OPERATING INSTRUCTIONS
WINDOWS
X-RAY TOOLING & INSPECTION

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Multiline Technology, Inc.
400 Broadhallow Road
Farmingdale, NY 11735
U.S.A.
Phone: (631) 249-8300
Fax: (631) 752-7948

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X-RAY TOOLING AND INSPECTION

TECHNICAL SECTION FOR SUPERVISORS AND ENGINEERS

INTRODUCTION

The following is the instructions for the Windows™ Operating System for the Optiline X-Ray Tooling and Inspection (XRT). The Optiline XRT is an X Ray Tooling and Inspection, pre-drill system that uses a combination of x-ray and computer technology to analyze target registration errors within the layers of laminated multilayer panels.

An x-ray vision system is used to locate two target stacks within the multilayer panel. The vision system is interfaced to a computer that measures the distance between the centers of both stacks and moves the panel with an X-Y-Theta deck so that any error between the nominal and measured target distance is evenly split. The deck positions the panel under the drills so that a "best fit" condition is found. Best fit positioning means the holes that will be subsequently drilled by the NC Drilling Machine will yield the largest possible annular ring per layer across the panel.

After the tooling holes are drilled into the laminated panel in the optimum position, these panels can be stacked and drilled without the need for additional drill offsets. Since each panel has its own tooling corrections in relation to its internal registration, even two panels which differ in internal registration can be stacked and drilled.

The first section covers the initialization of the software and how to go through a job setup. The second section is a more detailed explanation of the features of the operating software and how to navigate through these features. It includes detailed explanations of the Toolbars with appropriate graphics. It is intended for the Supervisor or Engineers of the area.

GENERAL SYSTEM DESCRIPTION

The controls and image monitors are located in the access lift door in the front of the system. The two black and white monitors display the x-ray image of the targets as seen by the cameras. They are labeled CAMERA #1, for the left side of the panel, and CAMERA #2 for the right side. Adjacent to each monitor are multi-turn potentiometers for adjusting the power supplied to each of the x-ray sources in kilo-volts and milliamps, and these values are displayed in digital read-out devices next to the potentiometers.

On the left side of the door is the key switch for turning the system on, and an x-ray On/Off push button switch. On the right side of the door is a switch for turning the spindles on and off, a resettable cycle counter, and an emergency off push button switch.

A series of indicator lamps indicating power on, EMO activated, interlock open, x-ray on, and hard limit reached are also located in this door.

When the lift door is in the closed position, a narrow opening is provided for the manual loading and unloading of panels. Panels are simply slid from the loading table into the cabinet. Some systems may be supplied with an optional automatic unloading assembly.

The System Monitor with menu screens for Set-Up and a graphical display of the SPC data for each panel processed is located on the left side with the keyboard.

ELECTRICAL ENCLOSURE

There are two electrical enclosures mounted on the left and right sides of the frame. Both have EMO switches on the top surface and the system printer is installed on the left enclosure. The right side electrical box contains the main breaker, relays, PLC, and the ∀5, ∀12, and 24 volts power supplies. The main machine power, via a line conditioner, enters the machine on this side. The left side electrical box contains the video cards, current regulators, and the 15 and 28 volts power supplies. The front skin houses the system computer and also push button switches for start and reset.

X RAY CABINET

The x-ray cabinet can be accessed for service and maintenance by raising the hinged lift door. The door has a special leaded glass window so that the operation of the system can be observed from the outside.
Mounted to bearing ways on the left and right are the Tooling Modules. Each module contains the drill mechanism, the x-ray source and the CCD x-ray camera. Surrounding the x-ray source port is an x-ray chain guard, with a special spiral design, to provide local x ray containment.

The tooling modules move left and right to accommodate the different panel sizes. A stepper motor moves the module and glass scales provide feedback as to the drill position. The drill motors are air powered and move in the Z axis by stepper motors. Feed rate is preprogrammed depending on panel thickness. An air actuated clamp surrounds the drill guide bushing during the drill cycle. It releases during the positioning sequence and clamps the panel during the drilling. The drill guide bushing is replaceable and is sized for the hole size to be drilled. The clamp is designed so that chips generated by the drills are collected and carried out of the enclosure by means of a vacuum system attached at the rear of the cabinet.

In the center of the material platform is a vacuum chuck (platen) that attaches to the bottom of the panel. This chuck is fixed to the X-Y-Theta deck below the cabinet base. It is the deck and vacuum chuck, directed by the computer, which positions the panel for drilling.

On the top of the cabinet is an indicator light to indicate that x rays are on. At the rear of the cabinet are mounted a Filter/Regulator/Lubricator for the various air cylinders within the cabinet and a Regulator/Lubricator to supply lubricated air to the drill spindle motors. The lubrication viscosity is different for drill motor spindles than the air cylinders. There is also a port in the center for the attachment of shop vacuum to carry away the debris generated by the drilling operation.

INSTALLATION

Remove packing material from the exterior and unbolt the unit from the shipping skids. Follow any instructions for unpacking that may be indicated on the equipment. Move the equipment to the operating site. When using a forklift, be sure to lift on the tubular frame, front and rear. Do not lift from the side.

The incoming power line must provide spike free voltage with voltage fluctuation not exceeding +/- 5%. A dedicated power line is required on the XRT. A local earth ground is required, wired to local electrical codes **. The earth ground is wired to the ground connection on the rear side of the XRT's electrical enclosure, however, do not power up the system until a Multiline Technical Service Technician is present.

Other Service requirements, vacuum, air, and service space required around the machine are specified on the X-Ray Tooling & Inspection system Footprint drawing. There are two oilers; one for the pneumatic valves and one for the air motors. Recommended: Mobil DTE Oil Light (ESSO VG32) for pneumatics and Mobil Whiterex 425 (White Mineral Oil) for drill spindles. All services should be available at the time of installation by Multiline.

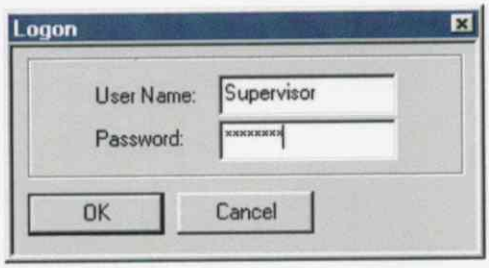
Drill bits are industry standard PCB drill, measuring 1.5 inches (38mm) long, 0.125 inches (3.18 mm) diameter shank, 165 degree tip, solid carbide. Six are provided. The machine also includes drill collets (6) and a gauge to check the drill bit height. A torque wrench to assist in replacing drill bits, and spindle oil are also provided along with some indicator bulbs.

Each machine is supplied with two copies of the manual and schematics. The copy of Windows™ operating system CD's are also supplied with the machine.

*** Note: Failure to install a local earth ground may result in damage to the XRT. Such damage may not be covered under the warranty.*

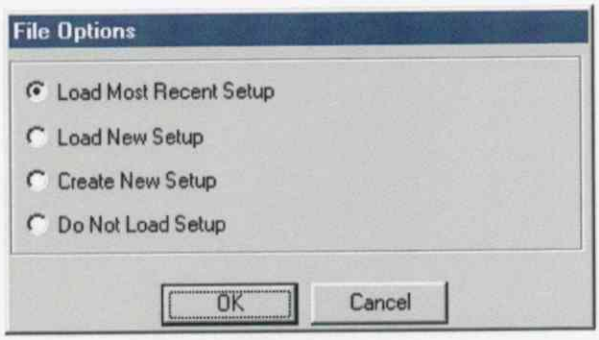
OPERATION

At the control panel, turn the key switch clockwise to the START position. It is spring loaded and will return to the ON position. The system will boot up and initialize the software. A prompt will appear for the user to logon to the system. The operator has to logon to the Windows system first and this will launch the Optiline application. The operator has to then logon on the Optiline application.



There is a 20 minute warm up for the x-ray system. The machine will go into this mode if the x rays have been left off for more than an hour. A banner will appear on the screen reporting that the machine is in warm up mode. There is a timer on this banner that reports the time left for the warm up to be completed. During the warm up mode the operator can enter all the setup data but has to wait until the warm up is complete to process reference targets.

After the operator has properly logged on to the system a dialog box titled File Options will start the setup process.



"Load Most Recent Setup" will load the parameters of the last job processed into the setup. This is typically used if the operator wants to continue the previous job.

"Load New Setup" allows the operator to view and select a job from the hard drive or import one from another networked drive. The system will load in the setup parameters for the selected job.

"Create New Setup" allows the operator to create new job setup parameters that are saved for later use.

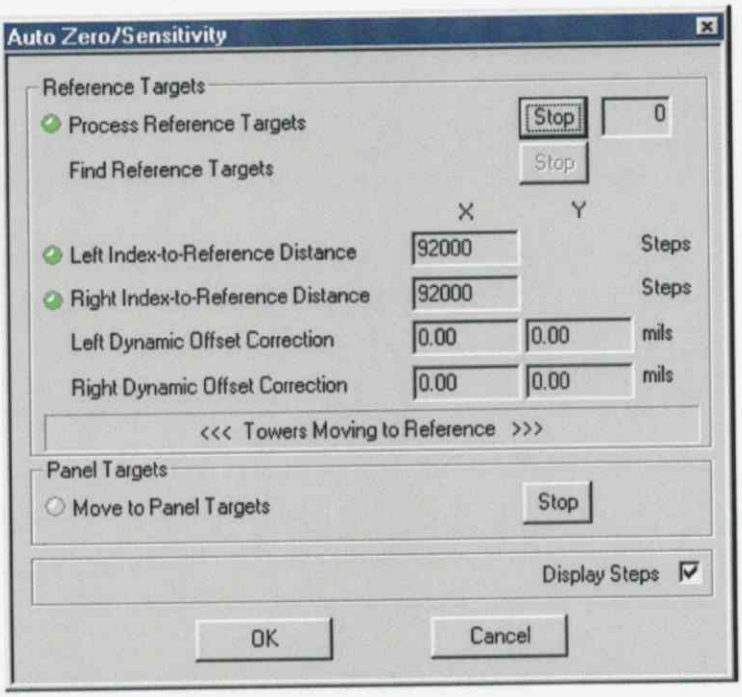
"Do Not Load Setup" bypasses loading job setup parameters. This dialog box "New Panel Size" will allow the operator to enter an X and a Y panel dimension. No other setup information is required, (default target configurations are used). When using this option none of the job information will be save, but the SPC data will be displayed on the screen and can be printed out.

Each option is detailed on the following pages.

LOAD MOST RECENT SETUP

If Load Most Recent Setup is selected then all of the job parameters of the last setup will be loaded as the parameters for the current setup. A dialog box titled 'Home Motors' will appear. Click Start to home the Deck, the Drills and the Drill Towers. The homing routine calculates the maximum distance of travel by moving to the limit switches for the Deck, Drills, and Drill Towers.

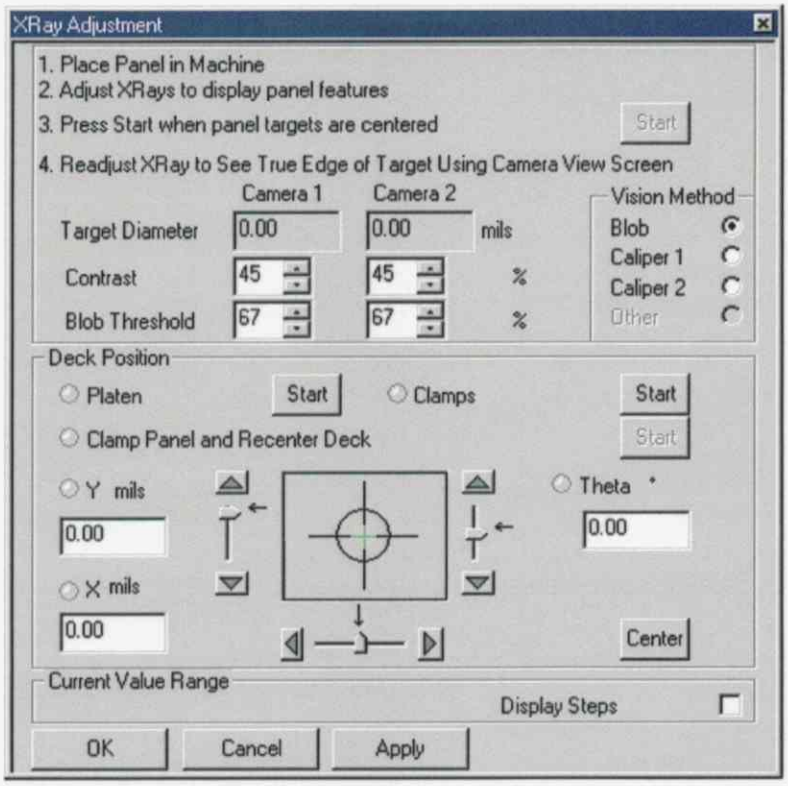
The next screen is the Auto Zero/Sensitivity. The Start icon on Process Reference Targets is used to move the drill towers to the reference targets, located on the outside edge of the IKO rail, and analyze the reference image. A dialog box will indicate that the x rays are ramping to reference levels. This may take a few seconds if the x rays were turned off.



After the x rays have reached the reference levels the Camera View (F3) will display the reference targets. The counter next to the Start icon will update itself each time the vision system processes the reference target. The reference target image will be analyzed 15 times to determine the zero position.After the reference targets have been established the Drill Towers will move to the appropriate panel size. The operator can toggle between steps and mils by checking on the Display Steps .

Place the panel in the machine and adjust the x-ray level so that the panel targets appear on the black and white monitors. The X Ray Adjustment screen provides step by step instructions on fine

tuning the x-ray power levels and facilitate moving the panel to the center of the monitors. Center the panel targets on the monitors using the Deck Position section.



The Deck Position section allows the operator to jog the panel to the center of the black and white monitors, and turn on/off the platen and clamps to hold the panel down if it is curled or warped. The Clamp Panel and Re-Center Deck icon holds the panel in place while the deck is centered. This allows the operator greater range of travel to move the panel targets in the field of view of the cameras.

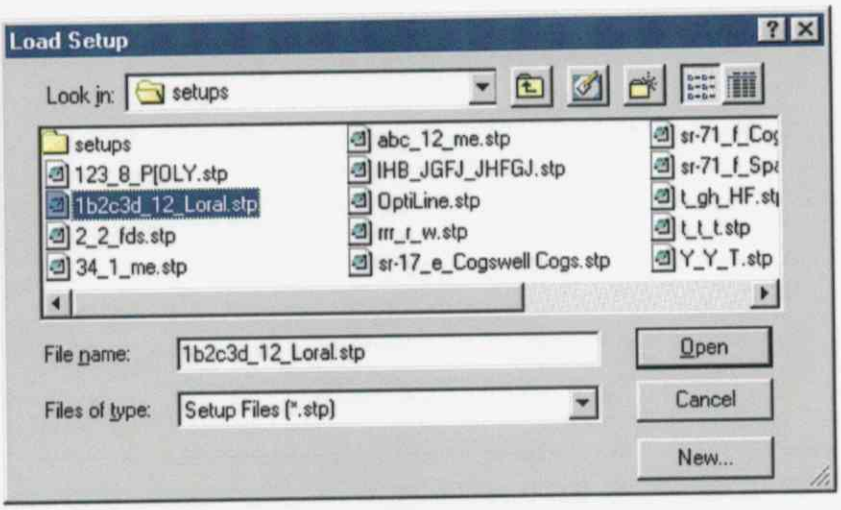
Once the targets are somewhat centered on the black and white monitors the operator presses the Start icon to for the vision system to analyze the target. The Vision Method option displays the available algorithms to determine the edge of the panel target. The Camera View screen (F3) displays the target and draws an outline on the edge of the target. Using the zoom in feature on the Camera View screen and the reported target diameter on X-Ray Adjustment screen the operator should be able to adjust the x ray levels so that the vision system can "see" the true edge of the target.

Caliper 1 and Caliper 2 are edge detection algorithms. Caliper 1 takes fewer samples and is faster, while Caliper 2 takes more samples and is slower. Blob is a threshold based edge detecting algorithm. The Blob Threshold determines where the system sets the edge of the target. Again using the Camera View screen (F3) and its zoom functions the operator should be able to adjust the x ray levels so that the vision system can "see" the true edge of the target. Clicking <OK> will make the desired changes but will close the dialog box, while clicking <Apply> will leave the dialog box open for other modifications.

At this point the system will wait for the operator to select the mode for processing production panels. See Operating Modes later.

LOAD NEW SETUP

If Load New Setup is selected, the title bar will indicate "Load Setup" and the display will list setup files that have been saved in the setup directory. This dialog box allows the operator to import setup files from any networked drive connected to the machine. The setup files have the extension *.STP* and this parameter can be used to find setup files.

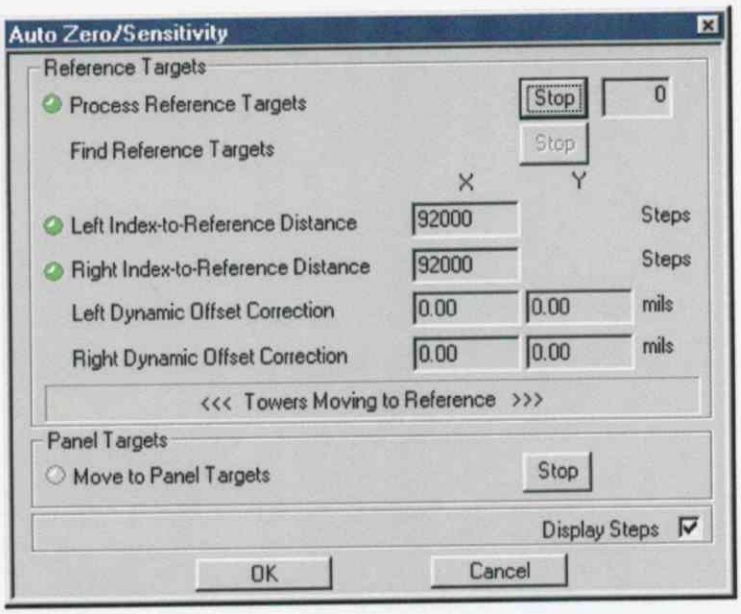


Double click on the desired file or highlight the file to be used and press <Open>. This will load all the setup parameters into the system.

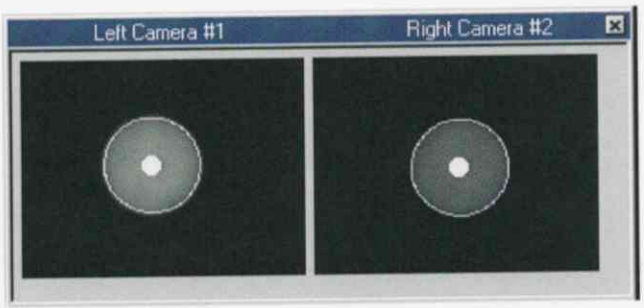
A dialog box titled 'Home Motors' will appear. Click Start to home the Deck, the Drills and the Drill Towers. The homing routine calculates the maximum distance of travel by moving to the limit switches for the Deck, Drills, and Drill Towers.

An LED type light next to each device will turn yellow as its moving to its limits and then turn green as its finished the homing routine. The deck will move on all of its axes at once, and the drills will move up and down to its limits. The drill towers will move to the outside of the machine and then to the index pulse located on the glass scale.

The next dialog box is the Auto Zero/Sensitivity. The vision system will process the reference target 15 times, and the Process Reference Targets counter is updated after each time.



After the reference targets have been established the Drill Towers will move to the appropriate panel size. The operator can toggle between steps and mils by checking on the Display Steps. The vision system will put an outline around the reference target and this image can be viewed on Camera View (F3).



Place the panel in the machine and adjust the x-ray level so that the panel targets appear on the black and white monitors. The X Ray Adjustment screen provides step by step instructions on fine tuning the x-ray power levels and facilitate moving the panel to the center of the monitors. Center the panel targets on the monitors using the Deck Position section.

The Vision Method option displays the available algorithms to determine the edge of the panel target. The Camera View screen (F3) displays the target and draws an outline on the edge of the target. Using the zoom in feature on the Camera View screen and the reported target diameter on X-Ray Adjustment screen the operator should be able to adjust the x ray levels so that the vision system can "see" the true edge of the target.

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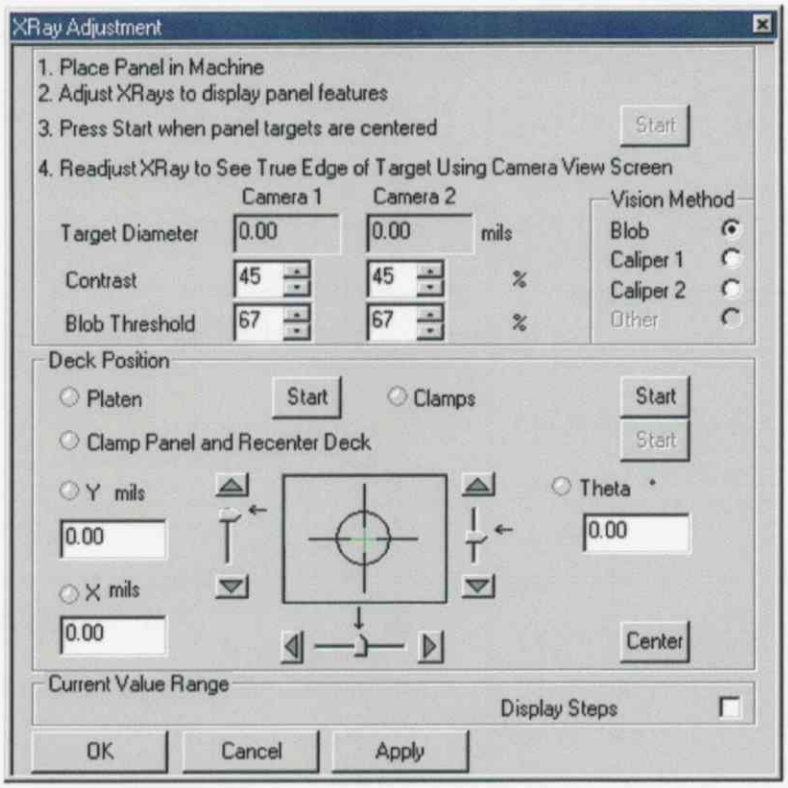
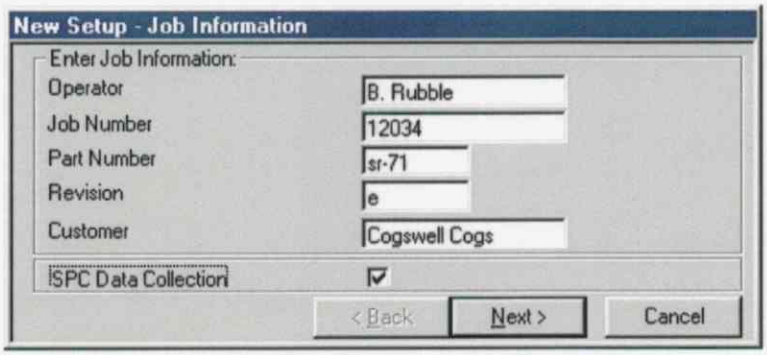


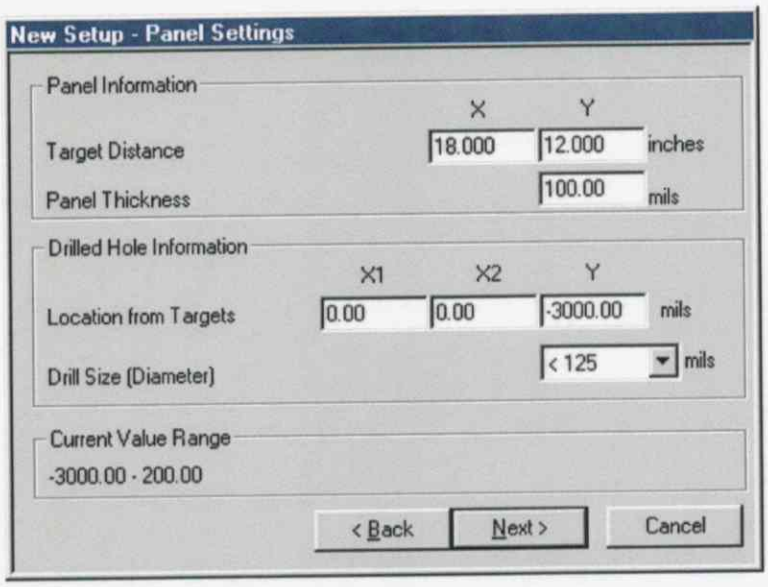
At this point the system will wait for the operator to select the mode for processing production panels. See Operating Modes later.

CREATE NEW SETUP

This selection allows the operator to create a new setup which can be stored in the computer and retrieved for later use. In the New Setup-Job Information window all the fields must be filled in to continue to the next page. If a field is left blank an alert message will be displayed and the operator cannot advance to the next page.



Selecting the SPC Data Collection will save the SPREAD and job information data to a file, which can later be imported to a spreadsheet for analysis.



The next page is the Panel Settings. The Target Distance in the X axis (long axis) is the nominal distance between the two fiducials. The Target Distance in the Y axis (short axis) is the nominal distance between the two fiducials. The dimension in the Y axis is not critical unless the job requires the Layer Analysis Package™ (LAP). LAP will be discussed in detail in the Tool Bars section of the manual.

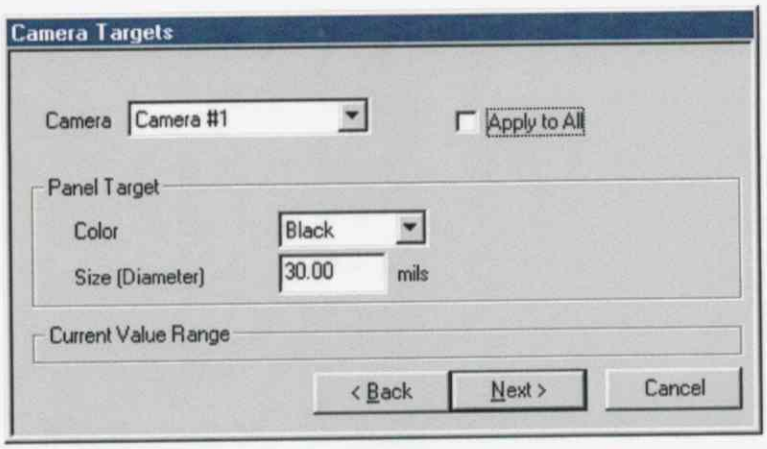
The Panel Thickness and Drill Size (Diameter) fields must be filled in with nominal panel thickness and the size of the largest drill bit used. These fields determine the drill profile used by the machine to process the panel.

The next section contains the Drilled Hole Information. The X1 and X2 fields are used position the drilled hole inboard or outboard with respect to the fiducials. The X1 is the left side and X2 is the right side. The default value of zero for X1 and X2 will drill the tooling holes on centerline with respect to the fiducials. A positive value for X1 or X2 will move the drilled holes inboard, and a negative value will move the drilled holes outboard with respect to the fiducials. X1 and X2 are independent and affect the hole to hole distance.

The Y value is used to set the distance from the fiducials to the drilled holes in the Y axis. The standard tooling distance is 2.875 inches from the fiducials. The operator can set any distance between 0.2 inches and !3.000 inches. A value of zero will drill out the fiducials on the panel. The operator must enter the proper sign for the value in this field.

The Current Value Range will display the minimum and maximum limits of a highlighted field and an error "Value Entry Error" is displayed if the entered number is outside the range.

Clicking Next will bring up the Camera Targets page of the setup folder.



The Panel Target size and color can be independently selected on either camera or a check in the Apply to All will set the current setting to both cameras. The target color is typically set to black but white targets can also be used. A black target is stack up of copper pads with a clear background. A white target is a stack up of clear area with a copper background. The Panel Target Size is the nominal diameter of the fiducials.

The Current Value Range will display the minimum and maximum limits of a highlighted field and an error "Value Entry Error" is displayed if the entered number is outside the range.

After selecting the parameters that are appropriate for the job, Click <Next>. The title bar will display New Setup-SPC Data.

SPC Printing

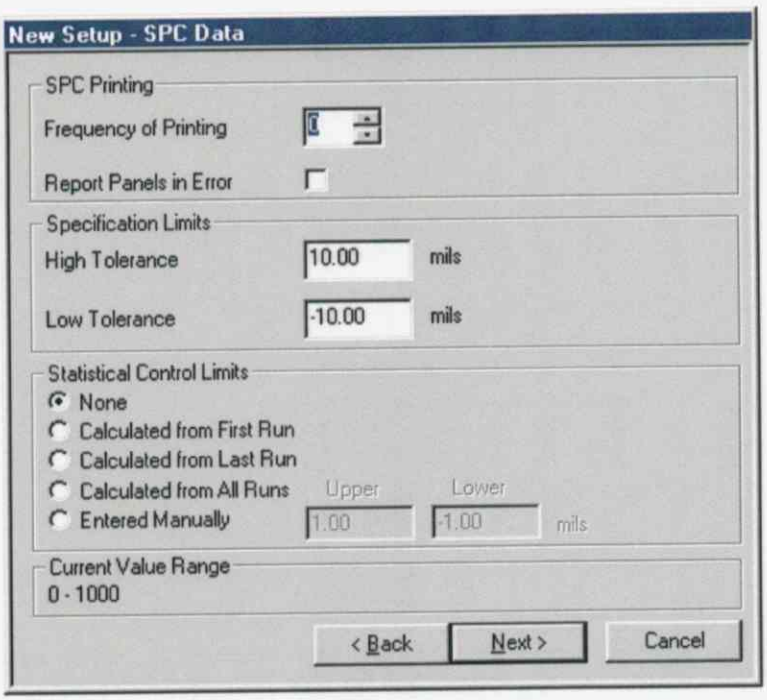
This feature is used to print out the SPC data generated by the computer. The Print Interval Time (under the Configurations menu select devices and choose the Options folder) sets the delay for the contents in the buffer to be printed. The Frequency of Printing sets the interval at which data is sent to the buffer. If zero is selected then only the statistical data after the job is completed is sent to the print buffer and printed only if the buffer is full or after the Print Interval Time delay, which ever comes first. If a one is selected then the data per panel is sent to the buffer and if two is selected then the data for every other panel is sent to the buffer, so on and so forth.

A check in Report Panels in Error will have only the panels that exceed the SPREAD tolerance saved, regardless of the interval of frequency of printing.

Specifications Limits

This refers to the SPREAD value, the stretch or shrink, of the panel between the panel targets. The allowable SPREAD for the product is inserted here. The machine will report "Failed" if the panel stretch/shrink is outside the set limits, and will not drill the panel.

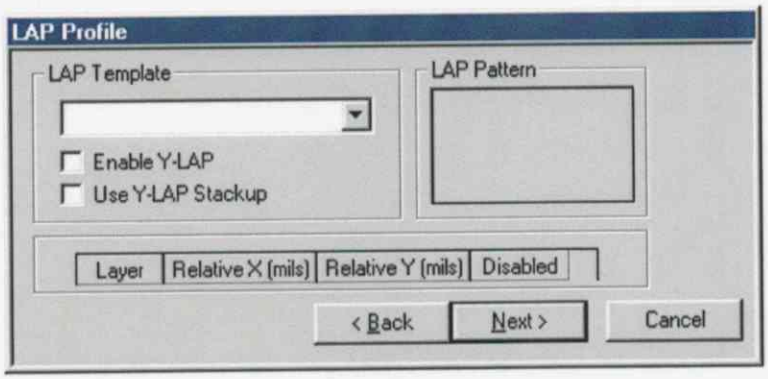
Note: Either or both of these limits can be positive or negative values. Use the negative sign key if required.



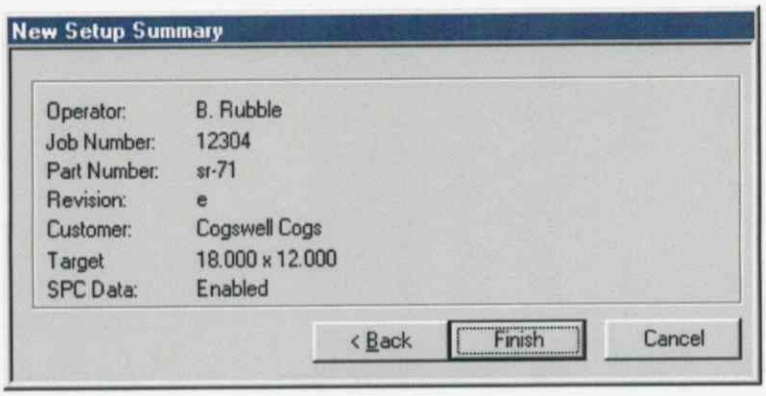
Statistical Control Limits

This feature is used to put control limits on the SPC graph. If control limits are to be displayed on the SPC graph, then select one of the choices. This entry has no effect on the operation of the system. The Current Value Range will display the minimum and maximum limits of a highlighted field and an error "Value Entry Error" is displayed if the entered number is outside the range.

The LAP™ profile dialog box appears next. LAP™ will be discussed in detail in the Tool Bars section of the manual.



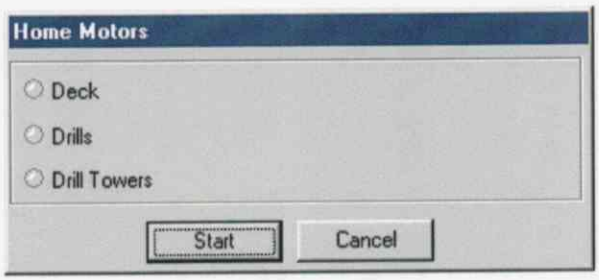
Click <Next> to finish the setup and a summary will be displayed. The operator can make changes if desired by using the <Back> icon.



Click the Finish icon and the computer will store the setup up information for later use. The top line of the program will now display the current setup in the following format: Part_Number_Revision_Customer.stp. The user that is currently logged on to the system will also be displayed next to the current setup.

There is a display bar on the bottom of the program that shows the current panel size, panel count, and a status bar. The status bar reports about the current process the machine is performing.

The program will now prompt the operator to Start the homing sequence. The machine will go through a sequence to determine its travel limits on the Deck, Drills, and the Drill Towers.

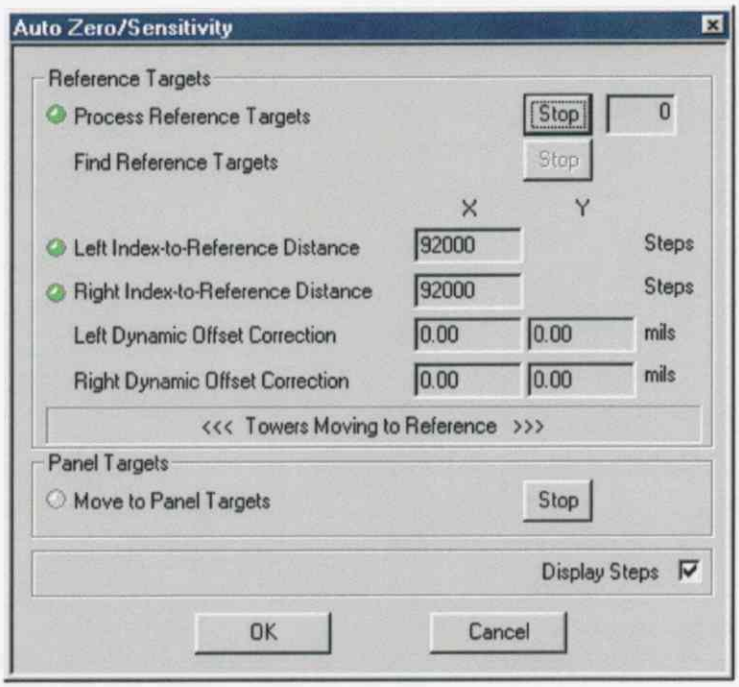


An LED type indicator next to the device will turn yellow as its moving to its limits and then turn green as the limit routine is completed. The LED will turn red if any error was encountered while the motors were homing.

After the machine has homed all the motors the Auto Zero/ Sensitivity and Camera View windows are displayed on the monitor. The operator can move any of the windows by holding the left mouse button down on the title bar of the window and dragging it to the desired place.

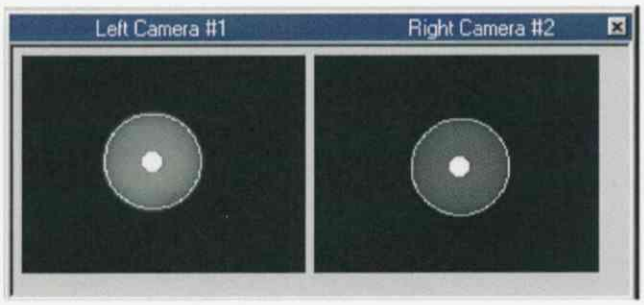
The Camera View window shows the image used by the vision system to process the panel. In x-ray systems, target to background contrast is achieved by adjusting the x-ray power presented to the camera. The operator should set the x-ray level such that the target stack up is clearly visible and not washed out by x rays.

A calibration target can be incorporated into the artwork. The square target is the calibration target on one layer that has the thinnest copper thickness. If the square target is not available, then use the LAP™ targets as an x-ray tuning target. The x-ray level should be set such that these targets have a crisp edge.



The Auto Zero/Sensitivity window will process the reference targets. The Drill Towers will move to the reference targets. The Left Index to Reference Distance and Right Index to Reference Distance counter will update as the towers are moving to the reference targets, and a message will say waiting for x rays to reach reference levels.

The vision system will process the reference target 15 times, and the Process Reference Targets is updated after each time. The vision system will put an outline around the reference target and this image can be viewed on Camera View (F3).



After the vision system has acquired the reference target it reports the Left and Right Dynamic Offset Correction. This value should be less than one mil. If the value is above one mil the system will report an error and the operator must press the Start icon next to Find Reference Targets.

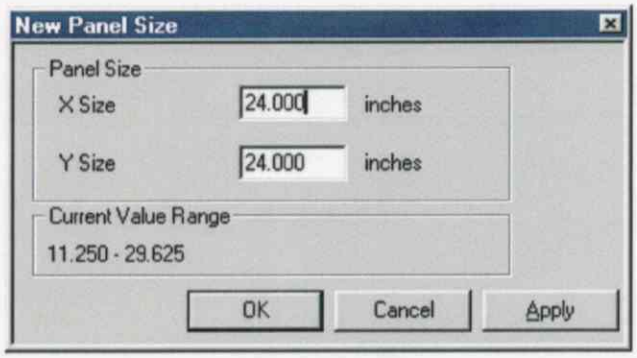
After the reference targets have been established the Drill Towers will move to the appropriate panel size. The operator can toggle between steps and mils by checking on the Display Steps .

Place a panel in the machine and adjust the x-ray level so that the panel targets appear on the black and white monitors. The X-Ray Adjustment screen will provide step by step instructions on fine tuning the x-ray power levels and report the size and current position of the panel targets. The Deck Position section allows the operator to jog the panel to the center of the black and white monitors, and turn on/off the platen and clamps to hold the panel down if it curled or warped.

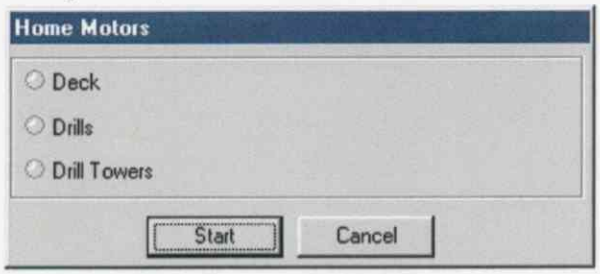
At this point the system will wait for the operator to select the mode for processing production panels. See Operating Modes later.

DO NOT LOAD SETUP

This option is used to create an abridged setup. The New Panel Size dialog box allows the operator to enter the X and Y sizes. The operator should enter the nominal distance between the two fiducials as the value for the X size, and similarly for the Y axis if available. The Current Value Range will display the minimum and maximum limits of a highlighted field and an error "Value Entry Error" is displayed if the entered number is outside the range.



The program will now prompt the operator to Start the homing sequence. The machine will go through a sequence to determine its travel limits on the Deck, Drills, and the Drill Towers.



The next screen is the Auto Zero/Sensitivity. The Start icon on Process Reference Targets is used to move the drill towers to the reference targets, located on the outside edge of the IKO rail, and analyze the reference image. A dialog box will indicate that the x rays are ramping to reference levels. This may take a few seconds if the x rays were turned off.

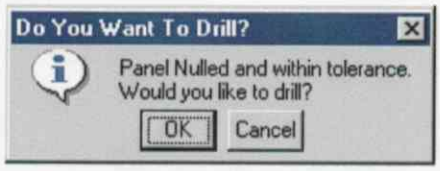
Place the panel in the machine and adjust the x-ray level so that the panels targets appear on the black and white monitors. The X-Ray Adjustment screen will provide step by step instructions on fine tuning the x-ray power levels and report the size and current position of the panel targets. At this point the system will wait for the operator to select the mode for processing production panels. See Operating Modes later.

OPERATING MODES

When the setup is complete the display will show a pictorial of the machine and the Mode icons are located in the center of the tool bar across the top. The modes are MAN (Manual), SEMI (Semi-Automatic), AUTO (Automatic) and STOP (Setup). After completing the setup, the icons will indicate that the system is in STOP mode.

The operator can now switch the machine to Semi or Auto to run production. The manual mode is primarily used as diagnostic tool.

In Semi mode the operator can press the Start icon on the top right of the tool bar or the Start button in front of the machine to start the nulling process. After the panel is nulled the operator is prompted with the following message if the panel is in tolerance.



If the panel is out of tolerance the following message will be prompted and clicking on <OK> will cause the machine to drill the panel and <Cancel> will abort drilling.

The Target Spread data is updated each time the panel is nulled and Panel Count is updated each time the panel is drilled. Both of the displays are located at the bottom of the screen.

In Auto mode the panel is automatically drilled after it is nulled if the spread is within tolerance.

ENDING A RUN

After a job has been completed, the operator may choose Close Setup under the File menu to finish the job. A dialog box will prompt the operator to save the changes to setup, if any. The Save Setup (Ctrl-S) option is used to save a new setup. The Save Setup As option is used to save a modified version of an existing setup under a different name.

The File menu may also be used to start another job. The operator can choose between create a New Setup or Load Setup to load an existing setup.

To turn off the machine, the operator should turn the key on the door to the off position. The system will begin to power down and display messages and prompts to confirm the power down command.

Note: the computer will remain on for several minutes after the operator has pressed the off button to allow windows sufficient time to close the application and shutdown properly.

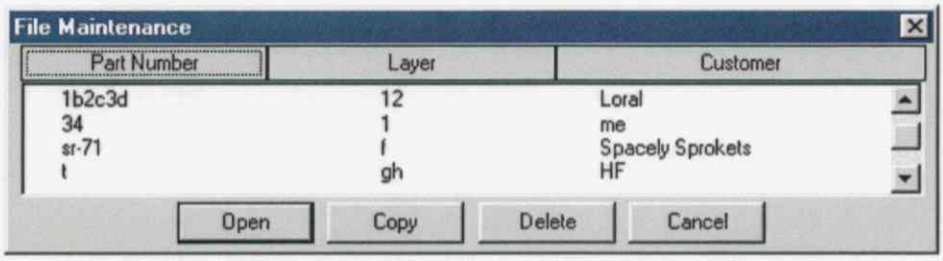
TOOL BARS

The top picture displays the menu bar for the machine. It shows the Multiline logo with the current setup and the user that has logged on to the system. The options File, Machine, View, Devices, Configurations, and Setup, can be accessed using the mouse or the Alt key and the underlined letter on each option.

File

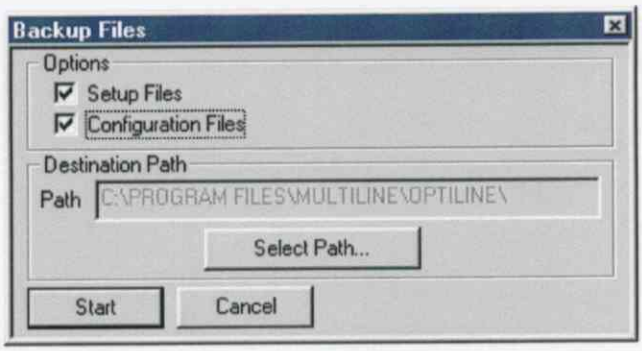
The top section of the File option allows the user to load, create, save setup and end a job session. The hot keys F12 and Ctrl-S are short cuts to the listed options. This dialog box also allows the user to Logon / Logoff or Exit the system.

The Maintenance option displays the contents of the setup directory. The saved setups are displayed as Part Number, Layer and Customer and can be sorted accordingly.

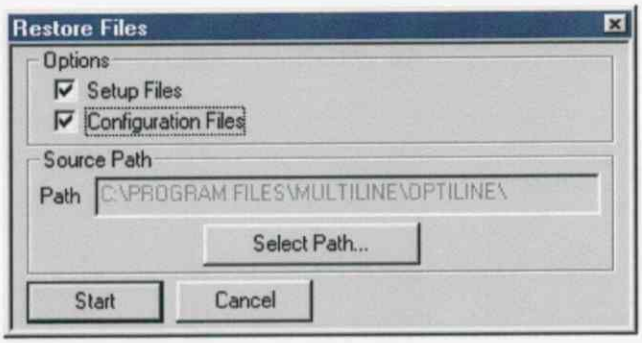


A saved setup can be loaded into the machine, copied with a different name (not renamed) and edited without changing the original setup or deleted.

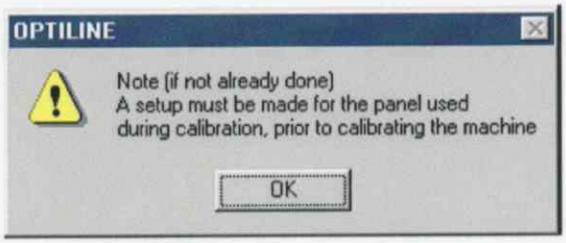
The machine Setup and Configuration Files can be saved to another directory or networked drive by the Select Path icon under the Backup Files option. The Start icon will begin the process.



The Restore Files option is used to return the machine to factory settings. The path is where the default settings are store and it can be any networked drive.



The Machine Setup wizard is designed to assist in calibrating the machine. *This procedure should only be done when the machine is installed.* A setup for the desired panel size used during calibration should be created prior to calibration.

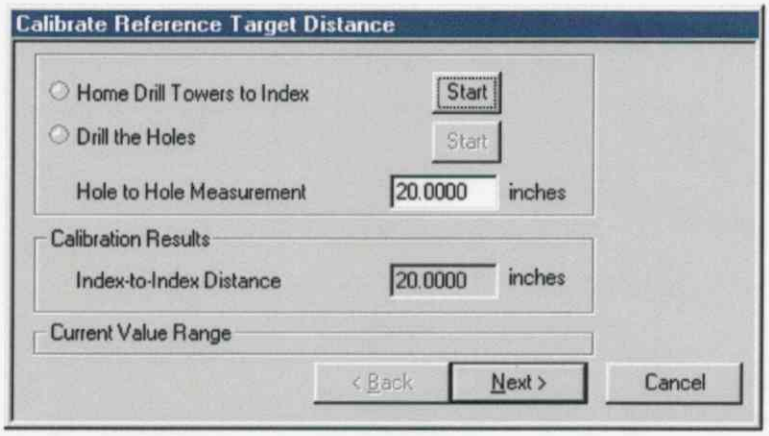


This wizard goes through the complete machine calibration. The first step is to set up the proper hole to hole distance. Load or create a setup for the desired panel size to be calibrated. Switch the machine to manual mode. The Start icon on the Home Drill Towers to Index will move both drill heads to the index pulse on the glass scale.

Note: The drill bit for the orientation (dummy) hole should be removed during the calibration process. So there will be only the right and left required tooling holes.

Press the start button to Home the Drill Towers to Index, after the drill towers locate the index pulse they will move to the panel size. Place a panel into the machine to highlight the start icon on Drill the Holes. Mark the position of the board relative to the front loading area using tape or a marker. Drill the board by clicking the Start icon on Drill the Holes and then mark the drilled holes as set #1. Place the panel into the machine again this time approximately 1 inch above the marked location to insure the holes are not double drilled. Mark this set as #2. Repeat this procedure and drill at least 4 sets of holes.

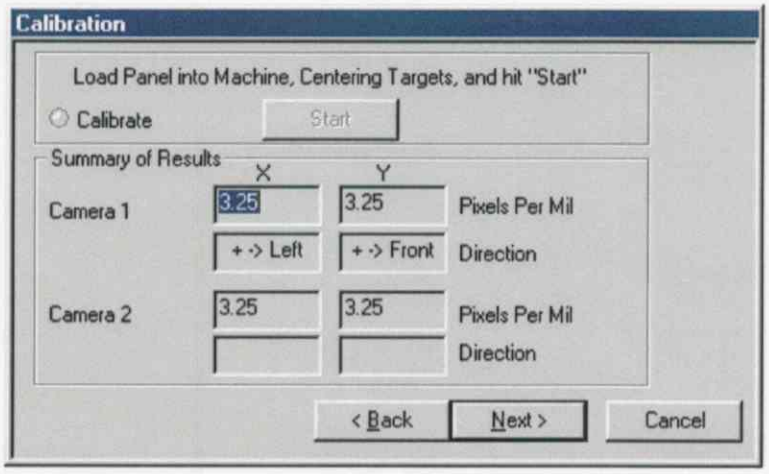
Measure hole to hole distance using a coordinate measuring machine (CMM) and then take an average of the measurement. Enter the average value into the Hole to Hole Measurement window.



Click the Next tab to continue with the calibration process.

This window is used to calibrate the Pixels Per Mil and the deflection of the motors. Place a panel into the machine and adjust the x rays until you get a clear image of the target. Center the target on the monitors as best as possible and then press the Start icon.

The machine will calibrate the pixels per mil by moving the panel a preset amount in the X and Y axis. This procedure will also set the deflection of the cameras. The proper deflection will ensure that pressing the right arrow key will move the panel targets to the right side of the monitors.



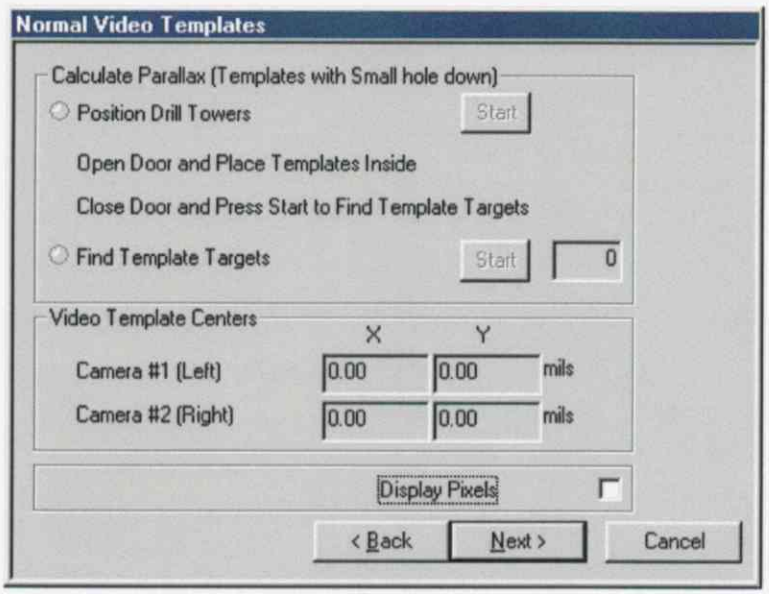
Click the Next tab to continue with the calibration process.

PARALLAX

The Video Templates are supplied with the machine. They are marked left and right. There is a small bushing at the end of the template held by a set screw. There are three locating stops on top of the plate that are approximately half an inch long. The locating stops are used to bank the template against the drill clamps.

The templates are used to adjust parallax between the camera and the x-ray tube. The tube and camera have to be properly aligned to eliminate the apparent difference in position of the target caused by a change in the point of observation, the x-ray tube.

The bushing has a small 0.062 inch hole drilled in it. To flip the cup loosen the set screw and gently push the cup through the plate, flip the cup and then insert the cup into plate. The top and bottom of the cup should be flush with the surface of the plate. The set screw should be snug so there is no play in the cup.



Press the Start icon to position the drill towers and then open the door to place the templates. There are two locating pins on the bottom of the plate. These pins are used to align the templates with the tooling holes in the machine. Use the locating stops to bank the templates against the drill clamps and then carefully place the templates into the machine tooling holes.

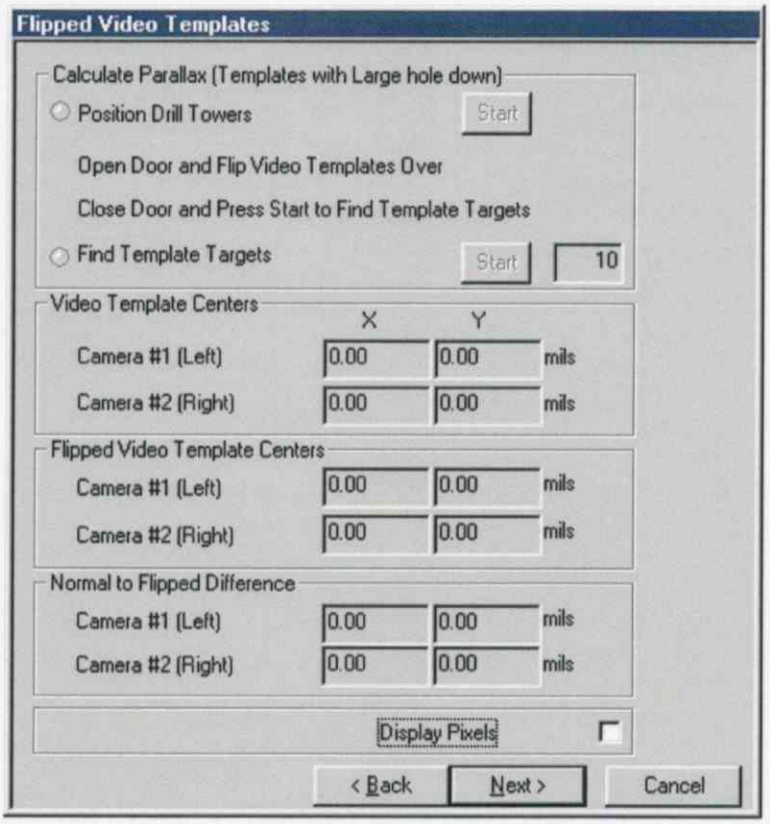
Once the templates are in the locating holes they should feel snug and the templates should not move. Make sure that the small holes are down on both templates for the Normal Video templates. Close the door and press the Start icon to Find Template Targets.

The vision system will now analyze the image and display the position of the targets on Video Template Centers. The X and Y axis position of the targets can be displayed in either pixels or mils depending on the check in the Display Pixels box.

Upon completion open the door and remove the templates. Loosen the set screw that holds the bushing and flip the cup over.

Click the Next tab to continue with the calibration process.

The Flipped Video Templates window is used to calculate the video centers with the large hole down. Press the Start icon to position the drill towers and then open the door to place the templates. There are two locating pins on the bottom of the plate. These pins are used to align the templates with the tooling holes in the machine. Use the locating stops to bank the templates against the drill clamps and then carefully place the templates into the machine tooling holes.



Once the templates are in the locating holes they should feel snug and the templates should not move. Make sure that the large holes are down on both templates for the Flipped Video Templates. Close the door and press the Start icon to Find Template Targets.

The vision system will now analyze the image and display the position of the targets on Video Template Centers. The X and Y axis position of the targets can be displayed in either pixels or mils depending on the check in the Display Pixels box.

The Video Template Centers display the position of the target with the small hole down. The Flipped Video Template Centers shows the position of the target with the large hole down. The Normal to Flipped Difference should be less than ONE mil.

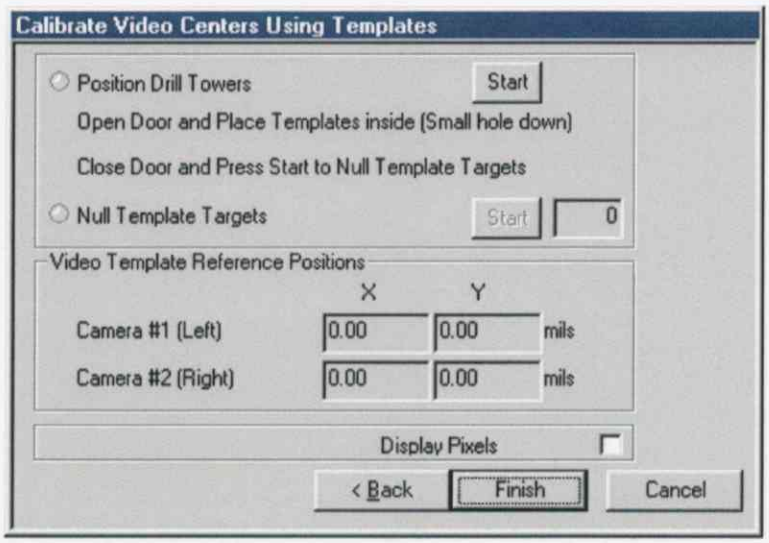
If the difference is greater than ONE mil in any direction then the position of that tube must be adjusted to eliminate parallax. If only one side is affected then adjust that side. If both sides need parallax adjustment then adjust one side and verify before continuing to the next side.

The x ray tube is mounted on a bracket with four screws. Slightly loosen the top right and bottom left screw, and use the two cam screws to move the tube position. The cam screws are in slots located on the bracket. The slot towards the front of the machine controls the tube movement in the Y axis, and the slot towards the back of the bracket controls the tube movement in the X axis.

Adjusting parallax is an iterative process. Once the tube has been moved the parallax between the tube and camera must be checked using the templates with the small and large hole down. A small (1/8) turn on the cam screw can result in a large movement on the tube. After you move the tube, snug the top right and bottom left screw so the tube is stable.

Click the Next tab to continue with the calibration process.

The last section of the calibration section involves in nulling on the template targets. Place the templates with the small hole down and press the Start icon to Null Template Targets. The window will now display the reference position for both cameras.



Click the <Finish> tab upon completion or use the <Back> tab to return to the previous window. The machine will now save the Video Template Reference Positions into memory. This is the position where the panel is nulled to when the machine aligns the panel.

The next item on the file menu is the Print option. The current Setup information can be printed along with the machine Configuration and Event Log. The Configuration contains all the preset machine parameters. The Event Log contains the history of machine and user actions.

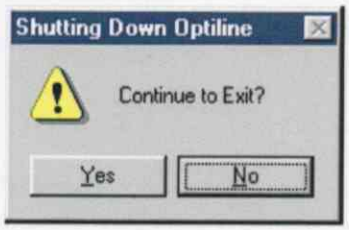
The Buffered Data option will print out the contents of the buffer without waiting for the Print Interval Time. After the machine has processed a panel, spread and panel information is sent to this buffer. When data is available to be printed the buffer key will be highlighted.

The Print Interval Time sets the delay for the buffer data to be printed. Approximately a page is printed at a time as the buffer fills up during production. If no new data enters the buffer then its content are printed after the set interval time.

The Logon and Logoff are the next options available under the File menu. There are two icons, an open lock and a closed lock, on the tool bar. This shows if there is a user currently logged on to

the system. The open lock icon is for new user to log on to the system and the closed lock icon is for the current user to log off the system

The last option under file menu is Exit. The system will prompt the user to verify to exit the program. Clicking <Yes> will shut the system down, and <No> will return the machine to the previous mode of operation.

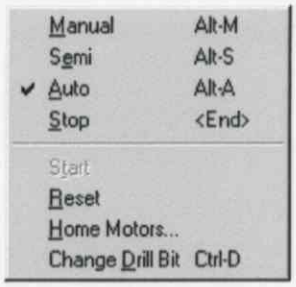


The software again alerts the user that system is about to be powered down. Clicking <OK> will exit the software application and turn off the machine. The message "Please wait while Optiline shuts down" displayed as the machine is turned off.

Clicking <Cancel> will return the machine to the previous mode of operation.

Machine

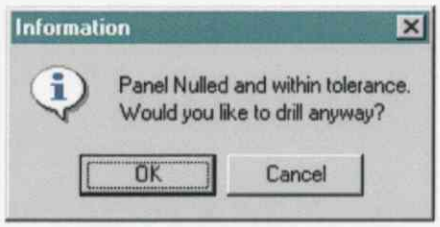
This menu bar shows the different modes of operation of the machine, and displays the current state by a check mark on the mode. It also allows the user to toggle between the different modes of operation using either the hotkeys or the mouse.



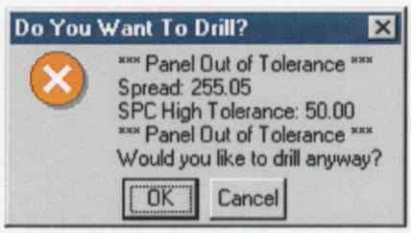
The Manual mode (Alt+M) allows the user access to all the devices available on the machine. This is dependent on the security level of the user. Security will be discussed later in this manual.

The Auto mode (Alt+A) is typically used when the machine is production. During this mode the machine will align panel and drill the panel provided it matched the target and spread requirements. If the panel failed either the target or spread requirement then the operator will be prompted with an error message.

The Semi-Auto mode (Alt+S) is exactly the same as the Auto mode with the exception that the user will prompted with "Panel Nulled would you like to drill?" for every panel.



If the panel is out of tolerance then the user is prompted with the following message and is given the option to drill if desired.



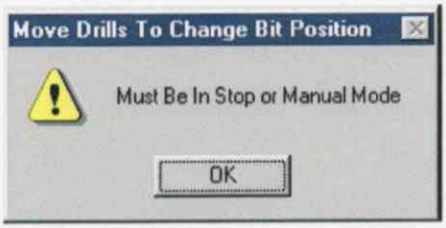
The Stop mode <End> allows the user to make changes to the configuration and setup files. This is dependent on the security level of the user. Security will be discussed later in this manual.

The Start option is used to begin the alignment process. It is like the start button on the console or on the machine itself.

Reset key is used to stop or abort the current process. This sends a reset signal to PLC. There is a reset switch also located on the console.

The Home Motors option is used to determine the travel of the X-Y-θ deck. The machine would normally home the motors when the machine is initially powered up. If any interlocks have been broken, the machine shuts power off to the motor drivers and the Home Motors icon will be displayed on the screen.

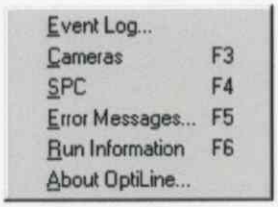
The Change Drill Bit (Ctrl-D) is used to change the drill bits in the machine. The machine must be in Manual or Stop mode for this function.



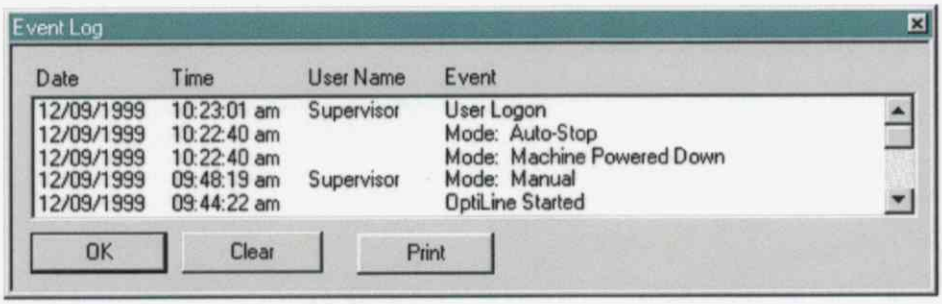
The bottom of the display will display the message "Moving Drill to Change Bits Position" and the drills heads will move to the change position. Make sure the present drill bit does not fall into clamps assembly by placing a cover over the clamps. Change the bits using the supplied torque wench. This wrench is factory preset to 17 inch pounds.

View

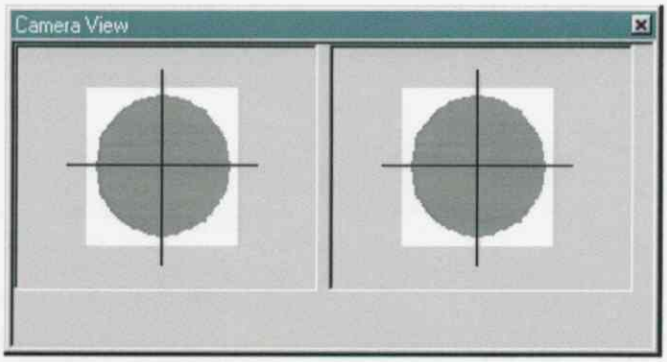
This allows the user access to the different display screens that report the status of the machine. The hotkeys are the function keys on top of the keyboard.



The Event Log keeps a history of the machine status via modes of operation and operator inputs. The record shows the date, time, the user logged on, and the event. The Print icon can be used to obtain a hard copy of the Event Log. The Event Log cannot be cleared without proper security access.



A display of what the vision system is analyzing can be pulled up on the screen using the F3 key or by clicking Cameras on the View menu. When the machine is processing a panel this display will show the targets with an outline around the edge and a plus sign in the calculated center. The movement as the targets are aligned to the optimum position can be seen on the Camera View display. The Camera View window below shows the reference targets with a box and crosshair.

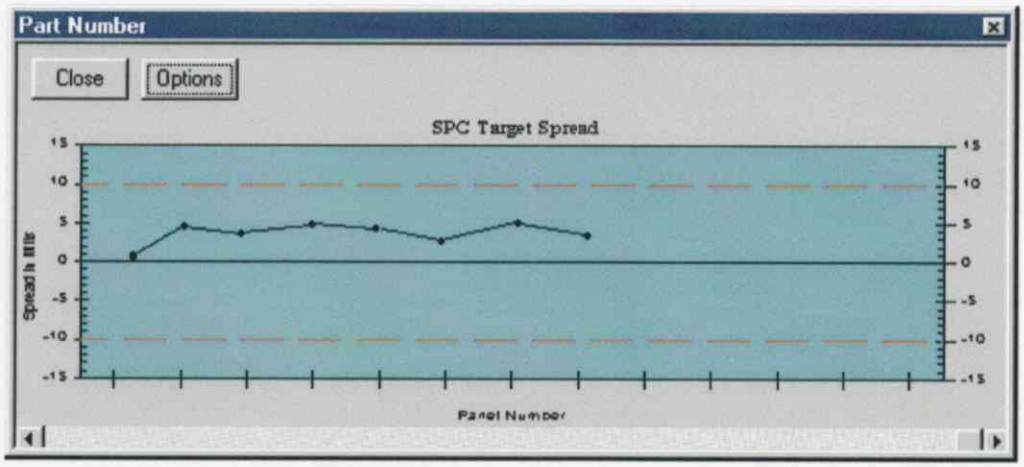


The operator can zoom in or out on the panel or reference targets using the right and left mouse key. When the mouse is placed on the targets the arrow turns into a magnifying glass with a plus or a minus inside it. The plus is the right mouse button and by clicking on it the user can zoom into the target. If you place the mouse (magnifying glass) on the cross hair "+" for the reference target or on the "x" for the panel target then the targets will be centered on the display screen.

SPC

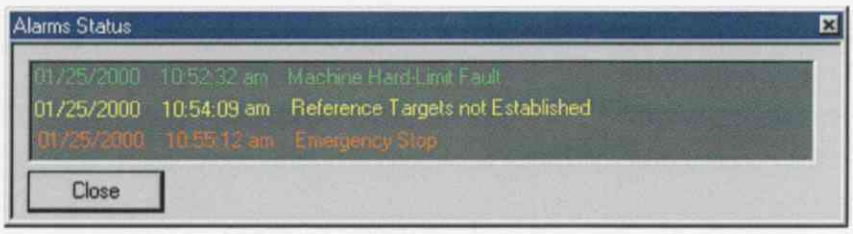
The SPC (F4) graph displays the spread data in mils or microns on the Y axis and panel number on the X-axis. The upper and lower limits are established in the job details during setup. The Options icon allows the operator change the color of the lines displayed on the screen. The Print option allows you to print out the graph

The graph can be stretched/shrunk by pointing the mouse on any edge of the SPC Graph dialog box (pointer turns into double headed arrow) and then holding the left mouse button down and dragging to appropriate size.



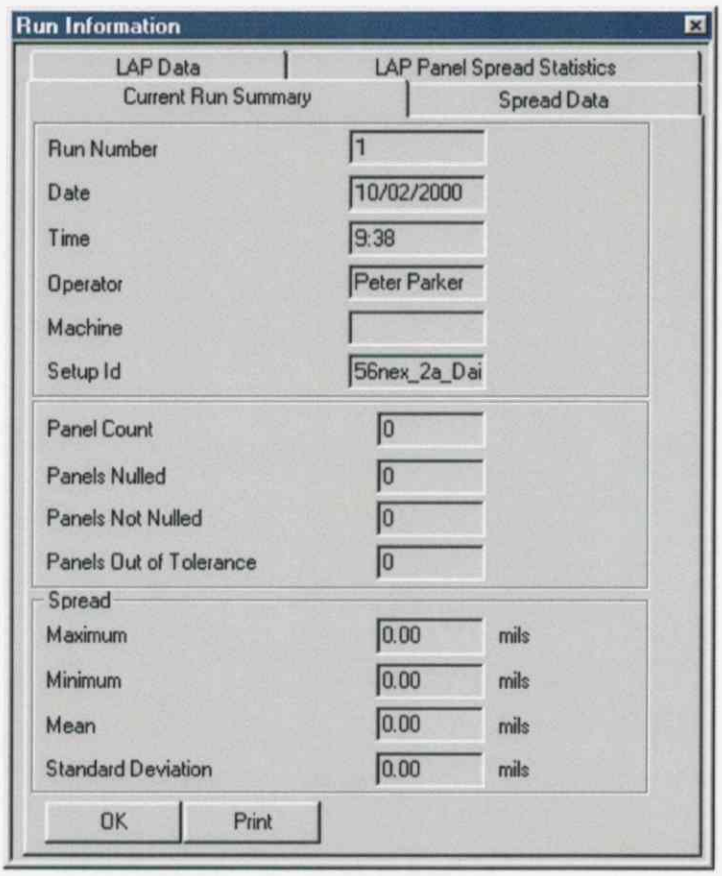
Error Messages

The Error Messages (F5) are displayed in window titled "Alarm Status". The alarms are displayed in three colors red; yellow, and green. A red alarm will stop the machine operation and must be cleared by the operator. A yellow colored message indicates the operator has acknowledged an alarm. The green colored display shows that the alarm has been cleared. The error messages are displayed with the date and time of the occurrence. The status bar on the bottom of the screen will display the color of the alarm if an alarm has been activated. The operator can press F5 or the exclamation icon on the tool bar to display the alarm.



Run Information

The Run Information window has four folders, Current Run Summary, Spread Data, LAP Data, and LAP Panel Spread Statistics. The Current Run Summary is broken into three sections. The first



section displays the setup information, the second section displays panel information, and the third section shows the SPC data. The SPC data is stored in the setups directory and has the path: C:\Program Files\Multiline\Optiline\setups. There are four files generated for every job, namely: *Filename*.STP, *Filename*.TAG, *Filename*.Spread, *Filename*.RunInfo.

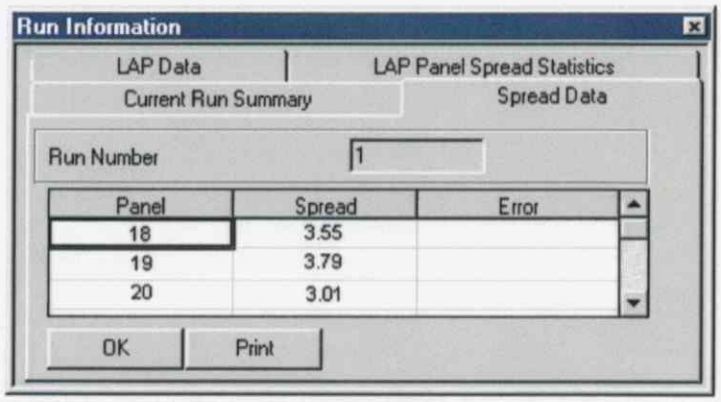
The file with the extension STP contains all the setup parameters. The TAG file contains the header data that can be used interpret the information from the Spread and RunInfo files. A file with the extension LAPResult is also generated if the Layer Analysis Package™ is preformed.

The Run Number shows how many times this particular job was processed by the machine. The Operator field shows the current user logged on to the machine (if security is active). The Machine field reports the serial number of the machine.

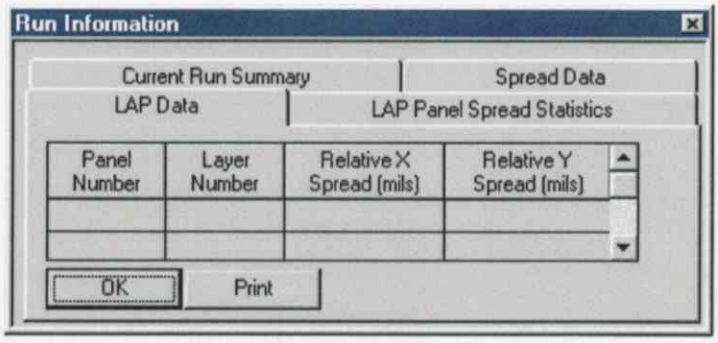
The panel section displays the history of processed panels. The panel count updates itself every time a panel is punched. There is also a resetable counter on the console for the operator to keep track of the number of panels punched in a job.

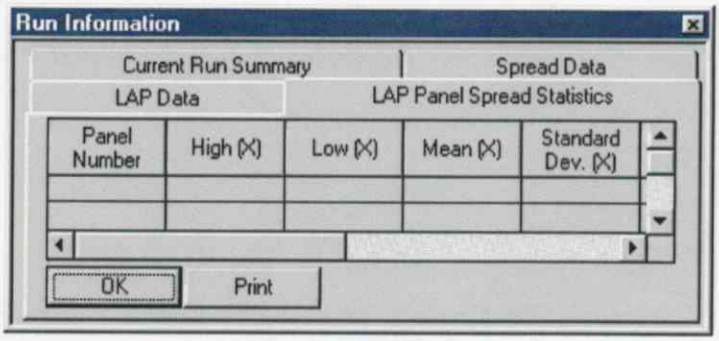
The spread section displays the statistical data for the current run. The units reported depends on the setting by the operator.

The Spread Data folder shows the panel number, spread, and error in a spreadsheet format. The Run Number shows the number of times this particular job was processed on this machine. The Print icon can be used to obtain a hard copy of this information.



The LAP Data folder shows spread information for the layers on the panel in the X and Y direction.

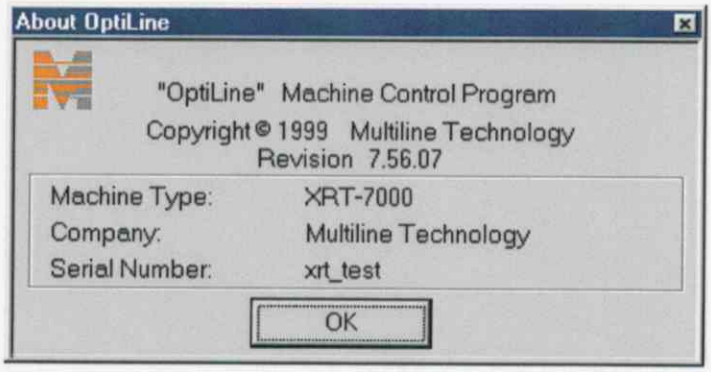




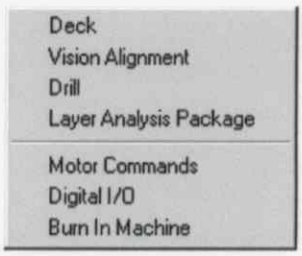
The LAP Panel Spread Statistics shows the statistical data for the panels. This folder calculates the spread data for all the LAP processed layers on a panel and displays the results. The low, high, average and standard deviation values are displayed per panel.

About Optiline

The last section of the View has the About Optiline page. Help is currently available through the Technical Services Department at (631) 249-8300. The About page contains vital information about your machine so please have the information displayed in the About page shown below when calling the Service department.



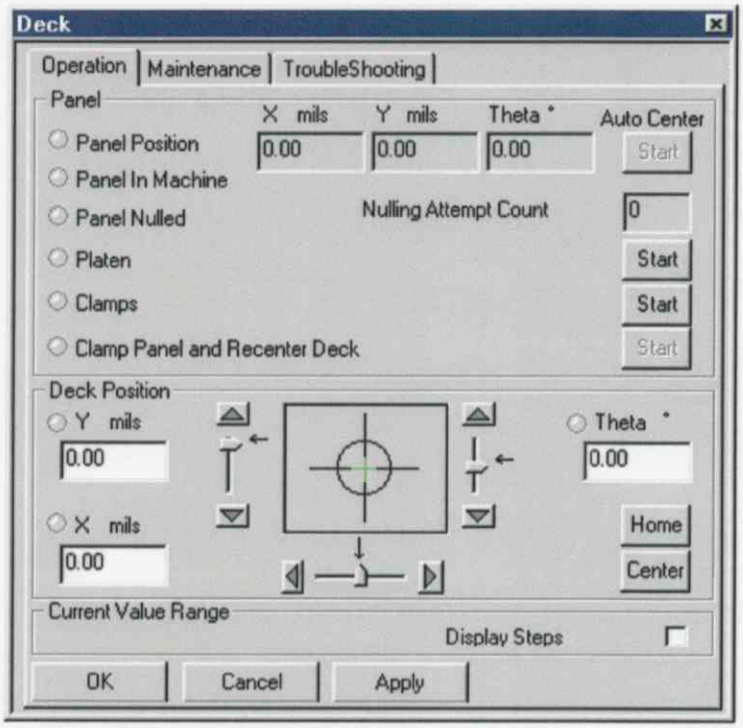
Devices



The next section on the menu bar is the Devices option. This is used mainly as a troubleshooting tool. The Devices option is broken down into the following folders: Deck, Vision Alignment, Drill, Layer Analysis Package™ (LAP), Motor Commands Digital I/O, and Burn In Machine.

Deck

The Deck is the moving table on which the panel is placed and aligned. The folder Deck has three sections: Operation, Maintenance, and Troubleshooting.



The Operation folder can be accessed from any mode, but the icons are only active in the Manual mode. The level of access a user has is based on the security privileges set for that user. Security will be discussed in the later sections of this manual. An "LED" type indicator shows the status of the different aspects of the deck, and the active state of the indicator is green.

The top section reports the panel information. When a panel is placed inside the machine the indicator for Panel In Machine will light up (green) and also a yellow rectangle will be displayed on the Deck Position section. The position of the deck is displayed in either steps or mils depending

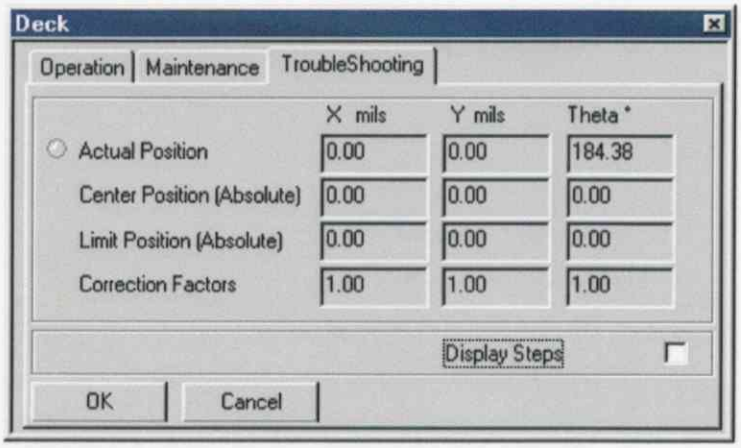
on the setting on the bottom of the page. The Auto-Center key starts the alignment process and the current deck position along with the "Null Attempt Counts" are updated.

The Clamp Panel and Recenter Deck icon is used to hold the panel in position and bring the deck to the home position. This feature is used if a limit is reached while trying to position the panel under the cameras.

The Deck Position section shows a pictorial representation the deck travel. The position of each axis is displayed in either mils or steps. The green cross represents the center of the deck. The deck can be moved using the mouse and dragging the pointer on the desired axis or by entering a numerical value in steps or mils. The deck can also be moved using the arrow keys (smaller increments) or the Page Up and Page Down key (larger increments), but the desired axis has to be highlighted first.

The "Home" icon is used to determine the number of steps between the limit switches on each axis. The LED display next to each axis turns on indicating that stage is moving. The deck travels to each limit switch and then rests at the center between the limit switches on every axis. This is the home position. The "Center" icon is used to bring the deck back to the home position.

The last section of the Operation window shows the Current Value Range and also the Display Steps option. The Display Steps option allows the operator to view the distance traveled by the deck in either mils or motor steps. The Current Value Range displays the limits for any highlighted section.

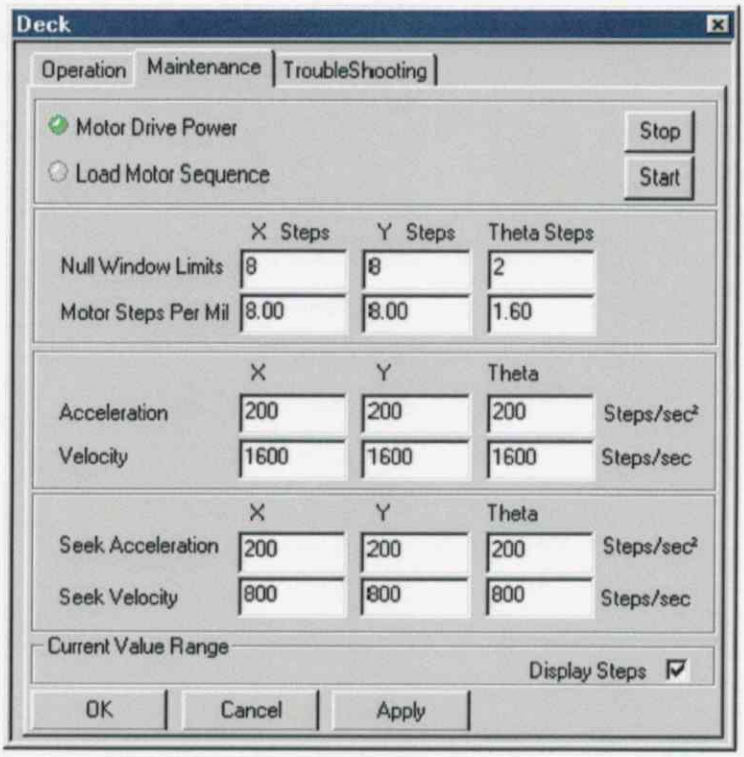


The TroubleShooting folder is used to determine if there is any play or malfunction in the deck. It shows the current position, the home or center position, the limit positions, and the correction factors.

The Actual position shows the current position of the deck. The Center Position (Absolute) is the midpoint of deck travel (between limit switches) and is the home position. The Center Position value shows the maximum deck travel from the "home" position in either direction.

The Limit Position (Absolute) shows the distance between the limit switches on an axis. This is the total travel for that axis. The Correction factor is used to account for any play in the deck.

The "Maintenance" folder in the Deck window contains the configuration variables. These values are preset from the factory and should not be changed. The Motor Drive Power toggle switch turns on or off the power to the motor driver for the deck. If the motor driver has been turned off then the deck should be "homed" again.



Load Motor Sequence is used if there is an error with the motor drivers. This option reloads the original motor parameters into the machine, and reinitializes them. The deck will have to be "homed" again.

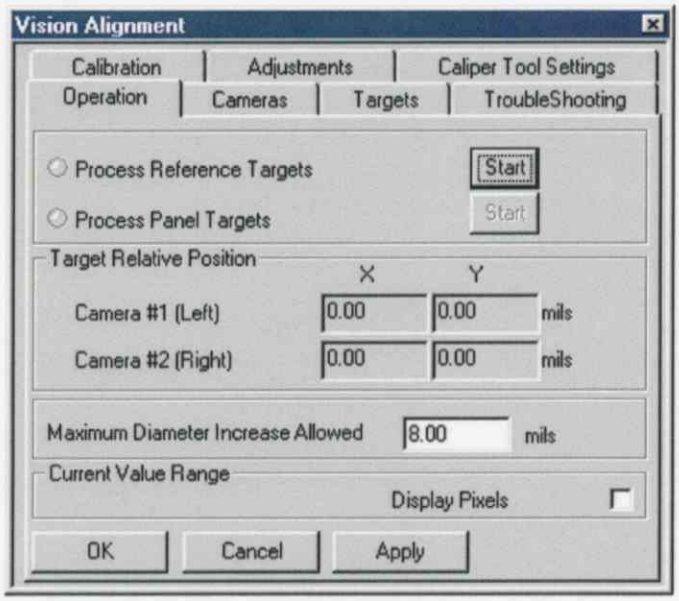
The Null Window Limits is the tolerance from the zero position set on each axis. The Null Window value uses both positive and negative limits. The value for X and Y axis is in linear travel, and Theta axis is in degrees. These values are factory set and should not be changed. Changing these values will affect the accuracy and the processing speed of the machine. The user can toggle the units between steps or mils using the Display Steps icon.

The leadscrew pitch used on each axis of the deck determines the Motor Steps Per Mil. This value should not be changed. The acceleration and velocity parameters determine the rate at which the motor pulses are sent to the motor drivers. The Seek Acceleration and Seek Velocity parameter are used when the deck is in the "Homing" routine.

The last section of the Maintenance folder shows the Current Value Range and also the Display Steps option. The Display Steps option allows the operator to toggle the units between mils or motor steps. The Current Value Range displays the limits for any highlighted section.

Vision Alignment

This section has the configuration variables that determine the color and size of the targets that are going to be processed by the machine. The Vision Alignment dialog box has six folders, Operation, Cameras, Targets, Troubleshooting, Calibration, Adjustments, and Caliper Tool Settings.

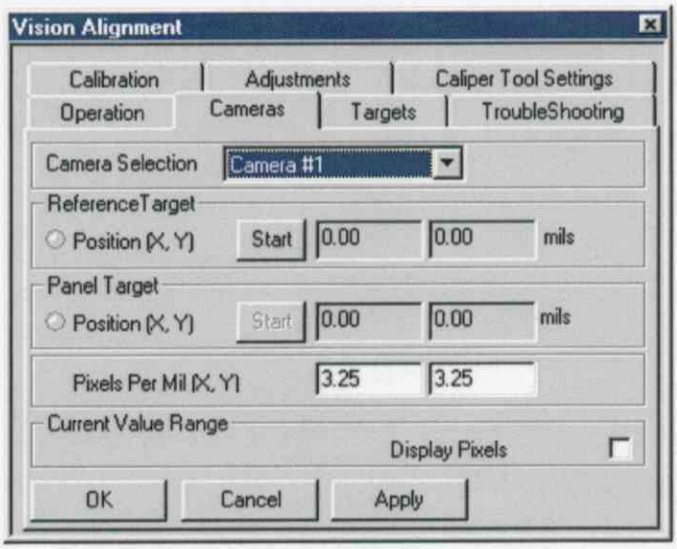


The Operation section allows the user to select the target to be processed. The Start icon for the Process Panel Targets will be highlighted if there is a panel in the machine. The Start icon for the Process Reference Targets will be highlighted if there is no panel in the machine.

The Reference targets are located in the machine and the Start icon will process the reference targets. The machine will calculate the sensitivity for the reference targets. Calculating sensitivity involves in confirming the size, area, center and circularity of the panel or reference target with a template of a perfect target stored in the machine.

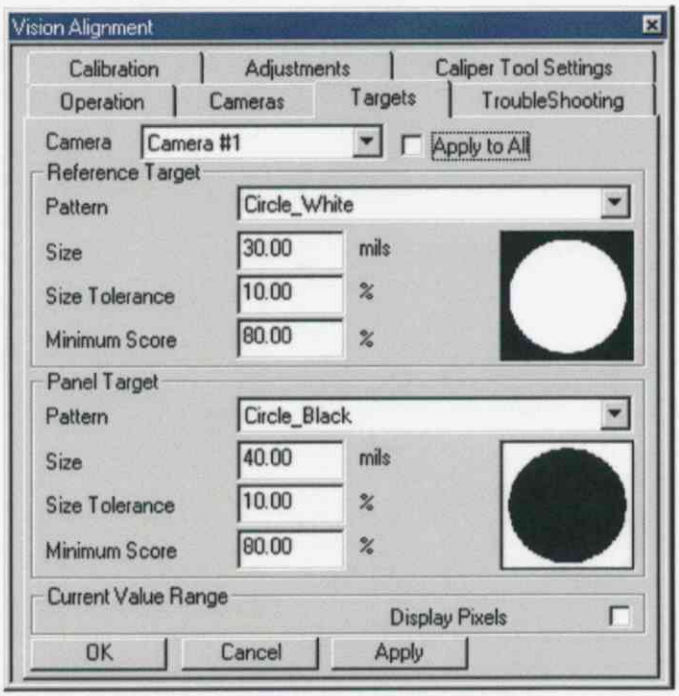
The X and Y axis positions are displayed for each camera. The vision system generates an X-Y coordinate system with the origin at the center of the reference target. The relative position is derived from this coordinate system. If there is an offset entered in the machine then the relative position will reflect the offset. The relative position can be displayed in either pixels or mils.

The Cameras folder allows the user to select one of the available cameras. It shows the position of the reference and panel target for the selected camera. It also shows the pixel per mils used to calculate the size of the targets. The Start icon will process the reference or panel target and reports the current position of the target in mils or pixels for the selected camera.



The pixels-per-mil shows the dimension of a camera pixel. This value is used in conjunction with the motor pulses per mil value to align the panel. The Display Pixels option allows the operator to toggle the units between mils or motor steps for the target position.

The Target folder displays the configuration and tolerance parameters set for the reference and panel targets. The option Apply to All is used to set all the cameras to the same parameters. The Color, Size (diameter), Size Tolerance, and Minimum Score are shown with default values.

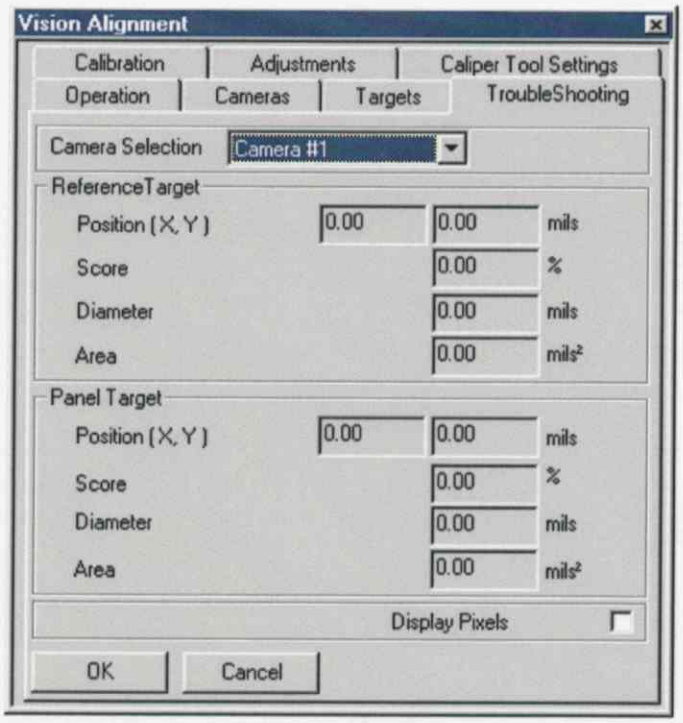


The target color is set to Circle_Black because of the stack up of targets. A Circle_Black target has a clear background with a solid target, and to Circle_White target has a solid background with

a clear target area. The target size (diameter) is the nominal diameter of the pad. The Size Tolerance has an upper limit of +10% and a lower limit of –10%. Therefore targets between 27 mils to 33 mils are acceptable. Reference target is a drilled hole and the vision system recognizes it as a white target.

The Minimum Score is a calculated by how well the target matches the template stored in the machine. A score of 100 is a perfect match. The default value is 80 and any value below 60 will display an alarm on the screen because accuracy maybe compromised.

The Display Pixels option allows the operator to toggle the units between mils or motor steps.



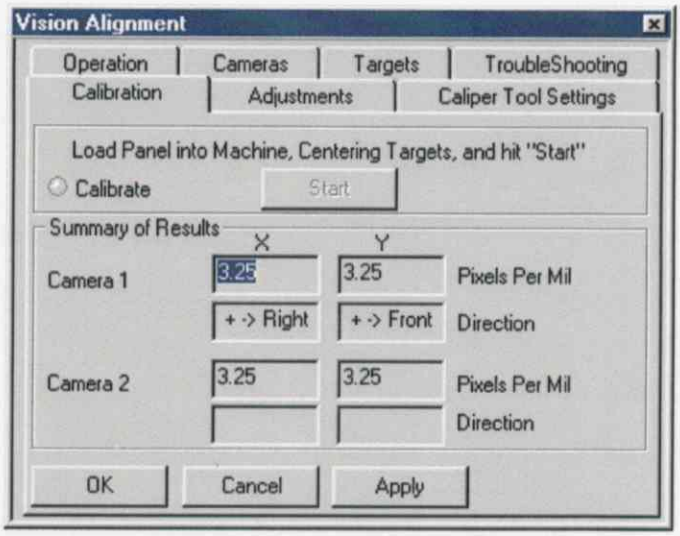
The Troubleshooting folder reports back the characteristics of reference and panel targets. The user can select either Camera #1 for the left side or Camera #2 for the right side. The top section shows the reference targets position in mils or pixels. The score, or circularity check, is displayed below.

The target Size (diameter) and area of the targets are determined using the pixel per mil value from the Cameras section of Vision Alignment. The Size is the average diameter of the target, and the area is calculated from pixel count and calculated from the diameter.

The main factors that affect target size and diameter are x-ray level and parallax, or alignment, of the camera and the x ray tube. For example if the x ray level is set very high the target area will be smaller and any misregistration will not be recognized by the vision system. On the other hand if the x-ray level is set too low the target will be larger than it should be. Since the size has changed (not uniformly) the center has also changed and this can lead to misregistration. The x-ray levels should be set using the X Ray Adjustment (F8) which reports the size of both targets

The Display Pixels option allows the operator to toggle the units between mils or motor steps.

The Calibration folder of the Vision Alignment section has a built in algorithm that calculates the pixels per mil values for X and Y-axis.

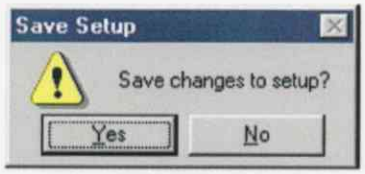


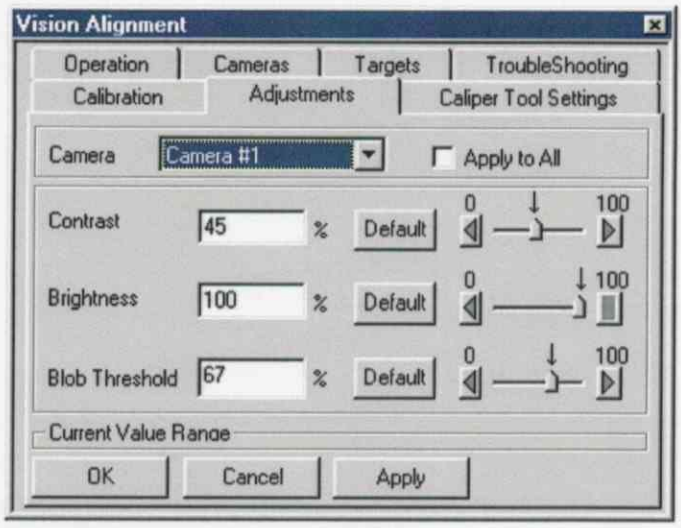
The operator should place a panel in the machine, adjust the x-ray level using the X Ray Adjustment screen (F8), and then click the start icon. The panel will move a set distance in both positive and negative of the X and Y-axis. The machine now will calculate the pixels per mil using the motor pulses and distance the targets moved on the screen. The direction field is used to account for deflections on the monitors, that is, a target that appears moving to the right is actually moving to the right. These settings are factory preset and should not be changed.

The Adjustments folder is used to fine-tune the image for the vision system. The Camera View, F3, displays the image from the left and right cameras. The Adjustments folder in conjunction with Targets and Troubleshooting folders can be used to optimize the machine's performance. The contrast and brightness can be adjusted using the mouse, or entering the desired value in the field or by using the using the TAB and arrow keys.

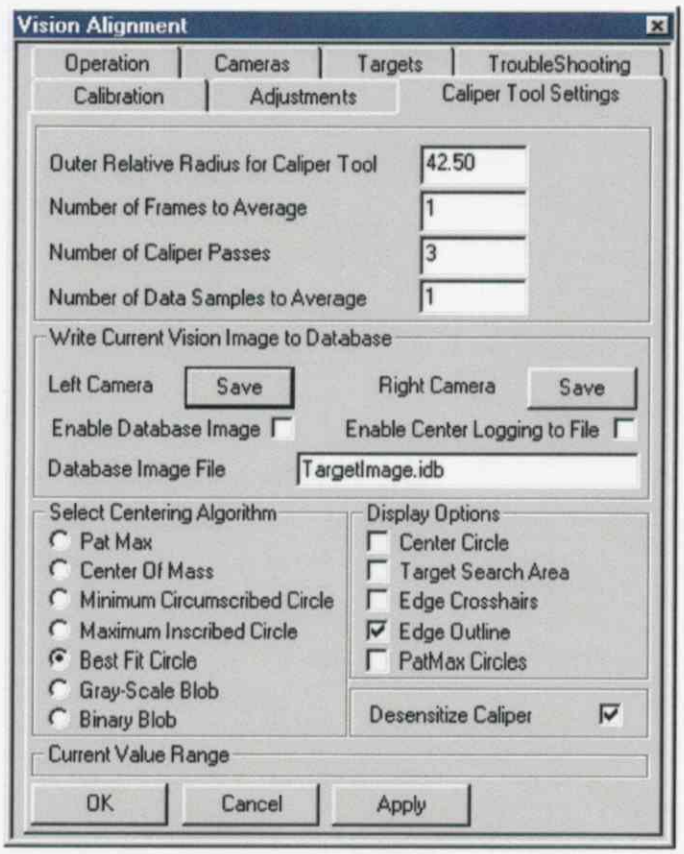
Blob is a threshold based edge detecting algorithm. The Blob Threshold determines where the system sets the edge of the target. Again using the Camera View screen (F3) and its zoom functions the operator should be able to adjust the x ray levels so that the vision system can "see" the true edge of the target.

The Camera View (F3) screen displays the panel target with an outline around the edge. Using the zoom features of the Camera View screen the operator can adjust the X-ray level such that the vision system can "see" the true edge of the target. The Brightness and Contrast adjustments can be made to fine tune the vision to detect the true edge of the panel target. The adjustments made on the screen can be viewed on the Camera View (F3) screen. Either camera can be selected independently and the changes made are saved as part of the setup. Upon clicking OK the machine would prompt to save the changes made.





The Default icon will restore the Contrast, Brightness ,and Blob Threshold settings to factory preset values.



The Caliper Tools Settings section is primarily used as diagnostic tool for engineers. The top section describes the template image stored in the machine. This is the image that the machine compares to when it processes the panel or reference targets.

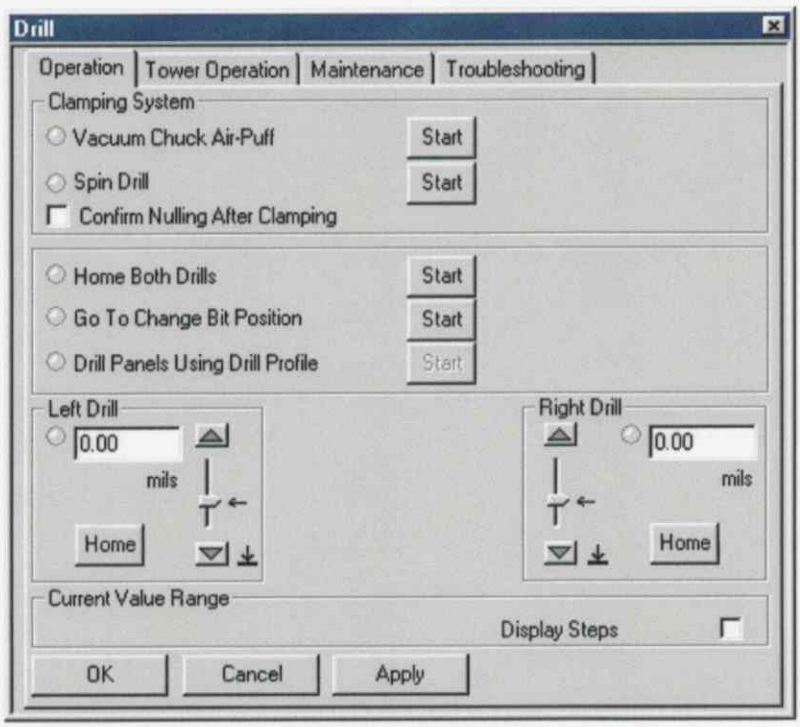
The second section allows the process engineer to save the panel target images to a database. The Enable Center Logging to File is used to save the center of the targets to a file in the database. The Database Image File is the name of the template image that is used when the vision system calculates the score.

The Select Centering Algorithm displays the available algorithms to determine the edge/center of the panel target. The commonly used algorithms are displayed on the X-Ray Adjustment (F8) screen. The Select Centering Algorithm screen allows the Process Engineer to use different combinations of the edge detecting methods for testing purposes. The Camera View screen (F3) displays the target and draws an outline on the edge of the target. Using the zoom in/out feature on the Camera View screen and the reported target diameter on TroubleShooting or the X-Ray Adjustment (F8) screen the Engineer should be able to select a particular algorithm that works best with the type of materials/construction used in the process.

The Display Options shows the different displays available for the Camera View screen.

Drill

The Drill window has four folders. The Operation section allows the user access to the individual drills and drill towers.



The Clamping System is the first section on the Operation folder. The Vacuum Chuck Air-Puff is used to release a panel that is held by the platen. The Spin Drill is used to turn the drill spindles on. The Confirm Nulling After Clamping should be enabled during production. This checks the position of the panel after the drill clamps come down, and verify that it has not moved out of the

Null Window. Disabling this feature may increase throughput, but can compromise the accuracy of the machine.

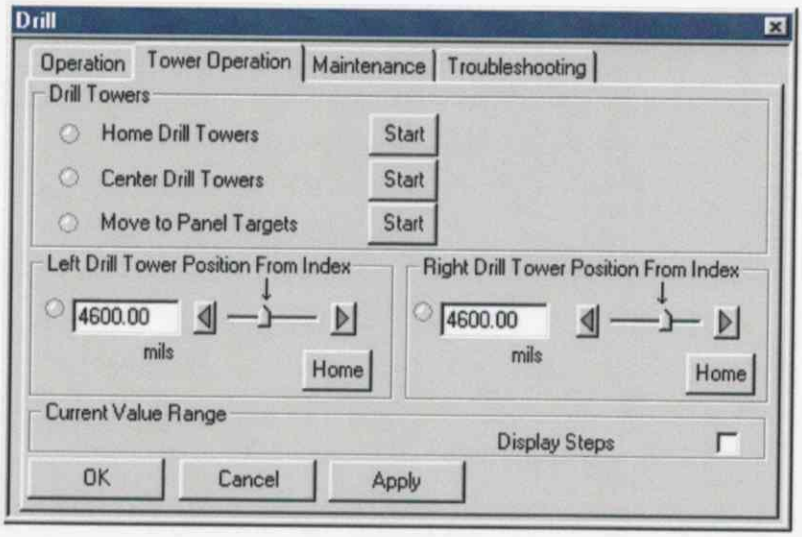
The Start icon for Home Both Drills will move both of the drill heads to the top and bottom limits. The Go To Change Bit Position will move the drills to drill bit change position. Use the supplied torque wrench to replace the drill bits and cover the area above the clamps such the drill bits do not fall into to it.

The Start icon on Drill Panels Using Drill Profile is used to drill the panel with the current settings. The current profile can be changed by clicking on the JOB icon. The Drill profile can be changed by increasing/decreasing the panel thickness and /or the drill diameter.

The last section on the Operation page shows a pictorial of the left and right drill with their limit switches. The drills can be moved up and down individually, using the slider with the mouse. After the slider is highlighted, the arrow keys or the page up/down keys. The arrow keys move the drill in small increments of about half a mil, while the page up/down in large increments of approximately one inch. The drill can also move a to particular position by typing a value in field which displays the current position.

A small arrow is depicted when the drills reach a limit. When controlling the drill using the slider make sure that the clamps are in the down position. If the clamps are not down this may cause damage to the collet and also cause stress on the drill motor

The drill Towers are the two large assemblies in the machine on which the drill heads and the x-ray system are mounted. The towers are mounted on an IKO rail and acquire their positional accuracy via glass scales mounted parallel to the IKO rail. The Tower Operation page displays the manual control functions of the drill towers.

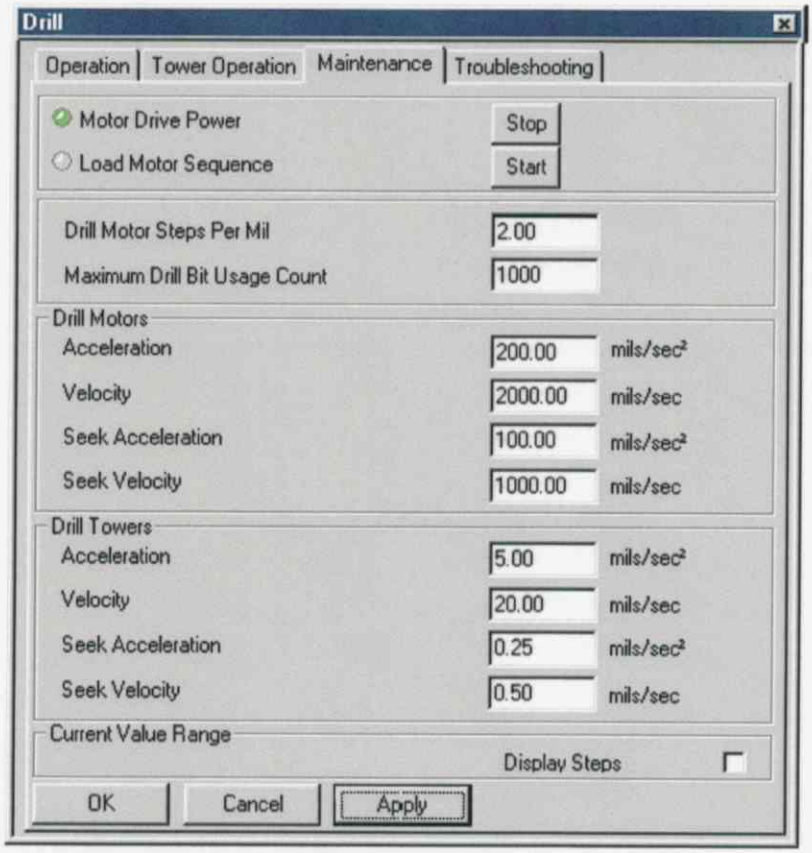


The Start icon on the Home Drill Towers will move the towers to the outside limit switch. If the x rays are on the reference targets may be visible but they will not centered on the screen.

The Center Drill Towers will move the towers to the Index Pulse on the glass scale. The towers will first move to the inside of the machine and then move to the Index Pulse. The Index Pulse is the home switch on the glass scale, and this position is physically marked by a arrow on the center glass scale cover.

The Move to Panel Targets icon will bring the towers to the current panel size position. The last section on the Tower Operation page shows a pictorial of the left and right towers with their limit switches. The towers can be moved left and right individually, using the slider with the mouse. After the slider is highlighted, the arrow keys or the page up/down keys. The arrow keys move the drill in small increments of about 0.05 mil, while the page up/down in large increments of approximately four inches. The drill can also move a to particular position by typing a value in field which displays the current position.

The Display Steps option allows the operator to toggle the units between mils or motor steps. The Current Value Range displays the limits for any highlighted section.



The Maintenance folder in the Drill page contains the configuration variables. These values are preset from the factory and should not be changed. The Motor Drive Power toggle switch turns on or off the power to the motor driver for the deck. If the motor driver has been turned off then the drill and towers should be "homed" again.

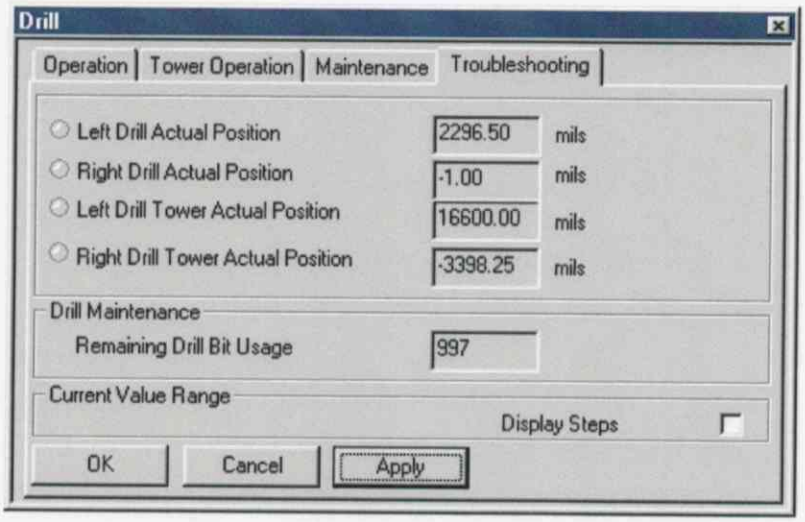
Load Motor Sequence is used if there is an error with the motor drivers. This option reloads the original motor parameters into the machine, and reinitializes them. The drills and towers will have to be "homed" again.

The leadscrew pitch used to determine the Motor Steps Per Mil. This value should not be changed. The acceleration and velocity parameters determine the rate at which the motor pulses are sent to the motor drivers. The Maximum Drill Bit Usage Count is used as a reminder to change the bits after the set number of hits.

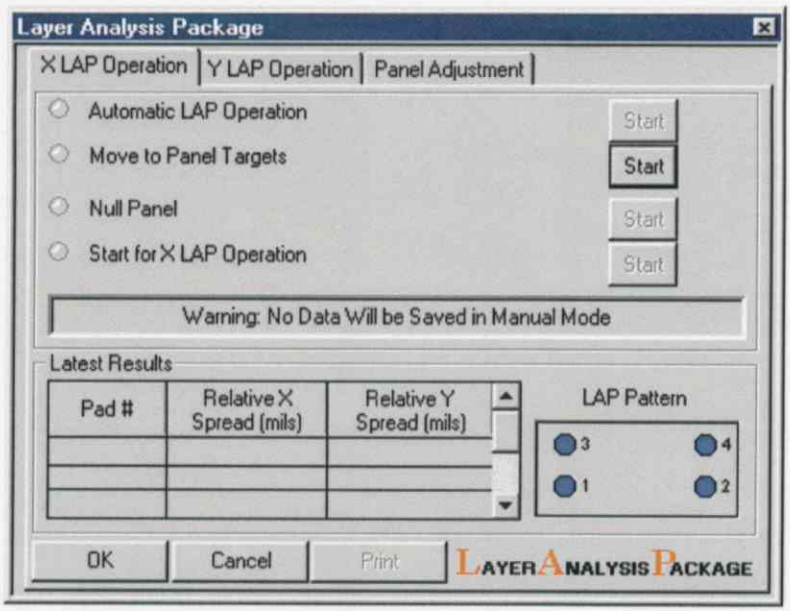
The Seek Acceleration and Seek Velocity parameter are used when the drills and towers are in the "Homing" routine, and the Acceleration and Velocity parameter are used during normal operation. The drills and tower sections have individual profiles.

The last section of the Maintenance folder shows the Current Value Range and also the Display Steps option. The Display Steps option allows the operator to toggle the units between mils or motor steps. The Current Value Range displays the limits for any highlighted section.

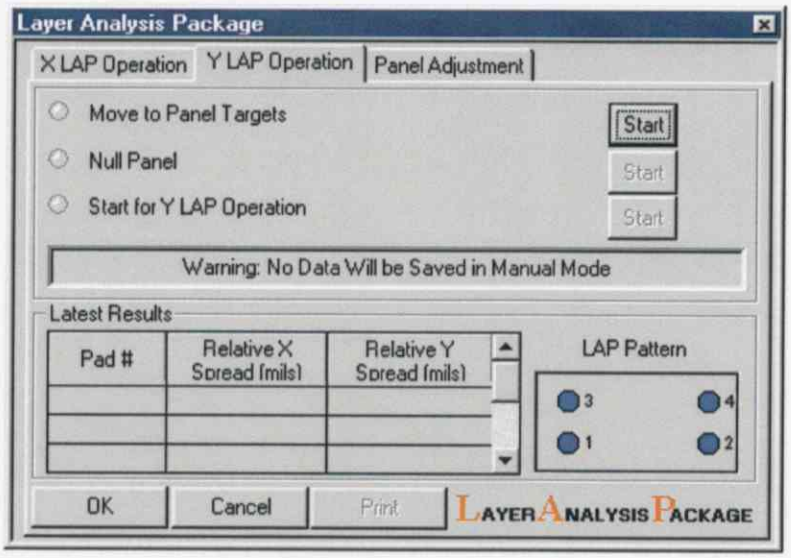
The Troubleshooting section is the last page of the Drill folder. The Troubleshooting folder is used to determine if there is any play or malfunction in the drill or the tower. It shows the actual position of the left and right drills and the left and right towers. The Drill Maintenance display the remaining hits on the current drill bits. The Display Steps option allows the operator to toggle the units between mils or motor steps. The Current Value Range displays the limits for any highlighted section.



The next section under Devices is the Layer Analysis Package™ or LAP. The Layer Analysis Package™ allows the user to calculate the spread values for both X and Y axes for each individual layer on a multilayer panel. This feature requires additional x-ray targets to be plotted and etched on each layer in a prescribed location



The X LAP Operation folder allows the user to perform LAP in the X axis. The Automatic LAP Operation Start ion will start the LAP process by nulling on the stackup. The panel will be moved to the first LAP target as prescribed in the LAP profile. The x-ray level should be adjusted so the single layer target can be processed by the vision system. The vision system creates a region of interest for the LAP target by making a blue square pad on the Camera view, (F3).



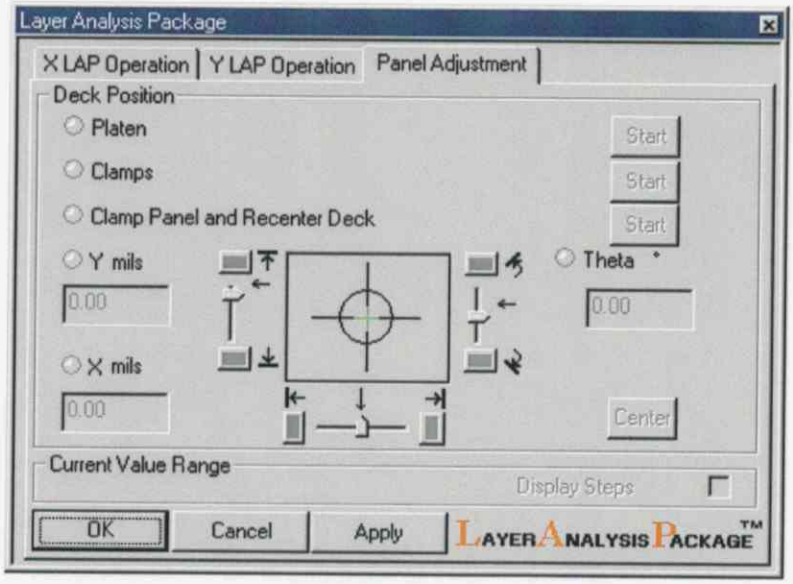
If the LAP target is not completely inside this region of interest then a bad image error will be prompted on the screen. The Panel Adjustment tab is used to adjust the panel position so the LAP target is in region of interest of the vision system.

The Y LAP Operation folder allows the user to perform LAP in the Y axis. The Start icon for Move to Panel Targets will position the drill towers to Y panel size as entered in the job setup. The Null Panel Start icon, will start the LAP process by nulling on the stackup.

The Start for Y LAP Operation will move to the panel first LAP target as prescribed in the LAP profile. The x-ray level should be adjusted so the single layer target can be processed by the vision system. The vision system creates a region of interest for the LAP target by making a blue square pad on the Camera view, (F3).

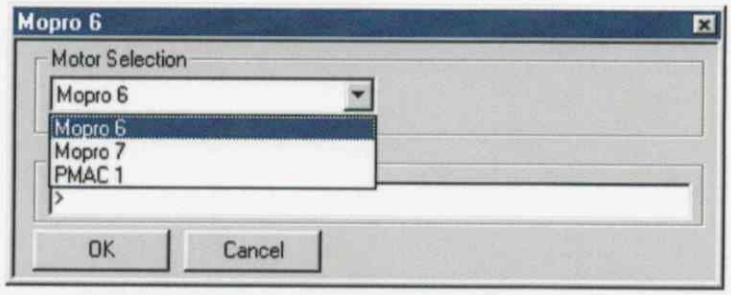
The data generated by the LAP process is stored in the Setups directory. It is stored with the setup as the filename and *.LAPResults* as the file extension. The file has a title with LAP Result Data and below this is a row that contains the header data. The LAP results are stored below and the data is separated by commas.

The Panel adjustment folder can be used to move the LAP targets into the region of interest. The platen and clamps can be activated individually to hold the panel. The Clamp Panel and Recenter Deck is used to bring the deck back to home position without moving the panel. This is used when the deck is at the end of its travel is a particular axis.



The next section under Devices is the Motor Commands. This folder allows access to the motor drivers of the machine. You can select the Mopro driver under Motor Selection and enter simple commands or execute small routines in the Motor Command.

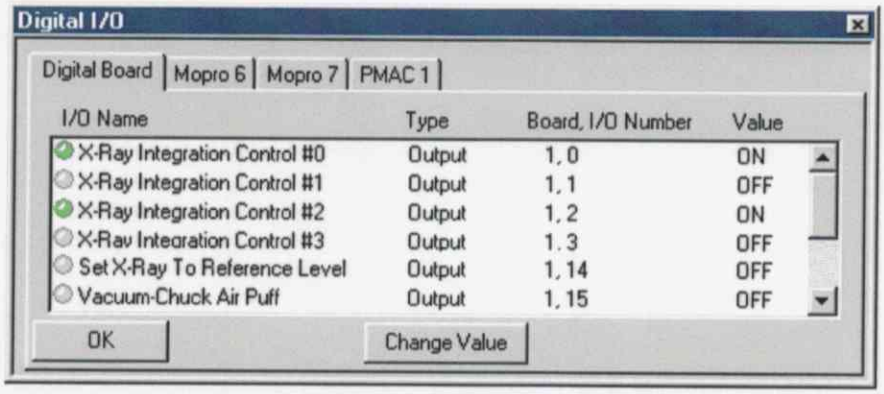
The Mopro driver can have from 4 to 6 axes. An axis can control the motion, both positive and negative, of a forcer motor, single punch block drive unit, an axis of the deck, or a drill motor. Mopro 6 controls the deck and Mopro 7 controls the drill. PMAC 1 is used to get feedback from the glass scales used to control the drill towers.



As a precaution be very careful when using Mopro commands because all of safety provided by the Optiline software are bypassed.

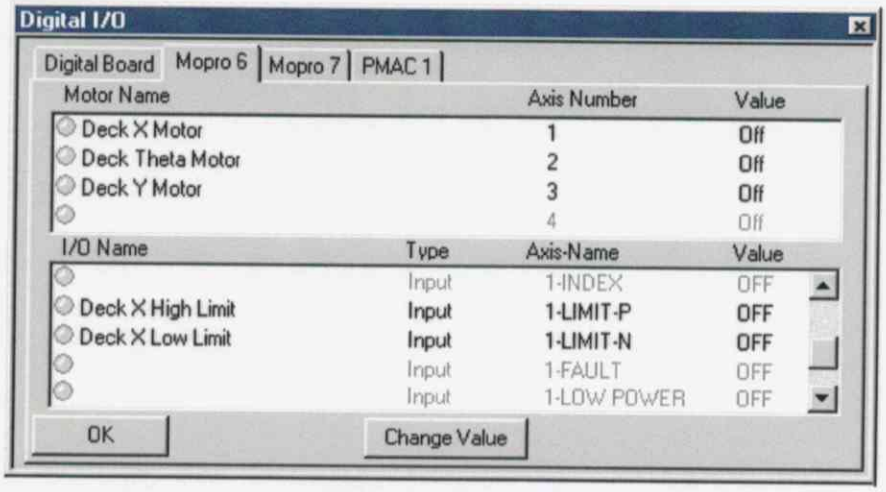
Digital I/O

The Digital I/O section displays the state of the different inputs (I) and outputs (O) of the machine. This section is mainly used as a troubleshooting guide. The Digital Board folder shows the name of the signal, type, location, and current value. The signals that are on or in the logic one state are displayed with a green light. The state of the input or output can be toggled using the mouse (double click) or select the signal and click on icon Change Value.



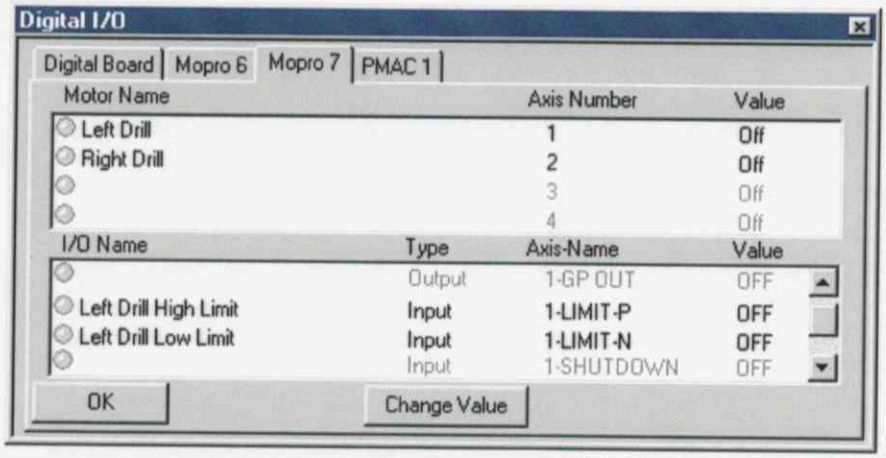
NOTE: Changing the state of inputs and outputs can lead to an unsafe condition where the safety features of the machine can be bypassed.

The second section of the Digital I/O contains the Mopro 6 folder. The top section shows the different deck motors controlled by Mopro 6. It shows the axis on the deck with the corresponding axis on the Mopro and the state of the driver.

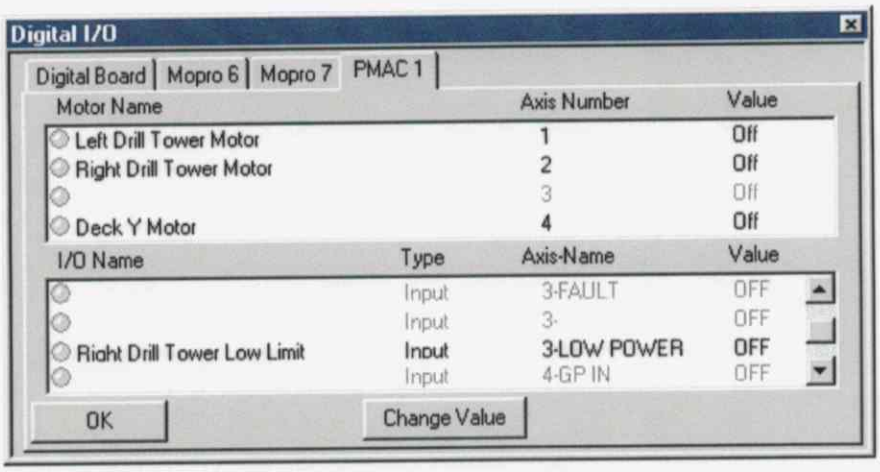


The bottom half shows the name of the signal, type, location, and current value. This section mainly contains the soft and hard limit switches for each axis of the deck. The state of the input or output can be toggled using the mouse (double click) or select the signal and click on icon Change Value.

The second section of the Digital I/O contains the Mopro 7 folder. The top section shows the drill motors controlled by Mopro 7. It shows the axis on the drills with the corresponding axis on the Mopro and the state of the driver.



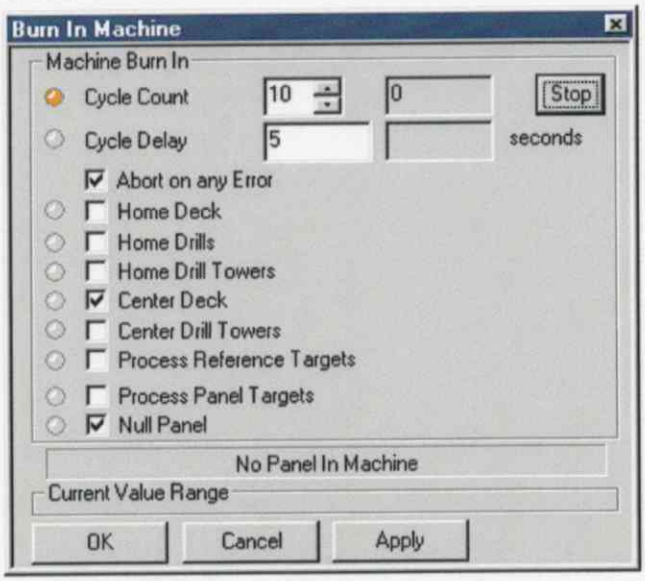
The bottom half shows the name of the signal, type, location, and current value. This section mainly contains the soft and hard limit switches for each axis of the drill motors. The state of the input or output can be toggled using the mouse (double click) or select the signal and click on icon Change Value.



The PMAC 1 folder controls the limit switches for left and right glass scales to drill towers and the glass scales for the Y axis (long move). The PMAC 1 software along with servo amplifiers and motors are used to control the drill towers. The Y axis glass scale is controlled by the PMAC 1 software but driven by MOPRO drivers.

The bottom half shows the name of the signal, type, location, and current value. This section mainly contains the limit switches for the towers. The state of the input or output can be toggled using the mouse (double click) or select the signal and click on icon Change Value.

The last item on the Devices section is Burn In Machine. This section is used as a troubleshooting aid, and is only available from Manual mode. The Burn In Machine is setup to be used as a programmable loop tape. The functions are selectable and the cycle count allows the user the set the number of times you want the machine to repeat the function.

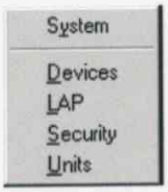


The Cycle Delay sets the time between the test events. The delay time is set in seconds. The delay time should be set such that there is sufficient time to complete a single test before beginning a next cycle.

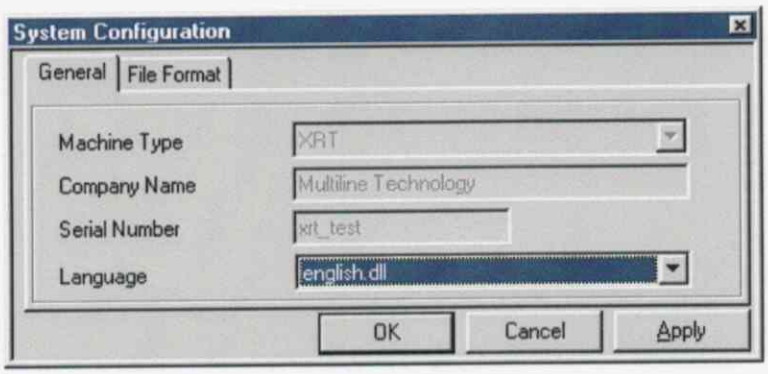
Selecting the Abort on any Error options exits the loop tape test and displays an error message on the bottom. The cycle count will update itself (green light) after each test (yellow light) is completed.

Configuration

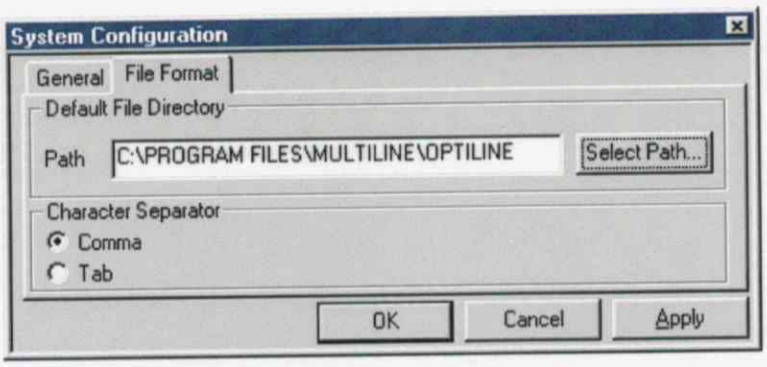
The Configuration option controls the basic system setup. There are five sections; System, Devices, LAP, Security, and Units.



The System Configuration has two folders. The General folder contains information about the machine type, serial number, company name and the language for which it is currently configured. The Language currently selected is the English.DLL. If another language is available select the new language, but the application must be restarted for the new language to take effect.

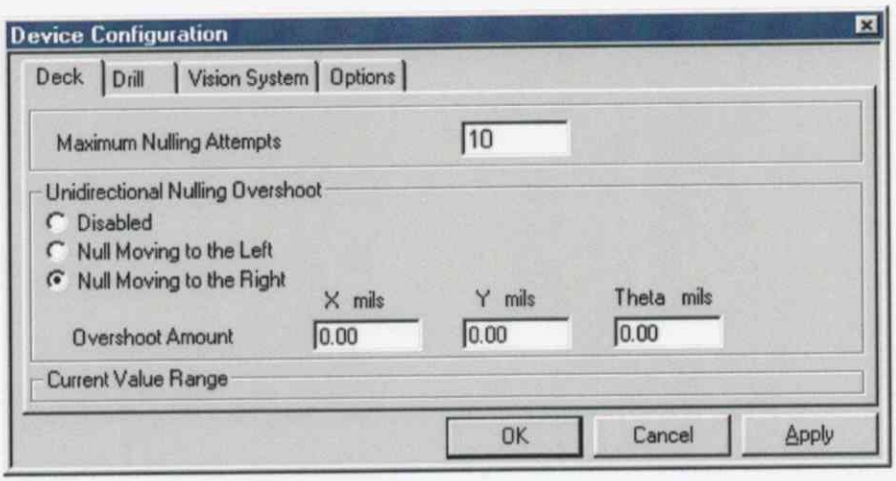


The last folder in the System Configuration is the File Format. This contains the path to the location where the Optiline program is stored. The Character Separator (comma, or tab) is used as a field delimiter when importing spread and job data files into another spreadsheet (i.e., Excel) to graph or view the data.



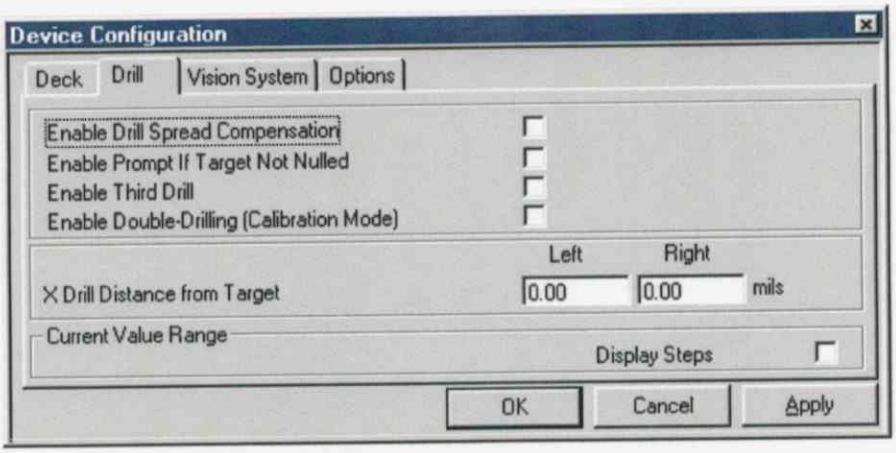
The Device Configuration page contains four folders Deck, Drill, Vision System and Options. The configurations are factory set and should not be changed. This page contains information about the features and options available on the machine.

The Deck folder has the configuration variables for Maximum Nulling Attempts, and Unidirectional Nulling Overshoot.



The Maximum Nulling Attempts is the number of times the system tries to align the panel to the "Null" or optimum position. If the panel is not aligned within 10 attempts the machine will report an error. A panel that is bowed or has excess flashing may cause this problem.

The Unidirectional Nulling Overshoot is a feature that is widely used on CNC machines. This enables the system to always null from the same direction. The direction and the amount of the overshoot are configurable by the user.



The Drill folder displays the available drill options. The Enable Drill Spread Compensation drills the board after adding the spread to the nominal distance. Therefore the hole to hole distance on the panel will vary according to the spread. The Null Correction must adjusted for this option to function properly.

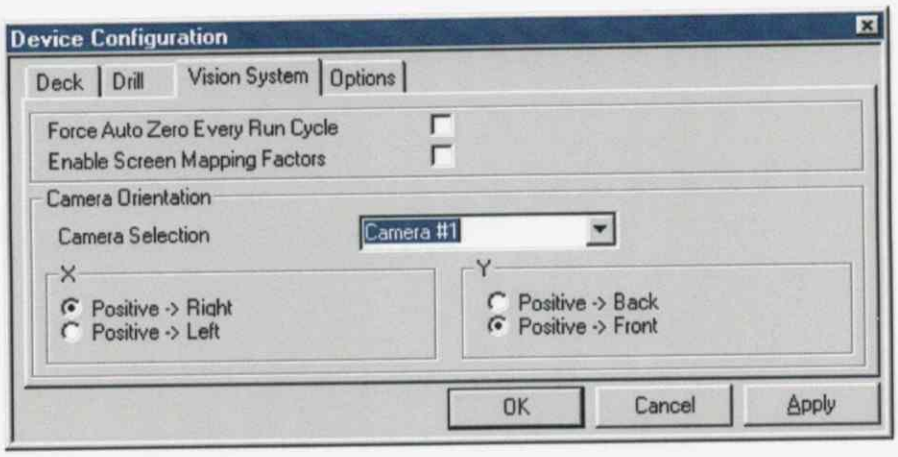
The Enable Prompt If Target Not Nulled displays an unload panel message for any reason the machine does not null the panel. Typically the panel is unloaded without the prompt.

The Enable Third Drill option is used on machine with a third movable drill. The distance for the third movable is prompted during setup. For machines with fixed third drill this prompt should be disabled.

Enable Double-Drilling (Calibration Mode) is used to test the long move. With this option enabled the machine will null and drill on the panel targets first and then make a long move and drill again. This double-drilling mode decreases the machine throughput and is typically only used during calibration.

X Drill Distance From Target allows the user to drill a set distance from right or left of the centerline of the target. The machine will null the panel, and then move either or both of the drill towers the preset amount before drilling the panel.

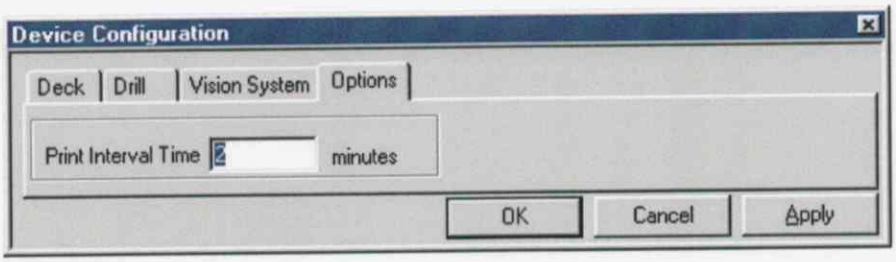
The Vision System folder controls the coordinate orientation for the cameras and the number of cameras present. The Camera Orientation defines the coordinate system for the vision system. The X and Y coordinates are selectable per camera. This is factory set and should not be changed.



The Force Auto Zero Every Run Cycle option will have the machine process the reference targets for every new job. Typically if the new job has the same panel size then the machine would skip the Auto Zero section to save setup time. But if a different size panel is to be processed, the software will automatically process the reference targets (Auto Zero).

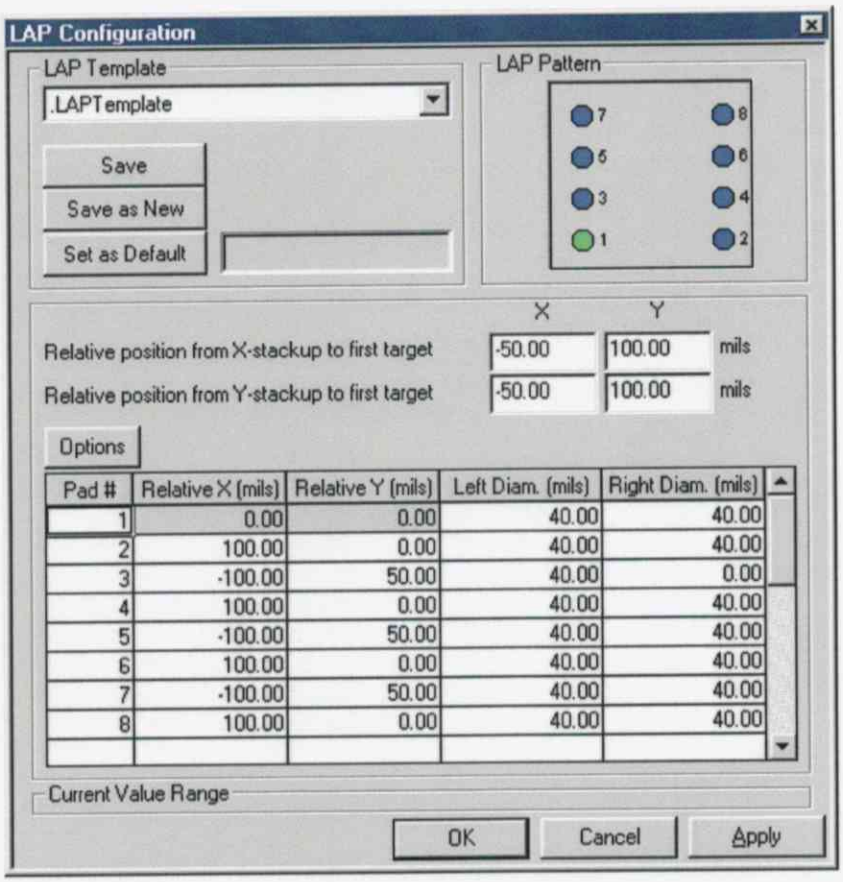
Enable Screen Mapping Factors was an algorithm designed to be used with older analog cameras. This feature maps the screen and depending on the position of the target, compensates for the slight variation in pixel size. The Windows system uses CCD cameras and therefore the variation in pixel size is negligible. This feature should be disabled

The Options folder shows the available options with the machine, currently the Print Interval Time. The Print Interval Time sets the delay for the buffer data to be printed. A page is printed at a time as the buffer fills up during production. If no new data is in the buffer then it will it will print out its contents after the set interval time.



Layer Analysis Package™

The Layer Analysis Package™ (LAP) is a software package that permits the user to calculate spread values for both the X and Y axis for each individual layer in a multilayer panel. This feature requires additional x-ray targets be plotted and etched on each layer in a prescribed location. Refer to the Layer Analysis Target Configuration Drawing Supplied with the system. The data from the LAP is displayed on the monitor and can be saved to file.



The LAP configuration page is used to setup different templates or LAP matrix profiles. The LAP template section is used to save an existing profile, rename an existing profile, and set a default profile. The Save icon stores the LAP profile entries under the filename displayed in the LAP Template field. If there is already an existing profile with this name, it will be *edited* to reflect the current values of all the fields

The Save As New icon prompts the user to enter a new filename. All of the information on this page will be saved as a new profile with this name. LAP profile filenames automatically get the extension *.LAPTemplate*, so do not include the extension in the name. The Set As Default icon sets the current profile as the default used with all setups that enable LAP. Note that the current profile is the one named in the LAP Template field.

The LAP Pattern of the current profile is displayed in the top right section. The targets are displayed and their relatives positions to each other.

The Relative position from X-stackup to first target sets the distance to the first LAP target to be processed in the X (long axis) direction. This distance is based from a coordinate system, which uses the X stackup of targets as the origin. The X and Y values should have the proper magnitude and direction to the center of the first LAP target.

The Relative position from Y-stackup to first target sets the distance to the first LAP target to be processed in the Y (short axis) direction. This distance is based from a coordinate system, which uses the Y stackup of targets as the origin. The X and Y values should have the proper magnitude and direction to the center of the first LAP target.

The Options icon facilitates in creating or editing existing LAP profiles by using common functions as Copy Row, Insert Row, Delete Row, and Paste.

A LAP profile is created by table which contains the relative positions of the targets on the individual layers with respect to the stackup. The first pad, or LAP target, has a relative position of 0.00 mils in X and Y axes. These fields are grayed out because The Relative position from X-stackup to the first target sets the origin at the stackup and the position for the first pad.

The Left Diameter sets the size of the left LAP target. The Right Diameter sets the size of the right LAP target, and they can be different. If a number of consecutive targets have the same diameter, entering the first and last values and then clicking on them in order will automatically fill in the intervening entries.

The Relative X and Y entries must be determined from the Panel Layout Drawing. Their signs are determined as follows:

> If the current target is above and to the right of the previous target, then the relative X and Y entries are both positive. If it is directly to the right of the previous target, the relative X entry is positive and the relative Y entry is 0.00.

Insert preventative maintenance sheet here.

Calibration

This process confirms the target to drilled hole and target split verification for the X-Ray Tooling & Inspection (XRT) systems.. The accuracy of the XRT is confirmed by using a copper clad panel about 0.062" thick. Drill a series of holes along the two panel edges representing the target locations for the panel size selected. The space between holes on the edge should be ½" so that the XRT will not drill out the target positions. The drilled hole size is typically 0.060".

In Manual mode click on the JOB icon on the toolbar and then select the Camera Targets folder. In the Camera Targets screen change the Camera 1 and Camera 2 (or select Apply to All for both cameras) Size (Diameter) to the diameter of the drilled hole. Also change the target Color to White since the drilled holes appear as a white center with a dark background. Click on OK and then switch to the Semi automatic mode to process the test panel.

Align the panel so that the first pair of targets (drilled holes) will be in the field of view of the cameras. Press Start and have the system position and null. If the appearance on the monitors is satisfactory, press Ok and drill the panel. Record the reported Spread value for the first set of targets.

Align the panel so that the second pair of targets will appear on the monitors when loaded into the cabinet. Null and drill the panel. Mark these holes as sample #2 and record the Spread value. Repeat this process until five samples have been aligned and drilled.

Verifying

The features drilled by the system always define the panel center. The front to back datum (Y axis) is established by the centerline of the left and right drilled hole. The left to right datum (X axis) is established by the centerline of the distance between the two drilled holes perpendicular to the Y axis. See the figure below and note the convention of positive and negative directions from the datums established above.

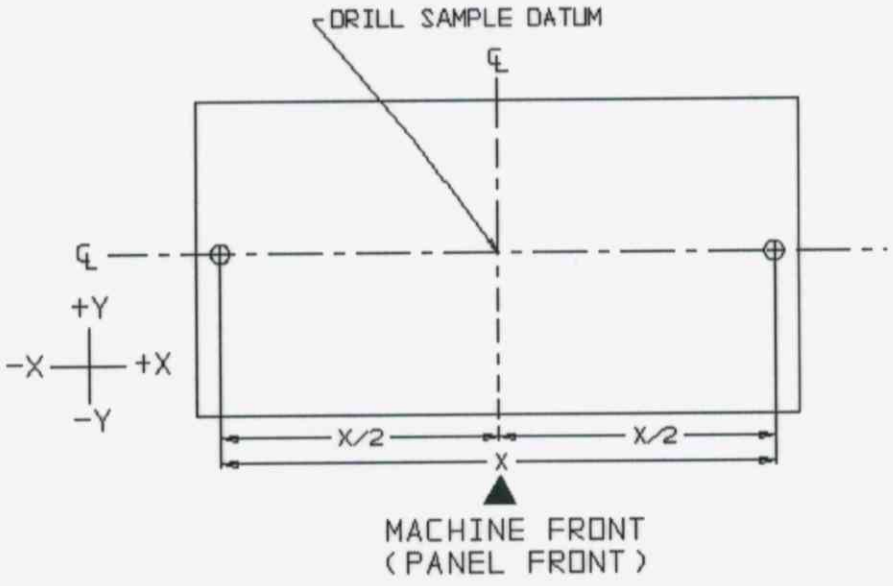


Figure 1

Measure and record the target positions, T1 and T2 from the datum in both the X and Y axes target positions are termed Y1 and Y2 for the left and right target from the Y axis and X1 and X2 from the X axis. See the figure below.

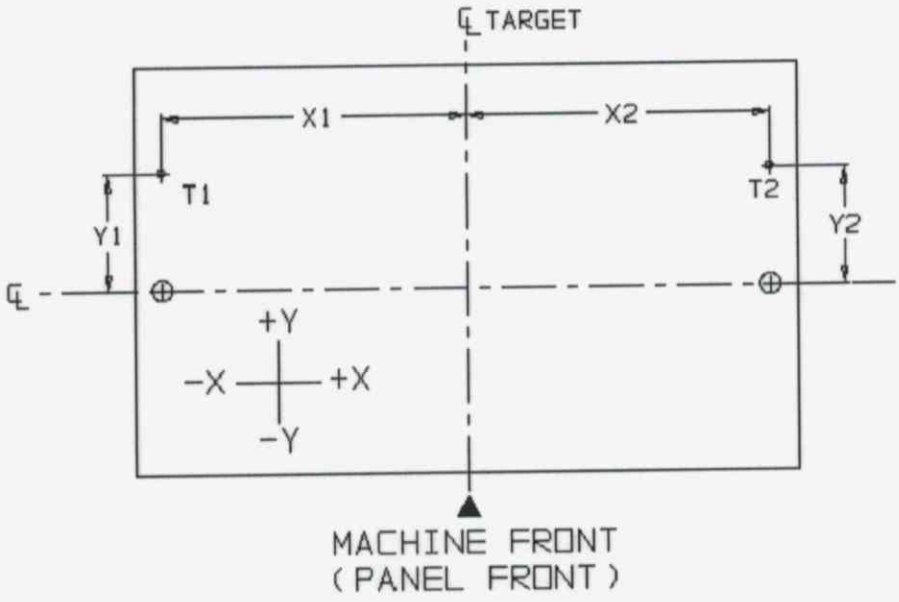


Figure 2.

Compare the average target locations Y1 and Y2 to the nominal Panel Layout dimensions. The difference between the nominal dimension and the average actual dimension will determine if a processing offset correction is required.

Compare the average target location, X1 and X2, to each other to determine if the targets are the same distance from the datum. This is the "split the difference" capability of the system. If X1 and X2 are not equal within the tolerance specified on the Panel Layout drawing, then an offset correction in X is required.

Refer to the Target Calibration/Verification Chart that follows.

Example: If the <u>average</u> of the measurement data is the following;

Test Measurement Example

Description	Location	Actual Value (inches)	Print Nominal	Error from Nominal	Error Direction
T1 target	X1 Y1	-11.6196 + 2.8761	-11.6250 + 2.8750	+.0054 +.0011	+ (right) + (up)
T2 target	X2 Y2	+11.6221 + 2.8738	+11.6250 + 2.8750	-.0029 -.0012	- (left) - (down)

The measurement data in this example indicates that the drilled holes are skewed with the target to drilled hole in the Y direction on the left side greater than nominal and the target to drilled hole on the right side shorter than nominal.

The X error is calculated as follows:

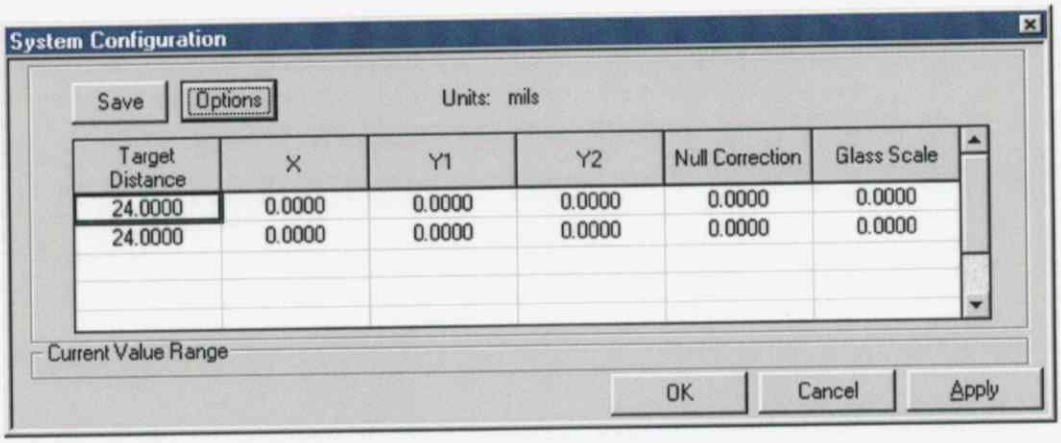
$$\frac{[X1] + [X2]}{2} \text{ or } \frac{[+.0054] + [-.0029]}{2}$$

equals +.00125".

The fact that the split is positive indicates that the system is not splitting the error in the center of the panel and that the drilled holes to the targets are off-center by .0012" to the right, or positive direction.

When entering measurement data on the Target Calibration/Verification Chart, it will be best to enter the readings in mils (thousandths of an inch) or microns. This is because the offsets in the configuration files are in mils and changes will be easier to understand.

Once the average errors have been calculated for X, Y1, and Y2, the change required to the offset file is to reverse the sign of the average error. The change must be added to the offset value presently in the configuration file for that panel size if there are any.



The Glass Scale offset column is used to fine tune the hole to hole distance per panel size. The Calibrate Index to Index Distance is used to based on the index pulse located on the glass scale, and that is a general value applied to all the panel sizes. The Glass Scale offsets use this general value and then add/subtract the desired amount to achieve optimal hole to hole distance. If you want to increase the hole to hole distance by 2.5 mils then enter a –2.5 mils offset into the Glass Scale offset column and vice versa. Null Correction is discussed in the next section.

The following page is an example of the chart used to collect data and calculate new processing offsets for your Vision System based machine. Please feel free to photocopy or otherwise reproduce this chart for your own use.

Target Calibration/Verification Chart

Test conducted by:_____ **Date:**_____

Machine Serial Number:_____

Panel size: X= ***24"*** **, Y=** ***18"***

	X1	Y1	Y2	X2	X error
Sample 1	*+5.4*	*+1.1*	*-1.2*	*-2.9*	*+1.2*
Sample 2	*+5.6*	*+1.2*	*-1.4*	*-3.1*	*+1.2*
Sample 3	----------	----------	----------	----------	----------
Sample 4	----------	----------	----------	----------	----------
Sample 5	----------	----------	----------	----------	----------
Average	*+5.5*	*+1.1*	*-1.3*	*-3.0*	*+1.2*

Note: all values are in mils (thousandths of an inch)

Offset Correction	Average Error	Change Needed
X	*+1.2*	*-1.2*
Y1	*+1.1*	*-1.1*
Y2	*-1.3*	*+1.3*

Machine offsets prior to testing	X= *+0.8*	Y1= *+1.7*	Y2= *-2.0*
Calculated offset change needed	X= *-1.2*	Y1= *-1.1*	Y2= *+1.3*
New offset value to be Entered	X= -0.4	Y1= +0.6	Y2= -0.7

Target Calibration/Verification Chart

Test conducted by:_____ **Date:**_____

Machine Serial Number:_____

Panel size: X= _____ **Y=**_____

	X1	Y1	Y2	X2	X error
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Average					

Note: all values are in mils (thousandths of an inch)

Offset Correction	Average Error	Change Needed
X		
Y1		
Y2		

Machine offsets prior to testing	X=	Y1=	Y2=
Calculated offset change needed	X=	Y1=	Y2=
New offset value to be Entered	X=	Y1=	Y2=

CHANGING OFFSETS

Once new offset values have been determined it is necessary to add them into the Configuration File for the panel size calibrated. It is possible that each panel size processed may carry its own particular offset values.

Null Correction

Null Correction can be calculated while you are calculating offsets. Using the reported spread value per test panel and determine an average. Using the Coordinate Measuring Machine measure the target to target distance (T1 and T2). See Figure 1 for proper target position nomenclature.

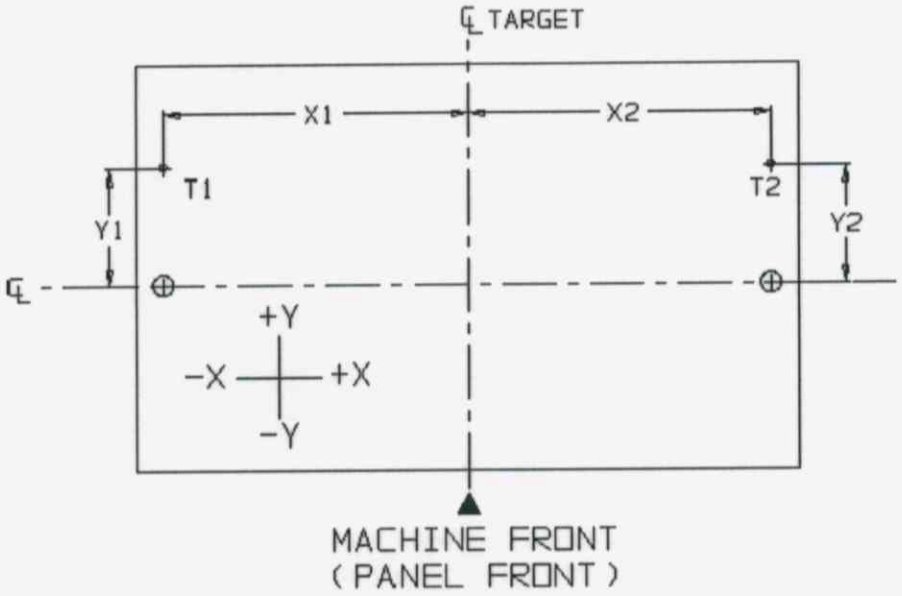


Figure 1- Target Position Nomenclature

Measure and record the target to target (T1 to T2) distance for each panel and compare this value to the SPREAD value plus the panel size (nominal target to target distance) for each panel.

*** NOTE SPREAD value is reported in mils or microns and should be converted to inches or millimeters before adding to nominal target to target distance.*

Null correction = distance (T1 to T2) – (SPREAD+nominal target to target distance)

The difference between these numbers is the Null Correction factor. This number (in mils) can be entered into the last column on the offset page. If there is null correction factor for this panel size then the new value must be added to the existing value. The machine can be fine-tuned by following this procedure for each panel size.

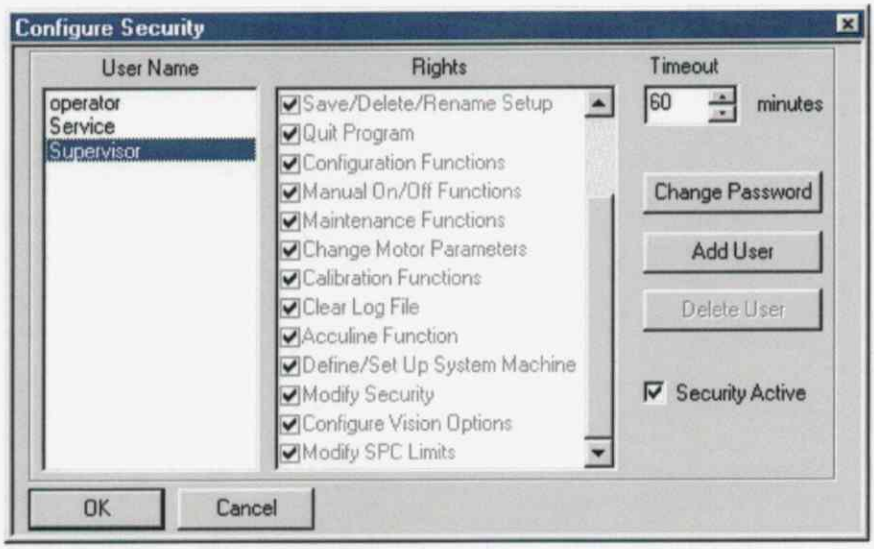
Once you have entered the null correction factor into the offset page go into semi mode and process the panel again. The spread value reported by the machine plus the nominal target to target distance should very close to the actual target to target (T1 to T2) distance.

Now you can take this panel and process it in the SEMI mode on another machine. Record the spread value reported by the machine, and use the above formula to calculate the Null Correction Factor. This process should be done on every machine so they all report the same spread value.

Now all the machines should report the same spread value for the test panel we used. Based on this information the operator can set the proper limits for the UPPER and LOWER tolerances. Keep one of the test panels a "GOLDEN" panel since you know the actual target to target distance and process this to verify the NULL Correction Factor in the future.

Security

The next item on the Configuration page is the Security folder. This should be setup up by the process engineer (Supervisor) for the department. The machine is initially setup with the Supervisor as the only user with access to all systems.



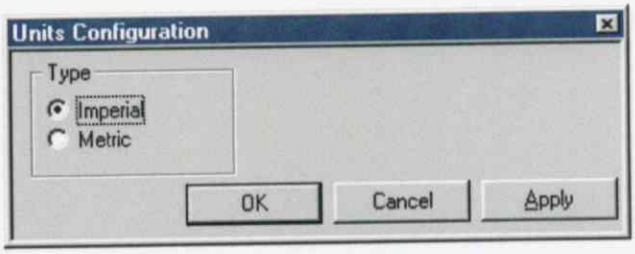
The Supervisor can add or delete users from the system and also control the Rights available to each user. The system is configurable such that each user can be setup with a unique password and privileges. A generic user with certain rights can be setup to be used just by the operators.

The Timeout field is a timer set by any user with the privilege to "Modify Security". This feature is used as a precautionary measure in case the user fails to log off the system. The system will log off the user after the set time limit. This time is typically set to 5 minutes with a maximum of 60 minutes.

The Security Active icon is used to toggle security protocols on or off. If security is disabled then a user does not need to logon into the system. It is highly recommended that security be enabled where multiple operators use the machine.

The Add User icon will prompt a dialog box where another user name can be entered and the password must be typed twice to confirm.

The last section of the Configuration page allows the user to select the Units used by the machine in calculations. The Units folder allows the user to select either Imperial or Metric, and the selection is affected throughout the machine.

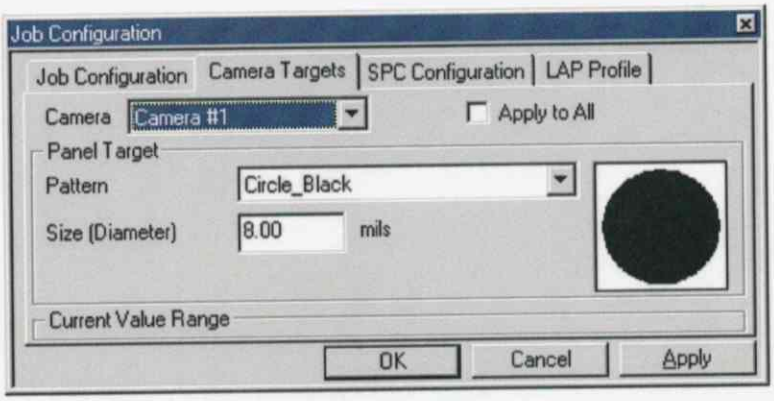


Setup

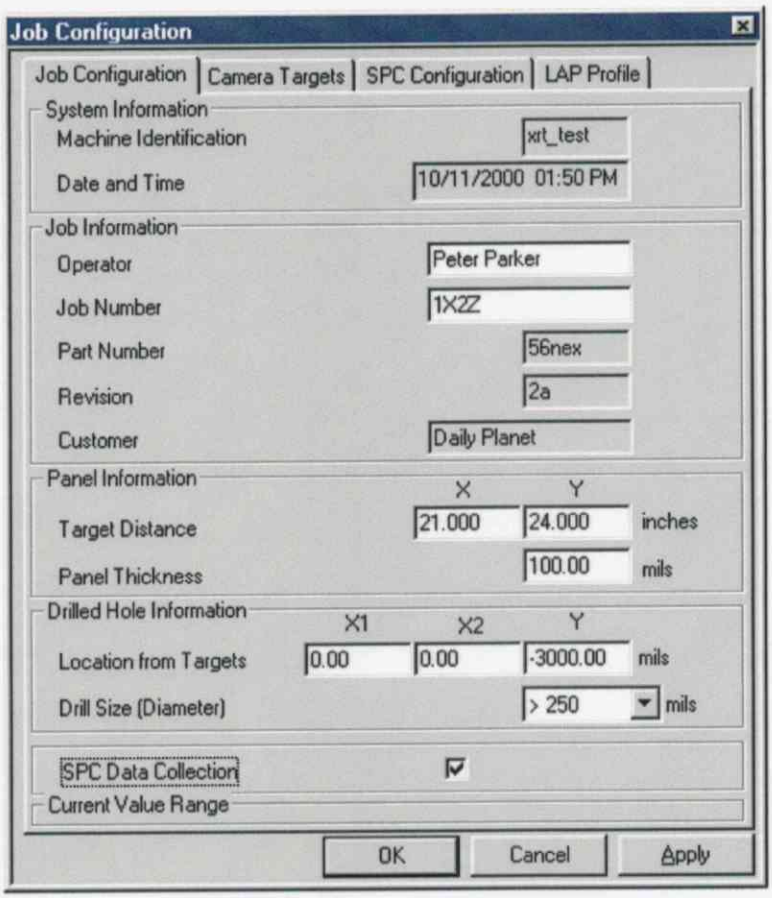
The Setup option has seven folders: Job (F7), Offsets, Template Video Centers, Parallax, Index-to-Index, Auto Zero/Sensitivity (F11), and X-Ray Adjustment (F8).

The Job (F7) icon has four folders: Job Configuration, SPC Configuration, LAP Profile, and Camera Targets.

The Camera Targets folder contains information about the panel. The Apply to All option will set the current settings of target size and color to all the cameras available on the machine.



The Job Configuration screen has five sections and displays the current setup information. The first section, System Information, displays the machine serial number, and date and time. These fields are grayed out and cannot be modified.



The Job Information section has the Operator and Job Number fields highlighted and they can be modified. If any changes are made the user will be prompted with a message to save changes to current setup.

The Panel Information displays the values for the current setup and can be modified. The X value is the target to target distance in the X axis and the Y value is the target to target distance in the Y axis. If any changes are made the user will be prompted with a message to save changes to current setup.

The Drilled Hole Information section has the current setting to where the panel is drilled after the machine has nulled a panel. The Drill Size is the diameter of the drill bits currently used and drill feed rate is determined from this value. If any changes are made the user will be prompted with a message to save changes to current setup.

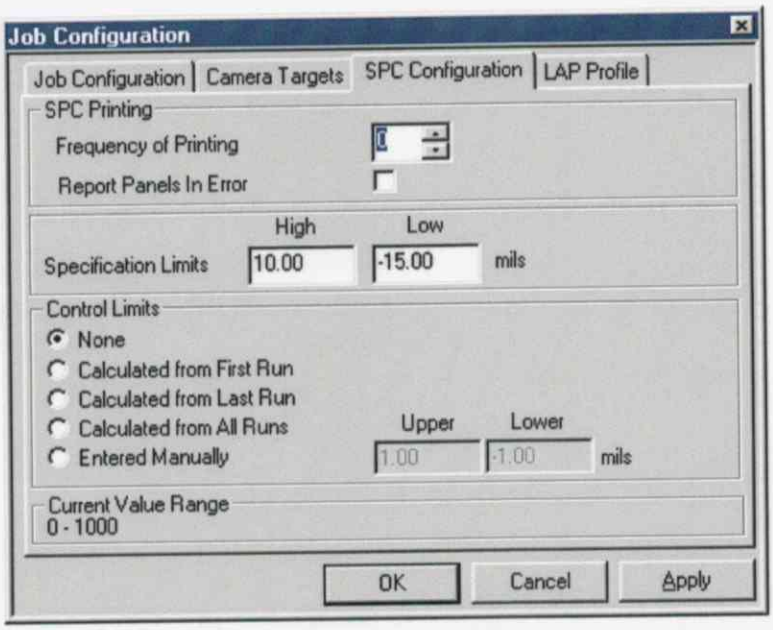
The SPC Data Collection saves the spread data to a file for further analysis. If any changes are made the user will be prompted with a message to save changes to current setup.

The SPC Configuration folder is used to print out the SPC data generated by the computer, and set the Specification and Control limits. The Print Interval Time (under the Configurations menu select devices and choose the Options folder) sets the delay for the contents in the buffer to be printed.

The Frequency of Printing sets the interval at which data is sent to the buffer. If zero is selected then only the statistical data after the job is completed is sent to the print buffer and printed only if the buffer is full or after the Print Interval Time delay, which ever comes first. If a one is selected then the data per panel is sent to the buffer and if two is selected then the data for every other panel is sent to the buffer, so on and so forth.

A check in Report Panels in Error will have only the panels that exceed the SPREAD tolerance saved, regardless of the interval of frequency of printing.

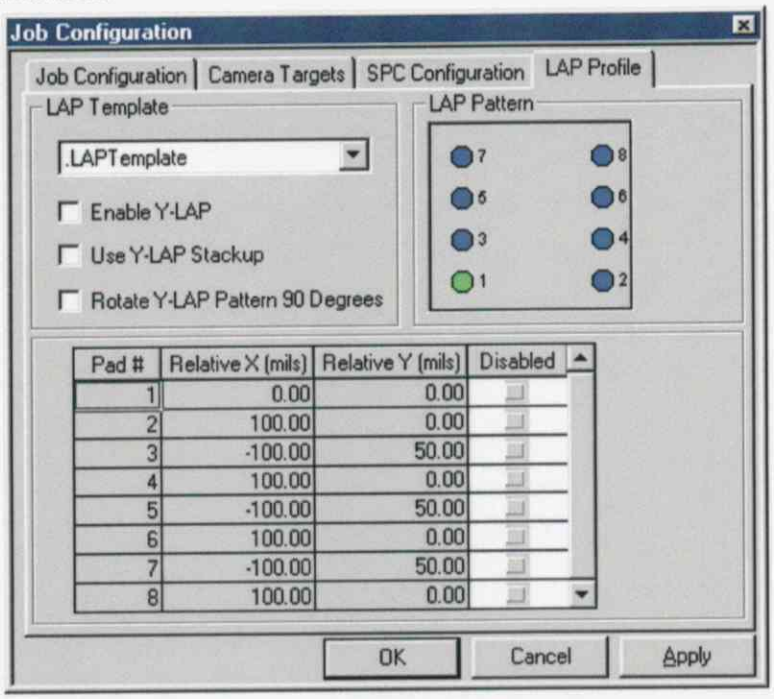
Specification Limits refers to the SPREAD value, the stretch or shrink, of the panel between the panel targets. The allowable SPREAD for the product is inserted here. The machine will report "Failed" if the panel stretch/shrink is outside the set limits, and will not drill the panel.



Note: Either or both of these limits can be positive or negative values. Use the negative sign key if required.

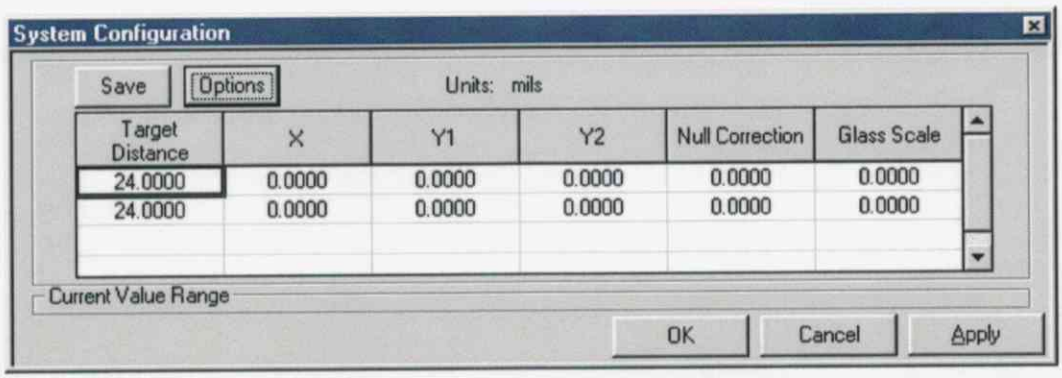
Statistical Control Limits is used to put control limits on the SPC graph. If control limits are to be displayed on the SPC graph, then select one of the choices. This entry has no effect on the operation of the system. The Current Value Range will display the minimum and maximum limits of a highlighted field and an error "Value Entry Error" is displayed if the entered number is outside the range.

The last section in the Job Configuration page is the LAP Profile folder. The LAP Template displays the current profile and enables LAP for the Y-axis. If there is no check mark in the Enable Y-LAP, then only X-LAP will run. Enable Use Y-LAP Stackup if the Y-LAP matrices have stackup targets. Do not enable or select Rotate Y-LAP Pattern 90 degrees, if, when the panel is rotated 90 degrees, the Y LAP matrices are traversed exactly like the X axis matrices.



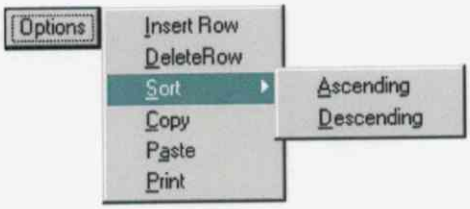
Enable/Disable individual layer via the "Disabled" column in the LAP Profile table. Layers that have a check mark in this box will not be processed. Verify that the graphically displayed matrix matches the desired profile. Disabled targets appear as an empty outline, while enabled targets will be colored in.

The Offsets folder on the Setup section is where all the machine offsets are stored. The spreadsheet format allows the user easy access to the machine offsets. The first column contains the nominal target to target distance and the machine selects the processing offsets from this field.



The X offset moves the shifts the panel left or right and the Y1 and Y2 offsets control the drilled hole distance in the Y axis. The Calibration section has detailed information on offsets.

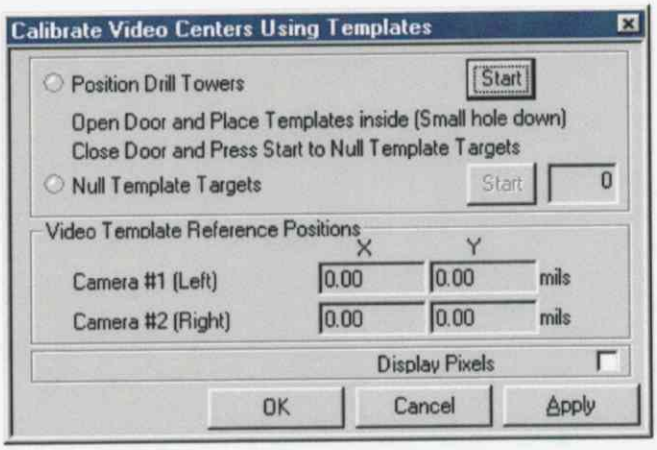
The Options icon shows all the spreadsheet functions available to the user. The user can copy, insert, delete, sort and paste offsets from one size to another.



After entering new data into this spreadsheet the user must click on the Save or Apply icon for the new values to be stored into the machine.

The next few sections under the Setup menu break down the calibration procedure into its individual parts. This allows a proficient user bypass the calibration wizard in the Machine Setup option in the File menu. The Video Templates are supplied with the machine. They are marked left and right. There is a small bushing at the end of the template held by a set screw. There are three locating stops on top of the plate that are approximately half an inch long. The locating stops are used to bank the template against the drill clamps.

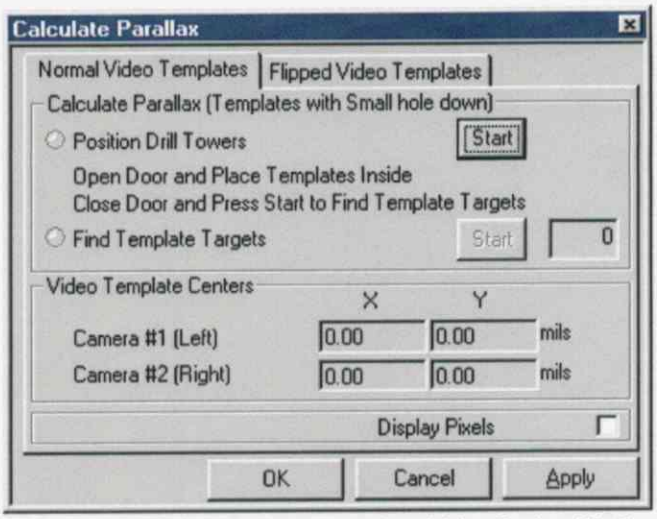
The Calibrate Video Centers Using Templates involves in nulling on the template targets. Place the templates with the small hole down and press the Start icon to Null Template Targets. The window will now display the reference position for both cameras.



Click the <OK> tab upon completion and the reference positions for each camera are displayed on the respective fields. The machine will now save the Video Template Reference Positions into memory. This is the position where the panel is nulled to when the machine aligns the panel.

The templates are used to adjust parallax between the camera and the x-ray tube. The tube and camera have to be properly aligned to eliminate the apparent difference in position of the target caused by a change in the point of observation, the x ray tube.

The bushing has a small 0.062 inch hole drilled in it. To flip the cup loosen the set screw and gently push the cup through the plate, flip the cup and then insert the cup into plate.



The top and bottom of the cup should be flush with the surface of the plate. The set screw should be snug so there is no play in the cup.

Press the Start icon to position the drill towers and then open the door to place the templates. There are two locating pins on the bottom of the plate. These pins are used to align the templates with the tooling holes in the machine. Use the locating stops to bank the templates against the drill clamps and then carefully place the templates into the machine tooling holes.

Once the templates are in the locating holes they should feel snug and the templates should not move. Make sure that the small holes are down on both templates for the Normal Video templates. Close the door and press the Start icon to Find Template Targets.

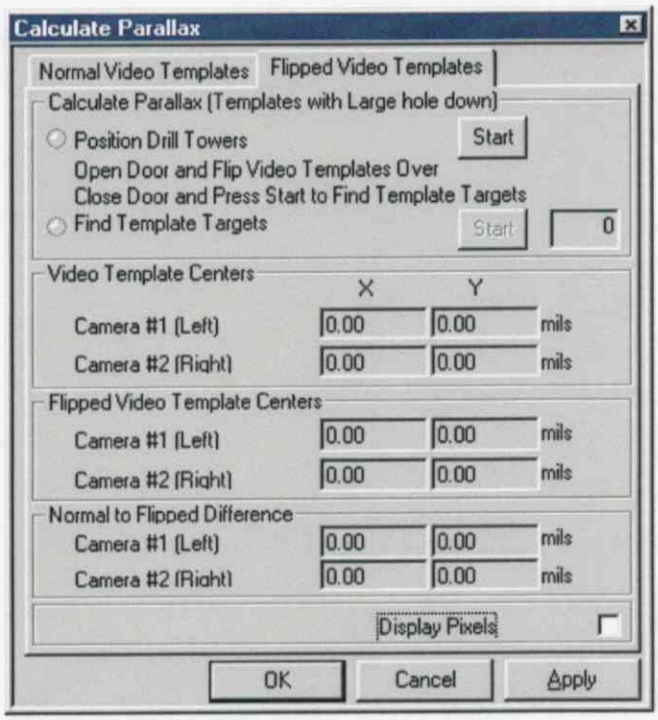
The vision system will now analyze the image and display the position of the targets on Video Template Centers. The X and Y axis position of the targets can be displayed in either pixels or mils depending on the check in the Display Pixels enable/disable box. Upon completion open the door and remove the templates. Loosen the set screw that holds the bushing and flip the cup over.

The Flipped Video Templates window is used to calculate the video centers with the large hole down. Press the Start icon to position the drill towers and then open the door to place the templates. There are two locating pins on the bottom of the plate. These pins are used to align the templates with the tooling holes in the machine. Use the locating stops to bank the templates against the drill clamps and then carefully place the templates into the machine tooling holes.

Once the templates are in the locating holes they should feel snug and the templates should not move. Make sure that the large holes are down on both templates for the Flipped Video Templates. Close the door and press the Start icon to Find Template Targets.

The vision system will now analyze the image and display the position of the targets on Video Template Centers. The X and Y axis position of the targets can be displayed in either pixels or mils depending on the check in the Display Pixels box.

The Video Template Centers display the position of the target with the small hole down. The Flipped Video Template Centers shows the position of the target with the large hole down. The Normal to Flipped Difference should be less than ONE mil.



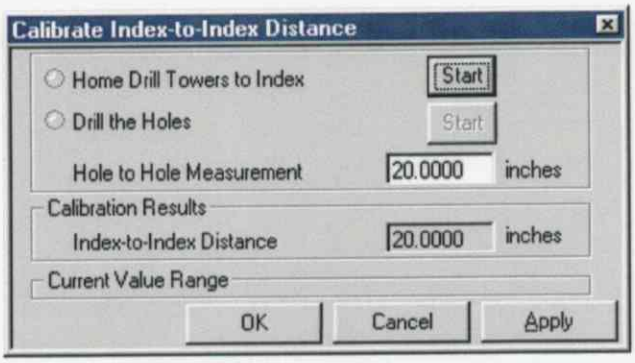
If the difference is greater than ONE pixel in any direction then the position of that tube must be adjusted to eliminate parallax. If only one side is affected then adjust that side. If both sides need parallax adjustment then adjust one side and verify before continuing to the next side.

The x ray tube is mounted on a bracket with four screws. Slightly loosen the top right and bottom left screw, and use the two cam screws to move the tube position. The cam screws are in slots located on the bracket. The slot towards the front of the machine controls the tube movement in the Y axis, and the slot towards the back of the bracket controls the tube movement in the X axis.

Adjusting parallax is an iterative process. Once the tube has been moved the parallax between the tube and camera must be checked using the templates with the small and large hole down. A small (1/8) turn on the cam screw can result in a large movement on the tube. After you move the tube, snug the top right and bottom left screw so the tube is stable.

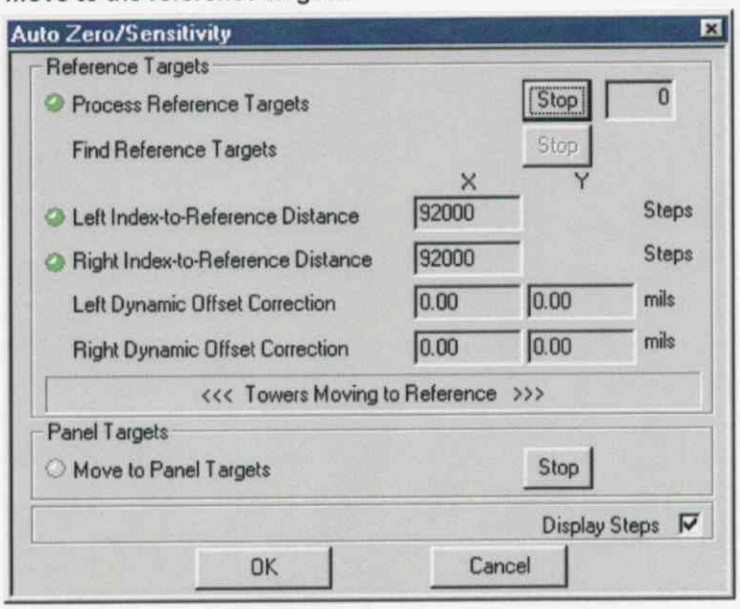
The Calibrate Index-to-Index Distance is to adjust the distance between the drilled holes. Press the start button to Home the Drill Towers to Index, after the drill towers locate the index pulse they will move to the panel size. Place a panel into the machine to highlight the start icon on Drill the Holes. Mark the position of the board relative to the front loading area using tape or a marker. Drill the board and then mark the drilled holes as set #1. Place the panel into the machine again this time approximately 1 inch above the marked location to insure the holes are not double drilled. Mark this set as #2. Repeat this procedure and drill at least 4 sets of holes.

Measure hole to hole distance using a coordinate measuring machine (CMM) and then take an average of the measurement. Enter the average value into the Hole to Hole Measurement window. The system will now calculate the Glass Scale Correction Factor which is used to determine the drill tower position per panel size.



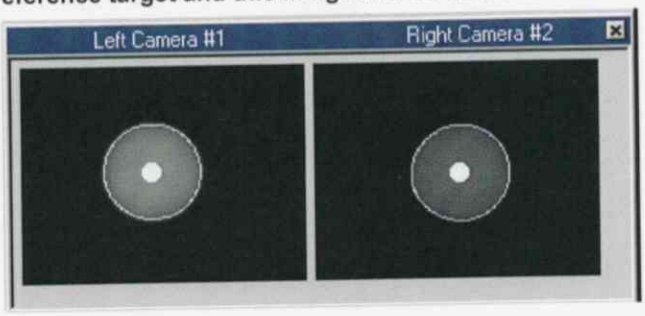
Note: The drill bit for the orientation (dummy) hole should be removed during the calibration process. So there will be only the right and left required tooling holes.

The Auto Zero/Sensitivity window will process the reference targets. The Drill Towers will move to the reference targets.



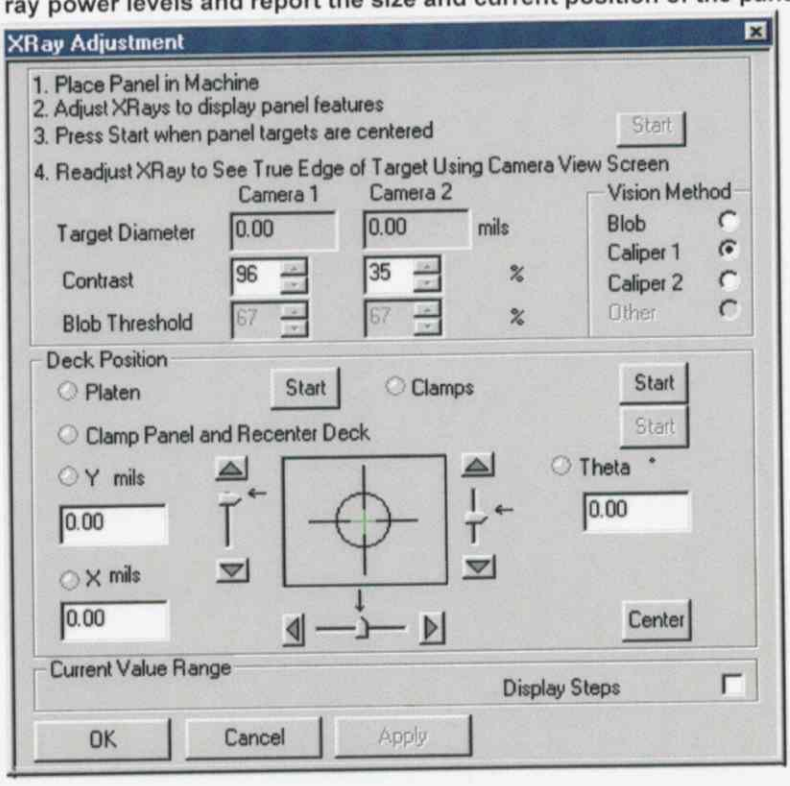
The Left Index to Reference Distance and Right Index to Reference Distance counter will update as the towers are moving to the reference targets, and a message will say waiting for x rays to reach reference levels. The Move to Panel Targets will bring the drill towers to the current panel size.

The vision system will process the reference target 15 times, and the Process Reference Targets is updated after each time. The vision system will put an outline around the reference target and this image can be viewed on Camera View (F3).



After the vision system has acquired the reference target it reports the Left and Right Dynamic Offset Correction. This value should be less than one mil. If the value is above one mil the system will report an error and the operator must press the Start icon next to Find Reference Targets. After the reference targets have been established the Drill Towers will move to the appropriate panel size. The operator can toggle between steps and mils by checking on the Display Steps.

The X Ray Adjustment screen will provide step by step instructions on fine tuning the x-ray power levels and report the size and current position of the panel targets.



The Deck Position section allows the operator to jog the panel to the center of the black and white monitors, and turn on/off the platen and clamps to hold the panel down if it curled or warped.

INFORMATION REGARDING THE SAFE USE OF MULTILINE X-RAY SYSTEMS

Some Registration Systems manufactured by Multiline Technology utilize x-ray sources as part of the machine vision system. Because exposure to x rays represents a health hazard, it is important that persons working near x-ray sources have an understanding of the properties of x rays and the level of hazard presented by these sources. It is also very important for persons working with x-ray sources to rigorously follow safe usage procedures without exception.

USER PROTECTION

Limitations of the occupational exposure of personnel to radiation have been set by the U. S. Nuclear Regulatory Commission (NRC) in its "Standards for Protection against Radiation" which can be found in the Code of Federal Regulations (CFR) Title 10, Part 20. Some state governments may also set some additional limits. Exposure limits are a separate issue from the cabinet leakage limits, which in the U.S. are defined by the FDA and can be found in CFR, Title 21.

In order for an employer to demonstrate compliance with these limitation, it will generally be necessary to monitor user radiation exposure. This is done by having personnel wear radiation dosimeters, or film badges. A number of companies provide a service which includes the film badges, film development, and records keeping (e.g. Landauer Inc. In Glenwood, Illinois, USA; phone 708-755-7000). Such companies will also help their clients comply with federal regulations by providing information about the regulations, their implications, and any changes in the regulations, such as occurred in 1994, as well as educational information about radiation and dosimetry.

It is also important to provide personnel with accurate, up-to-date information about the exposure limitation and the hazards and effects of radiation exposure. Personnel should also be advised of the hazards presented by the high voltage used to operate the x-ray tubes.

Multiline also recommends periodic surveying of radiation producing equipment to verify the integrity of the radiation shielding (see the discussion on Test and Construction).

PRECAUTIONS TO AVOID POSSIBLE EXPOSURE TO X-RAY RADIATION

1. Do not attempt to operate the x-ray generator with any door or access port open since open-door operation can result in harmful exposure to x-ray radiation. It is important not to attempt to defeat, modify, or tamper with any of the safety interlocks.

2. Do not try to operate the machine if the door is damaged in any way. The door must not be bent. The hinge must be maintained in good condition. The leaded glass window must not be broken or cracked.

3. The window in the door is made of leaded glass and this glass is designed to attenuate x-ray radiation. Do not replace the glass with ordinary glass or any material that does not

have equal or better attenuation properties. A damaged window should be replaced by a Multiline Technology Service Technician, or other properly qualified person.

4. Do not operate the machine if the x-ray cabinet has been damaged in any way. Evidence of damage would include, but may not be limited to the following:

a) dents, holes, or severe scratches on the inside or outside surfaces of the cabinet (a small indentation which does not penetrate through the cabinet wall could be hazardous, because it may thin the shielding material),

b) any bending or distortion of the metal structure around the door frame as this forms a protective labyrinth when the door is closed,

c) any bending or distortion of the x-ray cabinet, the door, or the structure at the top of the cabinet that covers the access port.

5. Do not modify the x-ray cabinet in any way. Do not drill or cut into either the inside or outside surfaces of the cabinet.

6. This system should not be repaired by anyone except Multiline Technology Service Technicans or other properly qualified personnel.

7. Some systems are supplied with an x-ray pre-alignment station (PAS) which uses a leaded-vinyl curtain for shielding. This curtain is subject to repetitive motion and is considered to be a "wear" item. It must be given special attention to ensure that it remains intact, pliable, and functional. In addition to wear-and-tear, various environmental effects may contribute to degradation of the leaded-vinyl curtain, including the effects of chemical attack, accelerated aging induced by exposure to radiation, as well as normal aging effects. Due to the number of variables, it is not possible for Multiline to provide a reliable estimate of the lifetime of the curtain, but this can be ascertained by visual inspection and checked with a radiation survey meter if there is any doubt.

8. Once a year, and immediately following any accidental damage or suspected damage to the x-ray cabinet, the system must be inspected by a qualified service person. In addition to a visual examination of the x-ray cabinet and leaded-vinyl curtain in the PAS unit, the inspection should also include a test for radiation leakage using a calibrated radiation detection instrument.

WHEN WORKING WITH THE EQUIPMENT, WEAR THE FILM BADGE.

THE NATURE OF X RAYS

X rays are a form of light which we cannot see with our eyes. X-ray light has a much shorter wavelength and much more energy per photon than does the more familiar visible light. Although the wave nature of light is well know and commonly observed, it is also a well established fact that light come in discrete quantities know as "photons", which can be thought of as particles and carry a definite amount of energy. X-ray photons each carry enough energy to break chemical bonds, and therefore pose a threat to living organisms because they can alter molecules and genetic materials. Genetic damage can lead to cancer and/or inheritable defects if the damage occurs in reproductive cells. Because it can produce ions by breaking chemical bonds, x radiation is often referred to as "ionizing radiation". The hazardous effects of ionizing radiation is well established for higher levels of exposure, but the scientific community is somewhat divided over the effects of low level exposure; as one might expect from occupational exposure and from natural background. One hypothesis is that even the very lowest exposure levels represent some hazard. A competing and conflicting hypothesis is that low level exposure presents little or no threat because cells will usually repair any damage done to them. The safest assumption for the purpose of safeguarding persons using x rays is to assume that any exposure to radiation poses at least some threat and should be minimized as much as possible. This is the philosophy of Multiline Technology and the U. S. FDA, which regulates usage of x-ray producing equipment and exposure of persons to x rays.

Reducing radiation exposure to as low as reasonably achievable, known as ALARA, a term coined by the U.S. government, is our policy.

THE X RAY SOURCES

The x-ray tubes used by Multiline are Kevex model K5014S-MF, operating at 35 kV. These will produce a spectrum of x rays in the range of 8 keV-35 keV. According to the manufacturer's specification sheet, the tube will produce 10 Roentgens per minute, measured at a distance of 1 foot from the x-ray tube window, when the tube is operated at full power; 50 kV and 1.00 mA. The federally allowable yearly whole body occupational limit is only 5 rem (5000

mr/year), so exposed portions of the body could potentially receive the yearly exposure limit in only a few minutes or less, were a person to stand in front of an unshielded x-ray tube operating a full power. An acute whole body exposure of only 200 Roentgens can result in death, this is the approximate threshold, and a 400 Roentgen exposure can produce death in about 50% of exposed persons. Realize however, that while much lower exposures will not produce any obvious symptoms, it could still result in damage to genetic material. Familiarity with x-ray safety, safe usage, and adherence to safe usage policy is of obvious importance.

It should be noted that an x-ray tube only produces radiation when there is emission current from the filament to the target, and there is no residual radiation when the tube is not operating.

The tubes from Kevex contain an oil made from petroleum which helps conduct heat away from the actual x-ray tube. The supplied Materials Safety Data Sheet suggests that diala

oil is not entirely non-hazardous, but appears to be a low level hazard. Contact with the oil should be avoided, just as is recommended for automotive engine oil, for example.

TEST AND CONSTRUCTION

Because it is not necessary to the function of industrial machines to expose persons to radiation, Multiline has a policy of limiting the emission of x rays from the exterior of its products to as low as reasonably achievable (ALARA). This is a higher standard than is actually required by the U.S. Food and Drug Administration which requires radiation emission from x-ray cabinet systems to be limited to no more than 0.5 milli-roentgen/hour at a distance of 5 centimeters outside any external surface [Code of Federal Regulations Title 21, Part 1020.40(c)(i)]. The radiation protection aspect of each system manufactured at Multiline is carefully checked and re-checked before shipment in accordance with FDA standards. This includes carefully scanning the exterior of the final product for stray x-ray emission while operating the x-ray tubes at the maximum recommended voltage and emission current. Operation at maximum tube voltage and emission current generates more x-ray intensity at every wavelength than any other mode of operation. In the process of scanning for leaks, Multiline also attempts to maximize the potential for leakage by adjusting any other

pertinent variables, such as x-ray tube position. Multiline does the leakage testing with scattering blocks placed in front of the x-ray tubes in order to simulate the effect of raw materials in the x-ray beam and produce significant scatter effects.

If Multiline finds measurable x-ray leakage, action is taken to reduce, or preferably completely eliminate the leak. In practice, a Geiger-Mueller proportional counter survey meter with a hand held probe is used to slowly scan the outside of the machine while it is running at maximum x-ray tube power. Prior to this scanning, the survey meter is checked for proper operation with a calibrated radioactive source and a background radiation level is also measured.

The first system of a new design is also checked using x-ray sensitive film so as to thoroughly map any leaks that might be missed by the hand held survey meter. In addition, Multiline employs a third party, a certified radiological health physicist, to perform a radiation survey and report on the first machine of any new design.

The Optiline PL (OPL) systems utilize 0.090" steel for the outer shell of the machine and recent testing indicates that the steel shell alone provides adequate shielding. The Pre Alignment Station (PAS) outer shell utilizes 0.062" steel and though it is normally operated only up to 35 kV and 0.50 mA, the PAS passes radiation emission testing with the x-ray tubes operated at full power; 50 kV and 1 mA.

In both of these systems, the x-ray tube windows face down. This geometry enhances safety because any radiation out the sides of the machine will have to result from scattering or reflection, with substantial attenuation, rather than from the direct beam. Below the tube and intercepting the entire cone of radiation in each unit is a base plate. In the Optiline PL, this base plate is 1" thick steel and in the Pre Alignment Station it is 0.5" aluminum. Except for some holes through which wires pass, these base plates are thick enough to stop almost all radiation incident upon them. Below the base plate is a cabinet

volume which is enclosed in interlocked 0.062" steel access panels, which are adequate to stop any scattered radiation. The upper shell does not have to stop any direct radiation from the x-ray tubes, only scattered x rays.

One special aspect of the PAS is that it has a long narrow slot which serves as a panel entrance port. This port is protected by a two layer leaded vinyl curtain,

the edge of which has been cut to create many parallel strips or "fingers" along the edge. This curtain is designed so that downward pressure collapses it to conform to whatever is being inserted into the unit, thereby closing all openings which could potentially emit radiation. Another important safety feature of the port is that the vertical opening is too narrow to admit the fingers of an adult.

PERSPECTIVE COMMENTS

It should be realized that most people receive a certain amount of unavoidable exposure from natural sources as well as exposure from choices we make. For x-ray safety considerations, radiation intensities are normally stated in terms of the rate at which energy would be deposited into an exposed person's tissues rather than just simply the power of the x rays carry. The standard unit of exposure is milli-roentgen/hour, or mR/hr. The unit of dose equivalent for biological damage is the "rem", short for "Roentgen equivalent in man". For soft tissue exposed to x-ray radiation, it turns out that the Roentgen and the rem are all approximately the same and can be used almost interchangeably in many situations. This is useful for estimation purposes.

To keep exposure in perspective, consider that a typical TV monitor will register about 0.013 mR/hr. See the tables below for an assessment of risk with other typical exposures.

Table 1. Contributions to annual radiation exposure for the typical person living in the US.

Radiation Source	Dose (mrem/yr)	Comments
Cigarette smoking	1300 - 2000	Dose to the lungs from inhaled radioactive particles
Radon in homes	200	Dose to the lungs
Medical exposure	53	X-ray images, etc.
Optiline PL	36	Normal working year
Terrestrial radiation	30	Naturally occurring radioactive isotopes
Cosmic radiation	30	Whole body dose
Round trip in US by air	5	Less atmosphere Overhead offers less Protection to cosmic rays
Building materials	3.6	Whole body dose
World wide fallout	<1	From nuclear weapons testing
Natural gas stove	0.2	Radon in the gas, dose to the lungs
Smoke detectors	0.001	Americium radioisotope

Table 2. Comparative average annual radiation dose for several occupations.

Occupation	Dose (mrem/year)	Comments
Airline flight crew member	1000	Exposure to cosmic rays
Nuclear power plant worker	200	Exposure to radiation from fuels, by products, and reactor
Grand Central Station worker	53	Radon gas, apparently
Optiline PL operator	36	Single shift, normal working year
Medical radiology personnel	30	

The federally allowable yearly whole body occupational limit is 5000 mrem/year.

MANUFACTURER'S WARRANTY

The following MULTILINE TECHNOLOGY warranties apply:

1. All equipment which contains artificial intelligence, electronic vision systems, x-ray or microprocessor based automation is under warranty for a period of ninety days from the date of shipment for all parts, with the exception of punches and dies, strippers and caps, and light bulbs, providing that the buyer complies with shipping instructions.

All labor, travel and expenses will be covered for a period of ninety days from date of shipment. Beyond the ninety days labor warranty period, labor will be billed per MULTILINE TECHNOLOGY's published rate schedule; travel and expenses will be billed at actual rates incurred.

2. All computer equipment is installed as an integral part of the machine operation and is warranteed by the manufacturer. Software is pre-installed. MULTILINE TECHNOLOGY retains ownership of the software.

This software is licensed to the purchaser strictly for operation of the equipment for which it is installed. Any attempt to alter, modify, or adapt the software, including, but not limited to translating, decompiling, disassembling, creating derivative works, and or utilizing this computer equipment for any other application unless specifically authorized by MULTILINE TECHNOLOGY will cancel this warranty and may cause damage to the equipment. This license and purchased right to use software automatically terminate if the purchaser fails to comply with any provision of the license agreement.

MULTILINE TECHNOLOGY retains all rights not expressly granted. Nothing in this document or in the licensing agreement constitutes a waiver of MULTILINE TECHNOLOGY's rights under the U.S. Copyright laws or any other federal or state law.

Because software is inherently complex and may not be completely free of errors, any incident of non-performance in accordance with specification must be reported to MULTILINE TECHNOLOGY immediately and operation of the equipment should cease, pending assessment by MULTILINE TECHNOLOGY.

3. All other equipment is under warranty for parts for a period of 12 months and labor for ninety days from date of shipment.

MULTILINE TECHNOLOGY's warranties apply if the equipment or other goods sold under this contract are in the possession of the original buyer (or lessee). MULTILINE TECHNOLOGY will replace or repair, at their option, free of charge, any part or parts, manufactured by MULTILINE TECHNOLOGY in which, upon examination, they find defective workmanship or material, provided that, on their request, the part or parts of the machine are returned to MULTILINE TECHNOLOGY's plant, and provided further, that there is satisfactory documentation that the machine has been installed and maintained in accordance with instructions in their Service Manual. All standard purchased parts carry original equipment manufacturer's warranties.

Neither MULTILINE TECHNOLOGY nor our local representative shall be liable or responsible for any expense or liability for repairs, additions or modifications made upon the product without their written consent.

THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES (WHETHER WRITTEN, ORAL OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE). IN NO EVENT, SHALL MULTILINE TECHNOLOGY OR OUR LOCAL REPRESENTATIVE BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, LOST PROFITS OR OTHER DAMAGES FROM LOSS OF PRODUCTION) CAUSED BY DEFECTIVE MATERIAL, OR BY UNSATISFACTORY PERFORMANCE OF THE PRODUCT, OR BY ANY OTHER BREACH OF CONTRACT BY MULTILINE TECHNOLOGY OR OUR LOCAL REPRESENTATIVE.

OWNER'S RESPONSIBILITY

The owner of this equipment is responsible for providing a proper environment and maintaining the equipment in accordance with manufacturer's specifications. Failure to comply with installation parameters (see footprint drawings), improper maintenance or misuse could void warranty.

MAINTENANCE SERVICE

Service beyond the warranty period will be furnished by MULTILINE TECHNOLOGY, or an authorized representative, chargeable at published rates.

LIST OF DRAWINGS

SE124	XYØ Motor Cable
SE126	XYØ Limit Switch Cable to Switch
SE196	Schematic Current Regulator
SE451	Drill Anaheim Settings
SE641	28 Volt Power Supply Modified
SE669	Motor Cable - Mopro to OPL Deck
SE683	Video Splitter Board
SE824	XEQ-0177 Main Logic Schematic
SE825	Glass Scale Power Supply
SE826	Driver/Controller Interface
SE827	XYØ Drive & Limit Switch
SE828	Mopro to XYØ Deck Cable
SE829	Base Plate T.B.
SE830	Hood T.B.
SE833	XRT Digital I/O Wiring
SE834	XRT Solenoid Wiring
SE835	X-Ray System Wiring
SE836	Drill Motor Wiring
SE838	Control Panel Wiring
SE839	Rear Skin Wiring
SE840	X-Ray Interlock System
SE841	Box #1 to Box #2 Interface Cables
SE842	Servo Controller Wiring
SE843	Video Sync Board Interface Cable
SE844	XEQ-0177 Card Cage Layout & Wiring
SE845	50 KPS & X-Ray Tube Cables
SE857	CCD Camera Interface Board Schematic
SE868	Splitter to Video Board Cable
SE878	XRT Front Skin Wiring
SP009	XYØ Limit Switch Location
SX098	Manual OPL Pneumatic Logic
ZI061	Volts to Wire Color Codes
ZI072	Pneumatic Lubricant for Pneumatic System & NSK Motors
ZI101	Servo Card Fine Tuning Instructions
ZI231	Safety Information (X-Rays)
ZI322	OPL/APA I/O Signal for Outside Equipment

OPL/XRT RECOMMENDED SPARE PARTS KIT (AS OF 05-26-04)

	QTY
CONSUMABLE PARTS	
SEAL, VAC CHUCK	12
FABCO AIR CYLINDER	2
AIR CYLINDER OPZ	2
SHOCK ABSORBER,5/16 DIA	4
COUPLER, MECH. HI-TORQ 1/4-1/4	3
LEAD SCREW XY MULTILINE 1/2-20	1
NUT, DRIVE 1/2-20 THD	1
VACUUM GEN SYS	2
LAMP,28V/.04A CM387 GEN INSTR	6
LAMP, 12V -WAGNER W-1003	6
INSURANCE PARTS	
SPINDLE, AIR MOTOR #NR-301	1
AIR MOTOR NSK# AM-310RA	1
CONN, 5/16" COMP X 1/8" NPT	2
MOPRO4-4 AXIS CONTROLLER (PC)	1
MIC AMP CNF-5LB FRC (ATP)	1
MOTOR STEPPER DOUBLE SHAFT	1
FIBER OPTIC SENSOR (PNP)BANNER	1
THERMOCOUPLE INPUT MODULE	1
OPL X-RAY TUBE THERMOCOUPLE	2
RELAY,CONTROL 24VAC/DC	2
48 DIGITL INPTS CARD #CIO-DI48	1
48 DIGTL OUTPTS CARD#CIO-DO48H	1
CURRENT REG PCB POPULATED	1
REWORK,3 AXIS ANAHEIM FLT PROT	1
X-RAY INTERLOCK BOARD	1
FAN 24VDC # 52431	1
4 WAY-2 POS SOL VALVE - 24VDC	1

NOTE: PART NUMBERS & REVISION LEVELS ARE SUBJECT TO CHANGE. USE AS REFERENCE ONLY CONTACT MULTILINE TECHNOLOGY'S SPARE PART DEPARTMENT WITH MACHINE SERIAL # (LOCATED ON THE REAR OF THE MACHINE) AND THIS DOCUMENT TO ORDER PARTS.

COMPLETE SPARE PART KITS ARE AVAILABLE AT A DISCOUNT