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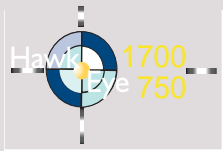
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A GUIDE TO HAWKEYE™

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SCOPE

This manual assumes that the reader has previously gained appropriate knowledge to be able to setup and run a board on the printing machine. The user should be familiar with the graphical icons, parameter definitions and other advanced features available in the DEK User Interface - Instinctiv™.

The user should be able to demonstrate knowledge of the general rules for producing good quality and consistent print. These rules include; machine, stencil and board cleanliness, appropriate tooling placement, appropriate applicator that is in good condition for the task, optimised printer set up for cleaning cycles and the correct print medium deposit.

The manual is aimed at personnel qualified to technician level and above who have undertaken DEK maintenance courses.

MANUAL OVERVIEW

This manual utilises many aspects of the Instinctiv™ style. The functionality embodied within this interface allows the HawkEye™ process to be easily understood and remembered. The process is fully explained along with appropriate techniques to optimise performance for production.



A GUIDE TO HAWKEYE

OVERVIEW

System Description

HawkEye™ is an ultra-high speed, integrated, automatic deposit verification system. It assesses up to 100% of printed board and gives a rapid go/no-go indication. In production, HawkEye provides immediate feedback on problems as they occur. The operator is able to make simple recovery choices:

- Reprint the board
- Clean the stencil
- Add more print medium to the process

The system is programmed to verify either the complete board or specific areas, for example, where print deposit density may be particularly high. This allows the user to adjust the total verification time and derive maximum value within the line beat rate.

Two camera variants are available; the HawkEye 750 and the HawkEye 1700, both run the same software package which is capable of reporting on easily defined scan areas.

The figure shows the different scan speed ratings of the camera types.

HawkEye 750 Camera

750 mm²/s

HawkEye 1700 Camera

1700 mm²/s

NOTE

Verification speed is dependant upon feature size.



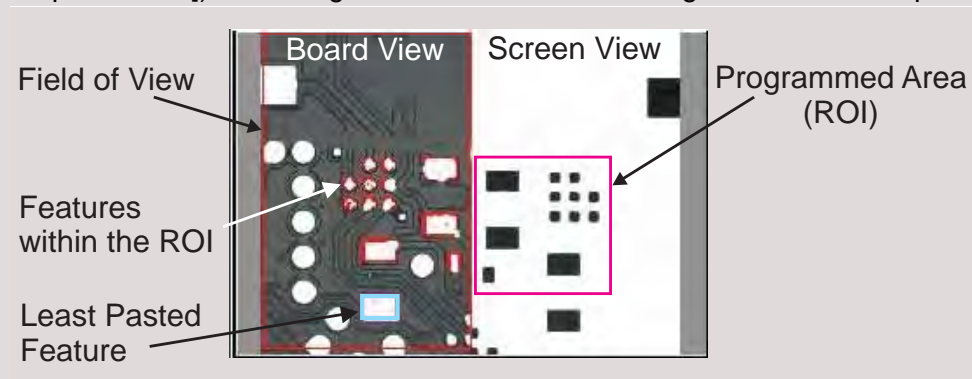
Practical Limitations

Field of View

A feature of HawkEye is that it indicates deposit levels on anything within the camera's field of view, programmed areas smaller than this are scanned but not exclusively reported. The camera field of view for each camera type is as follows:

- HawkEye 750 vision window = 5.4mm x 8.7mm
- HawkEye 1700 vision window = 11.3mm x 8.7mm

As can be seen in the figure, the red outer rectangle in the board view represents the total camera field of view. The area denoted by the pink outlined rectangle on the screen view represents the programmed area, the region of interest (ROI) (It should be noted that this rectangle is used to highlight where the programmed ROI is for this example only and it is not used by the system). The corresponding items are bordered with a red outline on the board view, these are the features within the programmed area. HawkEye reports on all items in the camera field of view and if the paste level falls below the programmed level on any item (see area with light blue outlined rectangle [this indicates a feature with the lowest paste level]) a warning or error alarm is raised regardless of the deposit levels in the area of the ROI.



Memory Size Limit

Due to memory size limitations of the HawkEye 750, the system cannot be used to scan fully populated substrates at the maximum board size of 508mm x 508mm (Standard Machine). This need not be a limitation of the system, if the user chooses to be selective about the areas to be scanned. See - Optimising for Production section for more details. The maximum area size that can be scanned using the HawkEye 750 camera is 335mm².

Print Offsets

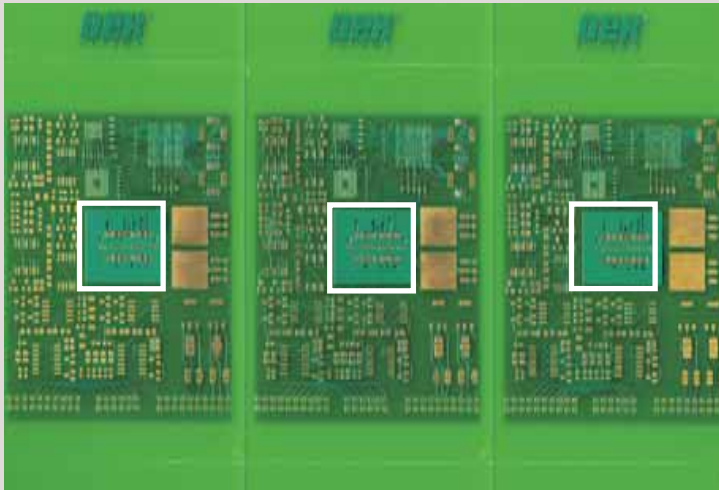
Users must determine the print offsets of the board and apply them before setting up areas, if the offsets are not applied before scanning, the system 'sees' these as an error condition and reports them as errors. In extreme cases the verification system is unable to resolve any alignment issues, ruling them out of the inspection setup altogether. See - Error Analysis section for more details.

Fiducial Exclusion

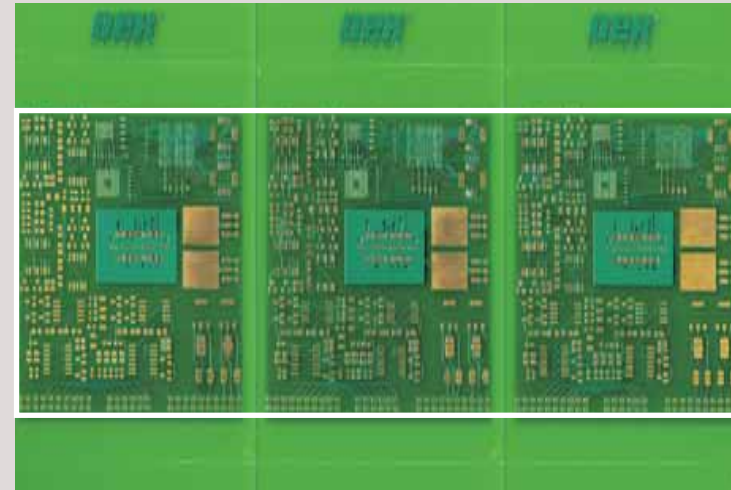
Occasionally HawkEye highlights additional screen fiducials as unprinted board pads, if this should occur programmed areas should be adjusted to avoid including these extra fiducials.

The HawkEye Philosophy

Subject to the limitations mentioned previously, the user can program HawkEye to verify specific areas or complete products.

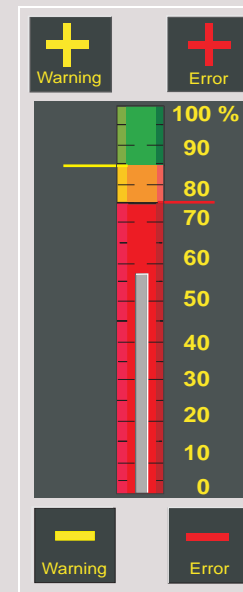


High Density Inspection - 2 seconds



Full Product Inspection - 20 seconds

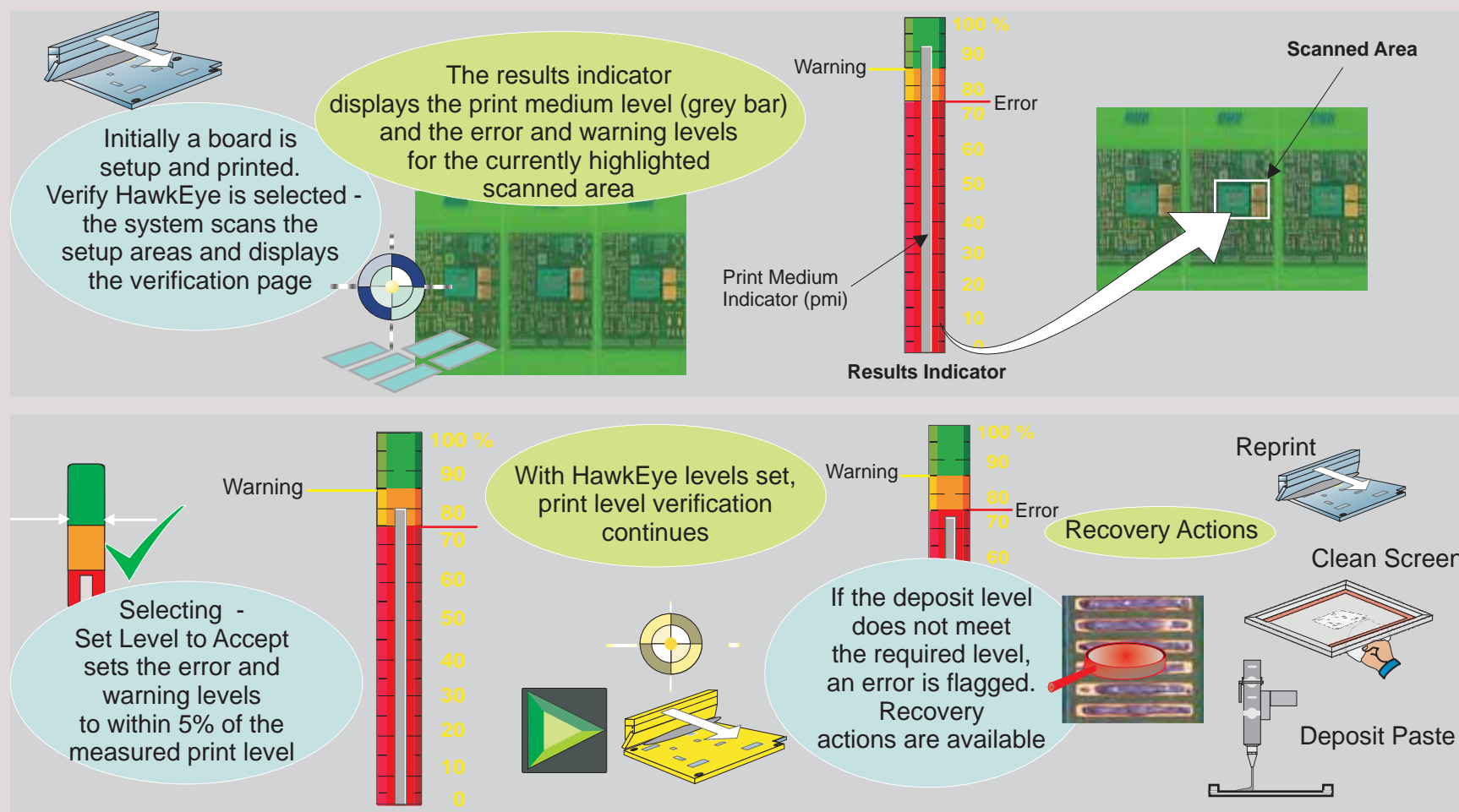
HawkEye uses a simple verification indicator (results indicator) without the need to display large amounts of data. It shows percentage readings to assist the setting of warning and error levels, the percentage deposit levels reported are accurate to $\pm 5\%$.



The Print and Verification Cycle Explained

The system requires a two-stage set up procedure. Initially it carries out a printed board verification of the programmed areas. This information is used to determine acceptable warning and error levels which are set for the process.

The levels applied to the setup print are maintained throughout the remaining print cycle. During printing, each board is verified as determined during the setup phase. Printing continues until the batch is completely processed or a deposit reaches an error level. In the error state, the operator has the option to carry out a recovery action to rectify the condition.

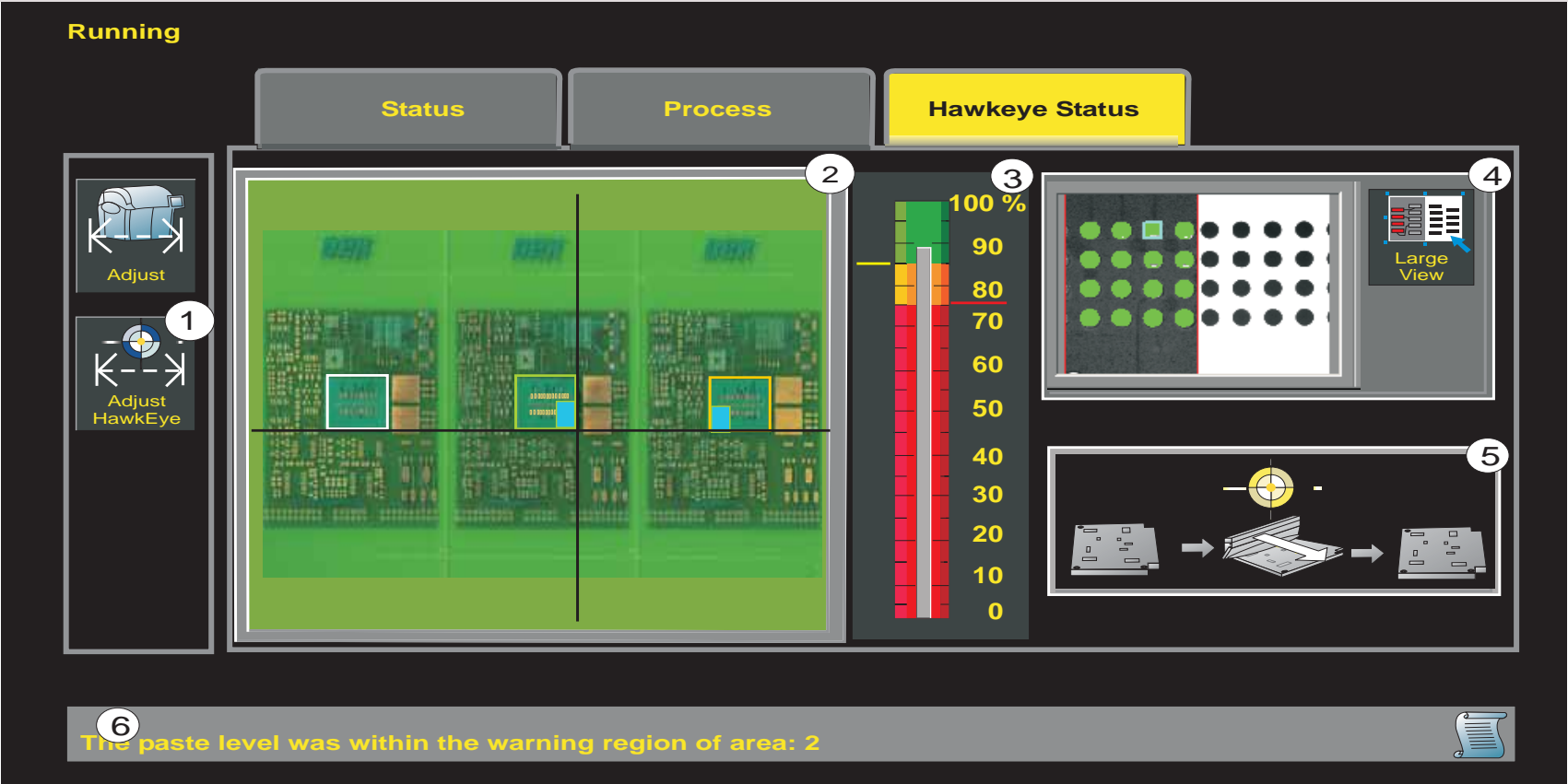




THE USER INTERFACE

The Interface

Status Page This graphic shows the Status page. When the machine is in run mode this page can be accessed at any time by selecting the HawkEye Status tab.



Item	Description	Item	Description
1	Adjust HawkEye Button	4	Vision Window
2	Board Representation Window	5	Board Mimic and HawkEye Active Indicator
3	Results Indicator	6	Prompt Bar



Adjust HawkEye Button



This button is used to access the adjustable functions that are available during production. If adjustment is not password controlled, the user can select Adjust HawkEye to amend selected parameters whilst in the run mode. When selected during a scan, the printer stops after the current scan and parameters are editable at the next scan phase of the production sequence. The editable functions are:

- Lighting
- Set Level to Accept
- Verification Start Rate
- Verification Rate

NOTE

Set Level to Accept is not selectable if Adjust HawkEye is selected before a scan has taken place.

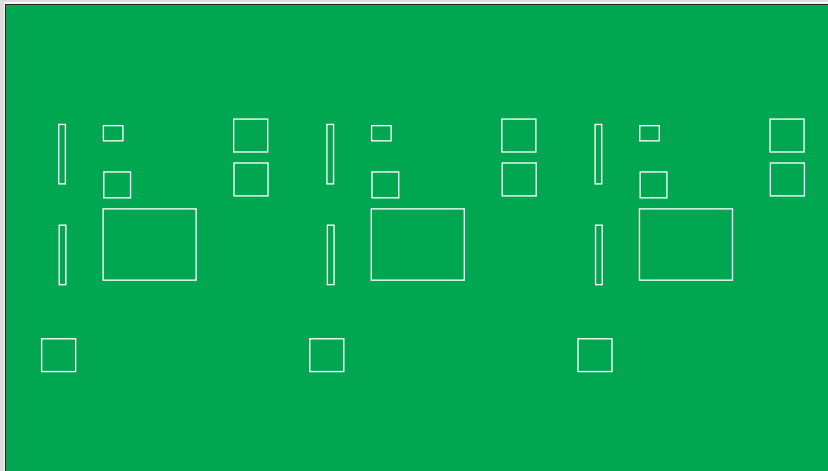
In Adjust HawkEye mode the user can select the area representation rectangles to navigate to specific areas to set the lighting or alter the verification start or verification rates as required. See - HawkEye Setup section of this manual for more details.

**Board
Representation
Window**

The board representation window shows the synthetic representation of the full board.

There are two ways to input data, either by entering coordinates or by loading an image file (Bitmap or Gerber).

In Setup mode - Add Area, if entering the co-ordinates, the user measures locations on the board one-at-a-time for each area to be scanned and then inputs these values to the interface. As areas are added, they are shown as a series of grey bordered rectangles.



Coordinate Data

If a suitable bitmap (.bmp) or extended gerber (.gbx) file is available, the image can be imported directly into the board representation window. The user can simply add areas for scanning by using this data as a reference and drawing the borders around the components.

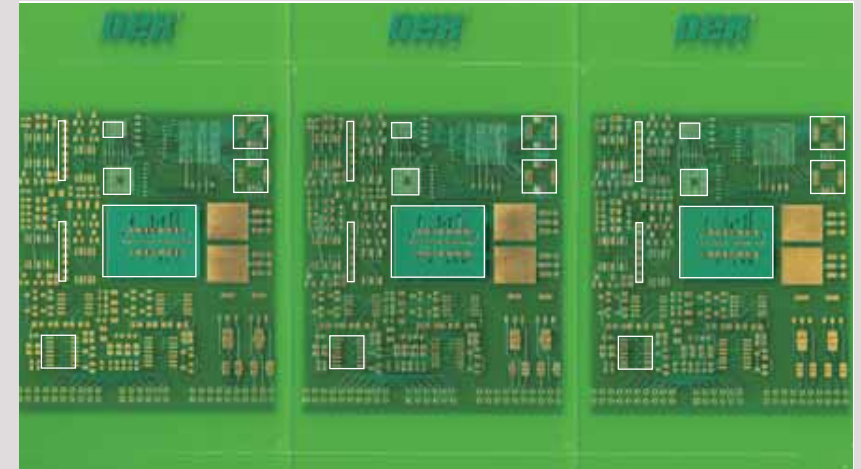
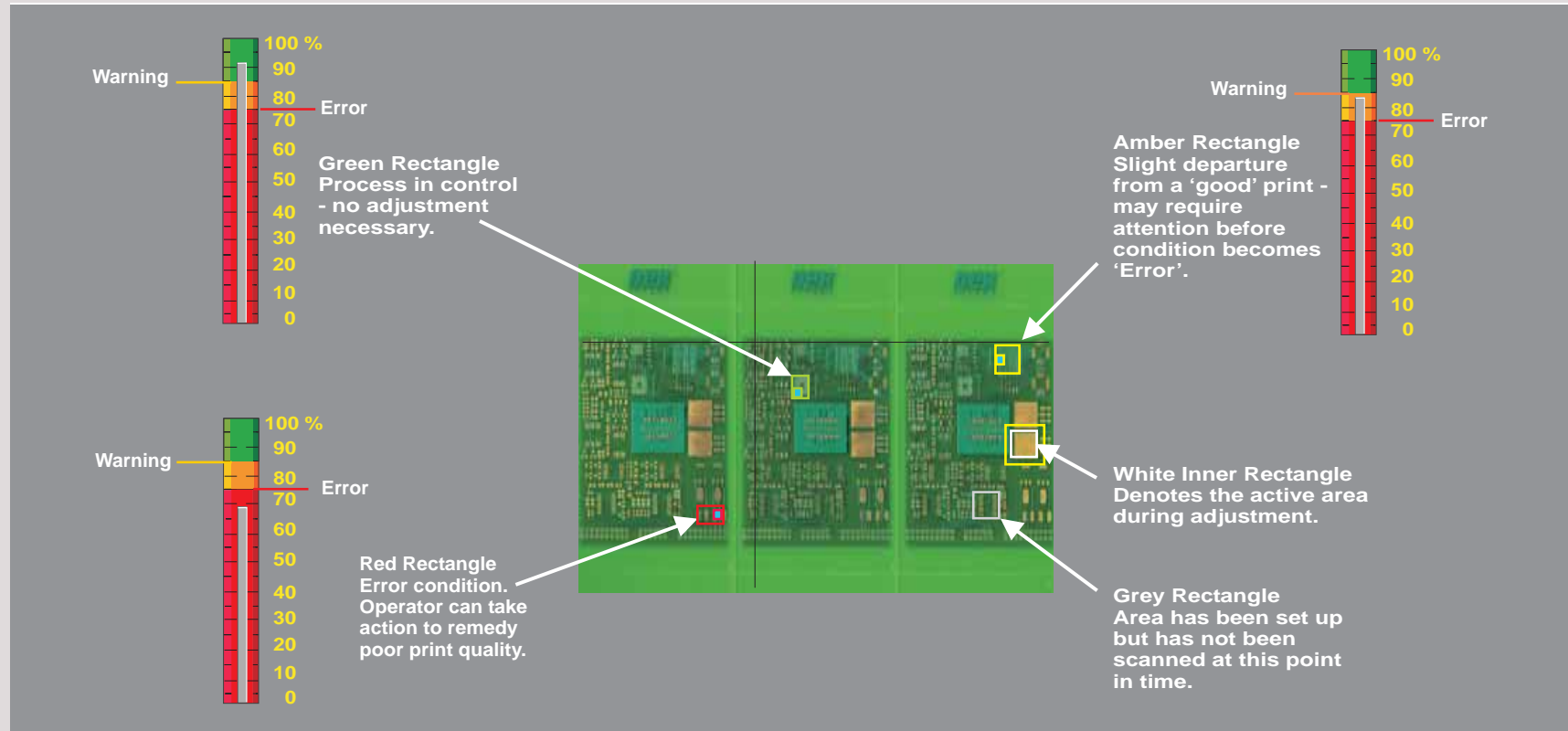


Image File

As the user inputs areas to be scanned, the camera moves to the coordinates and displays the location in the Vision Window. If the area needs to be adjusted, controls are available to make fine adjustments to position.

Results Indicator

The results indicator displays information about a highlighted scan area (denoted by a coloured outlined box in the board representation window).



The print medium indicator (grey bar in the centre of the results indicator) lies between levels of the three coloured bars, this indicates the print level for the scanned area of the least pasted feature.

The three colour bars are used to indicate:

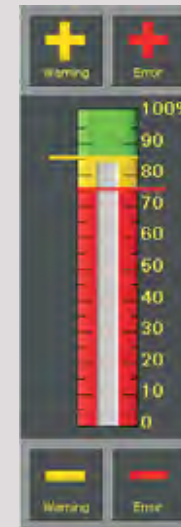
- Good print level (green bar - print is acceptable)
- Warning level (amber bar - print may be acceptable without rework)
- Error level (red bar - print level is unacceptable)

The print medium indicator in the centre is used to indicate:

- Percentage print medium (the grey bar bar rises and falls in the centre of the results indicator and shows the percentage print medium at each scanned area)

Print Medium Indicator

The print medium indicator, the grey bar in the centre of the results indicator is an active visual indicator, it represents the value of the print at the scanned area. If the indicator reaches the green level then no error reporting is necessary as the predetermined safe level of print has been achieved. In the board representation window, the outline of the area encapsulated is shown green and a blue rectangle within this area is presented to show that the area has been scanned and the least pasted feature has been determined.



If the indicator falls away to the amber zone, represented by the warning threshold level, the outline rectangle for this area turns amber and a prompt in the prompt bar states which named area falls within the warning threshold.

If the indicator falls outside the warning level into the error level an alarm is displayed.

In the board representation window, all scanned areas are shown and the display philosophy is repeated with green, amber and red rectangles surrounding the programmed areas.

Programmed areas that have not yet been scanned during the scan phase of the machine operation are represented by grey bordered rectangles.

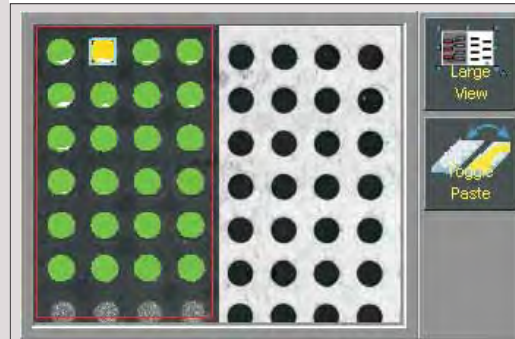
The currently selected area is shown with a white bordered rectangle.



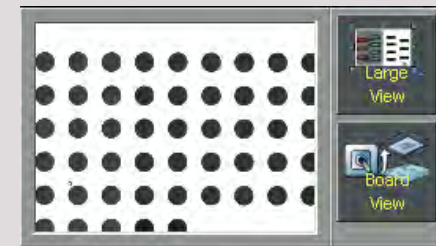
A GUIDE TO HAWKEYE THE USER INTERFACE

Vision Window

During production the user has a visual indication of the status of the current print, the area in the field of view of the camera is shown in the vision window. The user can select Large View to view enlarged detail.



Vision Window
Split Screen (HawkEye 750 option)

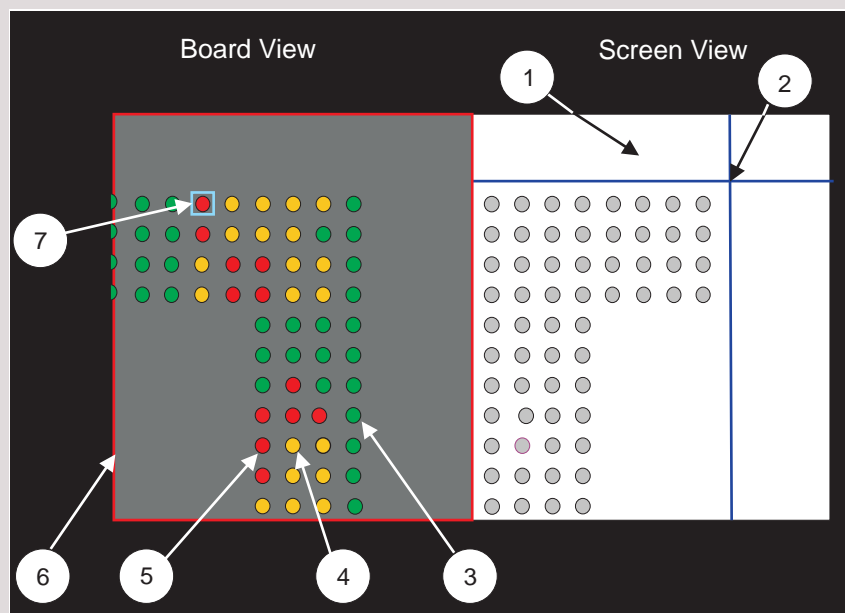


Vision Window Single Screen (HawkEye 1700 option)
Select Stencil View/Board View to change view mode



Large View selected.
Select Reduce View to change view mode

The graphic below is a drawn representation of the board and screen. In set up mode, the camera field of view (red outlined rectangle) is superimposed on the board view. In run mode, the software can 'paint' the scanned components with colours representing threshold levels and it highlights the pad with the least print medium deposit - shown as a light blue outlined pad.

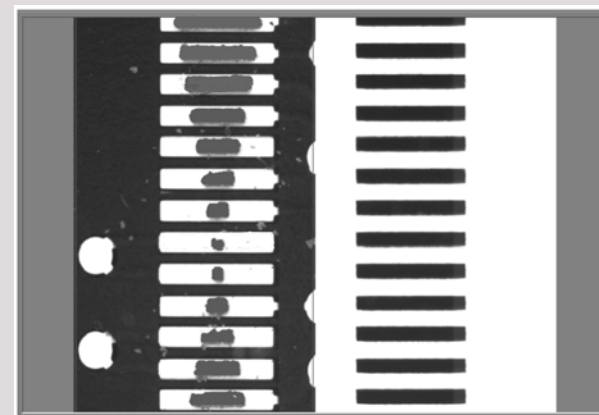


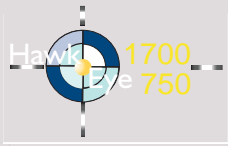
Item	Description
1	Screen view in setup mode
2	Set up alignment crosshair - used to program area
3	Pad above warning threshold (coloured green)
4	Pad below warning threshold (coloured amber)
5	Pad below error threshold (coloured red)
6	Camera field of view (red outline)
7	Pad with least print medium deposit (outlined blue)

If **Toggle Paste** is selected, this turns paste painting on, the varying levels of paste deposit can be quickly detected as shown graphically below. Paste levels are painted green, amber and red representing the various paste on pad levels. The pad with the least paste deposited is surrounded by a blue outlined box. Users can easily determine if the alarm levels that have been set are true.



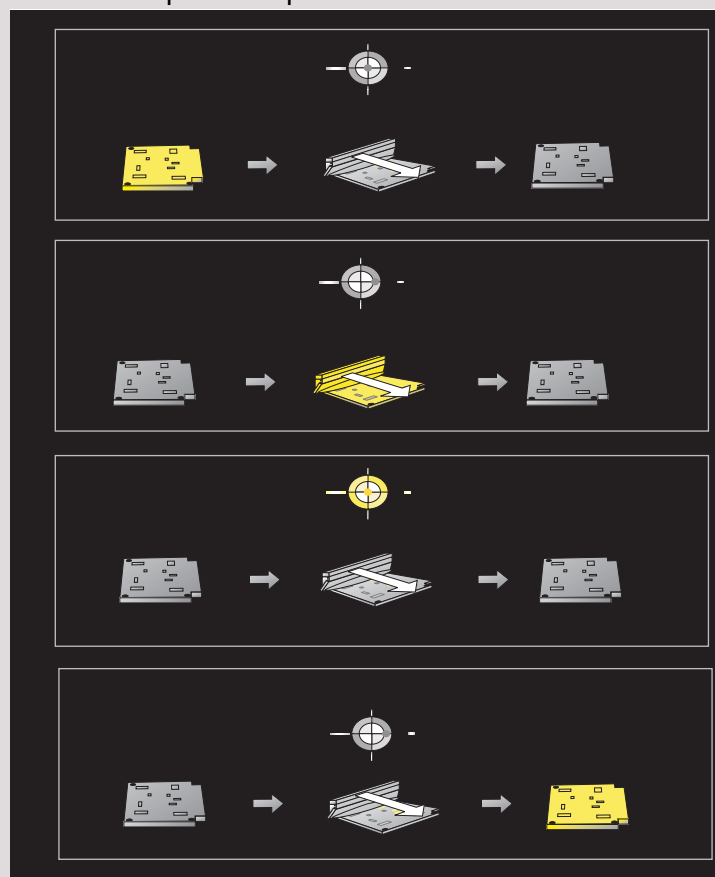
With paste painting off, the user can view the print medium on the pads without the paint overlay. This is useful for determining paste distribution, anomalies and paste to pad mis-alignment.





Board Mimic and Active HawkEye Indicator

The figure shows the board mimic and HawkEye indicators. The sequence starts with a board entering the machine, this is depicted by the yellow board indicator at the left (or right) inroad conveyor. The board enters the print station, the system carries out a fiducial search routine and the board is printed (represented by the squeegee travelling over the board in the direction indicated by the white arrow.) The camera carries out a scan of all the pre-programmed areas, the HawkEye indicator above the board mimic, turns on for the duration of the board scan. Finally, the board is passed downline. The sequence repeats for the next board.



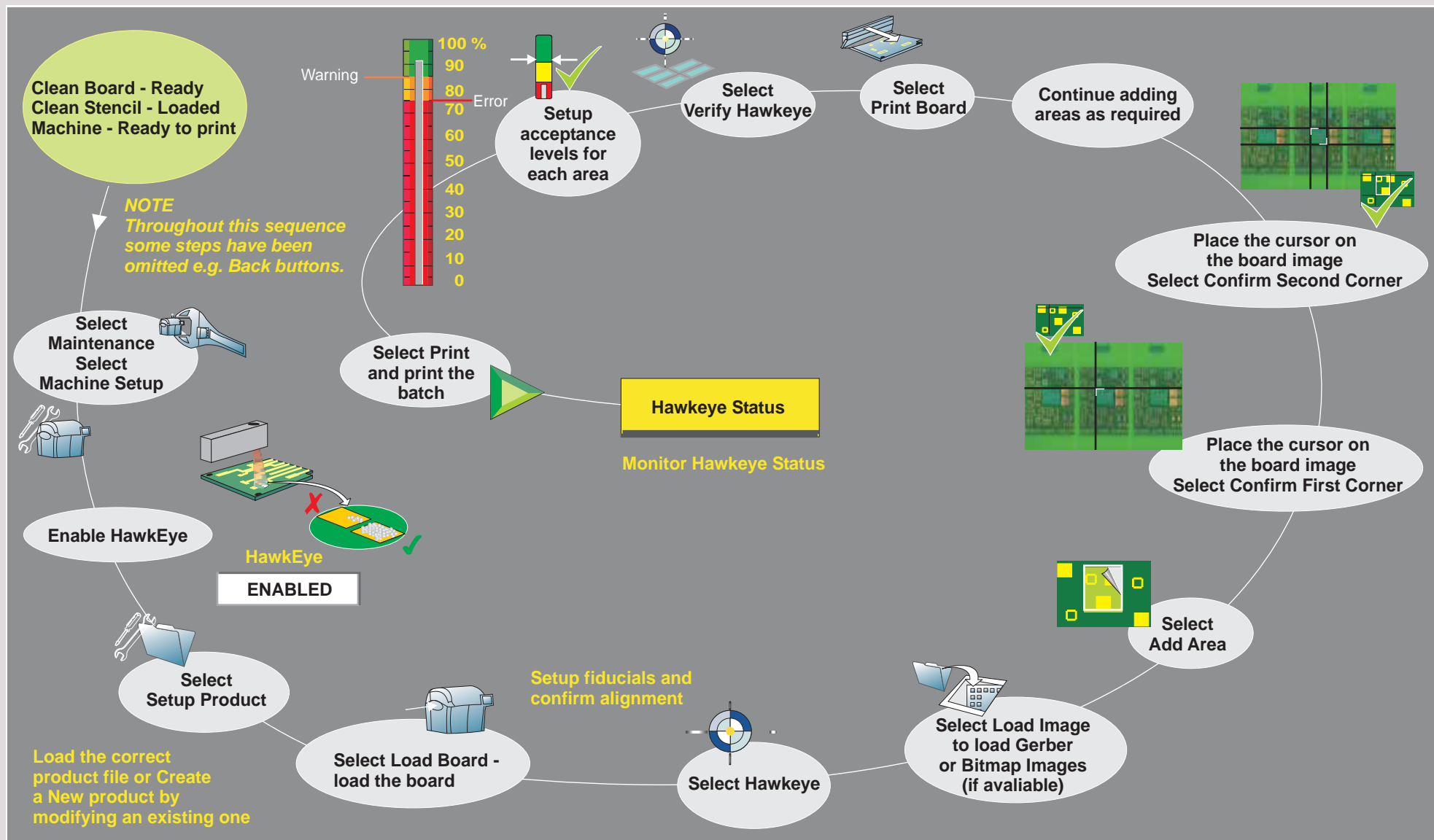
Prompt Bar

The prompt bar indicates the state of various events that are occurring during the different stages of production.

The paste level was within the warning region of area: 2

HAWKEYE SETUP

Setup Overview





The Setup Page

Adding Areas

Hawkeye provides an instinctive interface for setting up areas to be scanned.



Setup Using Coordinates

In the setup page select **Add Area**.



Using the board, measure the location of the first area to be scanned.

NOTE

With the board facing the feed direction (in the example below) the left edge is the datum point for X and the front edge is the datum for Y.

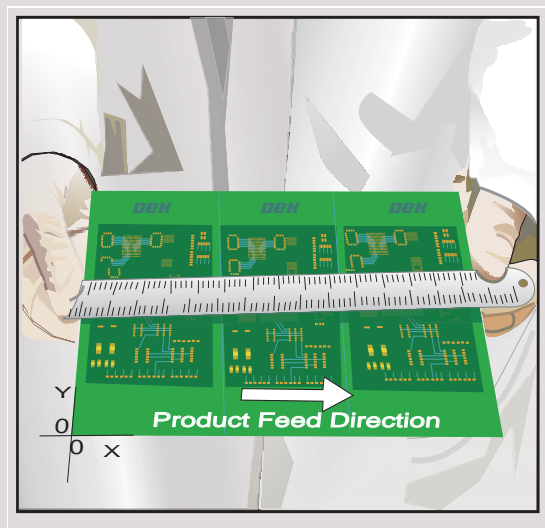
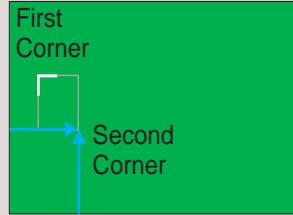
Select **Corner X** **Corner Y**. Input the X and Y coordinates to plot the position of the first corner in the top left position of the area.

Select **Accept**. Using the vision monitor check the crosshairs do not cut component pads but align closely to them. Use the nudge arrows to adjust position as required. Select **Confirm First Corner**.

Repeat the above in the bottom right hand corner of the area to create the second corner.

Select **Confirm Second Corner**.

Repeat this procedure to add other areas into the product file.

	<p>Input Coordinates</p> <p>Enter the coordinates of the first corner in the appropriate parameter panel for X and Y. Repeat for the second corner to fully describe the area. Use the vision window to confirm position.</p> 	<p>Corner 1</p>	
		Corner X	30 mm
		Corner Y	112 mm
		<p>Corner 2</p>	
Corner X			
Corner Y			



Setup Using Image Files

Selecting the **Load Image** button opens the file directory page where users can select an image file to load into the board representation window. Two file types can be loaded, Gerber (.gbx) or Bitmap (.bmp).

A graphical representation of the board is loaded into the board representation window.

Select **Add Area**.



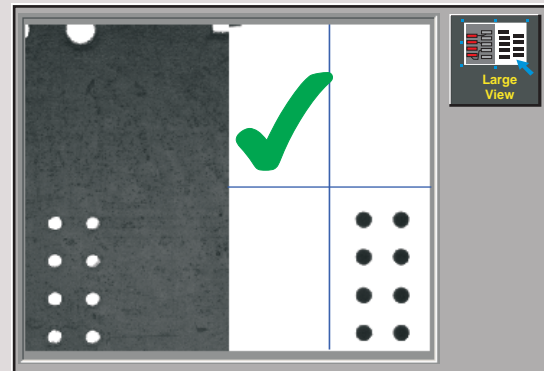
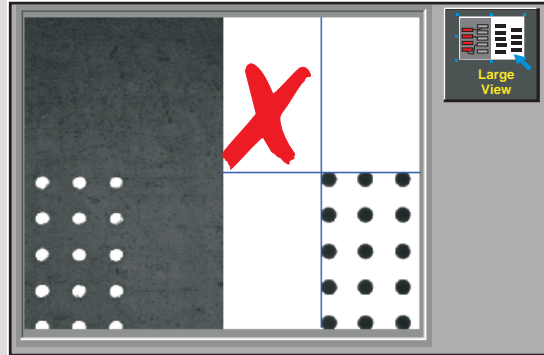
Place the cursor at the position on the graphic close to the first corner of the area to be scanned. See Image Controls information for details.

Select and confirm the first corner of the area to scan. Repeat the process for the opposite corner, the resultant rectangle is the first area to be positioned.



Repeat this procedure to add other areas.

Image Controls Monitor the **Vision Window** while using the Nudge Controls (see opposite) to align the crosshair for a fit that does not cut a component. To fine adjust, set the nudge adjustment level lower.

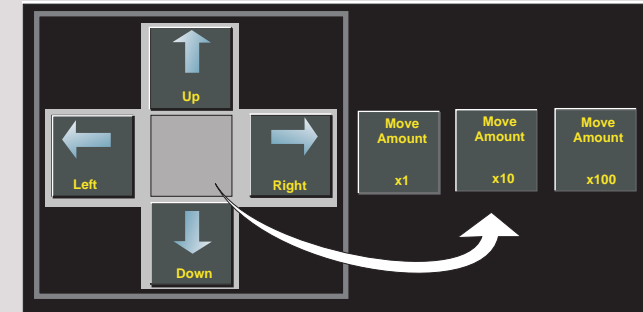


Large View can be used to increase the size of the image to confirm position. In the large view window a **Reduced View** button is available which returns the vision window to the original size.

NOTE

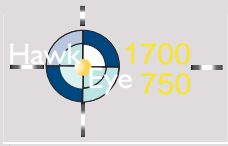
The examples above use a HawkEye 750 Camera

Nudge Controls are provided to assist with the movement of the crosshair into position, the central button if selected, provides a means to increase or decrease the amount of nudge movement in the selected direction by a factor of ten.



The board representation window has the following associated controls:

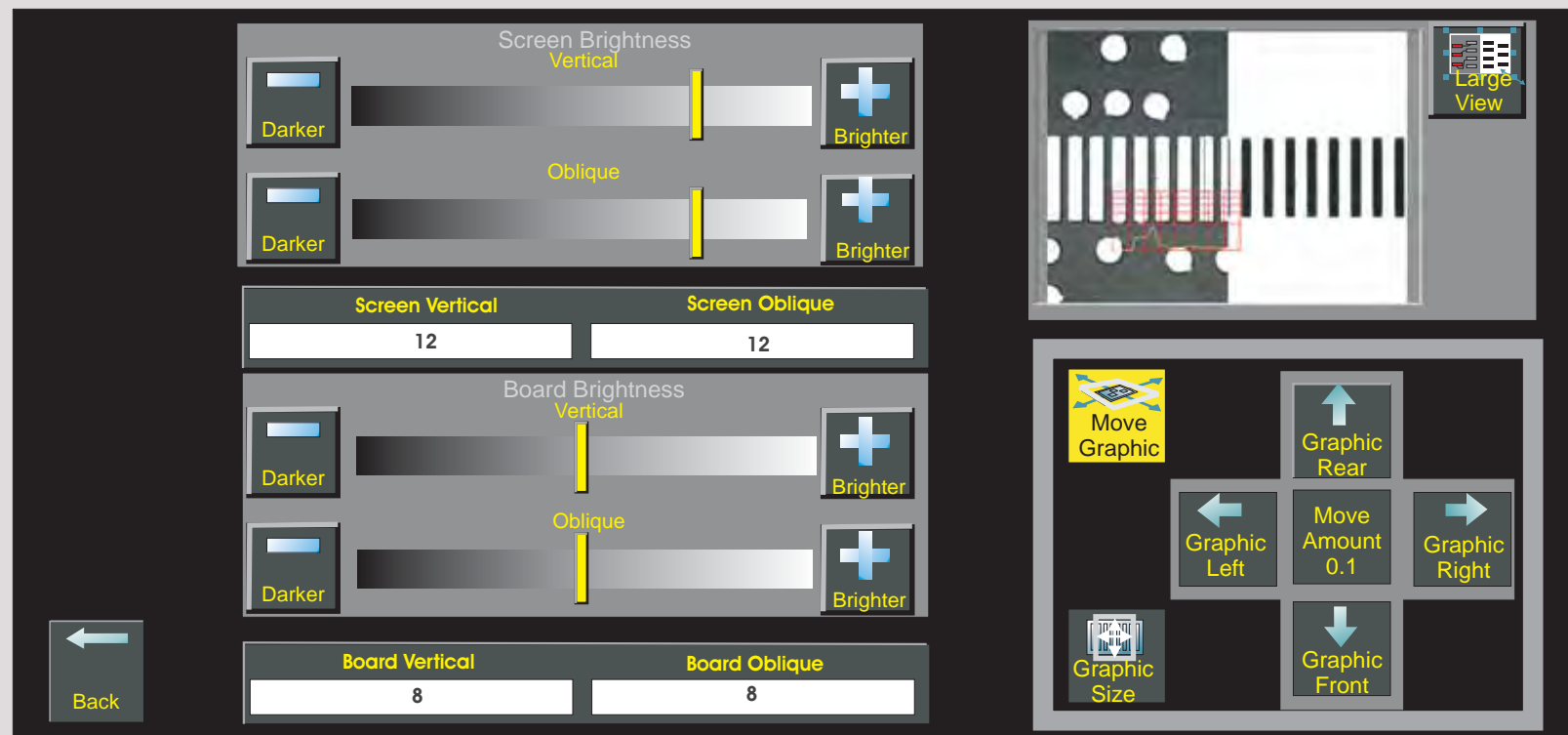
- **Zoom In** - Produces a close-up of a user- selected portion of the imported board image
- **Zoom Out** - Returns the image view to the previous zoom display level
- **Load Image** - Opens a file import menu for importing either a bitmap file (.bmp) or an extended gerber file (.gbx) into the board representation window
- **Show/Hide Image** - Shows or hides the gerber or bitmap image. This can be useful when viewing the location of programmed areas.



Lighting Adjustment

Lighting levels for screen and board can be set, the set levels apply to the whole board. Lighting levels should be set up using a clean unprinted board and a clean undamaged screen. Monitor the image in the vision window. A blue outlined rectangle with centre cross is shown, the size and location of this graphic can be adjusted by selecting **Move Graphic** or **Graphic Size** and using the nudge controls below the vision window. Once centred on the area and sized accordingly, the lighting levels can be adjusted so that the histogram graphic shows two well spaced peaks indicating a good contrast between light and dark. The factory default settings for brightness and contrast are usually adequate for most cases and lighting adjustment should not be considered the first line solution for any faults that occur. This facility is available during setup and when adjustment is selected during a print run.

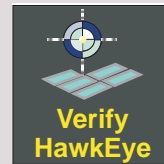
On completion of lighting setup, select **Back** to return to the previous page.



Print the Board Select **Print Board**. The board is loaded into the machine and printed.



Verifying HawkEye Select **Verify HawkEye**. The Verify HawkEye page is displayed.

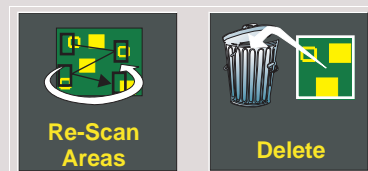




The Verify HawkEye page consists of many of the elements previously described. It has a board representation window and associated controls, a results indicator, a vision window and a lighting selection button. In addition there is a table for the scan area parameter set, the user can select areas on the board representation window or individual items in the table for closer examination. Finally, there are two buttons that are used to access the verification start rate and verification rate parameters.

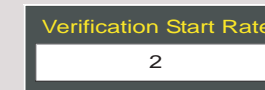
All of the areas that have been programmed are scanned and reported on. Individual views within each area can be selected, the camera moves to the view and displays the pads/apertures in the vision window.

Select **Re-Scan Areas** to perform another scan of all areas. Select **Delete** to delete the selected area or delete all areas.

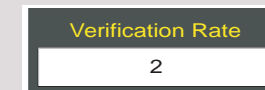


By selecting the **Set Level to Accept** button the software automatically sets warning and error levels to within $\pm 5\%$ of the measured print level.

The Verification Start Rate function works in conjunction with Verification Rate. The Verification Start Rate sets the number of boards to be passed through the system before verification takes place. In this example two boards are printed, HawkEye is active on the second board.



The Verification Rate determines the interval between scans. In this case verification takes place every second board in the batch and is ignored every other board.



Working together these parameters ignore the first board in the batch, verify the second, then the fourth and so-on until the batch is complete.



Scan Area Parameter Set

The Scan Area Parameter Set consists of:

- Name - number of the highlighted board image area.
- Rate - the user-defined number for the frequency that the area is scanned during production. Zero indicates the area is not scanned. One indicates that the scan proceeds every cycle, two indicates that the scan proceeds every other cycle and so on.
- Scan Time - is an indication of the time to scan the programmed area.



In the graphic, the areas named in the table (one and two) have been programmed to be scanned every cycle and the scan time is half a second for each. Area number three is set up as a complete scan of the whole board, this takes 60 seconds, it has been programmed to occur on the fifth cycle only (Verification Rate is set to five). The average scan time per cycle is therefore: $2 \times 0.5 + 12 (60/5) = 13.0$ seconds.



HAWKEYE REPORTING

HawkEye Alarm

Ensure that the machine is setup ready for a production run.

Check that the correct product file, board and screen are loaded and that the board and screen are both clean. Ensure that the print medium is prepared for printing and that the print applicator is fitted (calibrated as required). Set the batch count to zero and ensure that the batch limit is set for the number of boards to be printed.

Select **Print**.



If there are sites within the areas that are low on paste the system halts production and posts an alarm to the interface.



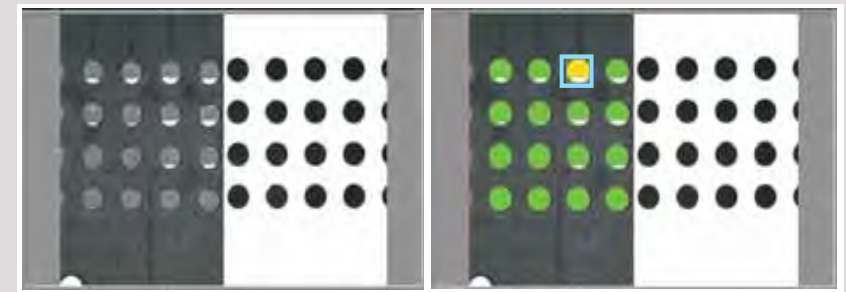
Use the vision window for on-board verification. Alternatively, the board can be removed and inspected off-line.

The user can determine whether to continue printing or to reject the current board. Select **Accept** to transfer the board downline or **Reject** to remove the board from the production run.

Select **Toggle Paste** to turn paste painting ON/OFF.



Turning paste painting off allows the user to view the print medium on the pads without the paste-painting overlay. This is useful for determining where the distribution is, if there are anomalies or if there is paste to pad misalignment. Switching the paste painting overlay back on again reveals the region of interest and shows the pad with the least paste for the print (blue rectangle). If the threshold levels have been correctly set, the user can determine immediately when any of these problems are likely to need attention or if it is simply a matter of adjusting the thresholds to an acceptable level for optimal production.



Paste Painting OFF

Paste Painting ON

Having inspected the paste deposit and verified it is acceptable:

NOTE

The following parameters are password protectable and may not be edited by some personnel.

Select **Adjust Levels and Rates**.

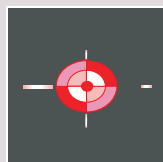


Select **Set Level to Accept**.



The Warning and Error levels automatically set to within 5% of the measured print level.

On completion, select **Accept**, control returns to the run page, printing continues unless an alarm level is reached. The HawkEye active indicator turns red to indicate an alarm condition exists.



Where warning areas exist they are displayed, only errors (coloured red) stop the machine.

Name	Rate	Scan Time
10	1	1.0S

If the print levels are unacceptable to the user there are several remedial actions to be taken. Select **Recovery Actions**.



Dependant upon which options are fitted to the printer, the context of the available buttons alters. An example of a typical set is shown below.



If taking these actions does not resolve the problem consideration should be given to:

- Incorrect placement of the area boundary graphic
- The contrast between the pad features and the board background may make it difficult for the vision system to differentiate between them
- Inaccuracies in the board to screen alignment

OPTIMISING FOR PRODUCTION

Setting A Line - Beat Strategy

Because areas can be setup for individual components, groups or even the whole board, it is possible to set a strategy that is tuned to the production run.

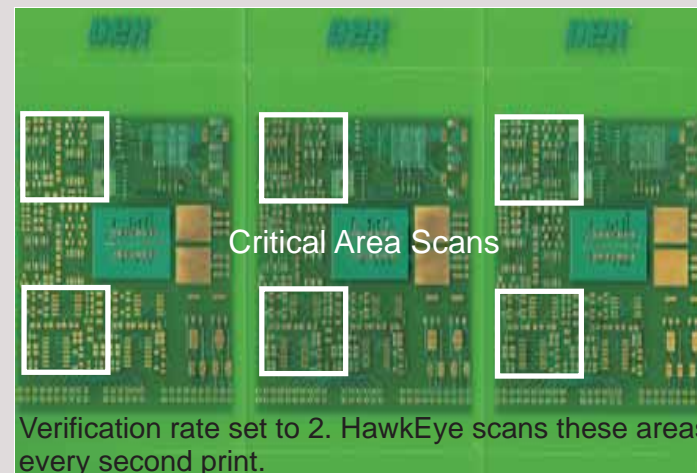
Increasing levels of verification may give added confidence that the printed board has the required level of print medium being deposited. However, if the user needs to finely tune the process to meet the line beat demands, using HawkEye's ability to set a different verification rate for each area means that the complete process can be tuned to the downline process.

For example: on every second board in the batch, critical areas may be setup for verification whereas, on every fifth printed board there may be a complete verification scan performed. In this instance, the whole board is verified and this takes slightly longer than if only one or two areas are set up. The difference in time is repeatable and may coincide with for example, process changes on a downline machine.

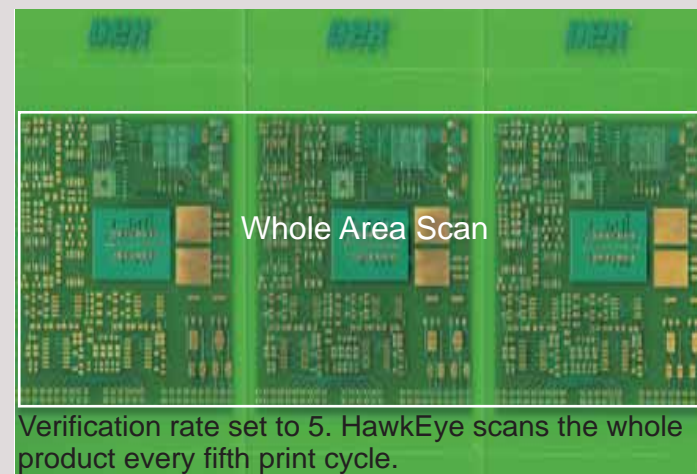
In the example shown the first board in the batch is printed without being scanned. The second is printed and scanned at the critical areas, the third is printed without being scanned, the fourth is printed and scanned at the critical areas and the fifth is printed with the whole board being scanned. They both coincide on the tenth print.

NOTE

Two images have been shown for diagrammatical reasons not because HawkEye requires both scan types.



Verification rate set to 2. HawkEye scans these areas every second print.



Verification rate set to 5. HawkEye scans the whole product every fifth print cycle.



MONITORING OUTPUT

SPC Data Recording

Parameters can be setup and used as monitors for Statistical Process Control (SPC) when running HawkEye, they are:

- HawkEye Area Errors - number of areas for which the paste level of the least pasted view is below the error level threshold for the area
- HawkEye Area Warnings - number of areas for which the paste level of the least pasted view is below the warning level threshold but above the error level threshold for the area
- HawkEye Feature Errors - number of features for which the paste level is below the error level threshold set for the area from which the feature comes
- HawkEye Feature Warnings - number of features for which the paste level is below the warning level threshold but above the error level threshold for the area from which the feature comes
- HawkEye Paste Percentage - the percentage of the least pasted feature within the least pasted view for each HawkEye area

The path to setup SPC parameters is: Setup\Options\SPC

Select the required SPC Parameters on the SPC parameters page and edit as appropriate.

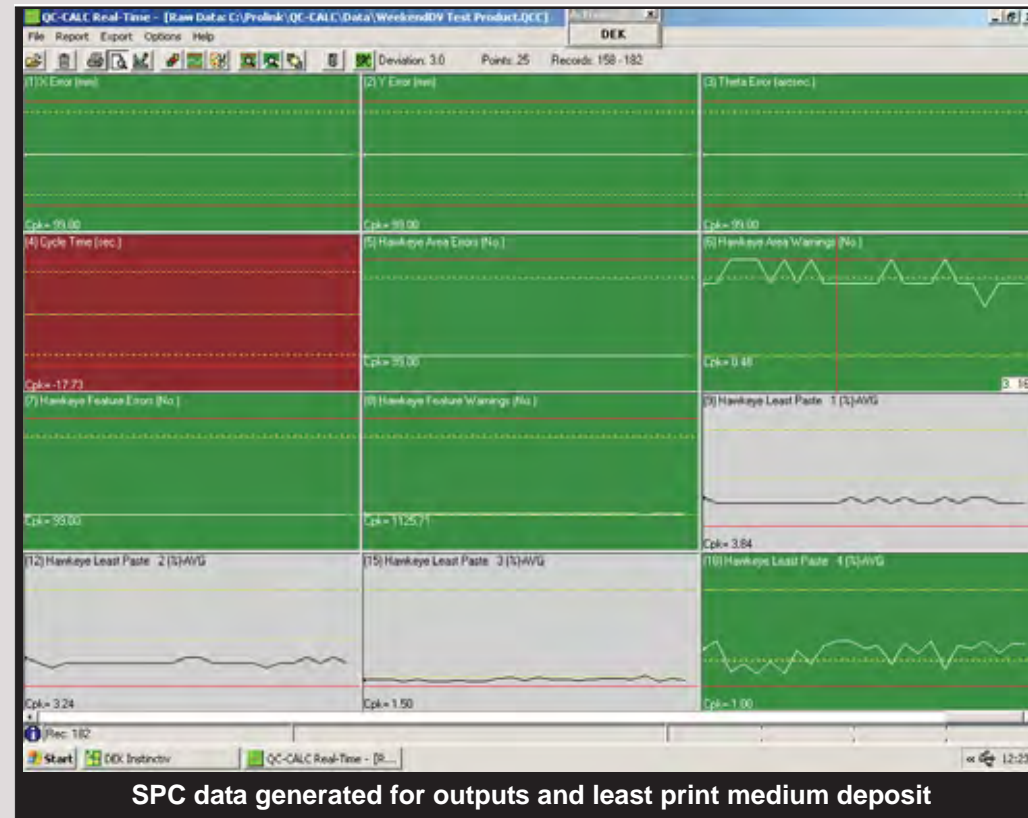


The path to edit SPC output events is: Setup\ Options\ SPC\ Edit Outputs.

Scroll down the page to check that monitoring has been turned on. The display event function should be **Yes** for all required HawkEye monitored SPC Events. The least pasted view for each area is recorded automatically and does not need to be setup.



With the printer operational the data is logged and plotted automatically. If the user has selected only HawkEye events the display shows these events and ignores all others. Otherwise the display shows all active events and the user must navigate to the relevant HawkEye plots.



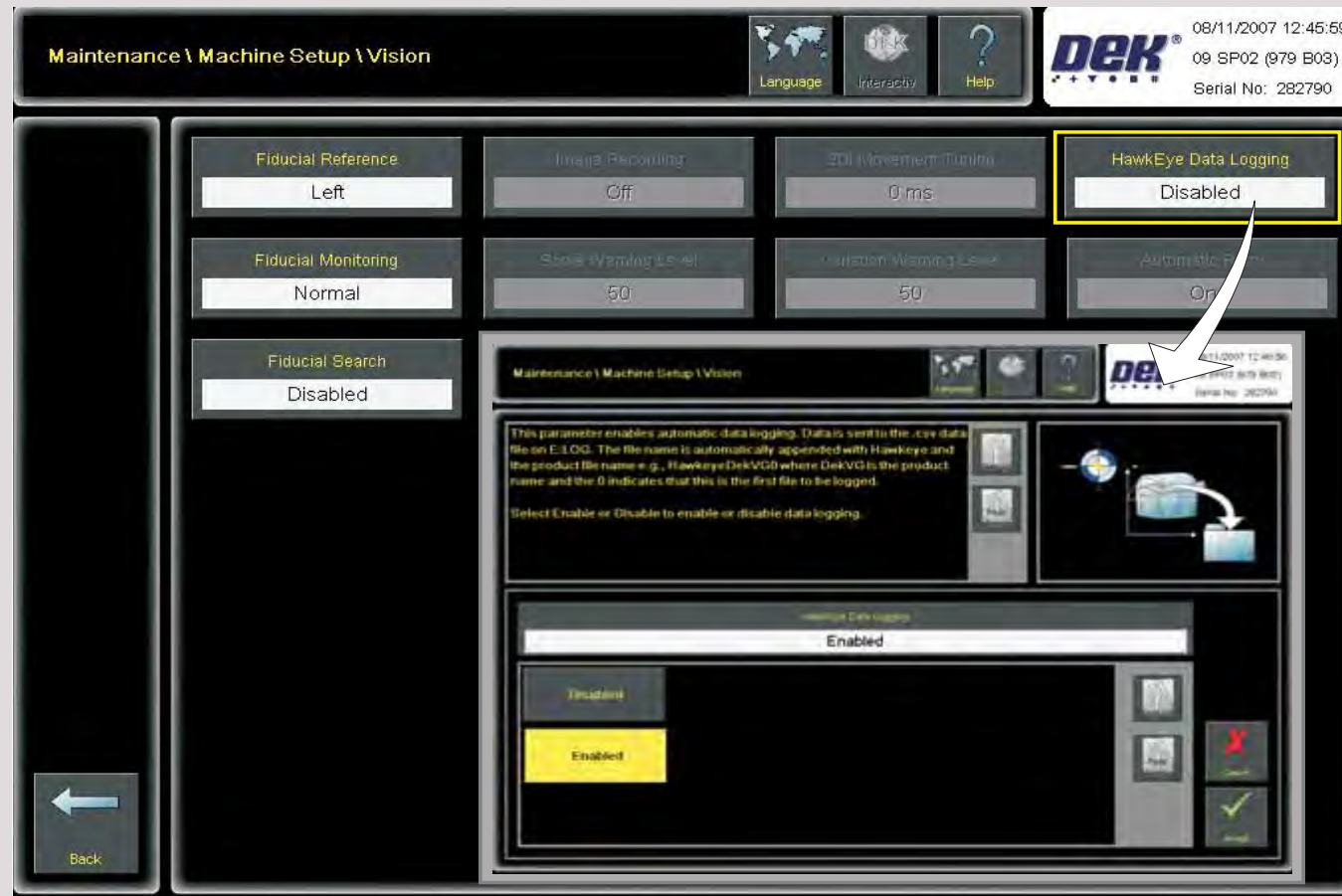
By selecting the peaks and troughs of the graph the user can extract time related information for example, area number and paste percentage deposit.

For more detailed information right click on an area of interest and select point or plot properties.



Data Logging

To enable data logging select Maintenance\Machine Setup\Vision. Select **Hawkeye Data Logging** and set to Enabled.



All Hawkeye events are reported on and logged. The data is stored in the .csv file on the system E drive at E:\log.

The file has a naming convention: HawkeyeProductName.csv.



Date and Time	Product Barcode	Batch Number	Area Name	X Pos	Y Pos	% Paste	Result	Warning Threshold	Error Threshold
12/11/2007 9:45 AM	2716859	12	1	121.41	104.41	90	P	85	75
12/11/2007 9:47 AM	2716859	13	1	121.41	104.41	76	W	85	75
12/11/2007 9:49 AM	2716859	14	1	121.41	104.41	80	W	85	75
12/11/2007 9:51 AM	2716859	15	1	121.41	104.41	80	W	85	75
12/11/2007 9:53 AM	2716859	16	1	121.41	104.41	90	P	85	75
12/11/2007 9:55 AM	2716859	17	1	121.41	104.41	92	P	85	75
12/11/2007 9:57 AM	2716859	18	1	121.41	104.41	80	W	85	75
12/11/2007 9:59 AM	2716859	19	1	121.41	104.41	75	W	85	75
12/11/2007 10:0 AM	2716859	20	1	121.41	104.41	70	E	85	75
12/11/2007 10:01 AM	2716859	21	1	121.41	104.41	68	E	85	75

Scrolling to the right enables data on other programmed areas to be shown. →

Logged Event	Definition
Date and Time	All events have a timed record of when they occur.
Product Barcode	Where used, this is an identifier for the board being processed.
Batch Number	Identifies the specific board within the batch to which the data relates.
Area Name	The number given by the system to identify the area being scanned.
X Pos	The location in X that corresponds to the centre of the least pasted view, measured from the bottom left corner of the board.
Y Pos	The location in Y that corresponds to the centre of the least pasted view, measured from the bottom left corner of the board.
% Paste	Percentage paste for the least pasted feature within the least pasted view.
Result	Indication of the scanned result for the named area. P = Pass, W = In the Warning Threshold, E = In the Error Threshold.
Warning Threshold	The threshold level that instigates a HawkEye warning.
Error Threshold	The threshold level that instigates a HawkEye error.

The size of the .csv file is limited to 1Megabyte. When the file has reached the maximum size it is archived by appending a sequence number to the file name and a new HawkEye.csv file is opened. The sequence numbers for archiving are 0 or 1. If both sequence numbers for the file have been used, the first (oldest) file is overwritten. The software posts a warning if the disk free capacity becomes less than ten percent.

ERROR ANALYSIS

Pre- Verification Scan Offset Elimination

Before areas are added to the verification strategy, the user must ensure that a board's print offsets are known and applied. For example, prior to printing, the printer aligns the stencil to the board. On a board, the stencil aperture is designed to align to the centre of the pad, as shown by the red and blue centroids in Figure 1 - Board to Stencil Alignment.

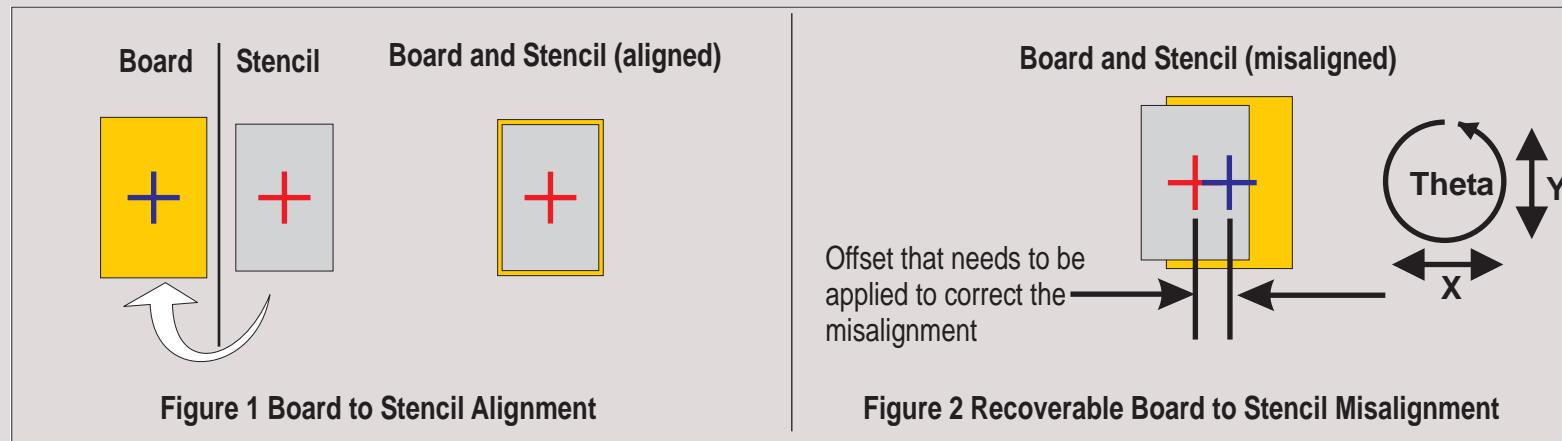
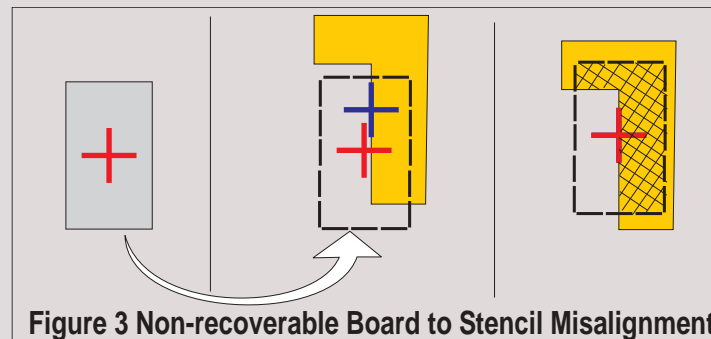


Figure 2 Recoverable Board to Stencil Misalignment, shows offsets in X and Y (can also be Theta) which need to be applied. The user programs these offsets into the product file; these then become known to the deposit verification process when areas are created. However, a board's design may include irregular shaped features as shown in figure 3 Non-recoverable Board to Stencil Misalignment. The board and stencil features are not designed to align with each other. In these situations, the print offsets may be difficult to establish, in extreme cases the verification system is unable to resolve any alignment issues, ruling them out of the verification setup. In figure 3, the blue centroid is in the centre of the pad, the red centroid is in the centre of the aperture and the hashed area denotes the location where the pad would have been printed had it aligned correctly.



For HawkEye this may cause the paste overlay to be offset causing incorrect paste painting alignment issues.



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