing, special language and scripts
Communication	Serial port or USB
Software	FluorWin 3.6
Electrical	90V-240V

VI. Statement of Limited Warranty

- This Limited Warranty applies only to the Thermoluminescence System and its optional accessories. It is valid one year from the date of shipment.
- If at any time within this warranty period the instrument does not function as warranted, return it and the manufacturer will repair or replace it at no charge. The customer is responsible for shipping and insurance charges (for the full product value) to PSI. The manufacturer is responsible for shipping and insurance on return of the instrument to the customer.
- No warranty will apply to any instrument that has been (i) modified, altered, or repaired by persons unauthorized by the manufacturer; (ii) subjected to misuse, negligence, or accident; (iii) connected, installed, adjusted, or used otherwise than in accordance with the instructions supplied by the manufacturer.
- The warranty is return-to-base only, and does not include on-site repair charges such as labor, travel, or other expenses associated with the repair or installation of replacement parts at the customer's site.
- The manufacturer repairs or replaces faulty instruments as quickly as possible; the maximum time is one month.
- The manufacturer will keep spare parts or their adequate substitutes for a period of at least five years.
- Returned instruments must be packaged sufficiently so as not to assume any transit damage. If damage is caused due to insufficient packaging, the instrument will be treated as an out-of-warranty repair and charged as such.
- PSI also offers out-of-warranty repairs. These are usually returned to the customer on a cash-on-delivery basis.
- *Wear & Tear Items* (such as sealing, tubing, padding, etc.) are excluded from this warranty. The term *Wear & Tear* denotes the damage that naturally and inevitably occurs as a result of normal use or aging even when an item is used competently and with care and proper maintenance.