# ACCUBAND CROP IMAGING COILBOX ENTRY SYSTEM MODEL C965C

## VERSION 6.0

## USER'S MANUAL

**Manual # 90465**
**Rev. A**
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# WARNING SUMMARY

## Intended Use

The Accuband Crop Imaging System, Models C965C, Version 6.0 is intended for the measurement of Strip width, Crop Imaging and Crop Cut length determination in metals rolling and processing applications. Do not use an Accuband Crop Imaging System in a manner not expressly described in this manual or approved by authorized KELK personnel or their agents. The outputs and the alarms will be unpredictable and both Accuband and the equipment to which it is connected may be damaged.

## Accessibility

The Accuband Crop Imaging System comprises of two main components: Accuband Width Gage and Accuspeed Laser Velocimeter. Please consult the Warning paragraphs from the User's Manuals of these two components for Accessibility details, cautions and recommendations.

## Technical Assistance

For Technical assistance on any KELK product, contact George Kelk Corporation at:

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# PREVENTING ELECTROSTATIC DAMAGE

**CAUTION**. Electrostatic Discharge (ESD) can damage static sensitive components used in this equipment. To prevent ESD, follow the guidelines below when handling, removing, or installing electronic assemblies, boards or components.

1. Handle boards as little as possible.
2. Store and transport boards only in static shielding bags or containers.
3. Boards should only be removed from their static protective packaging by personnel wearing a grounded wrist strap.
4. When boards have been removed from the equipment or their protective packaging, do not place them on any surface other than a properly grounded static dissipative mat.
5. Before installing or removing any boards, make sure that the equipment is properly grounded.
6. Personnel installing or removing boards from the equipment should wear a wrist strap which is grounded to the equipment chassis.

# PART 1 ABOUT THIS MANUAL

## 1.1 Applicability

This manual describes the operation of the ACCUBAND Crop Imaging System, Version 6, for a coilbox entry open loop configuration. It must be used in conjunction with the Accuband Width Gage and Accuspeed Laser Velocimeter user's manuals.

The sketches, drawings, and values used are for the information of the reader and not intended for procedures which are not specifically set forth in this manual.

Information is provided for operation, setup, and configuration of Accuband Crop Imaging Systems, Model C965C, Version 6.0, when used for the measurement of strip width, head and tail end profiling and crop cut length determination in metals rolling and processing applications.

The basic system may be combined with an Accucrop crop shear controller to form the KELK Closed Loop Crop Optimization System. Accucrop regulates the shear mechanism so that the shear blades will crop the transfer bar very close to the theoretical crop line set by the Accuband Crop Imaging System. For information and usage of other options, please see their corresponding user's manuals.

If additional technical assistance is required, contact KELK at the address given on the title page or our designated agent.

# PART 2 GENERAL DESCRIPTION

## 2.1 Introduction

The Accuband Crop Imaging System is made up of two main parts:

- Accuband Width Gage
- Accuspeed Laser Velocimeter

## 2.2 Scope

This chapter includes important terminology that the user will find helpful in understanding the Accuband Crop Imaging System. The system main components are described here, and how the Accuband Width Gage and the Accuspeed Laser Velocimeter are combined to create the Accuband Crop Imaging System, Model C965C.

This section is necessary for understanding the operating principles which will make troubleshooting and analysing operational results possible. The details here are limited to the Crop Imaging System. The details regarding the KELK Closed Loop Crop Shear Control are covered in the Accucrop user's manual.

## 2.3 System Configuration

### 2.3.1 General Description

Below is a brief description of the Crop Imaging system main components. For more detailed information, please see the Accuband Width Gage user's manual, Accuspeed Laser Velocimeter user's manual and Accuspeed Installation and Maintenance user's manual.

The Accuband Width Gage comprises of:

- Scanner - a rugged and thermally insulated sealed enclosure containing the cameras and all data processing electronics. It also contains a water cooling system and a laser used for camera alignment.
- Scanner support - composed of the Plenum chamber (providing a region of still positive pressure air around the cameras) and a suspension system tuned to protect the scanner from shocks and vibrations.
- Nozzle - provides a continuous downward airflow to assist in keeping dirt away from the camera windows and the optical path between the cameras and the strip clean of dust and steam.

- Scanner Power Supply and Calibrator Controls - provide 24 VDC power to the scanner and incorporate connection points for the communications interfaces.
- Cable / Hose assembly - provides interconnection cables for power and communication between the scanner and scanner power supply and calibrator controls
- Calibrator, Calibrator Carrier and Junction Box with cable - used for the scanner in-situ calibration.
- Discrete I/O Kit - provides communication with the gage through analog and logic I/O's.
- Operator's Interface (PC) - allows manual entry of the set-up data, and monitoring of the gage by the mill operator.
- Accuband Electronics Unit - houses the Discrete I/O kit, Accuspeed Electronics Unit and connectivity switches.

See Figure 2.1 for a typical Accuband Width gage layout.

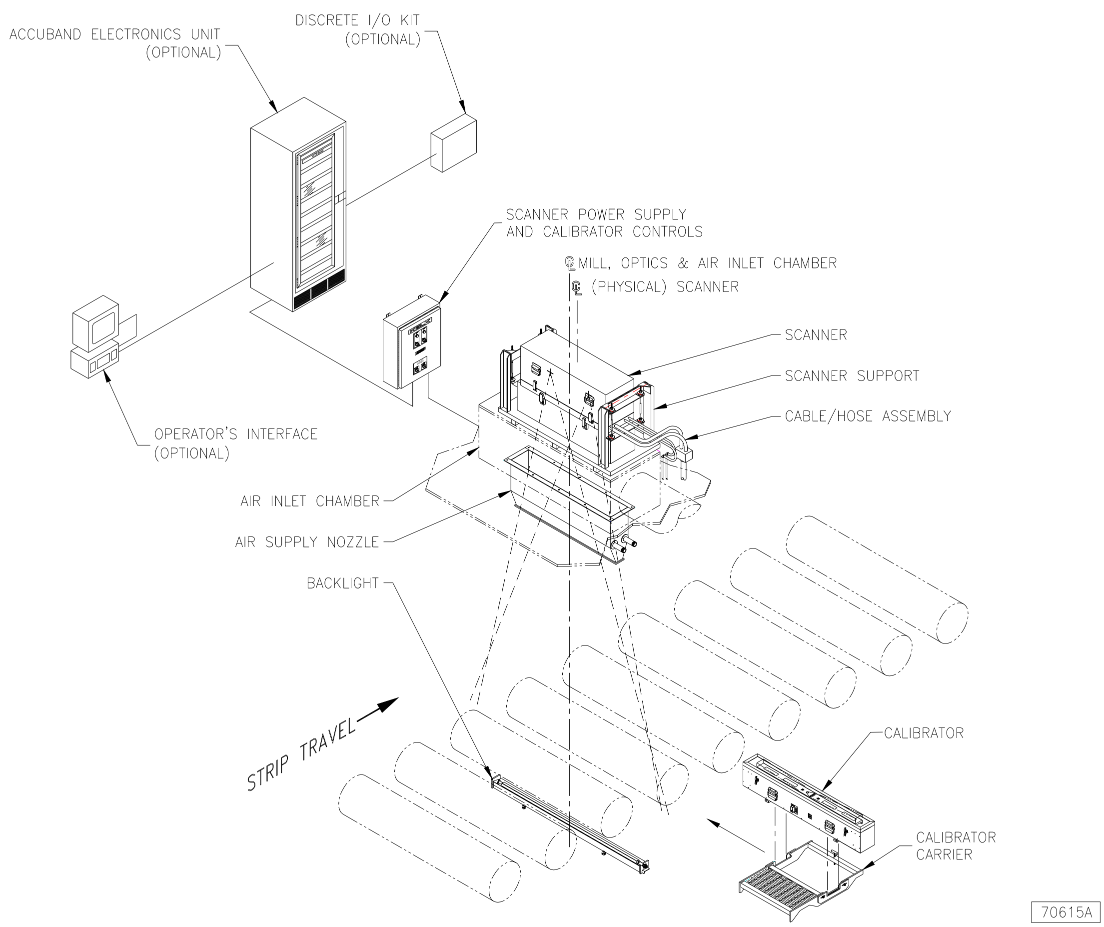



**Figure 2.1 Accuband Width Gage Layout**

The Accuspeed Laser Velocimeter comprises of:

- Optics Head assembly - generates an optical signal from which the moving material velocity and length is extracted.
- Head mount - allows the optics head to be mounted and aligned relative to the moving material.
- Optics Head extension cable - High temperature cable that connects the optics head to the Junction Box.
- Optics Head cable - PVC cable that connects the junction box to the electronics unit.
- Junction Box - connects the optics head cable with the extension cable.
- Electronics Unit - houses the signal processing and the external interfaces

See Figure 2.2 for a typical Accuspeed Laser Velocimeter layout.

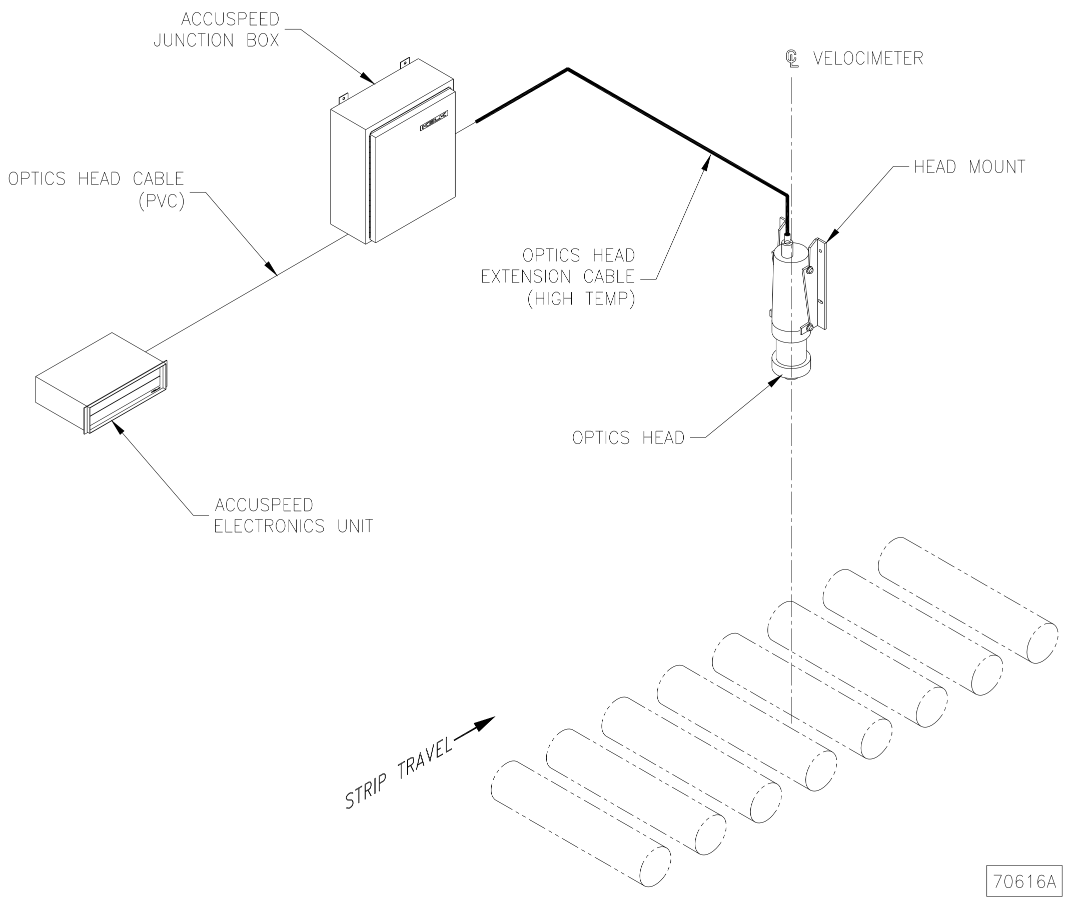



**Figure 2.2 Accuspeed Laser Velocimeter Layout**

### 2.3.2 Crop Image System Layout

The scanner, sitting on the scanner support and nozzle, is mounted on a platform 3-5 m (10-16 feet) above the roll table at the coilbox entry location. Scanner power supply and calibrator controls are installed about 10 m away from the scanner and the cable and hose assembly connects the two of them.

Calibrator and carrier are used during calibration, positioned under the scanner on the roll table. Power and controls to the calibrator is via a 20 m cable stored in the junction box positioned on the side of the roll table.

The Accuspeed Laser Velocimeter optics head is installed on the head mount a short distance after the scanner unit (approximately 1 or 2 rolls spacing), above the roll table at a factory defined stand-off distance. The Accuspeed junction box, usually 10 m away from the optics head, is installed on one side of the roll table (platform). The optics head extension cable and the optics head cable connects the optics head to the Accuspeed electronics unit via junction box.

The Accuband electronics unit cabinet is usually located in a clean environment (machine room) and contains the Accuspeed electronics unit, Discrete I/O kit and connectivity switches.

The operator’s control panel is installed either in the machine room or in the operator’s pulpit allowing manual entry of the set-up data and monitoring the gage performance.

See Figure 2.3 for a typical crop imaging system layout.

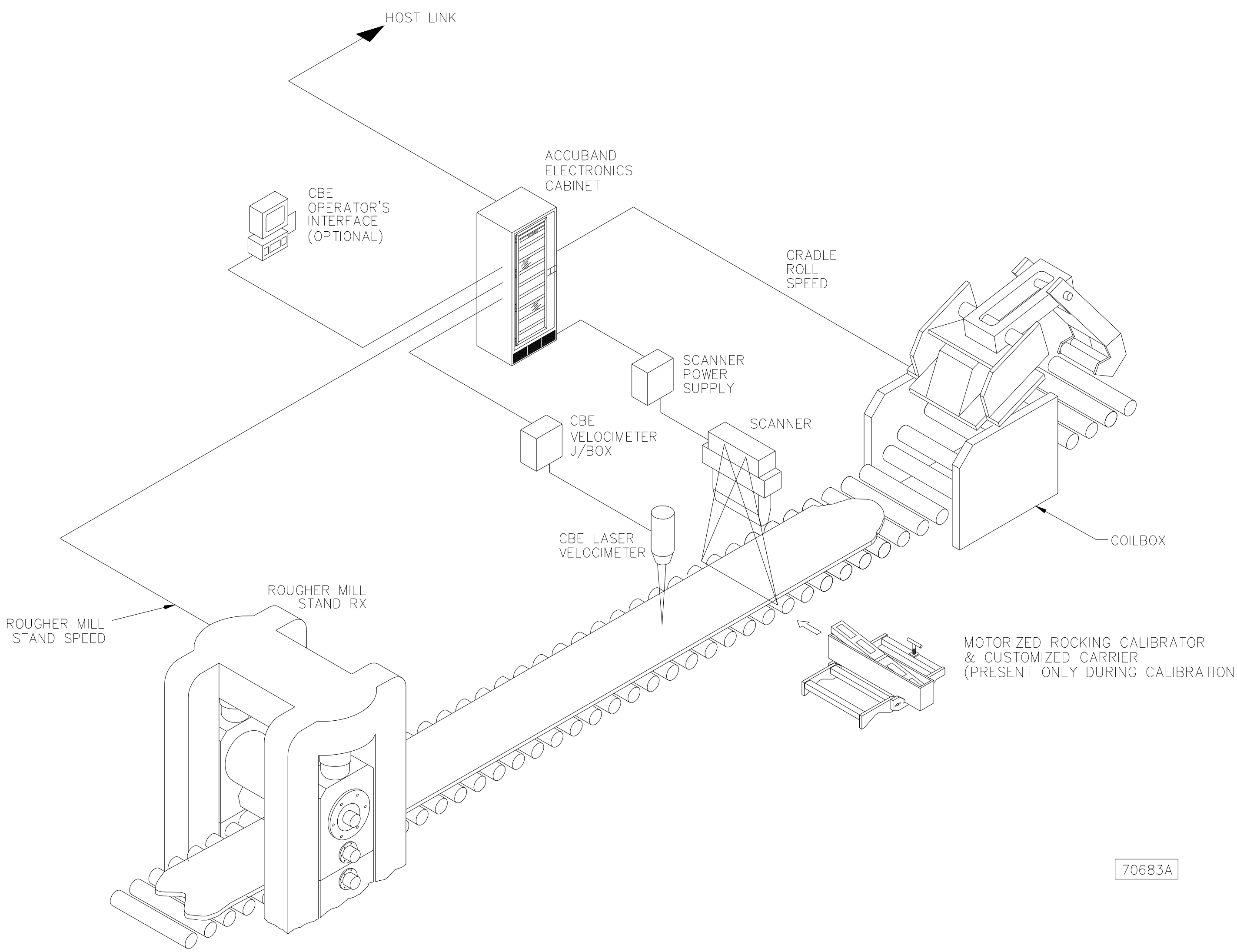



**Figure 2.3 Coilbox Entry System Layout**

### 2.3.3 System Features

Here are the main features of the Crop Imaging System:

- Absolute Width Measurement
- Width Deviation Measurement
- Centreline Deviation Measurement
- Crop Imaging
- Crop Shape Classification
- Cut Length Determination
- Crop Statistics

## 2.4 Communication

There are two communication interfaces:

- Ethernet ports
- Analog and digital I/O

The interfaces are usually accessed in the Accuband electronics unit and are normally connected to the mill control system by, or with the assistance of KELK personnel during commissioning.

**Ethernet Ports**

Generally, the Accuband Electronics Unit contains two type of Ethernet ports (switches) - Host and I/O.

- Host Ethernet switch - used for communication to the scanner primary port (Host), operator’s control panel and mill automation system (Host PC, etc.)
- I/O Ethernet switch - used for communication to the scanner secondary port (I/O), Discrete I/O Kit and Accuspeed electronic unit.

For more details on the scanner primary and secondary ports, Discrete I/O and Accuspeed electronics unit, please consult the corresponding user’s manual for each piece of equipment.

**Analog and Digital I/O**

There are three types of analog and digital I/O:

- Logic outputs - located inside the scanner power supply and calibrator controls
- Discrete I/O kit - usually located inside the Accuband electronics unit
- Accuspeed I/O - usually located inside the Accuband electronics unit (from Accuspeed electronics unit)

## 2.5 Logic Outputs

There are three logic outputs accessible inside the scanner power supply and calibrator controls:

- Scanner power ON
- Alignment laser ON
- Cut Initiate pulse. More information on this output is provided in part 3 of this manual.

## 2.6 Discrete I/O kit

The Discrete I/O kit is usually located inside the Accuband electronics unit cabinet, but can also be installed remotely inside the PLC cabinet. It provides communication with the gage through analog and digital I/O.

- 4 analog inputs - Usual assignment: Strip speed and strip temperature
- 4 analog outputs - Usual assignment: Strip width, centreline deviation, absolute width, spare
- 4 logic inputs- Usual assignment: Measure roll/cradle roll valid, Rougher Mill Metal in Mill (MIM).
- 8 logic outputs - Usual assignment: Strip in view, Width data valid, Gauge healthy, Width out of range, Scanner over temperature, Crop image healthy, Head image fault, Tail image fault.
- 1 tachometer input (optional) - Usual assignment: strip speed from a pulse tachometer

## 2.7 Accuspeed I/O

The Accuspeed analog and digital I/Os are connected via a terminal block located inside the Accuband electronics unit.

- 5 digital outputs - Usual assignment: System ready, Head overheat, Sync. Out (reserved), Data valid, Laser On
- 3 logic inputs - Usual assignment: Direction (reserved), Start acquisition (reserved), Interlock
- 1 analog output - Velocity

## 2.8 Interconnection Diagram

The interconnection block diagram for a crop shear entry image system contains the interconnection lines between main system components including the power supply to the scanner, calibrator and Accuband EU cabinet.

The Accuspeed EU usually is installed inside the Accuband EU cabinet together with the Discrete I/O kit and connectivity switches. The ethernet network is outlined including the ports and links between Scanner, EU cabinet, operator's interface and Host PC. All the digital and analog I/O are indicated including the calibrator controls. The following interconnection diagram (Figure 2.4) must be used just for reference only. Always consult the drawing package supplied for your specific installation. Please consult the Accuband width gage user's manual and Accuspeed Laser Velocimeter user's manual for wiring and safety requirements, warning and connection details.

There is an optional ethernet connection from the Host ethernet switch to the KELK Accucrop controller. The Accuband crop imaging system can be combined with the KELK Accucrop controller (optionally supplied) to form the KELK Closed Loop Crop Optimization System.

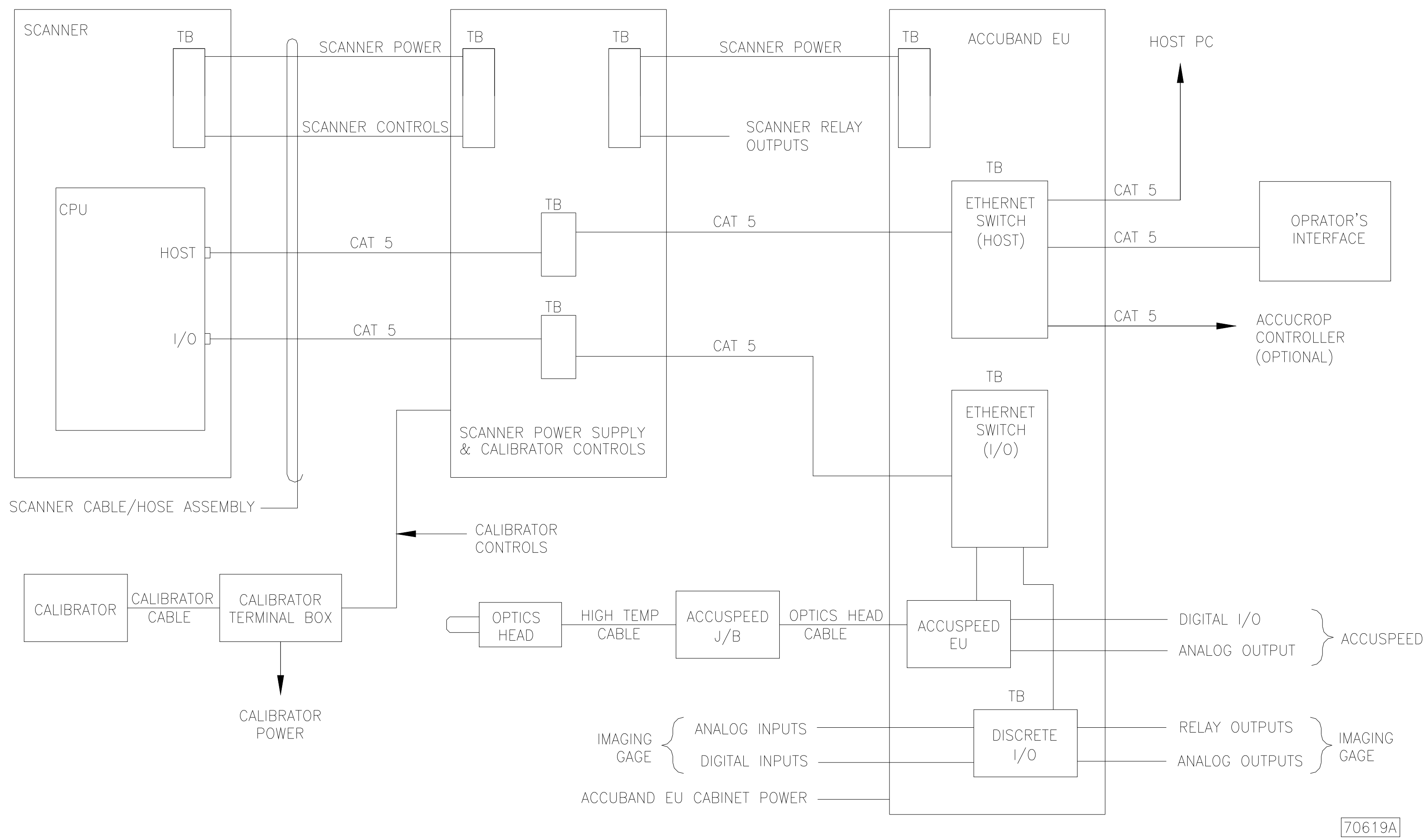



**Figure 2.4 Interconnect Block Diagram**

# PART 3 VELOCITY PROCESSOR

## 3.1 Introduction

The intent of this part of the manual is to describe the Velocity Processor's basic principle of operation, and to provide useful information for understanding the Imaging system operation described later in this manual.

## 3.2 General Description

The crop imaging system at the coilbox entry assumes that there are multiple bar speed sources available: Accuspeed Laser Velocimeter, Rougher mill roll stand speed, measuring roll or cradle roll speed, bar speed (from Host computer), default speed, etc. However, not all of them are accurate. The Velocity Processor must select the best and most accurate bar speed source and provide it to the crop imaging process and other internal processes. Some speed sources require calibration in order to be used.

## 3.3 Velocity Processor

The velocity processor collects speed data from multiple sources and combines them into accurate velocity inputs to the crop imaging process.

The Velocity Processor performs the following:

- Depending on the position of the bar and operating status of the various sensors, selects the best speed source.
- Calibrate secondary speed sources to primary source. Most tachometers are subject to errors due to slippage that can change depending on mill and material conditions. In order to maintain the best possible accuracy, these tachometers should be calibrated against the primary speed sensor - Accuspeed.
- Output the following data:

  A) System velocity, velocity source, calibration factor and status
  B) Head velocity, velocity source, calibration factor and status
  C) Tail velocity, velocity source, calibration factor and status

### 3.3.1 Speed Sources

- **Accuspeed Velocimeter**

  The Velocimeter is a non-contact optical sensor and provides the highest possible accuracy. It will always be used as the primary speed source when it is available. It is read via a MODBUS/TCP interface.

- **Measure roll and cradle roll**

  A measure roll or cradle roll contacts the strip and can be used to measure strip speed by determining the rotational velocity of the roll. The circumference of the measure roll must be known to convert rotational velocity to strip velocity. Speed from measure rolls and roll stands tend to be less accurate due to slippage and draft reduction effects between the strip and the roll. These effects change based on the material, size and temperature of the bar. For best results, roll speed inputs should be calibrated against a Velocimeter on the current bar before being used.

### 3.3.2 Roll Speed Sources

- **Analog tachometer**

  Analog tachometer produces a DC voltage (typically 0-10V) proportional to the rotational velocity. In the KELK crop imaging system, this voltage will be read with an analog input on the WAGO bus coupler. The supplied voltage will be converted into a specific velocity depending on the scaling applied.

- **Pulse tachometer**

  Pulse tachometer produces a specific number of pulses per revolution. By counting the number of pulses in a fixed time interval, the rotational velocity can be determined. In the KELK crop imaging system, a pulse tachometer can be optionally connected to a WAGO I/O module that can be used to read the frequency of a pulse train. A scaling of the distance per pulses will be applied here to convert the signal into bar velocity.

- **PLC data**

  It is also possible that the Host computer provide speed data by writing to a MODBUS/ TCP input register in the gauge. The PLC may also provide logic signals via MODBUS / TCP protocol such as MIM (Metal In Mill) or LAST PASS and still provide an analog speed source.

- **Default**

  The default speed can be configured to a fixed value. This value can be calibrated or locked to a specific value. Only one default speed can be defined and calibrated to the primary speed source.

### 3.3.3 Roll / Cradle Roll Speed Calibration

During periods when both roll speed and Velocimeter data are stable and measuring the same strip, the roll speed is calibrated to produce the same speed as the Velocimeter. A number of pairs of samples from the two speed sources are collected and a calibration factor is calculated. There is a series of checks in order to declare a calibration successful. Once the new calibration factor is available, the roll speed is corrected based on the ratio of the new calibration factor to the old.

### 3.3.4 Velocity Processor Outputs

- **System speed**

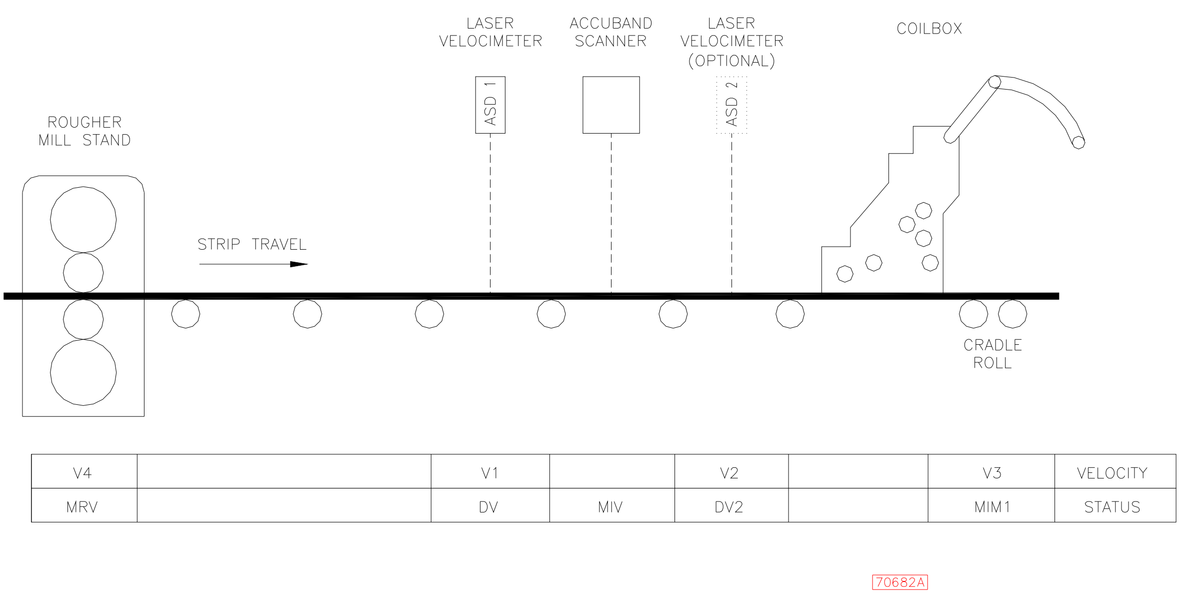
  The system speed will be provided for length and image processing. It is the bar speed at the scan line. Depending on the bar position, the velocity processor will decide what speed will be selected as a System speed from the following: Accuspeed Velocimeter, other calibrated speed sources, or calibrated default speed as a last resort.

- **Head and Tail speed**

  The head speed provided by the velocity processor is to be used for the bar tracking of the head. The tail speed is to be used to track the tail.

Figure 3.1 shows a typical representation of the sensors location and velocity sources available for an Accuband Crop Imaging System for a Coilbox Entry application.

**Figure 3.1 Sensors Location and Velocity Sources**




In the figure above (Figure 3.1), the bar moves from left to the right. The Velocity Processor defines three speeds: Head speed, Tail speed and System speed. As the bar proceeds through the mill, the velocity processor must select the best speed source based on a priority list.

The Rougher mill speeds (V4) and measure/cradle roll (V3) needs to be calibrated against the very precise speed generated by the Accuspeed Laser Velocimeter (V1). The calibration takes place only when the Accuspeed data is valid (DV) and the metal in mill (MRV) signals are enabled (High).

**The Head speed will be:**

- Laser Velocimeter speed (V1) if data valid.
- Optional Rougher Mill speed (V4) when Metal in Mill (MRV) is high.
- Default speed, if Rougher Mill speed source is not available.

Rougher Mill stand speed (V4) and default speed will be calibrated against the Accuspeed Laser Velocimeter (V1) when certain conditions are met. When a calibration is successful, the calibration factor is applied right away. For more information on head speed "back calibration", see section 4.3.10

**The Tail speed will be:**

- Optional Laser Velocimeter (V2) if data valid.
- Cradle Roll Speed (V3) if Metal in Mill (MIM1) is enabled.
- Default speed if MIM on measure/cradle roll is disabled.

Default speed will be calibrated against the Accuspeed Laser Velocimeter (V1) when certain conditions are met. When a calibration is successful, the calibration factor is applied right away.

### 3.3.5 Velocity Processor Interface

The Accuband scanner includes a Maintenance interface incorporating a number of windows for use during calibration, setup and maintenance. Refer to the Accuband user's manual to learn how to get access to the Maintenance interface, select the Maintenance login option and use KELK given password to get access. From all the windows available, select the **Velocity** tab - window. You should get an image similar with the one in Figure 3.2.

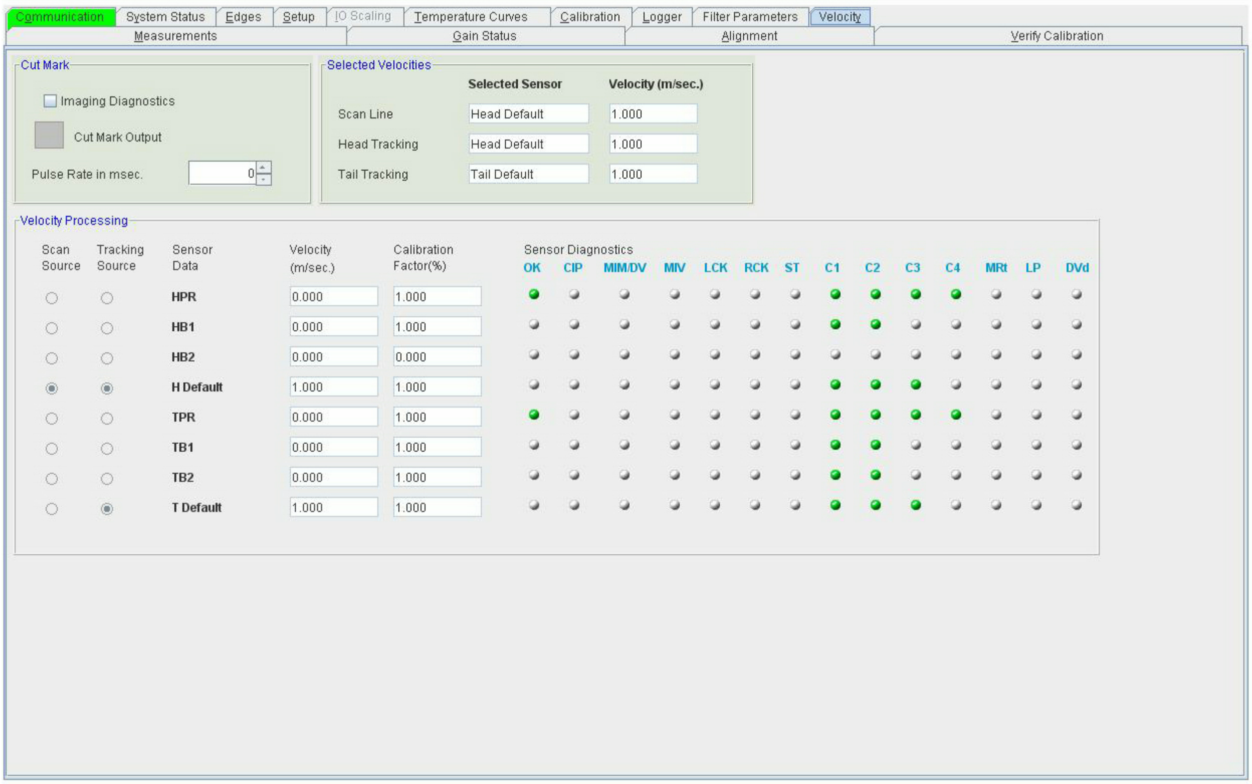



**Figure 3.2 Accuband Crop Shear Entry Velocity Processor Interface**

The Velocity window contains three smaller windows: Cut mark, Selected Velocities and Velocity Processing. The importance of each window is described below.

#### Cut mark window

This window is enabled only for Accuband Crop Imaging Systems located at the crop shear entry locations. Three options are available in this window that allows the user to diagnose and test the cut mark pulse produced by the scanner.

The cut mark window composes of the following items:

1. **Imaging Diagnostics** - Placing a check mark in this box allows the user to perform cut mark pulse diagnostics.

2. **Cut mark Output** - The option allows the user to set the cut mark line high or low. If the option is clicked it will illuminate green indicating that a logic high is present. Deselecting the option outputs a logic low to the cut mark line.
Note: For this option to work, the user must select the Imaging Diagnostics button and the Pulse Rate must be set to 0 ms.

3. **Pulse Rate in msec** - If Imaging Diagnostics is checked, the user can output a continuous trail of pulses of a particular period specified in this field. This feature is useful in troubleshooting any interface or timing issues when connecting to customer equipment. If the user enters a value of 10,000 a cut mark pulse will be initiated every 10 seconds from the Accuband scanner. The length of the pulse is configurable through the configuration manager.

**Selected Velocities window**

This window displays the System speed (Scan line speed), Head tracking speed and Tail tracking speed. The selected sensor and the speed in m/sec will be displayed in real time depending on the bar position and the speed sources available.

**Velocity Processing window**

This window contains important information on what velocity sources are available, their value and calibration factors, the source used for Head/Tail tracking, and a sensor diagnostic table.

Sensor data columns contains all the velocity sources available as follows:

- HPR = Head primary speed
- HB1 = Head backup 1 speed
- HB2 = Head backup 2 speed
- H default = Head default speed
- TPR = Tail primary speed
- TB1 = Tail backup 1 speed
- TB2 = Tail backup 2 speed
- T default = Tail default speed

Velocity and calibration factor columns will display in real time the sensors velocity (m/sec) and the calibration factor (%) when a calibration is successful.

Scan source and tracking (TRK) source columns will indicate using radio buttons what speed source is selected at the scan line and which one is selected for tracking the head and tail.

Sensor diagnostics is a table of status buttons for all velocity sources available, which will light green when active and grey when inactive. By positioning the mouse on top of the first line, you can get the full description of the status bits as follows:

- OK = Last calibration OK
- CIP = Calibration in progress

- MIM/DV = Metal in mill or Data valid
- MIV = Material in view
- LCK = Calibration locked
- RCK = Bar rocking/last pass
- ST = Start calibration OK
- C1 = Acceleration OK
- C2 = Calibration change within limits
- C3 = Velocity above zero
- C4 = Ratio within range
- MRt = MR time on
- ANP = Abort no path
- DVd = Debounce data valid

Depending on bar position and speed sources available, the operation of the velocity processor can be observed by following the status green lit radio buttons, the speed sources selected at the scan line, and for head and tail tracking. Maintenance personnel can use this screen to troubleshoot any problems related with the speed sources and observe if calibrations are being completed successfully.

## 3.4 Image Processing

Once the bar has travelled a distance equal to the body width boundary, the body width is calculated. This calculation is carried out on the data that is bounded by the distance for body width: 700 mm and the length for body width 300 mm preceding this limit. Both these parameters can be adjusted through the configuration manager. The average of the width samples becomes the body width.

The data in the buffer is then analysed for the type of shape:

- Percent of Body Width
- Fishtail
- Dog Bone
- Symmetry
- Rectangle

The algorithm for each of the above shapes is applied to the data buffer data. The cut length for each shape is recorded. Any offsets that have been requested are then added. These results are then checked against the minimum and the maximum allowable crop length. If for a given shape the resultant crop length is outside the maximum or minimum, then the result is set to that max or min. Finally the system will select the longest cut length as the amount to cut from the bar. For more detailed information on Image Processing, please see chapter 4.4.

# PART 4 IMAGING SYSTEM OPERATION

## 4.1 Introduction

The intent of this part of the manual is to provide an understanding of how the crop image is generated and processed in order to determine the crop shape and cut types (length). It describes the basic principle of operation and signal flow from crop image formation through the gage output.

## 4.2 General Description

The scanner assumes that there is a bar crossing the scanner line in a certain direction with a certain velocity. The end of the bar that crosses the scanner line first is called the Head and the other end is called Tail.

## 4.3 Imaging System

### 4.3.1 Head and Tail Detection

An essential part of the image processing is the detection of head and tail tips of the bar. A head of the bar is detected when there is a transition from OFF to ON for the Material in View (MIV). If the MIV has been OFF for a certain amount of time, then the tail tip of the bar is contained in the last scan data when the MIV was ON. This time should be properly adjusted. If the time is too small, a false tail condition may be met when the MIV drops due to scale or other conditions on the bar. If the time is longer than the interval between two subsequent bars, then they will be considered as one.

### 4.3.2 Modes of Operation

There are 2 distinctive modes of operation:

- Width only mode - scanner performs the instantaneous, minimum, maximum and average width (Width gage)
- Imaging mode - scanner performs the width only mode functionality plus forms the bar head and tail images and finds optimal cut length based on the crop parameters (Width gage and Crop imaging)

The parameters received by the Image Processor are:

- Scan data
- Bar parameters
- Head crop parameters
- Tail crop parameters

### 4.3.3 Configuration Parameters

There is a set of configuration parameters that affect the functionality of the Imaging Processor. Here are the ones that affect the imaging system operation:

| Parameter | Description |
|---|---|
| Scan buffer size | It is the capacity of the scan buffer in the number of lines. The number is installation dependent. |
| Back calibration distance | The distance by which back calibration is expected to be completed. |
| End of strip time | This is the time the MIV signal must stay OFF in order to declare the End of strip. |

### 4.3.4 Parameters Handling

There are three sets of parameters used by the Image processor:

- Bar parameters
- Head crop parameters
- Tail crop parameters

Each of these parameters has a default value hard coded that will be loaded at the scanner boot-up. After that, the parameters can be modified on a per-bar basis. The parameters can be changed any time, but the Image Processor reads them when the bar head has been detected. The parameters read are used for the current bar. They are available for reading as in-use parameters. If the parameters are changed when the bar is under the scanner, then they will be used for the next bar.

**Bar parameters**

These parameters will be applied to the entire bar.

- Material density
- Material thickness

### Head / Tail Crop parameters

There are 2 identical sets of crop parameters for head and for tail. See table below for their detailed description.

| Parameter | Description |
|---|---|
| Processing distance | The distance where the optimal cut length may be found. It is also the image length. |
| Body width distance | The distance from the tip where the width and centerline calculation starts. Body width interval is used to collect the data. |
| Body width interval | The interval used to collect the width and centerline deviation data. It starts from the body width distance towards the tip. |
| Crop modes | Can be set as one of the following:<br>• Optimized: cut length is determined based on the shape of the bar<br>• Fixed length: cut length is set to Fixed length<br>• Manual/Skip: cut length is set to zero |
| Fixed cut length | It is used when the crop mode is set to Fixed cut length. |
| Minimum cut length | Provides a limit for the cut length if Crop mode is Optimized or Fixed Length. If the calculated cut length is smaller than the Minimum cut length, then the Minimum cut length is selected. |
| Maximum cut length | Provides a limit for the cut length if Crop mode is Optimized or Fixed Length. If the calculated cut length is greater than the maximum cut length, then the Maximum cut length is selected. |
| Cut line offset | It is added to the cut length in Optimized mode. |
| Fish tail offset | It is added to the cut length found under Fish tail criterion. |
| Percent of body width | It is used to calculate a bar width at the cut length for Body Width criterion. |
| Percent of symmetry | It is used to calculate the centerline deviation at the cut length for Symmetry criterion. |
| Percent of Dog bone detection | It is used to calculate a bar width for the detection of the Dog bone shape. |
| Percent of Dog bone cut | It is used to calculate a bar width for Dog bone cut. |
| Rectangular shape reference | It is used for statistics. If the Cut length is smaller or equal with this reference, then the Crop shape and cut type are “rectangular”. |
| Boundary | Provides an offset from the tip of the bar where width statistics calculation starts (Min. Max. Ave. width ). |

### 4.3.5 Principles of Imaging

The Accuband cameras at the crop shear entry generates new data (edge position information) up to a rate of 1250 scans per second. The scanner adjusts the integration time of the cameras as part of the automatic gain control loop. This automatic gain control compensates for the changes in bar temperature. For this reason, the data rate from the cameras varies inversely with the temperature of the bar.

The edge information is passed on to the scanner. These edge positions are converted into width and centerline deviation measurements by the main processor unit.

The scan data contains the following:

- Strip in view status
- Material velocity for bar length calculation
- Head velocity for back calibration
- Material width and centerline deviation for cut length calculation
- Linearized edges transitions for image making

Scanner calculates the bar travelled distance using the material velocity from the scan data and the time lapsed between 2 consecutive scans. All this data is saved in a circular buffer and it will be used for the determination of the crop image, crop shape, cut type, cut length and crop statistics.

The entries into the data buffer are made for every scan. When this data is analysed to determine the crop image, linear interpolation is applied if certain scans are missing due to environment conditions.

### 4.3.6 Image Processing

The main goal of image processing is to find the head and tail cut length. The image processing for head is done separately from the tail. A processing distance for head and tail is defined in the scanner parameters. An optimal cut length can only be found within the processing distance.

The head processing starts when the current bar length has reached both the head body width distance and the head processing distance (see Body Width calculation).

The tail processing starts when the tail has been found and the bar is not shorter than the tail body width distance and the tail processing distance.

To start the processing, the scan data is copied from the circular buffer to a head or tail processing buffer to allow continuous circular buffer data update while processing collected data.

The size of the circular buffer is chosen according to the current installation parameters and measurement conditions. If the buffer capacity is too small, then a part of the data will be lost resulting in incorrect image processing and wrong cut length.

To generate a crop image the linearized light/dark transitions are used. Only scan lines with even number of transitions are used. The scanner starts from the very first line in the data buffer and makes an image entry for every line until it reaches the Processing distance.

A cut length depends on a crop mode. If the Crop mode is Skip cut or Manual, then the cut length is 0 mm. If the crop mode is Fixed length the cut length is set to the Fixed length value provided in the crop parameters. And, finally, if the crop mode is Optimized, the cut length will be the greatest value of cut lengths found based on the following criteria: % of Body width, Symmetry, Dog bone and Fish tail, and adds the Cut line offset provided in the crop parameters.

If crop mode is Fixed length or Optimized, the cut length is checked against the cut length limits provided in crop parameters as Minimum cut length and Maximum cut length.

The Cut length will never exceed the Processing distance. See Figure 4.1.

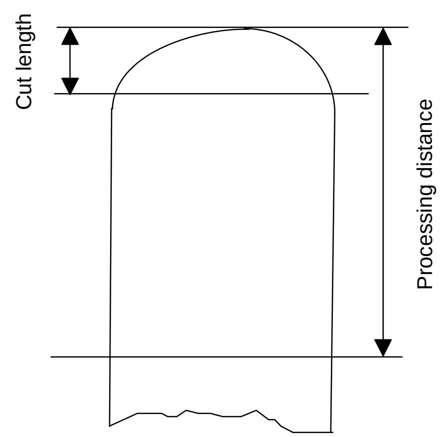



**Figure 4.1 Crop Image Processing Distance**

After the cut length has been detected the following steps are taken:

- Crop area is calculated
- Crop weight is calculated
- Crop shape is evaluated
- Cut type is evaluated
- Body width and centre line deviation at cut length are found
- Crop image is created

### 4.3.7 Enabling/Disabling Image Processing

The image processing can be controlled on per-bar basis using a digital input (Last pass) from the Discrete I/O kit. This input is checked every time when bar head is detected.

- If the digital input is enabled, (High) the scanner switches to Image mode and the image is processed along with the width data.
- If the digital input is disable (Low) than the scanner switches to Width only mode, and the scanner behaves just like a Width gage.

### 4.3.8 Crop Shapes

Below is a table showing the Crop shapes definitions:

| Crop shape | Condition |
|---|---|
| *Percentage of body width* | The optimal cut length has been found based on *Percentage of body width* criterion |
| *Symmetry* | The optimal cut length has been found based on *Symmetry* criterion |
| *Dog bone* | The optimal cut length has been found based on *Dog bone* criterion |
| *Fish tail* | The optimal cut length has been found based on *Fish tail* criterion |
| *Rectangular* | The optimal cut length is less or equal to the *Rectangular shape reference* provided in the crop parameters. This overwrites any shape defined above. For example, if the cut length has been found based on *Symmetry* criteria, but it is less or equal to the *Rectangular shape reference* the shape will be reported as *Rectangular* |

Here is a graphical representation of the crop shapes described above. See Figure 4.2.

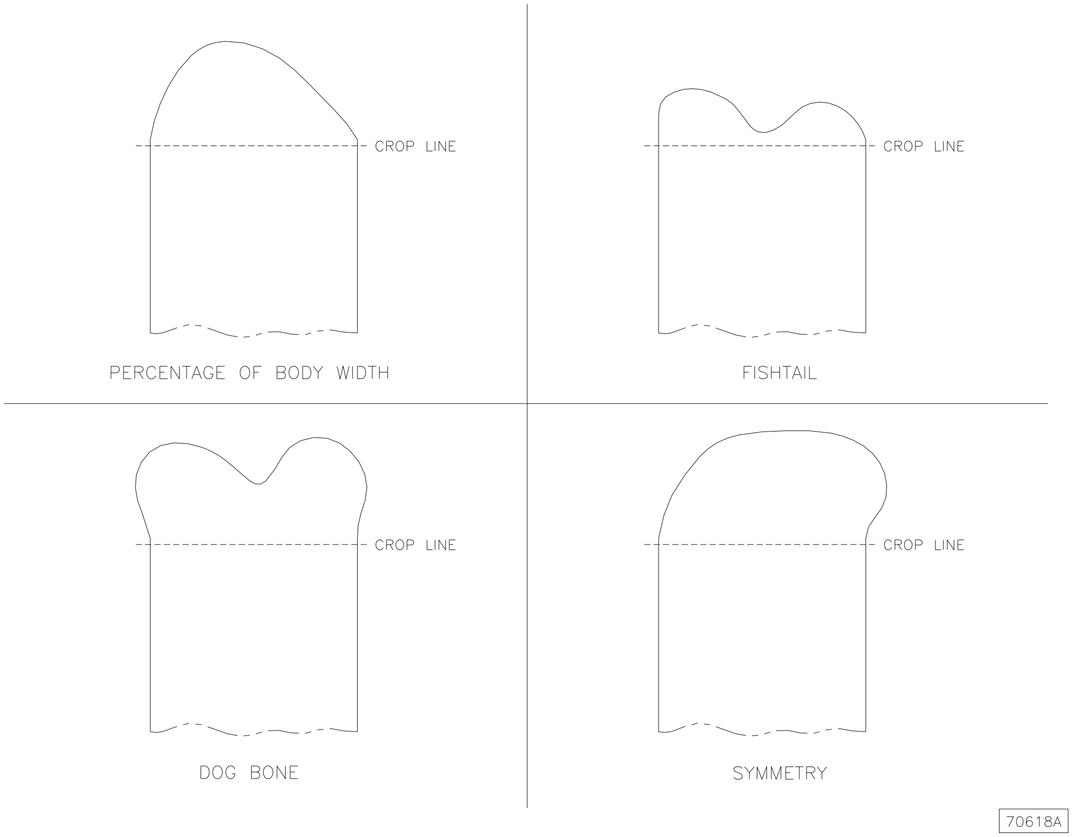



**Figure 4.2 Crop Shapes**

### 4.3.9 Cut Types

Here are the Cut type definitions:

| Cut type | Condition |
|---|---|
| % of body width | 1. Crop mode is Optimized<br>2. Cut length has been found based on % of body width criterion<br>3. Cut length + Cut line offset is between Min/Max. Cut length range |
| Symmetry | 1. Crop mode is Optimized<br>2. Cut length has been found based on Symmetry criterion<br>3. Cut length + Cut line offset is between Min/Max. Cut length range |
| Dog bone | 1. Crop mode is Optimized<br>2. Cut length has been found based on Dog bone criterion<br>3. Cut length + Cut line offset is between Min/Max. Cut length range |
| Fish tail | 1. Crop mode is Optimized<br>2. Cut length has been found based on Fish tail criterion |

| | |
|---|---|
| | 3. Cut length + Fish tail offset + Cut line offset is between Min/Max. Cut length range |
| Fixed length | 1. Crop mode is Fixed length<br>2. Cut length is between Min/Max. Cut length range |
| Minimum | 1. Crop mode is Optimized or Fixed length<br>2. Cut length is = to Minimum cut length as a result of calculation or forced after a limit check. |
| Maximum | 1. Crop mode is Optimized or Fixed length<br>2. Cut length is = to Maximum cut length as a result of calculation or forced after a limit check. |
| Manual | Crop mode is Manual cut |
| Skip | Crop mode is skip cut |
| Rectangular | 1. Crop mode is Optimized or Fixed length<br>2. Cut length is less or equal to the Rectangular shape reference provided in the crop parameters. |

Note the difference between the crop shape and cut type. Although they have the same names, the meaning may be different from case to case. The crop shape is always evaluated based on the optimal cut length found with one of the above criteria, but cut type also depends on crop mode, cut length offsets and limits.

**Example 1:**
The optimal cut length of 200 mm has been found based on the Percentage of body width criterion. The crop shape has been set to Percentage of body width, but since the crop mode is Fixed length, the resulting cut length will be taken from crop parameters and cut type will be set to Fixed length.

**Example 2:**
The optimal cut length of 50 mm has been found based on Symmetry criterion. The crop shape has been set to Symmetry. The minimum cut length for this bar is 100 mm. The resulting cut length will be set to 100 mm and the cut type will be Minimum.

**Example 3:**
The optimal cut length of 200 mm has been found based on Fish tail criterion. The crop shape has been set to Fish tail. Since the crop mode is Manual, the resulting cut length will be set to 0 mm and the cut type will be Manual.

**Note:**
If the Minimum cut length is less or equal to the Rectangular shape reference, the cut type will never be reported as minimum.

### 4.3.10 Head Image Sequence

When material reaches the Accuspeed laser, calibration of the Rougher Mill speed will begin. Although it is not mandatory to have this source available, having one will provide a backup speed in case the Velocimeter measurements/data valid drop out due to water, steam, scales, etc. Calibration of the Rougher speed is only performed when the metal in mill (MIM) is valid and data valid on the Accuspeed is high. It is preferred that the calibration of the Rougher mill stand be complete before the bar reaches the Accuband field of view. Calibration time varies based on a user configurable parameter (calibration buffer) found in the configuration manager. If during head imaging the Accuspeed data valid were to drop out, imaging and will be completed using the calibrated Rougher mill speed signal.

As the head end of the bar passes through the Accuband scanner, all width readings will be scaled based on the Accuspeed speed measurements or Rougher mill (when used as a backup).

### 4.3.11 Tail Image Sequence

When the cradle roll begins to turn and MIM1 (Figure 3.1) goes high, the Accuband gage will calibrate the cradle roll speed against the same laser Velocimeter it used for the head backup. Calibration will repeat until Data Valid from the Accuspeed drops out for a predetermined time.

As the end of the bar passes out of the field of view of the Accuband, the only speed source available is the calibrated cradle roll. If another laser velocimeter is installed after the Accuband scanner (V2 in Figure 3.1), then this speed will be used instead since it is more reliable, and the cradle roll will be used as a tail backup for the laser velocimeter.

### 4.3.12 Width Statistics Processing

The width statistics processing depends on strip boundaries settings for the bar. The boundaries allow to ignore some part of head and tail for statistic calculation. The length statistics calculation starts only when the current length exceeds sum of the head and tail boundaries.

The average width is calculated as a running average for the entire bar between the boundaries.

It is possible that no statistic will be calculated at all if the sum of head and tail boundaries exceeds the total bar length. See Figure 4.3.

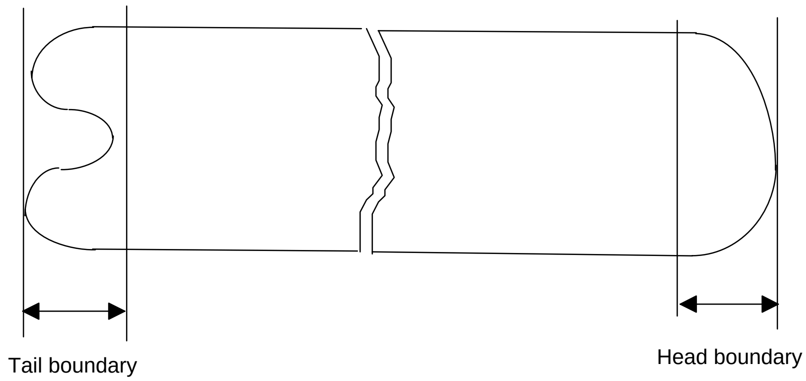



**Figure 4.3 Width Statistics Processing Distance**

## 4.4 Crop Criteria

### 4.4.1 Body Width Calculation

The body width and center line deviation are calculated as an average of these values in the *Body width interval*, which is defined by crop parameters on per-bar basis. See Figure 4.4.

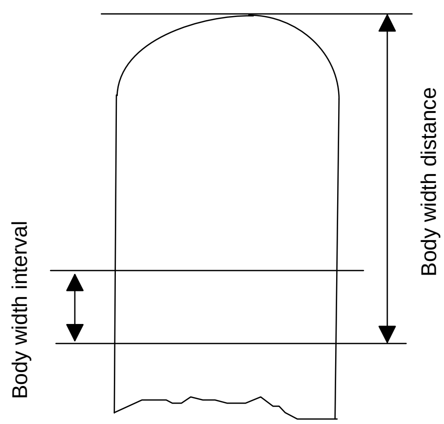



**Figure 4.4 Body Width Calculation**

### 4.4.2 Percentage of Body Width Criterion

In order to find an optimal cut length based on *Percentage of body width* criterion the Image processor starts from the very first line in the scan data buffer and looks for a line matching the following condition until it reaches *Processing distance*:

$$W_i = W_{bw}, \text{ where:}$$

$W_i$ scan width

$W_{bw}$ percentage of body width

$$W_{bw} = BW \times \%_{bw} / 100, \text{ where:}$$

$\%_{bw}$ *Percentage of body width* crop parameter

BW *Body width*

If the condition is met the bar length matching the scan line is taken as a cut length.

Since the buffer consists of a set of discrete scan samples it is virtually impossible to find an exact match for the criterion. More practical condition is:

$$W_{i-1} \geqslant W_{\%} \geqslant W_i$$

A linear interpolation is used to calculate the cut length. See Figure 4.5.

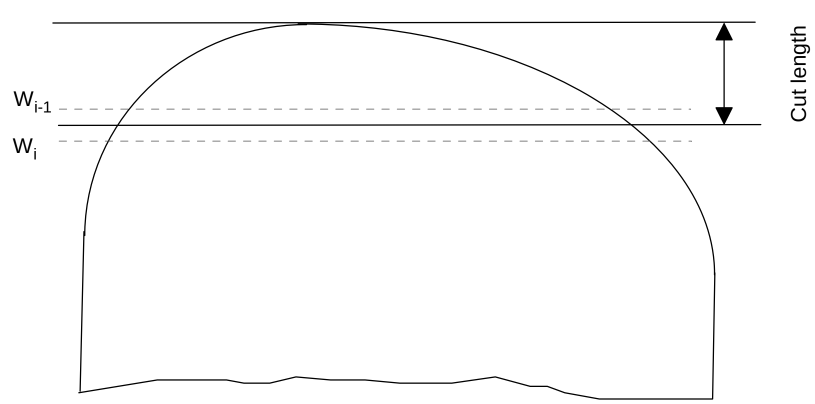



**Figure 4.5 Percentage of Body Width Cut Length**

### 4.4.3 Dog Bone Criterion

Finding an optimal cut length based on *Dog bone* criterion is done in two steps. First, dog bone shape has to be detected using the *Percentage of dog bone detection* crop parameter. The Imaging processor starts from the very first line in the scan data buffer and looks for a line matching the following condition until it reaches *Processing distance*:

$$W_i \geqslant W_{dbd}\text{, where:}$$

| | |
|---|---|
| $W_i$ | scan width |
| $W_{dbd}$ | percentage of dog bone detection |

$$W_{dbd} = BW \times \%_{dbd} / 100\text{, where:}$$

| | |
|---|---|
| $\%_{dbd}$ | *Percentage of dog bone detection* crop parameter |
| BW | *Body width* |

If the condition is met the Imaging processor keeps scanning further down until it reaches *Processing distance* to meet the following condition:

$$W_j = W_{dbc}\text{, where:}$$

| | |
|---|---|
| $W_j$ | scan width |
| $W_{dbc}$ | percentage of dog bone cut |

$$W_{dbc} = BW \times \%_{dbc} / 100\text{, where:}$$

| | |
|---|---|
| $\%_{dbc}$ | *Percentage of dog bone cut* crop parameter |
| BW | *Body width* |

Since the buffer consists of a set of discrete scan samples it is virtually impossible to find an exact match for the criterion. More practical condition is:

$$W_{j-1} \leqslant W_{dbc} \leqslant W_j$$

A linear interpolation is used to calculate the cut length. See Figure 4.6.

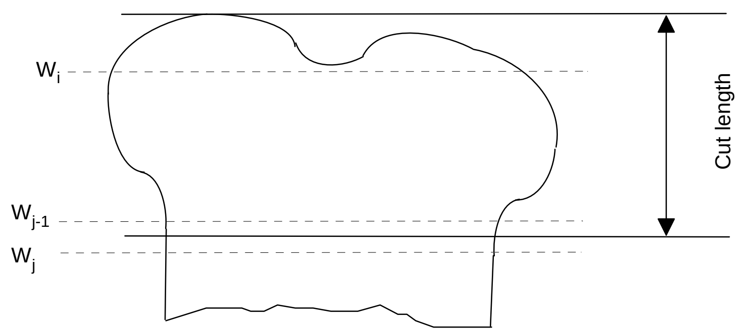



**Figure 4.6 Dog Bone Cut Length**

### 4.4.4 Symmetry Criterion

In order to find an optimal cut length based on *Symmetry* criterion the Imaging processor starts from the very first line in the scan data buffer and looks for a line matching the following condition until it reaches *Processing distanc*e:

$$SY = |CLD_{bw} - CLD_i|, \text{ where:}$$

| | |
|---|---|
| $CLD_i$ | scan center line deviation |
| $CLD_{bw}$ | center line deviation in the body width interval |
| SY | percentage of center line deviation in the body width interval |

$$SY = ( BW / 2 ) \times \%_{sy} / 100, \text{ where:}$$

| | |
|---|---|
| $\%_{sy}$ | *Percentage of symmetry* crop parameter |
| BW | *Body width* |

If the condition is met the bar length matching the scan line is taken as a cut length. Since the buffer consists of a set of discrete scan samples it is virtually impossible to find an exact match for the criterion. More practical condition is:

$$|CLD_{bw} - CLD_{i-1}| \geqslant SY \geqslant |CLD_{bw} - CLD_i|$$

A linear interpolation is used to calculate the cut length. See Figure 4.7.

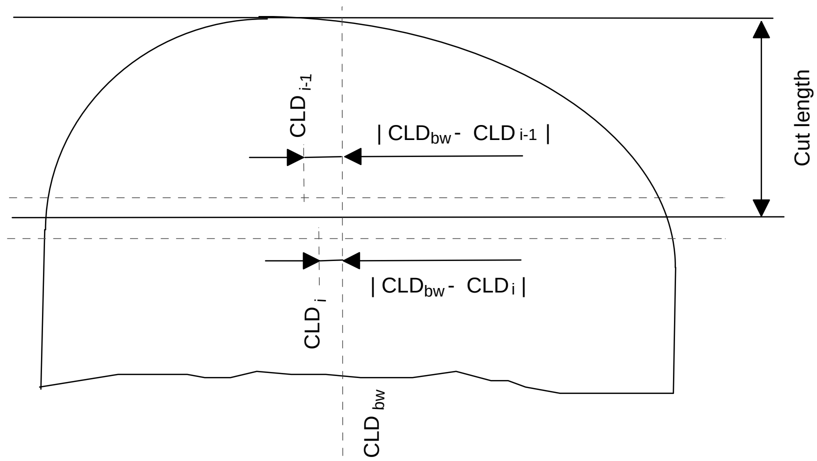



**Figure 4.7 Symmetry Cut Length**

### 4.4.5 Fish Tail Criterion

In order to find an optimal cut length based on *Fish tail* criterion the linearized edges/transitions are used. Only scan lines with even number of edges/transitions are taken into account. Every line may be split by the edges/transitions into a sets of segments and intervals.

For example, L1 has only one segment T1T2 and no intervals, but L2 has two segments: T1T2 and T3T4, and one interval: T2T3. The Imaging processor looks for a "root" of a fish tail, which is an interval farthest from the tip and which center is not "covered". Such interval would be T2T3 on L4. The T2T3 interval of L5 is located farther from the tip, but its center is "covered" with the T3T4 segment of L4. When the interval T2T3 of L4 is found the location of the very next line, i.e. L5 is used as a cut length. See Figure 4.8.

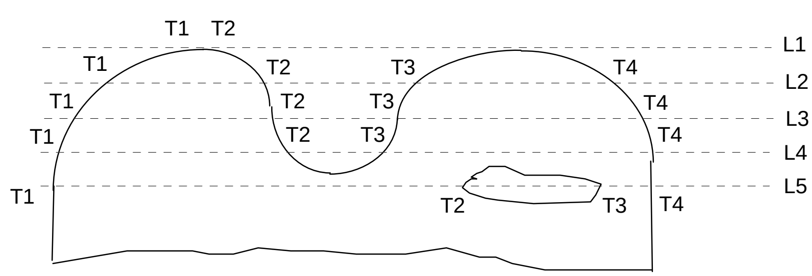



**Figure 4.11 Fish Tail Criterion**

Since a cut length may only be found within a *Processing distance* (see *Image processing*) the "root" of the fish tail or cut length may not be reported properly depending on the value of the *Processing distance*. For example, if L5 lies beyond the

*Processing distance* the cut length will be reported at L4 (same line where fish tail "root" was found), or if L4 lies beyond the processing distance the fish tail "root" will be found at L3 and cut length will be equal to L3 offset.

After the cut length is detected a fish tail offset (see *Crop parameters*) is added.

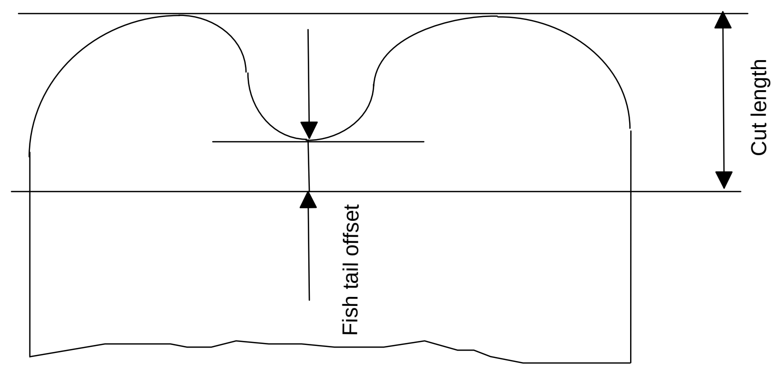



**Figure 4.8 Fish Tail Cut Length**

# PART 5 CROP IMAGING GUI

## 5.1 Introduction

The Graphical User Interface, GUI - also called Instrumentation Panel - is built on the Eclipse platform that allows it to be highly configurable and arranged to display processed data that suit the application. These views are intended to provide real-time updates for mill operators. This paragraph should be read in conjunction with the KELK Instrumentation Panel user's manual.

This manual contains a description of the GUI layout for the crop shear operator. When the Coilbox Entry Crop Imaging System is supplied together with the KELK Accucrop System to form the KELK Closed Loop Crop Optimization System, then this manual must be read in conjunction with the Accucrop user's manual, because the GUI layout for the crop operator looks different than the one presented here.

## 5.2 General Overview

The Instrumentation Panel window is composed of many windows called "tabs". Each tab view can display a variety of user-defined information like: device status, text/numerical data, plotting graphs and crop imaging.

The user can arrange the layout of the tab views, by changing the size, location or what it is displayed in each of them. Once satisfied with the arrangement and content of the tab view, the layout/perspective can be saved to a file. The alignment and content of the tab views is called a perspective.

Compared with the Accuband width gage perspective, the crop imaging GUI layout allows the user to graphically observe the head and tail end of the bar. A profile of each is drawn on the monitor, and the optimized cut line shows where on the bar the cut will take place. Informative data about the bar, all updated in real-time is displayed for both head and tail. The type of statistics and measurements displayed to the user include:

- Crop mode
- Crop shape
- Cut type
- Cut length
- Cut length adjusted
- Crop area
- Crop weight
- Bar area

## 5.3 Crop Imaging Perspective

The crop image perspective described in this manual provides a generic display of what has been provided with your installation. Please note that there may be small changes in the perspective provided in your software package. Such changes may show new tabs not listed here, or tab view in places other than the one displayed here. See Figure 5.1.

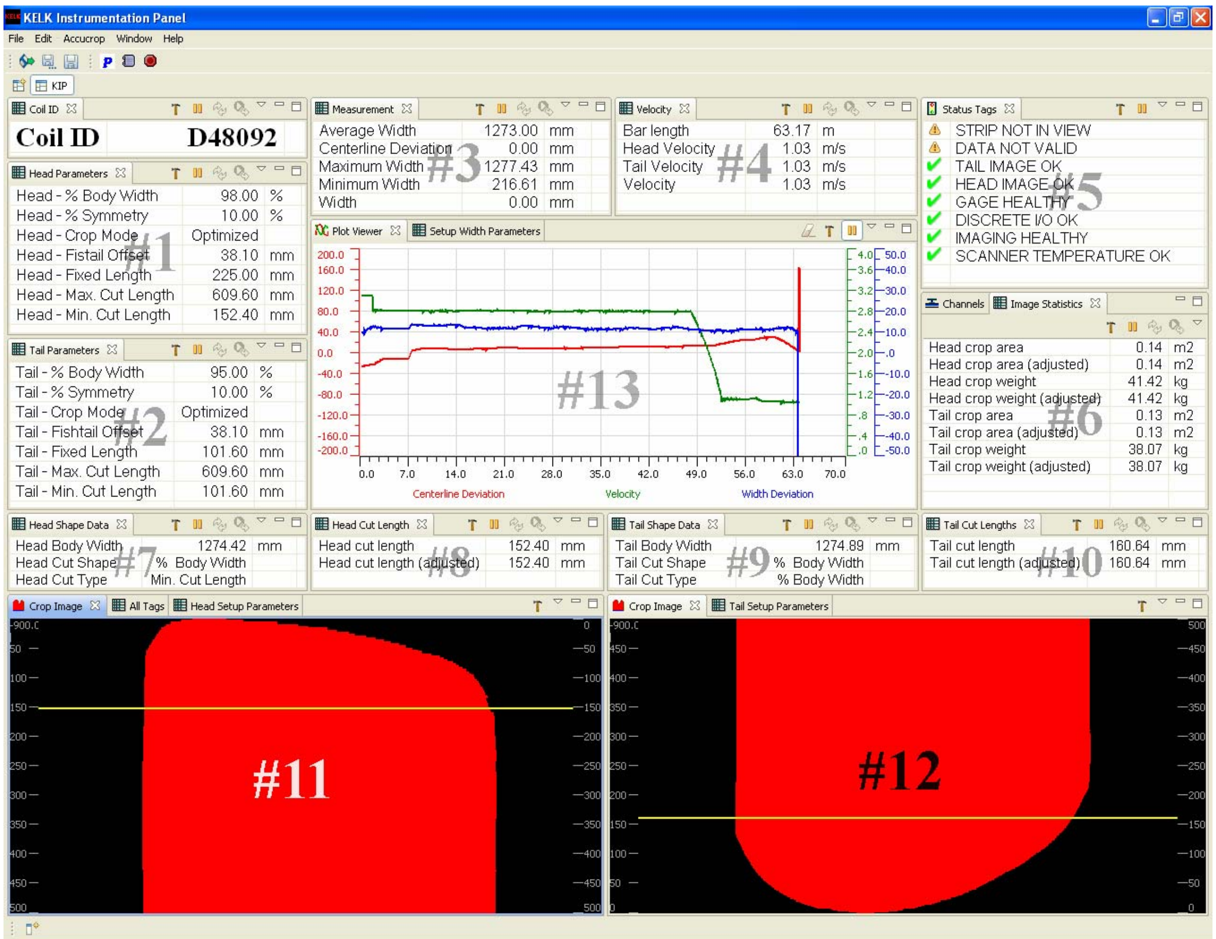



**Figure 5.1 Image Perspective**

### 5.3.1 Tab # 1 Head Parameters

Displays the current setup parameters that have been used by the Imaging Processor for the head of the bar in order to detect the head crop image and head cut length displayed in Tab # 11. All data in this view is read-only and cannot be modified. User may make changes to this data in Tab # 14, however, they will be applied to the next bar entering the scanner. All these parameters will be described in detail within Tab #14 together with the typical values used in the field for the system setup.

### 5.3.2 Tab # 2 Tail Parameters

Displays the current setup parameters that have been used by the Imaging processor for the tail of the bar in order to detect the tail crop image and tail cut length displayed in tab # 12. All data in this view is read-only and cannot be modified. User may make changes to this data in tab # 15, however, they will be applied to the next bar entering the scanner. All these parameters will be described in detail within tab # 15 together with the typical values used in the field for the system setup.

### 5.3.3 Tab # 3 Measurement

This tab view displays current bar width statistic information such Average width, Centerline deviation, Maximum / Minimum width and real time Width.

- Average width is the running average of the instantaneous width.
- Centerline deviation is the instantaneous centerline deviation of the bar at the scan line.
- Maximum width is the largest instantaneous width that was reported. See the width statistics processing - Strip boundaries for more details.
- Minimum width is the smallest instantaneous width that was reported. See the width statistics processing - Strip boundaries for more details.
- Instantaneous width is the real time width reported by the scanner. This will correspond to the Hot width if temperature curve 0 is being used, or to cold width if curve 1 to 63 are in use. If you do not have the cold width compensation feature, then this value will always be hot width. For details on setting up the temperature compensation curves see the Accuband width gage user’s manual.

All this data is read-only and cannot be modified. The centerline deviation and width values are plotted in real time in Tab # 13.

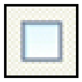
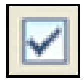
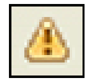
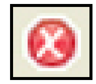
### 5.3.4 Tab # 4 Velocity

Bar length and strip velocity are displayed in this tab view. Velocity processor selects the best available analog speed sources and calibrates them against the very precise speed received from Accuspeed Velocimeter. Accumulated bar length is calculated using the bar speed (at the scan line) and is displayed in real time. The bar head / tail speed and bar velocity (system speed) are displayed real time as well in this view. All this data is read-only and cannot be modified.

### 5.3.5 Tab # 5 Status Tags

Status tags is specifically designed to provide detailed information about the operation of the crop imaging system, which includes measurement and hardware status. Status is indicated by a number of states, each represented by one of the four different levels:

**Condition Status Icons**

Neutral  Active (Healthy)  Caution  Fault 

This tag contains status indicators for the Accuband scanner like: Width data valid, Discrete I/O OK, Gage healthy, Scanner overheat and Strip in view. Their significance are described in the Accuband Width Gage user's manual.

There are also crop imaging system status tags displayed in this view as follows: Crop imaging healthy, Head imaging fault and Tail imaging fault. The meaning of imaging status tags are described later in the Troubleshooting chapter.

If the user desires to add or delete some of the status tags from the list, it can be easily done. If communication to the device is not established, the status description will be displayed with N/A. Once communication is made, all status indicators will update immediately. See the KELK Instrumentation Panel user's manual for more details.

### 5.3.6 Tab # 6 Channels / Image (Crop) Statistics

This tab window contains two tabs: **Channels** and **Image (Crop) statistics**.

A) **Channels tab** view can be displayed by selecting the corresponding tab view. It provides a list of connected devices (Scanner, etc.) to the KELK Instrumentation Panel and their associated tags. See Figure 5.2.

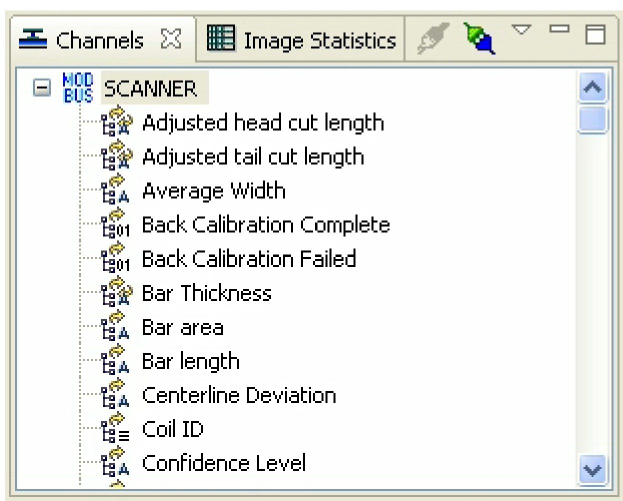



**Figure 5.2 Channels Tab Window**

B) **Image statistics tab** provides the user with head and tail crop area and weight measurement. All this data is read-only and cannot be modified directly in this view.

### 5.3.7 Tab # 7 Head Shape Data

This window displays the body width, head cut type together with head cut shape criterion calculated for the head end of the bar. This data refers to the head crop image displayed in Tab # 11. See the Imaging Processor Operation chapter for more details on the crop shape criterions and cut types. All this data is read-only and cannot be modified.

### 5.3.8 Tab # 8 Head Cut Length

This view displays the head cut length and adjusted head cut length for the head crop image displayed in Tab # 11. Refer to Imaging System Operation chapter for head cut length determination and cut types depending on crop modes selection. All displayed data are read-only and cannot be modified directly in this view.

### 5.3.9 Tab # 9 Tail Shape Data

This window displays the body width, head cut type together with head cut shape criterion calculated for the tail end of the bar. This data refers to the tail crop image displayed in Tab # 12. See the Imaging Processor Operation chapter for more details on the crop shape criterion and cut types. All this data is read-only and cannot be modified.

### 5.3.10 Tab # 10 Tail Cut Length

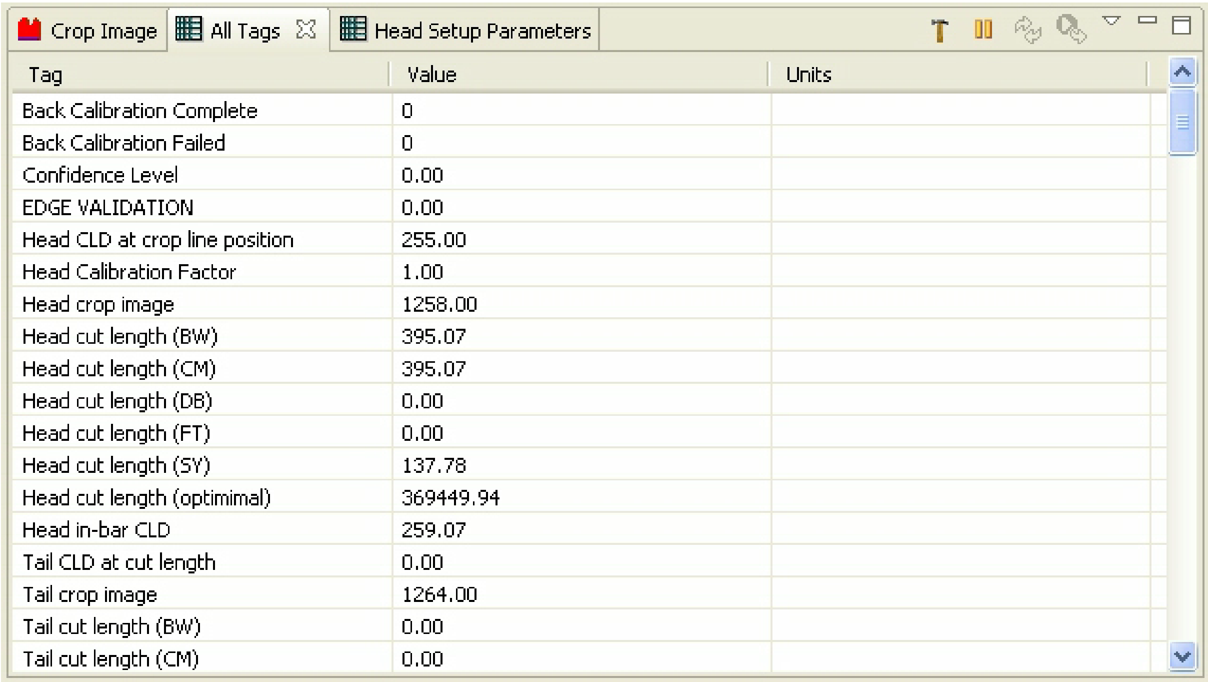
This view displays the tail cut length and adjusted tail cut length for the tail crop image displayed in Tab # 12. All this data is read-only and cannot be modified directly in this view.

### 5.3.11 Tab # 11 Head Crop Image / All Tags / Head Setup Parameters

This tab window contains three tabs: **Head Crop Image tab**, **All Tags tab** and **Head Setup Parameters tab**.

A) **Head Crop Image tab** outputs a visual display of the bar head end shape and the corresponding head cut line location. Head crop image is displayed once the data is available from the Image processor. The image will remain on the screen until a new strip comes into view. Together with the head crop image the head cut length is calculated and displayed as a blue line on the head image.

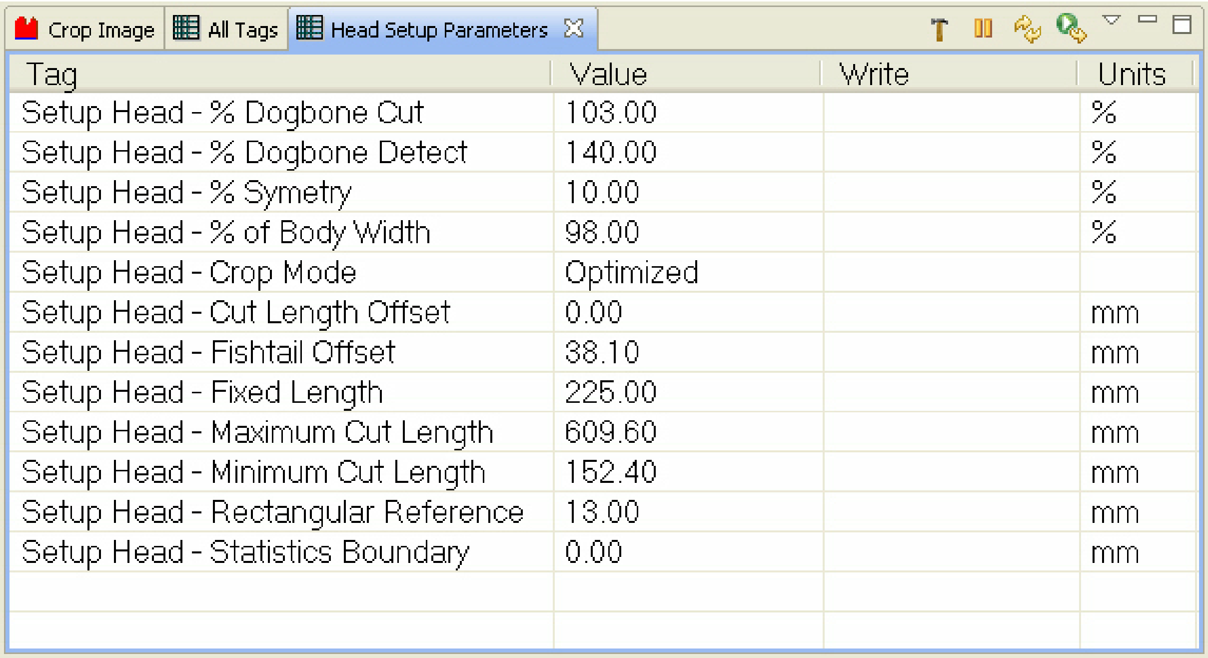
B) **All Tags tab** can be displayed by selecting the corresponding tab view. It contains a summary of all available tags for the devices connected. A scroll bar allows user to view the entire list. See Figure 5.3.




| Tag | Value | Units |
|---|---|---|
| Back Calibration Complete | 0 | |
| Back Calibration Failed | 0 | |
| Confidence Level | 0.00 | |
| EDGE VALIDATION | 0.00 | |
| Head CLD at crop line position | 255.00 | |
| Head Calibration Factor | 1.00 | |
| Head crop image | 1258.00 | |
| Head cut length (BW) | 395.07 | |
| Head cut length (CM) | 395.07 | |
| Head cut length (DB) | 0.00 | |
| Head cut length (FT) | 0.00 | |
| Head cut length (SY) | 137.78 | |
| Head cut length (optimimal) | 369449.94 | |
| Head in-bar CLD | 259.07 | |
| Tail CLD at cut length | 0.00 | |
| Tail crop image | 1264.00 | |
| Tail cut length (BW) | 0.00 | |
| Tail cut length (CM) | 0.00 | |

**Figure 5.3 All Tags Tab Window**

C) **Head Setup Parameters tab** view allows the user to set the head crop parameters. They can also be set by the Host computer (Level 2) if a communication protocol is defined for the system. These parameters will be used by the Imaging processor for the next bar entering the scanner field of view. Care must be taken when changing these parameters, because abnormal crop shape detection or cut type and length determination may occur. See the KELK Instrumentation Panel user's manual on how to update these parameters. Here are described the meaning of each parameter and typical values. Note that these values are just for reference only, and they must be fine tuned according with the site location. The crop defects tend to depend greatly with material type, width, steel making process and rolling process. Bars made from ingots have larger defects than those made from cast slabs. Roughing mills with hydraulic AWC tend to have larger defects than those that do not. See Figure 5.4.





| Tag | Value | Write | Units |
|---|---|---|---|
| Setup Head - % Dogbone Cut | 103.00 | | % |
| Setup Head - % Dogbone Detect | 140.00 | | % |
| Setup Head - % Symetry | 10.00 | | % |
| Setup Head - % of Body Width | 98.00 | | % |
| Setup Head - Crop Mode | Optimized | | |
| Setup Head - Cut Length Offset | 0.00 | | mm |
| Setup Head - Fishtail Offset | 38.10 | | mm |
| Setup Head - Fixed Length | 225.00 | | mm |
| Setup Head - Maximum Cut Length | 609.60 | | mm |
| Setup Head - Minimum Cut Length | 152.40 | | mm |
| Setup Head - Rectangular Reference | 13.00 | | mm |
| Setup Head - Statistics Boundary | 0.00 | | mm |

**Figure 5.4 Head Setup Parameters Tab Window**

- **Setup Head - % Dogbone cut** = percentage applied to the head body width by the Imaging processor when the Dogbone criterion is detected in order to determine the Head cut length. Note that this parameter must be greater than 100 % but smaller than Setup Head - % Dogbone detect. This parameter is inverse proportional with the Head cut length. Typical values are in the 102 to 103 % range.
- **Setup Head - % Dogbone detect** = percentage applied to the Head body width by the Imaging processor in order to detect the Dogbone criterion. Note that this parameter must be greater than Setup Head - % Dogbone cut. Typical values are in the 104 to 105 % range.
- **Setup Head - % Symmetry** = percentage applied to the centerline deviation at the Head body width by the Imaging processor in order to detect the Symmetry criterion and determine the head cut length. Symmetry is sometimes referred to as Asymmetry. It applies to the end of bar which has a significant amount of camber. Typical values are in the 10 to 15 % range.
- **Setup Head - % of Body Width** = percentage applied to the Head body width by the Imaging processor when the % of Body Width criterion is detected in order to determine the head cut length. This parameter is directly proportional with the Head cut length. Typical values are in the 93 to 98 % range.
- **Setup Head - Crop mode** = represents the crop mode applied by the Imaging processor to the bar head end as follows:

A) **Optimized mode:** the Head cut length is determined based on the shape of the bar, and the crop criterions are applied. This is the mode that will minimize the crop losses and should be used most of the time.

B) **Fixed length mode**: the Head cut length is set to Fixed length. User must specify the Head cut length value. See the Setup Head - Fixed length parameter for details. In some cases, crop optimization based on shape of the bar is NOT the main concern, and a large amount is cut off the bar to insure that the end has a good temperature, or to remove any significant camber. This mode is also the bench mark tool for determining the system accuracy.

C) **Manual mode**: the Head cut length is set to zero. Effectively, this is a method for disabling a cut. Selecting this mode is the same as saying: "Do not make a Head cut". The crop image will appear on the screen but without a crop line. Practically, setting the Crop mode to manual should be used when the head cut wants to be skipped for a number of bars in a row.

D) **Skip cut mode**: the Head cut length is set to zero. This mode must be used only when a double blade per drum shear is present. The system will skip the head cut and position the tail blade for the tail cut.

- **Setup Head - Cut Length Offset**: represents the offset added to the Head cut length calculated by the Imaging processor in Optimized mode. This offset is reflected in the Crop line position and Head cut length value. The offset does NOT apply when the Crop mode is set to Fixed length. During the normal rolling process, as the shear blades become dull, the crop may not separate and fall off the bar. This is due to the small size of the crop in Optimized mode, the temperature of the bar but mostly due to the condition of the blades. Under these circumstances adding an offset will insure that the crop end falls off the bar.
- **Setup Head - Fishtail offset**: represents the offset added to the calculated Head cut length under the Fish tail criterion. This offset is measured from the root of the fishtail. One practical consideration is that the root of the Fish tail can be much colder than the rest of the crop. This colder area can be difficult to cut and may result in only partial separation. Typical values are in the 25 to 75 mm range.
- **Setup Head - Fixed Length**: represents the Head cut length determined by the Imaging Processor when the Fixed length mode is selected. Fixed length values are site and material dependent. Typical values are in the 200 to 400 mm range.
- **Setup Head - Maximum Cut Length**: represents the maximum limit for the Head cut length determined by the Imaging Processor if the Crop mode selected is Optimized or Fixed Length. Usually, the maximum limit is selected to insure that the crop will not exceed the specified maximum crop length of the crop shear chute. Typical values are in the 500 to 600 mm range.
- **Setup Head - Minimum Cut Length**: represents the minimum limit for the Head cut length determined by the Imaging Processor if the Crop mode selected is Optimized or Fixed Length. Usually, the minimum limit is selected to insure that the crop will be clearly cut from the bar. Typical values are in the 100 to 150 mm range.

- **Setup Head - Rectangular Reference**: represents a reference limit for the Head cut length and should be used only for statistics. If the Head cut length determined by the Imaging Processor is smaller or equal with the rectangular reference, then the Crop shape and Cut type will be declared Rectangular. Then the occurrences of the Rectangular events can be statistically processed by Level 2 PC. However, during normal operation the Rectangular reference should be set smaller than the Setup Head - Minimum Cut Length.
- **Setup Head - Statistics Boundary**: represents on offset from the tip of the bar where the width statistics calculation starts. (Min. Max. and Average width).

### 5.3.12 Tab # 12 Tail Crop Image / Tail Setup Parameters

This tab window contains two tabs: **Tail Crop Image tab** and **Tail Setup Parameters tab**.

A) **Tail Crop Image tab** outputs a visual display of the bar tail end shape and the corresponding tail cut line location. Tail crop image is displayed once the data is available from the Image Processor. The image will remain on the screen until a new strip comes into view. The tail cut length is calculated and displayed as a blue line on the Tail image. See KELK Instrumentation Panel user's manual on how to scale the image size, or customize the head image and cut line colours.

B) **Tail Setup Parameters tab** view allows the user to set the tail crop parameters. They can also be set by the Host computer (Level 2) if a communication protocol is defined for the system. These parameters will be used by the Imaging Processor for the next bar entering the scanner. Care must be taken when changing these parameters, because abnormal Crop shape detection or Cut type and length determination may occur. See the KELK Instrumentation Panel user's manual on how to update these parameters. Here are described the meaning of each parameter and typical values. Note that these values are just for reference only, and they must be fine tuned according with the site location. The crop defects tend to depend greatly with material type, width, steel making process and rolling process. Bars made from ingots have larger defects than those made from cast slabs. Roughing mills with hydraulic AWC tend to have larger defects than those that do not. See Figure 5.5.

Crop Image | Tail Setup Parameters

| Tag | Value | Write | Units |
|---|---|---|---|
| Setup Tail - % Dogbone Cut | 103.00 | | % |
| Setup Tail - % Dogbone Detect | 140.00 | | % |
| Setup Tail - % Symetry | 10.00 | | % |
| Setup Tail - % of Body Width | 95.00 | | % |
| Setup Tail - Crop Mode | Optimized | | |
| Setup Tail - Cut Length Offset | 0.00 | | mm |
| Setup Tail - Fishtail Offset | 38.10 | | mm |
| Setup Tail - Fixed Length | 225.00 | | mm |
| Setup Tail - Maximum Cut Length | 609.60 | | mm |
| Setup Tail - Minimum Cut Length | 101.60 | | mm |
| Setup Tail - Rectangular Reference | 13.00 | | mm |
| Setup Tail - Statistics Boundary | 0.00 | | mm |

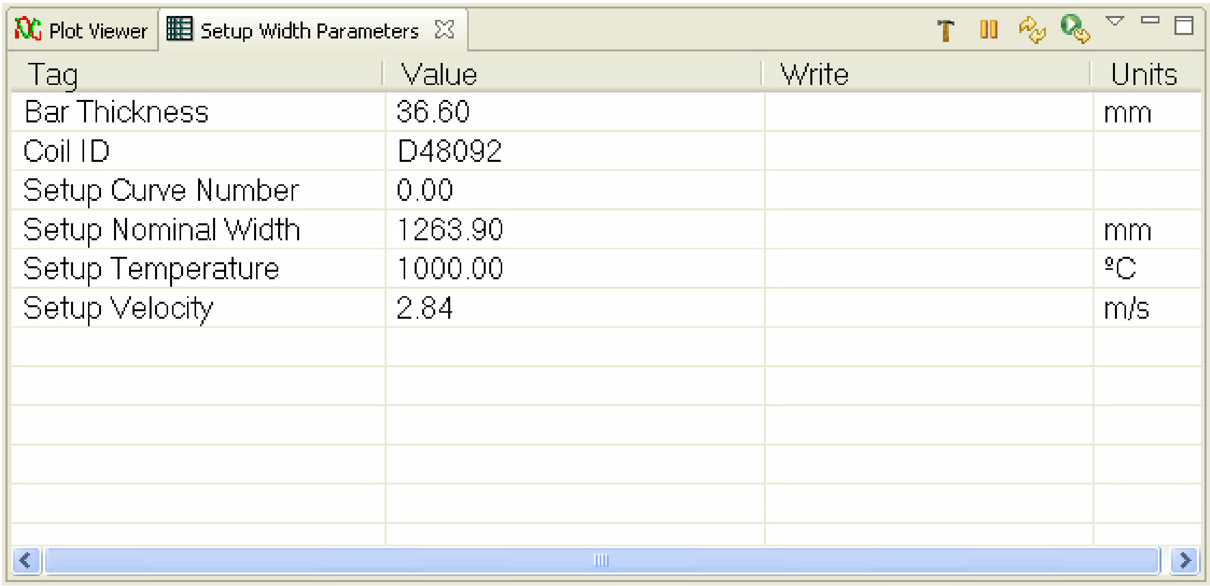
**Figure 5.5 Tail Setup Parameters Tab Window**

Tail Setup Parameters description and typical setup values are similar with the Head Setup Parameters described early in this chapter. Refer to the Head Setup Parameters paragraph for a full description but instead of "Head" use "Tail".

### 5.3.13 Tab # 13 Plot Viewer / Setup Width Parameters

A) **Plot Viewer tab** outputs a graphical display of scanner measurements. Using this plot viewer, operators can visually monitor a variety of "real" data that is collected from any device. A typical plot view will monitor such things as Scanner - Centerline Deviation, Width Deviation and Velocity. All plots are collected as real data from any device. Users may change the way the view displays data in numerous ways by adjusting scaling, color, limits, etc. Additional tags can be added and present ones can be removed if not necessary. See KELK Instrumentation Panel user's manual for more details.

B) **Setup Width Parameters tab** displays the setup parameters with respect to the next bar entering the scanner field of view. These parameters can be set either by the user from the operator PC terminal or by the Host computer (Level 2) if a communication protocol is defined for the system. In either case, the set-up process must take place between two consecutive bars, and the parameters will be used for the next bar entering the scanner field of view. Never update the parameters when the bar is under the scanner. Care must be taken when changing these parameters, because abnormal scanner operation may occur. See KELK Instrumentation Panel user's manual on how to update these parameters. Here are described the meaning of each parameter and typical values. Note that these values are just for reference only, and they must be updated according with the rolling process and site location. See Figure 5.6.





| Tag | Value | Write | Units |
|---|---|---|---|
| Bar Thickness | 36.60 | | mm |
| Coil ID | D48092 | | |
| Setup Curve Number | 0.00 | | |
| Setup Nominal Width | 1263.90 | | mm |
| Setup Temperature | 1000.00 | | ºC |
| Setup Velocity | 2.84 | | m/s |

**Figure 5.6 Setup Width Parameters Tab Window**

- **Setup Bar Thickness** = represents the bar thickness for next strip entering the Scanner Field of view. It will be used by the Imaging Processor to calculate the image statistics (Crop weight and Adjusted Crop weight for head and tail). Typical values are in the 10 to 60 mm range depending on the rolling process.
- **Setup Coil ID** = represents the bar ID for the next strip entering the scanner field of view. It will be used by Imaging Processor to identify the head and tail crop image. Coil IDs are usually defined by the mill schedule.
- **Setup Curve Number** = represents the alloy expansion curve number and will be used by the scanner right away to calculate the cold strip width. Never update this parameter while the strip is under the scanner. The alloy expansion curves must be defined and entered in advance in the scanner memory. They are defined by the user and depend on steel grades rolled in the mill. See the Accuband Width Gage user's manual for more details on how to enter the curves. Note that this is an optional feature, and may not be available with your system. If Temperature Correction Curve number is set to Zero, then no correction will be applied to the strip width and the Scanner will output Hot strip width. Typical values are in the 0 to 63 range depending on the steel grades rolled.
- **Setup Nominal Width** = represents the Nominal strip width and will be used by the Scanner right away to calculate the width deviation. Never update this parameter while the strip is under the Scanner. Typical values are in the 500 to 2500 mm range depending on mill geometry.
- **Setup Temperature** = represents the strip temperature and will be used by the scanner right away to calculate the cold strip width if the curve number parameter is

different than zero. Never update this parameter while the strip is under the scanner. Typical values are in the 600 to 1200 $^{0}$C range depending on material rolled.

- **Setup Velocity** = represents the strip speed and will be used by the Velocity processor together with other available speed sources in order to provide System speed, Head Speed and Tail speed for the Bar length calculation, Head and Tail image processing. Never update this parameter while the strip is under the scanner. Typical values are in the 0.5 to 2 m/sec range depending on material rolled

# PART 6 TROUBLESHOOTING

## 6.1 Introduction

The intent of this part of the manual is to provide troubleshooting instructions for Crop Imaging System operation and operator Industrial PC problems. For Width gage or Accuspeed measurement problems please consult the Accuband Width Gage user's manual and Accuspeed Laser Velocimeter user's manual.

## 6.2 Operator Industrial PC Problems

The operator Industrial PC provides an interface to the crop optimization system. Real time data, crop images and cut line placement can be visualized using the KELK Instrumentation Panel (KIP). Configuration parameters can be updated and system diagnostics performed from this terminal. The following sections present troubleshooting steps to some of the common problems that may arise: Video display problems and Industrial PC not running.

### 6.2.1 Video Display Problems

**Description:**

The Operator's station video display is generated by the operator Industrial PC. Some of the video display problems that may arise are: No video display, video display distorted, frozen video display.

**Possible causes:**

- Loose or damaged cables
- Faulty video monitor
- Internal hardware failure of the Industrial PC

**Solutions:**

- **No video display:** Check AC power supply to the monitor - power cord must be connected and main power switch must be ON. Look for the green power on indicator LED near the power switch - it must be illuminated. Check the connections on the video cable which runs from the Industrial PC to the monitor- it must be plugged with no loose or damaged connections. Check the main power switch on the Industrial PC- it must be ON. Check monitor display set-up for image brightness/contrast. Connect the monitor to a working PC - if display is still dark then the monitor is faulty and must be replaced with a spare. Connect other monitor and see if display comes on. If not, then Industrial PC or video card is damaged.

Replace the operator PC with a spare or see "Industrial PC not running" section for further troubleshooting steps.

- **Video display distorted:** Check monitor display set-up for image size, position and colour. Check the connections on the video cable which runs from the Industrial PC to the monitor- it must be plugged with no loose or damaged connections. Check the video card settings. Connect the monitor to a working PC - if video display is still distorted then the monitor is faulty and must be replaced with a spare. Test monitor on another PC and if monitor is OK then the operator PC (video card) is faulty. Replace operator PC with a spare.
- **Frozen video display:** If mouse and keyboard controls are frozen then reboot the Industrial PC. If problem persist then check PC for viruses or spyware, remove any software last installed or reinstall the Operating System. Otherwise, computer (video card) may be faulty. Replace operator PC with a spare.

### 6.2.2 Industrial PC not running

**Description:**

To determine any problems with the Industrial PC you must first look into the video display problems. Refer to the video display problems paragraph for troubleshooting. Some of the Industrial PC problems that may arise are: Industrial PC not booting, keyboard & mouse problems, Industrial PC no communication.

**Possible causes:**

- Loose or damaged cables
- Operating system failure
- Internal hardware failure of the Industrial PC.

**Solutions:**

- **Industrial PC not booting up:** Enter BIOS setup and check the booting sequence. If problem persist then the Operating System may need to be reinstalled or there is a hardware problem with the computer. Replace operator PC with a spare.
- **Keyboard & mouse problems:** Check the keyboard and mouse connection cables. Reboot the Industrial PC and check the settings in BIOS. Test the keyboard and mouse with another working PC and replace item not working. Check Windows drivers and if mouse/keyboard serial port still not working then computer is faulty. Replace operator PC with a spare.
- **Industrial PC no communication:** Check operator PC ethernet card IP address setup and ethernet cable connection. Check if the scanner IP address and name is set in the hosts file. From a command prompt window, try to "ping" the scanner to confirm the hardware connection. Check if the scanner is powered up and running. Refer to Width Gage user's manual for further scanner diagnostics. If connection to the scanner can be established from a different PC in the network then the Operating

System or the Ethernet card is damaged. Reinstall Operating System. Replace operator PC with a spare.

## 6.3 Crop Imaging System Operation Problems

The Crop Imaging System is a complex system made of two main components: Accuband Width Gage and Accuspeed Laser Velocimeter. Troubleshooting any problems related with this system will require a good understanding of the Width Gage and Laser Accuspeed operation and functionality. Refer also to the Velocity Processor and Imaging System Operation chapters described in this manual. Most of the problems can be identified through the KIP interface. Some of them will require the help of the Maintenance interface or Configuration utility. IBA logger will play a critical roll in troubleshooting (if supplied).

### 6.3.1 KELK Instrumentation Panel (KIP) problems

**Description:**

The Video display and Operator Industrial PC must be in good working order to troubleshoot any KIP problems. Refer to KIP User's manual for more details on operation and configuration. Java Runtime Environment must be installed on the Operator PC in order to use the KIP software. Some of the KIP problems that may arise are: KIP frozen, KIP layout change, no width data or plots, no Crop images display (updated), set-up data not being updated, distorted width plots or Crop images, wrong cut line placement

**Possible causes:**

- KIP configuration problems
- Operating system failure
- Internal hardware failure of the Industrial PC
- Digital inputs signal missing
- Communication with Host PC not working
- Strip with too much scale or cold edges
- Environment conditions - steam, water, debris
- Wrong setup parameters.

**Solutions:**

- **KIP frozen:** Close other programs running in parallel that may load the CPU. Close and restart the KIP software. Check the KIP connection to the devices (Scanner) and verify the KIP Scanner IP address setup. Check the Poll interval - default should be 100 ms. Reboot Operator PC and start KIP again. Check Operator PC communication (see "Industrial PC not communicating"). Check the "Measurement enable" digital input signal (if applicable).

- **KIP layout change:** KIP is highly configurable. The user can arrange the layout of the tab views in any way they like. The size, location and display in a tab view are all user defined. The layout (perspective) can be saved to a file for later use or for backup. To change the KIP layout, a different configuration file can be loaded. All gages are delivered with a default KIP layout depending on the gage location.
- **No width data or plots**: See "KIP frozen". Check if scanner field of view is free of steam and debris. Check if excessive water or scale are on the strip surface or edges are too cold. Check the KIP connection to the devices (scanner) and verify the KIP scanner IP address setup. Refer to Width gage user's manual for further scanner diagnostics.
- **Setup data not being updated:** See "KIP frozen". Check scanner connection to the Host computer (Level 2). Reboot scanner. Refer to Width Gage user's manual for further scanner diagnostics and communication protocol test.
- **Distorted width plots or Crop images:** Check that the setup data is received from the HOST PC for every bar and is correct. Check head / tail setup parameters. Check if excessive water or scale are on the strip surface or edges are too cold. Check environment conditions if scanner field of view is free of steam and debris. Check if any reflections from the side guide occurs or apron plate cut out is obstructed with scale. Check if velocity sources are available and within range. Check "Metal in mill" digital input. Scanner parameters may need to be fine tuned if there is a change in the rolling process and new materials or colder strips are being rolled.
- **Wrong cut line placement:** When the crop images are distorted then the cut line placement is very likely to be wrong. See the above "Distorted width plots or Crop images" for possible solutions. Check the Head /Tail cut line offset, and Minimum and Maximum values.

### 6.3.2 KIP - Status Tags

**Description:**

The KIP should be working and connected to the scanner in order to troubleshoot any Status Tags reported by the system. Some Status Tags are displayed in the KIP - Status tab window. More status tags can be added if needed. Refer to KIP User's manual for more details on operation and configuration. Width gage Status tags should be treated separately, so refer to the Accuband Width Gage user's manual. Typically, there are three Status tags for the Crop Imaging system: Crop Imaging Healthy, Head Image Fault and Tail Image Fault.

**Possible causes:**

- Accuband Width gage or Accuspeed not healthy or ready
- Analog speed sources missing, out of range or calibration failure
- Excessive Accuspeed velocity data valid loss over all scans of the image. Here we will address the problems for the crop shear entry configuration.
- Digital input signal missing.
- Strip with too much scale or cold edges
- Environment conditions - steam, water, debris

**Solutions:**

- **Crop Imaging Healthy:** Crop Imaging System is Healthy if the Accuspeed Laser is ON and if the Accuband Width Gage is Healthy. Refer to Accuband width gage or Laser Velocimeter user's manual if any of these conditions is missing.

- **Head Image Fault:** This status tag will be set if there is processing problems that would most likely cause an incorrect cut length at the time the head image has completed processing for display. Check environment conditions: is Accuspeed field of view free of steam and debris, or is there excessive water on the strip surface. Crop Imaging must be Healthy as well. You should expect an error in the Head cut length if this Status tag is present.

- **Tail Image Fault:** This status tag will be set if an analog speed source calibration failed. Check if the Analog speed sources are valid and within range. Refer to "Velocity processor" chapter. Check "Metal in mill" digital input. Check environment conditions: is Accuspeed field of view free of steam and debris, or is there excessive water on the strip surface. Crop Imaging must be Healthy as well. You should expect an error in the Tail cut length if this Status tag is present.

# PART 7 SPECIFICATIONS

## 7.1 Performance

| | |
|---|---|
| Crop Line Determination Accuracy | ± 5 mm (0.016 in.), 2 s, bar speed up to 4 m per second (13.2 feet per second) |
| On-line Width Accuracy | ± 0.4 mm (0.016 in.), 2 s, for field of view up to 1550 mm (82.7 in.) wide |
| Width Repeatability (Static) | ±0.16 mm (0.012 in.), 2 s, for field of view up to 1550 mm (82.7 in.) wide |
| Measurement Frequency | Up to 1250 measurements per second |
| Head End Response | Less than 4 mS |

## 7.2 Measurement Range

| | |
|---|---|
| Strip Width | As specified by user |
| **Field of View:** Width | Strip width plus allowance for lateral movement, as specified by user |
| Height | 450 mm (1.5 ft) |
| **Strip Temperature:** Model C965C (IR) | $600^0$C to $1300^0$C ($1110^0$F to $2370^0$F) |
| **Strip Edge Movement:** Hop | Up to 450 mm at 1 m per second (1.5 ft at 3.3 ft per second) |
| Lateral | Up to 500 mm (1.6 ft) per second, must remain within field of view. |

## 7.3 Communications

| | |
|---|---|
| Fieldbus | Ethernet (Modbus/TCP) |
| **Logic Outputs:** Scanner Power On | Contact rating 24 VAC/DC, 1 A |
| Alignment Laser On | Contact rating 24 VAC/DC, 5 A |

See also Imaging Discrete I/O.

## 7.4 Scanner

| | |
|---|---|
| **Power:** | 24 VDC, supplied from Scanner Power Supply |
| Circuit Breaker | 10 A |
| Fuses | 630 mA |
| Alignment Laser | CDRH Class 2, 10 mW, 635 nm solid state laser cross hair generator |
| **Enclosure:** | Nema 4 |
| Operating Environment | |
| Location | Fixed, indoors |
| Temperature | $70^0$C ($160^0$f) maximum |
| Humidity | 100%, non condensing |
| Altitude | 2000 m (6560 ft) |
| Pollution Degree | Ref IEC 61010-1 |
| **Cooling Water** | 10 l/Min (2.7 USGPM), $40^0$C ($104^0$F) maximum, 690 KPa (100 psig) maximum |

## 7.5 Scanner Power Supply with Calibrator Controls

| | |
|---|---|
| **Power:** 120/230 VAC | 85 to 264 VAC, 47 to 440 Hz, 320 VA |
| Installation Overvoltage Category | II. Ref IEC 61010-1 |
| Circuit Breaker | 4 A |
| **Operating Environment:** | |
| Location | Fixed, indoors |
| Temperature | $70^0$C ($160^0$F) maximum. Overheat warning at $60^0$C ($140^0$F) |
| Humidity | 10 to 90%, non condensing |
| Altitude | 2000 m (6560 ft) |
| Pollution Degree | Ref IEC 61010-1 |

## 7.6 Calibrator

| | |
|---|---|
| **Power:** 120 or 230 VAC | ± 20%, 50/60 Hz, 200 VA |
| Installation Overvoltage Category | II. Ref IEC 61010-1 |
| **Operating Environment:** Location | Fixed, indoors |
| Temperature | $50^0$C ($160^0$F) maximum |
| Humidity | 10 to 90%, non condensing |
| Altitude | 2000 m (6560 ft) |
| Pollution Degree | 2. Ref IEC 61010-1 |

## 7.7 Imaging Discrete I/O Kit

| | | |
|---|---|---|
| **Analog Inputs:** | Quantity | 4 |
| | Performance | 12 bits, 200 μS conversion time, group isolated |
| | Range | ±10 V, 1 MΩ maximum impedance, self powered |
| **Digital Tachometer Input (optional):** | Quantity | 1 |
| | Performance | Adjustable with frequency range |
| | Range | 24 V quadrature pulses |
| **Analog Outputs:** | Quantity | 4 |
| | Performance | 12 bits, group isolated |
| | Range | ±10 V, 5 KΩ minimum load impedance |
| **Logic Inputs:** | Quantity | 4 |
| | Rating | 15 to 30 VDC at 5 mA or dry contacts. |
| **Logic Outputs:** | Quantity | 8 |
| | Rating | Form C, 240 VAC, 6A |
| **Power:** | 120/240 VAC | 85 to 246 VAC, 0.4 to 0.8 A, 50 to 60 Hz |
| | Installation Overvoltage Category | II. Ref IEC 61010-1 |
| | Fuse | Internal, 1.25 A |
| **Operating Environment:** | Location | Fixed, indoors |
| | Temperature | $40^0$C ($104^0$F) maximum |
| | Humidity | 10 to 90%, non condensing |
| | Altitude | 2000 m (6560 ft) maximum |
| | Pollution Degree | 2. Ref IEC 61010-1 |

**Note:**

Refer to the Accuspeed Laser Velocimeter user’s manual supplied with your system for a complete list of Accuspeed specifications.