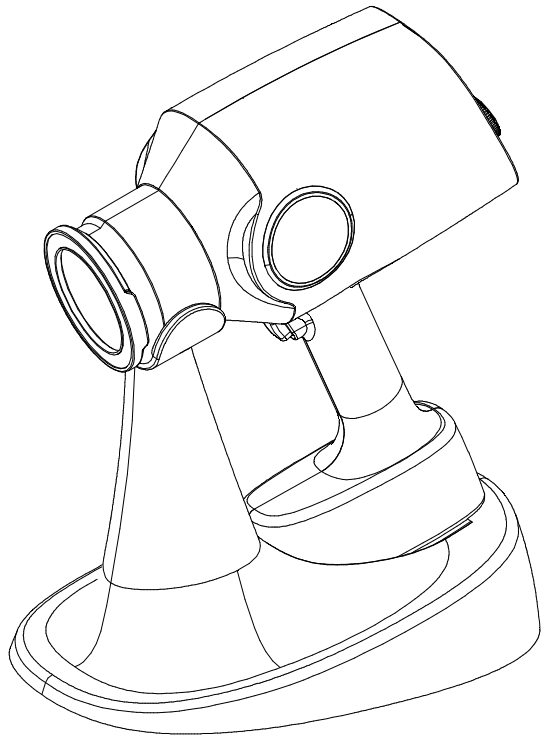




Portable Dental X-ray Machine

Operation Manual



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Basic Information

RAYL (2.0) is a portable dental X-ray machine.

This manual contains the description, operation instructions and imaging principle of RAYL dental X-ray machine.

It is recommended that you familiarize yourself with this manual thoroughly before using the equipment, so that you can use the equipment effectively.

Please follow all precautions, safety information and warnings mentioned in this manual.

This manual will use "Equipment" to refer to "RAYL".

Manual Name: RAYL Portable Dental X-ray Machine Operation Manual

Version Number: REV-B (Software Ver. 2.0)

Issue Date: Aug 2022

Revision History

Version	Issue Date	Reason for Change
VER-A	2020.02	First issue
REV-B	2022.08	Update

Please verify that you are using the latest revision of this document. Information pertaining to this manual is maintained by the manufacturer. If you need the latest revision, please contact your distributor, sales representative or manufacturer.

As technology continues to improve, this manual may not cover the most up-to-date information.

The pictures in this manual are used as illustrations only, and may be different from the actual equipment.

Attention

This manual will involve the following symbols.

Please make sure you fully understand the meaning of each symbol and fully follow its accompanying instructions.

In order to prevent equipment damage and personal injury, please comply with all warnings and safety information listed below.

	WARNING	Indicate a particular risk that is known to exist and that improper operation may lead to: ➤ Severe personal injury (operator, patient); ➤ Significant property losses.
	CAUTION	Indicate a particular risk that may exist and that improper operation may lead to: ➤ Minor injuries; ➤ Property losses.
	IMPORTANT	Indicate a potential problem that, by improper operation, may lead to: ➤ Property losses.
	NOTE	Indicate preventive measures or recommendations during the use of the equipment, specifically: ➤ This manual; ➤ Familiar with corresponding content.

1. Introduction

RAYL is a portable X-ray machine. Operation voltage is DC24V.

This equipment is an X-ray generating equipment powered by a rechargeable lithium battery that mainly used for dental examination (teeth and mandible). It consists of high pressure generator, X-ray tube and control system. The control system includes equipment controller, power controller, user interface, beam limiting device, backscatter shielding and optional remote exposure switch.

This equipment is used to irradiate the intraoral X-rays and imaging for diagnostic use.

1.1 Use Guide

This equipment as a portable X-ray machine is designed for adults and children to provide professional dentists and dental technologists with intraoral imaging and dental X-ray film generating equipment to facilitate the diagnosis and treatment of the condition of teeth, chin and other intraoral parts.

1.2 Operating Principle

When a high voltage is supplied to the X-ray tube that releases electrons from the cathode, the X-rays is excited and combined with X-ray generated from the anode. This equipment imaged by continuously emitting X-rays to patient's teeth.

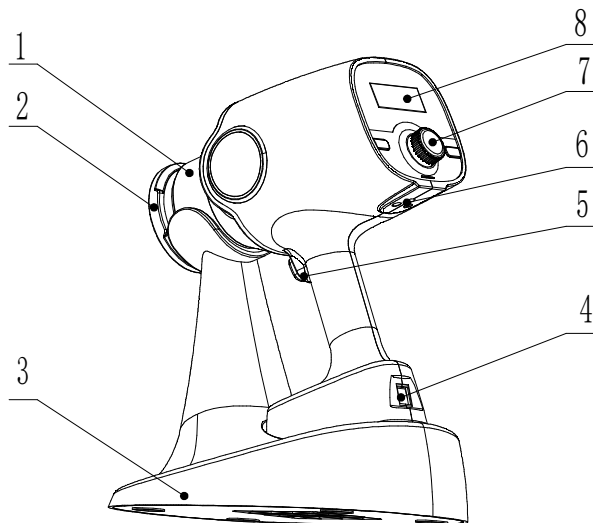
1.3 Component Composition

No.	Name	Standard	Optional	Quantity
1	Main Body	√		1
2	Machine Base	√		1
3	Power Charger (including power cord)	√		1
4	User Manual	√		1
5	Remote Exposure Switch		√	1

1.4 Technical Parameters

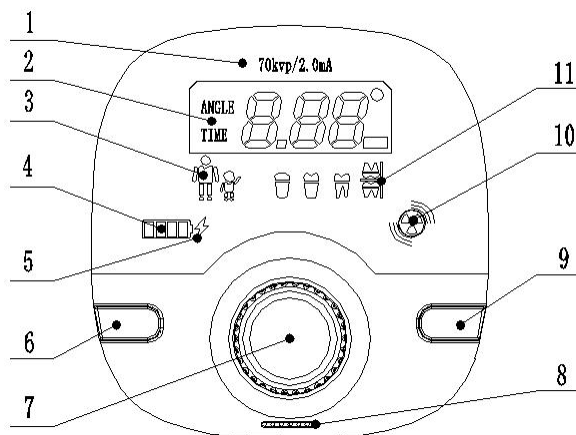
Power Adapter	Power Input:	100-240AC 50HZ 1.6A
	Power Output:	25.2VDC 1.7A
High Pressure Generator	Output Power:	120W
	Tube Voltage:	70KV
	Tube current:	2.0mA
	Working frequency:	70KHZ
	Focus-skin Distance:	110mm or 200mm
	Exposure Time:	0.01-2.0S
X-ray Tube	Maximum Working Voltage:	70KV
	Maximum Working Current	24mA (CP)/12mA (half wave self-rectifying circuit)
	Maximum Filament Current:	2.9A
	Filament Voltage (under maximum filament current 2.9A):	2.4-3.0V
	Nominal Focal Spot Value:	0.4mm
	Target Surface Angle:	12°
	Inherent Filtration:	≥0.75mmAl
Battery	Battery Capacity:	950mAh/21.09Wh
	Battery Voltage:	22.2V
Machine Parameters	Working Mode:	Intermittent loading
	Package Size:	490*280*410mm
	Net Weight:	1.6KG

1.5 Equipment Structure



No.	Name	Description
1	Beam Limiter	Limit the range of X-ray irradiation Equipment exposure mode: conical area + ring coverage (FOV: $\phi 6\text{cm}$)
2	Decoration Ring	Rotating buckle
3	Machine Base	To hold the main body
4	Power Socket	DC-015 socket 5.5*2.1mm
5	Exposure Button	Press to exposure
6	Support Interface	To support and fix the main body
7	Adjusting Knob	To adjust the exposure time
8	Control Panel	To display exposure settings and operating mode

1.6 Control Panel



No.	Name	Description
1	Tube Voltage/Tube Current Symbol	To indicate the tube voltage and tube current of the equipment
2	Angle/Time Display	To display exposure time, exposure Angle and error codes
3	Adult/Child Choice	To select patient type (adult or child)
4	Residual Power Display	To display the current remaining battery power
5	Charging Icon	If the red light is on, the remaining power is insufficient. Plug into the power supply for charging. The red light goes off after the battery is fully charged
6	SWITCH Button	To switch adult or child mode
7	Adjusting Knob	Rotate left (-)/right (+) to select exposure time, click to confirm
8	Buzzer Window	Exposure tone and mode confirmation prompt
9	SET Button	To switch tooth mode
10	Exposure Icon	To display exposure status (Green: ready; Yellow: in exposure)
11	Tooth Mode Display	To display the current tooth mode

2. Safety Instructions

2.1 General Safety Guidelines

- Exposure mode: continuous exposure, intermittent exposure 30 times, waiting for the next exposure.
- The design and manufacture of this equipment is to ensure the maximum safe operating, and the operation and maintenance of the equipment must be carried out in strict accordance with the safety specifications and operating instructions in this manual.
- Only qualified personnel are allowed to operate this equipment.
- Observe the working environment that a fire extinguisher should always be installed near the equipment.
- Except battery replacement, this equipment must be installed, maintained and provided with preventive or periodic maintenance services by professionals.
- Make sure the power switch is off when the equipment is disabled.
- Disconnect the power before cleaning the equipment.
- Do not place the equipment and its components in a humid environment or liquid.
- Avoid placing this equipment near chemical and gas storage facilities.
- Do not make exposure when the equipment is charging.

2.2 Warnings and Safety Instructions

	This equipment can be dangerous for operators and patients. Please read this manual carefully and strictly abide by its regulations and precautions.
	In order to avoid the danger of electric shock, this equipment must use a grounding-protected power supply device.
	Due to differences in radiation safety protection regulations in different countries or regions, the equipment owner has the responsibility and obligation to ensure that the equipment purchased complies with the corresponding local laws and regulations.

- Never disassemble the cover on this equipment by yourself.
- Never place the equipment in liquid, aerosol or spray. Exposure of this equipment to liquids may cause electric shock or damage to the equipment.
- Do not use spray-type cleaning on this equipment, as this may cause a fire.
- Do not place this equipment in a flammable and explosive environment.
- Do not stack flammable materials near this equipment.
- Never touch the SIP / SOP connector while touching the patient.
- Do not make any modification to the equipment, including electrical wires, as this will cause the equipment to be out of warranty immediately.
- We recommend that operators and patients wear lead-lined protective clothing unless other equivalent radiation protection devices are available locally.
- Children and pregnant women should consult a doctor before receiving X-ray exposure.
- In a specific working range, this equipment may be dangerous due to electromagnetic interference from other facilities.
- The power charger must be placed in an easily accessible place.

2.3 Battery Usage

- Ensure that equipment is charged in an environment far from the patient.
- Be sure to use batteries supplied or authorized by the equipment manufacturer. Otherwise, it may cause the equipment to catch fire or even risk explosion.
- Be sure to use the charger supplied or authorized by the equipment manufacturer. Otherwise, it may cause battery damage.
- Do not close the battery to a source of heat or fire, and avoid direct sunlight in the storage environment.
- Do not cause short circuit, distortion, breakage, destruction or dismantling of battery.
- Do not place battery in the box or drawer that may cause short circuits by other metal elements.
- Proper placement of positive and negative electrodes to ensure the normal operation of the equipment.
- Be sure to unseal batteries when replacement is required.
- Do not subject the battery to mechanical impact.
- Do not contact the media with the skin and eyes if the damaged lithium battery causes the internal media to leak out. If contact carelessly, be sure to clean the contaminated areas with plenty of water and a doctor in time.
- Do not dampen or soak the battery and keep it clean and dry.
- Be sure to place battery beyond the reach of children and pets.
- Seek medical attention immediately if the battery is accidentally eaten.
- Be sure to separate used battery from domestic waste, please classify them according to local regulations and dispose of it properly.
- The battery can be replaced by the user.
- Ensure that the equipment is cut off before replacing the battery.
- When the equipment is charged, the exposure function should be suspended.
- Do not charge the equipment for long periods when it is deactivated.
- If the equipment is not in use for a long time, it is recommended that it be recharged before it is reactivated.
- After the equipment has been idle for a long time, it may be necessary to carry out multiple recharges and discharges to the best condition of the battery.
- If the equipment is idle for a long time, be sure to cut off the power supply in order to prolong the battery life;
- Be sure to charge the battery regularly to extend its service life.
- If the long-term idle equipment does not cut off the power supply, it may cause the battery to fail to charge.
- According to the battery discharge test, a full charge is expected to be completed within an hour. If the equipment cannot be powered on after 2 hours of continuous charging, it indicates that the battery cannot be charged. Please contact your distributor, sales representative or manufacturer for maintenance and replacement.
- Do not charge the battery that can't be charged, as this may cause fire or even explosion, please contact your distributor, sales representative or manufacturer in time to replace the new battery.

2.4 Battery Maintenance

Environment temperature: 20°C~25°C; Relative humidity: ≤80%.

If the equipment is not used for 3 months, please charge and discharge the battery at least once.

2.5 Radiation Safety



To ensure the safety of operators and patients, please follow the following radiation safety rules when the equipment is in operation.

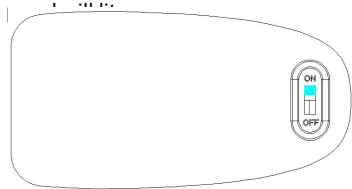
- The equipment shall be operated by qualified dentists or dental technologists.
- All users and patients should wear protecting shield, such as lead lined aprons, lead clothing, etc.
- The equipment shall be operated at a distance of more than 2 meters from other personnel (such as assistants or other patients). Otherwise, we recommend that these persons also wear protective shield or stand behind the lead baffle.
- Pregnant women shall not be exposed if not emergency.
- All users have to comply with the laws, regulations and provisions relating to radiation safety promulgated by the local government.
- Check the possibility of connecting the PID to the backscatter shield at the outer end of the sector area when placing the equipment.

3. Operation Guidance

3.1 Power On/Off

1. The power switch is located at the bottom of the equipment. Turn the handle to the "ON" position to startup the equipment. The following indications on the control

- Digital time display
- Tooth type options display
- Adult/Child options display
- Residual power display
- Exposure icon



2. Switch the handle to the "OFF" position to shut down the equipment.

3.2 Battery and Charging Status

1. Connect the power charger to the power socket of the equipment to start charging. Under charging state, battery icon will flash, from 0 grid to 4 grids back cycle display. When charging, the red light of the power charger will lit up and the green light will be off; When the battery is fully charged, the green light of the power charger will lit up, the red light will be off, and 4 grids of battery icon will keep in lit.



NOTE

Please remove the power charger in time when the battery is fully charged.

2. In the state of independent battery power supply (no power charger is connected and no external power supply), the current battery power is displayed. The number of battery cells is shown as follows:

When the battery is 21-22 volts, it displays 1 grid of power, and when it is less than 21 volts, it displays a blank, and flashes between the blank and 1 grid, indicating that the battery is under voltage; When the battery is 22-22.8 volts, it displays 2 grids of power; When the battery is 22.8-23.5 volts, it displays 3 grids of power; When the battery is more than 23.5 volts, it displays 4 grids of power. When the battery is under voltage, "E-1" alarm will display on the panel. In this case, Exposure cannot be performed (The equipment shall not exposure under charging condition to prevent explosion).

3. Please make sure that at least one grid of power is left before exposure.



NOTE

When the remaining power icon starts to blink, please connect the power charger to charge the battery immediately.



For more information, please refer to 2.3 Battery Usage.

3.3 Display Mode

Mode 1: Exposure time display mode

Mode 2: Angle display mode

The equipment is commonly used in Mode 1 and Mode 2, and the conversion operation is as follows:

Mode 1 is generally used by default during startup.

Keep pressing SWITCH button for 5 seconds in any state, release the button when hearing a beep, the panel will switch to Mode 2.

In Mode 2, the panel will switch to Mode 1 for 5 seconds by clicking any button, and then it will get back to Mode 2 automatically.

Keep pressing SWITCH button for 10 seconds under Mode 2, release the button when hearing beep (the buzzer will beep within 10s), the panel will switch to Mode 1.

3.4 Control Buttons and Operation Instructions

1. Power on the equipment, the buzzer beeps once and the machine will enter the standby state, the panel displays "000" as shown below:



Default setting is adult mode, first tooth selection, 0.10 seconds exposure time. Please refer to the exposure time list for further time setting.

2. **SET Button:** Press to switch tooth types, set four tooth types in a cycle, the corresponding tooth icon is lit up, and the time value of the current gear of the corresponding tooth will display.

The types of teeth are: incisors, canines, molars, and bimaxillary teeth (occlusal). The buzzer will beep once after each pressing, the icon of the corresponding tooth type selected will lit up and the default exposure time of each tooth type selected will display on the panel.

Tooth Type

Icon				
Type	Incisors	Canines	Molars	Occlusal

3. **SWITCH Button:** Press to switch patient modes, the icon of the corresponding patient mode selected will lit up and the default exposure time of each patient mode selected will display on the panel.

Patient Mode

Icon		
Type	Adult	Child

4. **Adjusting Knob:** Rotate to adjust the exposure time, turn the left to reduce the time of one gear, and turn the right increase the time of one gear. The middle button is the confirm button (press the confirm button to save the current time setting, otherwise it will be invalid). The knob can no longer be adjusted after turning to the gear of the maximum or minimum time. The buzzer will beep once after each gear of

time adjustment.

5. Angle Display: Keep pressing SWITCH button for 5 seconds, release the button when hearing a beep, the panel will switch the default time display mode to the Angle display mode.

In Angle display interface, the panel will switch to time display interface for 5 seconds by clicking any button, and then it will get back to Angle display automatically.

To return to the time display mode, please keep pressing SWITCH button for 10 seconds, release the button when hearing beep (the buzzer will beep within 10s), the panel will switch the Angle display mode to the default time display mode.

Time display mode is the default display mode, which means after the shutdown, the next startup will still be the time display mode as default.

6. Time Setting Memory: After the exposure time is adjusted, keep pressing the middle button of the adjusting knob for 3 seconds, release the button when hearing the beep to save the current time setting.

Keep pressing the middle button for 5 seconds, the buzzer will first beep within 3s and beep again within 5s, release the button when hearing the second beep to cancel the saved time setting and return to the default time.



When the exposure time is set manually, the value will be remembered by the equipment as the default value before any other operation of the next time startup.

7. Film Times Display: Keep pressing the SET button for 10 seconds, release the button when hearing a beep, it enters film times display mode, click any button to exit. The unit of count is 100 (if panel displays 001, it means has exposed for 100 times).

8. Exposure Button & Operation Instructions: In order to prevent misoperation, the equipment has **Exposure Lock** function. The operator needs to press the exposure button for 2 seconds to unlock the exposure function first, the buzzer will emit intermittent prompt tone, it will also trigger the countdown of exposure for 10 seconds displayed on the panel.

Press again the exposure button for more than 1.2 seconds within the countdown, the buzzer will keep beeping, and the exposure icon will show yellow to indicate the exposure is completed.



IMPORTANT

Short press the exposure button will not work, the equipment will not emit X-rays.

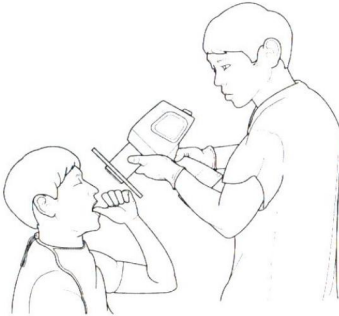
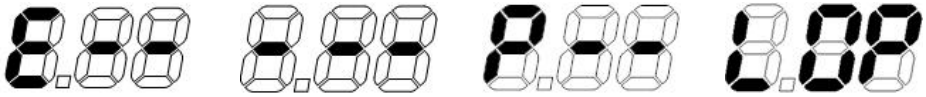
Exposure Lock function is to better protect the health of operators and patients.

The exposure process starts with a filament preheating process of about 1.2 seconds. During this period, the exposure button must be kept pressed, and the panel shows "E--".

After the preheating is completed, the equipment enters the exposure preparation process, which is very short so that is not easy for the operator to perceive it. Then the exposure starts immediately, the buzzer keeps beeping during this process, the exposure icon will also display yellow, and the panel will display "----" until "P--" is displayed after the end.

After that, the equipment enters the exposure interval waiting process, the panel will display "LOP" and blinking, the exposure interval should be 1:60 waiting time (the waiting time is 60 times the last exposure time), and the minimum interval is 10 seconds.

If there is an error, the exposure interval only waits 10 seconds to enter the error processing process, and the error code "E-?" will be displayed. Press any button to exit in the error state. The equipment returns to the standby interface.



Operation Demonstration

After selecting the tooth type, please adjust the exposure Angle. The following data is for reference only.

Tooth Type	Exposure Angle
Incisors	Maxillary: +40°~+50°; Mandibular: -22°~-28°
Canines	Maxillary: +40°~+50°; Mandibular: -17°~-23°
Molars	Maxillary: +25°~+35°; Mandibular: -2°~-8°
Occlusal	+3°~+12°



NOTE

The above Angle data is for reference only. The operator can change the Angle accordingly to achieve the best shooting effect.

In addition, because the hard/soft films, digital sensor and so on used by the operator are different, adjusting knob can be used to adjust the time to achieve a clear gray degree (if the exposure time is too long, the overall image tends to be black, otherwise white).

9. Remote Controller: The equipment is also equipped with optional remote exposure controller, after patient mode, tooth type, exposure time are selected, the operator can achieve remote exposure by pressing the switch of the remote controller for more than 1.2 seconds. The operator can unlock the equipment remotely by pressing the switch of the remote controller for 2 seconds, the buzzer will emit intermittent prompt tone, it will also trigger the countdown of exposure for 10 seconds displayed on the panel.

If the operator confirms the need for exposure, press again the exposure button for more than 1.2 seconds within the countdown, the buzzer will keep beeping, and the exposure icon will show yellow to indicate the exposure is completed.

The remote controller can achieve exposure operation at a distance of 10 meters without shielding.

10. Time Adjustment Range: The equipment time adjustment range is 0.01~2.0s. Turn the adjusting knob to increase or decrease the exposure time. The equipment will automatically return to default settings after exposure. Please refer to the exposure time list for more suggestions.

3.5 Sleep Mode (Power-saving Mode) Description

The equipment will automatically enter the sleep mode without any operation within 10 minutes by default to save power. When the equipment enters sleep mode, the display will be turned off, signal communication and other buttons response will be stopped.

Press SET button to get the equipment out of sleep mode. User can also turn off the power switch directly in sleep mode to fully cut off the power supply.

It is recommended to turn off the power supply if the equipment is not used for a long time.

4. Exposure Time List

4.1 Adult Mode Exposure Time

No.	Incisors (s)	Canines (s)	Molars (s)	Occlusal (s)
1				0.01
2				0.02
3				0.03
4				0.04
5				0.05
6				0.06
7			0.01	0.07
8			0.02	0.08
9			0.03	0.09
10			0.04	0.10
11			0.05	0.11
12			0.06	0.12
13			0.07	0.13
14			0.08	0.14
15		0.01	0.09	0.15
16		0.02	0.10	0.16
17	0.01	0.03	0.11	0.17
18	0.02	0.04	0.12	0.18
19	0.03	0.05	0.13	0.19
20	0.04	0.06	0.14	0.20
21	0.05	0.07	0.15	0.25
22	0.06	0.08	0.16	0.30
23	0.07	0.09	0.17	0.35
24	0.08	0.10	0.18	0.40
25	0.09	0.11	0.19	0.45
26	0.10	0.12	0.20	0.50
27	+0.01~0.2s per gear	+0.01~0.2s per gear	+0.05~2s per gear	+0.05~2s per gear
...	...	...	...	...
n	0.20	0.20		
n+1	+0.05~2s per gear	+0.05~2s per gear		

4.2 Child Mode Exposure Time

No.	Incisors (s)	Canines (s)	Molars (s)	Occlusal (s)
1				0.01
2				0.02
3				0.03
4				0.04
5				0.05
6				0.06
7				0.07
8			0.01	0.08
9			0.02	0.09
10		0.01	0.03	0.10
11		0.02	0.04	0.11
12	0.01	0.03	0.05	0.12
13	0.02	0.04	0.06	0.13
14	0.03	0.05	0.07	0.14
15	0.04	0.06	0.08	0.15
16	0.05	0.07	0.09	0.16
17	0.06	0.08	0.10	0.20
18	0.07	0.09	0.11	0.25
19	0.08	0.10	0.12	0.30
20	+0.01~0.2s per gear	+0.01~0.2s per gear	+0.01~0.2s per gear	+0.05~2s per gear
...	...	...	...	...
n	0.20	0.20	0.20	
n+1	+0.05~2s per gear	+0.05~2s per gear	+0.05~2s per gear	

5. Faults Description

Code	Fault	Panel Signal	Operation Prohibited	Solution
E1	Supply voltage is lower than exposure voltage	E-1	Any operation is prohibited	Charge the equipment in time until the voltage returns to normal; Check whether the battery output cables are correct connected; Check the power charger for damage or poor contact;
E2	Abnormal filament voltage	E-2	Any operation is prohibited	Manually cancel the error code or turn off and on again, wait for 1 minute and try again; Please consult your distributor, sales representative or manufacturer.
E3	Overcurrent protection	E-3	Exposure prohibited is	Manually cancel the error code or turn off and on again, wait for 1 minute and try again; Try charging and then try exposure again; Please consult your distributor, sales representative or manufacturer.
E4	Abnormal parameter	E-4	Exposure is not recommended	The internal parameters of the equipment are restored to factory initialization (without inspection); Please contact professional engineer.
E5	Abnormal memory	E-5	Exposure is not recommended	The internal parameters of the equipment are restored to factory initialization (without inspection); Please contact professional engineer.
E6	Abnormal exposure voltage detected	E-6	Can try exposure	Manually cancel the error code to return to the standby state for the next exposure.
E7	Abnormal exposure current detected	E-7	Can try exposure	Manually cancel the error code to return to the standby state for the next exposure.
E8	Hardware protection	E-8	Can try exposure	Manually cancel the error code to return to the standby state for the next exposure.
E9	Communication error	E-9	Can try exposure	Manually cancel the error code to return to the standby state for the next exposure; Please consult your distributor, sales representative or manufacturer.

6. Daily Use and Maintenance

- The equipment should be far away from the strong electromagnetic radiation environment.
- Regularly check whether the wire of the power charger is damaged.
- The equipment should be far away from strong acid and strong alkaline environment, and avoid contact with corrosive liquids.
- When the equipment is not in use, it should be properly stored to prevent children or non-professionals from touching the equipment.
- When the equipment displays 1 grid of power, please charge it immediately to prevent battery damage.
- When the equipment is not used for a long time, it should be ensured that the equipment is fully charged with 4 grids of power once and discharged within 3 months, and then stored after being fully charged with 4 grids of power.
- When charging, when the equipment displays 4 grids of power and does not flash, it means that the equipment is fully charged. It is recommended to remove the power charger immediately to prevent battery damage.
- It is forbidden to use the equipment to exposure in the charged state to prevent the battery from exploding and other hazards.
- Keep the surface of the equipment clean, wipe the equipment once a week to prevent liquid from entering the inside of the equipment.
- The equipment should be placed in a dry environment to prevent damage to electrical components.
- The equipment use and protection requirements must meet the relevant requirements of the local government.
- The disposal of equipment scrapped or battery scrapped must comply with the relevant requirements of the local government.