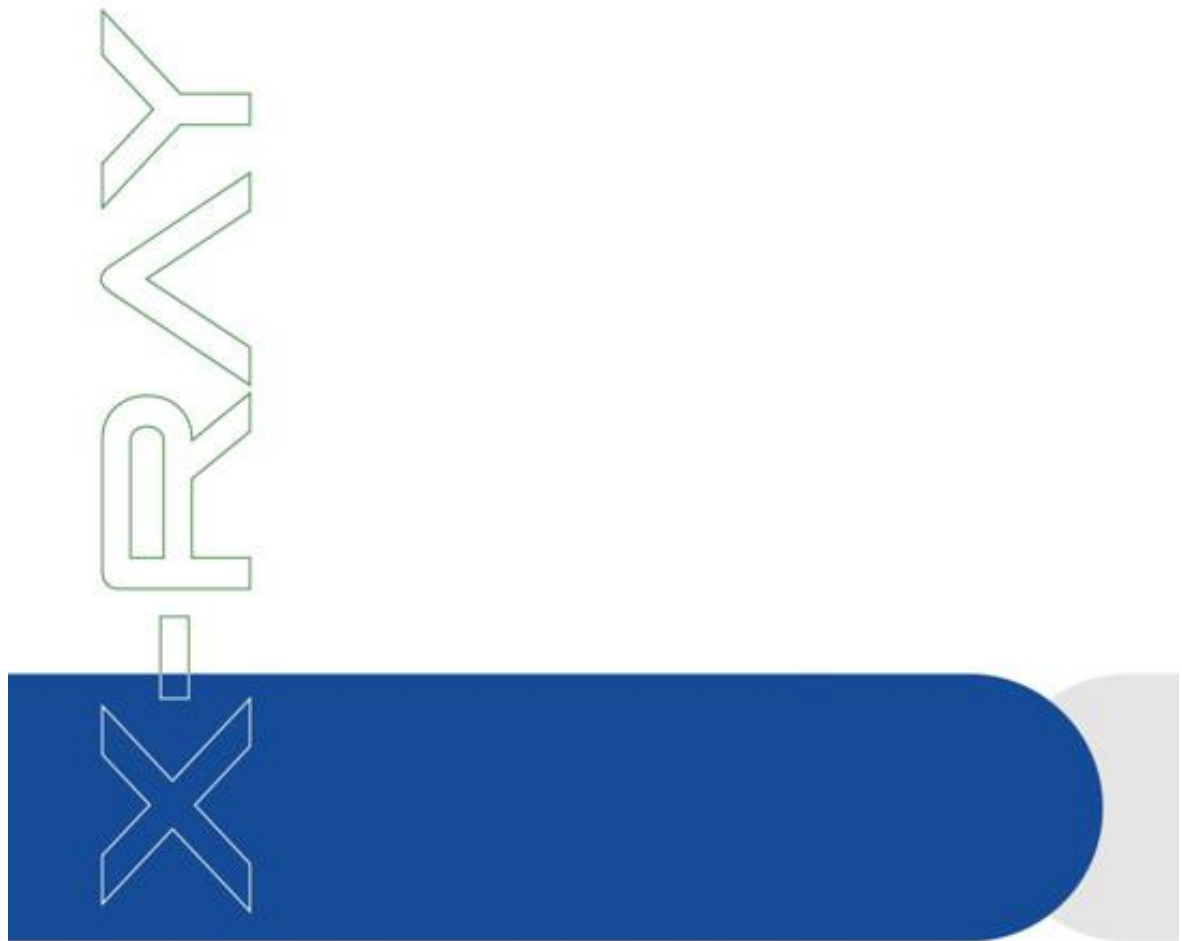


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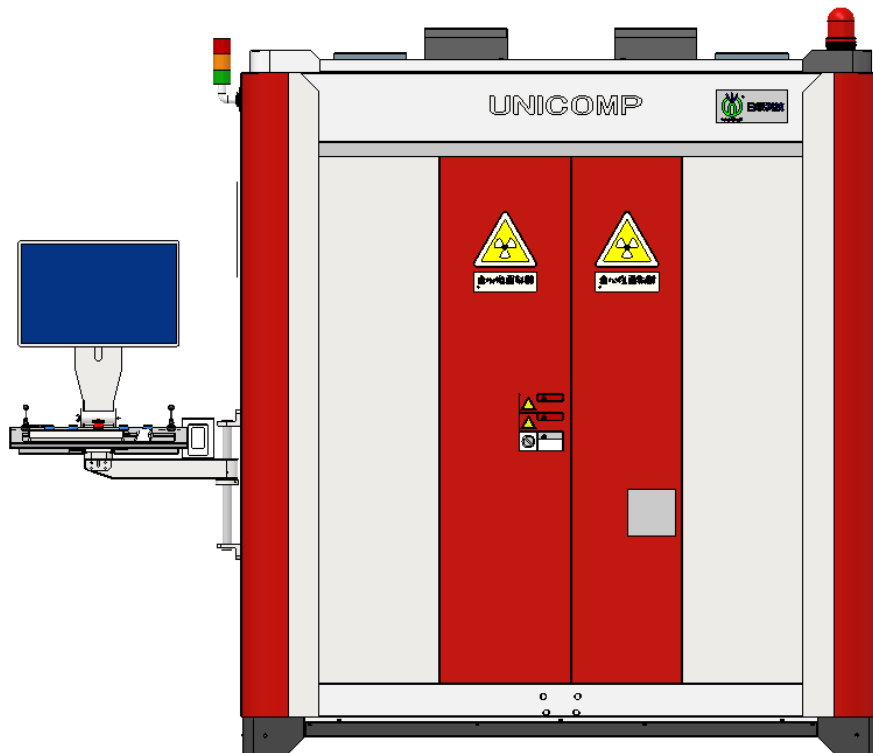
Industrial X-Ray Intelligent Testing Expert

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X-RAY

USER MANUAL



UNC-A

UNICOMP TECHNOLOGY

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Appendix:

(I) Checklist of Offline Testing Equipment for X-Ray Real-Time Imaging

(II) Maintenance List of Offline Testing Equipment for X-Ray Real-Time Imaging



Chapter 1 Product Safety Instructions

1.1 Overview

This Manual describes how to safely use the industrial X-Ray real-time imaging radiographic testing equipment of Unicom Technology, and also describes the composition and function of each system in the equipment. Please read this Manual carefully before operation or maintenance of the equipment.

Unicom Technology reserves the right to update the information of products (new versions of new parts or original parts). This Manual shall not be duplicated to the Third Party in any form without the written permission of the manufacturer.

Please read the warnings and precautions in this Manual. Different words are warnings of different levels of dangers to the user or the instrument. Please read these warnings in details and pay attention to them. The signs are shown below:



Caution: It reminds the user to operate and maintain properly to avoid damage or destruction to the system and other equipment.



X-radiation: warning of X-Ray radiation.



Warning: violation of rules may cause potential hazards. Proper operation and treatment are required to avoid injury.



Risk of pinching hands: reminder of hand crushing.



High voltage hazard: warning of high voltage and paying attention to high voltage protection.



Earthing

1.2 Warnings

Possibility of personal accident or device damage. Please read the following items carefully and pay attention to them.

1.2.1 Relevant laws and regulations

X-Ray device is applicable to the labor safety and health law, environmental protection regulations and rules for preventing ionizing radiation injury. Please follow these laws when using the device.



1.2.2 X-Ray leakage

Pay special attention during operation due to the harm caused by X-Ray to body:

- ★ Close the door of the X-Ray protection box during X-Ray irradiation.
- ★ Do not open the door of the X-Ray protection box during X-Ray irradiation.
- ★ Confirm that there is no X-Ray irradiation when opening the door of the X-Ray protection box.

- ★ Lead glass of the door is free of scratch, fracture, crack, etc.

Please confirm the above points and form a good habit

For safety, the interlocking mechanism that X-Ray cannot be irradiated if the door is open under normal conditions is adopted. Even if the material to be tested is large, do not interlock to cause short circuit. Irradiate the X-Ray with the door open.

In addition, for X-Ray protection of the X-Ray protection box, the X-Ray leakage amount (rate) shall also be determined as required. Confirm whether the value is always lower than the reference value, so as to check whether safety is maintained. X-Ray leakage shall be determined by the service company.

If the specified value is exceeded, please contact the Company.



1.2.3 Death by high-voltage shock

Electric shock may cause death or injury. The following items must be carried out by the Company's maintenance personnel.

- (1) X-Ray device

There are HV parts inside, so do not disassemble the X-Ray device, including the X-Ray tube, HV generator, HV cable and other X-Ray system devices.

(2) Electric control cabinet

The rear door on the back of equipment shall be opened only by professionals due to the AC380V energized part.

1.2.4 Disassembly and transformation of the device



Do not disassemble or transform this device:

(1) This device can generate X-Ray. Wrong methods used may cause harm to human body.

(2) Our company do not guarantee the safety and performance of device that is not transformed by the Company.

(3) Transformation may cause violation of regulations and deviation from specifications.



1.2.5 Inspection

Please check and repair as follows:

(1) The device must be inspected and repaired by the Company's maintenance personnel.

(2) Be sure to cut off the primary power supply during disassembly for inspection and repair.

(3) After the inspection and repair, the removed parts must be restored to their original state.



1.2.6 Hands and body pinching

The front door is relatively heavy, and will generate large inertia during its opening or closing. Please be careful not to pinch hands or fingers; open and close the door gently.

1.2.7 Discarding of devices

When this product and its accessories are discarded, please contact our company or our maintenance store. If the device is improperly discarded, the substances in the parts may pollute the environment.

1.2.8 Beryllium

Beryllium is used on the emission window of the X-Ray device. Beryllium powder is harmful to human body, so do not scratch the emission window or knock down the sample out of the emission window, except during normal use). In addition, vinyl chloride and other chemicals will produce aromatics after X-Ray irradiation, so they cannot be placed inside the device. Vapor is corrosive to the metal and is easy to cause danger.

1.3 Normal use

The radiographic testing system is specially designed to inspect industrial castings, weldments, pressure vessels, assembled parts, redundancy and other products of different sizes and weights. Normal use also includes inspection and maintenance according to the safety advice in this Manual.

1.4 Misuse

Applications outside the scope of this Manual are prohibited.

Because it may cause harm to personnel and equipment, the user shall bear all

1.5 Precautions

In order to use this device for a long time, please observe the following "Precautions for Use (Safety and Prevention of Hazards)" and use it correctly.

1.5.1 Installation environment of equipment

- (1) Keep it away from water.
- (2) Place it in a place where the ambient temperature is within 5-35°C.
- (3) Do not place it in a place where air (containing moisture, dust, salt, sulfur, oil gas and explosive gas) may have adverse effects.
- (4) Place it in a place without open fire.
- (5) Place it in a well-ventilated place away from direct sunlight.
- (6) Place it in a stable place without tilt, vibration or impact.
- (7) Preheat the device every month even when it is stopped or in storage. The service life of the X-Ray device that is not preheated will be shortened.

1.5.2 Precautions before use of device

- (1) Pay attention to the frequency, voltage and allowable current of the applied power supply.
- (2) Check whether the switch works normally in the contact state.
- (3) Please check whether the earthing is proper and secure.
- (4) Please check all wires are securely connected.

(5) On the signs in this Manual and the relevant equipment safety instructions, the so-called "certified qualified personnel" means that these personnel must be familiar with the commissioning and earthing of the equipment, as well as the steps and requirements of terminal equipment, devices, systems and circuit connections, and comply with the safety standards. Only certified and qualified personnel can work on this equipment.

(6) Safety precautions: In order to prevent personal injury or product damage, please read the "**Warning**" and "**Safety Advice**" in this Manual carefully before using this equipment.

1.5.3 Precautions in use of device

(1) Continuously monitor the device for abnormality.

(2) Stop the device immediately in case of abnormality.

(3) During X-Ray is enabled, the lead door must be closed to prevent personal injury caused by X-Ray radiation to the body.

(4) It is forbidden to let any part of the body enter the mechanical structure, so as to avoid personal injury.

1.5.4 Precautions after use of device

(1) When unplugging the wire, do not pull the wire directly or use brute force.

(2) Keep the device clean for next use.

(3) Do not cover the vent and prevent foreign matters from entering the equipment.

(4) During maintenance, the tag "No switching on when working" must be hung.

(5) Before equipment is put into use after being stopped for over 30 days, the complete equipment must be inspected by professionals.

1.6 Safety advices

1.6.1 Safety responsibility

In order to ensure normal and safe operation of the system, operators and maintenance personnel must take effective safety measures and follow safety guidelines in this Manual.

This Manual contains all important information for using the system.

This chapter must be read carefully, and the users must know all information in details. All important information shall be tagged and informed.

1.6.2 Operator training

The system shall be only operated by persons with necessary experience and expertise of X-Ray system, who have been trained on the operation of this professional system by Unicom Technology.

-Understand and master the basic knowledge and common safety rules of the equipment

-Equipment operation must comply with the equipment operation instructions and precautions contained in this Manual.

1.6.3 Implementation of safety measures

- Before the system is enabled, it is necessary to ensure and confirm that the personnel are in safe state after the system is enabled.

- Before operation of the system, all safety devices must be installed correctly and run well.

- A safety device (e.g. emergency stop button) can only be removed after the power of the entire system is cut off and any accidental connection is eliminated.

- The system must be checked for visible external damage and the effectiveness of all safety devices at least once a day.

1.6.4 Electrical safety

- The electrical cabinet shall be opened for maintenance and shall be repaired by workers with electrical qualification.



- The HV cable of the X-Ray tube and HV generator shall be only disconnected by experienced experts. Repair, maintenance and adjustment must be carried out by qualified staff that have been systematically trained.

- The electrical system must be checked regularly, and loose or damaged cables must be replaced immediately.



- The operator must disconnect the system and unplug the power cable when opening the cover/chassis and unplug the cable.

1.6.5 Alarm and safety

- Different emergency stop buttons are located in different positions of the lead chamber, on the door, (operator control panel) and in the inner wall of the lead chamber.

- Once the emergency stop button is pressed, all mechanical motions will stop and the ray tube shall be cut off immediately.

- Red light on the alarm flashes and beeps to remind the X-Ray equipment is tested. Pay attention



Emergency stop button



Alarm

1.6.6 Equipment maintenance and transformation

- Repair, maintenance and adjustment can only be completed by personnel with necessary qualifications from Unicom Technology.

- Equipment structure shall not be modified and transformed without approval of Unicom Technology.

- For all consequences arising from the unauthorized transformation of the equipment, Unicom Technology shall not bear any responsibilities or consequences.

- All damaged parts shall be replaced as soon as possible.

- Do not use parts or vulnerable parts that are not produced by the original manufacturer.

1.6.7 Locking after ray closing

- After the high voltage is cut off, the X-Ray tube must be cooled for at least 3min to dissipate the residual heat from the anode block before the system can be powered off.

- When the system is in the state of generating rays, do not turn the key switch to cut off the system, and must press the "Off" button for ray firstly.



- After the high voltage is cut off, the capacitor in the HV generator will maintain the potential for a certain period of time. During this period, ray may still be generated.

The maximum duration of potential is 4s (generally 1s). It must be confirmed that the time is over before entering the X-Ray lead chamber.

1.6.8 Equipment earthing

- Confirm that the earth wire of the external power supply is reliably connected to the equipment, and the earthing resistance of the ray source is less than or equal to 3Ω . This is to prevent personal injury caused by electric leakage.

- Confirm that the electrical insulation is greater than or equal to $1M\Omega$.

1.6.9 Personal protection

- The owner must provide all personal protective equipment.
- All safety equipment must be regularly checked for effectiveness and reliability.

1.7 Copyright

- Unicom Technology owns the copyright and reserves all rights.
- Any modification to or duplication (multiple users) of software of Unicom Technology, including backup, must be approved in writing by Unicom Technology.
- Contents of this Manual may be changed for improvement without notice.

1.8 Warranty and responsibility

General terms and conditions of sales and delivery of Unicom Technology are applicable here. The user shall understand these terms before signing the contract. Equipment damage caused by any of the following events is not covered by warranty claims

- Abnormal use of equipment,
- The equipment is damaged by incorrect installation, commissioning, operation, repair or maintenance by unauthorized personnel,
- Use the equipment when the equipment is faulty, the safety protection equipment is not installed correctly, or the safety protection equipment does not work,
- Transport, install, commission, repair and maintain the equipment without complying with provisions in this Manual,
- Change the equipment structure without permission
- Transform equipment without permission (e.g. structural change may cause damage to the ray protection equipment)
- Failure to fully inspect the worn parts of equipment

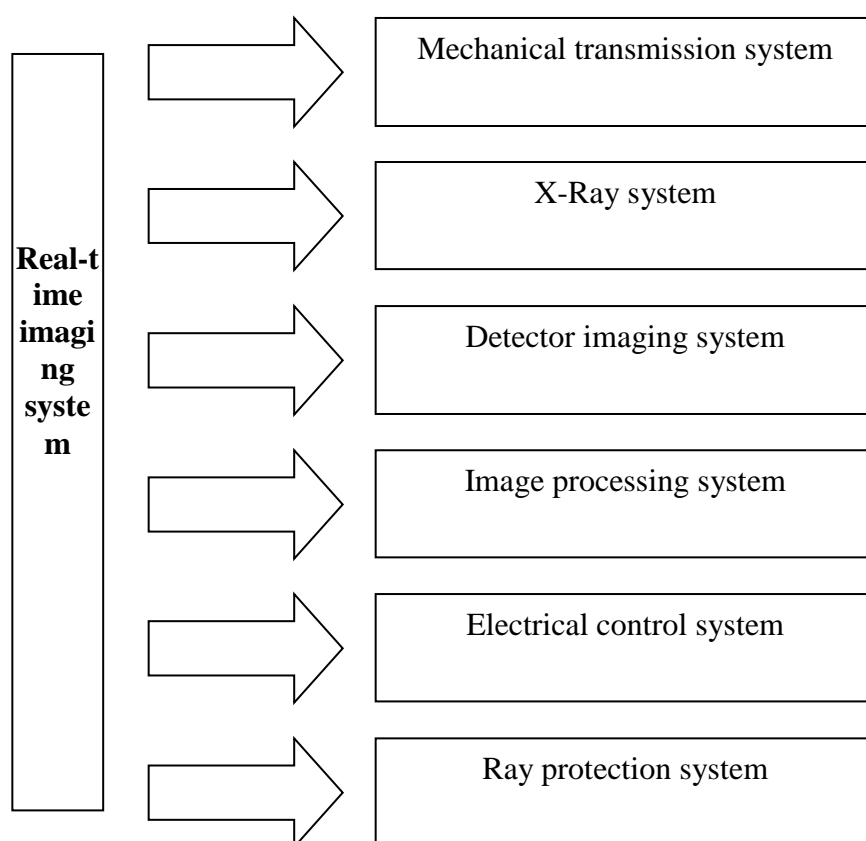
- Failure to fully carry out equipment maintenance
- Occurrence of force majeure
- Unicom Technology is not obliged to bear the damage caused by abnormal use of equipment

Chapter 2 Composition and Function of Equipment

2.1 Basic composition and principle of X-Ray system

2.1.1 Basic composition of X-Ray system

The real-time imaging equipment of this model is composed of an X-Ray system, a detector imaging system, an image processing system, a mechanical transmission system, a ray protection system and an electrical control system. Basic structure is shown in the Figure below:

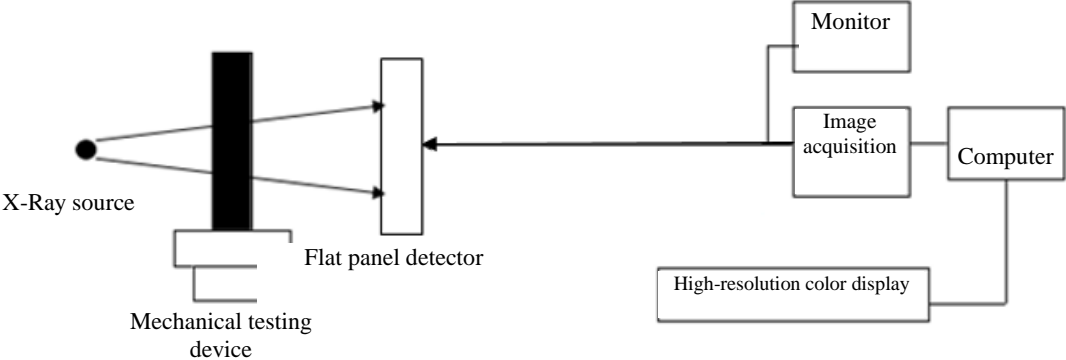


2.1.2 Basic principle of X-Ray system

After X-Ray transillumination of the tested object, the ray intensity changes, and the detector receives and converts the X-Ray into visible light or electron, reads the X-Ray through the circuit and carries out digital processing, and then sends the signal data to the

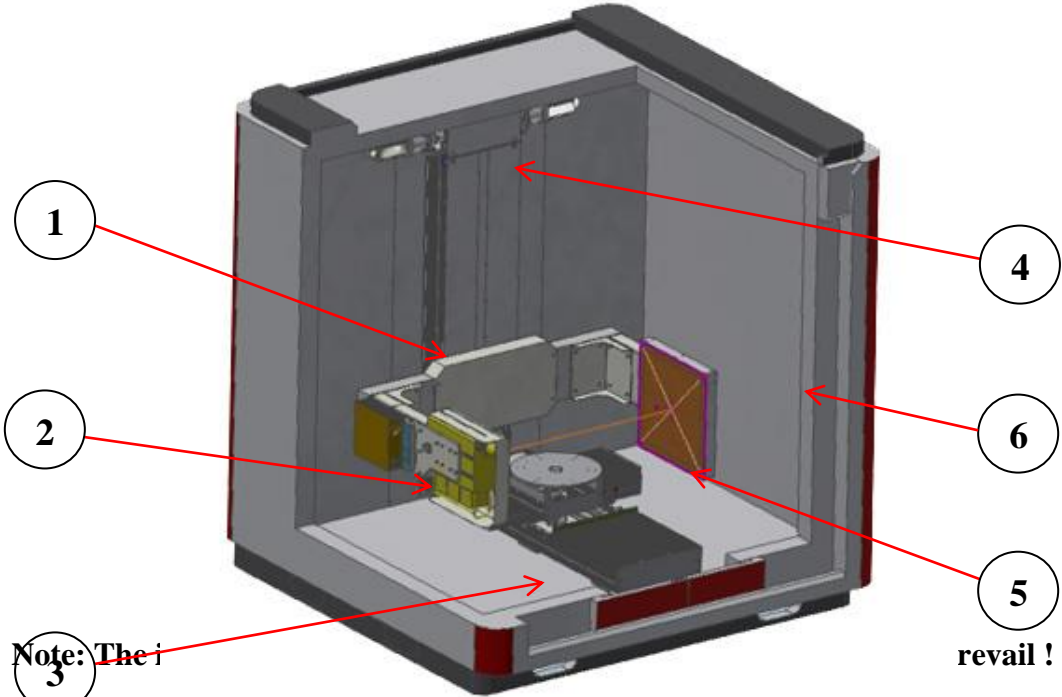
computer system to form an image that can be displayed, analyzed, processed and stored.

Basic schematic diagram is shown in the Figure below:



2.2 Mechanical transmission system

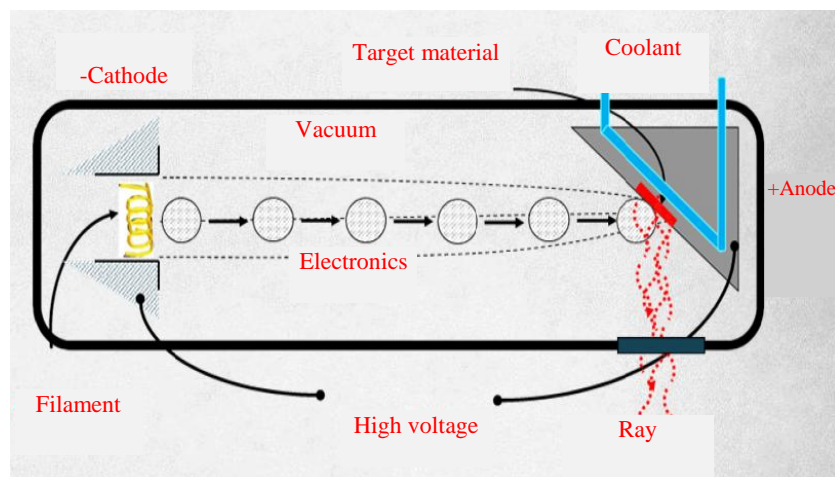
The mechanical transmission system is mainly composed of a C-arm, a mobile trolley system, a column transmission system, a ray tube mechanism and a detector mechanism. Each mechanism are modularized, with high reliability, high stability and high integration, see the Figure below:



- ①C-arm mechanism
- ②Ray tube mechanism
- ③Mobile trolley mechanism
- ④Column transmission system
- ⑤Flat panel detector mechanism
- ⑥Radiation protection system

2.3 X-Ray emission system

(1) The working principle of X-Ray source: X-Ray tube can be regarded as a vacuum tube under high voltage, including two electrodes. The cathode filament generates electrons after heating, and then moves at high speed under the action of high voltage and finally hits the anode metal target. After the target surface is impacted by high-energy electrons, most (about 99%) kinetic energy is converted into heat energy, and a small part is converted into X-Rays. Basic principle is shown in the Figure below:



(2) X-Ray tube is a controllable X-Ray generation device, which will not emit X-Ray after power off. It has the characteristics of safety and controllability. The main technical

parameters of the X-Ray source are tube voltage and regulation range, tube current and regulation range, focus size and load rate.

- (3) Tube voltage and adjustment range of the X-Ray source shall be compatible with the material and thickness range of the object to be tested, and shall have a larger tube current and a smaller focus size.

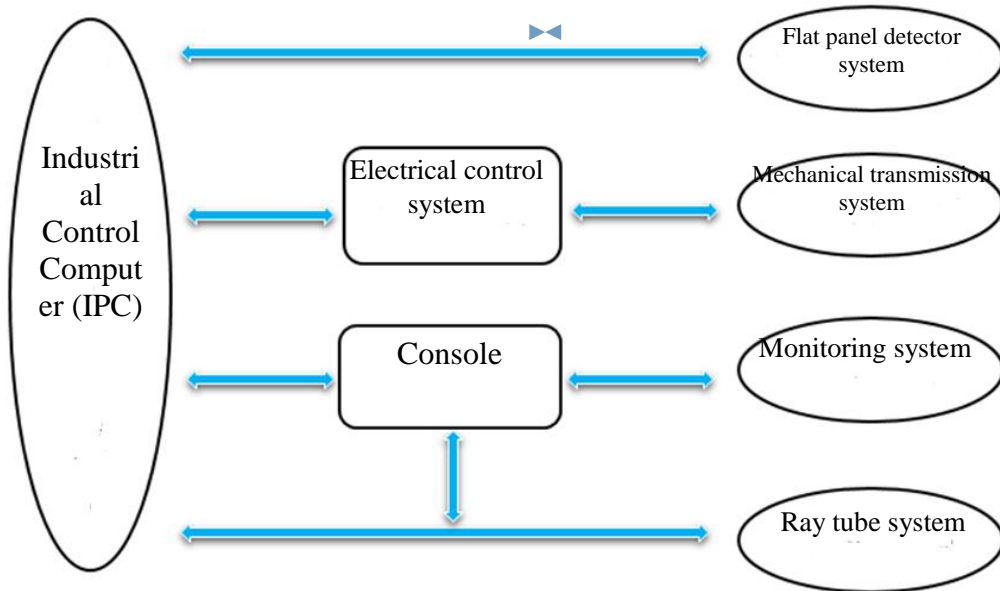
2.4 Imaging system of detector

- (1) Basic composition: amorphous silicon flat panel detector is an indirect digital X-Ray imaging detector. Its basic structure is composed of a layer of scintillator material (cesium iodide or sulfur oxides) on the surface, amorphous silicon photodiode circuit on the next layer, and the readout circuit of charge at the bottom layer.
- (2) Imaging principle: scintillator on the detector surface converts X ray (attenuated after passing through the object) into visible light. The amorphous silicon photodiode array under the scintillator converts the visible light into electrical signals, forming the stored charge on the capacitor of the photodiode. The stored charge of each pixel is proportional to the intensity of the incident X ray. Under action of the control circuit, the stored charge of each pixel is scanned and read out, After A/D conversion, the digital signal is output and transmitted to the computer for image processing to form a digital X-Ray image.

2.5 Image processing system

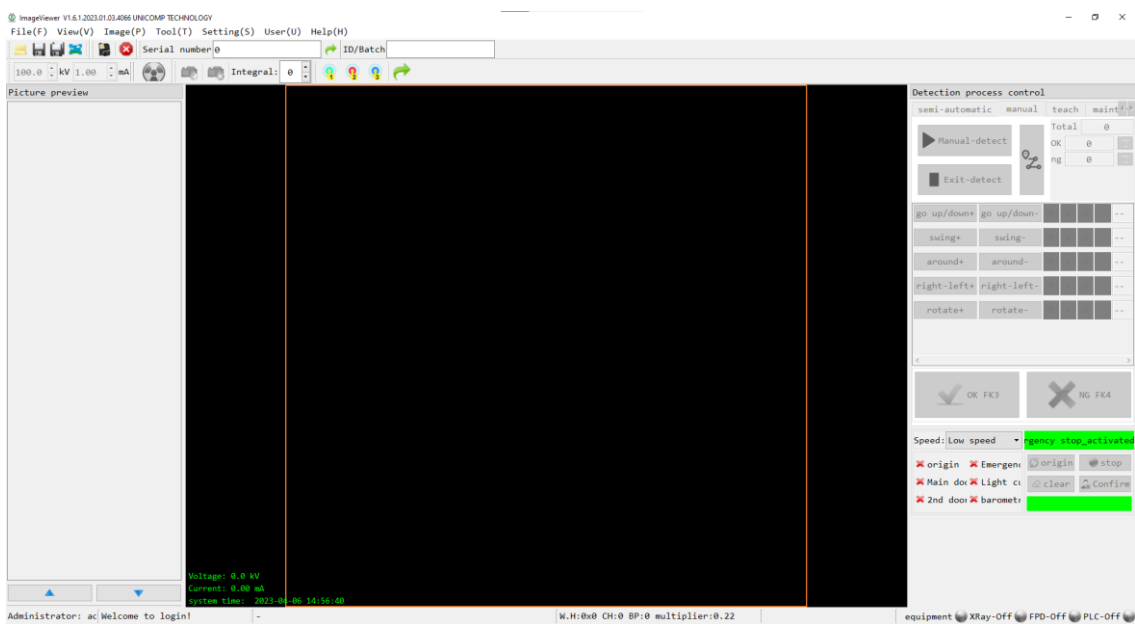
2.5.1 Hardware system for image processing

The hardware system for image processing consists of an IPC, a display, a console, a mouse, etc. Hardware transmission information is shown in the Figure below:



2.5.2 Hardware system for image processing

The image software is independently developed by Unicom. It features powerful functions, the full menu operation mode (the manual mode and the automatic mode) and free lifetime upgrade. When the software is enabled normally, the operation interface in Chinese appears, mainly including the tool column, toolbar, image adjustment area, image display area, state bar and parameter display area, see the Figure below;



2.6 Electrical control system

Basic composition: The electrical control unit is mainly composed of a computer processing system and a PLC logic control unit. It adopts a central integrated control mode, with the programmable logic controller (PLC) as the core, and the signals from various sensors on the site are fed back to the PLC. According to testing process, the PLC completes the corresponding motor motion control through logical procedure calculation to achieve automatic and accurate motion control, and also ensures personnel and equipment safety.



2.7 Radiation protection system

(1) Lead chamber: Steel- lead-steel sandwich structure on the outside; and the inner wall is a frame welded by square tubes, with sufficient strength, rigidity, stability, corrosion resistance, fatigue resistance and other properties within the service life to ensure the safety of the testing machine and operators.

(2) Safety interlocking unit: In case of maintenance or emergency, cut off the safety interlocking unit, disconnect the ray source, and stop the movement of each movement axis, to provide guarantee measures for equipment and life safety.

(3) Safety alarm unit: Sound-light alarm is installed above the lead door to remind the staff about radiation when the ray is emitted.

(4) Emergency button: Emergency stop button is designed in the lead chamber. Press this button to stop the equipment and ensure safety in maintenance.

2.8 Monitoring system

The on-site monitoring mainly consists of an infrared high-definition camera, a video recorder and a display. An infrared high-definition camera is installed in the testing chamber for real-time monitoring of the testing state in the testing chamber. It facilitates adjustment on

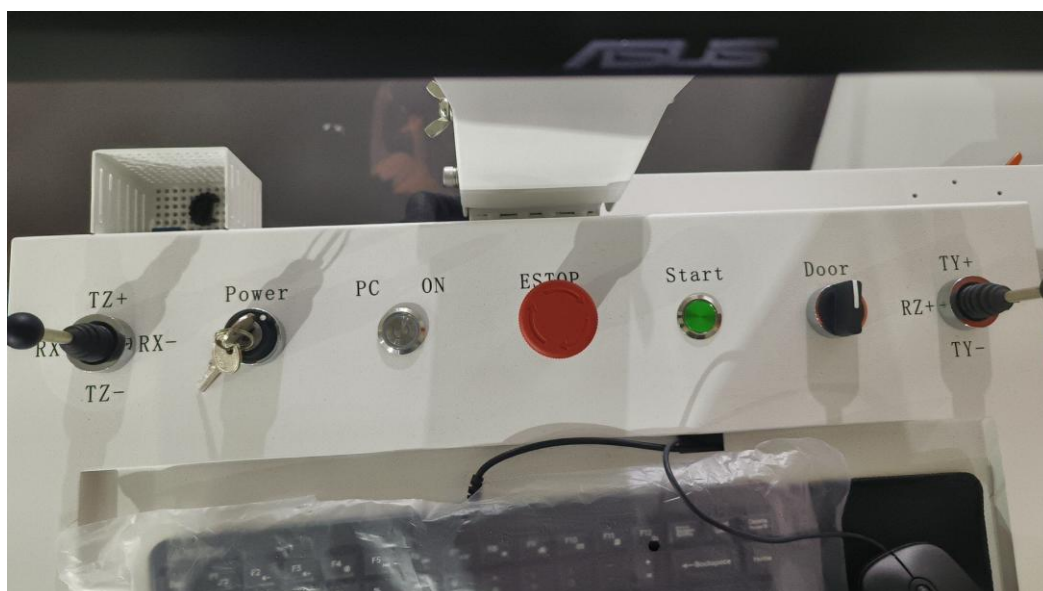
the testing angle of the work piece and monitors whether there is a person in the testing chamber.

Chapter 3 Equipment Operation Instructions

3.1 Preparations before testing

(1) Identification of console functions

The display on the upper left side of the console is an image display. The control panel is divided into two parts: A. control buttons and B. computer control component.



A: Control button part (from left to right)

1. C-arm operating handle: control the C-arm to ascend, descend, swing to left and swing to right;

2. Key switch: the equipment is power on, and the ray source is power on;
3. Lead door switch: control the opening and closing of the lead door;
4. Emergency stop: press the emergency stop button to cut off the high voltage and all control power supplies;
5. Enable testing: one-click enabling button in CNC program;
6. Computer enabling: the extended enabling switch of the enabling button of the control computer;
7. Lead door switch: control the opening/closing of the lead door;
8. Operating handle of load trolley: control the forward and backward movement and leftward and rightward rotation of the load trolley;

B. Computer control component

The computer control component includes a keyboard and a USB interface.

Keyboard: a keyboard and two photoelectric mice are provided before delivery;

USB interface: an extension of the USB port of the host of the IPC, which is located on the left side of the console, has the same function as the USB interface of the host.

(2) Power supply

Key switch for power supply is rotated to the right in the middle, indicating the control power of the equipment has been turned on. When it is rotated to the rightmost end, it

means that the ray tube and the equipment control are powered on simultaneously.

Key switch is shown in the Figure below:

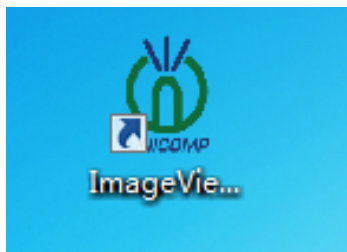


(4) Enabling of image software

(a) Enable the computer host and click the *Computer Enabling* control button.

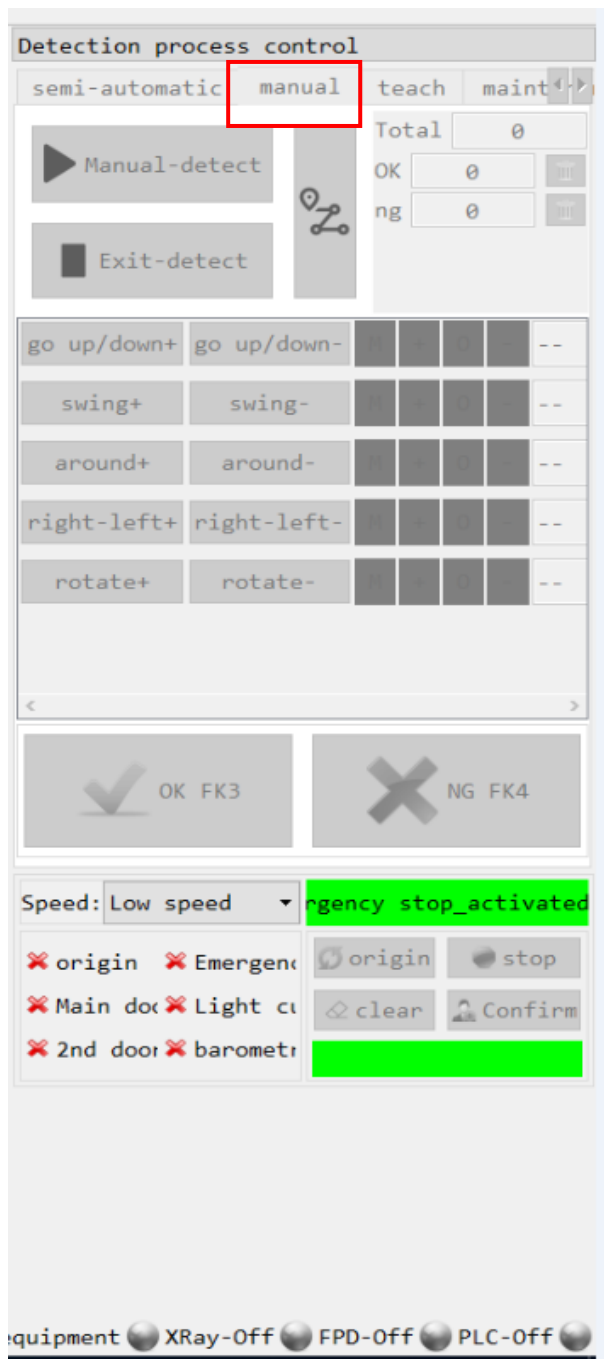
(b) Find the image processing software at the desktop, double-click the icon to enable the image processing software.

(c) Enter the software password 123 to decrypt the software. Software icon is shown in the Figure below.



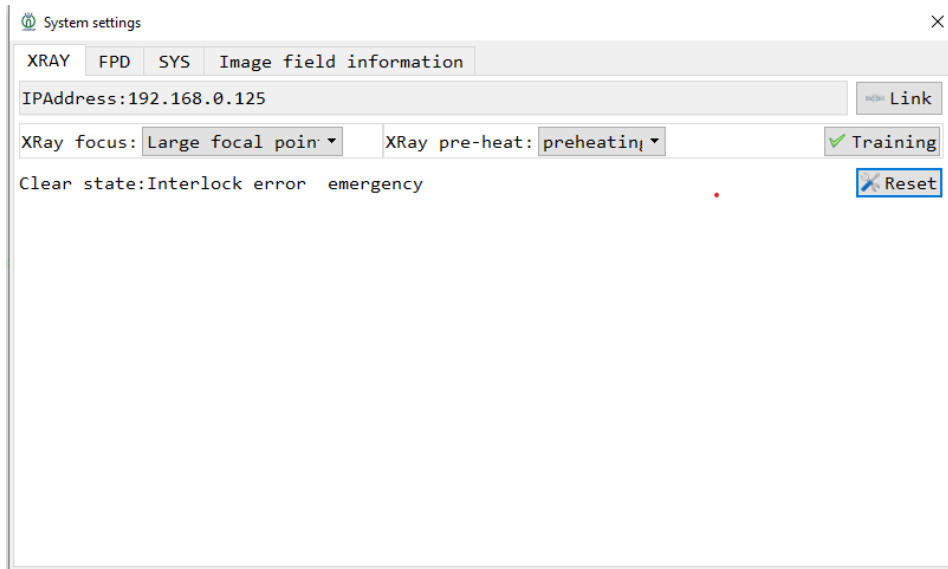
(5) Resetting of original point of equipment

After the image software is enabled, click "Manual" to enter the manual program, click the "Reset" button at the lower right corner of the image interface for resetting of each motion axis of the equipment, see the Figure below:



(6) Preheating of ray device

Preheating is required to give full play to performance of the X-Ray device. If X-Ray irradiation is stopped for more than a specified period of time, preheating is required. If it is more than 8h since the last X-Ray irradiation, preheating is required. Preheating is generally completed in about 15 minutes. If X-Ray irradiation is stopped for more than 3 months, the preheating will take about 2 hours at most, see the Figure below:



3.2 Basic operation process

Basic steps of manual operation is shown in Figure below :

Step 1: Turn the 《*Key Switch*》 to the right



Step 2: Click the 《*Computer Enabling*》 *Button*

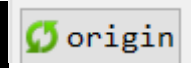


Step 3: Click 《*Image Processing Software*》




Step 4: Click 《*Manual*》 at the right of image software to enter manual program.



Step 5: Check 《*Reset State,*》 if it is not reset, click the  button to reset.



Step 6: Click 《*Manual Testing*,》 and the prompt box flashes  , open the lead door and put the workpiece in it.



Step 7: Click *Confirm Placement*, and the axis automatically feeds materials to the testing position. After feeding, the high voltage is enabled,

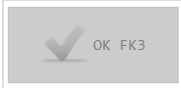
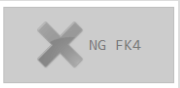


Step 8: Set the axis in the *Testing Axis Control* area



Step 9: the workpiece digital image processing software processes the image. See the *Operator Combination* of operation room for details



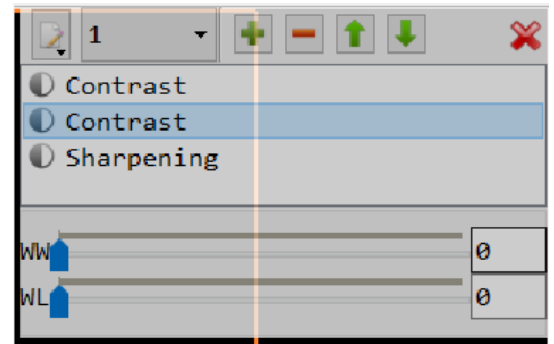
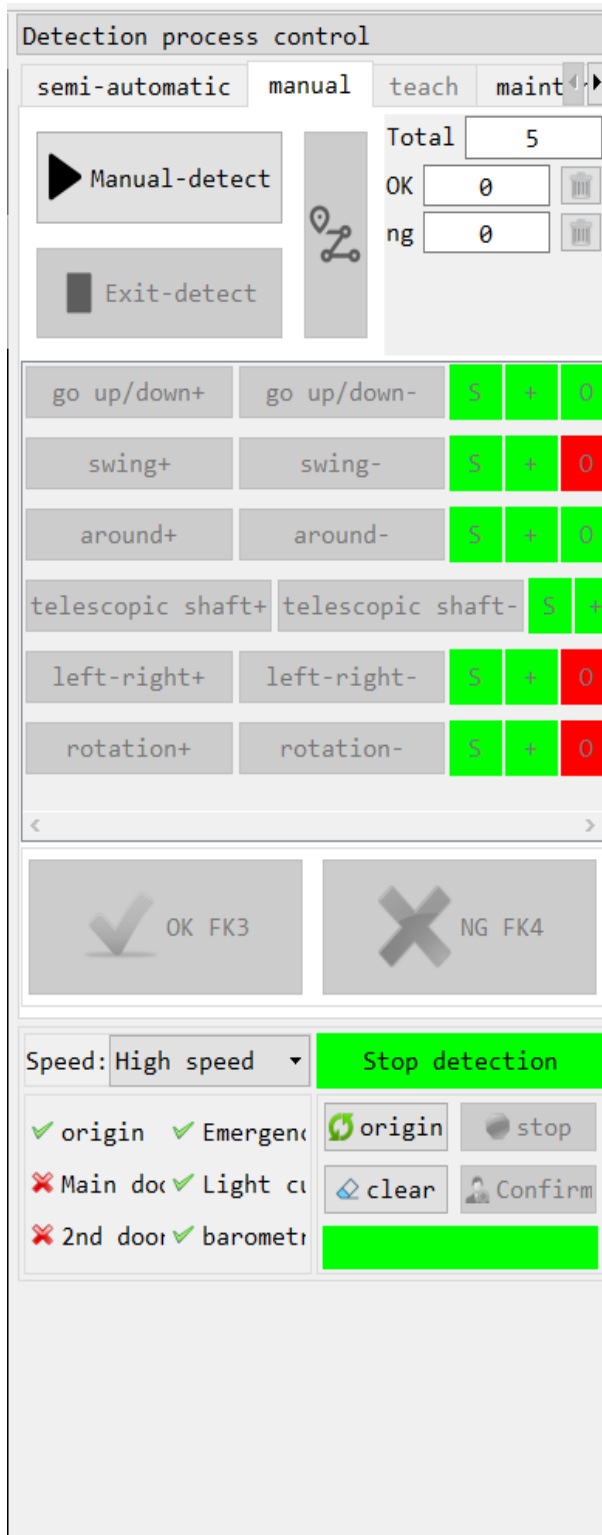
Step 10: After image processing, manually determine   .. After product determination, the high voltage is automatically turned off, and the axis automatically returns to the feeding position and waits for the next feeding.



Step 11: *Exit Testing*: click to exit the current manual program;



Step 12: Turn off computer and key switch



Schematic Diagram of Operation Steps

3.3 Testing mode

(1) Manual mode:

In the manual mode, all motion axes can be moved manually. In this mode, all testing parameters are set manually. No stored program can be used. Position of the ray tube, detector and product is set manually, and the operator evaluates the image results and loads/ unloads of the materials. For detailed operation, see **Section 3.4 Manual Testing Process**. The operation interface is as follows:

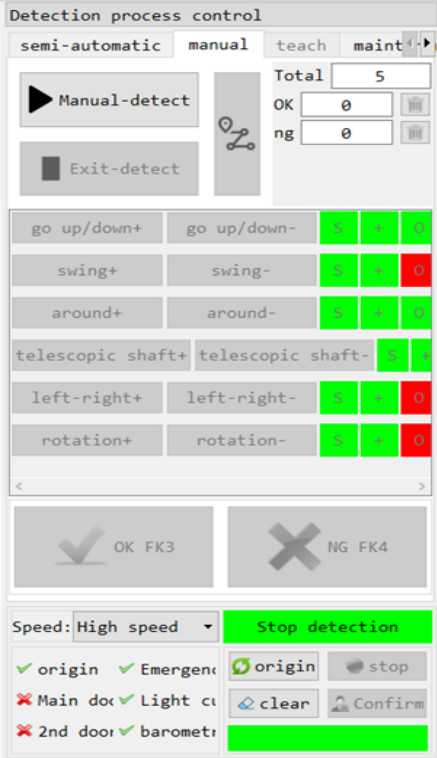


Fig. V-64 Manual Testing Interface

(2) Demonstration mode

Demonstration mode is used for generation of the testing program. After choosing this mode, all testing parameters shall be set manually. After this operation is completed, all settings are stored in a database. The set value of several steps generates the final testing program. For detailed operation, see **Section 3.4 Demonstration Program Process**. The operation interface is as follows:

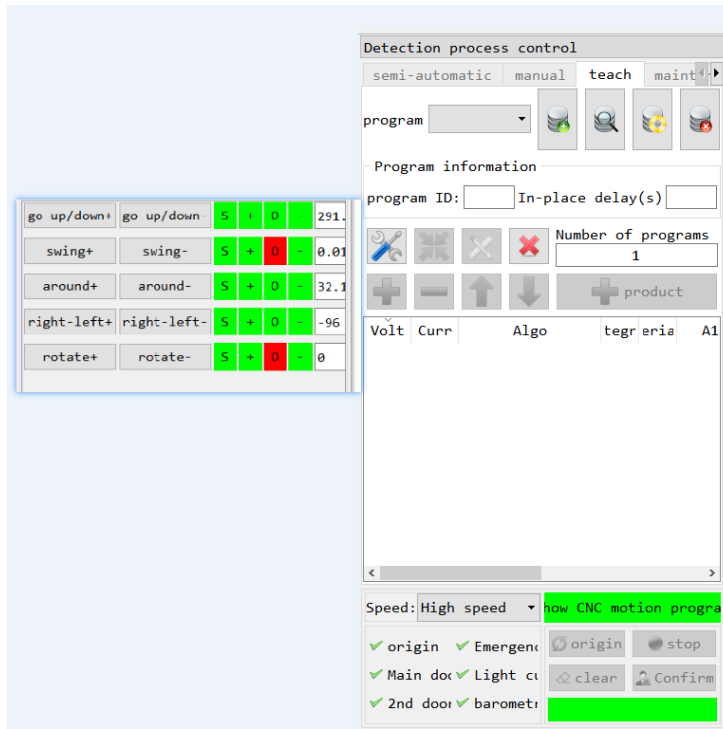


Fig. V-66 Demonstration Program

(3) Semi-automatic mode:

In the semi-automatic mode, choose the demonstration program, then the equipment will automatically move according to the program. choose the determination mode in confirmation column of the testing results. Three modes are optional. See Section 3.4 *Semi-automatic Process Testing* for specific operation mode

Three modes:

- A. Delay+product determination
- b. Determination of each testing point
- C. No determination is required

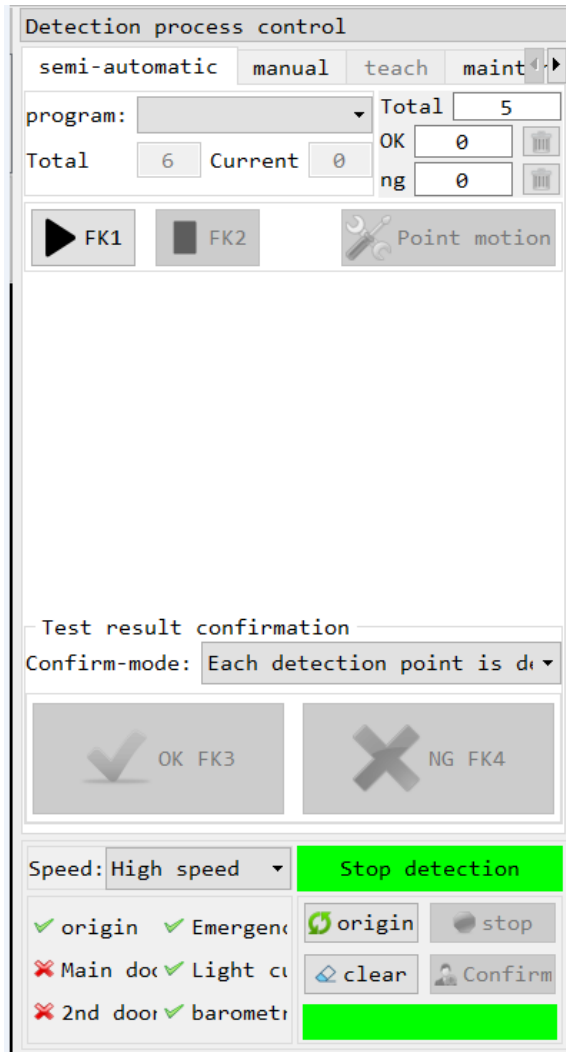


Fig. V-69 Semi-automatic Testing Interface

(4) Maintenance mode:

The maintenance process is that when the equipment is not in the automatic testing process, manual testing process or the demonstration process, the user can enable all mechanical actions on the equipment, e.g. click the testing axis separately (Fig. V-75). For detailed operation, see **Section 3.4 Maintenance**

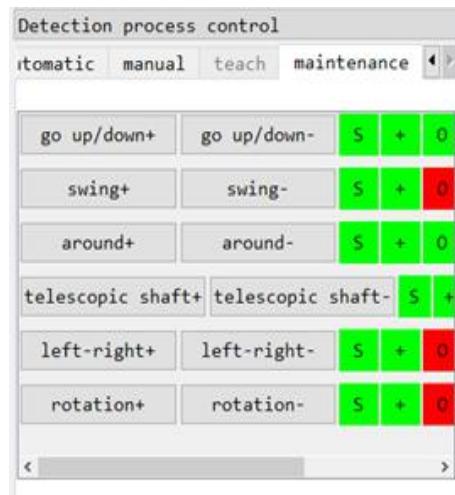


Fig. V-75 Testing Process Control

3.4 Image software operation and parameter setting

3.4.1 Preparation before equipment operation

- (1) Ensure the ground wire is well connected as required;
- (2) Ensure that the power supply system provides AC 220V $\pm 10\%$ as required;
- (3) Ensure that the ray source, imager and display are connected correctly as required;
- (4) Turn the key switch of the control panel clockwise, turn on the main power supply, reset the emergency stop button, and press the computer enabling button to power on the equipment;
- (5) Double-click the "Image Viewer" button on the desktop to, enable the "Image Viewer" image processing software.



Notes:

The X-Ray device has strict preheating procedure which must be strictly implemented. If it is enabled every day, the device will automatically enter the preheating procedures. If it is not enabled for more than 3 days or more, do not open the X-Ray directly after it is enabled. After it keeps warm for 30min, enable the X-Ray for

tube preheating. If it is not enabled for more than 15 days or more, let it keep warm for 60min after it is enabled, then enable X-Ray for tube preheating.

3.4.2 Overview of "Image Viewer" Application

The Image Viewer Application is a Windows Application for X-Ray NDT image viewing and management. The Image Viewer can be used with an external X-Ray detector and a X-Ray generator to realize real-time/static acquisition, processing, display and saving of X-Ray images; original X-Ray image data can also be viewed and processed without external hardware.

Main functions of the "Image Viewer" Application are shown in the Figure below:

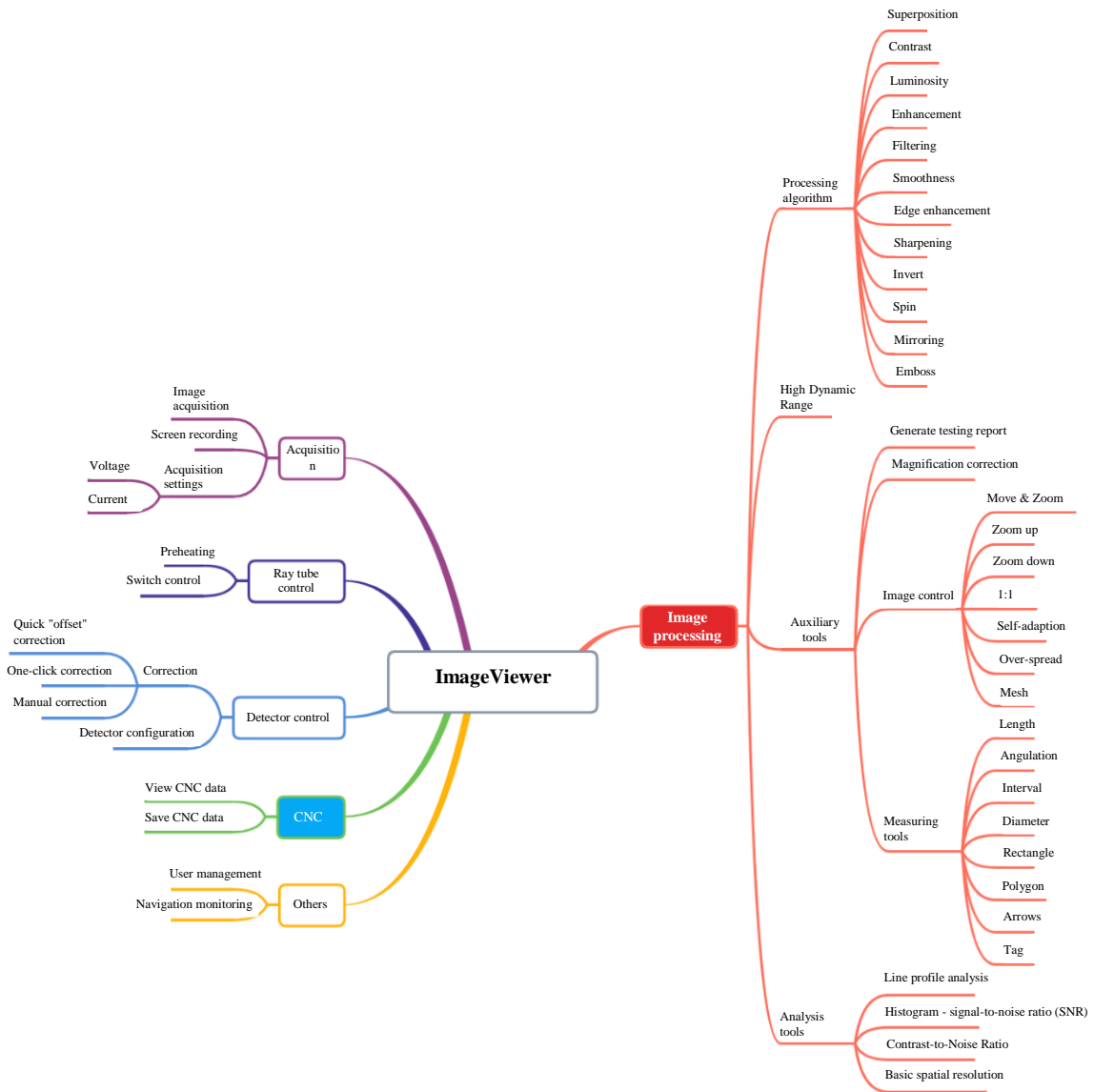


Fig. V-0 Application Function Diagram

3.4.3 Introduction to functions of "Image Viewer" Application

1. Overview of main interface of Image Viewer Application

The main view interface of the Image Viewer Application (Fig. V-1) mainly consists of the Application name, menu bar, shortcut toolbar, X-Ray toolbar, testing process control, monitoring navigation, image algorithm setting area, image display area, position/pixel display area, real-time information display area and external component state identification.

Application name: displays the name and version number of the Application;

Menu bar: contains entry to all function entries of the Application;

Shortcut toolbar: provides entry to common functions of the Application;

X-Ray toolbar: control X-Ray adjustment and switch;

Image algorithm setting: configure the algorithm package and adjust the image algorithm parameters (to adjust the image rendering);

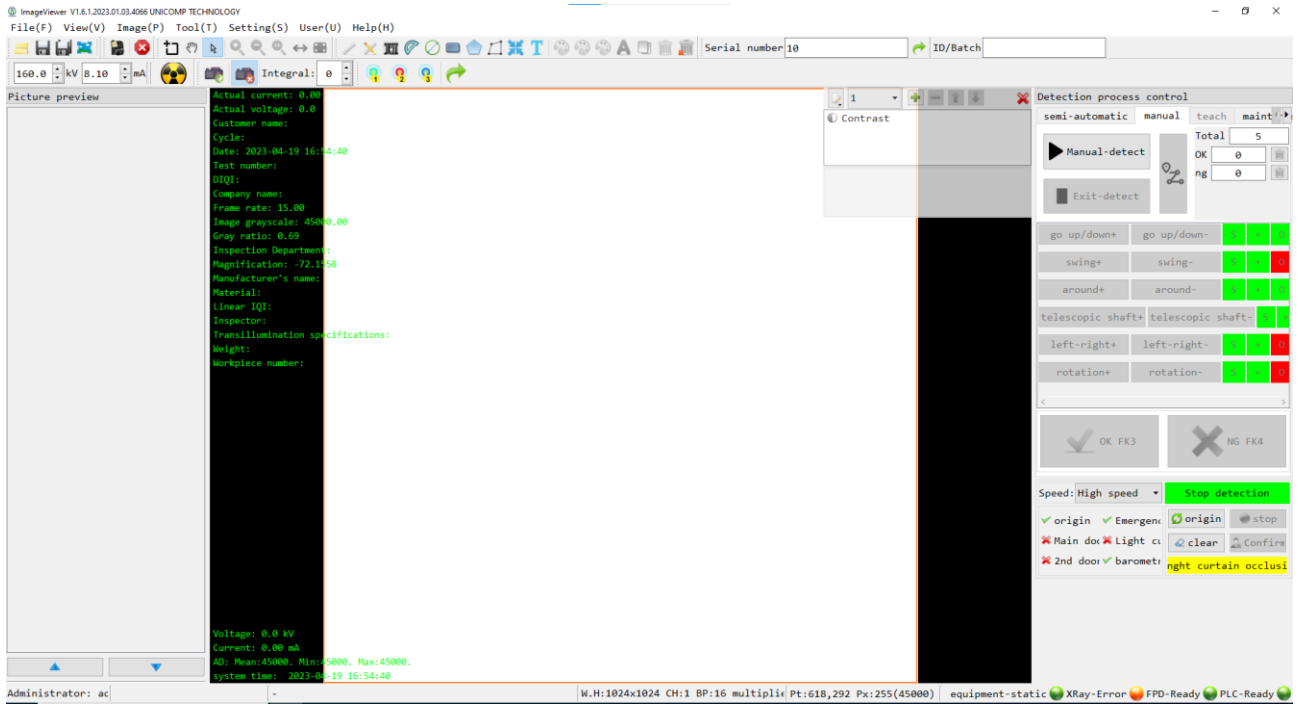
Testing process control: automatic/manual testing process control, demonstration program, motion axis operation, etc.;

Image display area: display the main area of the X-Ray perspective image;

Position/pixel display area: display the coordinates and pixel values of the current position;

Real-time information display area: displays the current login user, voltage, current, magnification and time and other real-time information;

Equipment state area: display the connection state area of external core components, e.g. X-Ray, detector and PLC controller;



2. Enabling & login

Double-click the "ImageViewer" shortcut on the desktop to open the user login interface (Fig. V-2). After entering the correct user name and password in the login interface, the user can enable the Application process to control the device to detect samples.

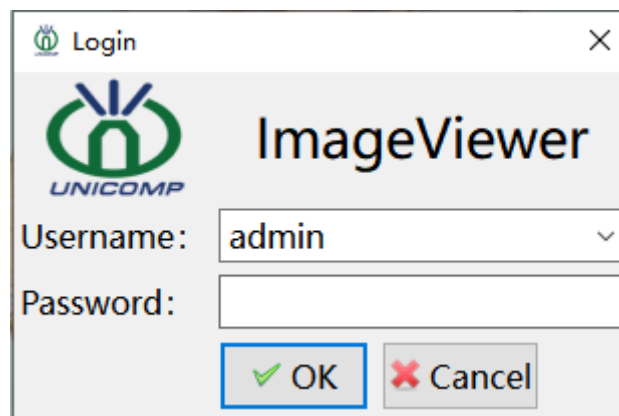


Fig. V-2 User Login Interface

3. Exit the Application

There are three modes to exit the Application:

- 1) Exit the Application by choosing "File (F)" -> "Exit (X)" in the menu bar (left in Fig. V-3).

2) Press the combination shortcut key "**Alt + F4**" on the keyboard to exit the Application.

3) Click the **X** button at the top right corner of the main interface of the Application to exit the Application.

No matter which method is used to exit the Application, a dialog box for reconfirmation will pop up before exit to prevent abnormal exit of Application due to user's misoperation (right in Fig. V-3).

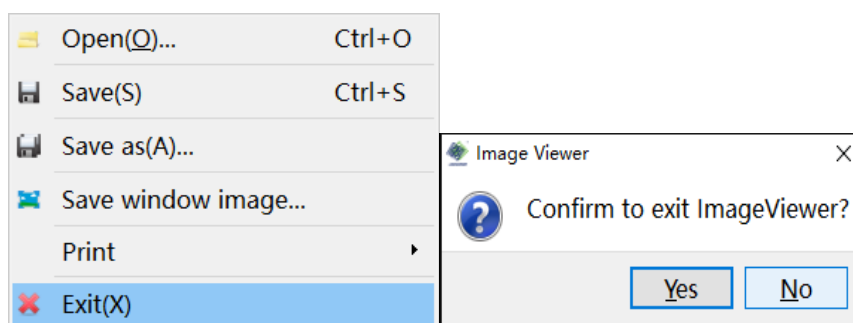


Fig. V-3 "Exit" Menu (left); Dialog Box of Exit Confirmation (right)

4. Operation state

All operation state of the Application are integrated and displayed in the state bar at the bottom of the main interface. If the state bar is not visible, the user can use the "**View (V)**" -> "**State Bar**" in the menu bar to re-open the state bar (Fig. V-4).

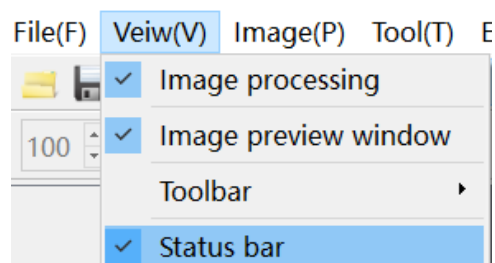


Fig. V-4 State Bar Switch

The running state displayed in the state bar at the bottom of the Application includes: log-in user, recent operation information, error information, image information (width, height,

number of channels, bit depth, magnification), coordinates and pixel values when the mouse moves on the image, and state information of external core components.

See Fig. V-4-1 and Fig. V-4-2 for specific information of the state bar:

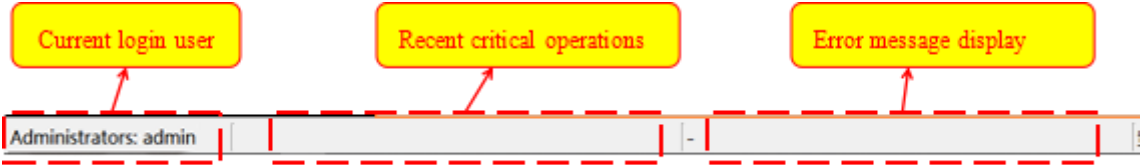


Fig. V-4-1 Left Side of Status Bar

Fig. V-4-1 Login User, Recent Operation, and Image Information

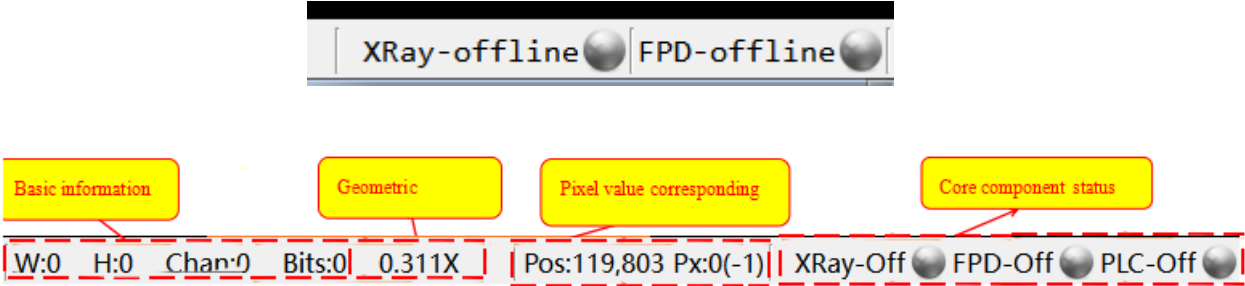




Fig.V-4-2 Right Side of Status Bar

Fig. V-4-2 Image Coordinate, Pixel Value, and Information of External Components

The color of the state icon of the core component corresponds to different statuses, as interpreted below:

 : in operation, the component is in use.

 : ready, the component is not in use; the navigation monitoring unit represents preview.



: an unknown state or the component is not successfully connected (offline).



: a warning or error state.

5. Image acquisition

After the image detector is connected normally, the user can control the image detector to acquire images and stop acquiring images in various ways. After acquisition starts, the image detector outputs the image data, and the Application displays the received image data in the image window. After acquisition stops, the image data in the image window is no longer updated.

△ Note: When the image detector is not connected successfully, the icon and menu are gray and cannot be operated and clicked!

Image acquisition

The image detector starts to acquire the image, and outputs the image data to the main image window of the Application for display. The user can use the "Start Acquisition" function to make the image detector to start acquisition and output the display image in the following ways:

1) **"Image (P)" -> "Start Acquisition"** in the menu bar. (Fig. V-5).



2) Shortcut button in toolbar

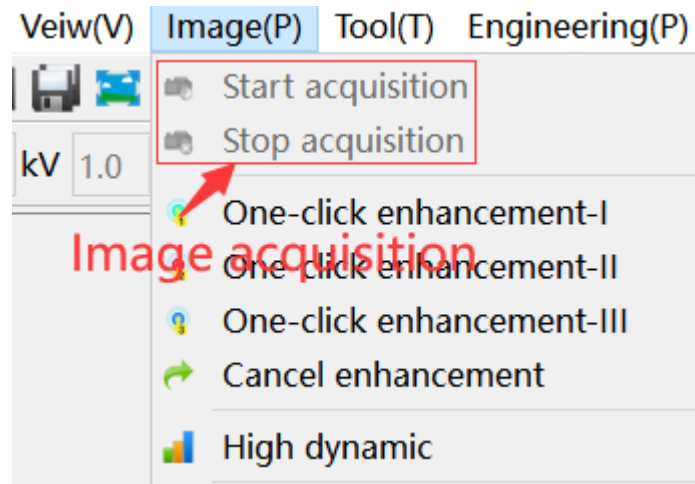


Fig. V-5 Image Acquisition

⚠️Note: when the acquisition is started, the high voltage will be turned on simultaneously.

Stop acquisition

Stop acquisition means the detector stops working: the detector closes the acquisition function, stops outputting image data, and the Application does not update the image display. The user can use the "Stop Acquisition" function to stop the detector acquisition in the following ways:

- 1) Menu bar "Image (P)" -> Stop acquisition. (Fig. V-5).




- 2) Shortcut button in toolbar

⚠️Note: When the acquisition is disabled, the high voltage will be turned off simultaneously.

6. Ray tube control

Ray tube (also known as CRT tube and light source) is a general term of X-Ray emission source and HV generator. The excitation of X-Ray requires an HV generator to provide sustained and stable ultra-high voltage and current. Through ray tube control, the user can monitor the voltage and current provided by the current HV generator, set and adjust the voltage and current, and open and close the ray tube.

⚠ Note: When the X-Ray tube is not connected successfully, the icon and menu are gray, and cannot be operated and clicked !

The user can click  to turn on/off ray of tube. After the ray tube is turned on, the actual voltage and current generated by the ray tube HV generator are displayed in the upper left corner of the image window. See Fig. V-6:

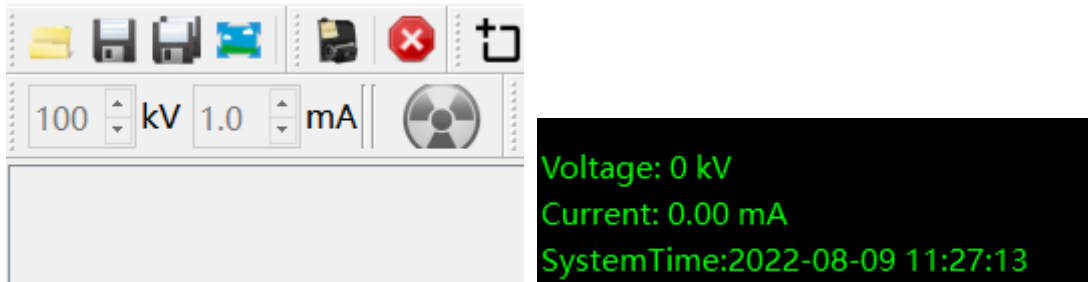


Fig. V-6 Tube Control (left), Actual Feedback Value (right)

7. Screen recording

The Application has the function of screen recording. The area of the screen recording is limited to the main X-Ray image display window. The video format supported by the Application is AVI format.

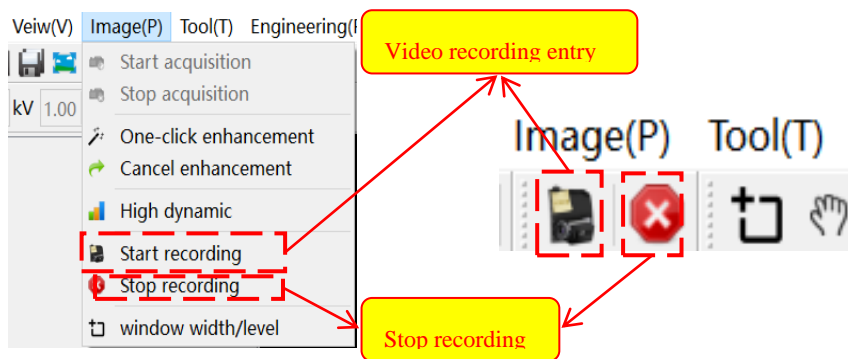



Fig. V-7 Video Recording Function

Enable recording



The user clicks the toolbar  or menu bar "Image(P)" ->"Record Video" to enter the video recording process (Fig. V-7). "Save Video" dialog box pops up in the Application, the user shall choose the path to save video and name the video file (Fig. V-7-1).

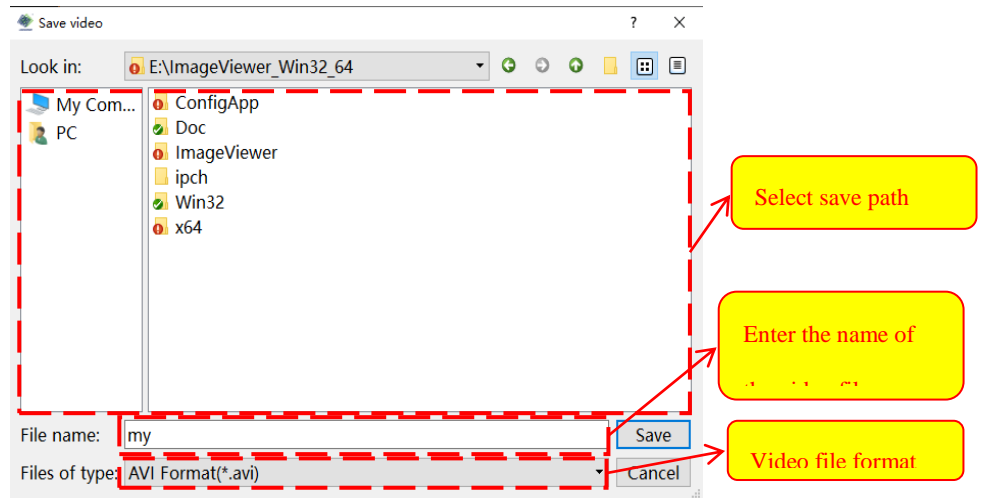



Fig. V-7-1 Save Video Dialog Box

Fig. V-7-1 Save Video Dialog Box

Stop recording



User clicks the toolbar  or menu bar "Image(P)" -> ->"Stop Recording" to stop the video of screen recording and finish recording.

8. Image processing

The Application provides a variety of operators to enhance different types of X-Ray perspective images, improve image details and resolution, and provide reference and assistance for operators to identify defects.

The Application also provides the function of saving multiple combinations of different operators. The user can easily switch between different operator combinations. Different operators produce different results on the image, and the joint use of multiple operators may

improve the image quality to a certain extent and highlight the details of the defect part. The image processing entry and image processing dialog box are shown in Fig. V-8. The window can be displayed and hidden in the menu bar "View (V)" ->"Image Processing":

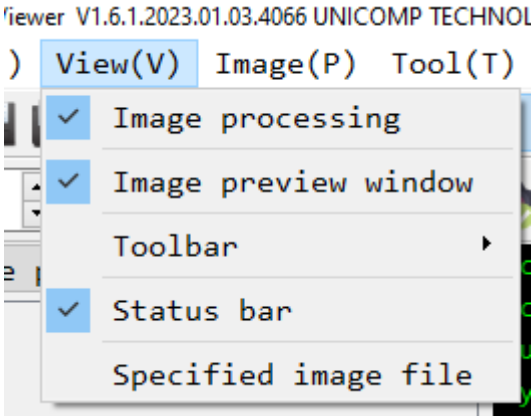


Fig. V-8 Image Processing Entry (L), Image Processing Dialog Box (R)

8.1 Overview of operator combination

Operator combination refers to the combination of a series of algorithms. The image processing interface provides functions, e.g.: create operator combination, delete operator combination, save operator combination, rename operator combination, define operator combination shortcut, and edit operator combination (add, delete, move up, and move down operator).

After choosing the operator combination that has been set and before sending the image acquired by the image detector to the Application, the Application will first apply the operator in the operator combination for image preprocessing, and then display the enhanced image in the image window.

Note:

① When the algorithm combination is applied, the operator is executed in the sequence displayed in the image processing interface when it is edited.

② The operator order may affect the image processing effect and efficiency!

③ If the user add the "superposition" operator, it is recommended that the "superposition" operator is placed in the first position!

8.2 Operator combination management

Operator combination management includes create, save, delete, rename, shortcut key and other functions. See function entry in Fig. V-9:

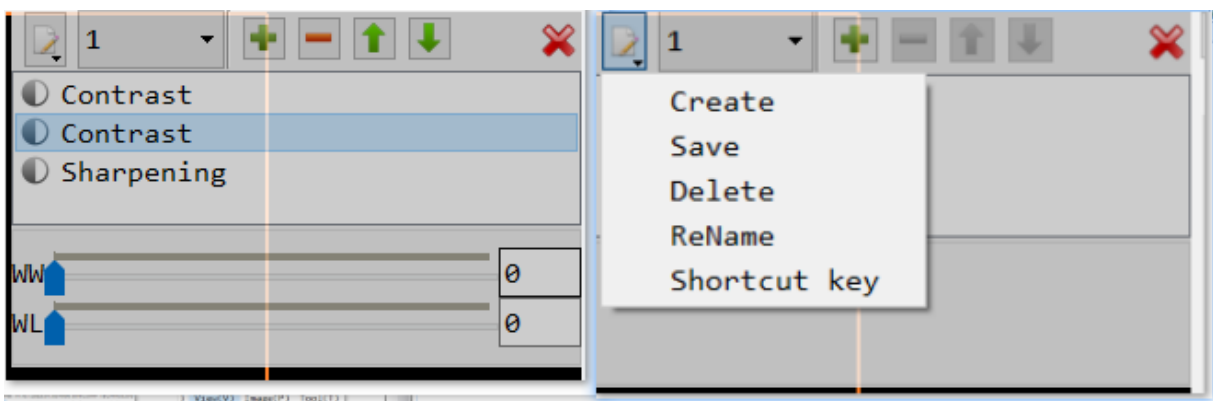


Fig. V-9 Operator Combination Management (L) and Management Menu (R)

◆Create

The Application supports new empty operator combinations. The combination process of creating operator is as follows:

- ① Click the operator combination management entry (left in Fig. V-9), and choose pop-up menu "Create" (right in Fig. V-9).
- ② Enter the name of new operator combination in pop-up dialog box.

- ③ Click "Confirm" to finish creating a new named empty operator combination.

⚠ Note: After creation, the new operator combination exists temporarily and shall be saved before being applied repeatedly in the next call.

◆ Save

Click the management operator combination entry (left in Fig. V-9), and click "Save" in pop-up drop-down menu (right in Fig. V-9). The save operation is to save the currently chosen operator combination for loading/creation into the configuration file.

⚠ Note: Any modification to the operator in the currently chosen algorithm group (including the newly created operator combination) must be saved before it takes effect !

◆ Delete

Click the management operator combination entry (left in Fig. V-9), and click "Delete" (right in Fig V-9) in pop-up drop-down menu to delete the operator combination currently chosen for loading and displaying. "- Dynamic -" and "- Static -" combinations cannot be deleted.

⚠ Note: Once the algorithm group is deleted, the deletion will take effect immediately and the deleted contents cannot be restored.

◆ Rename

Click the management operator combination entry (left in Fig. V-9), and click "Rename" (right in Fig. V-9) in the pop-up drop-down menu to rename the operator combination

currently chosen for loading and display. "- Dynamic -" and "- Static -" combinations cannot be renamed.

The renaming process is as follows:

- ① Choose "Rename" from the operator combination management menu;
- ② Enter the new algorithm group name in the pop-up dialog box;
- ③ Click "Confirm" to finish.

◆ Short shortcut key

The operator combinations contains multiple operators, and the Application can also create multiple operator combinations. Therefore, the Application has the function of setting shortcut keys for up to five operator combinations (shortcut keys can only be chosen from F1-F5).

After setting the shortcut key, the user can use the shortcut key to quickly switch and apply the corresponding operator combination in the process of Application image processing and display.

Click the management operator combination entry, click the "Shortcut Key"(right in Fig. V-9) in the pop-up drop-down menu to set shortcut for the existing algorithm group. The shortcut key setting process is as follows:

- ① Click the management operator combination entry (left in Fig. V-9), click the "shortcut key" in the pop-up drop-down menu to open dialog box for shortcut key setting (Fig. V-10).
- ② Choose the image processing algorithm group to set shortcut key from the algorithm group drop-down list on the left;

③ Choose the shortcut key you want to set from the shortcut key drop-down list on the right;

④ Click the "Save" button to save the settings.

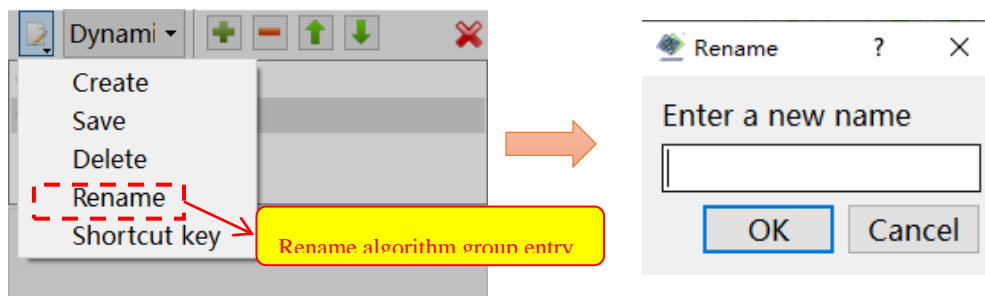


Fig. V-10 Shortcut Key Dialog Box

◆ Operator combination loading

In the drop-down list of the operator combination name (Fig. V-11) in the image processing interface, choose the operator combination name to be applied. The Application automatically loads the chosen operator combination, and all operator information in the operator combination will be applied to the preprocessing of the acquired image.

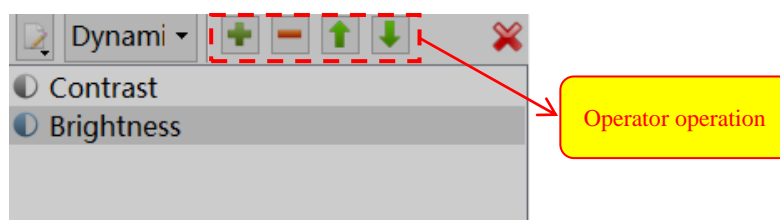


Fig. V-14 Operator Operation Entry

Fig. V-11 List of Operator Combination

8.3 Operator management

The Application provides a variety of image processing operators to choose from (see Operator details). The user can choose one or more operators to enhance the specified X-Ray image as required. The operator can be operated after loading the existing or new image processing algorithm group.

The Application can adjust the execution order of the operator, e.g. adding an operator, deleting an operator and moving an operator up/down. See operator operation entry (Fig. V-12):

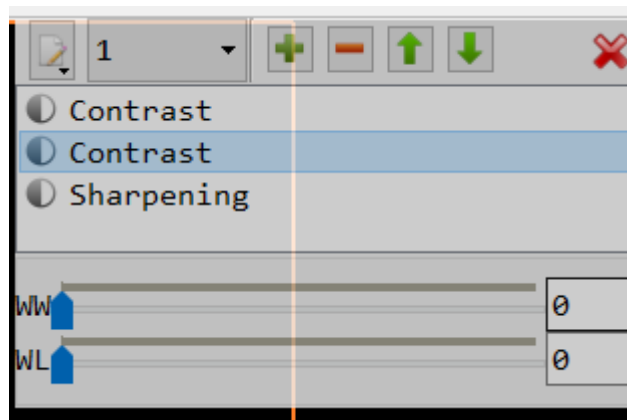



Fig. V-12 Operator Operation Entry

◆ Add operator

Click  in the image processing interface, pop up "Add Operator" window to add new operator. Entry of Adding Image Operator is shown in Fig. V-13. The operation steps are as follows:

- ① Choose the operator name to add and click OK;
- ② Choose the newly added operator on the image processing interface, and set the parameter of the new operator to an appropriate value;
- ③ Save the operator combination.

△Note: If the operator combination is not saved, the newly added operator will be removed by default after switching.

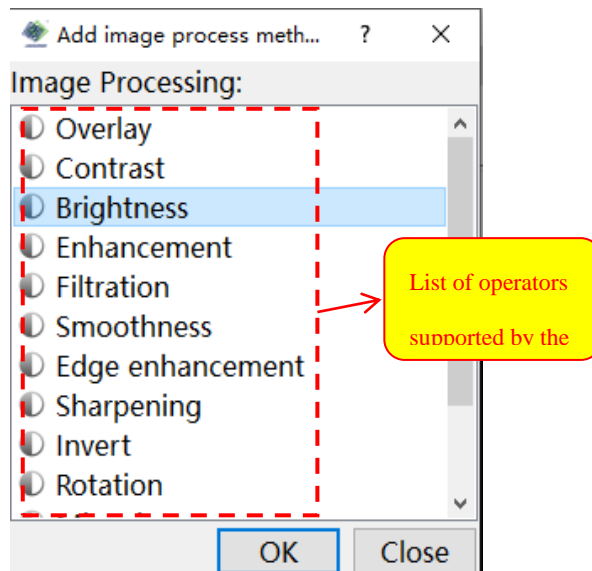



Fig. V-13 Add Operator

◆ Delete operator

The steps to delete an operator from the current operator combination are as follows:

① In the list operators for the current operator combination (Fig. V-8), choose the name of the operator to be deleted;

② Click  to delete the chosen operator immediately;

④ Save the operator combination.

△Note: If the operator combination is not saved, the operators deleted after switching will still be displayed in the algorithm group.

◆ Adjust execution order of operator

For the combination of several different operators, each operator is executed from top to bottom in the list. For some operators, different execution orders may bring different image processing effects, so it is necessary to move the operator.

(1) Move operator up

① Choose the name of the target operator in the list of operators for the current operator combination (Fig. V-8);

② Click to move the operator up for one bit;

③ Repeat step 2 until the operator moves to the destination;

④ Save the operator combination.

(2) Move operator down

① Choose the name of the target operator in the list of operators for the current algorithm group (Fig. V-8);

② Click to move the operator down for one bit;

③ Repeat step 2 until the operator moves to the destination;

⑤ Save the operator combination.

△Note: If the operator combination is not saved, the operator sequence after switching is still the sequence before moving.

8.4 Operator solution details

The Application provides a variety of image processing operators, which is convenient for the user to process the original image, so as to get a better image and help the user to judge and determine defects.

Different operators can produce different effects on the X-Ray perspective images, and the adjustable parameters of different operators are also different. The combination of different operators may achieve a better image processing effect. See Fig. V-13 Operator List for all operators supported by the Application

In the operator list, choose a single operator to adjust the operator parameters in the parameter setting area. The image effect after the operator parameters are modified is presented to the

X-Ray image window of the main interface in real time. See Fig. V-14 below, the operator parameter setting area (what is shown in the example is setting of "contrast" operator parameter) is below the list of operators.

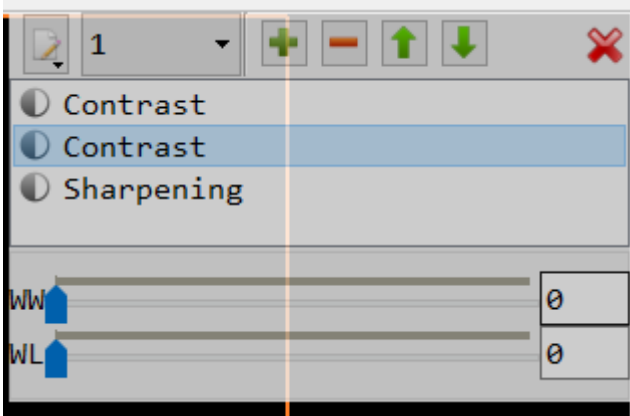


Fig. V-14 Operator Parameter Setting Area

8.4.1 Contrast

The contrast operator is also called contrast stretching and gray scale stretching. The main function of the contrast operator is to improve the dynamic range of the gray scale in image processing, which is equivalent to enhancing the contrast between different gray scales of the image. With the operator, the darker part of the X-Ray perspective image can be adjusted to be more visible. See Fig. V-14 for operator parameter setting interface with contrast ratio.

Fig. V-15 shows the rendering contrast after contrast ratio adjustment:

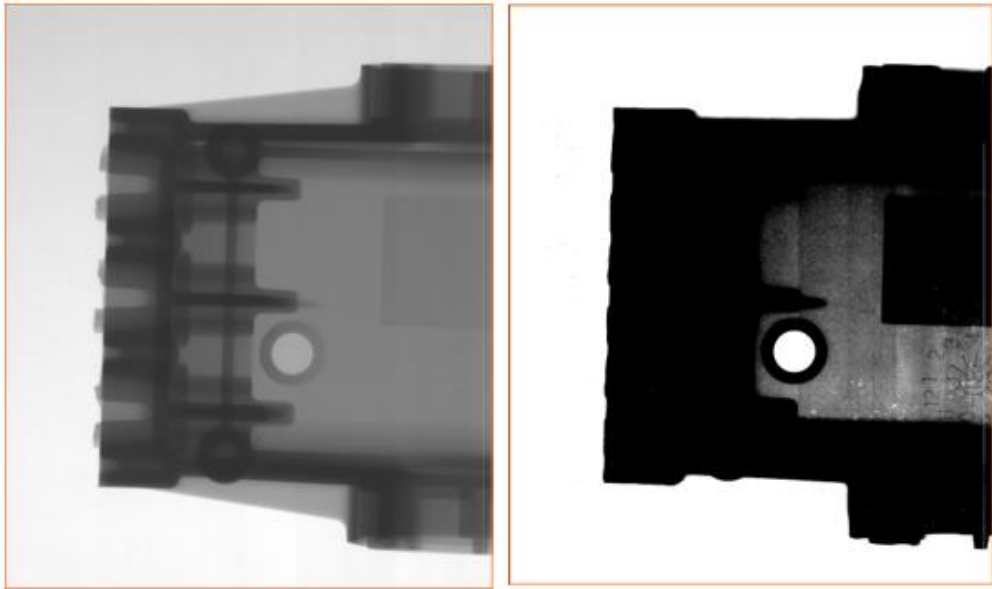


Fig. V-15 Original Image (L), Image After Contrast Processing (R)

8.4.2 Brightness

The brightness operator adjusts the brightness of the whole image. A larger parameter value of the brightness operator indicates a darker image; a smaller parameter value indicates a brighter image. The parameter value of the brightness operator is 1.0 by default, and is within 0.1~2.2. See Fig. V-16 for Parameter Setting of Brightness Operator:

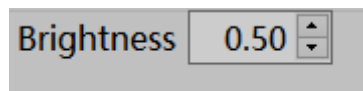


Fig. V-16 Brightness Operator Parameter Setting

Fig. V-17 shows the comparison between the original image and the rendering processed by the brightness operator with brightness 0.5 and 1.5:

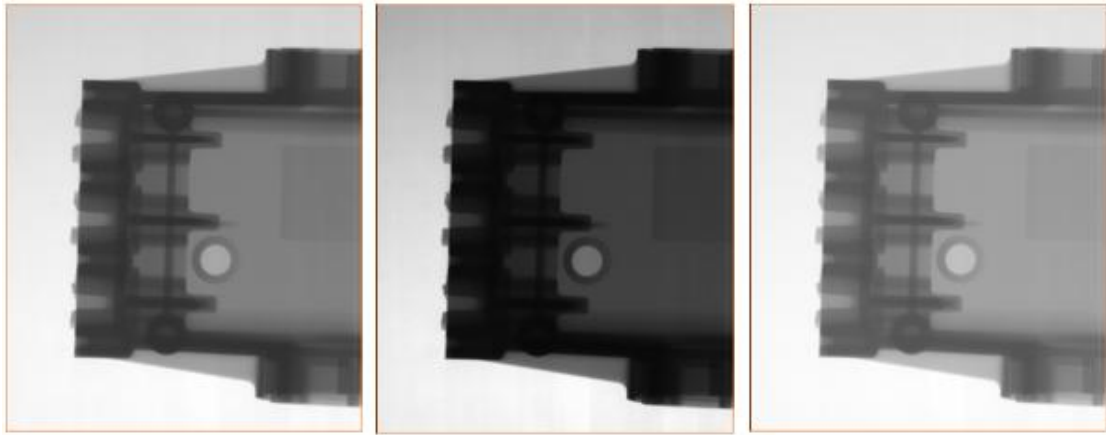


Fig. V-17 Original Image (L), Brightness 0.5 (M), Brightness 1.5 (R)

8.4.3 Enhancement

The enhancement operator can improve the recognition of image details and the image resolution. The size of the default area is 3 and the intensity is 3.

Region: the region size is in a single pixel, which is the calculation region parameter when the enhancement operator is executed. The value range is 1~201. A larger value indicates a wider edge at the junction in the enhanced image. The recommended reference value is 3 or 5.

Intensity: The execution intensity of the enhancement operator, with a value range of 1~20. A higher value indicates a more obvious enhancement effect, but a lower image SNR (large noise/graininess). See Fig. V-18 for Parameter Setting of Enhancement Operator:



Fig. V-18 Setting of Parameters of Enhancement Operator

See Fig. V-19 for Enhancement Operator Effect:

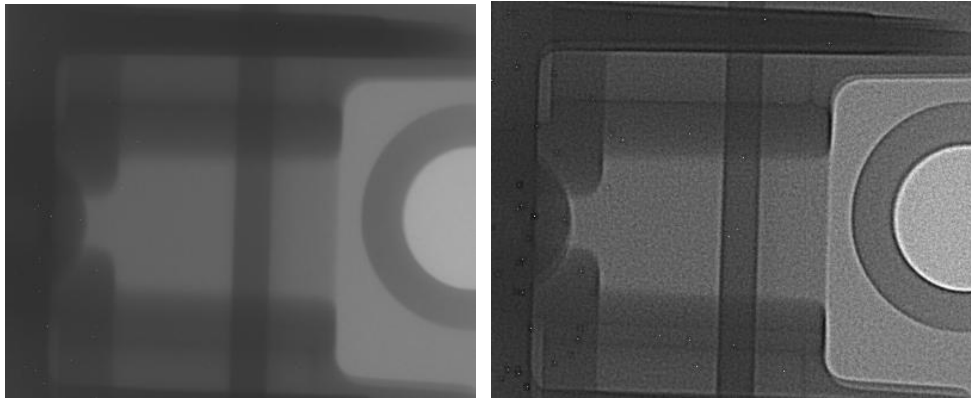


Fig. V-19 Original Image (L), Enhancement Processing (R)

8.4.4 Wave filtering

The filtration operator can remove the obvious noise (graininess) in the image while maintaining the details, and improve the SNR of the image to a certain extent. The parameter of the filter operator is "area size", the value of which is an odd number ranging from 3 to 37, being 3 by default. See Fig. V-20 for parameter setting entry:

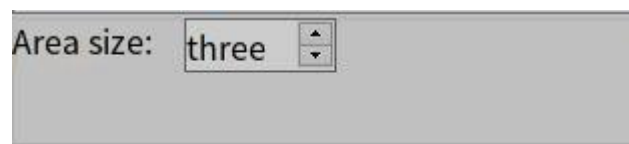


Fig. V-20 Settings of Parameters of Filter Operator

Fig. V-21 shows the comparison between the original image and the rendering after execution of the filter operator when size of the filter operator parameter area is set to 15:

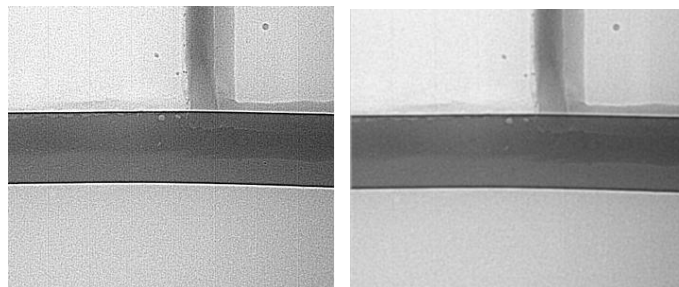


Fig. V-21 Original Image (L), Wave Filtering Processing (R)

8.4.5 Smoothing

The smoothness operator can blur the image. An appropriate value of the smoothness parameter can also eliminate the noise. The value of the smoothness operator parameter "Smoothness" is within 0.1 – 1.0, being 0.5 by default. A smaller smoothness indicates a stronger blur effect on the smoothness operator. See Fig. V-22 for setting of smoothing operator parameter "smoothness":

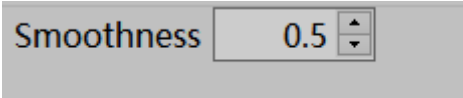


Fig. V-22 Settings of Parameter of Smoothing Operator

Fig. V-23 shows the application rendering by the smoothing operator on the original image, with the smoothness of 0.1 and 1.0 respectively.



Fig. V-23 Original Image (L), Smoothness (0.1), Smoothness (1.0)

8.4.6 Edge enhancement

Edge enhancement operator highlights the edge where light and dark of the image change greatly, making the image details clearer and facilitates the identification of defects. Edge enhancement operator can be equivalent to the combination of enhancement operator with filtration operator. The control parameters of edge enhancement operator are "area", "strength" and "noise reduction". See Fig. V-24 for parameter setting:

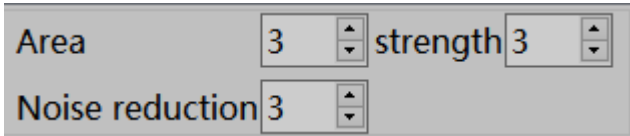


Fig. V-24 Settings of Edge Enhancement Parameters

Area: size of the area used for edge calculation by operator (unit: pixel). The values range from 3 to 201.

Intensity: intensity of the enhancement operator with respect to the brightness amplification. A larger value indicates a sharper contrast. The values range from 3 to 20.

Noise Reduction: degree of noise reduction for image after edge enhancement. A larger value indicates greater noise reduction. The values range from 3 to 37.

Fig. V-25 shows the original image after processing when the area size of edge enhancement operator is 5, intensity is 9, and noise reduction is 5:

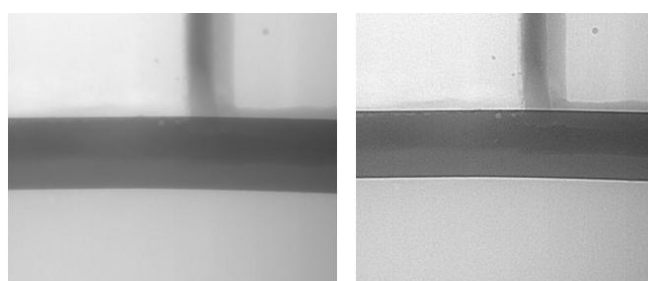


Fig. V-25 Original Image (L), Edge Enhancement (R)

8.4.7 Sharpening

The sharpening operator can slightly enhance the edge area of the image and the area of gray level jump, making the image details clear. There is no control parameter for the sharpening operator. Fig. V-26 shows the sharpening rendering:

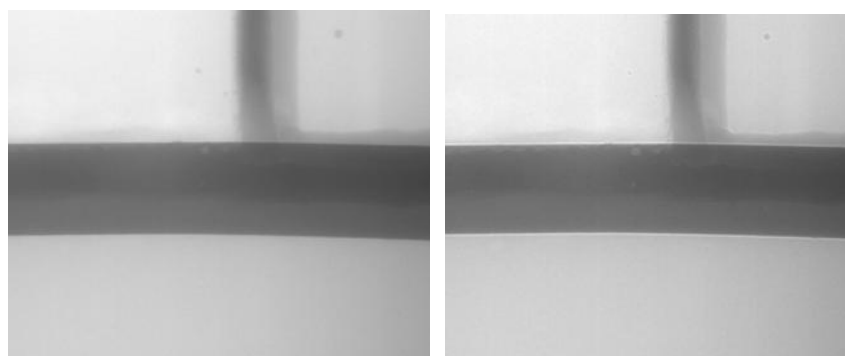


Fig. V-26 Original Image (L), Sharpening (R)

8.4.8 Reverse color

The invert operator makes the bright and dark areas of the image swap, that is, providing the invert effect (also known as negative film). Reverse color makes the color difference of some types of perspective images (e.g. weld image) more obvious, highlights the image details, and facilitates the user to observe and determine defects. There is no control parameter for the reverse color operator. Fig. V-27 shows the revert effect:

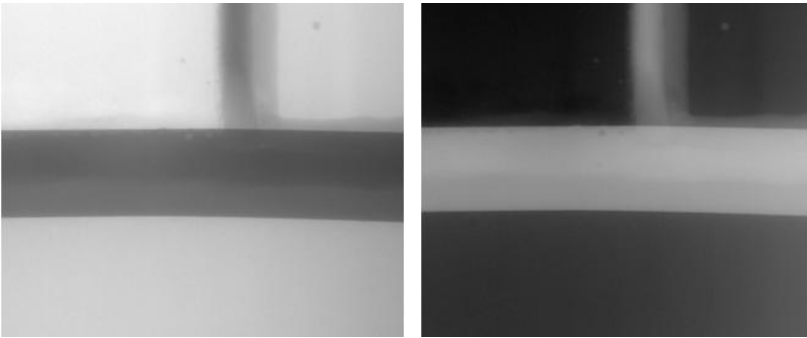


Fig. V-27 Original Image (L), Reverse Color Processed Image (R)

8.4.9 Rotation

The rotation operator can select any angle of the image. The control parameter of the rotation operator is "rotation angle". The user can enter the target rotation angle in the interface to rotate the image. The value range of rotation angle is $-360^{\circ} \sim 360^{\circ}$. See Fig. V-28 for parameter setting:

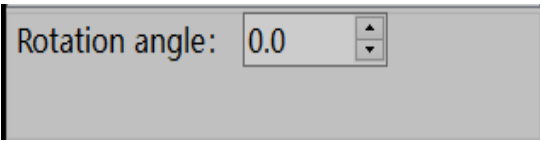


Fig. V-28-1 Parameter Setting of Rotation Operator

Fig. V-28 Rotation Parameter Setting

Fig. V-29 shows the effect of an image after 45° rotation:

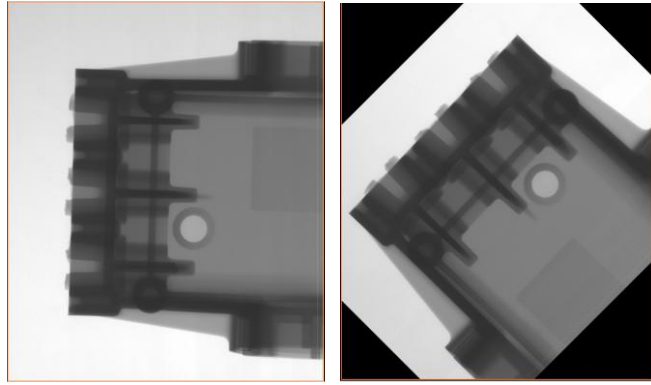


Fig. V-29 Original Image (L), Rotation for 45 °(R)

8.4.10 Mirroring

The mirroring operator can change the image symmetrically along the X/Y axis (also known as flip). See Fig. V-30 for the control parameter setting of mirroring:

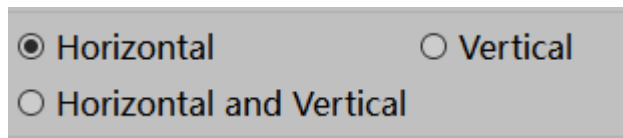


Fig. V-30 Mirroring Parameter Settings

The mirroring direction is divided into horizontal, vertical and horizontal & vertical direction:

Horizontal: the image is flipped up and down horizontally;

Vertical: the image is flipped left and right

Horizontal & vertical: the image is flipped both horizontally and vertically.

See Fig. V-31 for mirroring rendering:

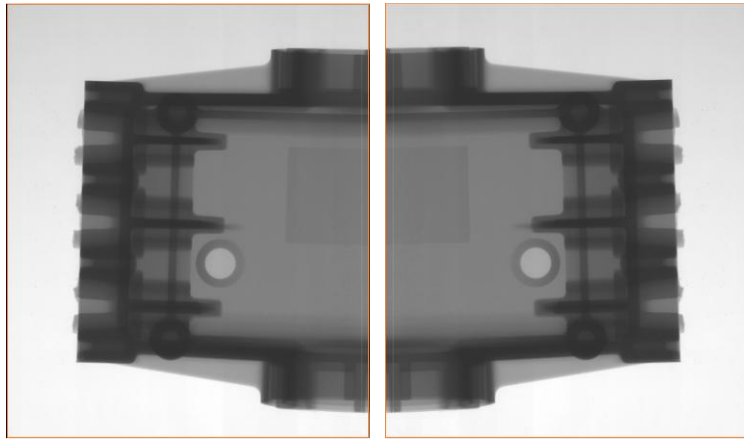


Fig. V-31 Original Image (L), Vertical mirroring (R)

8.4.11 Emboss

The emboss operator makes the image contour clear and blurs the flat area of the pixels, leaving only the contour of the image change with emboss effect, and enhancing the boundary of the pixel change in the image. There is no control parameter for the emboss operator. See Fig. V-32 for the execution rendering of the emboss operator:

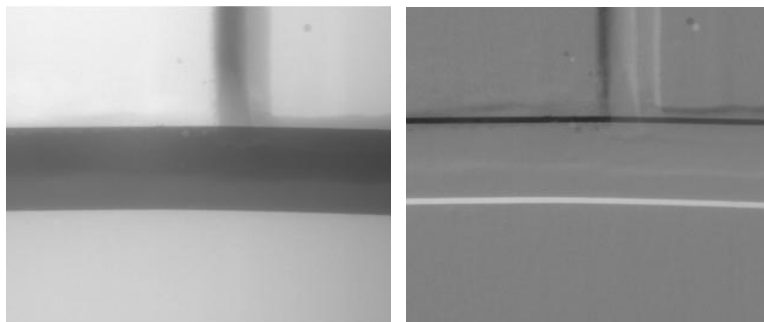


Fig V-32 Original Image (L), Emboss Processing (R)

8.4.12 Histogram equalization

Histogram Equalization is used to increase the global contrast of many images, especially when THE contrast of useful data of image is quite proximate. With this method, brightness can be better distributed in the histogram. It can be used to enhance the local contrast without affecting the overall contrast. Histogram equalization can achieve this function by effectively expanding the commonly used brightness. See the rendering in Fig. V-33:

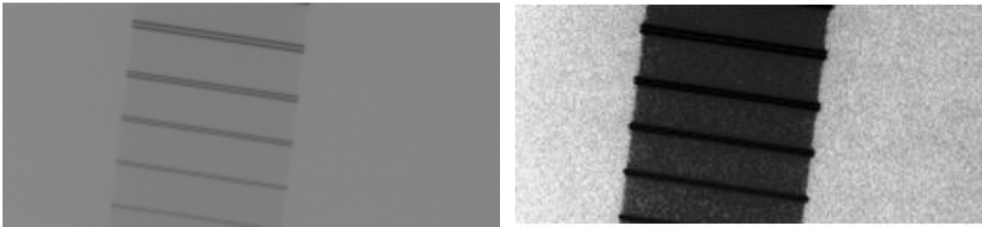


Fig. V-33 Original Image (L) , Histogram Equalization Processing (R)

8.4.13 Superposition

Superposition operator can superpose the acquired images according to the number of frames (range: 1~256). The higher the number of frames, the less image noise, and the longer the superposition time. See the rendering in Fig. V-34

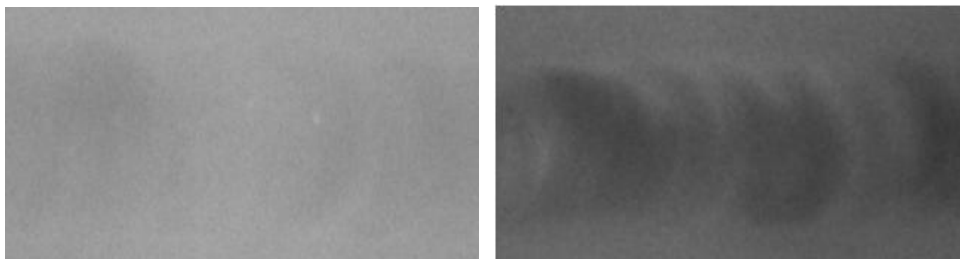


Fig. V-34 Original Image (L), Superposition (R)

8.5 High dynamic range

High Dynamic Range is short for high dynamic contrast image synthesis. With high dynamic range, the X-Ray images acquired under different exposure parameters at the same sample position can be synthesized into a high contrast image. In such an image, clear and visible images of different thickness of the sample are displayed simultaneously .

Click "Image(P)" ->"High Dynamic" in the menu bar to pop up dialog box of high dynamic range. See Fig. V-35 for the entry:

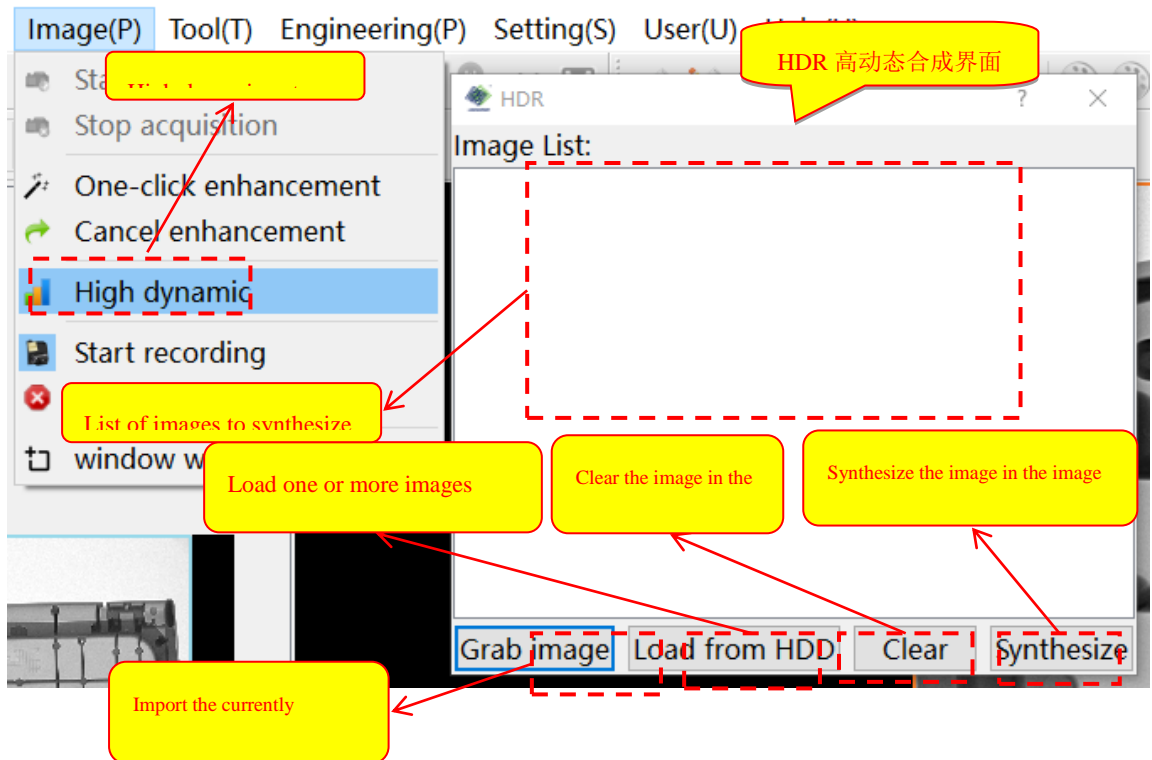


Fig. V-32-1 High Dynamic Image Synthesis

Fig. V-35 High Dynamic Entry (L) and High Dynamic Dialog Box (R)

High Dynamic Range (HDR) process:

- ① Click "Grab Current" or "Load from Hard Disk" to import the original image to be synthesized into the image list.
- ② Repeat step ①, until all the original images to be synthesized are imported.
- ③ Click "Synthesize" to synthesize high dynamic range images, and the synthesized high dynamic range image will be displayed in the main image display window.
- ④ If wrong images are imported or images need to be imported again, click "Empty" to remove all source images in the image list.

⚠ Note: All imported images must be X-Ray images acquired in different ray exposure conditions at the same position of the same workpiece to ensure the composite effect of the high dynamic range image.

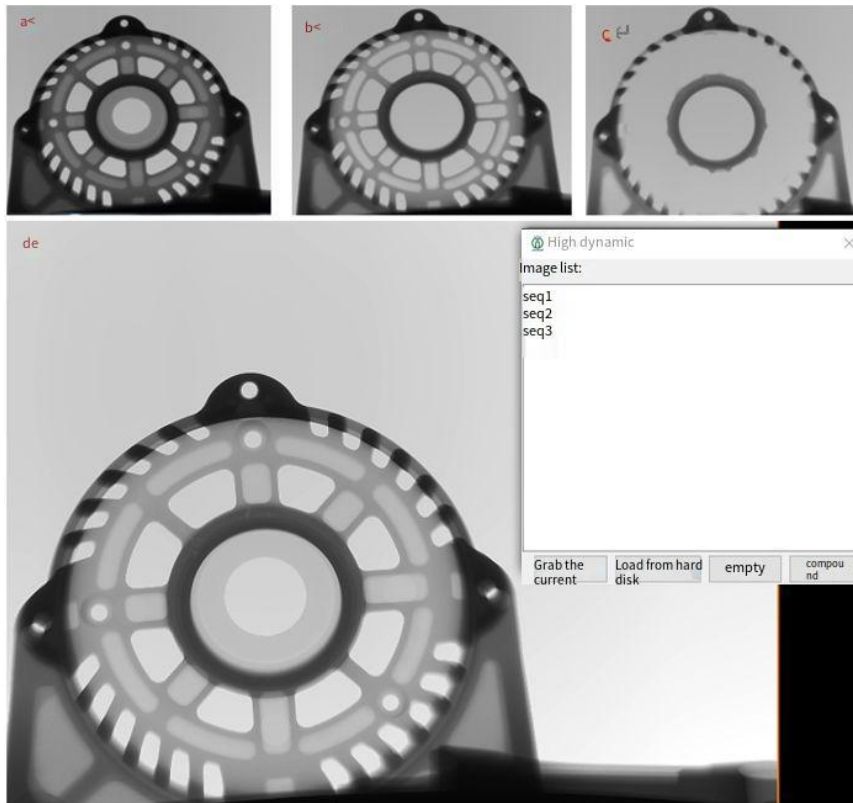


Fig. V-36 a. Low Exposure Image; b. Medium Exposure Image; c.High Exposure Image; d. High Dynamic Range Image after Synthesis

Fig. V-36 shows a rendering of the high dynamic range image after synthesis of three images of the same workpiece acquired after exposure at the same position under different ray parameters.

9. One-click enhancement

For one-click enhancement, a set of image processing algorithms is built into the software, click to apply the algorithm to image, or cancel. See Fig. V-37 for function entry :

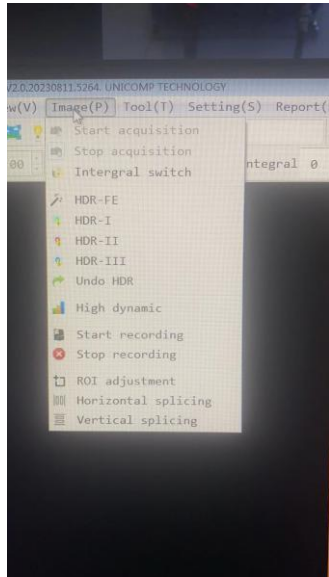


Fig. V-37 One-Click Enhancement Entry (L), Shortcut Tool (R)

10. Magnification correction

Magnification correction refers to the ratio of the pixel length to the actual length in the calculation image, and the recording process to configuration file of the Application. After magnification correction, the pixel length of the measured image can be converted to the physical length. In the case of low accuracy requirements, it can be used as reference data.

The user can use the magnification correction function via "Tool (T)" -> "Magnification correction" in the menu bar. See Fig. V-38:

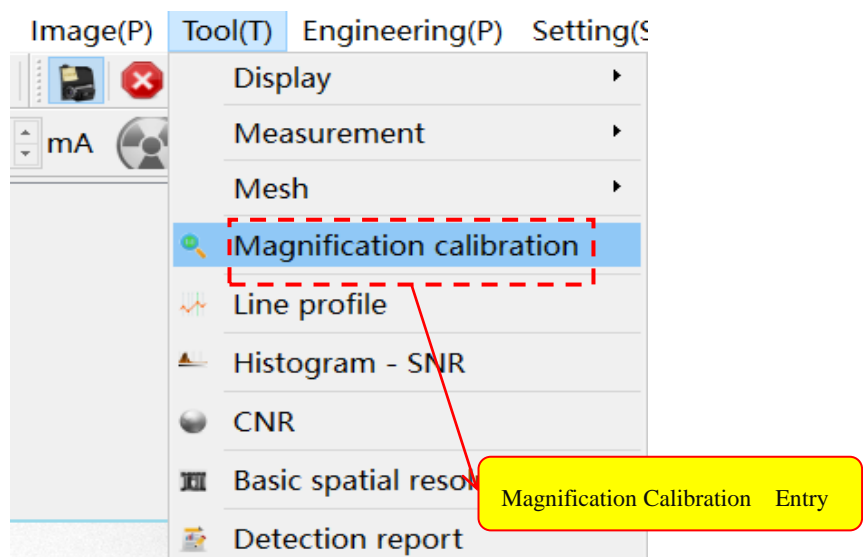


Fig. V-33 Magnification Calibration Entry

Fig. V-38 Magnification Correction Entry

When magnification correction is required?

When "Uncorrected" prompt appears near the image information display at the center of state bar of the Application bottom, it is necessary to correct the magnification immediately. (See Fig. V-39)



Width: 0 Height: 0 Channel: 0 Bit: 0 Multiplication: 0.884 Uncorrected


Fig. V-39 Prompt for Uncorrection

In other cases, magnification correction is required to ensure the relative accuracy of measurement results if any one of the following conditions is satisfied:

- 1) There is a big difference between the measured results and the actual physical size.
- 2) Distance between the X-Ray tube and the testing platform (on which the tested object is placed) changes.
- 3) The focus size of the ray tube changes.
- 4) Distance between the detector and the testing platform (on which the tested object is placed) changes.
- 5) Parameters related to imaging of the X-Ray digital imaging detector (e.g. a flat panel and linear array) are modified.

Steps of magnification correction:

- 1) Open or acquire one X-Ray image of calibration block.

- 2) Choose  and adjust image display to 1:1.

- 3) Check the physical length (width) of the calibration block in X-Ray image.
- 4) Open the image tool for correction via the menu bar "Tools" -> "Magnification Correction".
- 5) Drag three purple dots so that the two green line segments just cover the chosen calibration block, and ensure the blue line segment is perpendicular to the green one.
- 6) Enter the actual physical length of the correction block in the edit box and click OK to complete the correction.
- 7) Use the spacing measurement in "Measurement" to verify whether the correction is in effect.

See Fig. V-40:

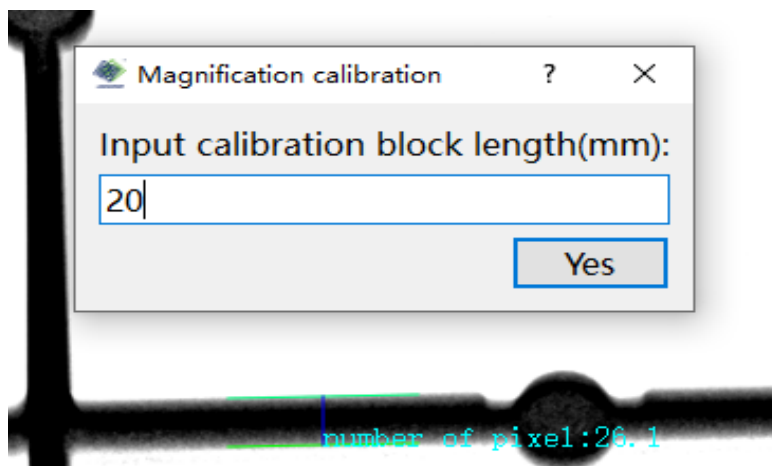


Fig. V-35 Application of Magnification



Fig. V-40 Magnification Correction

Note:

1) Before measurement function is used, magnification correction must be conducted to ensure the relative accuracy of the measurement results.

2) Due to the uneven height of the workpiece, there may be errors in the measured data, which can only be used as auxiliary reference data, but not as a basis for judgement !


11. Image measurement, marking and display

The Application can measure and add marks to the currently displayed image, and can also zoom and drag the image to move with the mouse. So the Application supports two different image display modes: measurement mode and zoom mode. The user can click the menu bar "Tool (T)" ->"Display" ->"Move & Zoom"/"Measure" or toolbar icon  /  to quickly switch between two modes.

After entering the measurement mode, the user can add graphics marks to the X-Ray image or measure the characteristics of the interesting parts in the X-Ray perspective image. At this time, the user cannot zoom and move the image.

After entering the zoom mode, the user can zoom and drag the X-Ray image with the mouse to adjust the display mode of the main image window. At this time, the user cannot measure or mark the image.

11.1 Move & zoom mode

If the Application is in the measurement mode, the user can click  icon in the toolbar to enter the zoom mode (Fig. V-41). In the zoom & move mode, the user can zoom and move the image with the mouse, and change the image display mode in the main image window.

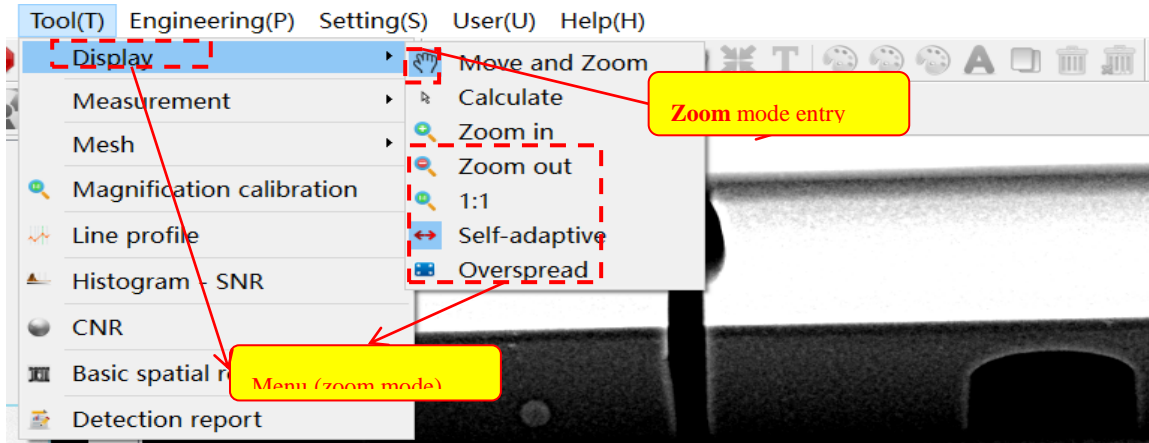


Fig. V-36-1 Menu (Zoom Mode)



Fig. V-41 Switch Zoom Mode Entry (L), Shortcut Tool (R)

11.1.1 Move & zoom image

Zoom:

In the zoom mode, the maximum zoom ratio of the image is 5. The user can zoom images in the following mode:

1) "Tool (T)" ->"Display" ->"Zoom in/out" in the menu bar.

2) In Toolbar : zoom in image. In toolbar : zoom out image.

3) The middle roller of the mouse rolls back and forth.


Movement:

In the zoom mode, hold down the left mouse button in the effective area of the image, and then drag the mouse to move the image. Release the left mouse button to stop the image movement.


11.1.2 Image display mode

The image supported by the Application can be displayed in the main image window in the following modes: "1:1", "self-adaption" and "over-spread". When the Application is enabled, the default display mode is "self-adaption", the user can freely switch the display mode as appropriate.


1: 1

The user clicks "Tool" ->"Display" ->"1:1" in the menu bar or toolbar icon  to switch the display mode to "1:1". At this time, the displayed image will be displayed in the window according to the original width-height ratio of 1:1.


Self-adaption

The user clicks the menu bar "Tool" ->"Display" ->"Self-adaption" or toolbar icon  to switch the display mode to "Self-adaption". At this time, the Application automatically calculates the appropriate display ratio of the image to ensure that the image size is not distorted while zoomed.

Over-spread

The user clicks "Tool" ->"Display" ->"Over-spread" in the menu bar or the toolbar icon  to switch the display mode to "Over-spread". At this time, the Application will zoom the displayed image to the maximum size of the entire main display window to spread the whole entire display window.

11.2 Measurement mode

Click  to enter the measurement mode, ensure that the image cannot be moved and zoomed during the measurement. After entering the measurement mode, the image cannot be zoomed and dragged with the mouse; meanwhile, all the toolbars for moving images in the toolbar are gray; the toolbar icons for marking and measurement become available (colored).

Click the "Tool (T)" ->"Measurement" in the menu bar to choose a measurement mode or the marking mode, and enter the measurement mode automatically. (See Fig. V-42)

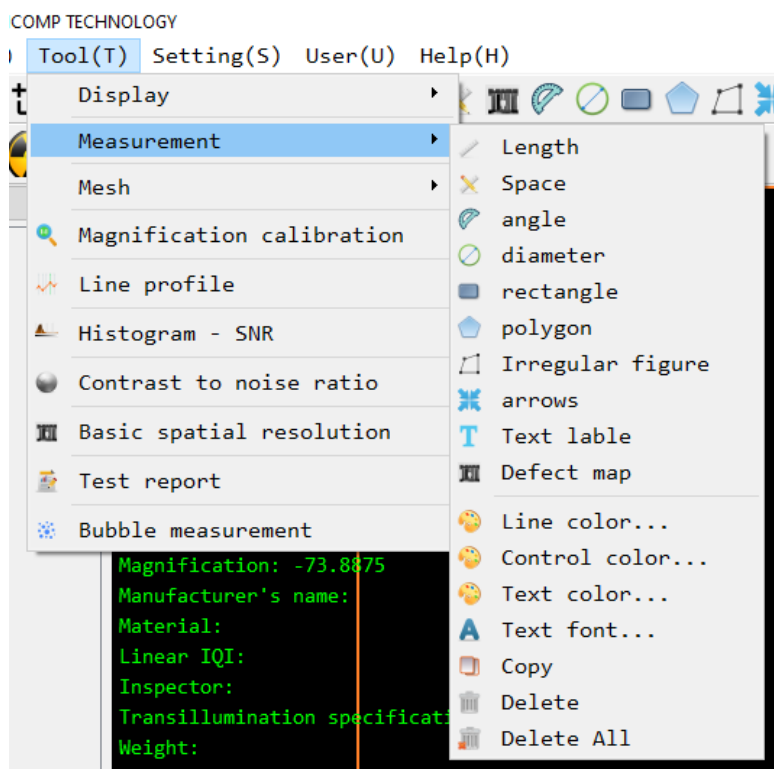


Fig. V-42 Measurement Menu and Shortcut Tool

11.3 Use of measurement and mark

In the toolbar, the user can quickly use the measurement and marking mode, and with the marking of the image, the user can get more information of the image, convenient to query after archiving. From left to right, the measurement mark toolbar includes: length, spacing, angle, diameter, rectangle, polygon, arrow mark, text mark, set line color, set control point color, set text color, set text font, copy mark, delete mark and remove all marks. (Fig. V-42).


Note:

- 1) User must enter the measurement mode to use measurement and mark!

2) Before using the measurement function, it is necessary to confirm whether the "Magnification correction" is required, otherwise the measurement result may be wrong ! (See when the magnification correction is required)

11.3.1 Length

Length measurement can be used to measure the pixel length of the specified part of X-Ray image, the length can be automatically converted and displayed as actual physical length (magnification correction is required). The specific steps of length measurement are as follows:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Length" in the menu bar to enable length measurement.

2) Move the mouse to the position to be measured, press and hold the left mouse button, drag the mouse for a certain distance, and a line segment is automatically made at the position where the mouse stops in the main image window, meanwhile, the physical length of this distance is displayed beside the line segment (see Fig. V-43).

3) Move 2 control points and adjust the line segment to just cover the position to be measured. The displayed length is the reference physical length of this position.

4) Repeat the above steps to add multiple length marks.

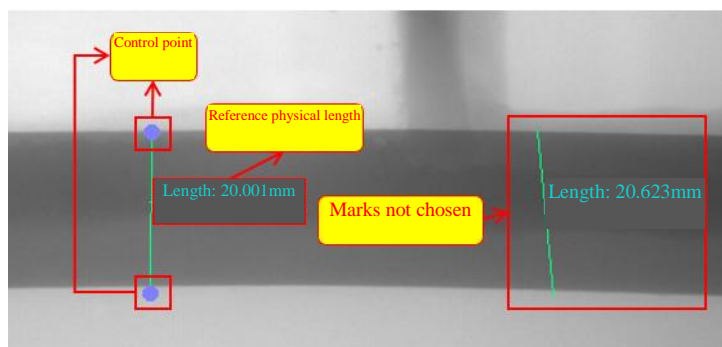



Fig. V-43 Length Measurement Mark

11.3.2 Spacing

Spacing measurement is used to measure the interval length of the specified position in the X-Ray image. The specific steps of spacing measurement are as follows:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Spacing" in the menu bar to enable the spacing measurement.

2) Move the mouse to the position to be measured, click the mouse for 3 times randomly near this position, and 3 control points appear in sequence. finally, when clicking for the 3rd time, the spacing mark is automatically made, meanwhile, the physical length of this segment distance is displayed beside the line segment (3 points clicked shall not be on the same line or at the same position (see Fig. V-44).

3) Move 3 control points respectively, so that two parallel lines just cover the position to be measured. At this time, the vertical line segment in the middle is the spacing of the position, and the spacing distance is displayed beside.

4) Repeat the above steps to add multiple spacing marks.

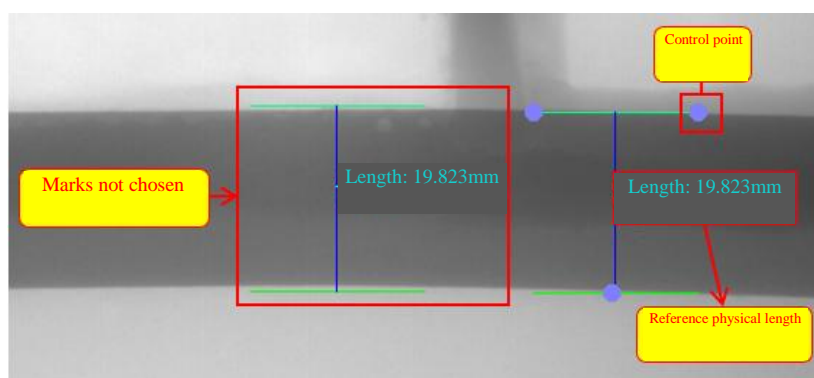



Fig. V-44 Spacing Measurement Mark

11.3.3 Angle

Angle measurement is used to measure the angle of a specified position in the X-Ray image. The specific steps of angle measurement are as follows:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Angle" in the menu bar to enable angle measurement.

2) Move the mouse to the position to be measured, click the mouse for 3 times randomly near this position, and 3 control points appear in sequence, finally, when clicking for the 3rd time, the angle mark is automatically made, meanwhile, the angle degree is displayed beside the mark (see Fig. V-45. Note: the 3 points clicked shall not be at the same position).

3) Move three control points respectively, so that the two lines just cover the position to be measured, and the angle degree is automatically updated and displayed next to the mark.

4) Repeat the above steps to add multiple angle marks.

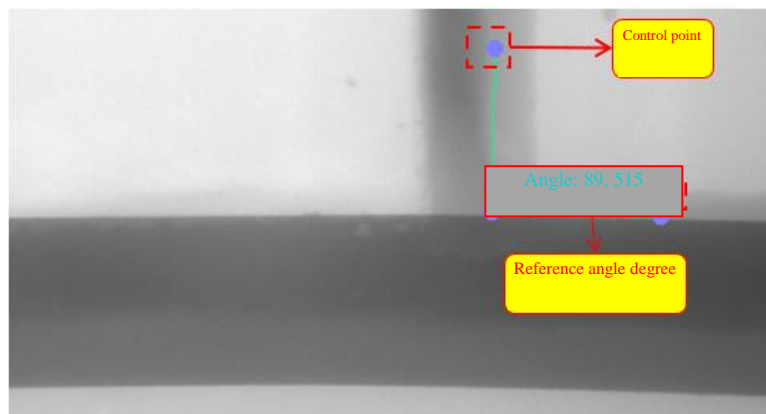



Fig. V-45 Angle Measurement Mark

11.3.4 Diameter

Diameter measurement is used to measure the diameter of the specified circular position in the X-Ray image. Specific steps of diameter measurement:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Diameter" in the menu bar to enable diameter measurement.

2) Move the mouse to the position to be measured, click the mouse for 3 times randomly near this position, then 3 control points appear in sequence, finally, when clicking for the 3rd time, the circular mark is automatically made, meanwhile, the diameter, perimeter and area of

the circular area are displayed beside the mark (see Fig. V-46. Note: The 3 points clicked shall not be on the same line, and any 2 points shall not be at the same position).

3) Move 3 control points respectively to make the circular area just cover the position to be measured, and the final measurement result will be automatically displayed next to the mark. The central cross position is the center of the circle.

4) Repeat the above steps to add multiple circular marks.

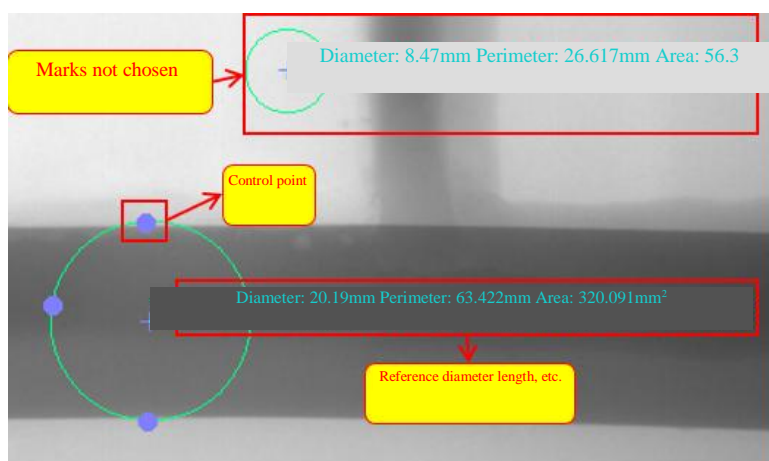



Fig. V-46 Diameter Measurement Mark

11.3.5 Rectangle

Rectangle measurement is used to measure the perimeter and area of the specified rectangle in the X-Ray image. The specific steps of rectangle measurement are as follows:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Rectangle" in the menu bar to enter rectangular measurement.

2) Move the mouse to the position to be measured and click once. When a control point appears in the image, click the control point and drag the mouse to make the rectangular area just cover the area to be measured. The length, width and area of the rectangle are automatically displayed near the rectangle box (Fig. V-47).

3) Click once on the rectangle. After the control point appears, click, hold and drag the control point by the mouse to modify the size of the rectangle. When the size of the rectangle changes, the measured values of the length, width and area are automatically updated.

4) Repeat the above steps to add multiple rectangle measurement marks.

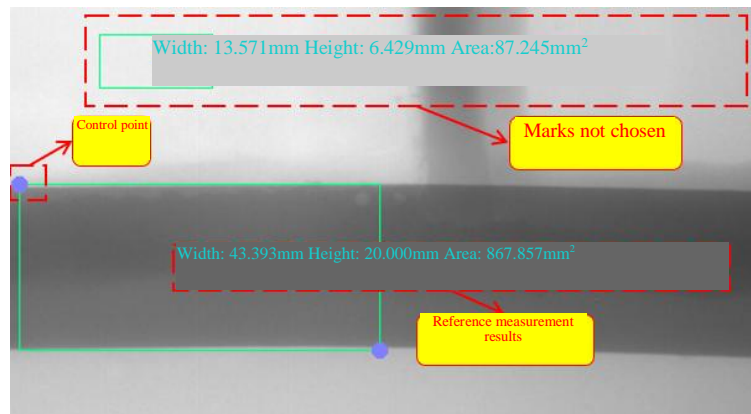



Fig. V-47 Rectangular Measurement Mark

11.3.6 Polygon

The polygon can be used to mark and measure the length and area of any shape zone in the X-Ray image. The specific operation steps of polygon measurement marking are as follows:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Polygon" in the menu bar to enter measurement.

2) Move the mouse to the area to be measured and marked, and add multiple control points at the edge of this position in turn (click the left mouse button to add one control point each time). Line segments are connected automatically between the control points. After the added control points surround the target area, double-click the left mouse button at the last control point to add a polygon surrounding the target area. (Fig. V-48).

3) Press the left mouse button at the control point and drag the mouse to change the position of the control point and correct the polygon shape.

4) Repeat the above steps to add multiple circular marks.

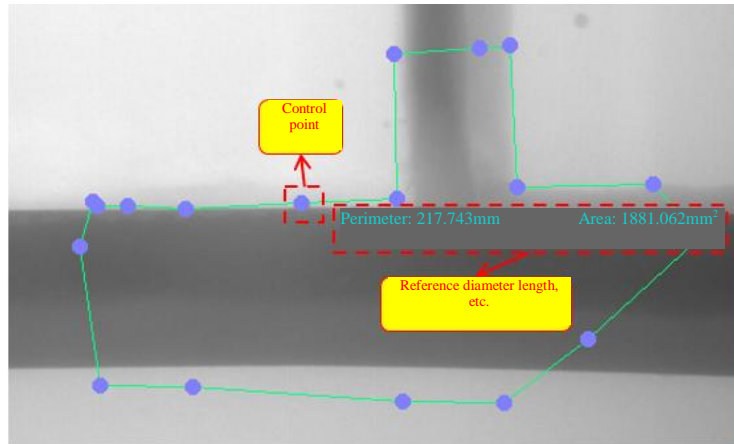



Fig. V-48 Polygonal Measurement Mark

11.3.7 Arrow

Arrow tag can be used to indicate the position in the X-Ray image for special instructions and marking. Steps to add arrow indication mark are as follows:

1) Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Arrow" in the menu bar to add.

2) Move the mouse to the position where an arrow indication mark is required, press and hold the left mouse button near this position, drag the mouse for a distance, an arrow mark appears in the image (Fig. V-49).

3) Click the arrow area with the left mouse button. After choosing the arrow, the user can modify the direction and size of the arrow mark and drag the arrow mark through the control point.

4) Repeat the above steps to add multiple arrow indication marks.

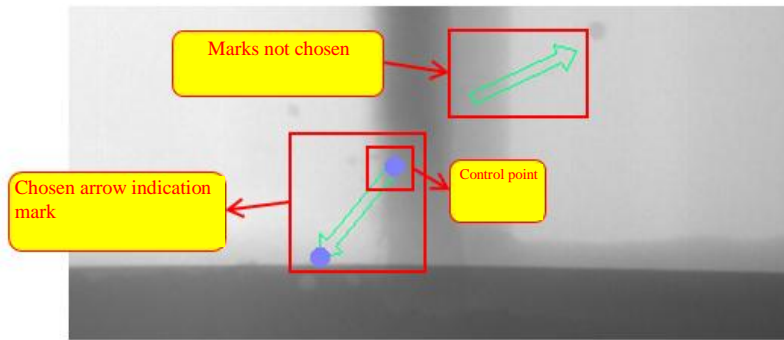



Fig. V-49 Arrow Measurement Mark

11.3.8 Text tag

The text tag can be added to the X-Ray image display area, and the user can customize the entered words. Steps to add text tags are as follows:

- 1) Click the toolbar icon  or "Tool (P)" ->"Measurement" ->"Tag" in the menu bar to add text tag.
- 2) In the area where X-Ray image tag shall be added, press and hold the left mouse button, drag the mouse and release it to see the opened text tag edit box (Fig. V-50).
- 3) Enter words in the text tag edit box to display the text in the text tag box synchronously; click to finish text editing, display the words in text editing box into the text tag; click to cancel this text editing and restore words in the original text tag.
- 4) Click the text tag area to choose the text tag, drag the control point to move and adjust the position and size of the text tag.
- 5) Repeat the above steps to add multiple text tags.

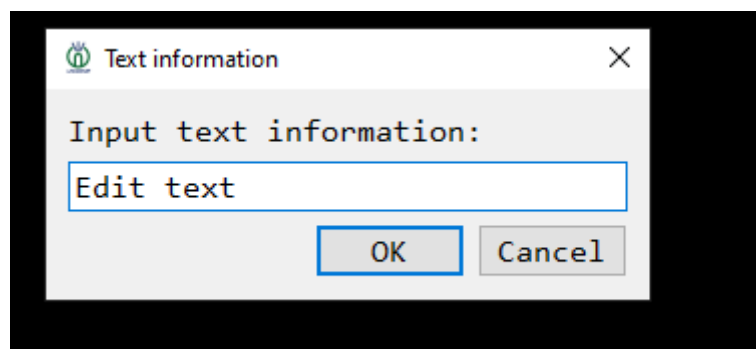


Fig. V-50 Text Tag Mark

11.4 Display setting and control of mark

The mark mainly consists of the control point, line, text, etc. the Application provides the setting entry to modify these components (Fig. V-51 and Fig. V-52). The sequence is line color setting, control point color setting, text color setting, text font setting, and tag copy, tag deletion, and all tags removal.

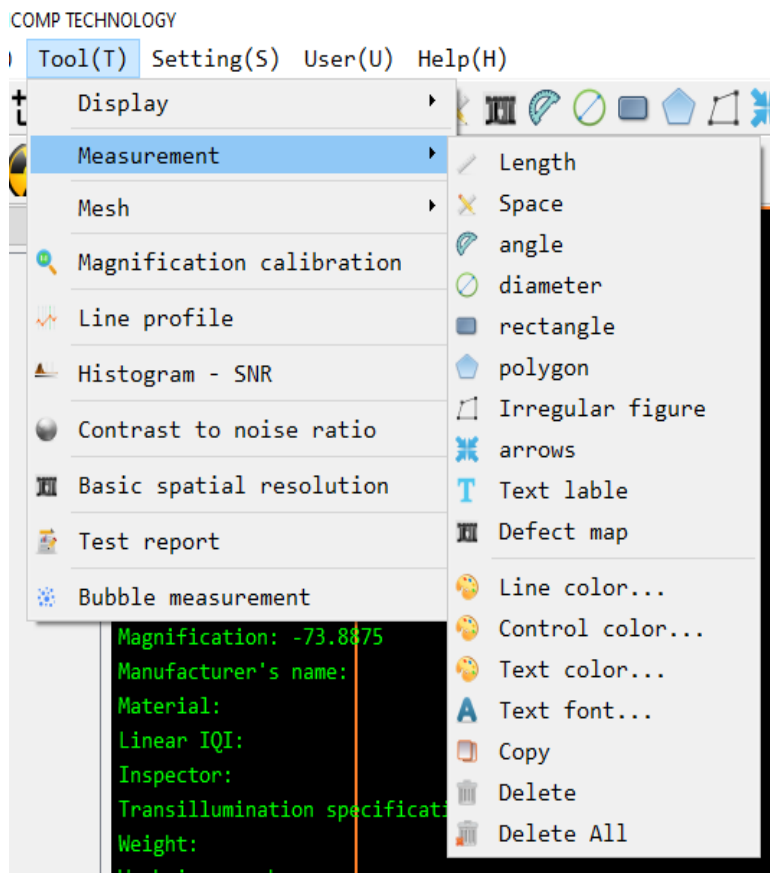



Fig. V-51 Tag Attribute Setting and Tag Management Entry



Fig. V-52 Shortcut Tools for Tag Attribute Setting and Tag Management

11.4.1 Line color setting



Click the toolbar icon  or "Tool (T)" ->"Measurement" ->"Line Color..." in the menu bar to enter line color setting After color setting, click "OK" to apply the new color, or click "Cancel" to cancel the modification. See Fig. V-53:

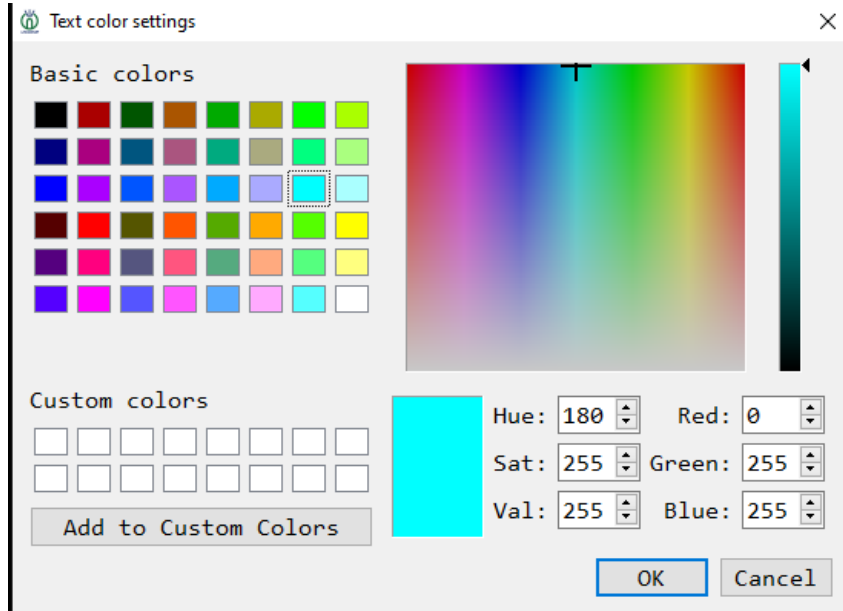



Fig. V-53 Color Setting

11.4.2 Color setting of control point




Click the shortcut toolbar icon  or "Tool (T)" ->"Measurement" ->"Control Point Color..." in the menu bar to enter line color setting (Fig. V-53) After color setting, click "OK" to apply the new color, or click "Cancel" to cancel the modification.

11.4.3 Text color setting


o



Click the shortcut toolbar icon  or "Tool (T)" ->"Measurement" ->"Text Color..." in the menu bar to enter the line color setting (Fig. V-54). After color setting, click "OK" to apply the new color, or click "Cancel" to cancel the modification.

11.4.4 Text font



Click the shortcut bar tool icon  or "Tool (P)" ->"Measurement" ->"Text Font..." in the menu bar to enter the text font option (Fig. V-54). Font choice can be used to set the font, font style, font size, underline, comment line and other properties respectively, and the font effect is displayed in the font example window. Click "OK" to apply new text font, and click "Cancel" to cancel modification.

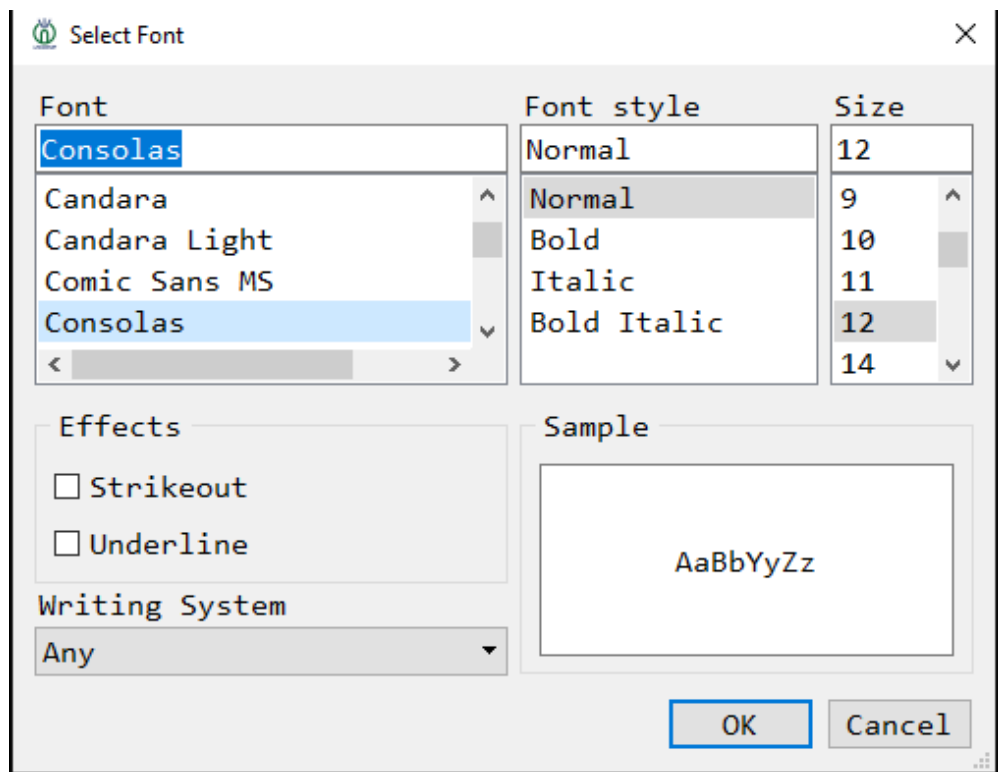





Fig. V-54 Font Setting

11.5 Mark control

Mark controls include copying, mark deletion and mark removal, entry, as shown in Fig. V-42.

Copy: choose the mark object and click the shortcut tool , or "Tool (T)" ->"Measurement" ->"Copy" in the menu bar to copy a mark that is the same as the current one;

Delete: choose the mark object and click the shortcut tool , or "Tool (T)" ->"Measurement" ->"Delete" in the menu bar to delete the current mark. This operation is irreversible;

Delete All: click the shortcut tool , or "Tool (T)" ->"Measurement" ->"Delete all" in the menu bar to delete all current marks. This operation is irreversible;

11.6 Grid

The Application provides a function to add grid to the image and divide the image into grids (see Fig. V-55). The user can use the grid function to divide the image into grids. The user can also customize the note text in the upper right corner of each grid.

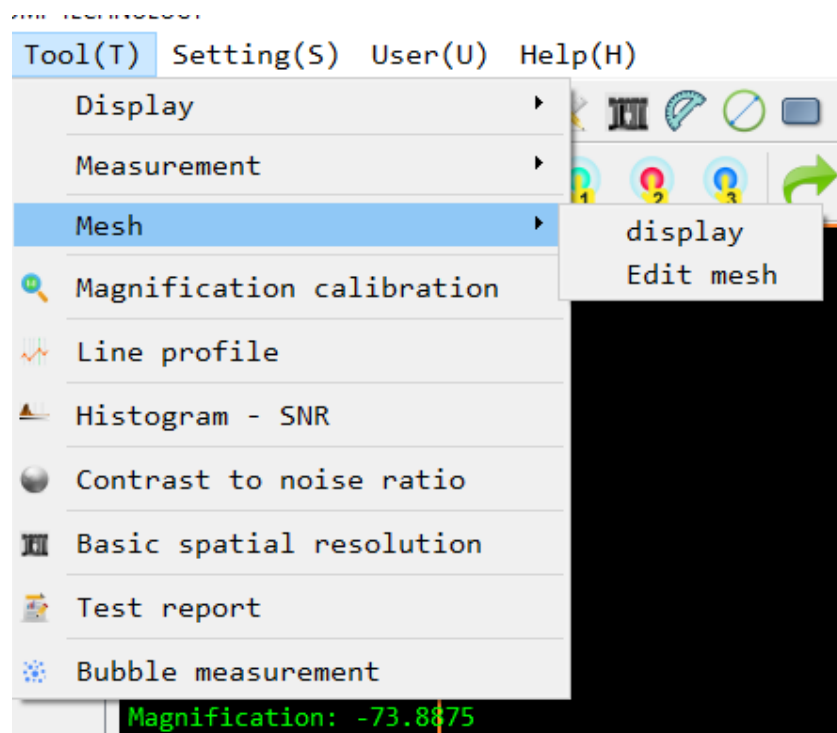


Fig. V-55 Grid Function Entry

Display

The user can open or close the grid display via "Tool (T)" -> "Mesh" -> "Display" in the menu bar. See Fig. V-56 for grid display effect. Grid notes (text displayed in the upper right corner) can be customized.

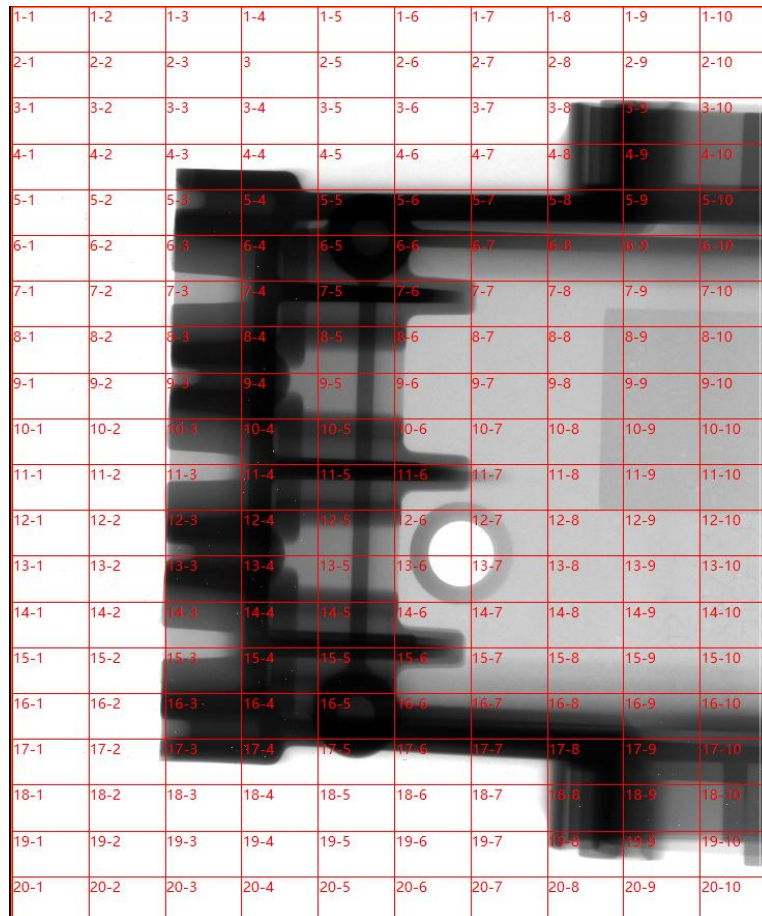


Fig. V-56 Grid Display Effect

Edit mesh

The user can click "Tool" -> "Grid" -> "Edit Grid" in the menu bar to open the Edit Grid dialogue box (see Fig. V-57). All changes in the Edit Grid dialog box are immediately reflected in the image displayed in the image window.


The user can directly set the number of grid rows and columns. The number of rows and columns determines the number of grids (rows x columns) in the image.

The user can directly double-click to specify the grid area in the grid display preview in the Edit Grid dialog box to directly modify the note text of the grid.

The user can click "Default Text" button to restore all notes from the grid to default text. The default text format is "mesh row - mesh column".

The user clicks "Remove" button to remove all notes from the grid.

11.7 Defect atlas

The program provides the defect atlas function (Fig. V-58) to compare the image acquired in real time and the standard atlas library. Click toolbar icon  or "Tool (T)" ->"Measurement" ->"Defect Atlas" in the menu bar to enter defect atlas function.

The user can enter the main interface to choose the type of atlas library (E505 atlas by default), choose different types of atlas in the same atlas, add/delete customized atlas, or choose negative film.

Usage: choose the image for contrast from the image list, drag it to the target position and release it.

For a single contrast image, the user can click the image to drag it randomly and click the right mouse button to close the specified atlas.

For interface with circular atlas on the right, the size of the defect of the current circular hole can be displayed after magnification correction.

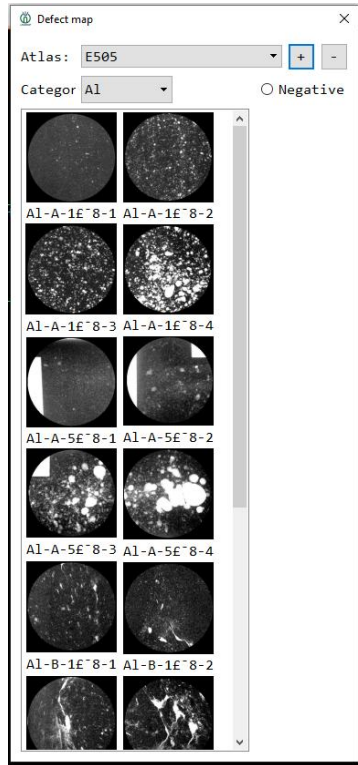
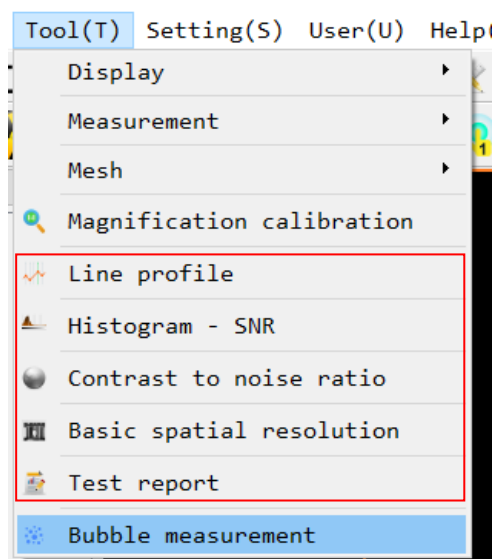


Fig. V-58 Defect Atlas

12. Image analysis

Image analysis means that the user can use the tool provided by the Application to analyze the pixel characteristics of the corresponding area of the image, and to help the user determine the defect or image quality. Tools for image analysis include histogram - SNR, line profile, contrast-to-noise ratio, and basic spatial resolution. See Fig. V-59 for function entry of image analysis:



12.1 Histogram - SNR

Histogram - SNR function can be used to count the number of each pixel grayscale in the specified rectangular area, and generate a chart to display. According to the shape and value of the chart, the user can analyze the gray scale distribution state and distribution pattern of the pixels in the specified area. The maximum value, minimum value, SNR and mean value of pixels in the area are available via analysis statistical results. Click "Tool (T)" ->"Histogram - SNR" in the menu bar to open the histogram - SNR measurement interface. Steps of applying the histogram statistics:

- 1) Click "Tool (T)" ->"Histogram - SNR" in the menu bar to enter the Histogram - SNR interface (Fig. V-60).
- 2) According to the rectangle mark, the rectangle mark is controlled to choose the image area for histogram analysis.
- 3) After area choice, the analysis results are automatically updated and displayed in the histogram - SNR interface.
- 4) By dragging the rectangle and changing the size of the rectangle, the user can measure the histogram distribution in different areas of the image to help analyze the image quality.

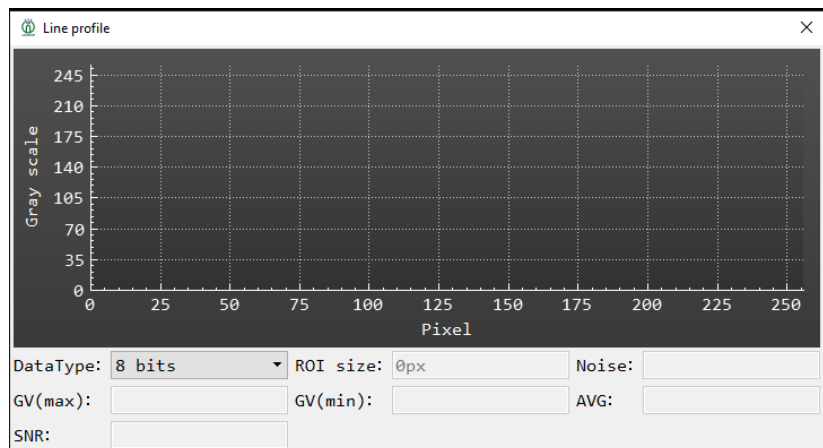


Fig. V-60 Histogram Statistics

Fig. V-60 shows the results of pixel analysis and statistics in the chosen area of the current rectangular mark. The results in the statistical information are described as follows:

1) The X and Y coordinates of grayscale distribution icon respectively indicate:

Vertical Ordinate - Total Number: the total number of pixels accumulated in the current specified area for each pixel gray level.

Horizontal Ordinate - Grayscale Value: all gray levels of pixels.

12.2 Line profile chart

The line profile can be used to count the grayscale of each pixel on the specified line segment, and form a curve chart to display. According to the shape and value of the chart, the user can analyze the grayscale distribution state and distribution pattern of the pixels in the specified area. By analyzing the statistical results, including the maximum value, minimum value, SNR and pixel mean, as well as the shape of the image, the user can know fluctuation of pixels on the line segment (e.g. measure image of double-wire image quality indicator). Click "Tool (T)" ->"Line Profile Analysis" in the menu bar to open the analysis interface of line profile and use the statistical function of the line profile chart. See Fig. V-61:



Fig. V-47 Line Profile Window

Fig. V-61 Line Profile Analysis

Steps of using the line profile:

- 1) Click "Tools (T)" ->"Line Profile Analysis" in the menu bar to enter the line grayscale profile analysis interface.
- 2) According to the use of length measurement, the user can control the line segment mark to choose the line profile area to be analyzed.
- 3) After area choice, the result of line profile is automatically updated and displayed in the line profile window.
- 4) Adjust the position size of graph tool of line segment to measure the pixel distribution of the line profile in different areas of the image, and help the users to analyze the image.

Fig. V-42 shows the distribution statistics results of pixel values at each position in the target area of the current line segment. Each result in the line profile analysis interface is described below:

- 1) The X and Y coordinates of the grayscale distribution icon respectively indicate:

Vertical Coordinate - Grayscale Value: grayscale value of image pixel.

Horizontal Coordinate - Pixel: position of pixel starting from the first point on the line segment.

- 2) Data source: image displayed in the Application is "enhancement data (8 bits)", while the original image data are "raw bits". During statistical analysis, the user can choose "data source" to view the statistical analysis of the original image and the displayed image respectively.

3) Through statistical analysis of the line profile, multiple data are available according to results, including:

ROI size: size of the target area by rectangle mark (pixel length).

Minimum value: the minimum value of pixel at each point in the area.

Maximum value: the maximum value of pixel at each point in the area.

Average value: average value of all pixel values in the area.

Noise: abnormally changed interfere grayscale value in the image grayscale.

Signal-to-Noise Ratio: SNR in the target area. The result value indicates the quality of the image in the area. The higher SNR, the higher uniformity of image in the area, and the better image quality in the area.

12.3 Contrast-to-Noise Ratio (CNR)

Contrast-to-Noise Ratio refers to the difference of SNR between adjacent areas in image. In the Application, it is defined as the SNR difference between the "loop" area and the central "circle" area in the ROI chosen.

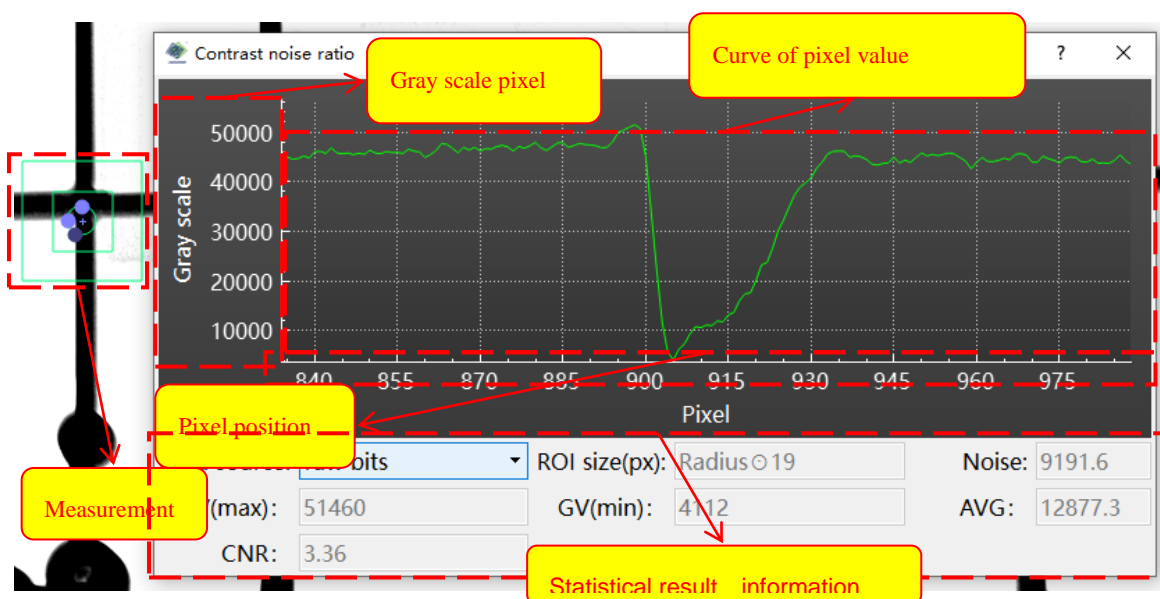


Fig. V-43 Measurement of Contrast Noise

Fig. V-62 Contrast-to-Noise Ratio Measurement

Measurement process of contrast-to-noise ratio is as follows:

1) Click "Tool (T)" ->"Contrast-to-Noise Ratio (CNR)" in the menu bar to open the analysis interface of CNR (Fig. V-62).

2) Drag the graph tool to mark the measurement area on the image: choose the graph tool, press and hold the left mouse button and drag the mouse to drag the graph tool; click and choose any of the three purple control points in the middle of the graph tool, press and hold the left mouse button on the control point, and drag to change the size of the graph tool.

3) Adjust the graph tool to just cover the measured area.

4) Measurement results such as CNR are automatically displayed in the interface.

Fig. V-43 shows measurement results of the CNR for the measurement area currently chosen. The results in the line profile analysis interface are described as follows:

1) The X and Y coordinates of grayscale distribution icon respectively indicate:

Vertical Coordinate - Grayscale Value: grayscale value of image pixel.

Horizontal Coordinate - Pixel: position of pixel starting from the first point on the line segment.

2) Data source: images displayed in the Application

are "enhancement data (8 bits)", while the original image data are "raw bits". During statistical analysis, the user can choose "data source" to view the statistical analysis of the original image and the displayed image respectively.

3) Through statistical analysis of the line profile, multiple data are available according to results, including:

ROI size: size of the target area by rectangle mark (pixel length).

Minimum value: the minimum value of pixel at each point in the area.

Maximum value: the maximum value of pixel at each point in the area.

Average value: average value of all pixel values in the area.

Noise: abnormally changed interfere grayscale value in the image grayscale.

Contrast-to-Noise Ratio (CNR): difference of signal-to-noise ratio (SNR) between adjacent areas in the measurement area. The result value indicates the change of image in the area. the lower the CNR value, the higher the image uniformity, and the better image quality in the area.

12.4 Basic spatial resolution

The basic spatial resolution (iSRb) is a measure of the smallest details that can be displayed in the X-Ray perspective images. The Application uses the double-wire image quality indicator (EN462-5) to measure the basic spatial resolution of the testing system (detector, testing axis and X-Ray system, collectively called as testing system).

EN462-5 double-wire image quality indicator has 13 pairs of small metal wires. After imaging of double-wire image quality indicator, the Application mainly measures the pixel change value Dip (%) between each pair of the 13 pairs of wires, and matches the wire diameter with the Dip value of each pair of wires one by one to get the wire diameter when the Dip is 20%. The wire diameter is the iSRb value of the testing system of this equipment, i.e. basic spatial resolution. The basic spatial resolution of the Application is in the unit of um.

1) Preparation before testing:

① Attach the double-wire image quality indicator (EN462-5) to detector surface with 5° angle formed horizontally between the image quality indicator edge and the detector.

② Remove other obstructions between the detector and X-Ray.

③ Click "**Tool (T)**" ->"**Basic Spatial Resolution**" in the menu bar to open the iSRb measurement interface (Fig. V-44).

2) Steps of basic spatial resolution measurement:

① Open a X-Ray perspective image locally or acquire a X-Ray perspective image of a double-wire image quality indicator (EN462-5) from the equipment in real time (the exposure should not be too large when the image is acquired, so that the whole area of double-wire image quality indicator area can be seen clearly).

② Drag the fishbone mark in the main image window to make superposition between double-wire image quality indicator image and graphic tag. Do not cover the text mark!

③ Click "iSRb Analysis", the Application will start measuring the value of iSRb and update the result in the iSRb measurement interface (Fig. V-63).

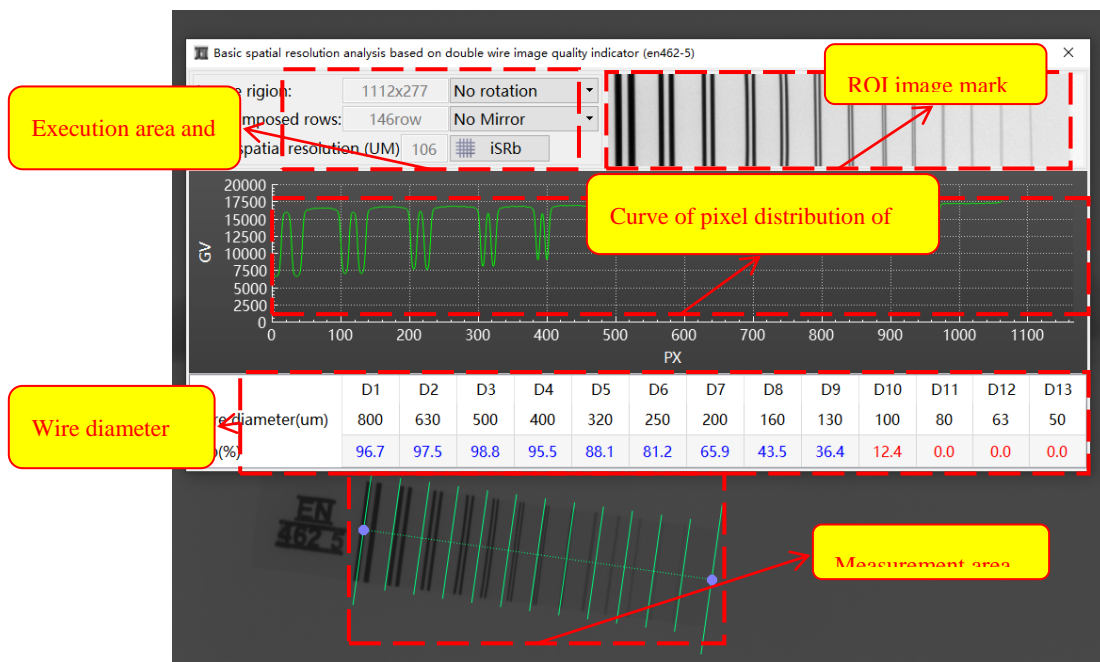


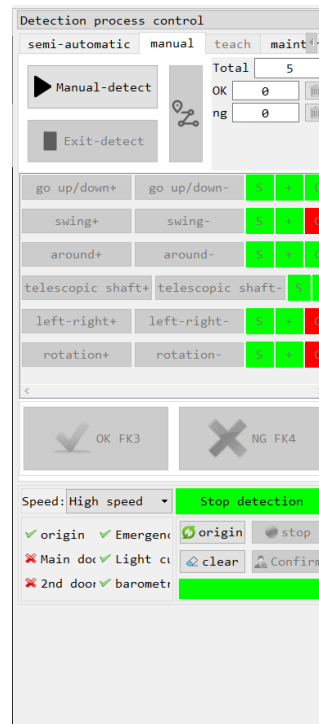
Fig. V-44 Measurement of Basic Spatial Resolution (iSRb)

Fig. V-63 Measurement of Basic Spatial Resolution

Fig. V-63 shows the results of measurement and analysis of basic spatial resolution applying EN462-5 dual-wire image quality indicator. The basic spatial resolution (iSRb) may fluctuate due to different sizes and different imaging conditions of the chosen areas.

13. Testing process control



The testing process includes but is not limited to CNC. The testing process control includes "semi-automation", "manual", "demonstration" and "maintenance".



control.

process"

13.1 Manual testing process

- 1) Click "Manual" to enter the manual program (Fig. V-64), and check whether the reset prompt in the bar below is , if not, click  to reset;

(Fig.

the state

button to




- 2) Click "Manual testing", the prompt box flashes , open the lead door to put the workpiece, and close the lead door;

Fig. V-64 Manual Testing Interface

- 3) Click "Confirm Placement", the axis automatically feeds materials to the testing position. After that, the high voltage is enabled,
- 4) Set the axis in the "Testing Axis Control" area (Fig. V-65), "lift + control axis": rise; "lift - control axis": fall; "swing + control tray": tilt towards direction of ray tube; "swing - control tray": tilt towards detector; "front/rear + control axis": move inside cabin; "front/rear - control axis": move outside cabin; "left/right + control tray": move towards light source; "left/right - control tray": move towards detector; "rotate + control tray": rotate clockwise; "rotate - control tray": rotate counterclockwise.

- 5) The user determines the image   by axis position control and image processing. At the end of product determination, high voltage disconnects automatically. The axis turns to the feeding position automatically and waits for the next feeding.

6) "Exit Testing": click to exit the current manual operation program;

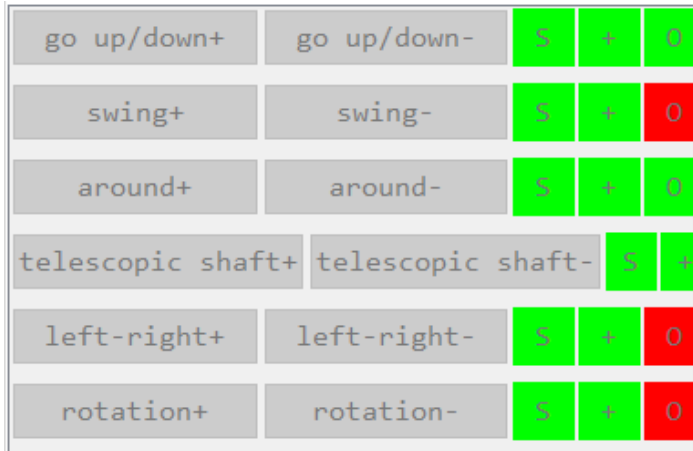


Fig. V-65 Testing Axis Control

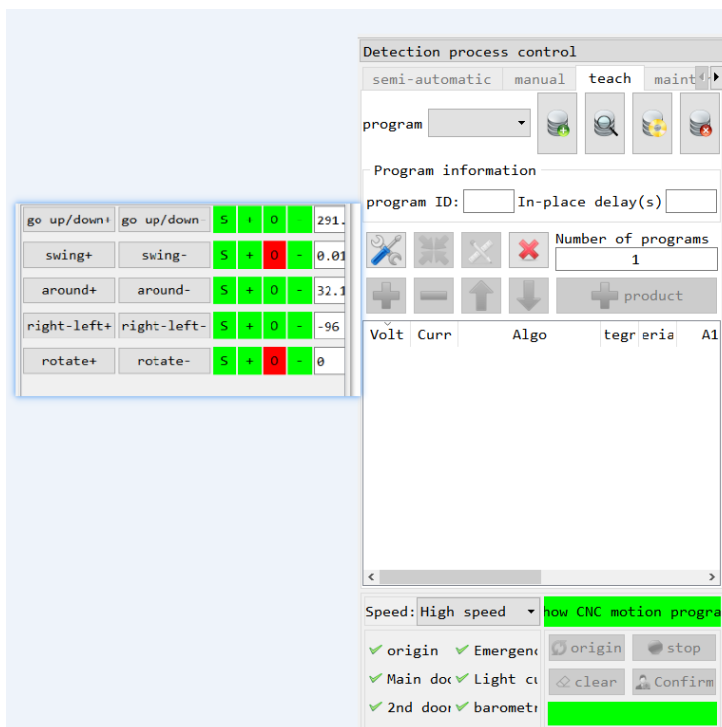
















Fig. V-66 Demonstration Program

13.2 Demonstration program process

- 1) Enter the demonstration program from the manual operation program (see Fig. V-64). Check "Manual" to enter the manual operation program, check whether the reset prompt in the state bar below is , if not, click the  button to reset;
- 2) Click "Manual Testing", the prompt box flashes , open the lead door to put workpiece, and close the lead door;
- 3) Click "Confirm Placement", and the axis automatically feeds materials to the testing position. After that, the high voltage is enabled;
- 4) Click  to enter the demonstration mode (Fig. V-66) to display "Demonstration of CNC Motion Program" in prompt bar, click  to create a new program, enter the program name in pop-up box (Fig. V-67), click "OK" to save it, click  to control the axis, adjust the axis to the appropriate position, choose the appropriate voltage and current, perform superposition and algorithm processing of image, choose  to add and save one or more points. choose  to delete the chosen points, choose  to perform the function of sequence rise for the chosen points, choose  to perform the function of sequence fall for the chosen points, click  to move the axis to the chosen demonstration point.
- 5) Choose  to pop up the prompt box (Fig. V-68), update the current information to the specified point, set the program, choose , enter the program ID and time delay, save the current demonstration program. Refer to the number of frames of superposition operator for time delay. Too less time may cause not enough superimposed number.
- 6) The saved program can be viewed in the program bar. After the target program is chosen, the point display box will display the corresponding point, voltage, current, contrast value, superimposed frame number, axis rise/fall value, swing value, front/back value, left/right value, and rotation value.

7) The user can choose  to copy and change the current program.

8) The user can also choose  button to delete the current program.

⚠Note:

- 1、 The deleted program and point cannot be restored.
- 2、 Click "Save" after the program changes.

13.3 Semi-automatic testing process

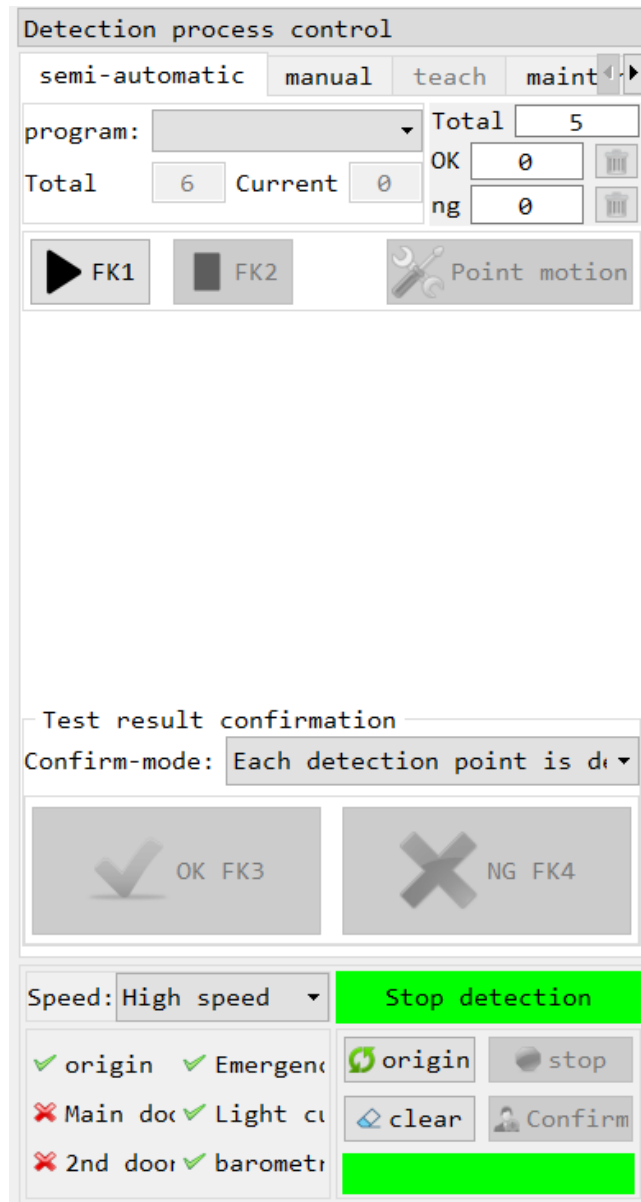
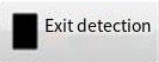
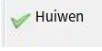


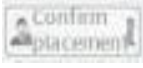


Fig. V-69 Semi-automatic Testing Interface



- 1) Click "semi-automatic" to enter the CNC semi-automatic program. If the previous step is performed in the manual program, please click  button to switch to semi-automatic program.
- 2) After entering the semi-automatic mode, the user chooses the program that has been demonstrated in the program bar. The total point of the current demonstration program is displayed at the total point, and the current point displays the point where the current program is located.



3) Check whether the reset state in the state bar below is , if not, click the  button to reset;

4) Click  button --- click , and the axis automatically feeds materials to the testing position. After that, the high voltage is enabled;

5) Choose the determination mode in the testing result confirmation column. three modes are available (Fig. V-70).



a. Delay + product determination: the program will automatically save the image for each point, and the saved images will be displayed in the left display column (Fig. V-71).

After the program runs,   appears, and the image is determined to be qualified, "1" will be added to the "pass" position. If the image is determined to be unqualified, "1" will be added to the "unqualified" position. The suffix of the saved file is displayed as NG;

b. Determination of each testing point: after the program runs to each testing point,   will pop up to determine each point. The program will save the image of each point, and the saved image will be displayed in the left column (Fig V-71). Suffix "REJ" will be added to the unqualified image. Suffix "NG" of the folder will also be displayed. Same item with "unqualified" result at any point in the testing will be determined as "unqualified item";

c. No determination is required: the program will automatically save the images of each point and will not determine the items. Image at each point will be saved automatically when the program is running.

The program starts running automatically. In the running process, the user can click

 button to pause the CNC program after it reaches the point, or can also click  to terminate the CNC program.

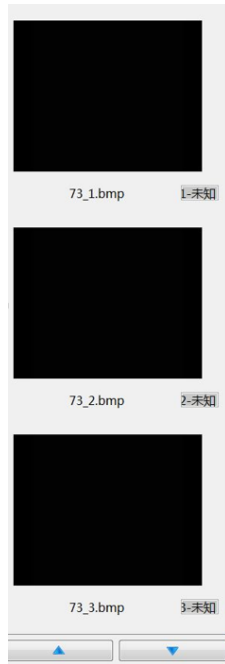




Fig. V-71 Column for Display of Saved Image

Inching Button : When the semi-automatic program is in operation, click  button to pause the CNC program after it reaches the point. Click  icon to view the position of each axis at the current point, or adjust the current axis parameters in the testing axis control area. After adjustment, click  to update the current information to the specified point (Fig. V-72)

button to pause the CNC program after it reaches the point. Click  icon to view the position of each axis at the current point, or adjust the current axis parameters in the testing axis control area. After adjustment, click  to update the current information to the specified point (Fig. V-72)

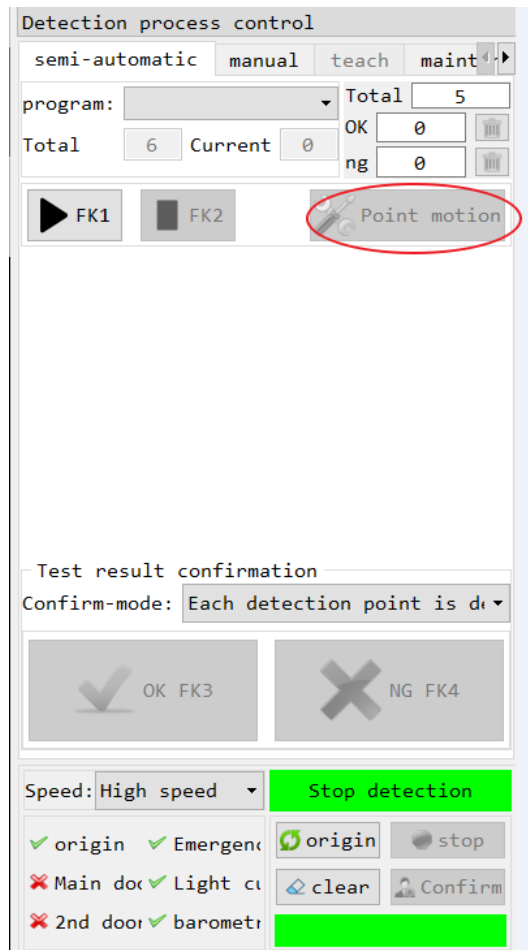





Fig. V-72 Effect of Inching Button

Stop Button : the user can click this button to stop at any time in the resetting process to stop resetting of the testing axis, click "reset" again to continue resetting.

Material Removal Button : when the testing axis stops during the testing, click the material removal button to enable the testing axis to the feeding position.

Reset Button : refers to the process in which the testing axis moves to the original point (also called null point) and the position pulse count is reset. Resetting aims to ensure motion accuracy of the equipment that uses the Application in the CNC testing, so frequent resetting is required for the equipment during operation (Fig. V-73).

The resetting situations of the testing equipment include:

- 1) After pressing the emergency stop switch once, all signals of the equipment will be reset, so resetting is required.
- 2) Resetting is recommended when the Application program is enabled for the first time.
- 3) After the user stops resetting in the resetting process.
- 4) When the position is found to deviate while the program is running during automatic process testing.
- 5) When a new program is created during the demonstration process.

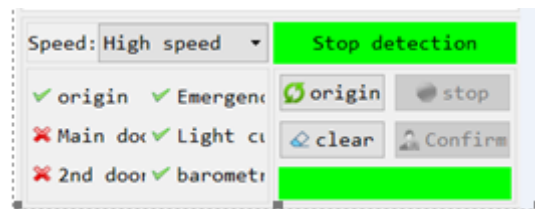




Fig. V-73 Reset State of Equipment

⚠️ Note: It is not recommended that the user place samples on the tooling table during resetting.

Statistics of tested samples: the Application can count the number of samples tested by the equipment when the user detects the samples by automatic testing and manual testing. See Fig. V-74 for statistical interface of the number of tested samples:

Total: the total number of samples tested since the use of the Equipment and the Application. It cannot be modified or reset.

Pass: the number of qualified samples tested when the Application is enabled. The user can click  to reset this value to 0.

Defect: the number of unqualified samples tested when the Application is enabled. The user can click  to reset this value to 0

13.4 Maintenance

Maintenance Process is that the user can perform all mechanical actions on the equipment when the equipment is not in the automatic testing process, the manual testing process or the demonstration process, e.g. independent inching of the testing axis (Fig. V-75)

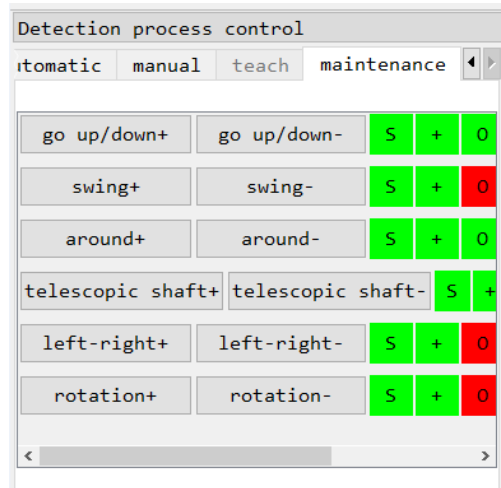


Fig. V-75 Testing Process Control

Axis Motion Control

Lift + Control Axis: rise

Lift + Control Axis: fall

Swing + Control Tray: tilt towards ray tube;

Swing - Control Tray: tilt towards detector;

Front/Rear + Control Axial: move towards cabin;

Front/Rear - Control Axial: move outside cabin;

Left/Right + Control Tray: close to light source;

Left/Right - Control Tray: close to detector;

Rotate + Control Tray: rotate clockwise;

Rotate - Control Tray: rotate counterclockwise;

Dynamic/Static State of Axis

S: indicates the current testing axis is static.

D: indicates the current testing axis is moving.

Positive Limit State

-: indicates the positive limit of the current axis is not triggered; axis reaches positive limit.

P+: indicates the current axis reaches the positive limit; and positive limit is triggered, the current axis cannot continue to move in the positive direction.

Negative Limit State

-: indicates the current axis does not reach the negative limit; and the negative limit is not triggered.

N-: indicates that current axis reaches negative limit, and the negative limit is triggered; the current axis cannot continue to move in the reverse direction.

Origin Point State

O: indicates that no resetting is performed for the current axis.

O: indicates the current axis has been reset. Resetting has been successfully performed.

14. Testing report

The Application provides the preparation and printing of testing report. After filling the relevant information in the report template in the testing report window, the user can print out the generated testing report or save it as a PDF file.

Enter the testing report template interface (Fig. V-76) via "Tool (T)" ->"Testing Report" in the menu bar to fill in the testing report.

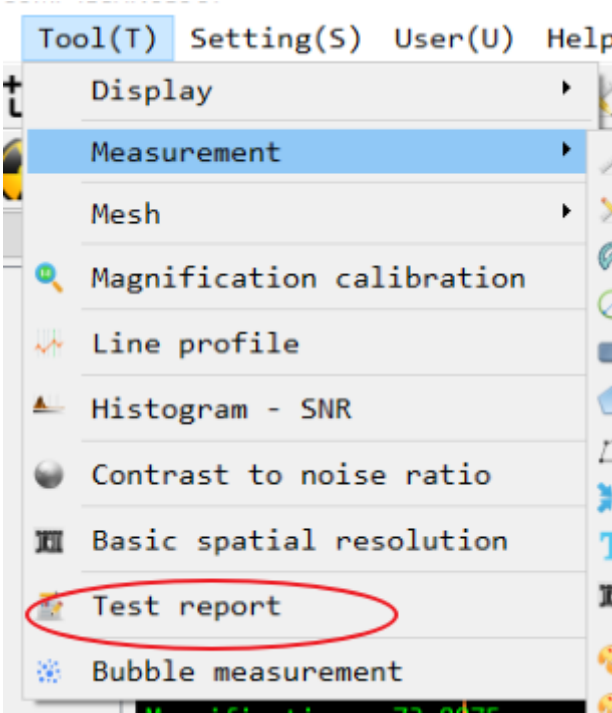


Fig. V-76 testing Report Entry

14.1 Testing report template

See Fig. V-77 for generation template of the testing report. The user can choose appropriate template from "Basic", "Concise", "Typical" and "Professional" templates for recording. Only "Basic" testing report template is described as follows.

ReportContainer

Basic Simple Standard Professional CustomizeA

Product name: Product class:

Report No: Serial number:

SPEC: Material:

Executive standard: Test Conditions:

Detection ratio: Acceptance level:

Quality grade: Weld length:

Welding process: Weld number:

Image-forming condition

XRay type: FPD type:

Focus size(mm): Pixel size(mm):

Focal length(mm): FPD SPEC:

Voltage(kV): Filter:

Current(mA): IQI:

Exposure time(s): DIQI:

Transillumination: Image quality(W):

Magnification: Image quality(D):

Image format: Gary value:

SNR:

Software processing method

Number of imaging

Total: Repair for 1st time: Repair for 2nd time: Repair for 3rd time:

Evaluation of the results

I (Piece): II (Piece): III (Piece): IV (Piece):

Defect details

Fig. V-77 Template of Basic Testing Report

Fill in the following information:

Information of company using the testing equipment

- (1) Name of the manufacturer: name of the casting manufacturer.
- (2) Alternative names of the manufacturer: other names of the casting manufacturer (English name, alternative name or abbreviation).
- (3) LOGO: logo of the casting manufacturer (it can be modified or deleted).

Sample information:

- (1) Name of testing sample: name of the casting for Non-Destructive Testing (NDT) in the testing report.
- (2) Number: the corresponding number of the casting to be tested.
- (3) Quantity: the total number of castings to be tested.
- (4) Sample Submission Time: submission time of the casting for testing
- (5) Manufacturing specifications: standards and specifications used in manufacturing of the casting.

Information of testing applicant's department:

- (1) Information of the applicant: information of the applicant who applied for testing of the casting (name, contact information, etc.).
- (2) Applicant's Department: name of applicant's department submitting the casting for testing.
- (3) NDT requirements: standards and requirements for NDT of castings (e.g. key testing position, sampling rate and evaluation standard).

NDT information:

- (1) NDT No.: the beginning number of NDT results - images.
- (2) NDT standards: evaluation standards adopted by NDT evaluation.
- (3) Number of images: the number of images acquired in the process of NDT, unit: sheet.
- (4) Saving format of images: image saving format, supporting JPEG (*.jpg), BMP (*.bmp), PNG (*.png), DCM format(also called industrial DICONDE format, *.dcm)).
- (5) Tube current: average ray tube current used in NDT, unit: mA.

(6) Tube Voltage: average ray tube voltage used in NDT, unit: kV.

(7) Transillumination Mode: the mode of imaging after the ray penetrating the workpiece during NDT, including single wall with single shadow, single wall with overlapping shadow, multiple wall with overlapping shadow.

Testing report information:

(1) Report No.: Testing Report No.

(2) Testing Time: actual start time of NDT.

(3) Testing Person: operator or image evaluator responsible for NDT equipment.

(4) Actual Testing Quantity: actual total quantity of products after NDT of equipment.

(5) Quantity of Qualified Products: quantity of qualified products after NDT evaluation.

(6) PassRate: rate of qualified products after NDT evaluation.

(7) Quantity of Defective Products: quantity of unqualified products after NDT evaluation.

(8) Defect Rate: reject rate of the products after NDT evaluation

(9) NDT Conclusion: quality conclusion of NDT products made by NDT personnel.

Review information:

(1) Reviewer: information of relevant personnel (e.g. the name, department and contact information) to review the testing report.

(2) Review Time: testing report review time.

Defect detail:

(1) Defective part: the part where the product is defective.

(2) Defect type: the type of defects found through inspection (bubble, porosity, looseness, slag inclusion, etc.).

(3) Defect Notes: description of other information of defect (e.g. the number of defective product, image number of defect found, and defect size).

Defect detail

Defect detail include defect position, defect type and notes. The user can add it manually in the testing report interface, or print out the testing report and complete it later.

In the testing report interface, the user can manually add the details of defects found in the NDT evaluation to the testing report. If the user does not add any Defect detail, in the generated testing report, the Application will provide a form up to 10 blank lines for Defect detail by default, which can be completed in writing by the user after printing. Right click the form column for Defect detail, pop up the right-click menu, choose to delete, modify and add.

Defect detail -add

Right click "**Add**" in menu to pop up the defect information editing window (Fig. V-78). The user can edit the defect information to be added in the defect information editing interface. The defect location refers to the spatial location of the defect found on the product; the defects are classified into porosity, bubble, looseness, slag inclusion and other defects; note information is edited and added by the user.

Defect detail - modify

Right click the defect information to be modified in the Defect detail area to pop up the right-click menu; click "Modify" to modify the defect information currently chosen. Modification of defect information is similar to addition thereof. Refer to "Defect detail - Add" for details.

Defect detail- delete

Right click the defect information to be deleted in the Defect detail area to pop up the right-click menu; click "**Delete**" to delete the defect information currently chosen. Dialog box will pop up from the Application to remind the user whether to continue deletion.

14.2 Preview of testing report

After filling in the testing report, the user can click button "**Preview**" to check correctness of information generated. See Fig. V-79 for example of the preview effect:

The screenshot shows a software window titled "ReportContainer" with a menu bar containing "Basic", "Simple", "Standard", "Professional", and "CustomizeA". The main area contains a form for generating a testing report. The form includes the following fields and controls:

- Manufacturer name:
- Manufacturer alias:
- UNICOMP LOGO:
- Sample name: Sample ID: Sample q:
- Sample SPEC: Send date:
- Inspect unit: Sender:
- Detection requirements:
- Report No: Inspection:
- Rec date: Rec:
- Voltage(kV): Current(mA): Trans:
- No of images: Detection No: Image format:
- Total: Qual: acc(%): Unqual: Fail(%):
- Inspector: Detection date:
- Conclusion:
- Defect details table:

part	type	notes

At the bottom of the form, there are three buttons: "generate PDF", "Print", and "preview".

Fig. V-79 Preview of Testing Report

14.3 Printing & saving (in PDF format) of testing report

(1) Print: After the user completes the testing report, the user can choose to click "**Print**" button in the testing report interface to directly connect the printer to print the report (printer must be connected to the computer and is enabled normally).

(2) Save as a pdf file: the user can also click the "**Generate PDF**" button to save the testing report as an unmodifiable report file in PDF format. When the file is saved as file in PDF format, the user shall specify the directory for saving the generated PDF file, and specify PDF file name of the testing report generated.

15. System setting

The user can preheat the ray, correct the detector and enable other settings via "**Settings (S)**" → "**System Setting...**" in the menu bar (Fig V-80).

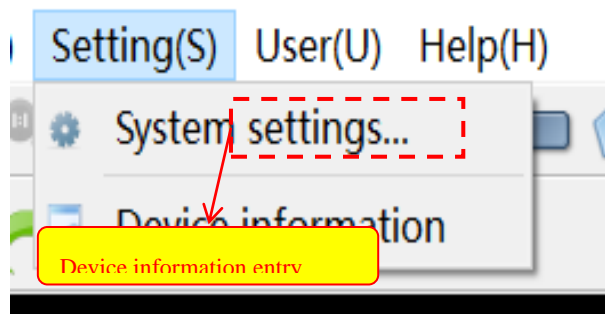


Fig. V-49 Device Component Information Entry

Fig. V-80 System Setting Entry

15.1 Ray tube setting

Ray tube setting provides functions such as management and setting of X-Ray tube and HV generator. Enter ray tube setting interface via "**Setting (S)**" → "**System Setting...**" → "**Ray Tube**" in the menu bar (Fig. V-81).

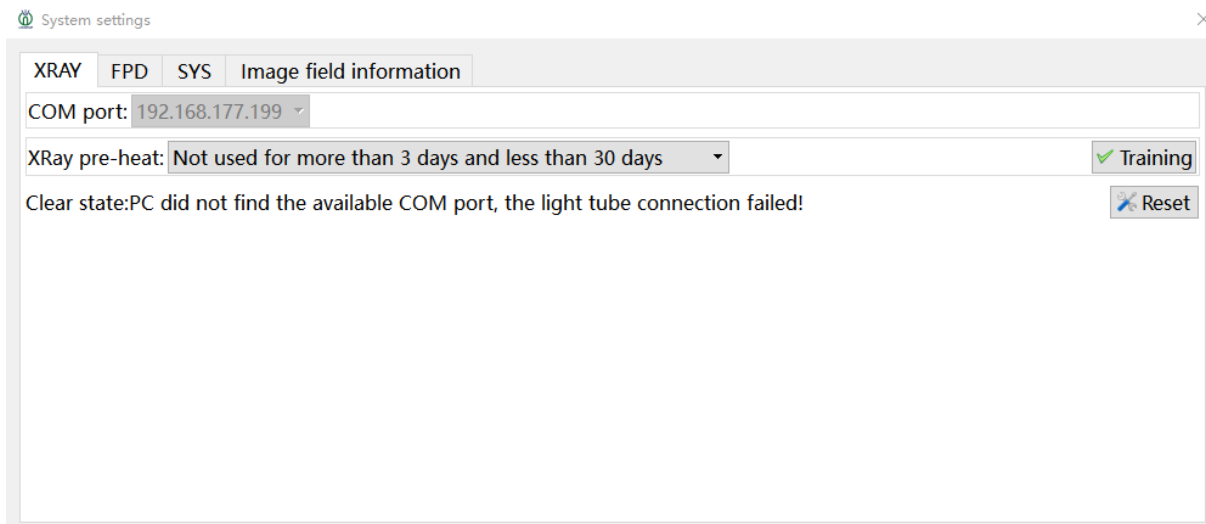


Fig. V-81 Ray Tube Setting



: If error occurs in ray tube, after elimination of error, the user can click "Reset" to remove the error and restore state of ray tube.



: Preheat the X-Ray ray tube (also called "Training"). When the X-Ray ray tube has not been used for a period of time, "preheating" is required for the ray tube before it is reused to ensure ray tube can be enabled normally. The Application provides preheating conditions in different preset conditions. Click the drop-down menu to switch.

15.2 Detector setting

The detector configuration provides the functions of managing and setting of X-Ray tube and HV generator. Enter the Setting-Detector interface via the "**Settings (S)**" → "**System Settings...**" → "**Detector**" in the menu bar (Fig. V-82).

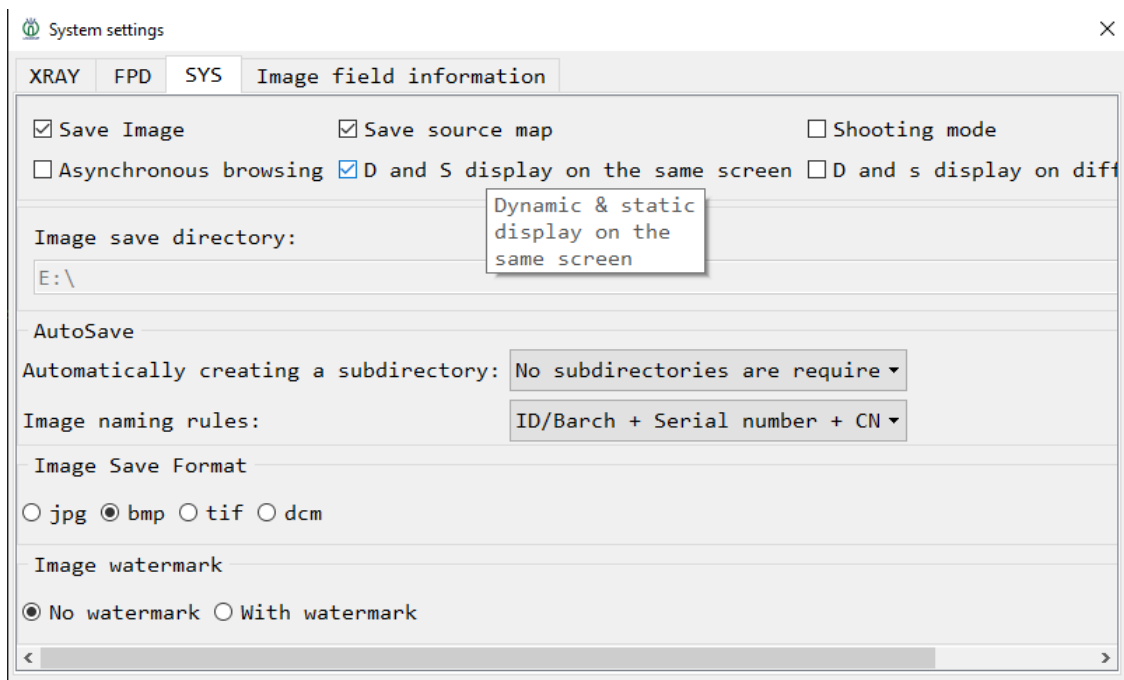


Fig. V-82 Detector Setting

15.2.1 Detector setting

Detector mode:

Choose the acquisition mode supported by the detector. The acquisition mode provided by different detectors are different, and the user can switch as required. **Before the acquisition mode of the detector is switched, the detector must stop acquisition !**

Acquisition frame rate:

The acquisition frame rate of the detector refers to the number of images that can be acquired by the detector per second in a fixed exposure time. Different detectors have different frame rate ranges, different detectors have different frame rate ranges of acquisition mode. **Before the acquisition frame rate of the detector is switched, the detector must stop acquisition !**

15.2.2 Detector correction

After the detector has been used for a period of time, the image data acquired by the detector may be affected by various factors, and the image quality will be gradually degraded. At this time, these effects can be corrected by detector correction (Fig. V-83). During the correction process, prompt text and progress will appear.

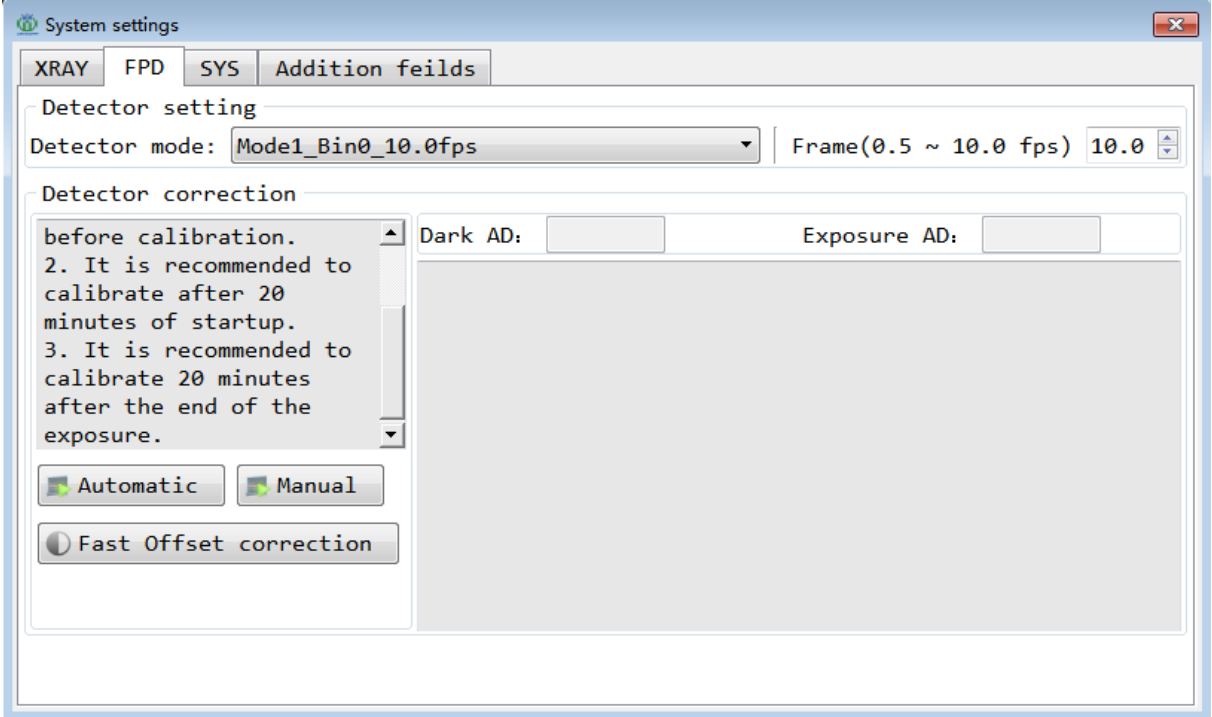


Fig. V-83 Correction

Quick offset correction

Because the "offset" correction template file has short timeliness, the "offset" correction template shall be updated and generated frequently. Quick offset correction function is designed based on such requirements. The user can apply " **Quick offset correction** " to update the "offset" correction template. After the "offset" correction process is completed, the Application will prompt in the information display box (Fig. V-83). After starting "offset" correction, the user can click "**Stop Correction**" button to stop correction.

One-click correction

When the Application connects the detector and X-Ray controller simultaneously, the user can use " **one-click correction**" function. During one-click correction, the user does not

need any other operation. The Application automatically completes a series of operations of "*Close X-Ray*" -> "*Execute Offset Correction*" -> "*Open X-Ray*" -> "*Execute Gain Correction*" -> "*Generate Correction File*". At any time, the user can click "Stop Correction" button to stop the correction and restore the detector state. When the Application obtains enough image data, the Application will automatically generate correction templates (including offset template, gain template and defect template). After successful one-click correction, the Application will automatically exit the correction process.

Manual correction

Manual Correction refers to the semi-automatic correction process that requires the user to manually enable and set up X-Ray parameter to coordinate with detector calibration during detector correction. Manual Correction is applicable when "one-click correction" cannot be performed successfully or the Application is not connected to control X-Ray.

The user clicks "manual correction" button to enter the manual correction process:

When the user is required to assist in controlling the X-Ray, the prompt dialog box will pop up from the Application to remind the user of the operation to be assisted.

The current correction prompt information is displayed in the right information prompt area (Fig. V-84). The user performs the corresponding operation according to the prompt of the Application. After the user performs the required operation, click "**Next**" button to inform the Application to perform the next correction operation.

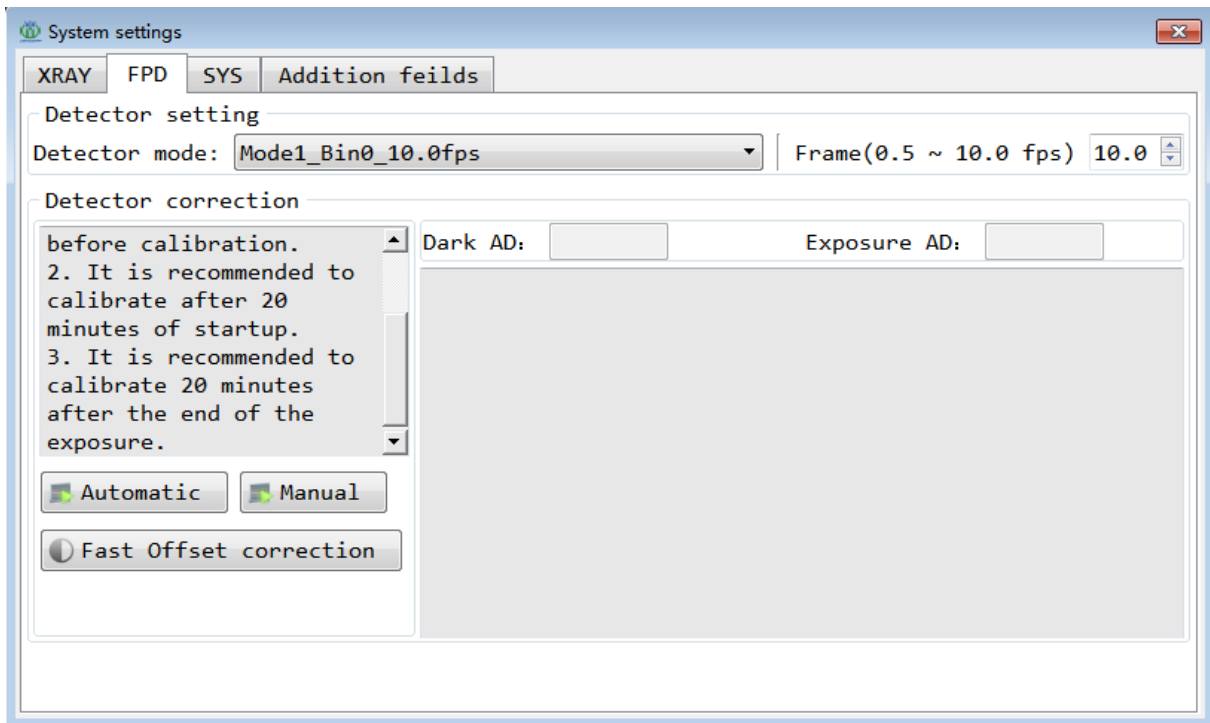


Fig. V-84 Manual Correction

15.3 System settings

Key parameters used in automatic/manual testing process can be modified and viewed in system settings. All settings here are saved, and all settings of the system remain valid when the Application is enabled next time.

In the system settings, the user can modify and save image, save source image, enable review mode and photographing mode, dynamic/static switching, image saving path, image naming mode, image saving format and other necessary information settings in automatic testing process (CNC). Enter the system setting interface via "**Settings (S)**" → "**Configuration...**" → "**System**" in the menu bar (Fig. V-85).

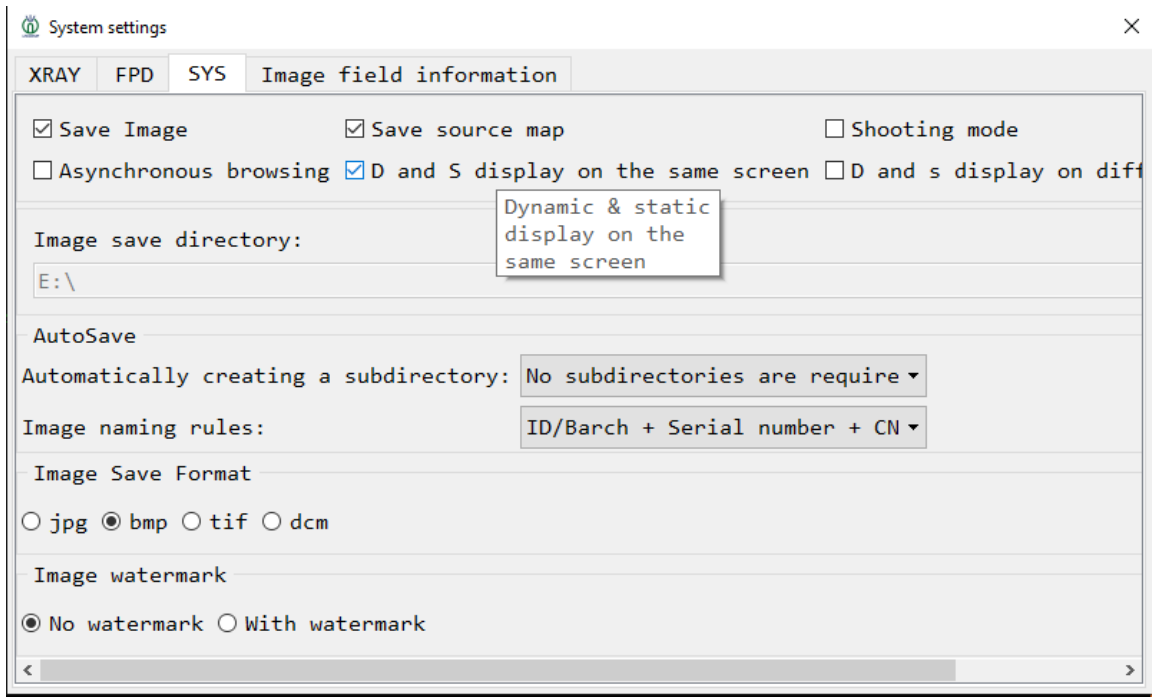


Fig. V-85 System Settings

15.3.1 Save image

After "save image" is chosen and after the image reaches the testing position in the testing process, the Application will automatically save the perspective image of the testing result to the specified top-level directory according to the specified naming rules and the specified image format.

If "save image" is not chosen, then the image will not be automatically saved to the local disk after the image reaches the testing position in the testing process.

15.3.2 Dynamic/static switching

Dynamic/Static Switching refers to the superposition state in the operator combination that is automatically processed by the Application according to the motion state of the device testing axis in the testing process.

After "Dynamic/Static Switching" is chosen, a small window appears at the lower right bottom of the main window to display the image of the testing axis in motion. The image is displayed in the main window when the motion stops. In the motion process of the testing axis, the Application automatically processes the superposition of operator group in image processing as 1. When all testing axes are static, the Application uses the superposition operator in the operator combination, and the processed image is displayed in the main window.

15.3.3 Photographing mode

After the "shooting mode" is chosen, the setting area is expanded in the toolbar (Fig. V-86), the user can set up the preset exposure time, which will be closed at the fixed time after the ray is enabled. Ray excitation caused by "Image (P)" → "Acquisition" in the menu bar or the acquisition tool.....in the toolbar will not turn off the ray at the fixed time.

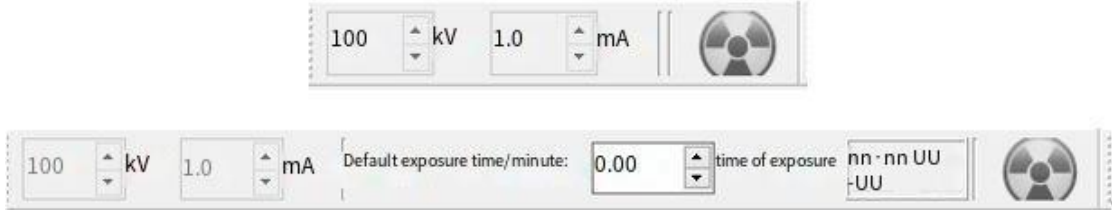



Fig. V-86 Disable Shooting Mode (upper), Enable Shooting Mode (lower)

15.3.4 Review mode

Choose "review mode" here, another image window will be displayed at the lower right corner of the software to display images acquired in real time. Double click this window to close the review mode. If the user has opened the image preview window on the left, double-click the image preview area to enable the review mode. The image area in the original main window can be used to load the OK image of the tested piece for comparison and determination.

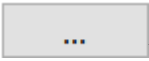
If "save image" is chosen by the user simultaneously, the image preview area on the left side will be used to display the image acquired in the point when CNC is running. At this time, the user can click "view (V)" → "specify image file" in the menu bar to open the second image preview area for recording the loaded image. See the enabling effect in Fig. V-87.

 Note: After the review mode and the dynamic/static switching mode are enabled simultaneously, when the image is acquired, the acquired image is not displayed in the main window and can be restored until the review mode is disabled!

15.3.5 Save source image

After "save source image" is chosen, each time when the device executes CNC, a 16-bit TiF format image will be saved in RawImage folder generated under D disk (or C disk if no D disk).

15.3.6 Image storage directory

Click  to open the file manager, choose the top-level directory for image storage during CNC operation.

15.3.7 Automatic storage setting

Automatic creation of subdirectory: pull down and switch to choose to create a subdirectory under the top-level directory. The naming mode includes date and ID/batch.

Image naming mode: pull down and switch to choose the name of image saved in the top-level directory/ subdirectory. The naming modes include user-defined, ID/ batch + testing quantity + CNC point, time, ID/ batch + CNC point.

When ID/batch is chosen, the user must enter information at ID/batch in toolbar; otherwise no subdirectories will be created or images will be generated without ID/ batch information.

15.3.8 Image storage format

The Application supports four image storage formats: JPG, BMP, TIFF and DCM.

15.3.9 Image watermark

Choose "**watermark**", the system will store the image with watermark information, choose the watermark information to be added by switching to "**image field information**" in the system settings (see 15.4 Image Field information).

15.4 Image field information

Image field information (including "enter field" and "generate field") is used for saving additional watermark information in the case of image storage(Fig. V-88). After chosen, information will appear in the left top corner of the image area of software.

Enter field: the user shall enter the contents. Optional information includes unit name, workpiece No., testing part No., radiographic specification, testing personnel, customer name, material, weight, manufacturer, testing department, mono-wire image quality indicator and double-wire image quality indicator

Generate field: optional equipment information is automatically acquired and generated by the software, including the date, actual voltage, frame rate, image gray scale ratio, cycle time, actual current, image gray scale, and magnification.

16 Equipment information

Equipment information allows the user to view detailed parameters and state information of the core components connected to the Application. Enter the equipment information view interface via "Settings (S)" → "Equipment Information" in the menu bar

The user can view the detailed parameter information and state information of the core components connected to the Application (Fig. V-90). Equipment Information includes information of the X-Ray generator (cumulative X-Ray excitation duration, last connection date, etc.), detector information (cumulative use date, last connection date, etc.), and information of other external components that may be connected.

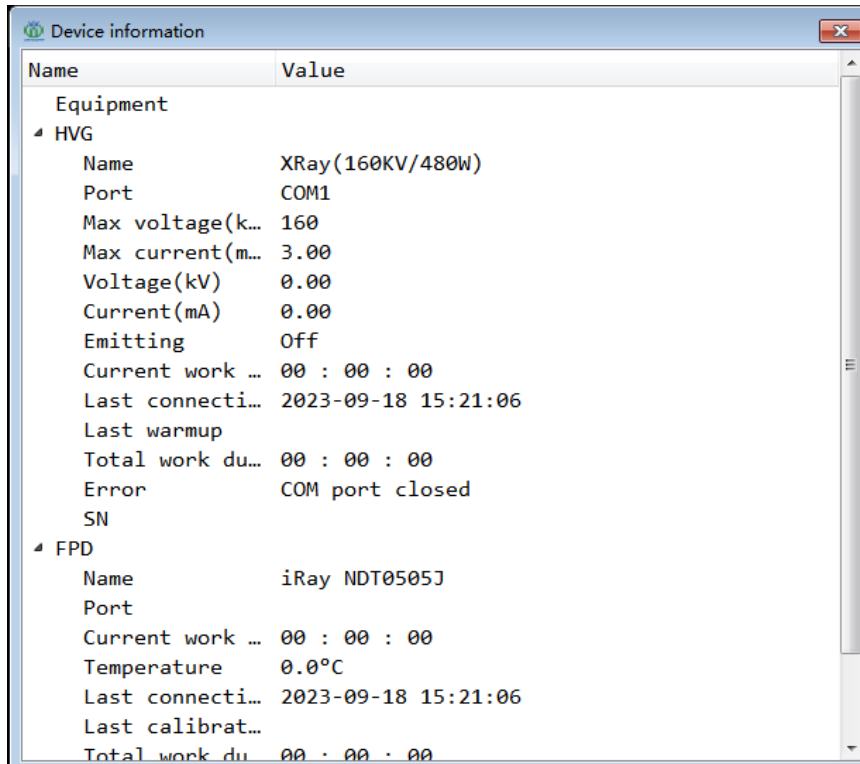


Fig. V-90 Equipment Information

17 User management

The Application provides the function of user permission control. Log in to verify user name and password to enable the Application. Users with different permissions may be limited to enable some functions. Enter the user management page via "User (U)" ->"User Management..."entry in the menu bar

17.1 Permission level

Operator: user at operator permission level can view information and change password. The user at operator permission level can only view his/her own user information, e.g. user name, user level and last login time.

Administrator: user at administrator permission level has more functions than user at operator permission level, including add user, delete user, view all user information and change password.

See Fig. V-92 for management interfaces of users with different permissions:

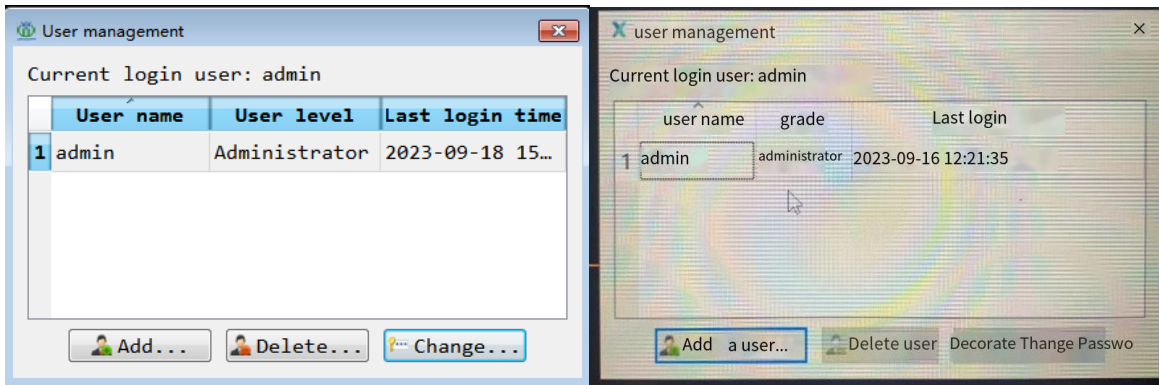


Fig. V-92 User Management

17.2 Add user

Administrator-level user can add new user, click "Add User" button to enter "Add User" interface (Fig. V-93). Enter new user name, passwords and confirm password, click "OK" to add a new user. Only one administrator is defaulted in the system, user added in this way has operator permission.

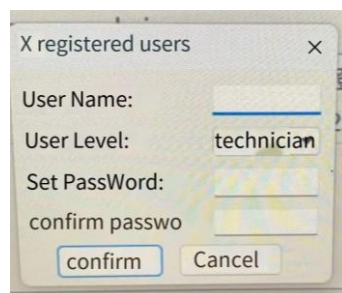


Fig. V-93 Add New User

17.3 Delete user

Choose the user item to be deleted in the user list, click "Delete User", the warning dialog box pops up from the Application for reconfirmation of deletion. Once confirmed, all information of the chosen user can be deleted successfully.

Password change is a common function to users at any level. Steps to change password are as follows:

- 1) Click the currently logged-in user in the list, and the "Change Password" button becomes clickable.

2) Click "Change Password" button to enter the password change interface (Fig. V-94).

3) Enter a new passwords in the edit box after clicking "Set Password" and "Confirm Password", click to change the password.

4) If the user enters different passwords twice, the dialog box will pop up from the Application to prompt.

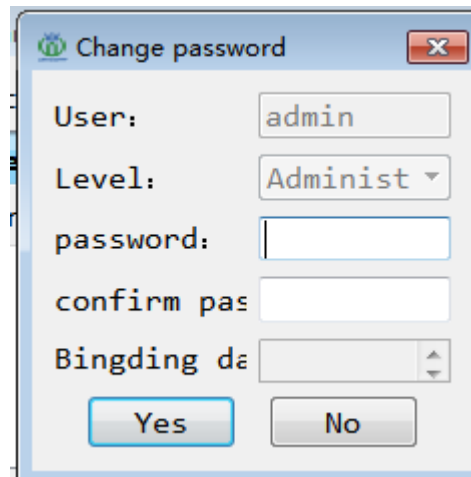


Fig. V-94 Change Password

17.5 Log off

Click "User (U)" ->"Log off" (Fig. V-95) in the menu bar to log off the current user (without exiting the program) and directly switch to other user login.

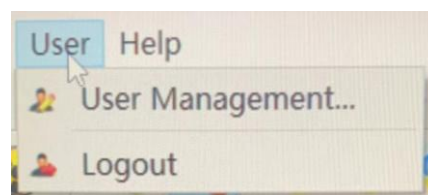


Fig. V-95 Logout Entry

18 Help

Click "Help (H)" ->"About" in the menu bar to view information of the Application (Fig. V-96)

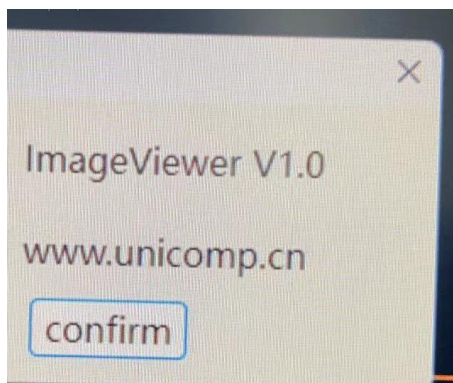


Fig. V-96 About

19 View menu

The "View (V)" menu in the menu bar control to display and hide different interfaces. The user can customize to display or hide X-Ray control interface of ray tube, image processing interface, testing process control interface, standard toolbar, acquisition toolbar, display & zoom toolbar, measurement toolbar, state bar, etc. Click the corresponding view menu to display or hide the corresponding interface. If the mark is displayed in front of the view menu, it indicates the interface has been displayed in the main interface; otherwise, it indicates the interface has been hidden by the user and does not appear in the main interface.

See Fig. V-97:

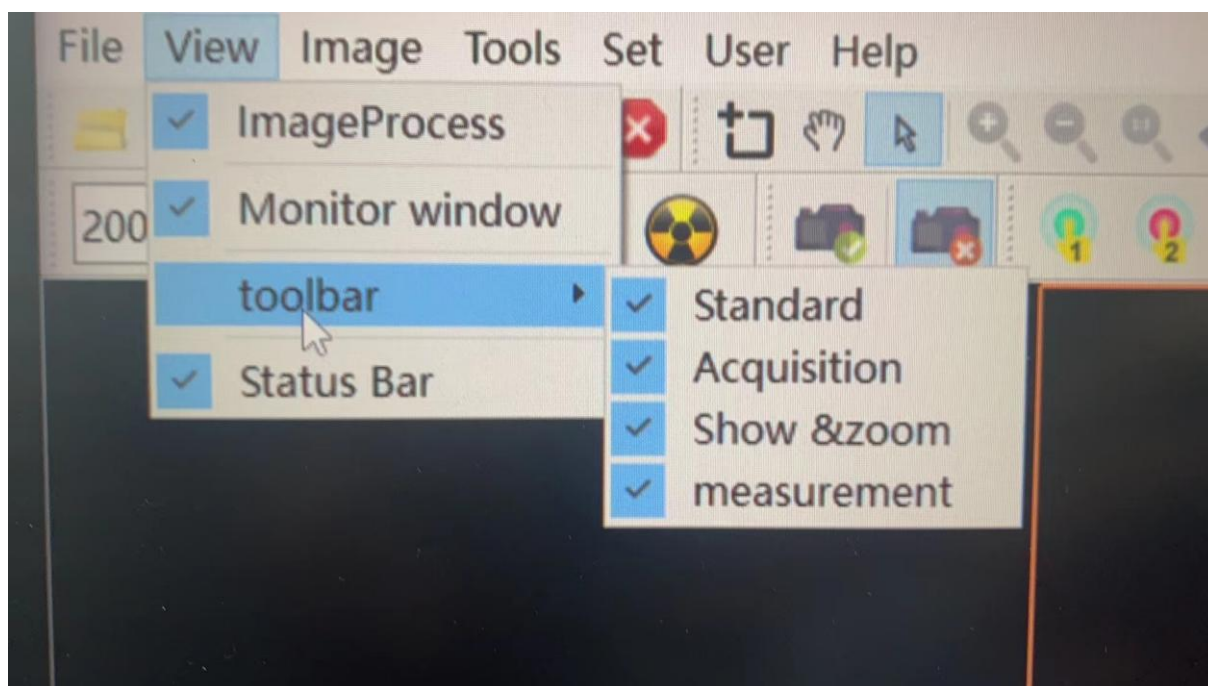


Fig. V-97 View Menu

20 File menu

The Application "File (F)" menu provides function options: open image, save image, save as, save window image, print image, exit Application. See Fig. V- 98 for File Menu.

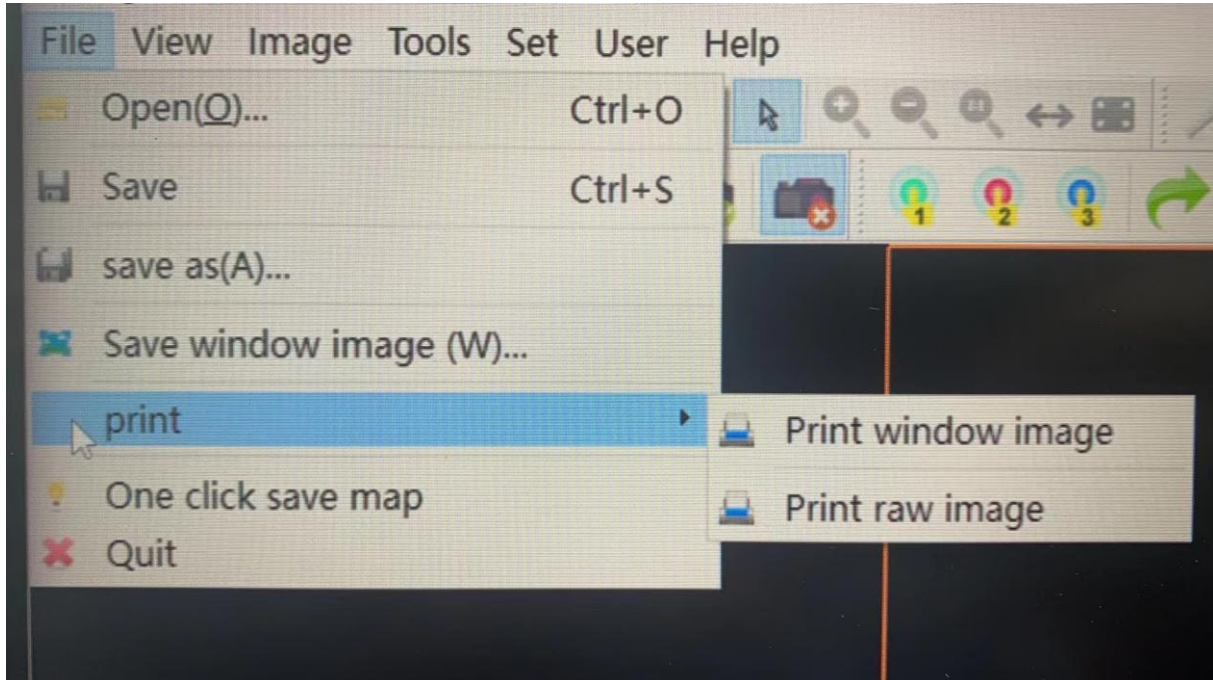


Fig. V-98 File Menu

20.1 Open image

Click "File (F)" -> "Open (O)..." in the menu bar of the file menu or click



icon.in the file toolbar to pop up Open File window. The Application only supports opening the image files in the formats of JPG, BMP, TIFF and DCM, so only the files with the above four suffixes are displayed in the Open Image dialog box. The image chosen to open will be loaded into the image display area.

20.2 Save image

Click "File (F)" -> "Save (S)..." in the menu bar or click




icon in the file toolbar to save image. As the image saving function is to overwrite and save new image according to the "open image" path and original image name, so the warning dialog box will pop up

sometimes for reconfirmation of the user's operation. Click "OK" to save the image displayed in the current Application to the local disk according to the name and path of the original image.


20.3 Save image as



Click "File (F)" -> "Save as (A)..." in the menu bar or click  icon. in the file toolbar to pop up the Open File window. Choose the directory for image to be saved → enter the image file name → choose the format for image to be saved → click "Save (S)" button to save image.

20.4 Save window image



Click "File (F)" ->"Save Window Image(W)..."in the menu bar or click  icon in the file toolbar to pop up "Open File" window. Choose the directory for image to be saved →enter the image file name → choose the format for image to be saved → click button to save all the contents displayed in the main image window of the Application to the local disk as image files.

Click "file (F)" ->"save window image(W).

20.5 Print image

Print Image function include "Print Original Image" and "Print Window Image" according to different image sources. Difference between Original Image and Window Image is shown in Fig. V-99.

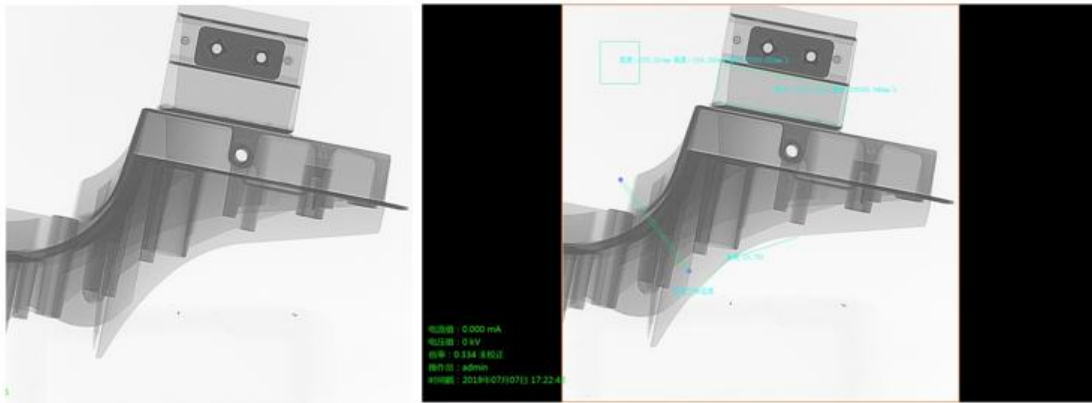


Fig. V-99 Original Image (L), Window Image (R)


1) Print original image

Print Original Image refers to printing of original image displayed in the main image window of the Application, excluding the text marks and other added marks displayed on the interface.

2) Print window image

Print Window Image refers to printing of original image displayed in the main image window of the Application, including all contents displayed, e.g. text marks and other added marks on the interface.

21 Common trouble-shooting of the Application

Q1:  displayed in the lower right corner of the Application indicates X-Ray control toolbar is grayed out and cannot be clicked, and X-Ray system fails to communicate.

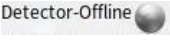
A1: Enable the software and reconnect after checking and trouble-shooting of the following items:

- 1) Check whether the power supply of HV generator is enabled;
- 2) Check whether the communication cable (network cable or serial interface cable) is connected properly;

3) When the power is "on" and the network cable is connected normally, try to turn off the power supply of HV generator completely for half an hour before powering on again.

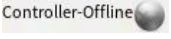
4) Check whether the serial interface or network interface connected to the communication line is correct;

5) If network cable communication is adopted, please confirm whether IP address has been modified.

Q2:  in the lower right corner of the Application indicates the detector fails in connection or communication.

A2: Re-enable the software after checking and trouble-shooting of the following items:

- 1) Whether the detector is connected to the power supply;
- 2) Whether the network cable for detector is connected properly.
- 3) Whether IP address of PC network port connected to detector is set up correctly.

Q-3:  displayed in the lower right corner of the Application indicates communication of PLC controller fails.

A-3: Re-enable the software after checking and trouble-shooting of the following items:

- 1) Whether PLC controller is power on.
- 2) Whether the communication line is connected normally and whether the connection port is connected incorrectly.
- 3) Whether IP address of communication network card between PC and PLC is modified.

Q-4: The prompt "equipment is not reset" is always displayed when the automatic process or manual testing is enabled.

A-4: Choose "Reset" in the testing process control, try again after resetting.

Chapter 4 Diagnosis and Trouble-shooting

4.1 Analysis of common faults and trouble-shooting methods

Description of fault	Cause of fault	Trouble-shooting Methods
Motor of the operating handle is disabled.	<ol style="list-style-type: none"> 1. Poor connection or disconnection of the connecting line or the control line of the motor; 2. Contactor does not close after the button is pressed; 3. Main circuit fuses or the control circuit is fused; 4. Thermal relay acts and break contact is separated; 5. Driver failure or damage occurs; 6. Motor is damaged; 	<ol style="list-style-type: none"> 1. Reconnect the stepping motor or the control line according to inspection result; 2. Check whether the contactor coil is damaged; replace the contactor; 3. Replace fuse of the main/control circuit; 4. Check whether the rated value setting of the thermal relay is too small; adjust the rated parameters of the thermal relay; 5. Check whether the stepping driver has failure or damage; adjust or replace the driver; 6. Replace the motor.
The lead door cannot be closed	<ol style="list-style-type: none"> 1. Whether the emergency stop button in the lead chamber is pressed; 2. Signal source for the light curtain testing is shielded; 3. Motor wire is loose or disconnected; 4. Motor is damaged; 5. The limit switch of the lead door is damaged. 	<ol style="list-style-type: none"> 1. Check whether the emergency stop button in the lead chamber is pressed, and reset the emergency stop button in the lead chamber; 2. Check whether the signal source is shielded by object within the testing range of the light curtain, if it is shielded, remove the object; 3. Check whether the electrical wiring is wrong; 4. Check whether the motor is damaged, and replace the motor if it is damaged; 5. Reconnect or replace the limit switch.
Fail to enable the ray	<ol style="list-style-type: none"> 1. Whether the emergency stop button in the lead chamber is pressed; 2. The lead door is not closed properly; 3. Signal source for light curtain testing is shielded; 4. Motor cable for the lead door is poor connected or damaged; 5. The limit switch is poor connected or damaged. 	<ol style="list-style-type: none"> 1. Reset the emergency stop button in the lead chamber; 2. Close the lead door again; 3. Remove the shelter; 4. Reconnect the motor cable or replace motor; 5. Reconnect or replace the limit switch.
Overcurrent protection	<ol style="list-style-type: none"> 1. Generator failure; 2. Ray tube breakdown. 	<ol style="list-style-type: none"> 1. Check and repair the generator; 2. Replace the ray tube.
Mechanical movement is over limit	<ol style="list-style-type: none"> 1. Limit switch is displaced or loose; 2. Limit switch is damaged. 	<ol style="list-style-type: none"> 1. Correct the position of limit switch; 2. Replace with new limit switch.
Phase sequence protection	<ol style="list-style-type: none"> 1. Phase sequence of 3-phase power supply is wrong; 2. Phase sequence protector is damaged; 	<ol style="list-style-type: none"> 1. Adjust the power input phase sequence of 3-phase power supply;

	3. Voltage is too high or too low.	2. Replace the phase sequence protector; 3. Check whether the power supply voltage is normal.
--	------------------------------------	--

Chapter 5 Maintenance

5.1 Maintenance

(1) Maintenance of this equipment mainly includes electrical maintenance and mechanical maintenance.

(2) Electrical maintenance is mainly applied for all electrical parts related to this equipment to ensure normal operation and prolong the service life of all electrical appliances. The mechanical maintenance includes lubrication and cleaning of this equipment.

(3) Equipment shall be maintained according to Appendix II *Maintenance List of Offline Testing Equipment for X-Ray Real-time Imaging*.

5.2 Description of warranty period

The following situations are not covered in the warranty:

(1) Unauthorized removal of mechanical parts and replacement of electrical components (tearing off the anti-removal signs);

(2) Natural disasters, e.g. earthquakes, floods and other factors of force majeure;

(3) Water ingress and dampness of electrical components;

(4) Continuous operation with obvious noise, vibration, etc. without inspection.

5.3 Cleaning and proposal

(1) At the end of life cycle of equipment, the X-Ray testing equipment shall be not endanger to the user and environment after proper treatment.

(2) Coolant used in the equipment operation system may cause damage to environment, so the waste liquid must be properly disposed according to the measures specified in relevant laws and regulations.

(3) For disposal of oil and lipid substances in equipment, greasy cloth and oily water shall not be discharged together with industrial and domestic wastewater.

(4) X-Ray tube contain the beryllium window and the shielding lead substance harmful to environment. All components containing these two substances must be disposed of in a manner beneficial to the environment.

(5) If required by the user, Unicomp Technology will provide support for appropriate disposal of the above substances. Please send these substances to a qualified company for waste treatment, so that recyclable substances can enter the recycling cycle to reduce deterioration of the environment.

Contact us:

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Website: <http://www.unicomp.cn>

Pay attention to ionizing radiation!

Appendix (I):

Checklist of Offline Testing Equipment for X-Ray Real-Time Imaging		
Inspection before equipment is enabled (the following items 1-14 must be inspected after power-off)		
S/N	Inspection Items	Remarks
1	Check null line, live line, earthing wire and cable of main power supply are in good conditions, without leakage of electricity;	
2	Check the fixed bolt is not loose, otherwise, tighten it immediately;	
3	Check no deformed surface of the whole mechanical mechanism;	
4	Check no oil leakage in the engine gearbox and HV generator;	
5	Check no leakage in water pipe and air pipe of equipment;	
6	Check no obstacle is in linear guide rail, arc rack and transmission part; remove any obstacle immediately to avoid damage to device;	
7	Check no bearing connection is disaligned or loose, otherwise, adjust it with the regulating screw;	
8	Check the lubrication of linear guide rail, ball screw, gear, rack and bearing in good condition;	
9	Check no electric appliance is defective or short-circuited, any problem must be handled properly by professionals;	
10	Check whether the operation buttons of the equipment are flexible;	
11	All handles for controllers (switches) shall be in zero position;	
12	Check whether there is poor contact or short circuit in electrical appliances;	
13	Check whether the lead chamber, console and electrical control cabinet are clean, if not, clean them immediately to avoid abnormality or damage to equipment;	
14	Confirm specification of power supply connected to equipment comply with provisions in "Technical Parameters".	
Inspection after power-on of equipment		
S/N	Inspection Items	Remarks
1	After power-on, check to ensure voltage is normal;	
2	Check leakage of electricity of all motors;	
3	Check the shutdown time of the ray source (preheating is required after shutdown for over 3 days);	
4	Perform a test run to ensure good and reliable interlocking function of the electrical device of each limiting device for the lead door, C-arm lifting, C-arm swing, left/right of ray source, left/right of imager, trolley access, HV interlocking; ensure stable and reliable action of the equipment;	
5	Pay attention to operation of each mechanism from time to time during equipment operation, and check to ensure no abnormal noise and odor;	
6	Pay attention to the operating conditions of each safety device from time to time;	
7	During the interval between operations, the user shall check whether	

	the heating or temperature rise has exceeded the typical value on the bearing and motor body, reducer and transmission parts of each mechanism;	
8	After work, the user shall cut off the power supply of equipment, clean the equipment, and lock the lead door;	
9	Remove various off-site articles left after work;	
Note: Please check the equipment as required and fill in the actual inspection results in the remark column to ensure normal operation of equipment.		


Appendix (II):

Maintenance List of Offline Testing Equipment for X-Ray Real-time Imaging		
S/N	Maintenance and inspection items	Remarks
1	Check the lubrication of the gear and rack every 7 working days, and determine whether to add gear lubricating grease as appropriate;	
2	Check the running state of the linear slide and ball screw regularly every 7 working days, and clean them or inject lubricating oil; (lubricating oil (Mobil No. 2) for guide rail is used for the linear slider)	
3	Clear the radiator every 7 working days;	
4	Clear and check the cylinder parts every 7 working days;	
5	Clear the entire equipment every 30 working days;	
6	Check all bearings and inject the lubricating oil every 90 working days;	
7	Clean the cable socket of HV cable and replace silicone grease every 90 working days;	
8	Clear the storage disk space of IPC every 90 working days to ensure enough space available;	
Note: Maintain the equipment as required to ensure normal operation and extend the service life of the equipment.		


Note:


- 1. Lubrication is to add a layer of lubricating oil film to the working surface of the component to reduce the friction and wear of component in the working process and extend the service life.**
- 2. When the lubricating grease is injected to the equipment, the lubricating grease must be kept clean. Do not use the lubricating grease containing impurities or deteriorated grease. Different types of lubricating greases shall not be mixed. The lubricating grease shall be injected in an appropriate amount.**
- 3. The gear and rack are important and easily worn parts, please lubricate and maintain the gear and rack regularly in every working day.**
- 4. It is better to inject the lubricating grease after the work shift. At this time, the gear is hot and static, and the lubricating oil of gear can be completely dispersed to form a durable oil film.**




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