Edmunds Gages

EPIC-CAG™

User Guide

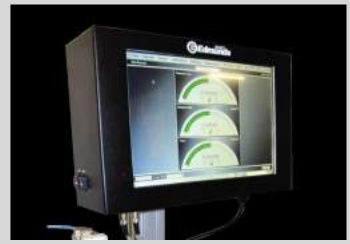
Revision 3.0 08/12/20

EPIC Version 3.15

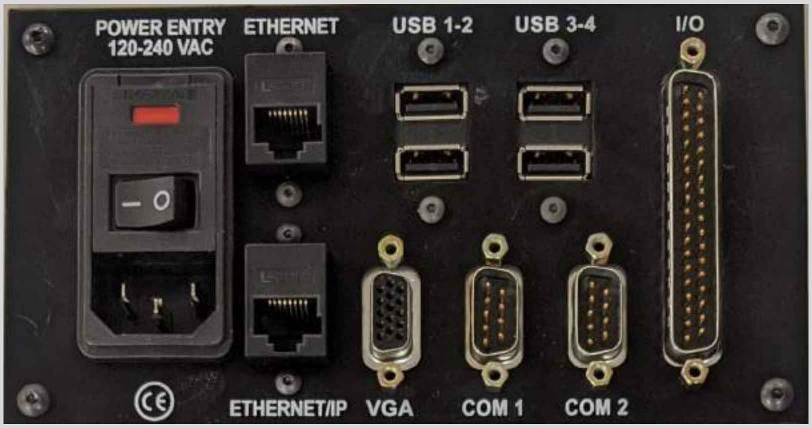
Farmington, CT USA 06032
TEL: (860) 677-2813
info@edmundsgages.com
www.edmundsgages.com

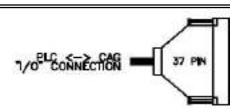
Table of Contents

1. SECTION: EPIC CAG Hardware Specifications and Description

Hardware Specifications		
	EPIC CAG™ 	**EPIC ADAMM** 
CPU	Intel® ATOM™ E3825 2 core, 1.33 GHz	Intel® ATOM™ E3825 2 core, 1.33 GHz
Memory	2 GB of DDR2 SODIMM	2 GB of DDR2 SODIMM
Storage	Solid State Industrial C-Fast Card 16 GB	Solid State Industrial C-Fast Card 16 GB
Operating System	Windows Embedded Standard 7 or Windows 10 IoT Enterprise	Windows Embedded Standard 7 or Windows 10 IoT Enterprise
Video	LCD or Analog VGA or Flat Panel (simultaneous operation supported) LCD: 15" Industrial GFG 5-wire touchscreen, 1024 x 768 resolution VGA: Analog VGA resolution up to SXGA 1024x768	LCD: 15" Industrial GFG 5-wire touchscreen, 1024 x 768 resolution
Ethernet	2 Intel® 10/100/1000 Mbps Ethernet controller	2 Intel® 10/100/1000 Mbps Ethernet controller
Digital I/O	22 GPIO Bidirectional lines	
Serial Ports	2 serial ports (RS-232/422/485)	2 serial ports (RS-232/422/485)
USB Ports	4 USB 2.0 ports	4 USB 2.0 ports
Sensor Inputs	Up to 32 inputs, software configurable for LVDT or Air/Elec ** Expandable to 64 Inputs with remote signal conditioning box*	Up to 8 inputs, software configurable for LVDT or Air/Elec
Power	120-240 VAC, Fused at 5A. Power consumption is 46 Watts (max)	120-240 VAC, Fused at 5A. Power consumption is 46 Watts (max)
Industrial Operating Temperature	-40°C to 70°C	-40°C to 70°C
Mechanical	Dimensions: 11.5" H x 16.0" W x 9.75" D Weight: 27 lbs (12.2kg)	Dimensions: 14.2" H x 16" W x 5.5" D Weight: 15 lbs (6.8kg) * 22" H with stand

EPIC CAG™ Connections



Connector/Port	Typical Device Connections
Power Entry 120-240 VAC & Power Switch	120-240 VAC, Fused at 5A: Power cable provided with unit. Power Switch (Turn CAG On/Off)
USB 1-2 **USB 3-4**	USB 2.0 Ports (1-4) ● USB Start Gage Pushbutton(s)  ● USB Start Gage Footswitch(s)  ● USB Memory stick for Result & Setup storage  ● Digital Probe(s) USB Interface Module ● USB Mouse (wireless or corded) ● USB Keyboard (wireless or corded) ● USB Touch Screen (remote monitor) ● USB Printer
ETHERNET	Ethernet Port: Intel® 10/100/1000 Mbps ● Facility network for offload of measured results ● Machine Control for Feedback Compensation (Fanuc FocusII,Okuma Thinc, etc..) ● Vision sensors and Code Scanners (Cognex®, Keyence etc..) ● Edmunds Remote Signal Conditioning Box (SO# XXXXXXXX).
ETHERNET/IP	Ethernet Port: Intel® 10/100/1000 Mbps ● EtherNet/IP connection to Allen Bradly PLC
COM 1 **COM 2**	Serial Ports (RS-232/422/485) ● Data collector or computer for offload of measured results ● Vision sensors and Code Scanners (Cognex®, Keyence etc..) ● *TELESIS*® Part Markers
VGA	VGA Monitor Port Video Monitor (external/remote) connection
I/O	Discrete Parallel I/O Interface Connection For communication with external machine controls (PLCs, Robots, Gantries, etc..) See: *Section 3.1 Standard Parallel IO Communications* 

EPIC ADAMM Connections

Bottom of Enclosure

Side of Enclosure

Connector/Port	Typical Device Connections
Power 120-240 VAC & Power Switch	120-240 VAC, Fused at 5A: Power cable provided with unit. Power Switch (Turn CAG On/Off)
USB 1-2 USB 3-4	<u>USB 2.0 Ports (1 & 2 bottom)(3 & 4 side)</u> ● USB Start Gage Pushbutton(s)  ● USB Start Gage Footswitch(s)  ● USB Memory stick for Result & Setup storage  ● Digital Probe(s) USB Interface Module ● USB Mouse (wireless or corded) ● USB Keyboard (wireless or corded) ● USB Printer
ETHERNET	<u>Ethernet Port: Intel® 10/100/1000 Mbps</u> ● Connect to facility network for offload of measured results
ETHERNET/IP	<u>Ethernet Port: Intel® 10/100/1000 Mbps</u> ● Connect to facility network for offload of measured results
COM 1 COM 2	<u>Serial Ports (RS-232/422/485)</u> ● Connect to data collector or computer for offload of measured results
VGA	<u>VGA Monitor Port</u> Video Monitor (external) connection

EPIC CAG Input(s) Connections

The EPIC CAG™ can be configured for up to 32 inputs. Inputs are provided in banks or 4 inputs.

There are two types of inputs that can be be utilized with the EPIC CAG™, electronic (LVDT) and Air/Electric (A/E). Both input types utilize the same connector style. The same input connection can be used for either a LVDT input or A/E input. The type of input connected is programmed within the EPIC software application (see SECTION 1.3.4 Input Setup).

Inputs - Inputs are identified within the EPIC software as follows and connector locations can be seen in the image below:

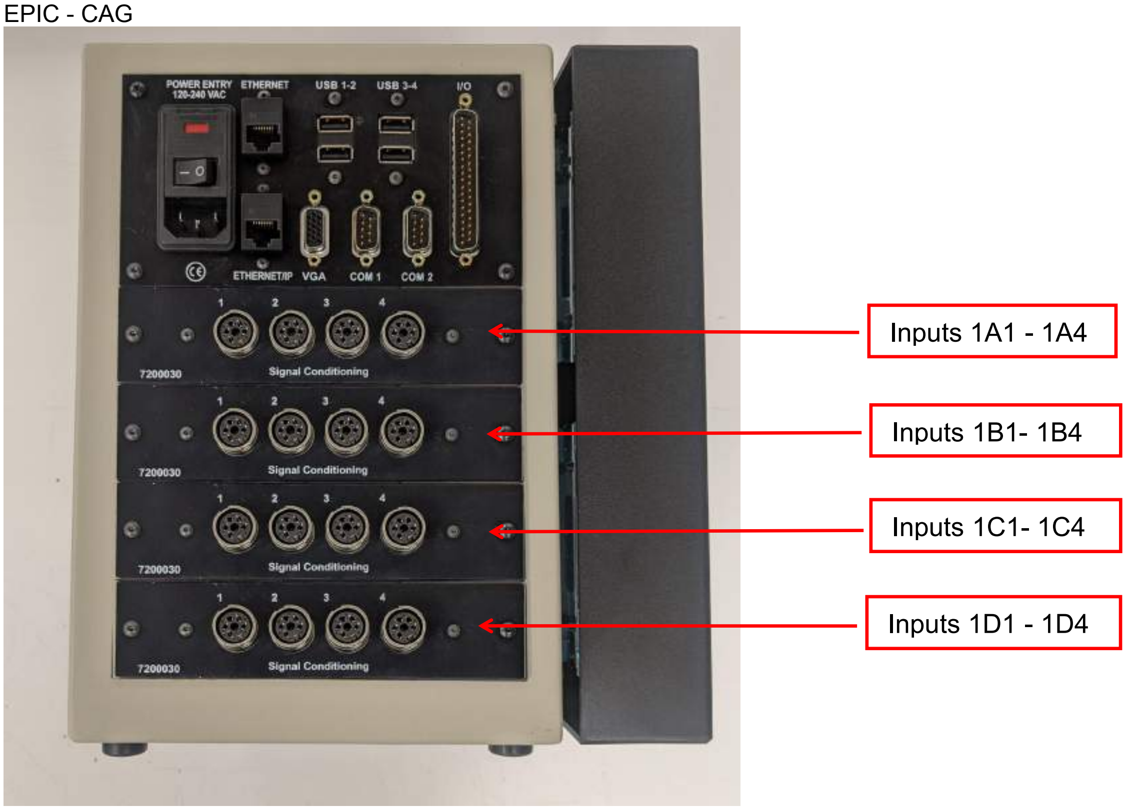
1 A 1

Corresponds to the Input's position on the Signal Conditioning Board. (1,2,3,4)

Corresponds to the Row in the Signal Conditioning Box. (A,B,C,D)

Corresponds to where the input is located. (1 - Left Side, 2 - Right Side)

EPIC - CAG



EPIC-ADAMM


Inputs 1A1 - 1A4
Inputs 1B1 - 1B4
A1
A2
A3
A4
B1
B2
B3
B4
USB1
USB2
ETH1
ETH2
COM1
COM2
POWER
100-240 VAC, 50/60 HZ

2. SECTION: EPIC Software Specifications and Options

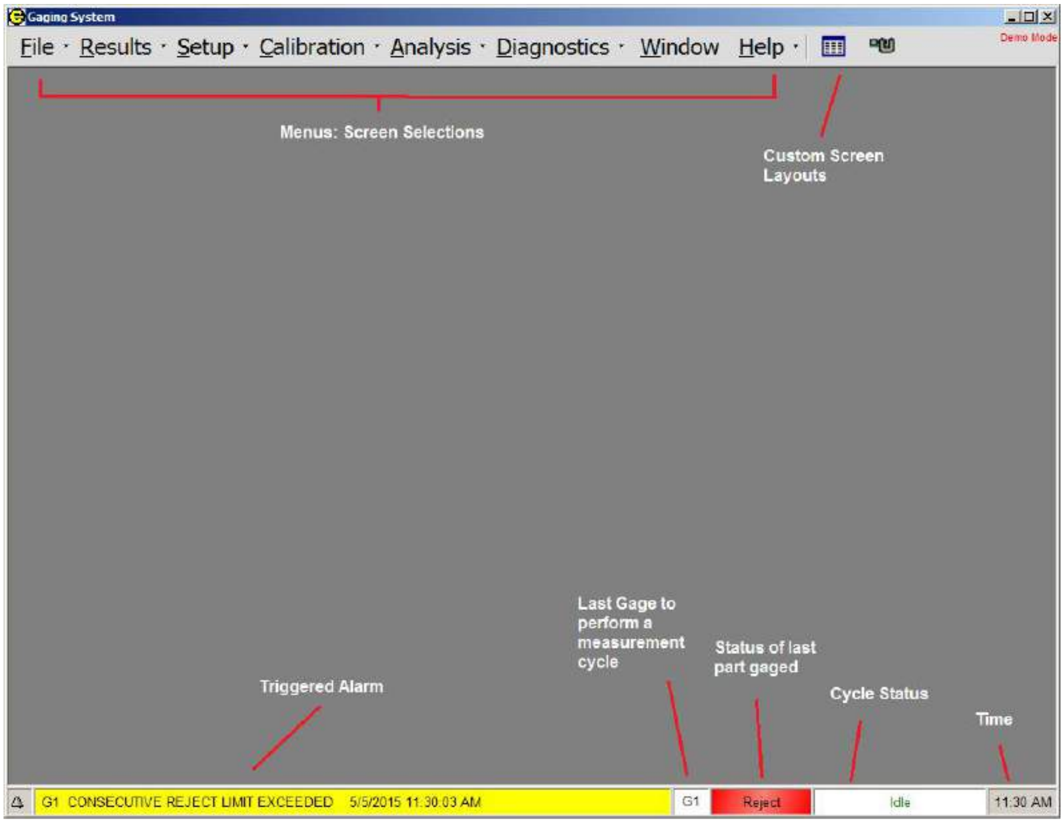
EPIC CAG™		
Software Feature	Maximum	Notes
Inputs (LVDT, A/E)	32	Expandable beyond 32 with remote signal conditioning box
Setups	300	Depends on the size of each Setup (number of Check, Gages , Inputs, stored results etc…
Gages	32	
Checks	125	Optional software module required
Sort Classes	40	
Result Records (Gage Data File)	30,000	Depends on number of Checks programmed in the system.
Gage Data File: User Defined Fields	5	The Gage Data File can be sorted by User Defined Filed 1 only.
Feedback Compensation (machines per Gage setup)	8	Optional software module required
Gaging Positions	20	

EPIC ADAMM		
Software Feature	Maximum	Notes
Inputs (LVDT, A/E)	8	
Setups	200	Depends on the size of each Setup (number of Check, Gages , Inputs, stored results etc…
Gages	4	
Checks	12	
Sort Classes	40	Optional software module require
Result Records (Stored in Gage Data File)	50,000	Depends on number of Checks programmed in the system.
Gage Data File: User Defined Fields	5	The Gage Data File can be sorted by User Defined Filed 1 only.
Feedback Compensation (machines per Gage setup	8	Optional software module required

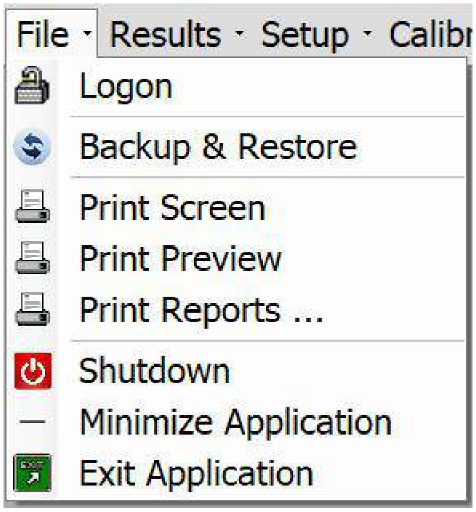
Optional Software Modules	
Software Option	Notes
Feedback Compensation to Machine Control	Feedback Types: Parallel I/O Edmunds Serial (RS232) Okuma Serial (RS232) Okuma Thinc (Ethernet) GE Focus2 (Ethernet) Allen Bradly EtherNet/IP Ethernet File Transfer +/- Pluse Comp. (dedicated IO) Ethernet File Transfer
Verification	Zero Verification Automation
Part Graphics	Includes sequential photo/graphics prompting
Approach Limits	
Temperature Compensation	Edmunds Temperature probes required.
Sort Classes	
QDAS™	Offload measured results in QDAS File format
EtherNet/IP Data Offload	
Multi-Language	English Spanish (Mexico) Chinese Portuguese

3. SECTION: Menus - Screen Descriptions

EPIC Main Screen

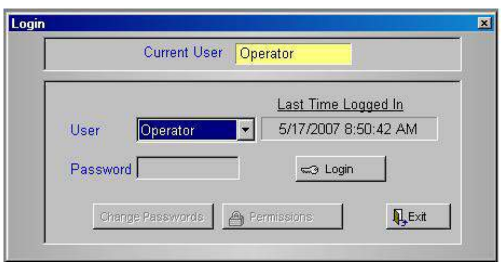


3.1. File



3.1.1. Logon

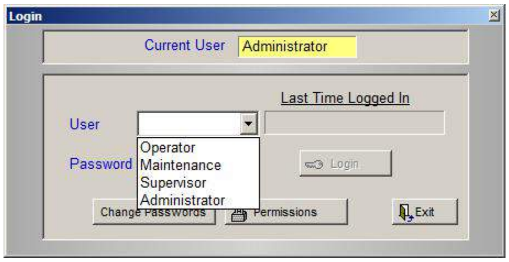
The “Logon” screen lets the operator login as one or four users (Operator, Maintenance, Supervisor, or Administrator) . The user password and permissions can be change when logged-in as Administrator. When the system is first started the “Operator” user is automatically logged-in and does not require a password.



NOTE: Administrator login requires a password. The Administrator password is generated by the system and can not be changed. Authorized users should have access to this password or the password can be obtained by contacting Edmunds Gages.

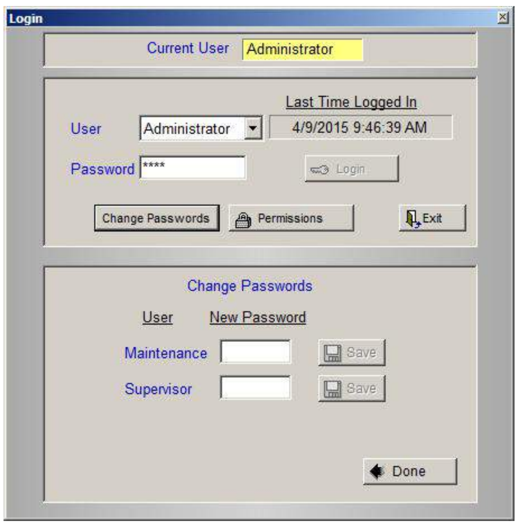
3.1.1.1. User

Use the pull down menu to login as Operator, Maintenance, Supervisor, or Administrator. The administrator can program the different users to have different permissions regarding what can be accessed or changed.



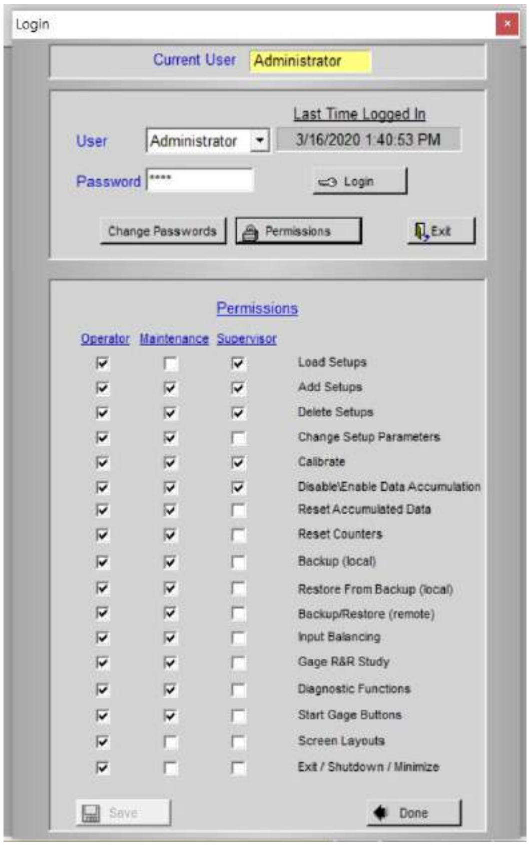
3.1.1.2. Change Password

Only the administrator is allowed to change user passwords. There is no password required to login as "Operator". The passwords must be 4 character long (numbers and/or alpha characters).



3.1.1.3. Permissions

The administrator is allowed to program various permissions for the operator, maintenance, and supervisor.



3.1.2. Backup & Restore

The “Backup & Restore” screen provides the user a way to backup the current programmed Setup(s) and stored data (measured results). There are two options for Backup/Restore they are local and remote. The local option provides and easy and quick method to Backup and Restore the system without the need for a remote connection or USB drive. The local Backup is created on the CAG™local drive in a predefined location. Only one Backup is stored on the local drive, therefore each time a local Backup is made the existing Backup is overwritten. The remote option provides a way to Backup and Restore the system to and external (remote) location such as a USB drive or network drive.

3.1.2.1. Backup (local)

Backup (local) creates a system backup, including all programmed setup parameters and stored results. The backup is stored on the CAG™local drive in a predefined location. The current backup will be overwritten. The date and time of the last backup made is displayed.

NOTE: It is recommended to do a local Backup whenever Setup has been changed.

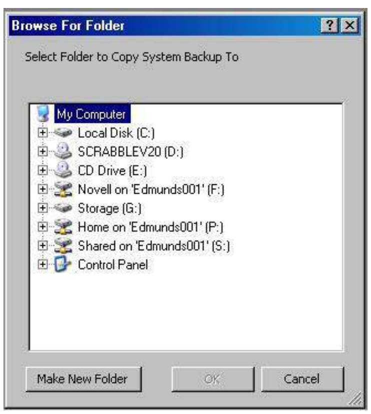
If Setup has been changed and the system has not been backed up, the “Backup” button will be RED indicating backup needed.

3.1.2.2. Restore (local)

Restores the complete system from the current backup that is stored on the local drive in a predefined location. The current setup will be overwritten including all stored results.

3.1.2.3. Backup (remote)

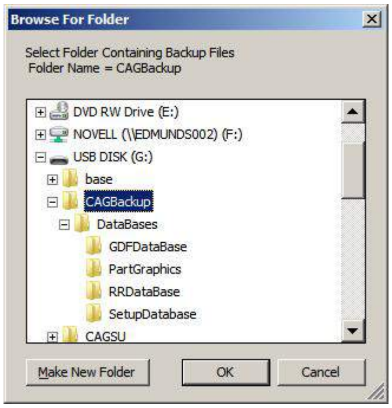
Backup (remote) creates a system backup at a users selected location. The backup location may be a USB drive or network folder. The backup includes all programmed setup parameters and stored results. The backup does not contain the EPIC system files required to run the application, to make a full backup see *Section 7 Backup & Restore System*.

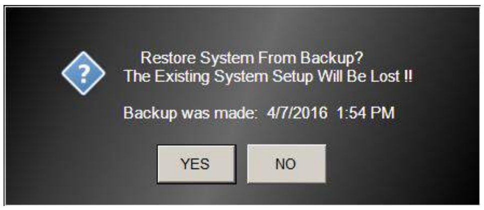


NOTE: The name of the remote backup folder that is created will be “CAGBackup”. This backup folder name should not be changed. The restore routine will not recognize the backup if the name is changes.

3.1.2.4. Restore (remote)

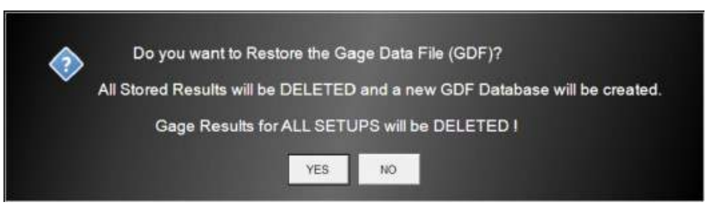
Restore (remote) will restore the system setup and data from remote location. The remote location may be USB drive or Network folder. In order to restore the system, the user needs to browse to remote location containing the backup folder “CAGBackup” and select the folder. The current setup will be overwritten including all stored results.





3.1.2.5. Restore Gage Data File

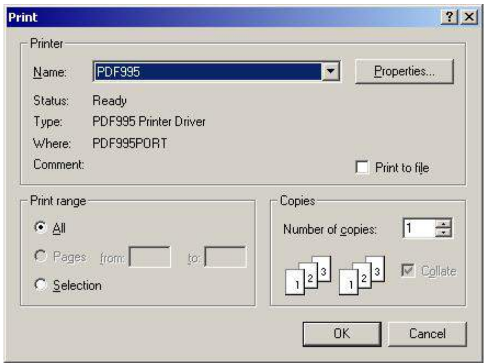
Restore GDF will delete the existing Gage Data Files for all Setups. All measured results will be lost. A new empty Gage Data File (GDF) will be created when Setup is loaded. Restore Gage Data File should only be performed if the GDF has become corrupt or unreadable (the GDF can be reset in the Gage Data File screen). Restore Gage Data File can only be performed if the user is logged in as Administrator.



3.1.3. Print Screen

Print Screen

Allows the operator to print the current screen to a PDF file or an installed printer. If the screen is to be printed to a PDF file select "PDF995" and printer.

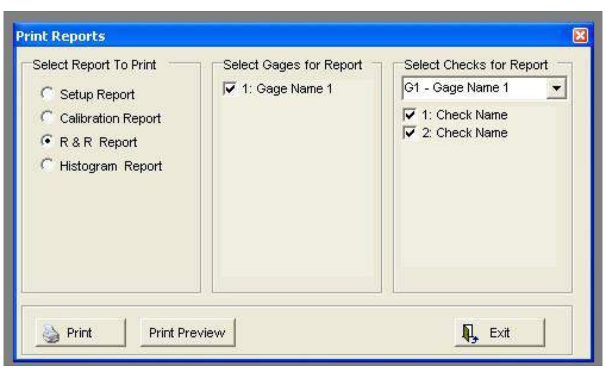


3.1.3.1. Print Preview

Displays the print screen in preview mode.

3.1.4. Print Reports ...

Allows the operator to print the following reports to the system default printer:



3.1.4.1. Setup Report

Prints a complete list of setup parameters for the currently loaded setup.

3.1.4.2. Calibration Report

Prints the calibration and verification (optional) results for the selected Gages.

3.1.4.3. R&R Report

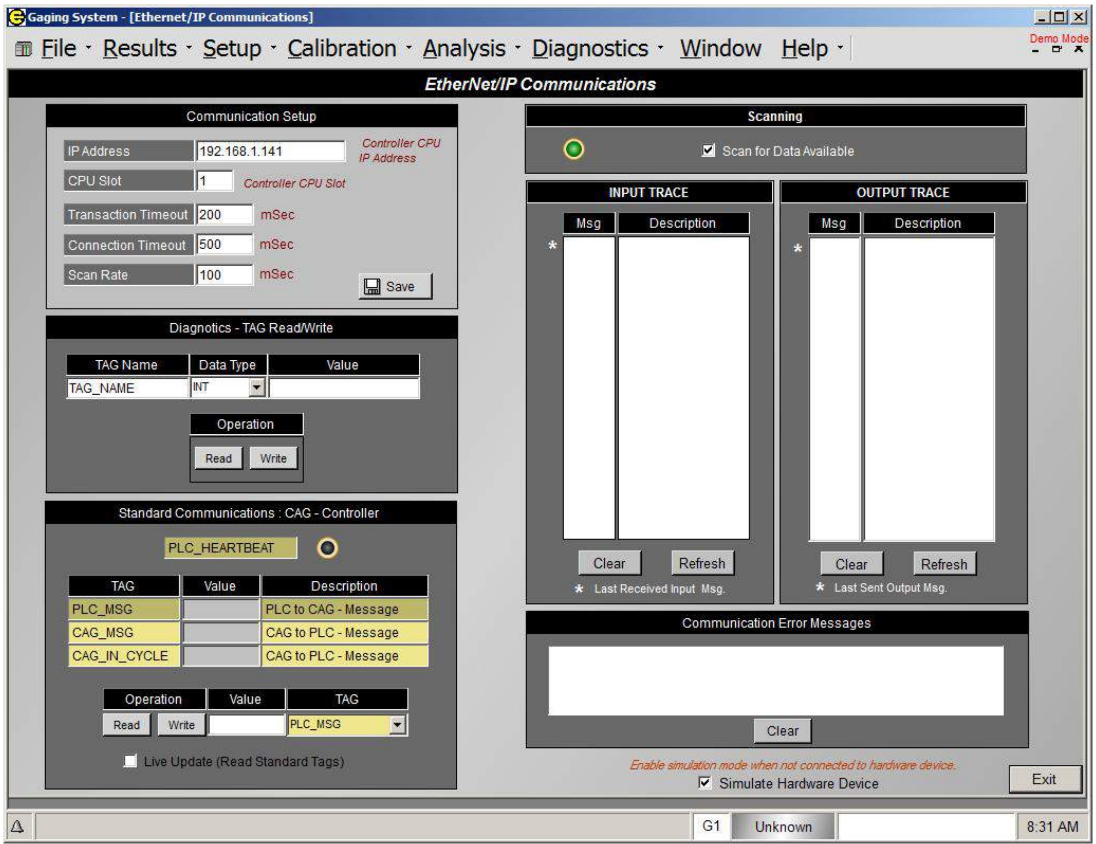
Prints the R&R results for the selected Gages and Checks.

3.1.4.4. Histogram Report

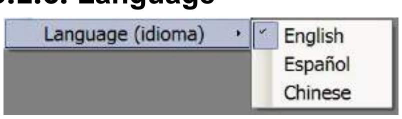
Prints the Histogram charts for the selected Gages and Checks.

3.1.5. EtherNet/IP Comm.

See [Section 3.2 - EPIC Standard EtherNet/IP Communication]



3.1.6. Language



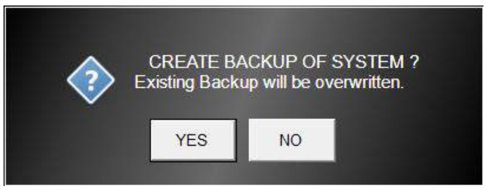
Language Selection - English, Spanish, Chinese

3.1.7. Backup System

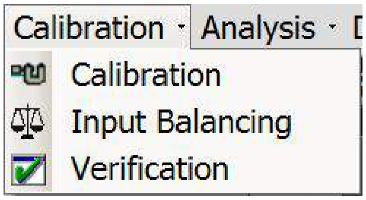
When the Backup System menu is selected a system backup is created, including all programmed setup parameters and stored results. The backup is stored on the CAG™ local drive in a predefined location. The current backup will be overwritten. The date and time of the last backup made is displayed in the Backup & Restore screen. (See Backup & Restore menu for more detail on local backup)

NOTE: It is recommended to do a local Backup whenever Setup has been changed.

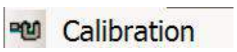
If Setup has been changed and the system has not been backed up, the "Backup System" menus selection will be RED indicating backup needed.



3.2. Calibration



3.2.1. Calibration



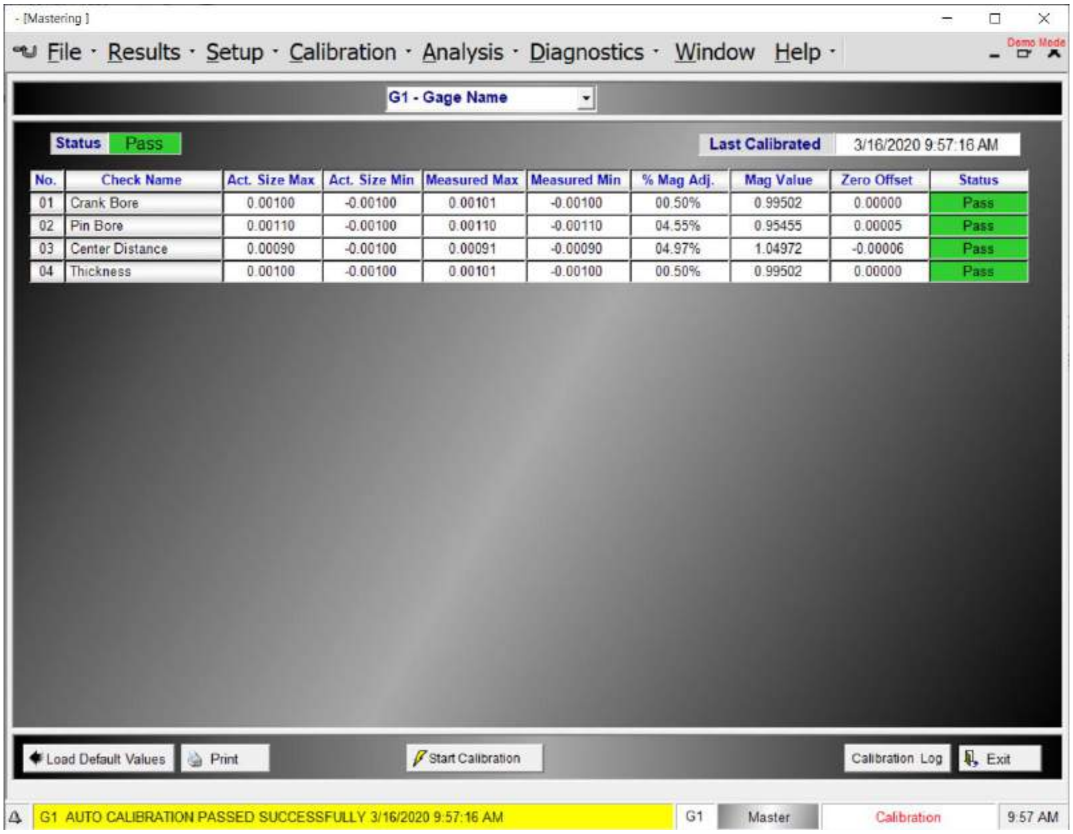
The analog signal received from the gaging fixture is an uncalibrated signal that must be scaled before converting it to an actual dimension. The EPIC software calculates a gain multiplier (MAG) and a zero offset (ZERO) for each part characteristic (Check) by taking readings from a max and a min master of known dimensions. This MAG and ZERO are then used to convert the input voltage to an actual dimension. The formulas used to calculate MAG and ZERO OFFSET are:

$$\textbf{MAG} = \frac{\text{ActualMax} - \text{ActualMin}}{\text{MeasuredMax} - \text{MeasuredMin}}$$

Zero = ActualMax – [MAG * MeasuredMax]

Corrected Reading = (Raw Reading * MAG) + ZERO

Where: Actual Max is the known size of Max Master from the master certification report.
Actual Min is the known size of Min Master from the master certification report.
Measured Max is the gaged size of Max Master.
Measured Min is the gaged size of Min Master.



<u>For each Check the following information is displayed:</u>

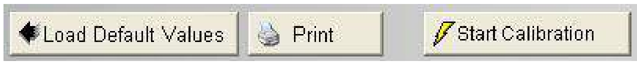
Check Number - The programmed Check number.
Check Name - The programmed name of the Check .
Actual Size Max – The actual max master size from the master certification report.
Actual Size Min – The actual min master size from the master certification report.
Measured Max – The size measured by the gage in the last calibration cycle.
Measured Min – The size measured by the gage in the last calibration cycle.
% Mag Adjust - The percentage of adjustment applied to the measured difference in master readings to obtain a Mag value of 1.00.

%Mag Adjust = Absolute Value (1 - Mag) * 100

Mag Value – The numeric value multiplied times the measured difference in master reading to obtain the actual max/min difference.
Zero Offset – The numeric value added to any gaged reading to correct for the zero offset.
Status – The status of the Check from the last calibration cycle.

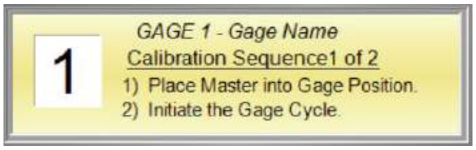
Unknown	Default values loaded, Gage has not be calibrated.
Pass	Check passed calibration
Max=Min	Max measured reading equals Min measured reading
Min>Max	Min measured reading is greater than Max measured reading
Mag Adj	%Mag Adjust is greater than %Mag Adj Limit. The default limit is 25% (see Limits)
Zero Adj	Zero Adjust is greater than Zero Adj Limit. The default limit is .002 (see Limits)
Sat Input	One or more of the Inputs used in the Check formula contain Saturated readings.

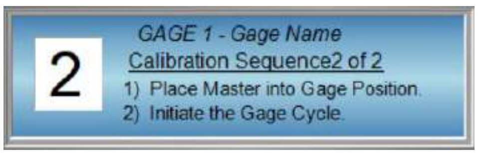
NOTE: If on the Check Setup screen the Enabled box is not selected for a Check then the check will NOT be displayed on the Calibration screen.



Start Calibration

Select this button to begin the gage calibration cycle. The CAG™ will prompt the operator to load the first master and begin the calibration cycle. Refer to the individual gage documentation for specific calibration procedures. **All Checks must "Pass" during a calibration cycle for the gage to be successfully calibrated.**





Load Default Values

Resets all Mag Values to 1.000 and all Zero Offsets to 0.0000.

Master Sizes and Sequence Number

Select Setup → Check Setup to enter the master sizes and sequence numbers.

Calibration Fail Conditions

Max = Min

The measured Max and Min sizes are equal. This indicates the same master or no masters were introduced to the Gage during the calibration sequence.

Min > Max

The measured Min size was greater than the Max Size. This indicates the masters were introduced in the wrong sequence.

Mag Adj Error (% Mag Adjustment > 25%)

The percentage of Mag adjustment required to calibrate the Check exceeds the default value of 25% (see Limits). This indicates the input requires adjustment.

- ✓ With an electronic input, the LVDT needs to be repositioned so that the raw reading is closer to the master reading from the calibration report.
- ✓ With an Air input the Mag of the air input needs to be adjusted.

Zero Error (Zero Adj > .002 inch)

The amount of zero correction required to calibrate the Check exceeds the default value of .002 in (see Limits).

With an electronic input the LVDT needs to be re-positioned so that the raw reading is closer to the master reading from the calibration report.

With an Air input the Zero of the air input needs to be adjusted.

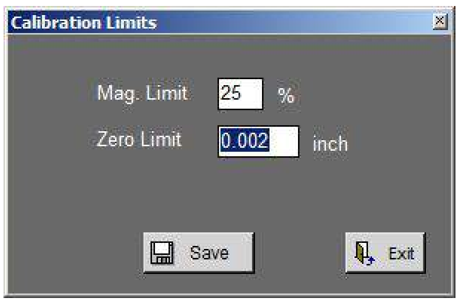
Saturated Inputs

One or more of the Inputs used in the Check formula contain Saturated readings. The raw Input value exceeds the saturation limits during the calibration cycle (see Inputs Setup Screen).

Calibration Limits (%Mag Adj Limit / Zero Adj)

In most cases in is not recommended to change the default calibration limits. The causes of failed calibration should be investigated first.

To access the Calibration Limits the user must be logged in as ***ADMINISTRATOR.*** When logged in as administrator the “Limits” button will be visible on the bottom of the screen.

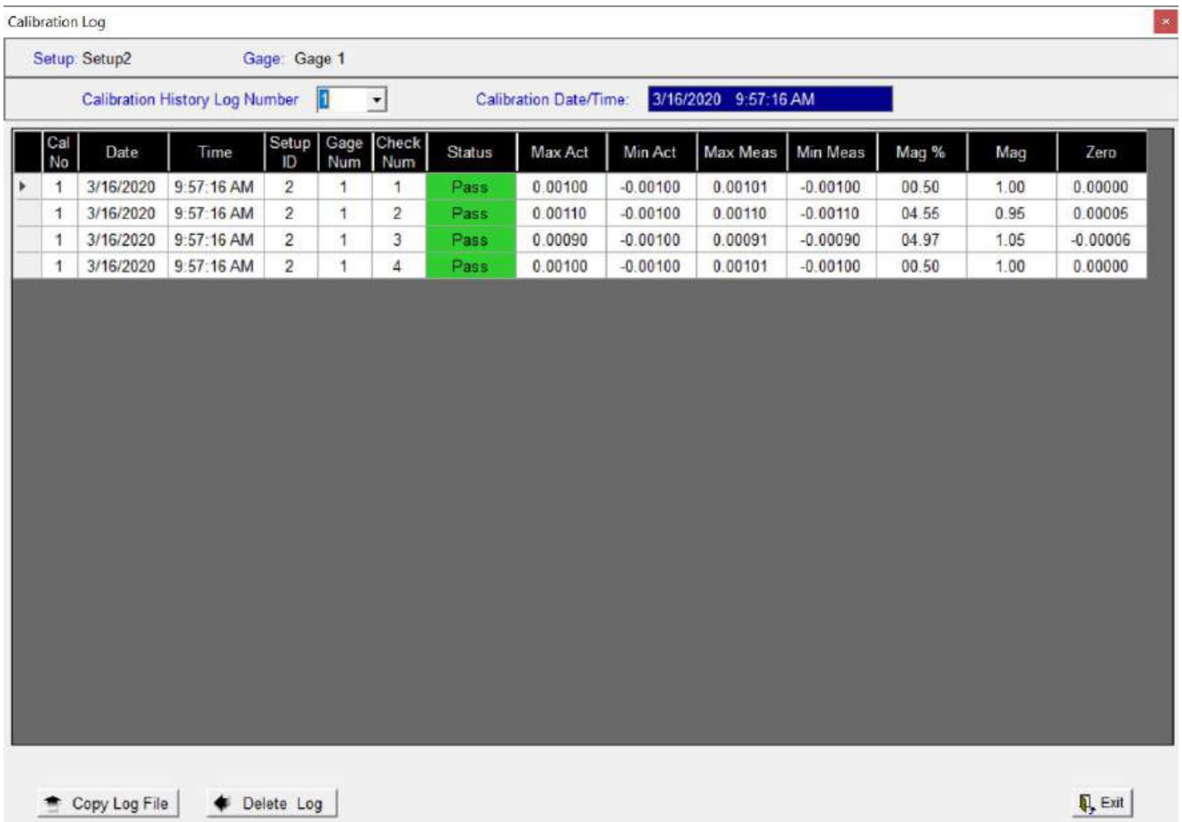


Zero Limit:
Enter limit in Inch, it will be converted to mm if needed when it is used.
If '0' is entered, the limit will automatically be set based on Check Resolution as follows:
.2 = 3 decimal places
.02 = 4 decimal places
.002 = 5 decimal places
.0002 = 6 decimal places

3.2.1.1. Calibration Log

The Calibration Log stores the calibration results for last 10 calibrations performed on the system. The Calibration Log is accessed by selecting the “Calibration Log” button on the bottom of the Calibration screen. The calibration results are written to the Calibration Log as the completion of a calibration cycle.

NOTE: In previous versions of the EPIC application, the previous calibration results where written to the Calibration Log at the start of a calibration cycle and the Calibration Log did not contain the current calibration results.



Cal No	Date	Time	Setup ID	Gage Num	Check Num	Status	Max Act	Min Act	Max Meas	Min Meas	Mag %	Mag	Zero
1	3/16/2020	9:57:16 AM	2	1	1	Pass	0.00100	-0.00100	0.00101	-0.00100	00.50	1.00	0.00000
1	3/16/2020	9:57:16 AM	2	1	2	Pass	0.00110	-0.00100	0.00110	-0.00110	04.55	0.95	0.00005
1	3/16/2020	9:57:16 AM	2	1	3	Pass	0.00090	-0.00100	0.00091	-0.00090	04.97	1.05	-0.00006
1	3/16/2020	9:57:16 AM	2	1	4	Pass	0.00100	-0.00100	0.00101	-0.00100	00.50	1.00	0.00000

Copy Log File

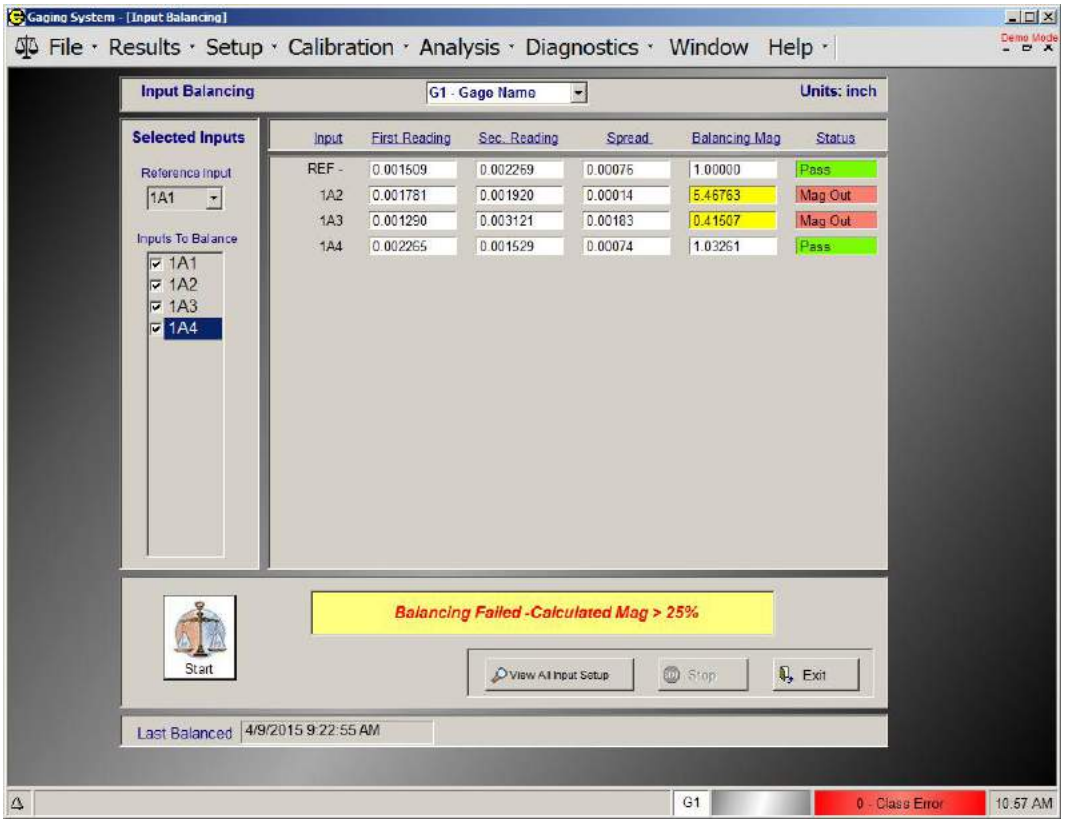
The Log File can be copied to a user specified location such as USB drive by selecting the “Copy Log File” button. The calibration results will be copied to a “.csv” file that can easily opened with spreadsheet program such as Microsoft Excel. The naming format of the log file is “S1G1CalLog.csv” where S1 indicates the Setup ID, G1 indicates the Gage Number.

Delete Log

The Log File can be deleted by selecting the “Delete Log” button.

3.2.2. Input Balancing

This menu allows an operator to balance several inputs in relation to one "reference" input. The balancing algorithm calculates a "Balancing Mag" for each of the inputs by reading the inputs concurrently and comparing the readings to the reference input reading. If a balancing routine is required for a Gage set up, a balance master may be supplied for the balancing routine. If no balance master is supplied, a master or a part with the maximum clearance for the balance inputs may be utilized.



Reference Input

Selected inputs can be balanced relative to a REFERENCE input.
The balancing algorithm calculates a Balancing Mag for each
of the inputs by reading the inputs concurrently and comparing the readings
to the reference input readings.

Input Bal. Mag = (Ref. Reading 1 - Ref. Reading 2) / (Input Reading 1 - Input Reading 2)

Inputs to Balance

Select the inputs to be balanced from the list. **The referenced input must be selected.**

Balancing Procedure

1) Load the appropriate part or master onto the gage.
2) Press the “Start” button on the Input Balancing screen.
3) The system will prompt the operator to shift the part to one side.
4) With the part or master shifted toward the reference input press “Continue”.
5) The system will prompt the operator to shift the part to the opposite side.
6) With the part or master shifted away from the reference input press “Finish”.

7) The results of the balancing procedure will be displayed on the system. If the balance procedure is successful the Balance Mag value will be applied to the input, see the Input Setup screen.

Balancing A/E Inputs

If an A/E input does not balance on the first attempt perform the following procedure:

1) With the part or master on the gage, bias it in the direction of the reference input and press “Start” on the Input Balancing screen. Observe the “First Reading” for the reference input. Using the *"ZERO"* knob of the A/E block for the input to be balanced, adjust the display for the “First Reading” of the input to match that of the reference input.

2) Do not press “Continue”. This allows the operator to see live readings in the First Reading column on the display. Bias the part in the opposite direction. Observe the reading for the reference input in relation to the input being balanced. If the value for the balance input is less than that of the reference input, the Mag needs to be increased. If the value for the balance input is more than that of the reference input, the Mag needs to be decreased.

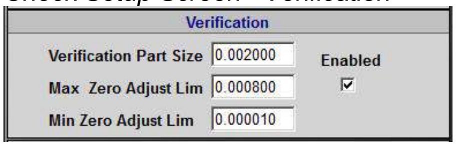
3) To increase the Mag, turn the *"MAG"* knob of the A/E block for the corresponding input clockwise until the display reads approximately 5 times the noted difference, regardless of the direction the display changes. After adjusting the Mag, turn the *"ZERO"* knob in the same direction as the *"MAG"* knob to correct the display to match the reading of the reference input.

4) Bias the part in the opposite direction. Observe the reading for the reference input in relation to the input being balanced. If the value for the balance input still does not match that of the reference input, the Mag will have to be adjusted again according to the procedure above. When the values for the balancing inputs matches those of the reference input press “Stop” on the Input Balancing screen and then perform the balancing routine.

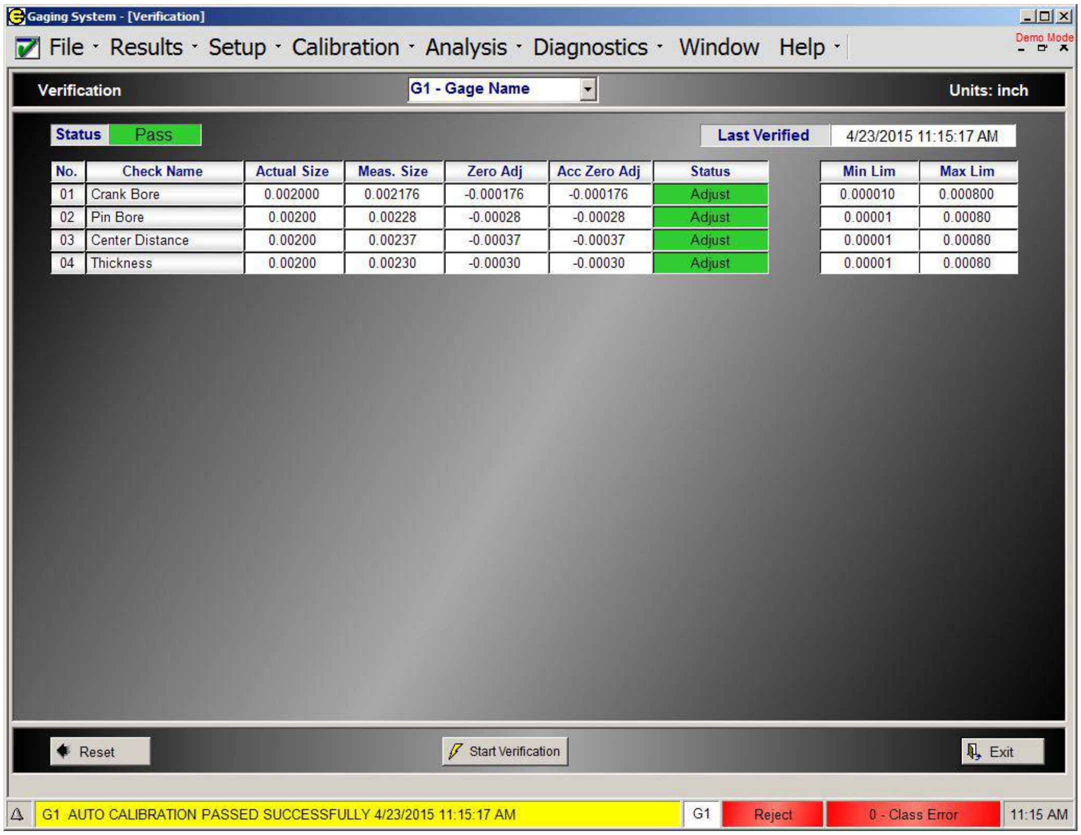
3.2.3. Verification (Optional)

Once the Gage has been calibrated, the means to verify the stability of the process is provided by the Verification menu. The checks that will utilize verification are set up in the menu “Check Setup”. Once verification is enabled, the Gage will be verified from the Verification menu.

Check Setup Screen - Verification



This menu initiates the verification process and displays the results. Each mastered Check, for which verification has been defined, is displayed with the following information:



No. - The number of the Check being verified.

Check Name - The name of the Check being verified.

Actual Size - The actual size of the verification master for the Check selected. This value is programmed as the “Verification Part Size” on the Check Setup screen from the Master Calibration report.

Measured Size - The check size of the verification master as measured in the last verification cycle.

Zero Adjustment - The difference between the actual size and the measured size of the verification master.

Acc Zero Adjustment - The accumulated zero adjustment of all verification cycles. In order for the gage to pass Verification the accumulated value cannot exceed the programmed Max Zero Adjust limit.

Status – The status of the Check from the last Verification cycle.

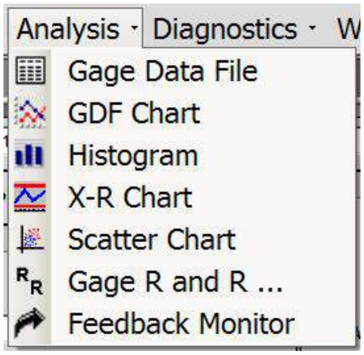
Unknown	Default values loaded, Gage has not be verified.
Pass	Check passed verification - no zero adjustment made, zero adjustment below min zero adj limit.
Adjust	Check passed verification - zero adjustment made.
Max Zero Adj	Accumulated zero adjustment exceeds max zero adjustment limit.
Sat Input	One or more of the Inputs used in the Check formula contain Saturated readings.

Min Limit - Minimum amount of zero offset applied during verification.
If the verification zero offset is less than this value then no zero offset adjustment will be applied.

Max Limit - Maximum accumulated verification zero correction allowed.
If the accumulated zero offset exceeds this limit the verification will fail.

Start Verification - Initiates the gage verification cycle. The system will prompt the operator on the steps required.

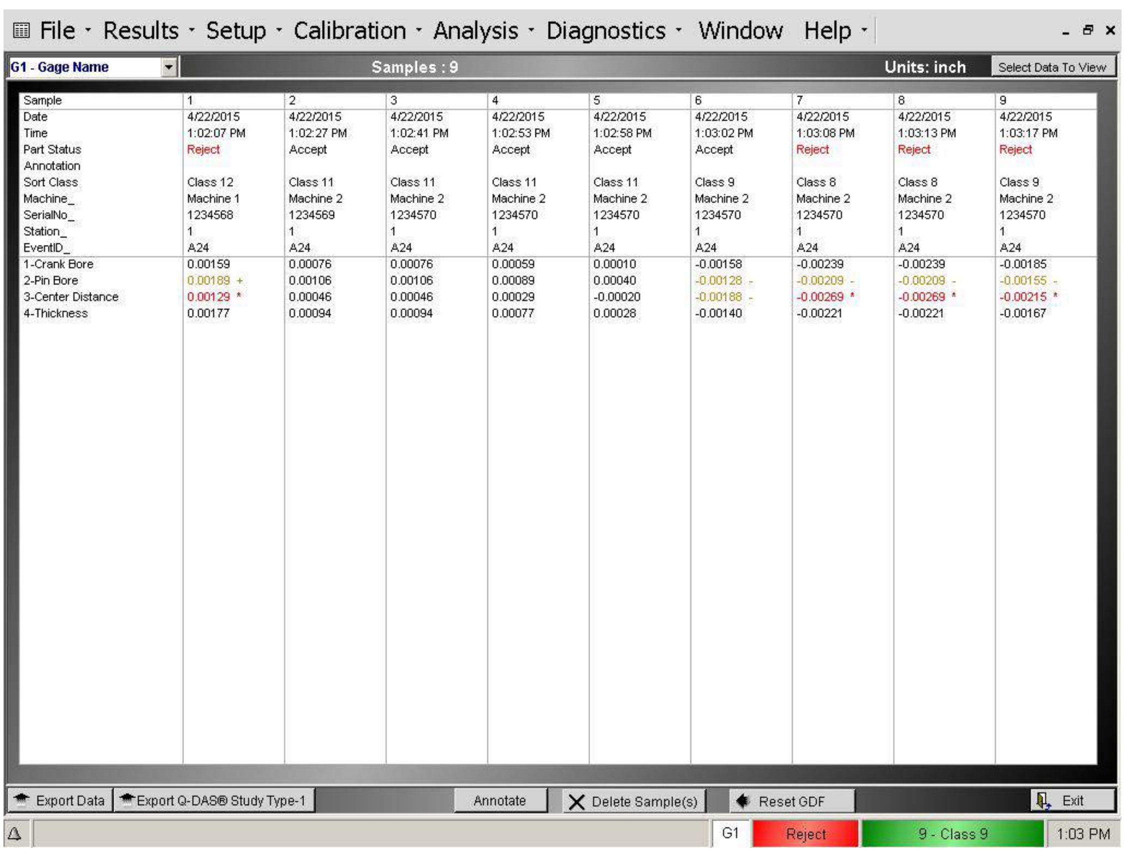
3.3. Analysis



3.3.1. Gage Data File (GDF)

The Gage Data File on the EPIC system contains all of the information stored for each part gaged. There is one file for each Gage programmed on the EPIC system.

NOTE: Checks that are not "Enabled" in the "Check Setup" screen will be displayed as "Disabled" in the GDF



For each gage cycle the following information is recorded:

Sample – The sample number since the last data reset.

Date – The date the samples was taken

Time – The time the sample was taken

Part Status – The status (Accept or Reject) of the part. If any part Check results are out side of the USL and LSL then the part will be rejected.

Sort Class (Optional) – If sort classes are defined for a part Check then the sort class into which the part falls will be displayed.

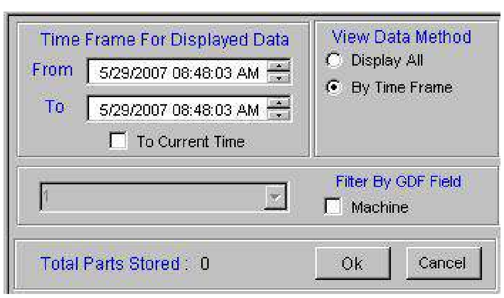
User Defined Fields (Optional) - The user can define additional information to be stored for each sample. For example, a field may be defined to specify the sample as coming from one of four different machines. In the GDF screen displayed above, Machine, SerialNo, Station, EventID are user defined fields. User defined fields are setup in Gage Setup screen.

Check Results - The results of all enabled Checks are displayed.
If a Check status is "Reject", that is outside of the USL (upper specification limit) or LSL (lower specification limit), then an asterisk will be placed next to the results to denote a reject on that Check feature and the value will be RED. (Optional) If the Check results are outside of the UAL (upper approach limit) or the LAL (lower approach limit) then a "+" or "-" will be placed next to the results and value will be YELLOW.

NOTE: If the Check results are outside of the URL (upper reasonable limit) or the LRL (lower reasonable limit) then data **will not be recorded** for that part.

Select Data to View

Allows the operator to select what data to display. The display options are:



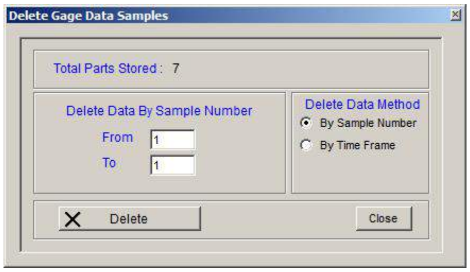
Display All – Displays all accumulated data for the current Gage.

By Time Frame - The operator can select to display only samples taken in a given time frame. The operator can select to display data from a given date and time to another date and time or from a given date and time up to the current time by selecting "To Current Time"

Filter By GDF Field - If User Defined Field is used and setup for sorting (See UDF Setup in Gage Setup Screen).

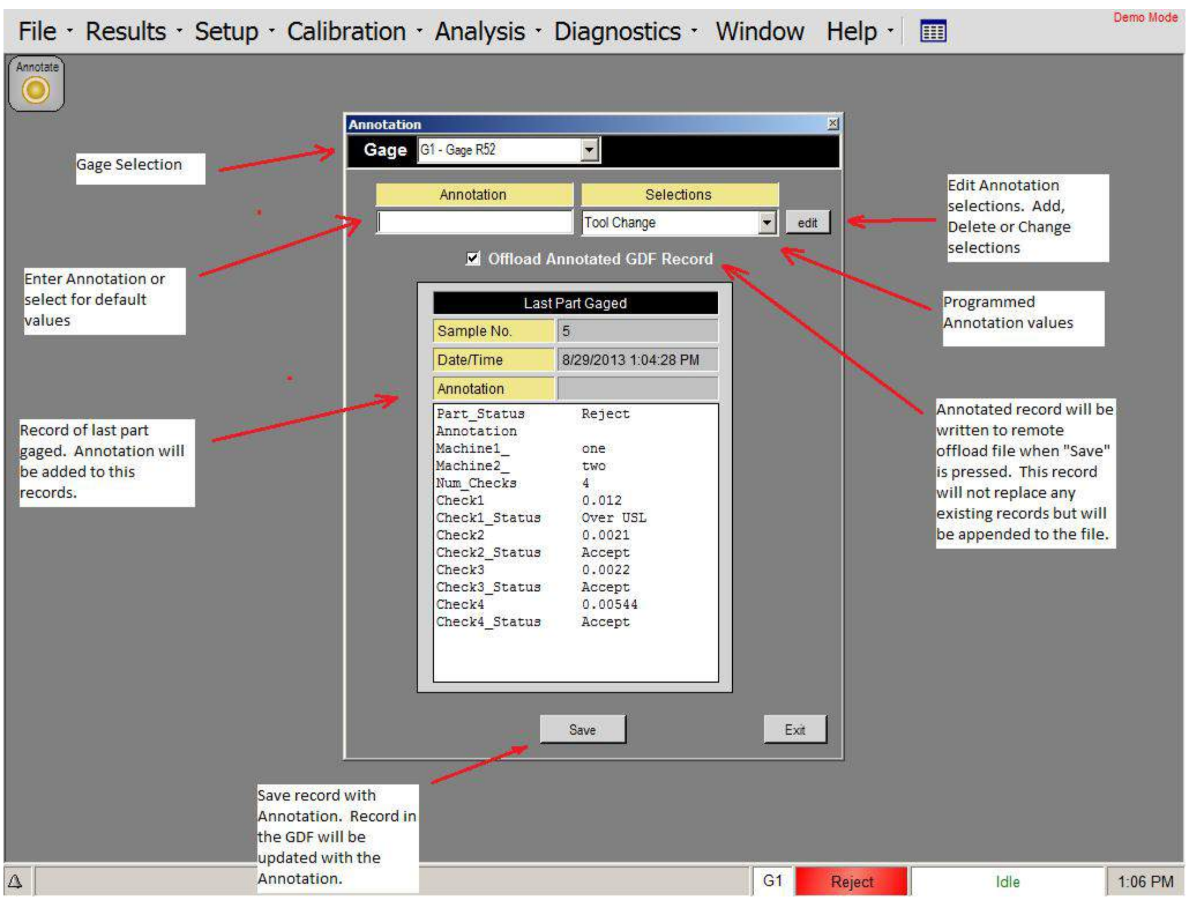
Delete Sample

Allows the operator to delete a sample or range of samples by sample number or time frame. Enter a sample number(s) in the From and To boxes and press "Delete".   The system will prompt "Sample (#) will be deleted from the Gage Data File. Do you want to delete the sample." Press "Yes" to delete the sample.



Annotate

The Annotation Option of the EPIC software provides the ability for the user to assign an explanatory note to a measurement part record stored in the Gage Data File (GDF).   Annotations are useful for identifying special point in the GDF, such as new operator, excessive tooling wear, or a change of material.   The user has the ability to enter predefined annotation notes that can be selected at time of annotation or enter the annotation directly. (**See** ***Section 2 Annotation***, for full description)



Reset GDF

Clears all data from the GDF for the current Gage.

Export Data

The measured results stored in the Gage Data File can be exported to comma delimited text file (GageName.cvs). The export location can reside locally on the EPIC system or externally on USB memory drive or mapped Network drive.

<u>File Record Format :</u>

The individual fields of the comma-delimited file are described below.

Header Information
The first section of the file contains the header information.

- The first line contains the **date** the file was created.
- The second line contains the **time** the file was created.
- The third line contains the **name** of the Gage the data is from.
- The fourth line contains the **number of Checks** for which data was recorded.
- The fifth line contains the **number of samples** in the file

<u>Gage Data Records Format</u>
Sample Number, Date-Time, Part Status, Sort Class*, UDF1*, UDF2*, UDF3*, UDF4*, UDF5*, Result1, Status1, Result2, Status2,…….

* Optional fields

Each line contains results for a single part, with commas separating the individual fields, which are described below.

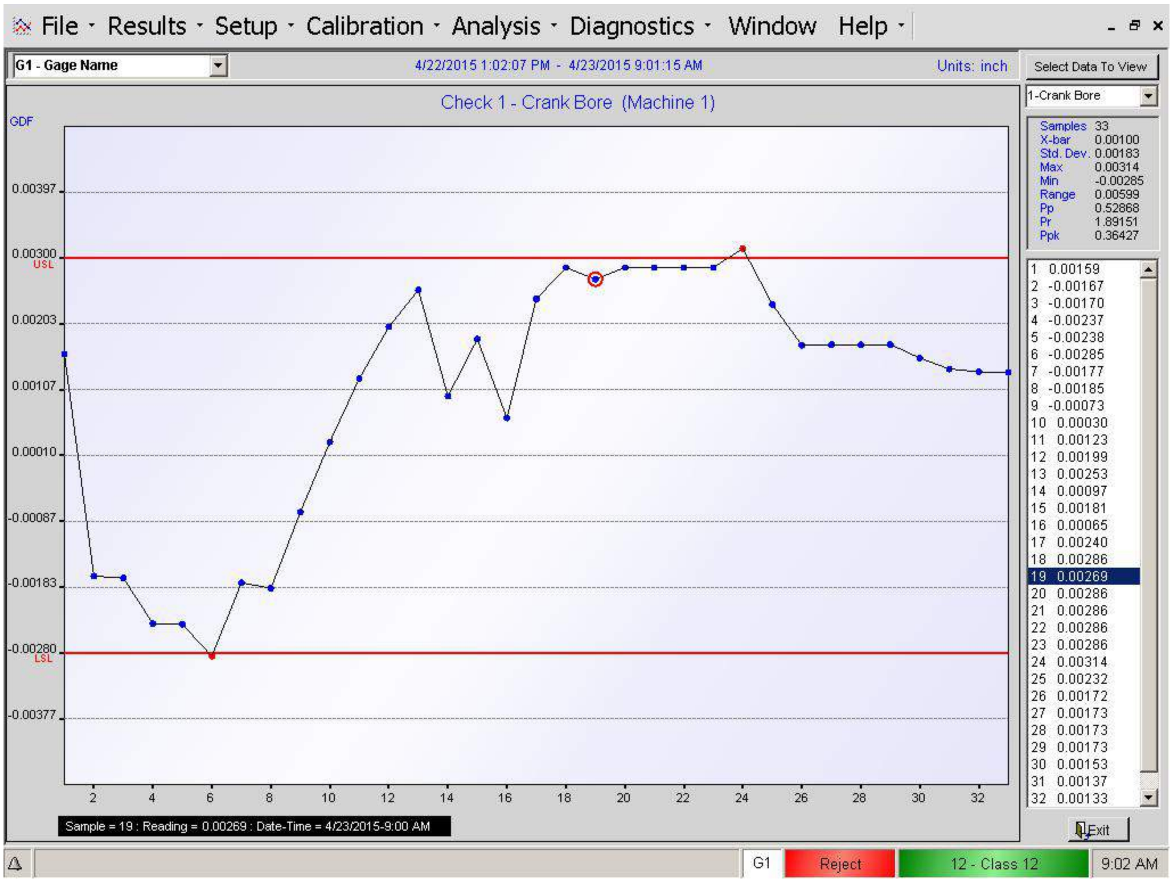
- The first field is the **sample number**
- The second field is the **date and time** the sample was taken.
- The third field is the overall **status** of the part (Accept or Reject)
- The next field lists the **sort class** result for the part. This is an **optional** field and will not be included if sort classes are not defined for the gage.
- The next fields contain any **user-defined-field** data, such as defining what machine or spindle the part was machined on. These fields are **optional** and only included if user defined fields have been created in the Gage Setup screen. A maximum of five user-defined-field can be defined.
- The next two fields contain the actual gage **reading** of Check #1 and the Check **status** (Accept, Over USL, Under LSL, Over UAL, Under LAL) of Check #1.
- The data fields then continue with the gage reading and check status for all the other checks in the same manner as Check #1.

File Example:

```
Date, 3/24/2011
Time, 12:46 PM
Gage, G1-G-51547
Number Checks, 3
Number Samples, 6

1,3/17/2011 12:22:08 PM, Accept, 0.0033, Accept, 0.0018,Accept, 0.0025,
Accept,
2,3/17/2011 12:22:08 PM, Accept, 0.0034, Accept, 0.0017,Accept, 0.0025,
Accept,
3,3/17/2011 12:22:08 PM, Accept, 0.0037, Accept, 0.0018,Accept, 0.0025,
Accept,
4,3/17/2011 12:22:08 PM, Accept, 0.0031, Accept, 0.0018,Accept, 0.0025,
Accept,
5,3/17/2011 12:22:08 PM, Reject, 0.0033, Reject, 0.0012,Accept, 0.0025,
Accept,
6,3/17/2011 12:22:08 PM, Accept, 0.0032, Accept, 0.0018,Accept, 0.0025,
Accept,
```

3.3.2. GDF Chart

The Gage Data File Chart is generated from the stored gaged data. The display is a chart of all gage readings for the selected Check and selected data range.



<u>Select Data to View</u>
Allows the operator to select what data from the gage data file to display.

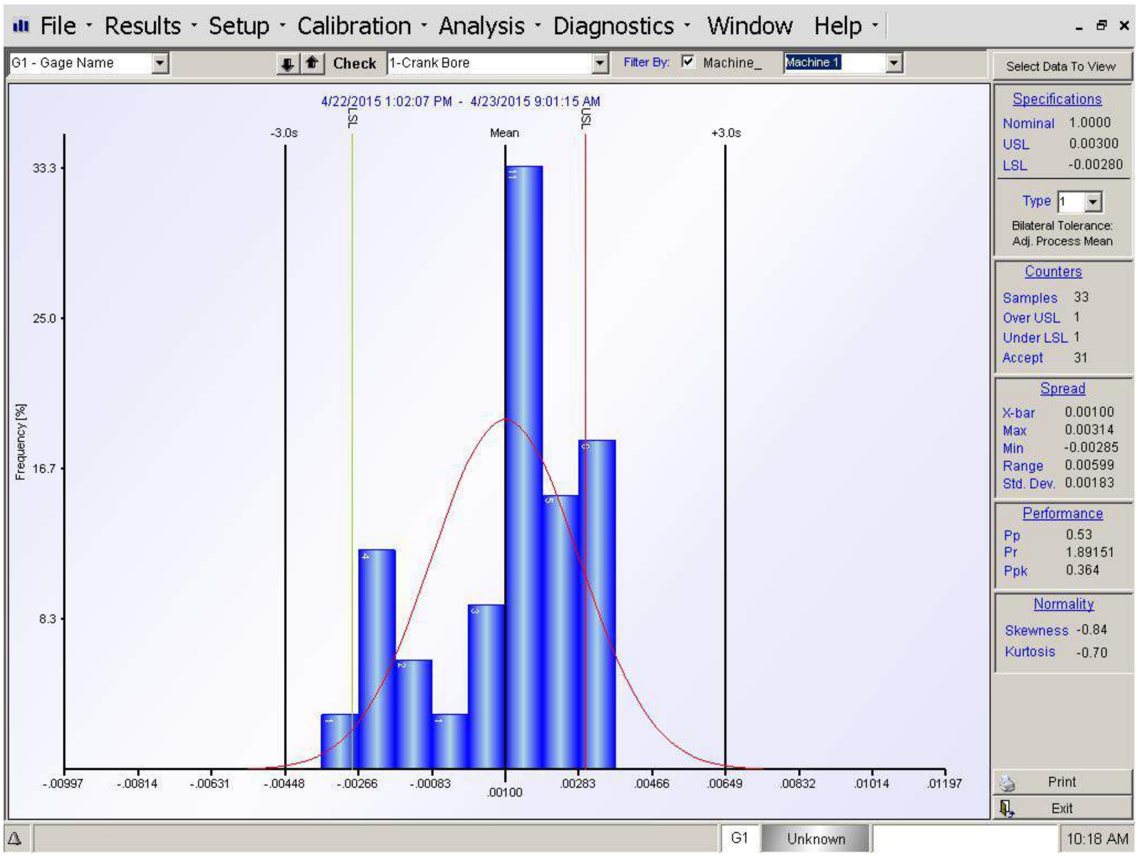
Display All – Displays all accumulated data from the gage data file for the selected check.
By Time Frame - The operator can select to display only samples taken in a given time frame.
By Sample Range - The operator can select to display a range of samples.
Last Parts Gaged- The operator can select to display only the results from a selected number of the last parts gaged.

For each Check the following is displayed:
Samples – Total number of samples viewed.
X-bar – Average of the samples viewed
Max – The maximum reading of all samples viewed
Min – The minimum reading of all samples viewed
Range – The difference between the max and min samples
Std. Dev. - The standard deviation of the sample viewed.
Pp - Process Performance
Pr – Performance Ratio
Ppk - Performance Index

* see *APPENDIX A - Performance/Process Capability Calculations*

3.3.3. Histogram

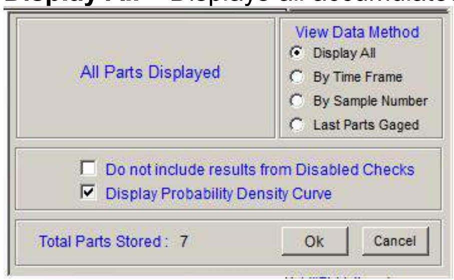
A Histogram is a bar graph, which displays the relative frequency of occurrence of values within a group of observations. A separate histogram display is generated for each part Check. The pull down menu at the top the screen can be used to select which check's data will be displayed. The histogram is generated from the stored gaged data.



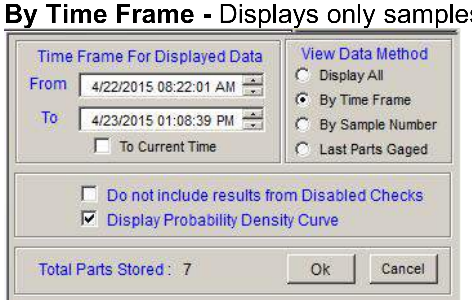
Select Data to View

Allows the operator to select what data from the gage data file to display.

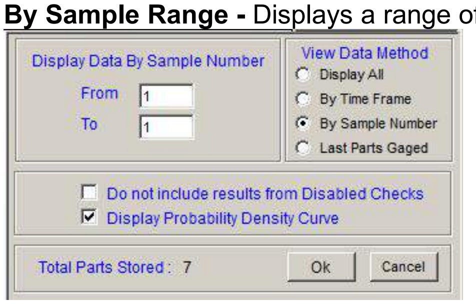
Display All – Displays all accumulated data from the gage data file.



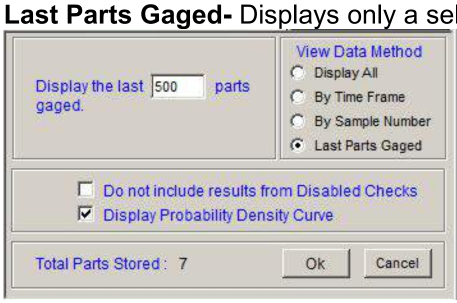
By Time Frame - Displays only samples taken within a given time frame.



By Sample Range - Displays a range of samples.



Last Parts Gaged- Displays only a selected number of the last parts gaged.



Histogram Display

There are 5 floating vertical lines displayed on the Histogram:

1) Mean of the Sample
2) USL - Upper Specification Limit
3) LSL - Lower Specification Limit

4) $x + 3\sigma$
5) $x - 3\sigma$
σ = standard deviation

The Histogram also displays additional information for each check:

Specifications
Nominal Size – The nominal size programmed for the check.
USL - The Upper Specification Limit programmed for the check.
USL - The Lower Specification Limit programmed for the check.

Tol. Type
Specification Type Selection
Type 1: Bilateral Tolerances, Adjustable Process Mean
Type 2: Bilateral Tolerances, Non-Adjustable Process Mean
Type 3: One-Sided Tolerance, or Zero-Based Tolerance

Counters
Samples – Total number of samples included in the histogram.
Over USL - Number of samples above the USL.
Under LSL - Number of samples below the LSL.
Accept - Number of samples acceptable parts in the sample.

Spread
X-Bar – The average of all the readings in the sample.
Max - The maximum reading in the sample.
Min - The minimum reading in the sample.
Range - The difference between the maximum and minimum readings in the sample.
Std. Dev. - The standard deviation of the sample.

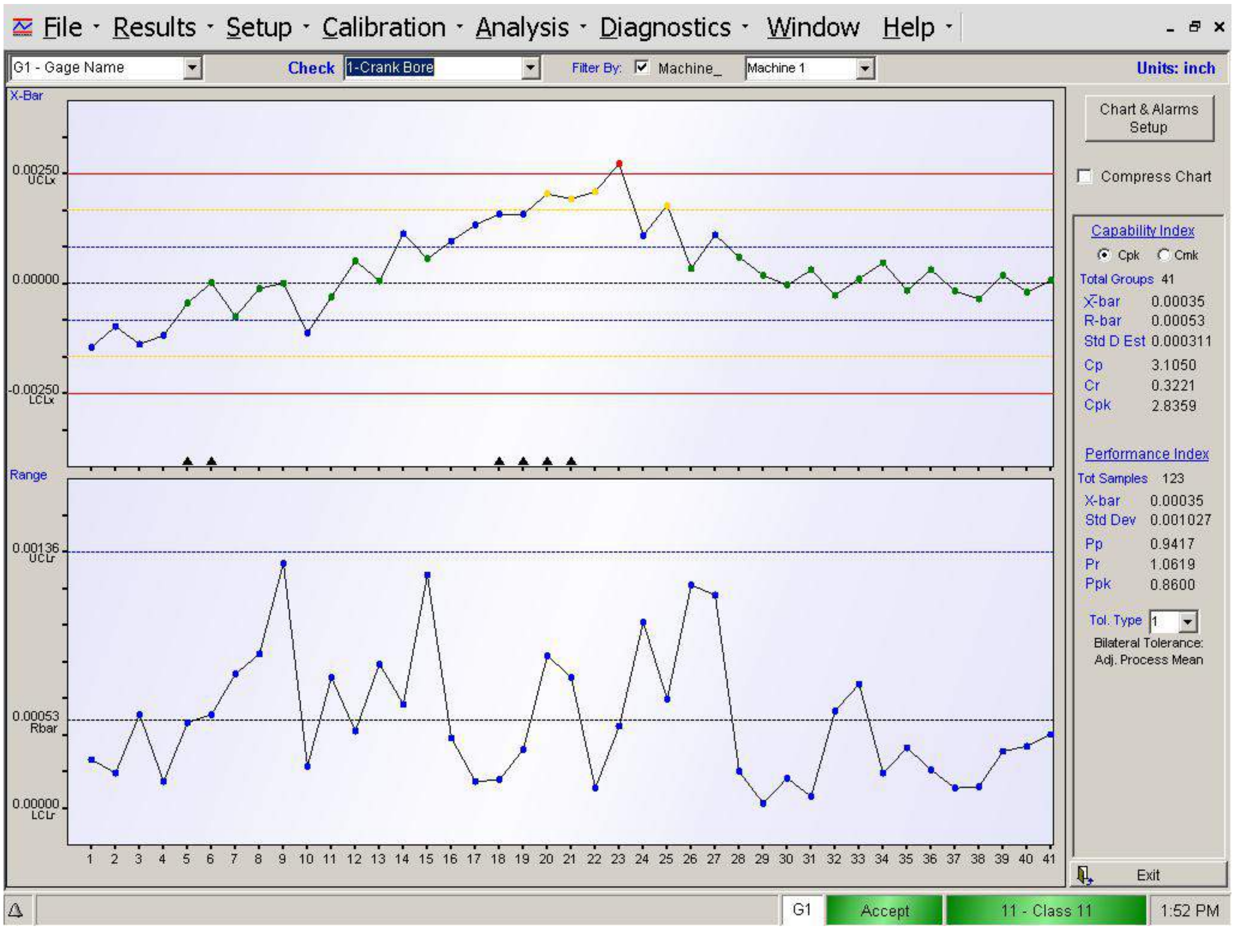
Performance (see **Appendix A** for Performance Capability Description and Calculations)
Pp – Relationship of process distribution to spec limits. If Pp is >=1.33, process is considered capable.
Pr – Inverse of Pp.
Ppk- How centered the process distribution is. If Ppk is >=1.33, process is considered capable.

Normality
Skewness- The Measure of Symmetry.
For a Histogram with normal distribution, Skewness = 0.
Skewness >0, distribution extending to the right.
Skewness <0, distribution extending to the left.

Kurtosis
The Measure of whether the data is peaked or flat relative to Normal Distribution.
For a Histogram with normal distribution, Kurtosis = 0.
Kurtosis >0, distribution sharp peak.
Kurtosis <0, distribution relatively flat.

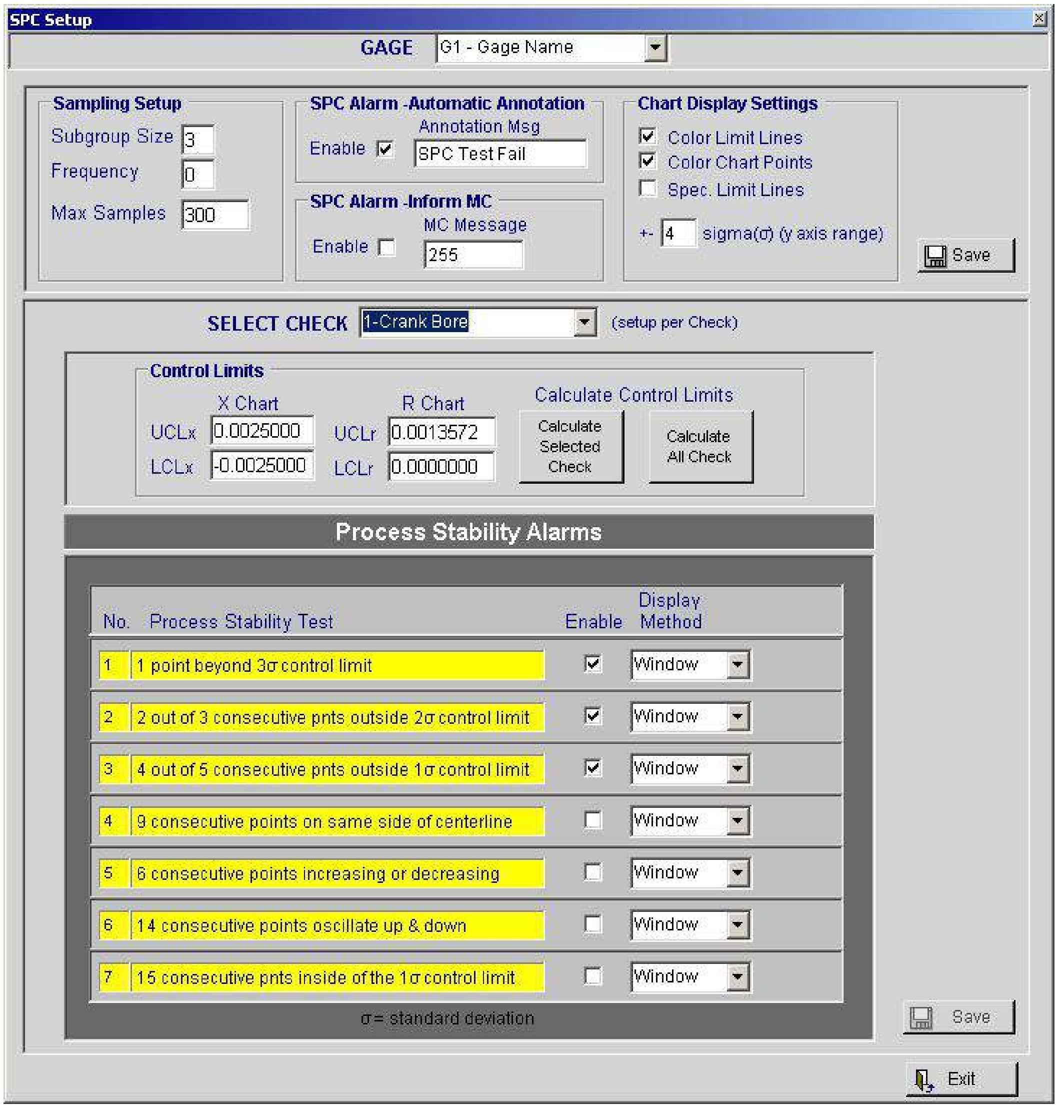
3.3.4. Xbar-R Chart

The Xbar-R chart plots the process mean (Xbar chart) and process range (R chart) over time for measured data in subgroups. This combination control chart is widely used to examine the stability of processes in many industries.



3.3.4.1. Chart & Alarm Setup

When you select to "Chart & Alarms Setup" the SPC Setup screen is displayed. Each Gage setup can have a different set of control charts setup parameter defined and each Check setup can have different control limits and alarming defined.



3.3.4.2. Sampling Setup

This value defines the number of samples in a subgroup for a Check. Subgroup size can be value 1 to 15. Each Check have the same subgroup size. A subgroup is represented on the chart as a point.

Frequency - Number of Consecutively Gaged parts skipped between Sample plots (subgroup).

Max Samples - Maximum number of samples used (display and analysis).
Example: if Max Samples is set to "300" then the last 300 measured readings will be used, if subgroup size is set to 3 then 100 chart points will be displayed.

3.3.4.3. SPC Alarm - Automatic Annotation

Enable - If enabled, annotation will automatically be logged in the Gage Data File when any of the “Process Stability Alarms” are triggered for any Check. The annotation can be viewed in the Gage Data File screen or on the chart (see Viewing Chart below).

Annotation Msg - Message that will be written to Gage Data File if a Process Stability Alarm is triggered and Automatic Annotation enabled. Message can be a maximum of 15 characters.

3.3.4.4. SPC Alarm - Inform MC

Enable - Enable- Inform Machine Control of Process Stability Alarm . If an Process Stability Alarm is triggered, this programmed message will be transmitted to Machine Control (PLC etc..). This is primarily used to shutdown the machine control when an out of process condition occurs.

MC Message - Message that will be transmitted to Machine Control (PLC etc..) if a Process Stability Alarm is triggered and Inform MC enabled.

3.3.4.5. Chart Display Setting

Color Limit Lines - Uses colored lines to show the boundaries for the control chart zones.
Within control charts, there are four zones:

Green :	From the center-line to ±1 standard deviation.
Blue :	From ±1 standard deviations to ±2 standard deviations.
Yellow:	From ±2 standard deviations to ±3 standard deviations.
Red :	Outside ±3 standard deviations

Color Chart Points - Plots the subgroup data points using a colored dot to show which zone contains the point.

Spec. Limit Lines - Plots the specification limits for displayed Check on the control chart. If the specification limits do not plot on your control charts after activating this feature, this indicates that your process is in such control that the spec limits would chart outside the control chart.

Y axis range - Used to specify the range of the Y-axis (the vertical axis) of your control charts. The range value is + number of standard deviation from median center line.

3.3.4.6. Control Limits

There are a set of control limit for each feature being measured (Check).
UCLx - Xbar chart upper control limit
LCLx - Xbar chart lower control limit
UCLr - Range chart upper control limit
LCLr - Range chart lower control limit

New control limits can be either be entered manually or have the software calculate new limits from the active data in the gage data file. Your control charts are the indicator of when you may need to modify or recalculate your control limits. For example, let's say you make an improvement to your process—you replace an old, unreliable piece of equipment with a new machine. After replacing the machine and beginning to make your product again, let's say your control charts begin to show that you have a great deal less variation in your product. At this time, you may want to recalculate your control limits to reflect the improved process.

Manually Entering New Control Limits
Control limits can be manually enter for the current data file at any time. For example, perhaps you've been performing your SPC analysis by hand in the past and have already established your control limits for a process. To enter new limits, select the Check you want to modify and enter the new limit in the text boxes provided and select "Save" when done.

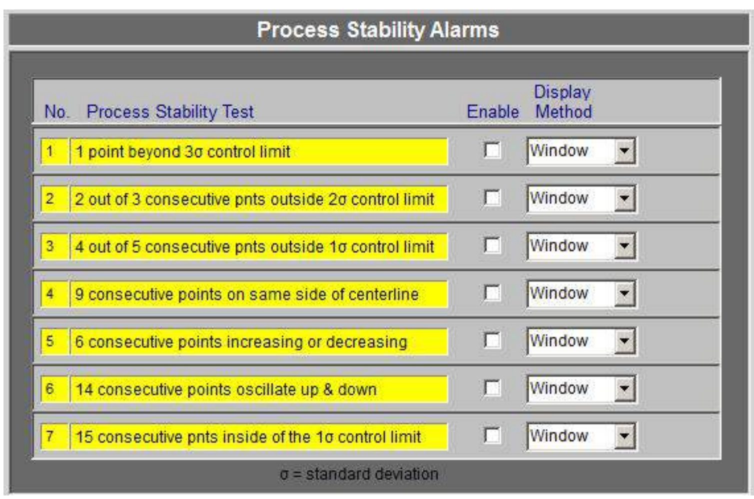
Calculating New Control Limits from Existing Data

Select the "Calculate Selected Check" button to calculate new control limits for the currently select "Check". The calculated control limits will be base on the currently accumulated readings.

Select "Calculate All Check" button to calculate new control limits for all "Checks". The calculated control limits will be base on the currently accumulated readings

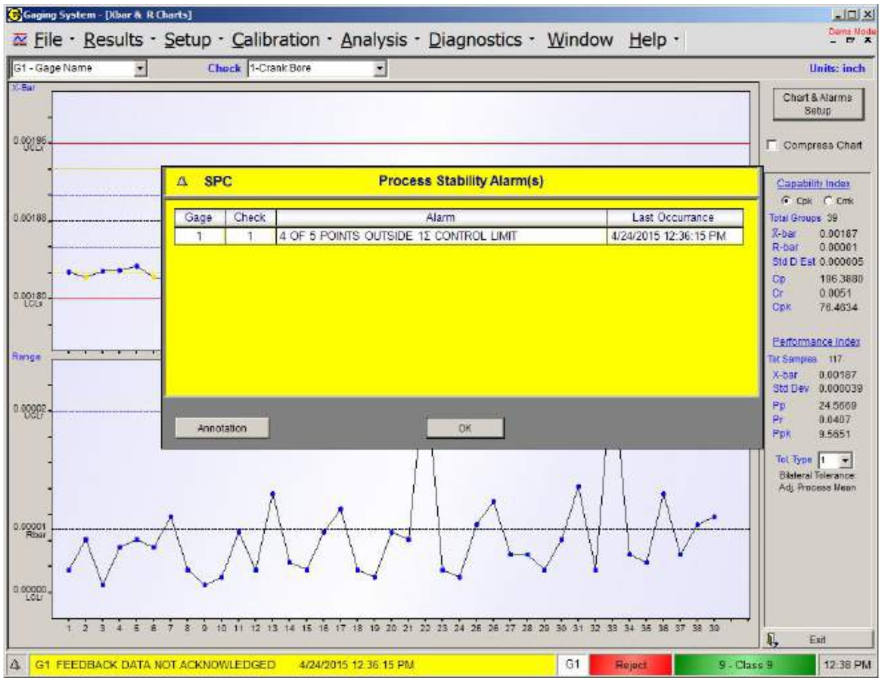
EPIC calculations for control limits:
UCLx = $\bar{x}$ + (3 * (StdDev / Subgroup Size))
LCLx = $\bar{x}$ - (3 * (StdDev / Subgroup Size))

3.3.4.7. Process Stability Alarms

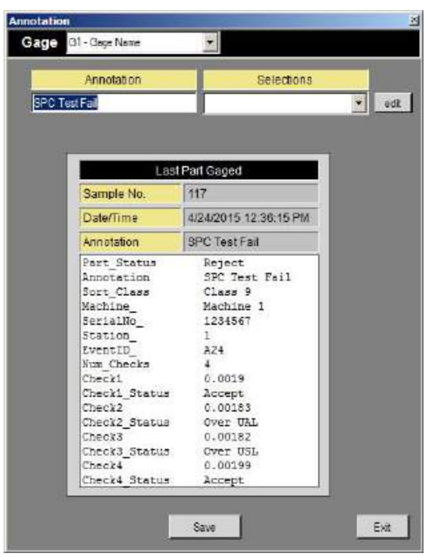


There are seven process stability alarms that can be activated for each Check independently. The alarms are generated from sample data charted the Xbar chart. The alarm process stability test is performed when new data is added to the gage data file at the completion of a measurement cycle when the Enable checkbox is selected.   If a process stability test fails the alarm will be activated and displayed according to the "Display Method". The alarm will also be logged in the SPC Alarm Log (see Alarm Display).

Display Method - Select the display method (Status Bar, Window, or None) for the alarm. If Status Bar is selected then the alarm will be displayed on the bottom line of the EPIC application. If Window is selected the alarm will be displayed in a pop up window (see figure below).



Annotation from Alarm Window Display
When a process stability alarm is triggered and displayed (Window) there is an option to annotate the gage data file with cause of alarm. Select the “Annotation” button to bring up the following screen that allows an annotation message to be entered.

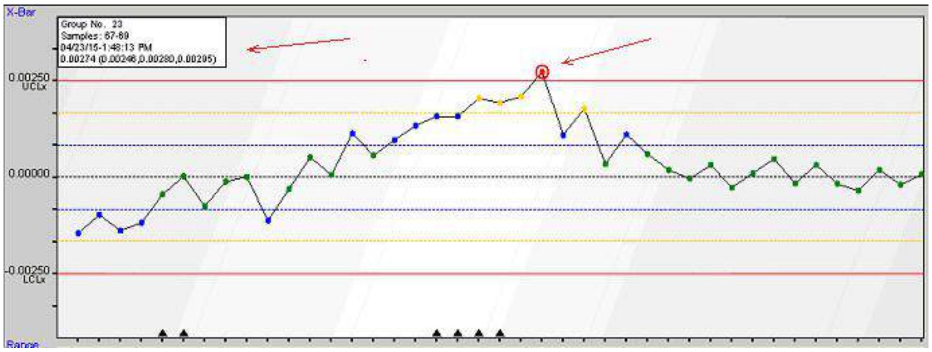


3.3.4.8. Viewing Chart

The control chart shows the upper and lower control limits (UCL and LCL) and the individual subgroup data. There is also the option to display color limit lines and specification limits. When a large amount of subgroup data has been collected that will not fit on the display a scroll-bar will be displayed to allow scroll back and forth through the chart data.

Viewing Subgroup Data

When viewing a control chart, click on any subgroup point displayed on the chart to receive a small data table which displays information about that particular subgroup, including subgroup number, sample that makeup the subgroup, date and time, subgroup data readings, and annotation.



Viewing Annotation

The control charts also shows if Annotation has been attached to any subgroup by displaying a black triangle flag on the axis below the subgroup. To view the Annotation click on the triangle flag (see figure below).

Compress Chart - The control chart window also contains a Compress Chart checkbox. Use this option when you have collected more subgroup data than fits in the control chart window at one time. The Compress Chart option compresses your control chart so that all subgroups are visible in the control chart window.

Process Capability

See ***Appendix A*** for Performance / Process Capability Description and Calculations

---

Cpk - Process Capability Indices Cp and Cpk are normally used when determining the capability of a continuous production process and where the sampling of parts is made continuously during the production.

Cmk - Machine Capability Indices Cm and Cmk are used when determining the ability of a production machine to produce, for example as acceptance test of new equipment. The sampling of parts is made in a short period of time without changes in machine settings. All efforts are make to try to isolate the influence on the machine from other factors.

Total Groups- Total number of subgroups used in generating the chart.
X-bar - Average (Mean) of the average of each subgroup values
R-bar - Average range of all the range values (Xmax-Xmin) for each subgroup
Std D Est - Estimated Standard Deviation (Std Dev Est). Std Dev Est = Rbar / d2
Cp - Process Capability.
Cr - Capability ratio.
Cpk - Process Capability index.

Performance Capability

See ***Appendix A*** for Performance / Process Capability Description and Calculations

---

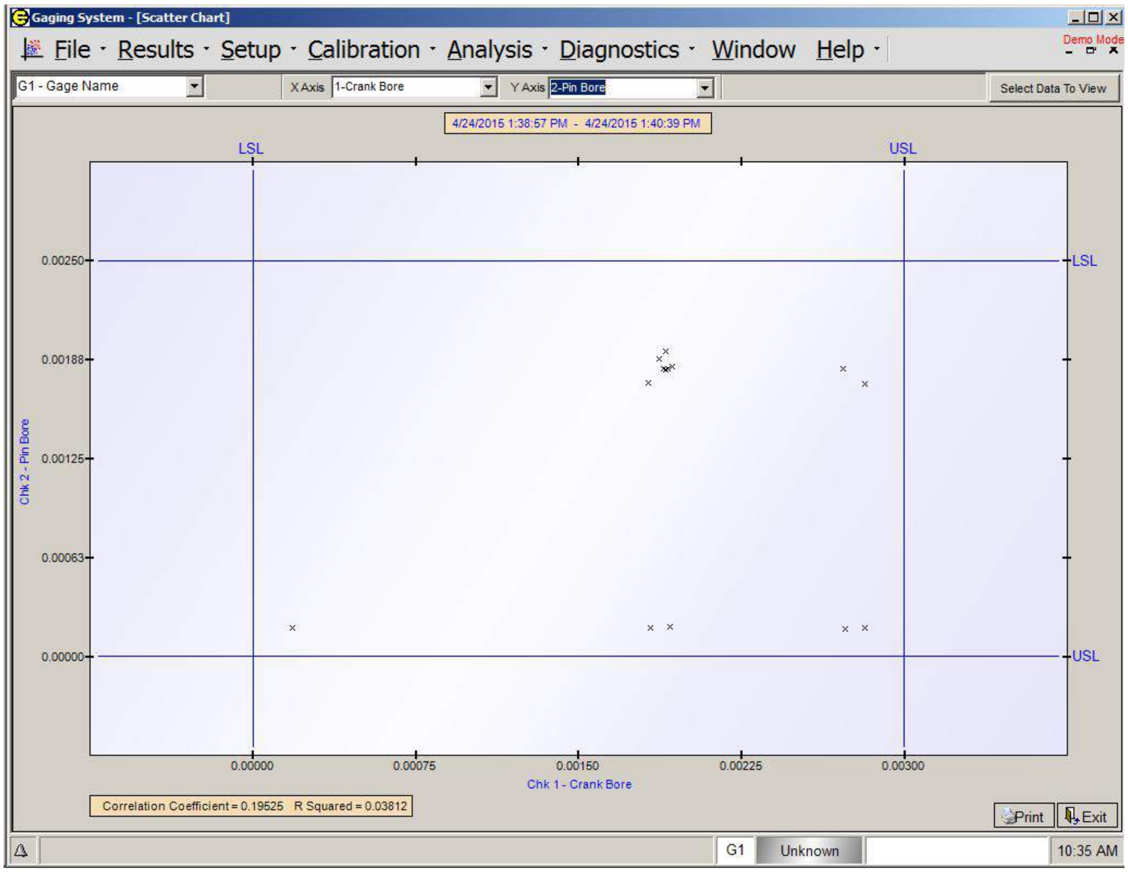
Performance Capability Indices Pp and Ppk are normally used when determining the possibilities of a process to produce within specified requirements and where the sampling of parts is made in the form of a large sample taken on one occasion.

Total Sample - total number of samples.
Xbar - Average (mean) of all readings.
Std Dev - Standard Deviation
Pp - Performance index.
Pr - Performance ratio.
Ppk - Performance index.

Tol. Type - Specification Type Selection
Type 1: Bilateral Tolerances, Adjustable Process Mean
Type 2: Bilateral Tolerances, Non-Adjustable Process Mean
Type 3: One-Sided Tolerance, or Zero-Based Tolerance

3.3.5. Scatter Chart

The Scatter Chart generates a plot of two variables (Part Checks), one against the other to display trends. The Gage, Part Checks and Data Viewing Method are selected in this menu.



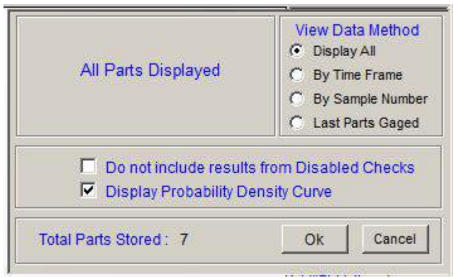
Gage - By using the pull down menu, the operator selects the gage in which the part checks to be monitored are programmed.

X Axis - By using the pull down menu, the operator selects the X Axis Part Check to be displayed.

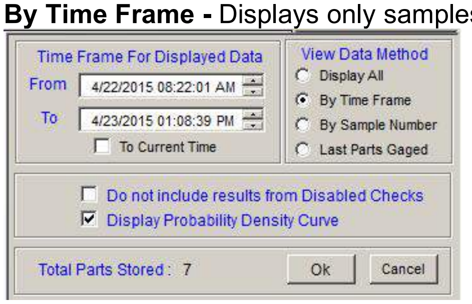
Y Axis - By using the pull down menu, the operator selects the Y Axis Part Check to be displayed.

<u>**Select Data to View**</u>
Allows the operator to select what data from the gage data file to display.

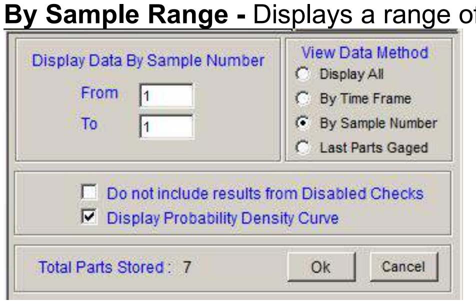
Display All – Displays all accumulated data from the gage data file.



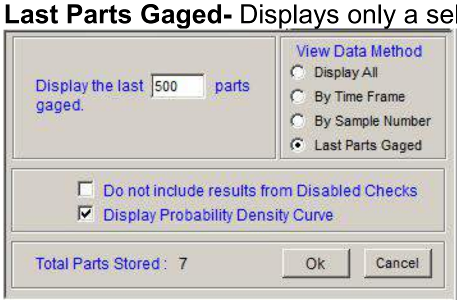
By Time Frame - Displays only samples taken within a given time frame.



By Sample Range - Displays a range of samples.

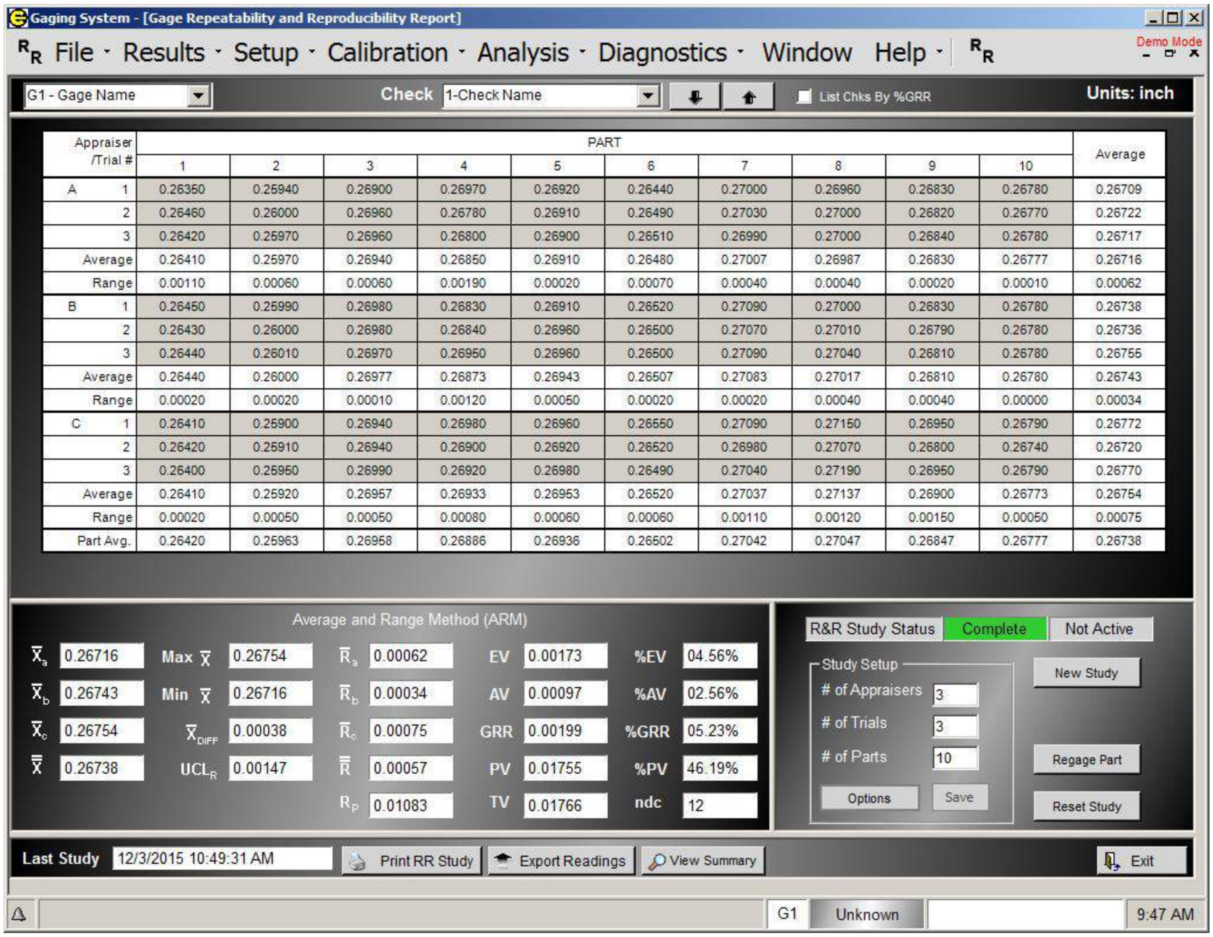


Last Parts Gaged- Displays only a selected number of the last parts gaged.



3.3.6. Gage R and R

$^{R}_{R}$ Gage R and R ...



Appraiser /Trial #		PART 1	2	3	4	5	6	7	8	9	10	Average
A	1	0.26350	0.25940	0.26900	0.26970	0.26920	0.26440	0.27000	0.26960	0.26830	0.26780	0.26709
	2	0.26460	0.26000	0.26960	0.26780	0.26910	0.26490	0.27030	0.27000	0.26820	0.26770	0.26722
	3	0.26420	0.25970	0.26960	0.26800	0.26900	0.26510	0.26990	0.27000	0.26840	0.26780	0.26717
	Average	0.26410	0.25970	0.26940	0.26850	0.26910	0.26480	0.27007	0.26987	0.26830	0.26777	0.26716
	Range	0.00110	0.00060	0.00060	0.00190	0.00020	0.00070	0.00040	0.00040	0.00020	0.00010	0.00062
B	1	0.26450	0.25990	0.26980	0.26830	0.26910	0.26520	0.27090	0.27000	0.26830	0.26780	0.26738
	2	0.26430	0.26000	0.26980	0.26840	0.26960	0.26500	0.27070	0.27010	0.26790	0.26780	0.26736
	3	0.26440	0.26010	0.26970	0.26950	0.26960	0.26500	0.27090	0.27040	0.26810	0.26780	0.26755
	Average	0.26440	0.26000	0.26977	0.26873	0.26943	0.26507	0.27083	0.27017	0.26810	0.26780	0.26743
	Range	0.00020	0.00020	0.00010	0.00120	0.00050	0.00020	0.00020	0.00040	0.00040	0.00000	0.00034
C	1	0.26410	0.25900	0.26940	0.26980	0.26960	0.26550	0.27090	0.27150	0.26950	0.26790	0.26772
	2	0.26420	0.25910	0.26940	0.26900	0.26920	0.26520	0.26980	0.27070	0.26800	0.26740	0.26720
	3	0.26400	0.25950	0.26990	0.26920	0.26980	0.26490	0.27040	0.27190	0.26950	0.26790	0.26770
	Average	0.26410	0.25920	0.26957	0.26933	0.26953	0.26520	0.27037	0.27137	0.26900	0.26773	0.26754
	Range	0.00020	0.00050	0.00050	0.00080	0.00060	0.00060	0.00110	0.00120	0.00150	0.00050	0.00075
Part Avg.		0.26420	0.25963	0.26958	0.26886	0.26936	0.26502	0.27042	0.27047	0.26847	0.26777	0.26738

3.3.6.1. Gage R&R Overview

Gage R& R or GRR
Gage repeatability and reproducibility studies determine how much of your observed process variation is due to measurement system variation. Gage R&R is an estimate of the combined variation of repeatability and reproducibility.

Gage Repeatability - Equipment Variation (EV) - is the variation in measurements obtained when one appraiser uses the same gage for measuring the identical characteristics (part checks) of the same parts.

Gage Reproducibility - **Appraiser Variation (AV)** - is the variation in the average of measurements made by DIFFERENT appraisers using the same gage when measuring identical characteristics of the same parts.

$$SSp = \sum_{j}^{n} (X_{i...}^{2}) - \frac{X_{...}^{2}}{nkr}$$

Assessing Repeatability and Reproducibility
EPIC system provides two methods for assessing repeatability and reproducibility: Average and Range Method (ARM), and ANOVA (Analysis of Variation) method. The ARM method breaks down the overall variation into three categories: part-to-part, repeatability, and reproducibility. The ANOVA method breaks down the variation into four categories: part-to-part, reproducibility (appraiser), reproducibility (part-to-appraiser), and repeatability (equipment).

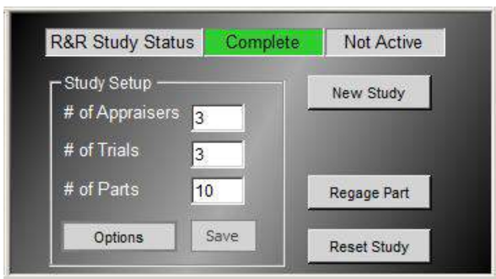
ARM and ANOVA methods are in accordance with Automotive Industry Action Group (AAIG) (2010), MSA (Measurement System Analysis Reference Manual), Fourth Edition.

3.3.6.2. Gage R&R Setup

A complete R & R study is conducted on a sample size of 1 to 10 parts, in two or three trials and is performed by different appraisers: A, B, and C. A partial or "simulated" R & R study can be conducted by a single appraiser using the ARM method to quickly verify gage Repeatability, exclusively, as an aid in detecting any tooling problems that may be present.

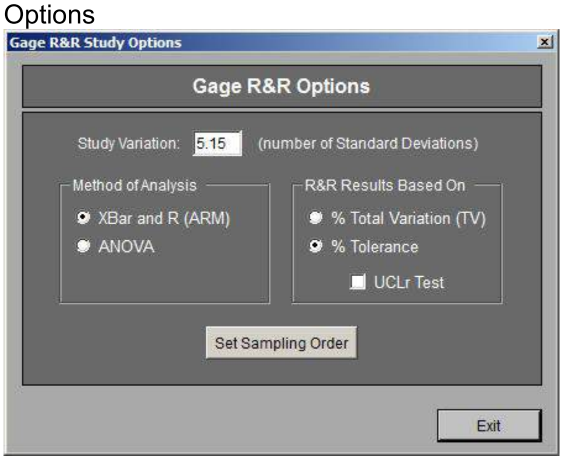
When an R & R study is enabled, regular gaging is disabled, SPC charts are not updated, and no feedback is sent to the machine control.

Study Setup



# of Appraisers - Number of appraisers to be used in the study. There must be from 1 to 3 appraisers for ARM study and from 2 to 3 appraisers for ANOVA study.
# of Trials - Number of trials for each part. Must be either 2 or 3.
# of Parts - Number of parts to be used in the study. Must be between 1 and 10.

Options



Study Variation (sv) - Multiplier used in study variation calculations. The default multiplier is 5.15, which is the number of standard deviations needed to capture 99% of the process measurements. A 99% spread is on considered to represent the full spread of measurement error. A 99.7% spread is represented by a multiplier of 6, which is +-3σ and represents the full spread of a "normal" curve.

Method of Analysis
XBar and R (ARM) - The ARM method breaks down the overall variation into three categories: part-to-part, repeatability, and reproducibility.

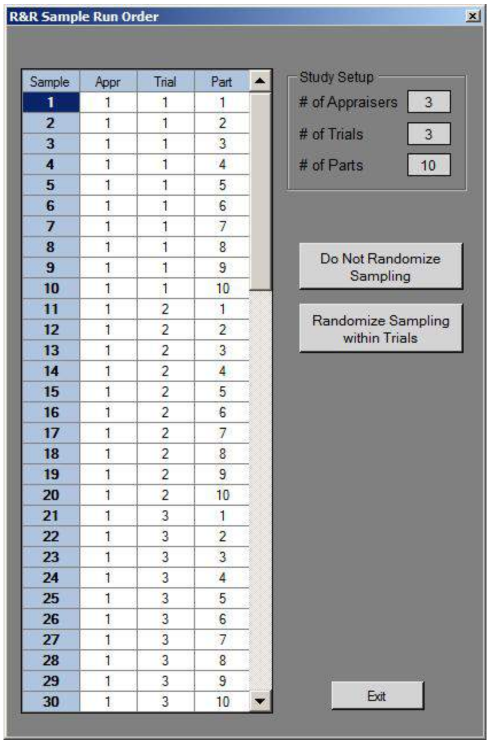
ANOVA -The Analysis of Variation (ANOVA) method breaks down the variation into four categories: part-to-part, reproducibility (appraiser), reproducibility (part-to-appraiser), and repeatability (equipment).

R&R Results Based On
% Total Variation (TV) - %EV, %AV, %GRR, %PV are computed as a percentage of the Total Variation (TV)
% Tolerance - %EV, %AV, %GRR, %PV are computed as a percentage of the part tolerance

UCLr Test - This test compares the upper control limit range (UCLr) to the data accumulated in the R&R test and discards any reading which exceeds the upper control limit range. If this box is checked then any reading which exceeds the upper control limit will be discarded.

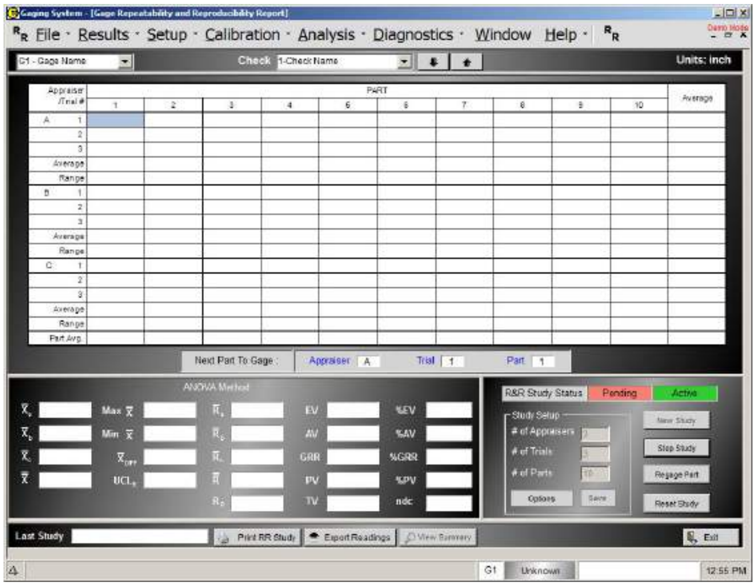
Sampling Order
The order in which parts are measured is important when using the ANOVA method. If the parts are not measured in a random manner, this can lead to a source of bias. A randomizing algorithm has been incorporated in the EPIC software that can be used to generate a random sampling order. When the "Set Sample Order" button is selected the "Sample Run Order" grid is displayed. The "Randomize Sampling withinTrials" button can be selected to generate the random order. If the ARM analysis method is being used it is recommend to use a non-randomize sampling order to make the study easier to conduct. The sample order can also be manually entered for those who want to generate a custom sample run.

NOTE: Sample order can only be changed after R&R study has been reset "Reset Study" and a new study has not be started.



3.3.6.3. Performing a Gage R&R Study

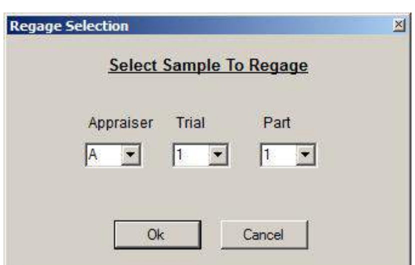
1. Use the pull down menu in the upper left corner of the screen to select the gage on which the gage R&R study
2. Under “Study Setup” enter the number of appraisers (1-3), the number of trials (2-3) and the number of parts (1-10) to be used in the study.
3. Select “New Study”. The system will alert the operator that any existing gage R&R data for the current Gage will be deleted. Select “Yes” to continue.
4. The system will prompt with next part to be gaged. The part to be gaged will also be highlighted in blue on the screen. The sample order is setup under the “Option” section.



5. Have the first appraiser load part on the gage and initiate a gage cycle.
6. The system will prompt for the next appraiser, trial, and part to be gaged.
7. Continue to gage parts as prompted by the system until the study is completed. To pause in the middle of the study select “Stop Study”. The study can be continued by selecting “Continue Study”.

Regage Part

If an error occurs when measuring a part during a gage R&R, an individual part may be re-gaged rather than repeating the entire study. For example, if a part is not properly seated in the Gage when the start gage command is issued the gage will record incorrect readings. These readings can be over written using Regage Part. When the “Regage Part” button is pressed a dialog box will open allowing the operator to select the Appraiser number, Trial number, and Part number to be regaged (see figure below).

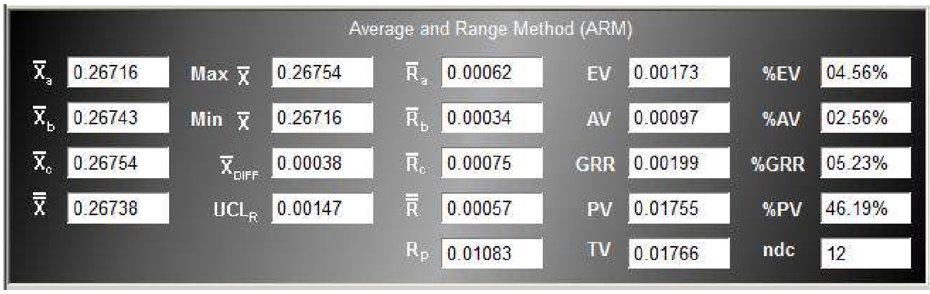


Gage R&R Results

When the R&R study has been completed the result will be calculated and displayed.

You can determine whether your measurement system is acceptable using the following guidelines.
If the Total Gage R&R percentage in the %GRR (% Tolerance, %TV) is:
· Less than 10% - the measurement system is acceptable.
· Between 10% and 30% - the measurement system may be acceptable depending on the application.

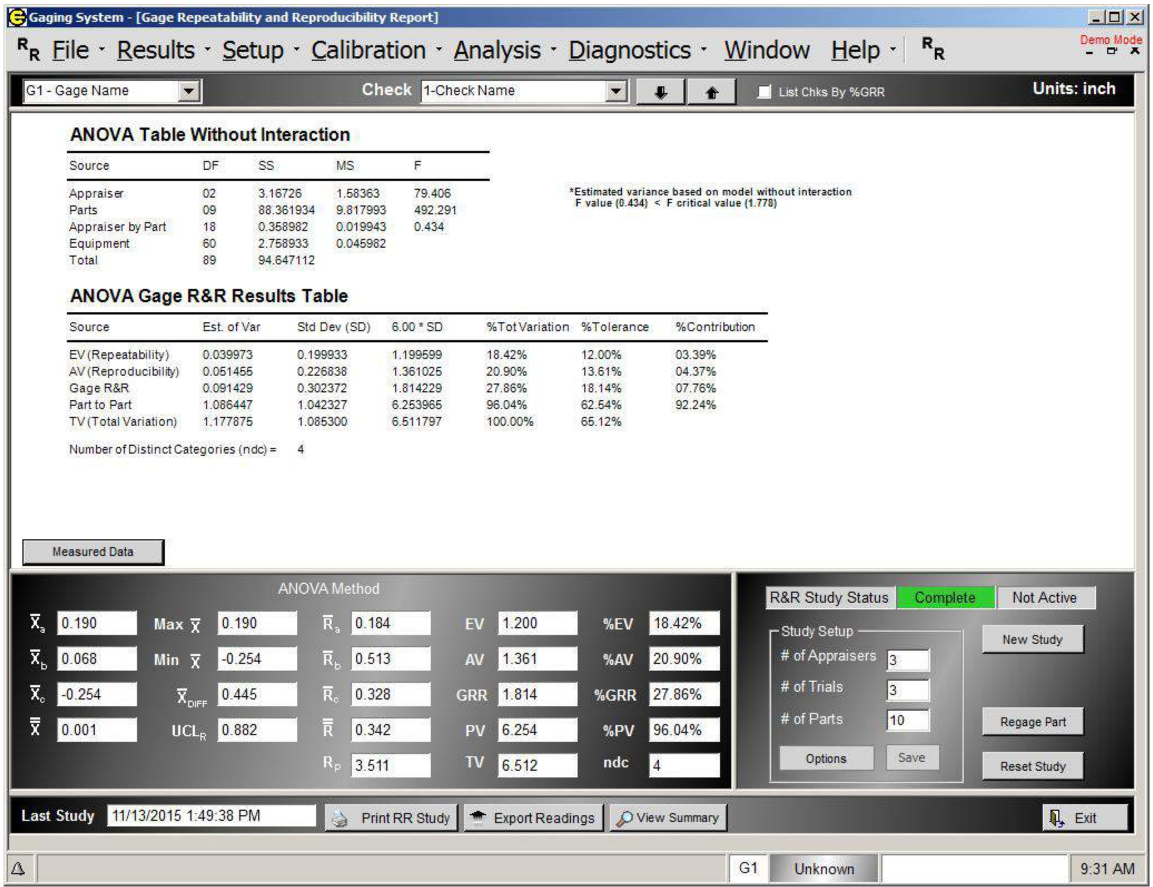
Study Results



EV - Equipment Variation (Gage Repeatablity)
AV - Appraiser Variation (Gage Reproducibility)
GRR - Gage Repeatablity and Reproduciblity
PV - Part Variation
TV - Total Variation (GRR and Part Variation)
%EV - Equipment Variation as percentage of Total Variation or Total Tolerance
%AV - Appraiser Variation as percentage of Total Variation or Total Tolerance
%GRR - Gage Repeatablity and Reproduciblity as percentage of Total Variation or Total Tolerance
ndc - number of distinct data categories

See Appendix D for calculations:

Study Result - ANOVA Study



Source	DF	SS	MS	F
Appraiser	02	3.16726	1.58363	79.406
Parts	09	88.361934	9.817993	492.291
Appraiser by Part	18	0.358982	0.019943	0.434
Equipment	60	2.758933	0.045982	
Total	89	94.647112		

Source	Est. of Var	Std Dev (SD)	6.00 * SD	%Tot Variation	%Tolerance	%Contribution
EV (Repeatability)	0.039973	0.199933	1.199599	18.42%	12.00%	03.39%
AV (Reproducibility)	0.051456	0.226838	1.361025	20.90%	13.61%	04.37%
Gage R&R	0.091429	0.302372	1.814229	27.86%	18.14%	07.76%
Part to Part	1.086447	1.042327	6.253965	96.04%	62.54%	92.24%
TV (Total Variation)	1.177875	1.085300	6.511797	100.00%	65.12%	

$\bar{X}_a$	0.190	Max $\bar{X}$	0.190	$\bar{R}_a$	0.184	EV	1.200	%EV	18.42%
$\bar{X}_b$	0.068	Min $\bar{X}$	-0.254	$\bar{R}_b$	0.513	AV	1.361	%AV	20.90%
$\bar{X}_c$	-0.254	$\bar{X}_{DIFF}$	0.445	$\bar{R}_c$	0.328	GRR	1.814	%GRR	27.86%
$\bar{\bar{X}}$	0.001	UCL_R	0.882	$\bar{\bar{R}}$	0.342	PV	6.254	%PV	96.04%
				R_p	3.511	TV	6.512	ndc	4

The *ANOVA Table*

- *Source* column is the cause of variation.
- *DF* column is the *degree of freedom* associated with the source
- *SS* (sum of squares) column is the deviation around the mean of the source.
- *MS* (mean square) column is the sum of squares divided by degrees of freedom.
- *F* (ratio) column is calculated to determine the statistical significance of the source value.

The Gage R&R Results Table

This table shows the calculated variance of the ANOVA study for the system. The variance is expressed in terms of standard deviation for easy of interpretation. In the above example the measure of spread is given in 6 times the standard deviation (6 * SD). The table shows the 6σ spread for a measure of repeatability (EV) and measure of reproducibility (AV). If the interaction of part and appraiser is significant then and estimate of its variance component is given. In the example above the interaction of part an appraiser was not significant so variance is “without interaction”. The variation expressed as a percentage of total variation and percentage of tolerance are given in columns 4 and 5. The % Contribution is given is column 6. If you are looking at the *%Contribution* , the corresponding standards are:

· Less than 1% - the measurement system is acceptable.

· Between 1% and 9% - the measurement system is acceptable depending on the application, the cost of the measuring device, cost of repair, or other factors.

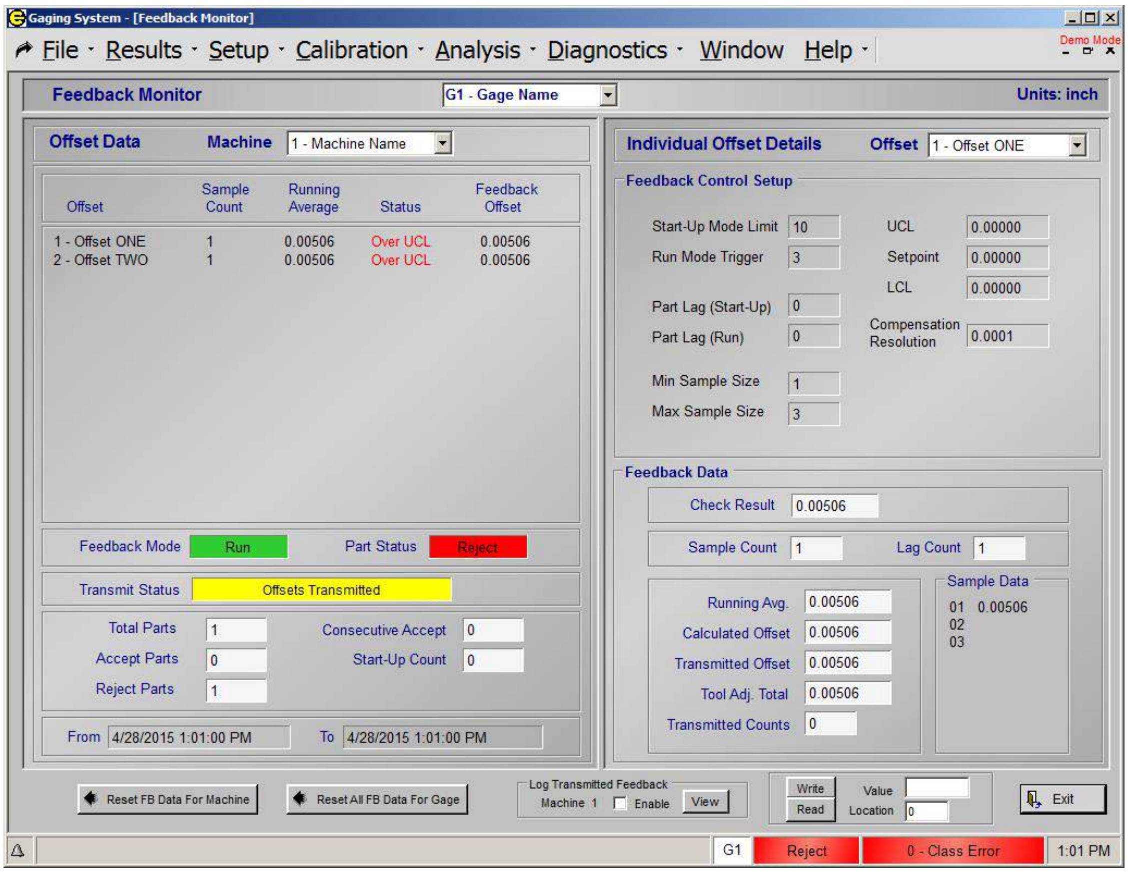
See Appendix D for calculations:

3.3.7. Feedback Monitor

Feedback Monitor

The Feedback monitor menu allows the operator to view the compensation amounts and rates for the process.

See also *Section 4 Feedback Setup and Operation*



3.3.7.1. Offset Data

Offset – The name of the current offsets.
Sample Count – The number of samples used to calculate the offset.
Running Average – The running average of the offsets.
Status – The status
Feedback Offset – Amount of offset applied to the last part.
Feedback Mode – The current mode of feedback (Run or Start-Up)
Part Status – The status of the last part gaged.
Total Parts – Total number of parts gaged since last reset of feedback data
Accept Parts -Total number of Accept parts gaged since last reset of feedback data
Reject Parts -Total number of Reject parts gaged since last reset of feedback data
Consecutive Accept - The number of consecutive Accept parts gaged since last reset of feedback data
Start-Up Count – The number of parts used in the Start-Up mode.
Time Stamp – The From and To time of the current feedback data
Reset – Resets Feedback data for either Gage or Machine

3.3.7.2. Individual Offset Details

The Feedback control set-up and data for each individual offset can be viewed here. The offsets can be selected using the pull-down menu.

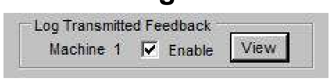
3.3.7.3. Feedback Control Setup

The Feedback Control Setup is taken from the Feedback Setup menu and is for display only.

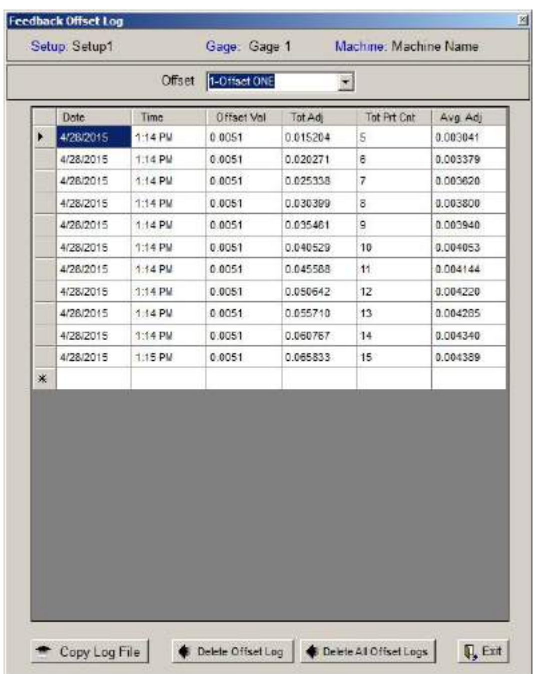
3.3.7.4. Feedback Data

Check Result – The last measured result for the Check associated with the offset
Sample Count – The current number of samples.
Lag Count – The current number of lag parts.
Running Average – The running average of the sample data.
Calculated Offset – (Running Average – Set Point)*(Comp Rate) This is calculated when the Running Average violates the Control Limits for the check.
Transmitted Offset – The calculated Feedback Offset to be transmitted if the Tooling Adjust Limits are not exceeded.
Tool Adjustment Total – The total of the tooling adjustments since the last feedback reset.
Transmitted Counts – The number of counts transmitted thru the binary coded messages via the parallel I/O.
Sample Data - The values used to compute the Running Average.

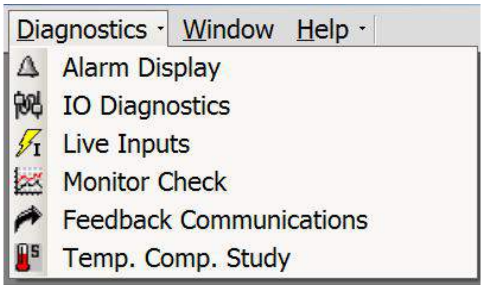
3.3.7.5. Log Transmitted Feedback



If enabled, Transmitted Offset Data will be logged. The offset data will be written to a comma delimited text file that can be viewed or copied (see figure below).

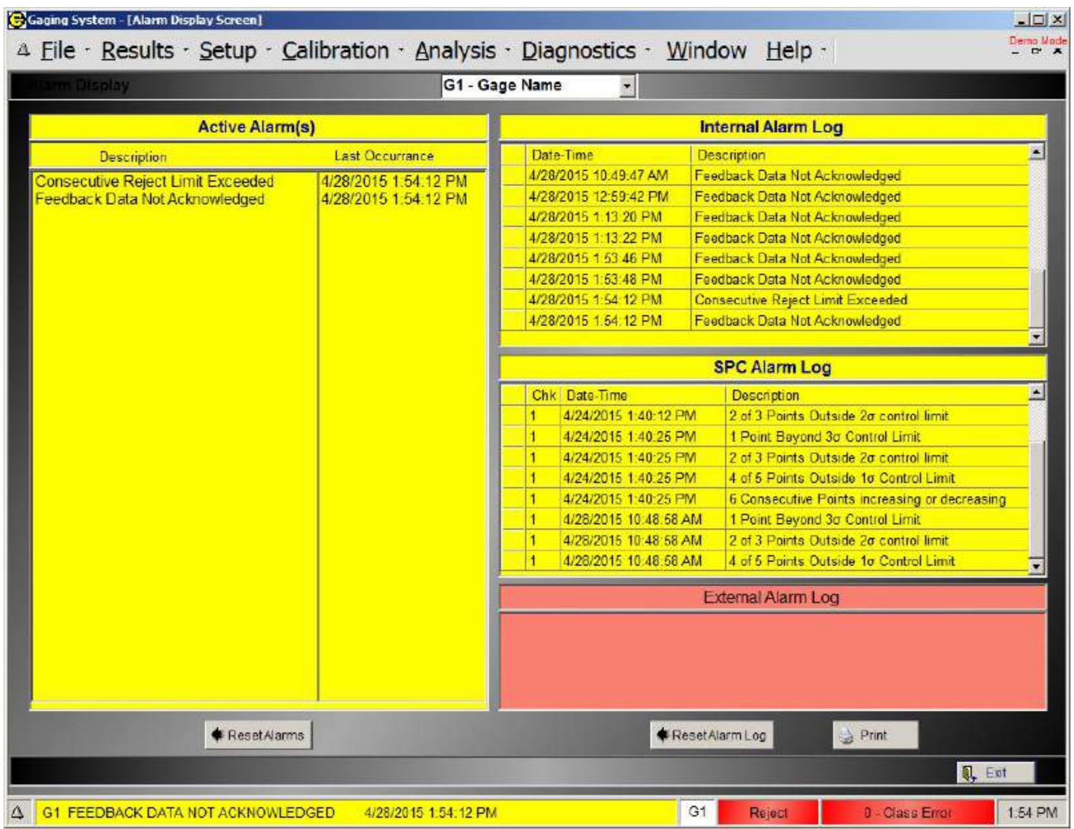


3.4. Diagnostics



3.4.1. Alarm Display

Alarm Display screen displays a log of system alarms with the date and time the alarm occurred.



Active Alarm(s) - alarms that are currently active and have not been acknowledged.
Internal Alarm Log - a log of the last 25 internal alarms that were triggered. Internal alarms are alarms triggered from the EPIC CAG™ system as opposed to alarm triggered from an external connected controller (PLC).
SPC Alarm Log - a log of the last 25 SPC Alarms (Process Stability Alarms) that were triggered.
External Alarm Log - a log of the last 25 external alarms that were triggered. External alarms are received from external machine control such as controlling PLC.

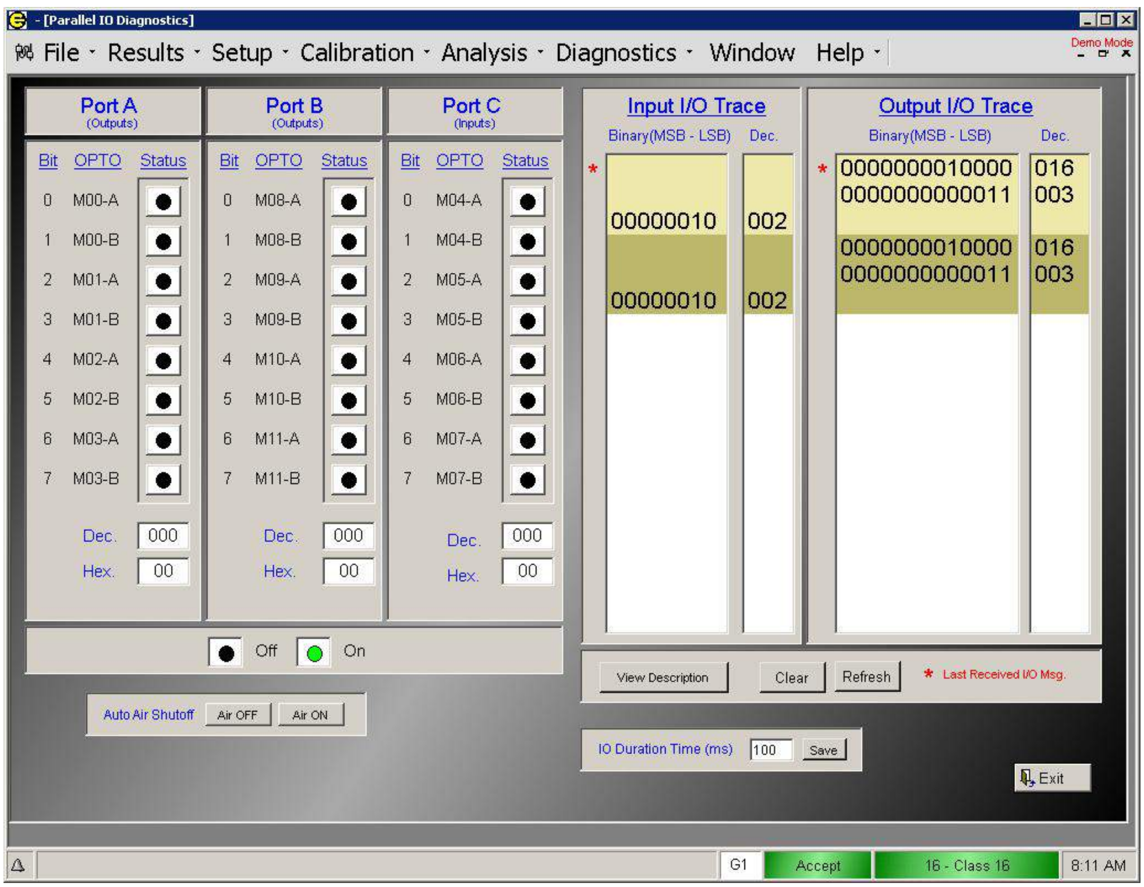
3.4.2. IO Diagnostics

The IO Diagnostics screen is used to view the communication between the EPIC CAG™ system and the external controller (PLC). The IO Diagnostics screen that will be displayed will depend on the type of communication configured for the system. There are two standard interfaces for communication between external controller and the EPIC CAG™ system, Parallel IO and EtherNet/IP. The two types of interfaces are explained in detail in *Section 3.1* and *Section 3.2*.

3.4.2.1. Parallel IO Communications

See *Section 3.1 Parallel IO Communications* for more details.

The IO Diagnostic screen used for Parallel IO Communication is display below. It pictorially displays the three ports of digital IO (Port A, Port B, Port C).

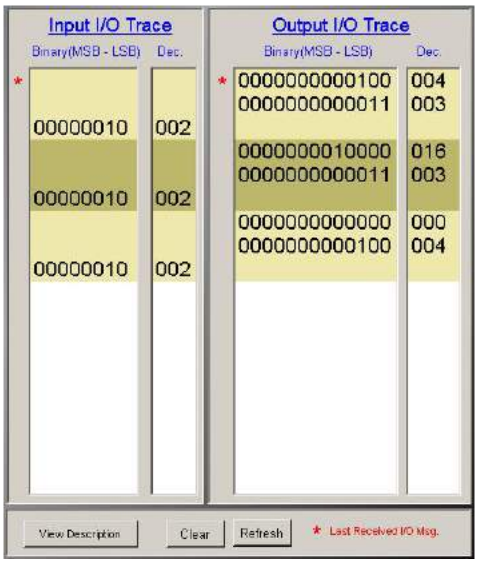


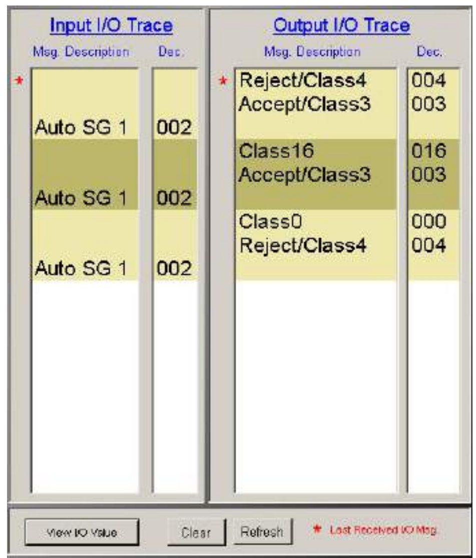
<u>**Outputs – Ports A & B**</u>
Bit - the bit number on the output port.
OPTO - the location/label of the output on the opto board (optically isolated relay board).
Status - a green dot indicates that the output is ON and a black dot indicates that the output is OFF. Click on the status button to force the output ON.

<u>Inputs – Port C</u>
Bit - the bit number on the output port.
OPTO - the location/label of the output on the opto board.
Status - a green dot indicates that the input is ON and a black dot indicates that the input is OFF.

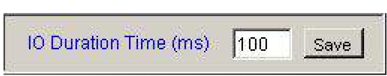
<u>Input I/O Trace</u>
The Input I/O Trace displays the last 15 messages received in the Input buffer. The display shows the message in binary that can be used to see what individual input is on/off easily. It also shows the message in decimal. If the *Description* button is pressed, a brief description of the message will be displayed.

<u>Output I/O Trace</u>
The Input I/O Trace displays the last 18 messages transmitted in the input/output buffers. The display shows the message in binary that can be used to see what individual input is on/off easily. It also shows the message in decimal. The input and output messages are grouped by color. Each group of messages having the same background color represents on gaging cycle. If the ***View Description*** button is pressed, the description of the message will be displayed.





<u>IO Duration Time</u>
Allows the operator to program the length, in milliseconds, of the I/O message as sent by the EPIC system to the PLC. For example, if the IO Duration Time is set for 100, the output lines used for the message will be held ON for a duration of 100 milliseconds then turned OFF.



<u>Auto Air Shutoff (Optional)</u>
The Air Off and Air ON buttons provide means of testing the Auto Air function. When the Air ON button is pressed the output used for controlling the air will be turned ON. The output(s) used to controlling the auto air shutoff are programmed in the Check Setup screen.

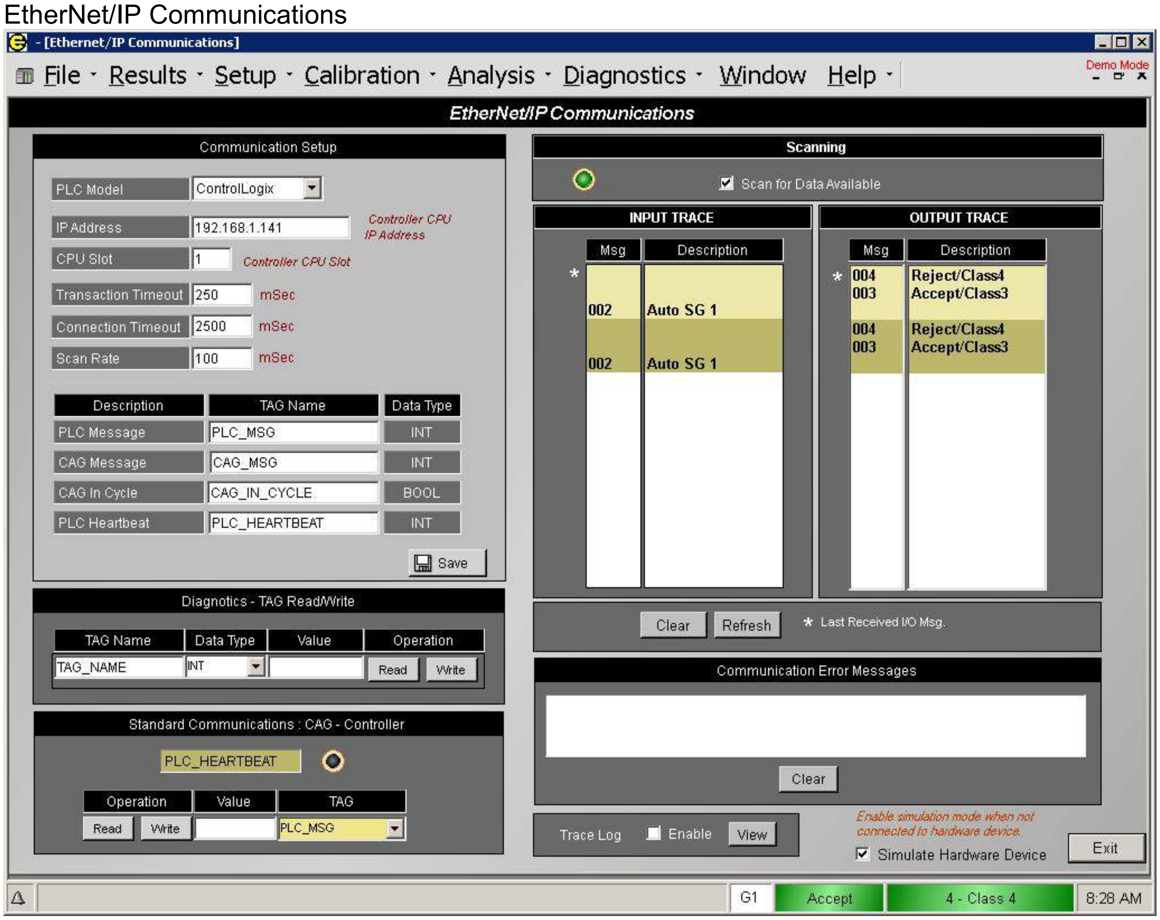
3.4.2.2. EtherNet/IP Communications

Communication between EPIC CAG™ system and Allen Bradley ControlLogix Controllers is achieved using EtherNet/IP (Industrial Protocol). Control commands and status are passed between the EPIC CAG™ and AB Controller (PLC) by means of reading and writing messages to predefined memory locations (TAGS) residing on the AB Controller.

See *Section 3.2 EtherNet/IP Communications.*

The IO Diagnostic screen used for EtherNet/IP Communication is display below.

EtherNet/IP Communications



<u>Communication Setup</u>

IP Address - address of the controller CPU.

CPU Slot - controller CPU slot

Transaction Timeout - Transaction Timeout occur when a query is sent but no reply is received within the number of milliseconds specified by the Timeout Transaction setting.

Connection Timeout - Connection Timeout occur when system tries to connect to the controller but can not within the number of milliseconds specified by the Connection Timeout setting.

Scan Rate - the amount of time in milliseconds between each query for new data.

Diagnostics - TAG Read/Write

Read - To read a TAG value from the controller, enter TAG name and Data Type and select Read button. The value will be displayed in the Value textbox. A value returned of "9999" indicates an error has occurred and the TAG could not be read.

Write- To write to a TAG on the controller, enter TAG name,Data Type and the value to write then elect the Write button. If the value can not be written a error message will appear.

Standard Communications: CAG - Controller

PLC_HEARTBEAT - The PLC Heartbeat is used to verify communication between CAG™ and PLC. The LED will switch between GREEN and RED when communication is working correctly.

Display the value of communication Tags

TAG	Value	Description
PLC_MSG		PLC to CAG - Message
CAG_MSG		CAG to PLC - Message
CAG_IN_CYCLE		CAG to PLC - Message

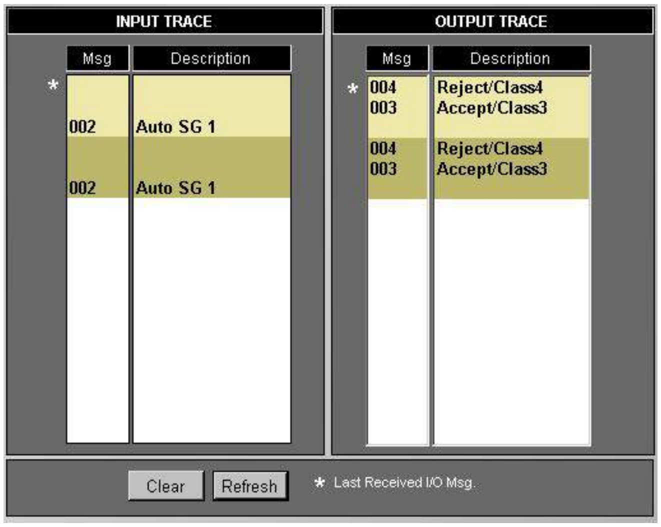
Read/Write to the predefined communication Tags

Operation		Value	TAG
Read	Write		PLC_MSG

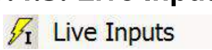
Scanning

Scan for Data Available: Scanning must be enabled to receive new data (messages) from the controller. If the LED is Green the system is Scanning and operating correctly. If the LED is Red the system is not scanning.
Scan for Setup Load: Scanning must be enabled to receive Load Setup ID message from the controller. If scanning is enabled the "PLC_LOAD_SETUP_ID" Tag containing Setup ID will be read from the Machine controller. The Setup corresponding to the read Setup ID will be loaded automatically. (See System Setup screen for more details).

INPUT & OUTPU TRACE
The Input/Ouput Traces displays the last 18 messages received. The displays show the message number and description.



3.4.3. Live Inputs

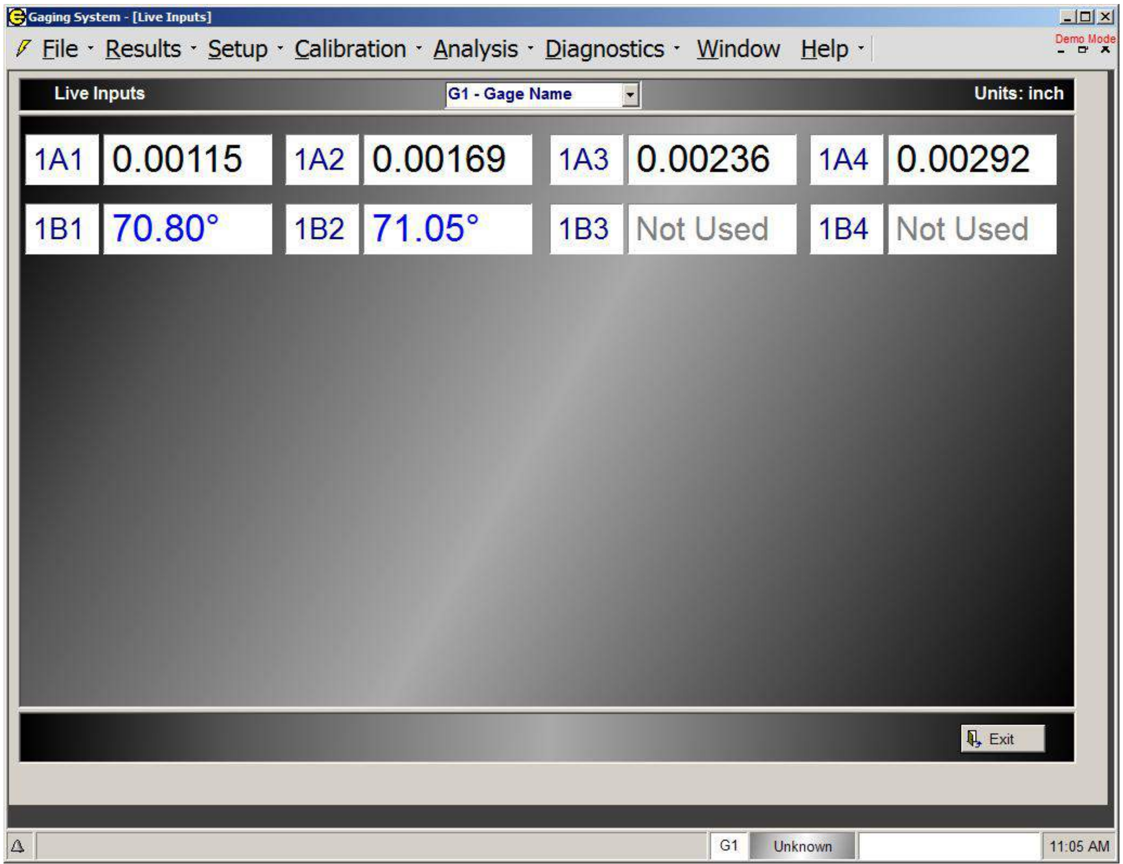


This screen displays live readings of all active Inputs. An active Inputs is an input that is used in a defined Check formula or assigned to a temperature compensation probe set.

Reading = Input Value * Polarity/Mag * Balancing Mag + Input Offset

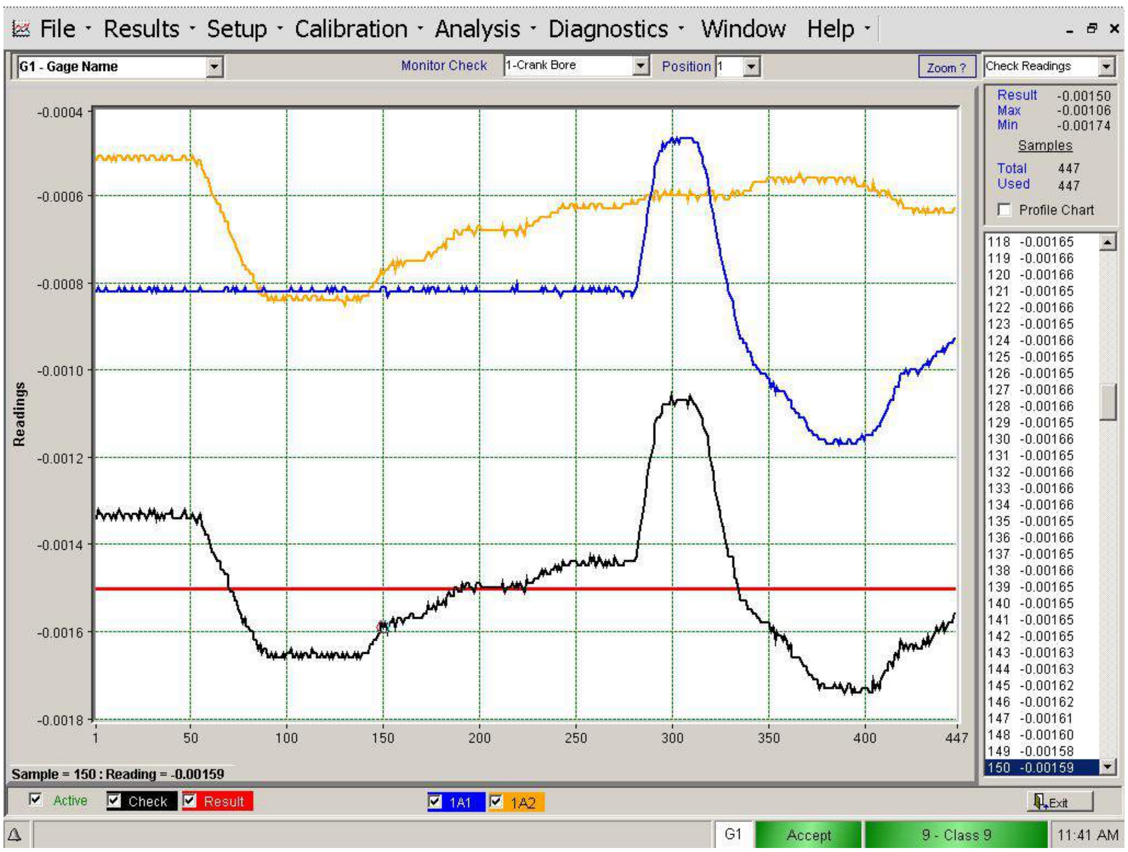
Reading = 1A1, 1A2, 1A3, etc…
Input Value = LVDT or Air/Electronic (A/E) Input reading
Polarity/Mag = Defined in Inputs Setup screen.
Balancing Mag = Defined in Inputs Setup screen and Input Balancing screen
Input Offset = Defined in Inputs Setup Screen.

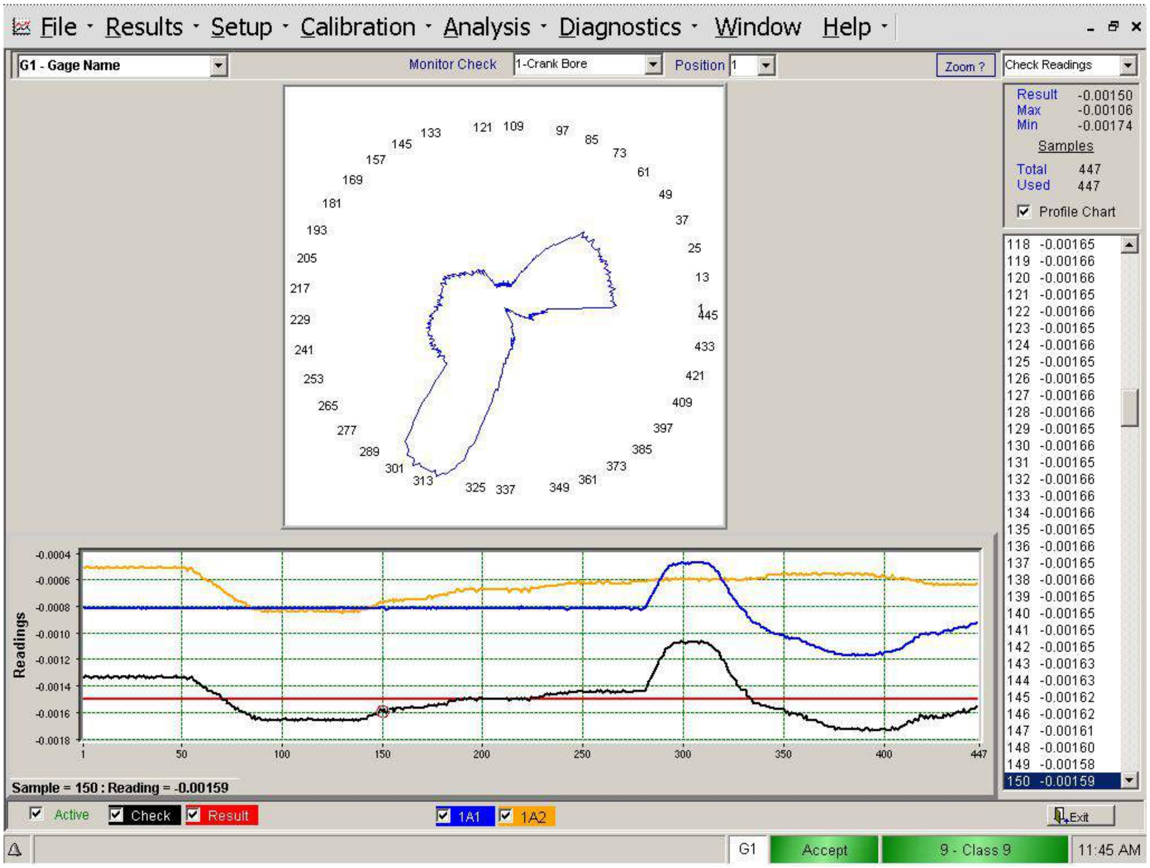
Gage Selection - Use the pull down menu at the top center of the screen to select the gage . All inputs programmed in the Checks for the selected gage will be displayed.


Gaging System - [Live Inputs]
File · Results · Setup · Calibration · Analysis · Diagnostics · Window Help ·
Demo Mode
Live Inputs
G1 - Gage Name
Units: inch
1A1 0.00115
1A2 0.00169
1A3 0.00236
1A4 0.00292
1B1 70.80°
1B2 71.05°
1B3 Not Used
1B4 Not Used
Exit
G1
Unknown
11:05 AM

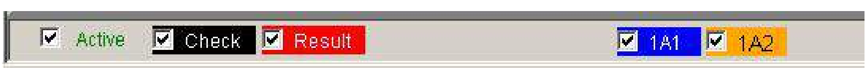
3.4.4. Monitor Check

This display contains specific information on the readings used to calculate a Check. It includes a chart of all readings taken for the individual inputs that make up the Check as well as the Check result. In also includes information on the total number of readings taken, the number of readings passing cutout and rotation tests, and the number of saturated readings. The High and Low readings are displayed as well as the Max and Min queue entries. Only one Check may be monitored at a time.





Gage Selection - Use the pull down menu in the upper left corner of the screen to select a gage.
Monitor Check - Use the pull down menus in the upper center section of the screen to select a Check from the current gage and a position of the selected Check to monitor.



Active - Select this box to activate Check monitoring for the selected Check. If the Active box is selected and any or all of the Check, Result, or Input boxes are checked then data will be recorded for the selected items when the current Check is gaged.

Check - All readings associated with the selected Check will be listed. To record the readings from a Check activate the “Check” box and select “Active”. The next time a start gage command is initiated the readings from the Check will be displayed in the corresponding color.
Result- The result of the Check selected will be shown as a horizontal red line on the chart.

Inputs- All readings associated with the selected input will be listed. To record the readings from an input activate the input box and select “Active. The next time a start gage command is initiated the raw readings from the input will be displayed in the corresponding color.

Profile Chart - The Profile Chart option can be displayed by checking the Profile Chart box. This chart is useful in setting up a type of roundness check or cut-out detection.

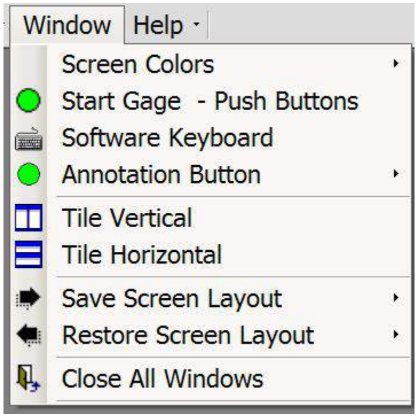
The number of readings taken is shown on the outside of the chart and the shape of the chart gives an indication of part geometry.

3.4.5. Feedback Communications (Optional)

Feedback Communications

See *Section 5.1 Focus2 Feedback*

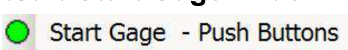
3.5. Window



3.5.1. Screen Colors

Choose background screen color. There is a choice between black or blue background color.

3.5.2. Start Gage - Push Buttons

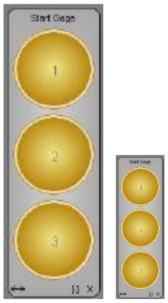


Selecting the “Start Gage – Push Buttons” option will create a “Start Gage” button that will display on all screens. A “Start Gage” signal is sent to the system if this button is pushed. This enables the operator to initiate a gage cycle from any displayed screen. To remove the “Start Gage” icon, click the “X” in the lower right hand corner of the icon. The Start Gage button can be moved to desired location on the screen by click-hold and drag with a mouse.

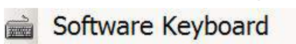
Multiple Start Gage Buttons - a Start Gage button will be displayed for each Gage that is setup in the system. The Start Gage buttons will be labeled with the Gage number in the center of the button. To change the orientation of the buttons from vertical to horizontal select the **<-->** symbol. To display only one Start Gage button with the option to select the Gage from a drop-down box, select the **[-]** symbol. Selecting the **[+]** will display all the Start Gage buttons.

Resize Start Gage Button

The Start Gage button(s) can be resize by placing the cursor on the edge of the button frame where the cursor changes to to the resize icon and holding down the right mouse button and dragging to the desired size.



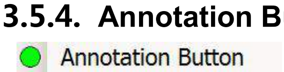
3.5.3. Software Keyboard



Selecting this option will bring up Windows Software Keyboard. To enter data, place cursor in the field to be edited and select the keys on Software Keyboard.

NOTE: An embedded Keypad can be activated and used to enter data in any field in the EPIC application by simply double clicking the field that needs editing. The embedded Keypad can also be activated when using a touch-screen by pressing twice on the field.

3.5.4. Annotation Button (Optional)



When the Annotation Option is installed as part of the EPIC system an "Annotation Button" can be displayed on the screen by selecting "Enable" under this menu option. See *Section 2* for more information on Annotation.

3.5.5. Tile Vertical

The Tile feature for displaying multiple screens is available **only** when the "**Multiple Screens**" option is selected in the System Setup Menu.

Tile Vertical : The multiple screens selected will be displayed top to bottom.

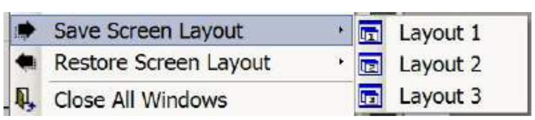
3.5.6. Tile Horizontal

The Tile feature for displaying multiple screens is available **only** when the "**Multiple Screens**" option is selected in the System Setup Menu.

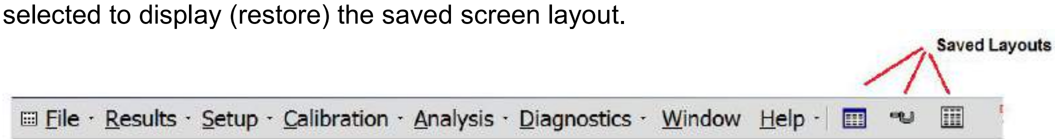
Tile Horizontal : The multiple screens selected will be displayed left to right.

3.5.7. Save Screen Layout

The system allows the operator the ability to save 3 screen layouts for fast retrieving. To save a screen layout open the screen(s) to be saved. Click on "Window" in the Menu bar and select "Save Screen Layout". Click on one of the 3 options listed and that screen will be saved under that Layout number.



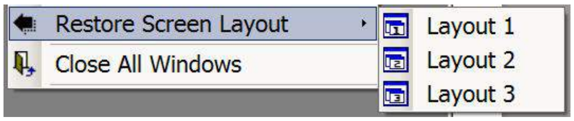
When a screen layout is saved, an icon will be displayed on the Main screen menu bar. This icon can be selected to display (restore) the saved screen layout.



To remove (clear) a saved Screen Layout close all screens and "Save Screen Layout" to the Layout number to be removed.

3.5.8. Restore Screen Layout

The selected Layout (1,2,3) will be restored (displayed).



3.5.9. Close All Windows

All open Windows (screens) will be closed

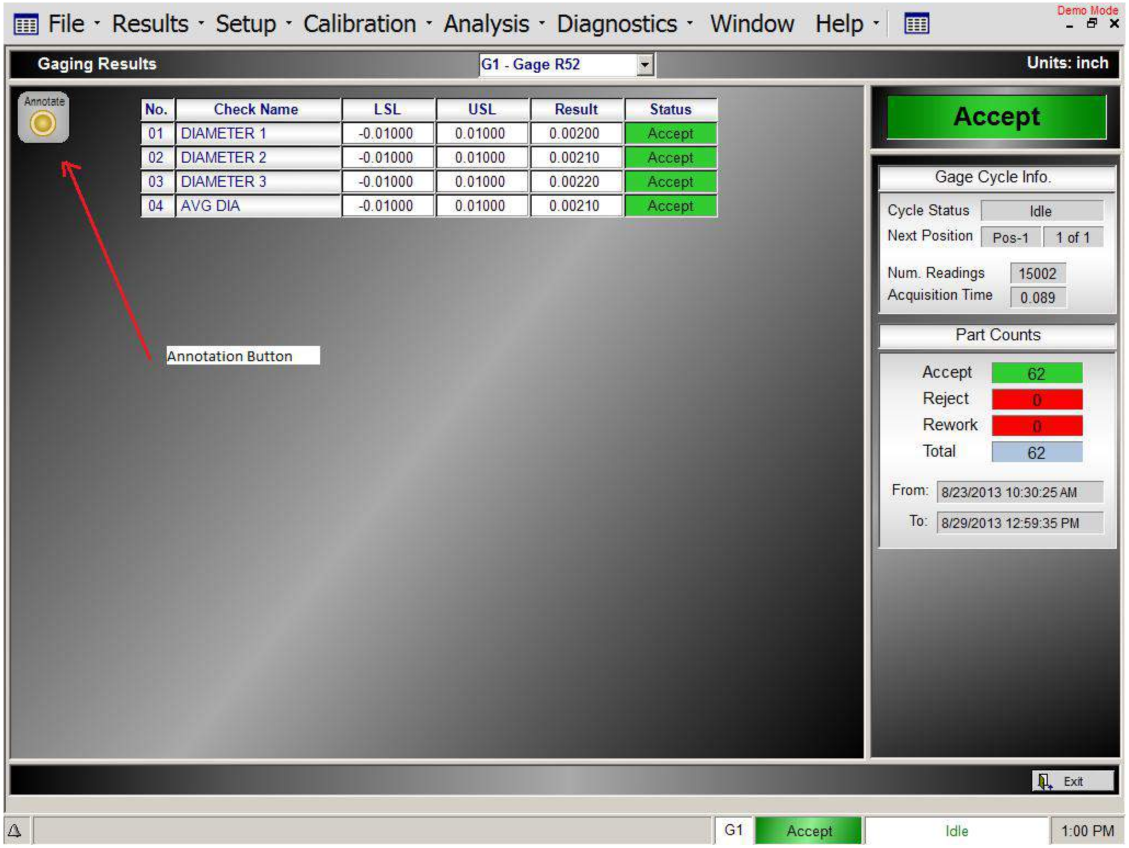
4. SECTION: Annotation - Gage Data Records

The Annotation Option of the EPIC software provides the ability for the user to assign an explanatory note to a measurement part record stored in the Gage Data File (GDF). Annotations are useful for identifying special point in the GDF, such as new operator, excessive tooling wear, or a change of material. The user has the ability to enter predefined annotation notes that can be selected at time of annotation or enter the annotation directly.

4.1. Annotation Button (Figure 1, Figure 2)

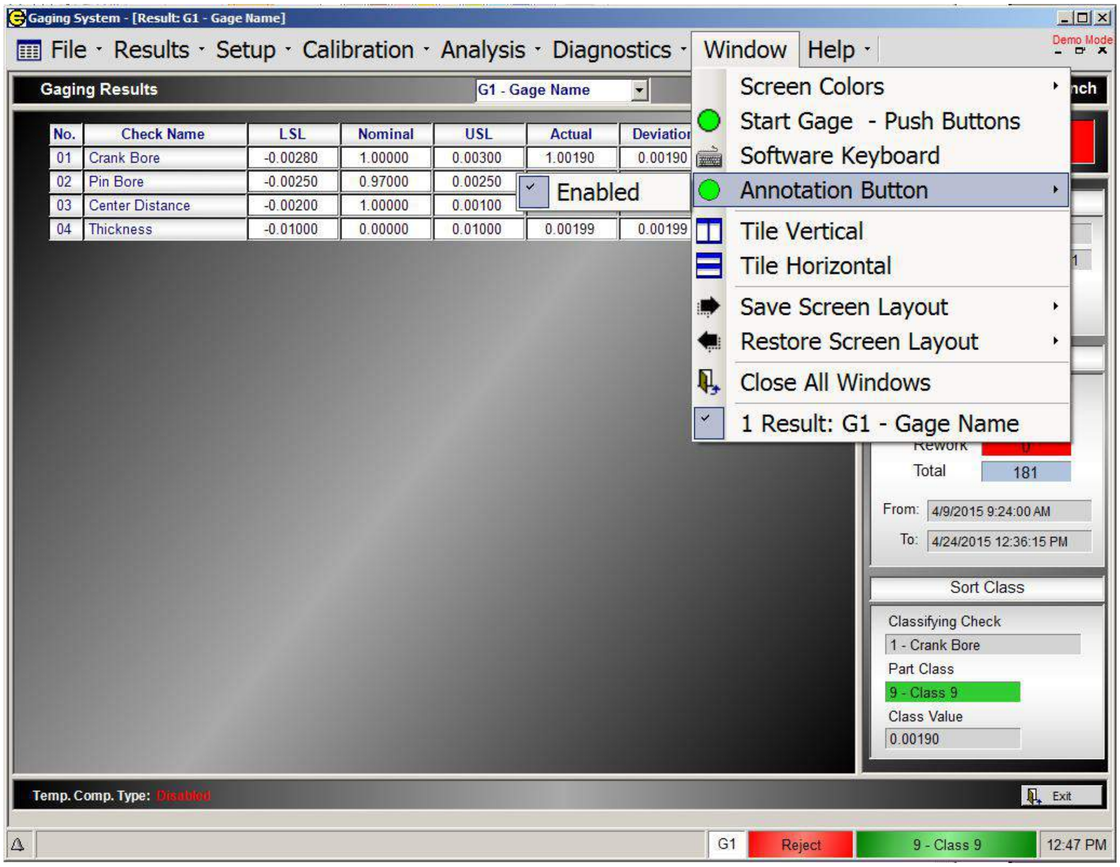
When the Annotation Option is installed as part of the EPIC CAG system an “Annotation Button” will be displayed on the screen. This button can be moved around the screen giving the user the ability to place it at a convenient location. The Annotation Button can be disabled (not displayed) in the “Window – Annotate Button” menu (see Figure 2). Pressing the Annotation Button will bring up the Annotation Screen. The Annotation Screen allows the user to assign annotation to the last part record stored in the gage data file.

FIGURE 1.



File · Results · Setup · Calibration · Analysis · Diagnostics · Window Help ·
Demo Mode
Gaging Results
G1 - Gage R52
Units: inch
Annotate
No. | Check Name | LSL | USL | Result | Status
01 | DIAMETER 1 | -0.01000 | 0.01000 | 0.00200 | Accept
02 | DIAMETER 2 | -0.01000 | 0.01000 | 0.00210 | Accept
03 | DIAMETER 3 | -0.01000 | 0.01000 | 0.00220 | Accept
04 | AVG DIA | -0.01000 | 0.01000 | 0.00210 | Accept
Annotation Button
Accept
Gage Cycle Info.
Cycle Status Idle
Next Position Pos-1 1 of 1
Num. Readings 15002
Acquisition Time 0.089
Part Counts
Accept 62
Reject 0
Rework 0
Total 62
From: 8/23/2013 10:30:25 AM
To: 8/29/2013 12:59:35 PM
Exit
G1 Accept Idle 1:00 PM

FIGURE 2.

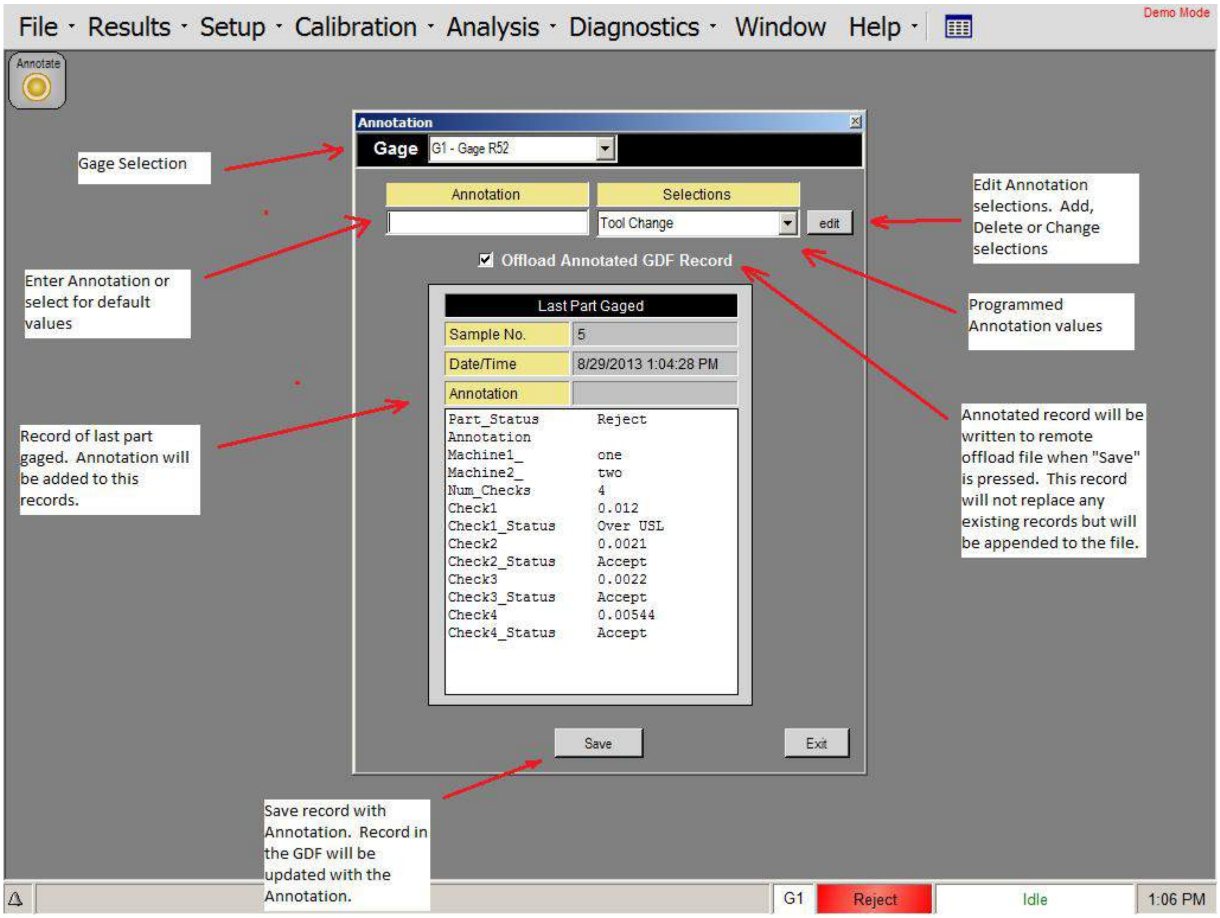


Gaging System - [Result: G1 - Gage Name]
File Results Setup Calibration Analysis Diagnostics Window Help
Demo Mode
Gaging Results
G1 - Gage Name
No. Check Name LSL Nominal USL Actual Deviation
01 Crank Bore -0.00280 1.00000 0.00300 1.00190 0.00190
02 Pin Bore -0.00250 0.97000 0.00250
03 Center Distance -0.00200 1.00000 0.00100
04 Thickness -0.01000 0.00000 0.01000 0.00199 0.00199
Enabled
Screen Colors
Start Gage - Push Buttons
Software Keyboard
Annotation Button
Tile Vertical
Tile Horizontal
Save Screen Layout
Restore Screen Layout
Close All Windows
1 Result: G1 - Gage Name
Total 181
From: 4/9/2015 9:24:00 AM
To: 4/24/2015 12:36:15 PM
Sort Class
Classifying Check
1 - Crank Bore
Part Class
9 - Class 9
Class Value
0.00190
Temp. Comp. Type: Disabled
Exit
G1 Reject 9 - Class 9 12:47 PM

4.2. Annotation Screen (Figure 3)

The Annotation Screen is displayed when the Annotation Button is pressed. The screen will display the last part gauged (last record stored in the gage data file). The "Gage" drop down box can be used to select the last part gauged for a different Gage. The user can enter the annotation note by typing in the Annotation input box or by double clicking on the input box and using the on screen keyboard. The annotation note can be a maximum of 15 characters. The user also has the option to select the annotation note from the Selections drop down box containing preprogrammed annotation notes. Once the annotation note is entered, the SAVE button must be pressed for the annotation to be written to the gage data file. If the EPIC system is setup to offload the part measurement record to a network file or remove device file, the "Offload Annotated GDF Record" checkbox will be displayed on the Annotation Screen. If the "Offload Annotated GDF Record" checkbox is selected (checked), the annotated record will be offloaded (re-transmitted) when the SAVE button is pressed. Note: this may result in the offload file containing duplicate measurement records, one with annotation and one without. The duplicate records will contain the same date-time stamp.

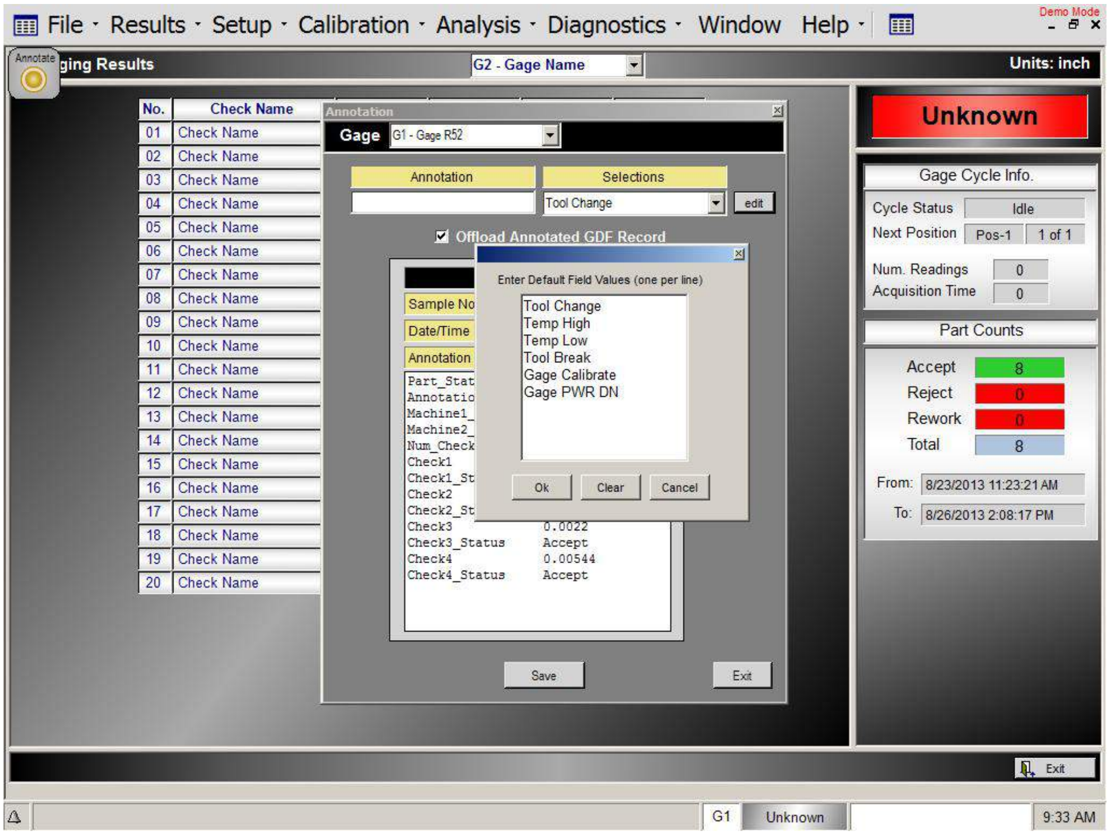
FIGURE 3.



Entering Predefined Annotation Notes (Figure 4)

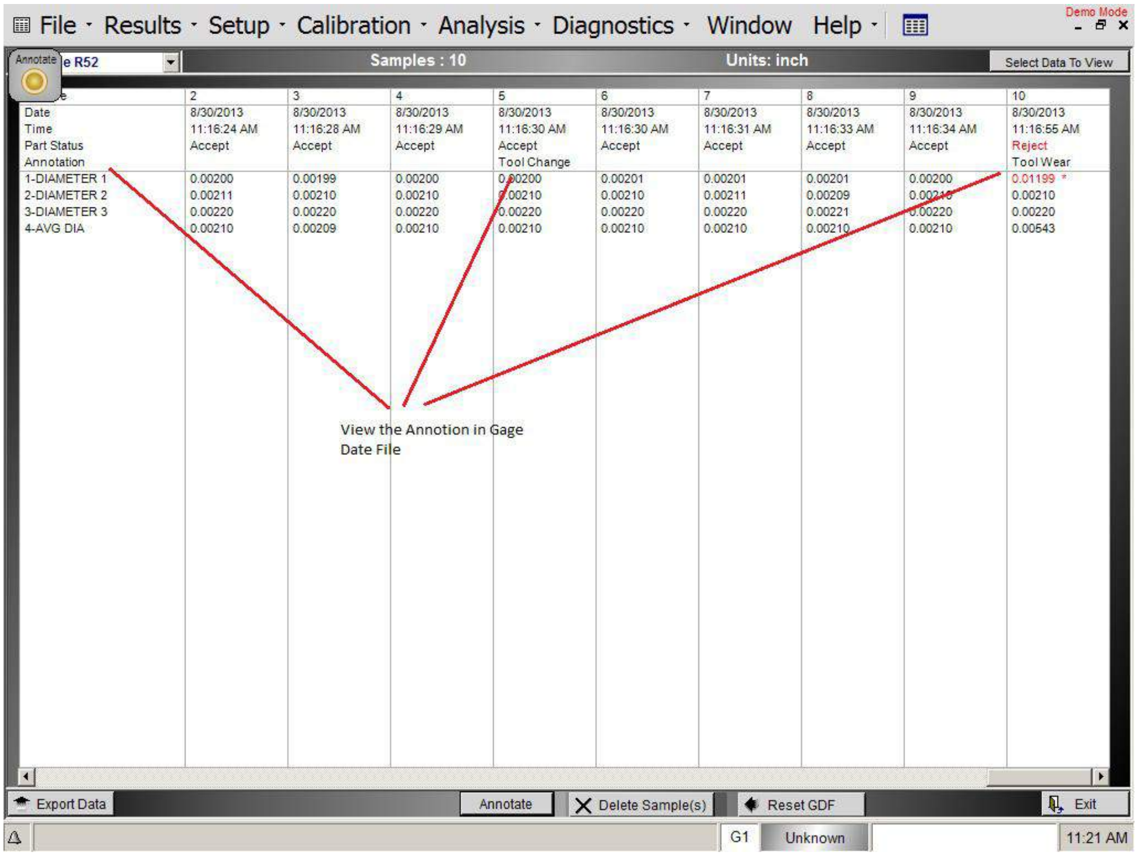
To enter predefined Annotation notes the user would select the “edit” button on the Annotation Screen. An input box screen will appear and user would proceed to enter the Annotation notes. The Annotation notes can be a maximum of 15 characters.

FIGURE 4.



4.3. Viewing Annotation in the Gage Data File (Figure 5)

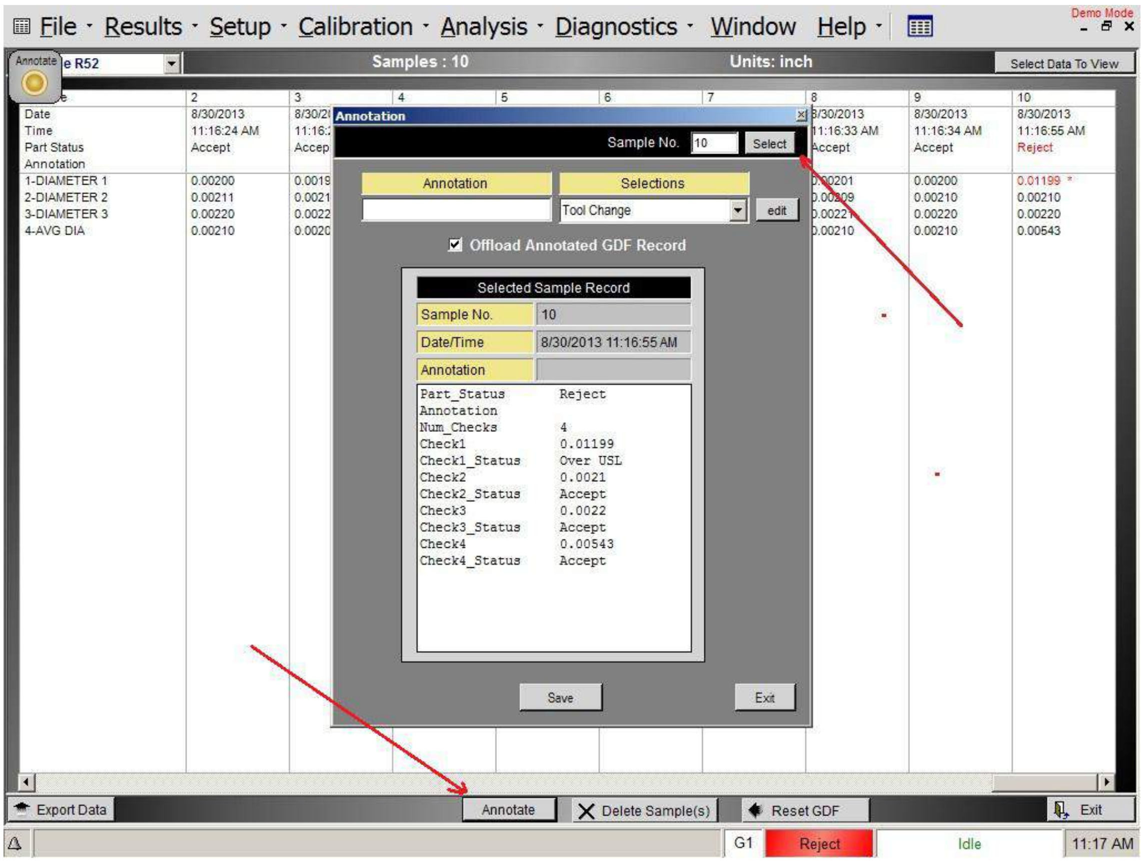
FIGURE 5.



4.4. Adding Annotation to Previous Measurement Records (Figure 6)

The user can Annotate previous measurement records in the Gage Data File by selecting the “Annotate” button on the bottom of the Gage Data File Screen. When this button is selected, the Annotation screen will be displayed with an option to enter a “Sample No.”. The user can enter a record sample number and hit the “Select” button to load that sample record in the Annotation screen. Annotation can then be entered and saved.

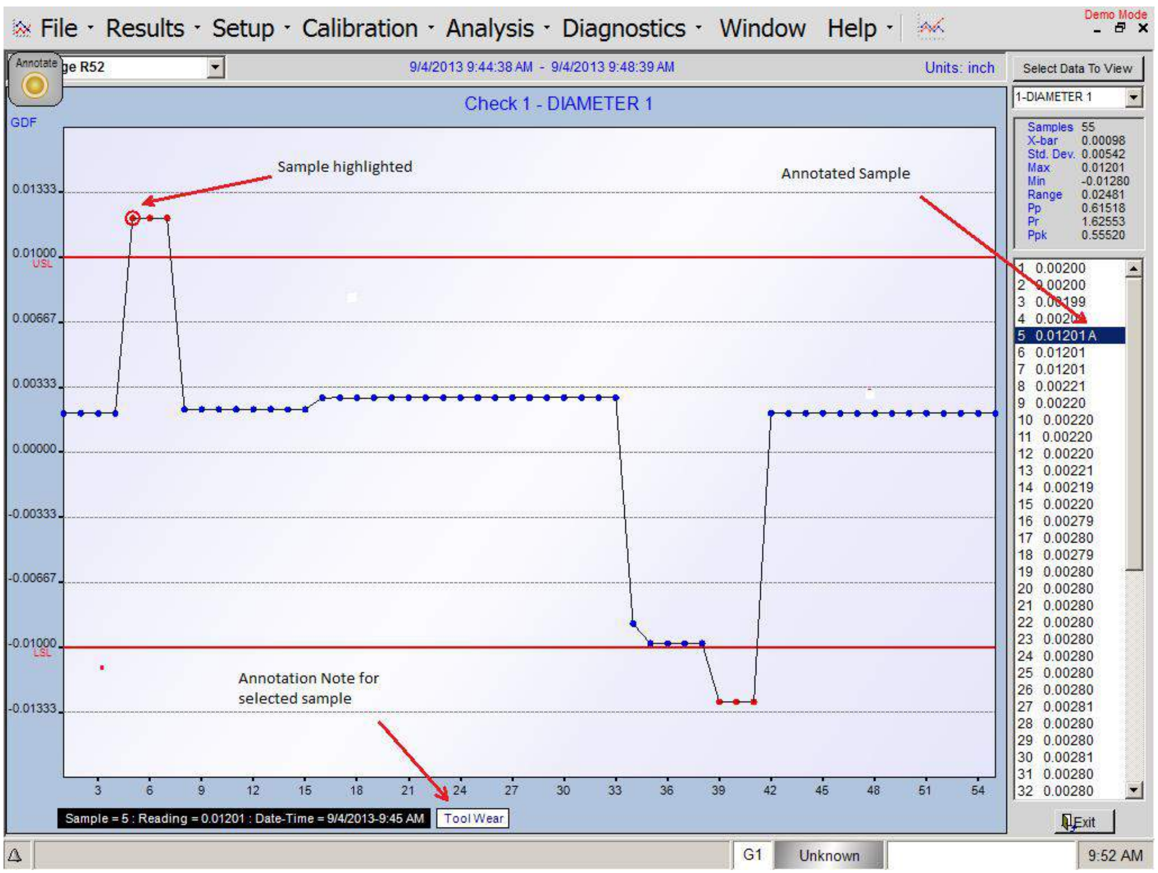
FIGURE 6.



4.5. Viewing Annotation in the Gage Data File Chart (Figure 7)

Measurement records containing a previously entered Annotation Note can be identified in the list of readings on the right side of the screen. Readings will be followed by the letter “A”, indicating that an Annotation Note has been entered for that record. To view the Annotation Note, the user can select the reading containing the Annotation (“A”) and the Annotation Note will be displayed on the bottom of the screen and the sample will be highlighted on the chart. Sample points on the chart can also be selected and the reading will be highlighted in the list of readings and if there is an Annotation Note associated with that record it will be displayed on the bottom of the screen.

FIGURE 7.



5. SECTION : EPIC CAG Communications

5.1. EPIC CAG Standard Parallel I/O Communications

Communications with the Edmunds EPIC CAG™ is accomplished via a discrete parallel interface. All parallel communication lines are optically isolated providing a versatile interface between a sensitive microprocessor system and a factory environment. Most applications dictate the use of 120 VAC opto I/O modules, but "DC" requirements are easily satisfied by direct replacement.

EPIC CAG™ communication is distinctly different depending on the CAG™ type, auto or manual. A manual CAG™ typically provides a 37-pin connection to be used in conjunction with the Edmunds external control push-button pack. The automatic CAG™ configuration implements an asynchronous protocol. The remainder of this section will exclusively discuss attributes of the automatic CAG™ protocol. ***See Section 3.1.4. CAG™ Wiring For Automatic Parallel IO Communication*s.

Note that information in this section only exemplifies the standard configuration and is subject to change where applicable. The protocol depicted here, however, will most likely be modeled. Refer to the Application Specific Setup section for inclusive details of all modifications.

As with any asynchronous communications, a protocol, or set of conventions governing the format and timing of the data transfer must apply. EPIC CAG™ utilizes a simple handshaking type protocol to enhance its interface compatibility. Communication is bi-directional, meaning both the EPIC CAG™ and the external device may initiate communication. For the most part, however, the EPIC CAG™ only responds to or acknowledges external requests.

First, a discussion of how a message or command is transferred between the CAG™ and an external device may be appropriate. An illustration that represents a standard configuration is given below:

EPIC CAG OUTPUTS	EPIC CAG INPUTS
5 data lines, bits 0-4	7 data lines, bits 0-6
1 data available line	1 interrupt line

In the event the direction of communication is not clear, the EPIC CAG™ inputs correspond with the external device's outputs. Note that 7 data lines for both the CAG™ and the external device only exemplifies a typical configuration and is subject to change where applicable.

The CAG™ input data lines provide the means to transfer information from an external device to the CAG™. The CAG™ input interrupt line will initiate a hardware interrupt. The CAG™ will handle this interrupt by reading the data lines and responding appropriately. In effect, the interrupt indicates to the CAG that a valid message or command is present on the data lines.
The CAG™ output data lines provide the means to transfer information from the CAG™ to an external device. The CAG™ output line, data available, will ensure the receiving device that the information on the data line is valid on a low to high transition.

The information transferred by the data lines is encoded as a binary representation. To state simply, each message has a unique code, or bit pattern.

Communication with the CAG™ may be initiated by writing the appropriate bit pattern on the data lines and asserting the interrupt. It is important to ensure that the data lines are electrically stable when the interrupt is asserted. The maximum pulse length of the interrupt is not a consideration since the CAG™ is triggered on the rising edge of the pulse. The user must only ensure the turn on and off time for the opto isolators are satisfied (typically 5 to 15 ms).

Similarly, the CAG™ communicates to an external device by writing the appropriate bit pattern on the data lines and asserting the data available line. The I/O Duration Time is programmable. If the CAG™ is required to send a series of messages, 1ms is the minimum time between data available pulses.

5.1.1. EPIC CAG™ Input Messages

Start Gage
The CAG™ performs the task of translating an electronic signal to a useful numeric representation. In doing so the CAG™ must sample the inputs (i.e. LVDTs) an appropriate number of times and execute an algorithm(s) to acquire a numeric result. This function is termed "GAGE" or "GAGING". For obvious reasons, the CAG™ must be informed when to initiate this function. Through parallel communication, the CAG™ can be instructed to begin this process. This command is termed "Start Gage". Two types of start gage messages are available, auto and manual. They both prompt the CAG™ to initiate the algorithms discussed above; however, distinct differences apply. A manual start gage requests the CAG™ to gage and that's all. With the manual start gage command, the CAG™ will acquire a numeric result for the sampled inputs and update the current part status, however the CAG™ will NOT update the SPC charts, counters, feedback, and so on.

The auto start gage message requests the CAG™ to gage and update all appropriate SPC charts, counters, feedback variables, and any or all other functions the CAG™ provides.

Since the CAG™ has the ability to access any gage setup on request, it is only appropriate that a start gage message, for both auto and manual, exist for each gage setup. Simply, for each gage setup there is a corresponding auto and manual start gage message. In response to a start gage message, the CAG™ will acknowledge with a part status message.

End Gage
It was defined in the discussion for the start gage command that the CAG™ samples the inputs an appropriate number of times, and then executes an algorithm(s) to attain a numeric result. This definition holds for many applications; however, it may be desirable to acquire input readings while the part is in motion. This dynamic process adds the flexibility of externally controlling at what time the CAG™ starts and stops collecting input readings. Until now, the discussion has focused on static gaging which only required a start gage indication. With dynamic gaging, an "End Gage" command is needed to instruct the CAG™ to end the current input sampling. The CAG™ can also be configured to end this process after a programmed time interval, in which case the end gage command is not necessary.

Auto Mastering (Calibration)
When a CAG™ is used in a full automation environment it can be instructed to initiate a mastering sequence by the PLC. The “Auto Mastering” command will put the CAG™ into Calibration Mode. When in Calibration Mode a start gage message will begin the mastering process as programmed in the “Check Setup” menu. The masters must be introduced to the gage in the correct sequence by the PLC controlled process.

Abort Mastering (Calibration)
If a situation arises where the PLC detects an unfavorable condition an “Abort Mastering” message can be sent to the CAG™ to stop the mastering process.

Auto Verification (Optional)
When a CAG™ is used in a full automation environment it can be instructed to initiate a verification cycle by the PLC. The “Auto Verification” command will put the CAG™ into Verification Mode. When in Verification Mode a

start gage message perform a Verification cycle as programmed in the “Check Setup” menu. The verification master must be introduced to the gage by the PLC controlled process.

Reset Feedback
The CAG™ feedback data used to transmit offsets to the machine can be reset by the PLC. This is usually done when a tooling change has been made.

Machine ID
The identity of the machine that is supplying offset data to the CAG™ is supplied with this command. The Machine ID can be used in Feedback application where the identity of the machine supplying the part is required.

Reset Position
If the multi-position gage cycle is interrupted the PLC can issue a “Reset Position” message to the CAG reset the gaging position to the start position.

Load Setup
The load setup message(s) is used to automatically load the EPIC system with a different Setup.

External Device (PLC) ---> EPIC CAG   Messages
The table below references each available message with the appropriate bit pattern.

Note: The interrupt input (opto M7 C7 - bit 7) will need to be turned ON for the message to be acted on by the CAG™.

	Interrupt	MESSAGE					
	opto M7 C7 - bit 7	opto M6 C5 - bit 5	opto M6 C4 - bit 4	opto M5 C3 - bit 3	opto M5 C2 - bit 2	opto M4 C1 - bit 1	opto M4 C0 - bit 0
Manual Start Gage 1	1	0	0	0	0	0	1
Automatic Start Gage 1	1	0	0	0	0	1	0
Manual Start Gage 2	1	0	0	0	0	1	1
Automatic Start Gage 2	1	0	0	0	1	0	0
Manual Start Gage 3	1	0	0	0	1	0	1
Automatic Start Gage 3	1	0	0	0	1	1	0
Manual Start Gage 4	1	0	0	0	1	1	1
Automatic Start Gage 4	1	0	0	1	0	0	0
End Gage	1	0	0	1	0	0	1
Auto Mastering Gage 1	1	0	0	1	0	1	0
Auto Mastering Gage 2	1	0	0	1	0	1	1
Auto Mastering Gage 3	1	0	0	1	1	0	0
Auto Mastering Gage 4	1	0	0	1	1	0	1
Abort Mastering	1	0	0	1	1	1	0

Reset Feedback Gage 1	1	0	1	0	0	1	0
Reset Feedback Gage 2	1	0	1	0	0	1	1
Reset Feedback Gage 3	1	0	1	0	1	0	0
Reset Feedback Gage 4	1	0	1	0	1	0	1
Machine ID 1	1	0	1	0	1	1	0
Machine ID 2	1	0	1	0	1	1	1
Machine ID 3	1	0	1	1	0	0	0
Machine ID 4	1	0	1	1	0	0	1
Machine ID 5	1	0	1	1	0	1	0
Machine ID 6	1	0	1	1	0	1	1
Machine ID 7	1	0	1	1	1	0	0
Machine ID 8	1	0	1	1	1	0	1
Reset Position Gage 1	1	0	1	1	1	1	0
Reset Position Gage 2	1	0	1	1	1	1	1
Reset Position Gage 3	1	1	0	0	0	0	0
Reset Position Gage 4	1	1	0	0	0	0	1
Auto Verification Gage 1	1	1	0	0	0	1	0
Auto Verification Gage 2	1	1	0	0	0	1	1
Auto Verification Gage 3	1	1	0	0	1	0	0
Auto Verification Gage 4	1	1	0	0	0	0	1
Load Setup ID 1	1	1	1	0	1	0	0
Load Setup ID 2	1	1	0	0	1	0	1
Load Setup ID 3	1	1	0	0	1	1	0
Load Setup ID 4	1	1	0	0	1	1	1
Load Setup ID 5	1	1	0	1	0	0	0
Load Setup ID 6	1	1	0	1	0	0	1
Load Setup ID 7	1	1	0	1	0	1	0
Load Setup ID 9	1	1	0	1	0	1	1
Load Setup ID10	1	1	0	1	1	0	0
Load Setup ID11	1	1	0	1	1	0	1

5.1.2. CAG™ Output Messages

Acknowledge

The CAG™ transmits an "Acknowledge" message in response to a fault code message.

End Gage
The CAG™ transmits an "End Gage" message in response to a manual start gage or to an auto start gage during a mastering sequence

Good, Reject or Rework Part Status
The CAG™ transmits a part status message as an acknowledgment to an auto start gage.

R & R Sort
The CAG™ transmits an "R&R Sort" message to acknowledge an auto start gage during the R&R study.

Class
The CAG™ can classify a part into 30 programmable categories. If the CAG is setup to classify then the class data will always be present on the **second** data available strobe during an auto start gage.

Shutdown
The CAG can be configured to notify an external device of an undesirable event or sequence of events, such as a consecutive reject error for example. When necessary the CAG will transmit a "Shutdown" message. This message is initiated by the CAG and requires no response.

EPIC CAG Messages ---> External Device
The table below references each available message with the appropriate bit pattern.

Note: The data available output (opto M10 B5 - bit 5) will be turned ON when the message is ready to be acted on by the external device.

	Data Available	MESSAGE				
	opto M10 B5 Bit 13	opto M2 A4 Bit 4	opto M1 A3 Bit 3	opto M1 A2 Bit 2	opto M0 A1 Bit 1	opto M0 A0 Bit 0
ACK	1	0	0	0	0	1
End Gage	1	0	0	0	1	0
Accept Status	1	0	0	0	1	1
Reject Status	1	0	0	1	0	0
Rework Status	1	0	0	1	0	1
R&R Sort 1	1	0	0	1	1	0
Shutdown	1	1	1	1	1	1
Class Error	1	0	0	0	0	0
Class #1	1	0	0	0	0	1
Class #2	1	0	0	0	1	0
...						
Class #30	1	1	1	1	1	0

5.1.3. Examples: Parallel IO Communications

Example #1

Application: Typical Automatic Gage Cycle:

A. Single Gage

B. No Classifying

1. PLC Sends Start Gage Message to initiate the measurement cycle.

   The PLC will set the binary coded message on data bit 0 thru data bit 4 and wait for a short duration for the lines to setup before activating the Interrupt. The message and Interrupt will remain on until a response is received from the CAG™.

PLC -> CAG - Sends Start Gage Message

	Interrupt	MESSAGE					
	opto M7 C7 - bit 7	opto M6 C5 - bit 5	opto M6 C4 - bit 4	opto M5 C3 - bit 3	opto M5 C2 - bit 2	opto M4 C1 - bit 1	opto M4 C0 - bit 0
Automatic Start Gage 1	1	0	0	0	0	1	0

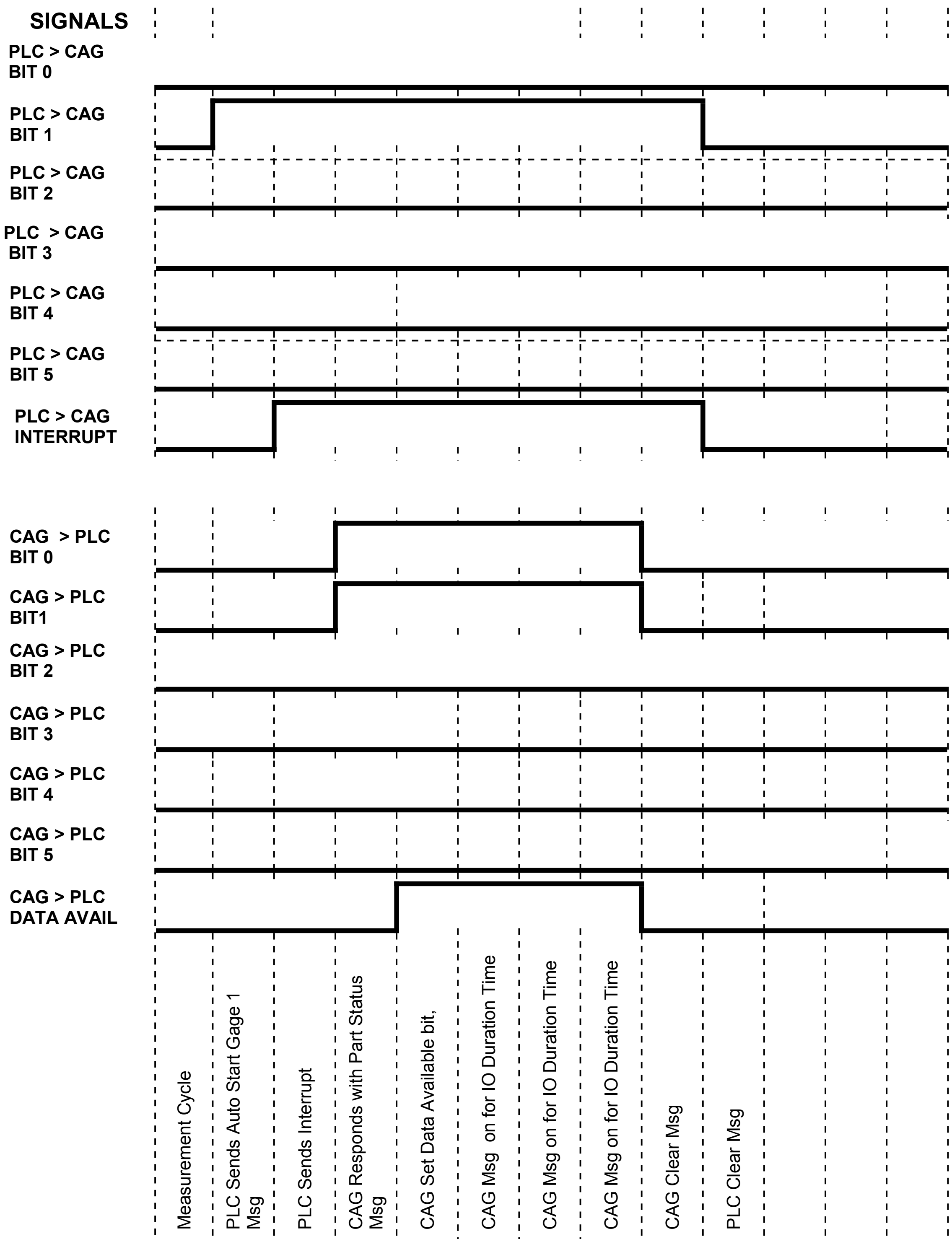
2. CAG™ responds with Status message at the completion of the measurement cycle.

   The CAG™ will set the binary coded message for status on data bit 0 through data bit 12 and wait for a short duration for the lines to setup before activating the data available line. The data available line will remain on for the programmed message duration in IO Diagnostics screen.

CAG -> PLC - Sends Status Message (Accept Part)

	Data Available	MESSAGE				
	opto M10 B5 Bit 13	opto M2 A4 Bit 4	opto M1 A3 Bit 3	opto M1 A2 Bit 2	opto M0 A1 Bit 1	opto M0 A0 Bit 0
Accept Status	1	0	0	0	1	1

Example #1 Timing Diagram Typical Automatic Gage Cycle



Example #2
Application: Typical Automatic Gage Cycle:
A.Single Gage
B. Classifying

1. PLC Sends Start Gage Message to initiate the measurement cycle.

The PLC will set the binary coded message on data bit 0 thru data bit 4 and wait for a short duration for the lines to setup before activating the Interrupt. The message and Interrupt will remain on until a response is received from the CAG™.

PLC -> CAG - Sends Start Gage Message

	Interrupt	MESSAGE					
	opto M7 C7 - bit 7	opto M6 C5 - bit 5	opto M6 C4 - bit 4	opto M5 C3 - bit 3	opto M5 C2 - bit 2	opto M4 C1 - bit 1	opto M4 C0 - bit 0
Automatic Start Gage 1	1	0	0	0	0	1	0

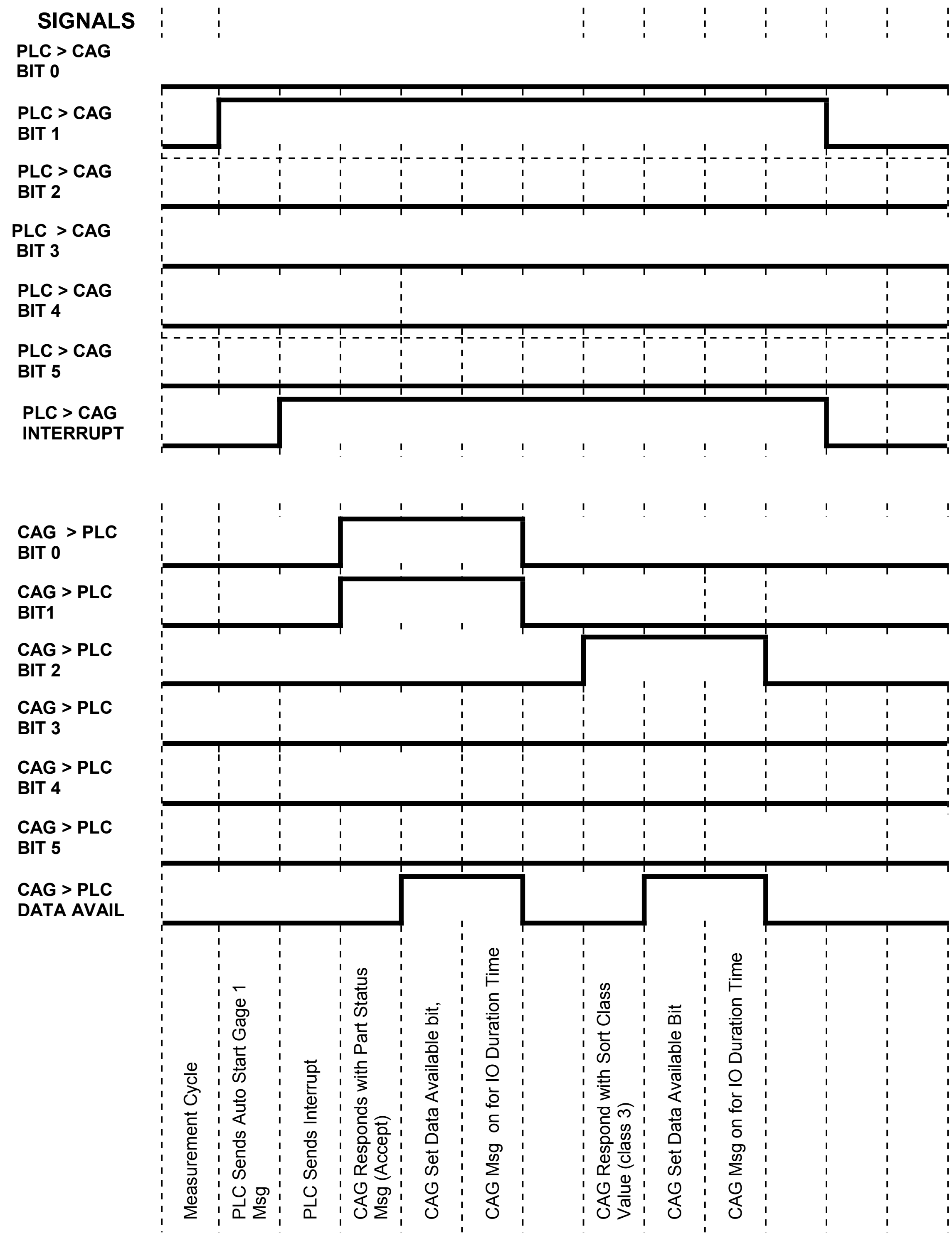
2. CAG™ responds with Status message followed by the Class message at the completion of the measurement cycle.

The CAG™ will set the binary coded message for Status on data bit 0 through data bit 12 and wait for a short duration for the lines to setup before activating the data available line. The data available line will remain on for the programmed message duration in IO Diagnostics screen.
The CAG™ will then set the binary coded message for the Class number on data bit 0 through data bit 12 and wait for a short duration for the lines to setup before activating the data available line. The data available line will remain on for the programmed message duration in IO Diagnostics screen.

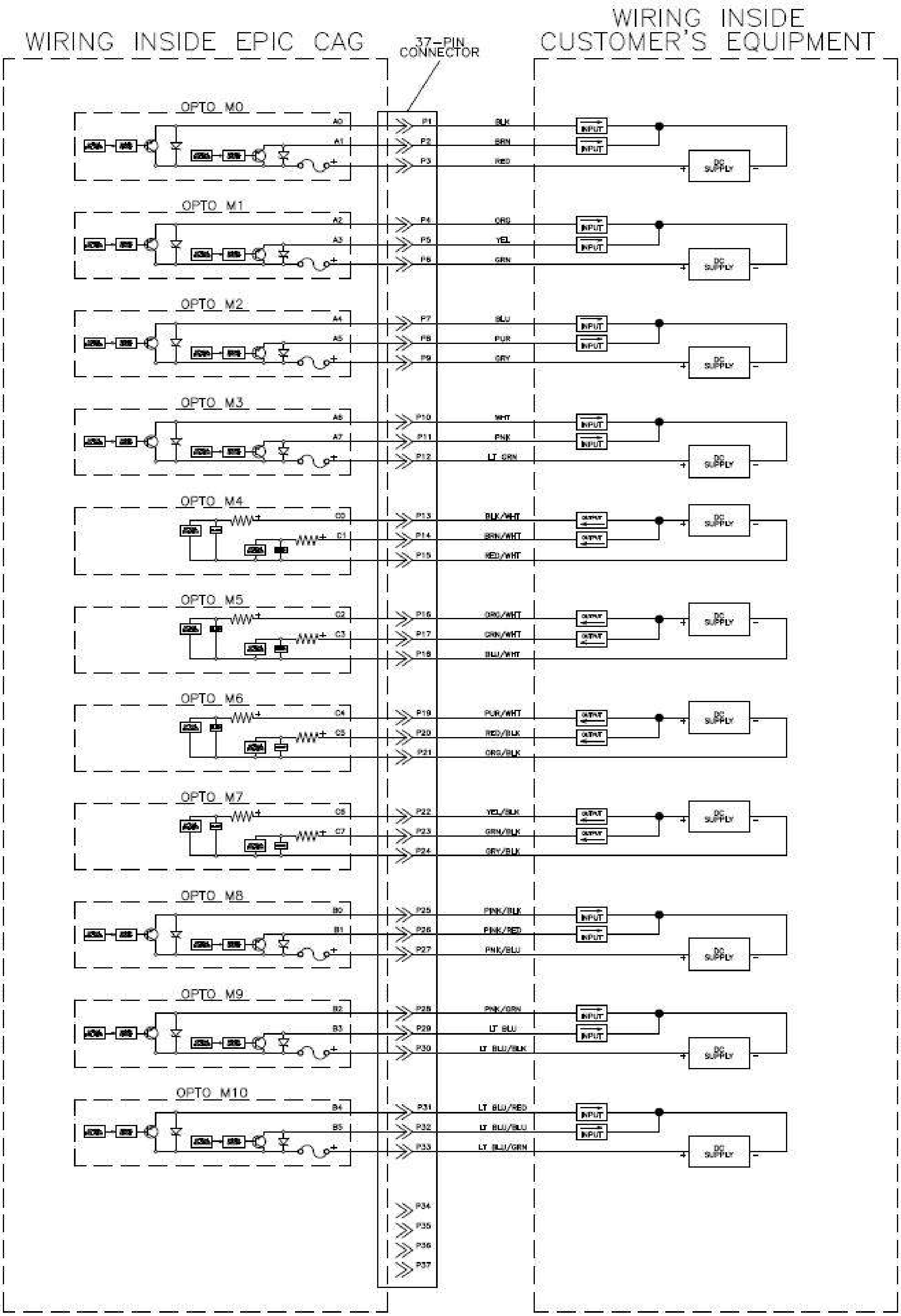
CAG -> PLC
CAG Sends Status Message (Accept Part)
CAG Sends Class Message (Class #2)

	Data Available	MESSAGE				
	opto M10 B5 Bit 13	opto M2 A4 Bit 4	opto M1 A3 Bit 3	opto M1 A2 Bit 2	opto M0 A1 Bit 1	opto M0 A0 Bit 0
Accept Status	1	0	0	0	1	1
Class #3	1	0	0	1	0	0

Example #2 Timing Diagram, Single Gage Gage Cycle with Sort Classification

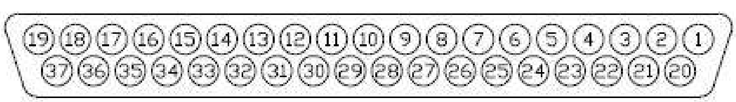


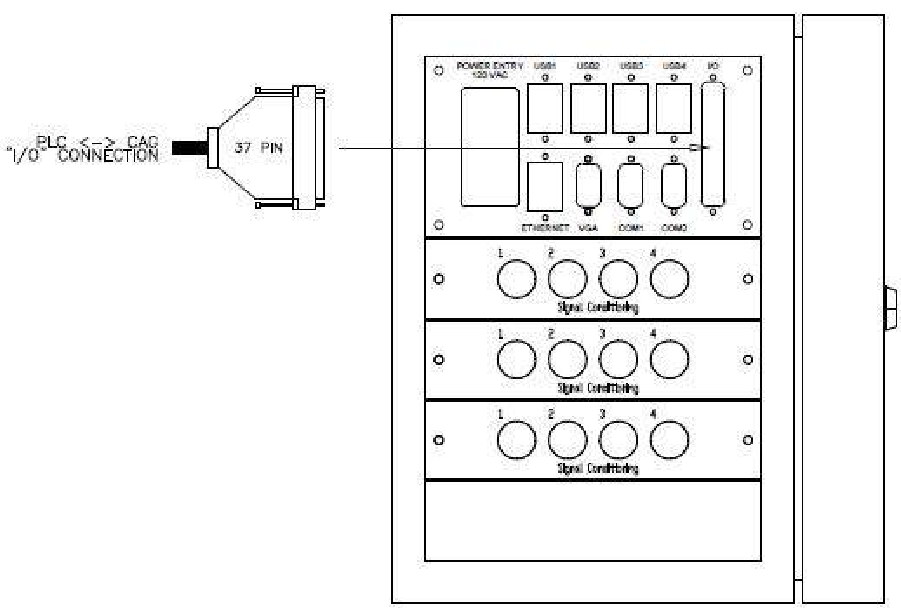
5.1.4. CAG™ Wiring For Automatic Parallel IO Communications



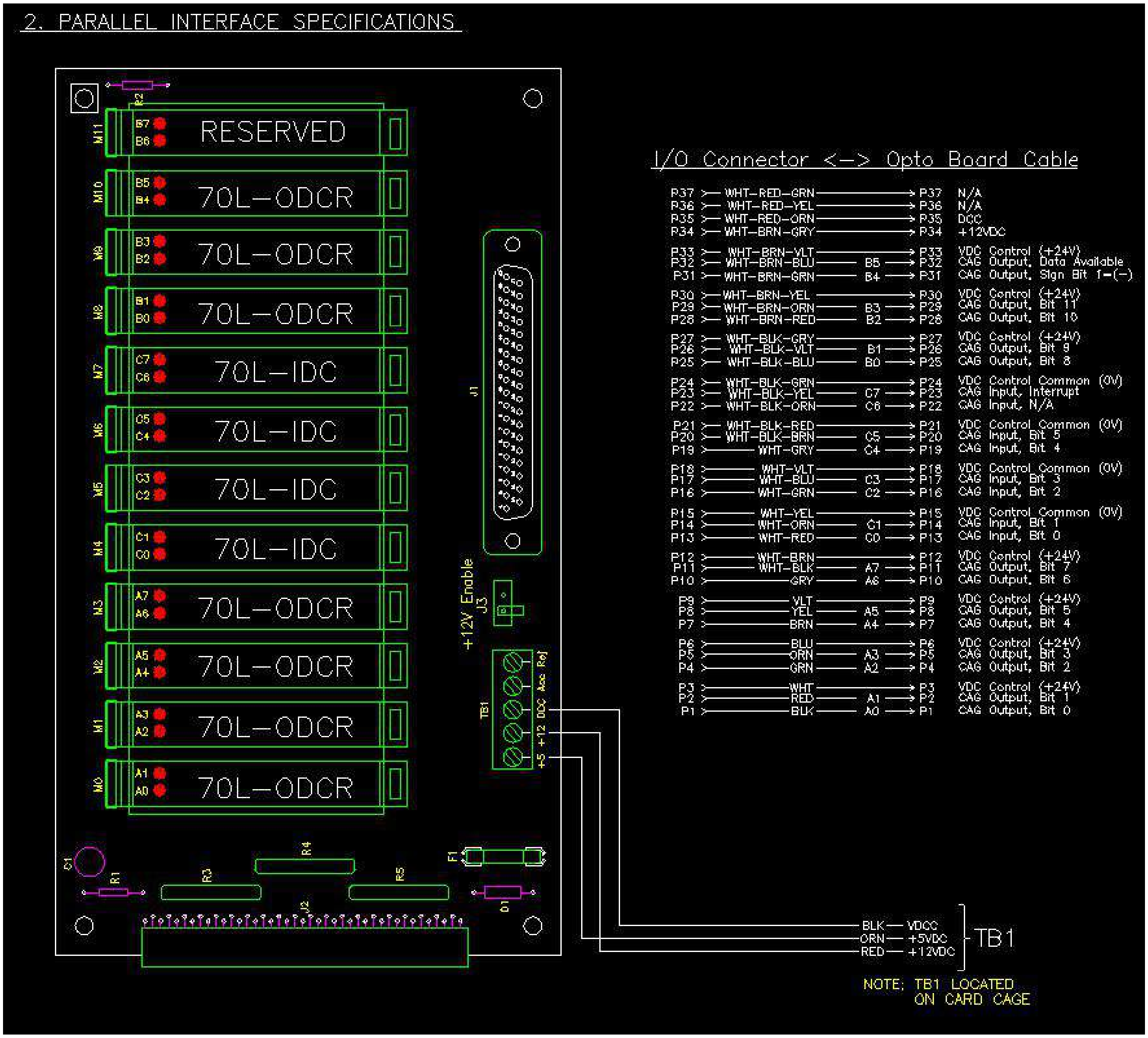
Connector J1 Pin Assignments

PIN #	COLOR	WIRE #	DESCRIPTION
1	BLK		CAG -> PLC, BIT 0, M0-A
2	BRN		CAG -> PLC, BIT 1, M0-B
3	RED		24 VDC CONTROL LINE
4	ORG		CAG -> PLC, BIT 2, M1-A
5	YEL		CAG -> PLC, BIT 3, M1-B
6	GRN		24 VDC CONTROL LINE
7	BLU		CAG -> PLC, BIT 4, M2-A
8	PUR		
9	GRY		24 VDC CONTROL LINE
10			
11			
12			
13	BLK/WHT		PLC -> CAG, BIT 0, M4-A
14	BRN/WHT		PLC -> CAG, BIT 1, M4-B
15	RED/WHT		24 VDC CONTROL COMMON
16	ORG/WHT		PLC -> CAG, BIT 2, M5-A
17	GRN/WHT		PLC -> CAG, BIT 3, M5-B
18	BLU/WHT		24 VDC CONTROL COMMON
19	PUR/WHT		PLC -> CAG BIT 4, M6-A
20	RED/BLK		
21	ORG/BLK		24 VDC CONTROL COMMON
22	YEL/BLK		
23	GRN/BLK		PLC -> CAG, INTERRUPT, M7-B
24	GRY/BLK		24 VDC CONTROL COMMON
25			
26			
27			
28			
29			
30			
31			
32	LT BLU/BLU		CAG -> PLC, DATA AVAIL, M10-B
33	LT BLU/GRN		24 VDC CONTROL LINE
34			SPARE
35			SPARE
36			SPARE
37			SPARE





Internal EPIC CAG Wiring



OPTO CHOICES	FUSE RATING	ADDITIONAL QTY.
DC INPUT, GRAYHILL #70L–IDC	–	4
AC INPUT, GRAYHILL #70L–IAC	–	0
DC OUTPUT, GRAYHILL #70L–ODCR	1.00A/CH	7
AC OUTPUT, GRAYHILL #70L–OAC	3.15A/CH	0

5.2. EPIC CAG Standard EtherNet/IP Communications

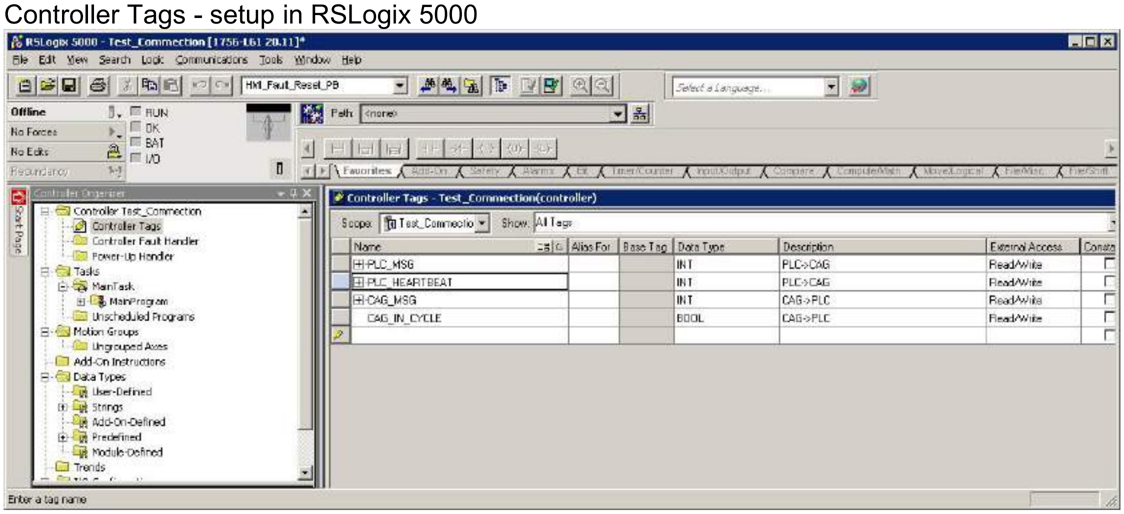
CAG (EPIC) ← → Allen Bradley ControlLogix Controller (PLC)

Communication between Edmunds EPIC CAG™ units and Allen Bradley ControlLogix Controllers is achieved using EtherNet/IP (Industrial Protocol). Control commands and status are passed between the CAG™ and AB Controller (PLC) by means of reading and writing messages to predefined memory locations (Tags) residing on the AB Controller.

TAGS that must be defined on Allen Bradley Controller (PLC)

Tag Name	Scope	Data Type	Description
PLC_MSG	Controller	Integer	PLC --> CAG message
CAG_MSG	Controller	Integer	CAG --> PLC message
CAG_IN_CYCLE	Controller	Boolean	CAG --> PLC message
PLC_HEARTBEAT	Controller	Integer	PLC --> CAG message

Controller Tags - setup in RSLogix 5000



PLC → CAG
Messages from the PLC Controller to the CAG™ unit (Start Gage, End Gage, Reset etc…) will be written to "PLC_MSG" tag by the PLC. The CAG™ will scan the "PLC_MSG" Tag for any change if value. If the Tag value changes and the value is greater than zero "0", the message will be acted upon. The CAG™ will clear the Tag value (set to 0) right after it is read.

CAG → PLC
Messages from the CAG™ unit to the PLC Controller (Part Status, End Gage, Class etc…) will be written to the "CAG_MSG" tag by the CAG™. The PLC will scan the "CAG_MSG" tag for a valid message. The PLC will clear the tag (set to 0) after it has acted upon the message.

CAG IN CYCLE
The CAG™ will set the "CAG_IN_CYCLE" Boolean tag to "1" when the CAG™ is in cycle (gauging). The "CAG_IN_CYCLE" tag will be cleared ("0") when the gaging cycle is complete. The PLC can monitor this tag to insure a gaging cycle is not initiated when the CAG™ is currently in a gage cycle.

PLC HEARTBEAT

The PLC Heartbeat can be used to verify communication between CAG™ and PLC.
If the PLC sets the “PLC_HEARTBEAT” Integer tag to “1”, the CAG™ will then set it to zero “0”. The PLC can use this as a way to insure communications exists.

5.2.1. PLC Messages (PLC → CAG)

TAG: PLC_MSG

Start Gage

The CAG™ performs the task of translating an electronic signal to a useful numeric representation. In doing so the CAG™ must sample the inputs (i.e. LVDTs) an appropriate number of times and execute an algorithm(s) to acquire a numeric result. This function is termed "GAGE" or "GAGING". For obvious reasons, the CAG™ must be informed when to initiate this function. Through Ethernet/IP communication, the CAG™ can be instructed to begin this process. This command is termed "Start Gage". Two types of start gage messages are available, auto and manual. They both prompt the CAG™ to initiate the algorithms discussed above; however, distinct differences apply. A manual start gage requests the CAG™ to gage and that's all. With the manual start gage command, the CAG™ will acquire a numeric result for the sampled inputs and update the current part status, however the CAG™ will NOT update the SPC charts, counters, feedback, and so on.

The auto start gage message requests the CAG™ to gage and update all appropriate SPC charts, counters, feedback variables, and any or all other functions the CAG provides.

Since the CAG™ has the ability to access any gage setup on request, it is only appropriate that a start gage message, for both auto and manual, exist for each gage setup. Simply, for each gage setup there is a corresponding auto and manual start gage message. In response to a start gage message, the CAG™ will acknowledge with a part status message.

End Gage

It was defined in the discussion for the start gage command that the CAG™ samples (reads) the inputs an appropriate number of times, and then executes an algorithm(s) to attain a numeric result. This definition holds for many applications; however, it may be desirable to acquire input readings while the part is in motion. This dynamic process adds the flexibility of externally controlling at what time the CAG™ starts and stops collecting input readings. Until now, the discussion has focused on static gaging which only required a start gage indication. With dynamic gaging, an "End Gage" command is needed to instruct the CAG™ to end the current input sampling. The CAG™ can also be configured to end this process after a programmed time interval, in which case the end gage command is not necessary.

Auto Calibration (Mastering)

When a CAG™ is used in a full automation environment it can be instructed to perform a calibration (mastering) sequence by the PLC. The “Auto Calibration” command will instruct the CAG™ to begin the calibration process as programmed in the Calibration menu. The masters must be introduced to the gage in the correct sequence by the PLC controlled process (see example of auto calibration cycle below).

Auto Verification (optional)

When a CAG™ is used in a full automation environment it can be instructed to perform a verification sequence by the PLC. The “Auto Verification” command will instruct the CAG™ to begin the verification process as programmed in the Verification menu. The verification masters must be introduced to the gage by the PLC controlled process.

Abort Calibration and Verification

If a situation arises where the PLC detects an unfavorable condition an “Abort Mastering” message can be sent to the CAG™ to stop the mastering process or verification process.

Reset Position

If the multi-position gage cycle is interrupted the PLC can issue a “Reset Position” message to the CAG™ reset the gaging position to the start position.

PLC Messages - Complete List

ACTION	PLC_MSG Tag (Integer)
Manual Start Gage 1	1
Auto Start Gage 1	2
Manual Start Gage 2	3
Auto Start Gage 2	4
Manual Start Gage 3	5
Auto Start Gage 3	6
Manual Start Gage 4	7
Auto Start Gage 4	8
End Gage	9
Auto Calibration Gage 1	10
Auto Calibration Gage 2	11
Auto Calibration Gage 3	12
Auto Calibration Gage 4	13
Abort Calibration & Verification	14
Reset Feedback Gage 1	18
Reset Feedback Gage 2	19
Reset Feedback Gage 3	20
Reset Feedback Gage 4	21
Feedback Machine ID 1	22
Feedback Machine ID 2	23
Feedback Machine ID 3	24
Feedback Machine ID 4	25
Feedback Machine ID 5	26
Feedback Machine ID 6	27
Feedback Machine ID 7	28
Feedback Machine ID 8	29
Reset Positions Gage 1	30
Reset Positions Gage 2	31
Reset Positions Gage 3	32
Reset Positions Gage 4	33
Auto Verification Gage 1	34
Auto Verification Gage 2	35
Auto Verification Gage 3	36
Auto Verification Gage 4	37
Load Setup ID1	52
Load Setup ID2	53
Load Setup ID3	54
Load Setup ID4	55
Load Setup ID5	56
Load Setup ID6	57
Load Setup ID7	58
Load Setup ID8	59
Load Setup ID9	60
Load Setup ID10	61
Manual Start Gage 5	65
Auto Start Gage 5	66
Manual Start Gage 6	67
Auto Start Gage 6	68
Manual Start Gage 7	69
Auto Start Gage 7	70
Manual Start Gage 8	71
Auto Start Gage 8	72
Manual Start Gage 9	73
Auto Start Gage 9	74
Manual Start Gage 510	75
Auto Start Gage 10	76
Manual Start Gage 11	77
Auto Start Gage 11	78
Manual Start Gage 12	79
Auto Start Gage 12	80

5.2.2. CAG Messages (CAG → PLC)

TAG: CAG_MSG

Acknowledge
The CAG™ transmits an "Acknowledge" message in response PLC command.

End Gage
The CAG™ transmits an "End Gage" message in response to a manual start gage or to an auto start gage during a mastering sequence

Good, Reject or Rework Part Status
The CAG™ transmits a part status message as an acknowledgment to an auto start gage during static gaging and to an end gage message during dynamic gaging.

CAG Messages

Description	CAG_MSG Tag (Integer)
Acknowledge (ACK)	1
EndGage	2
Accept Status	3
Reject Status	4
Rework Status	5
R&R	6

5.2.3. Example of a Typical Gaging Cycle:

TAG	VALUE	DESCRIPTION
PLC_MSG	0	Initial state, PLC_MSG tag clear with a value of "0"
PLC_MSG	2	PLC Initiates the gaging cycle by writing a "2" in PLC_MSG tag. In this case "2" is the "Auto Start Gage 1" message.
PLC_MSG	0	CAG reads the PLC_MSG tag, and then clears the message by writing "0" to PLC_MSG tag
		CAG acts on the message and starts a gaging cycle
CAG_MSG	3	At the completion of the gaging cycle, the CAG writes the part status (3, 4, or 5) to the CAG_MSG tag
CAG_MSG	0	PLC reads the part status from the "CAG_MSG" tag and then clears the message by writing "0" to "CAG_MSG" tag.

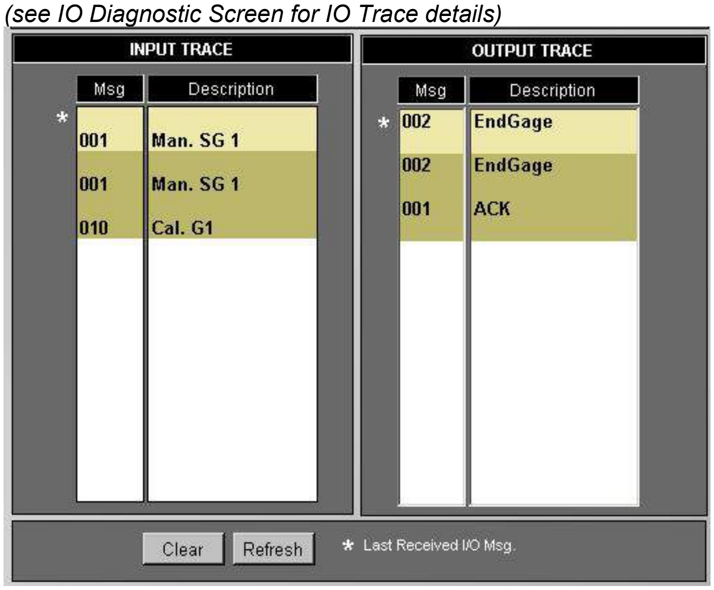
5.2.4. Example of a Typical Automatic Calibration Cycle:

TAG	VALUE	DESCRIPTION
PLC_MSG	0	Initial state, PLC_MSG tag clear with a value of "0"
PLC_MSG	10	PLC puts the CAG in calibration mode by writing a "10" in PLC_MSG tag. In this case "10" is the "Auto Calibration Gage 1" message. The CAG Calibration screen will automatically be displayed if it is enabled in System Setup screen. 
CAG_MSG	1	The CAG writes Acknowledge (ACK) to the CAG_MSG tag. This informs the PLC that CAG has successfully been put in Auto Calibration Mode.
CAG_MSG	0	PLC reads the ACK from the CAG_MSG tag and then clears the message by writing "0" to CAG_MSG tag.
		Master 1 is introduced to the gage. In most cases this will be the Max Master.
PLC_MSG	1	PLC Initiates the gaging cycle by writing a "1" in PLC_MSG tag. In this case "1" is the "Manual Start Gage 1" message.
		CAG acts on the message and starts a calibration gaging cycle. The calibration cycle will measure Master 1 and store the measured results.
CAG_MSG	2	At the completion of the calibration gaging cycle, the CAG writes the End Gage message to the CAG_MSG tag.
CAG_MSG	0	PLC reads the End Gage message from the "CAG_MSG" tag and then clears the message by writing "0" to "CAG_MSG" tag.
		Master 2 is introduced to the gage. In most cases this will be the Min Master.
PLC_MSG	1	PLC Initiates the gaging cycle by writing a "1" in PLC_MSG tag. In this case "1" is the "Manual Start Gage 1" message.

		CAG acts on the message and starts a calibration gaging cycle. The calibration cycle will measure Master 2 and store the measured results.
CAG_MSG	2	At the completion of the calibration gaging cycle, the CAG writes the End Gage message to the CAG_MSG tag. The CAG screen will update with the Calibration Status.
CAG_MSG	0	PLC reads the End Gage message from the “CAG_MSG” tag and then clears the message by writing “0” to “CAG_MSG” tag.

Note: The EPIC CAG™ can be setup to write the Calibration Pass/Fail status to the PLC and display a Calibration status Alarm (see Alarm Setup screen).

IO Trace Showing the Automatic Calibration Cycle Example
(see IO Diagnostic Screen for IO Trace details)



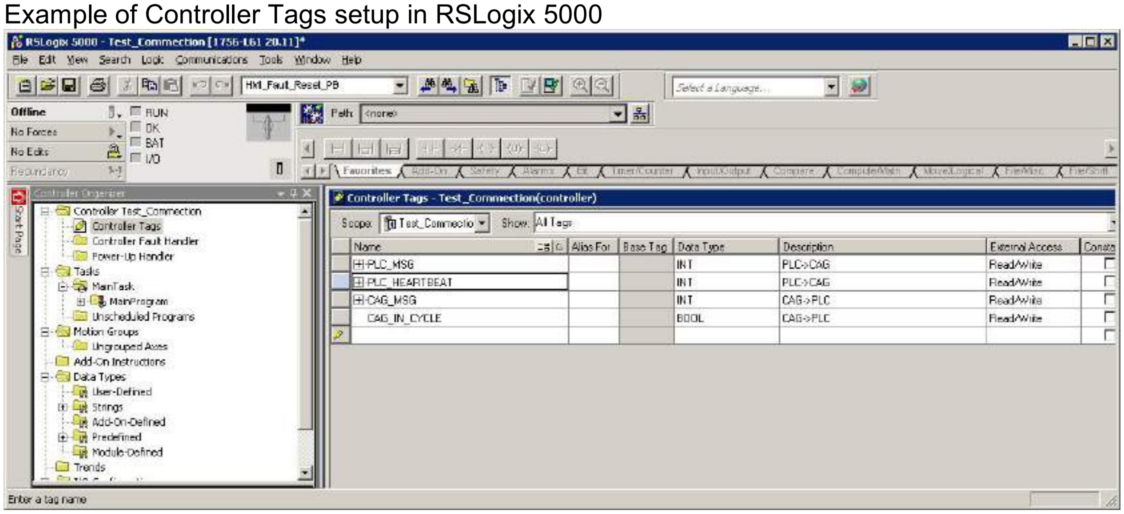
5.3. Establish Connection (CAG and PLC Controller)

1. Create the required Controller Tags in the Allen Bradley Controller

TAGS that must be defined on Allen Bradley Controller (PLC)

Tag Name	Scope	Data Type	Description
PLC_MSG	Controller	Integer	PLC --> CAG message
CAG_MSG	Controller	Integer	CAG --> PLC message
CAG_IN_CYCLE	Controller	Boolean	CAG --> PLC message
PLC_HEARTBEAT	Controller	Integer	PLC --> CAG message

Example of Controller Tags setup in RSLogix 5000

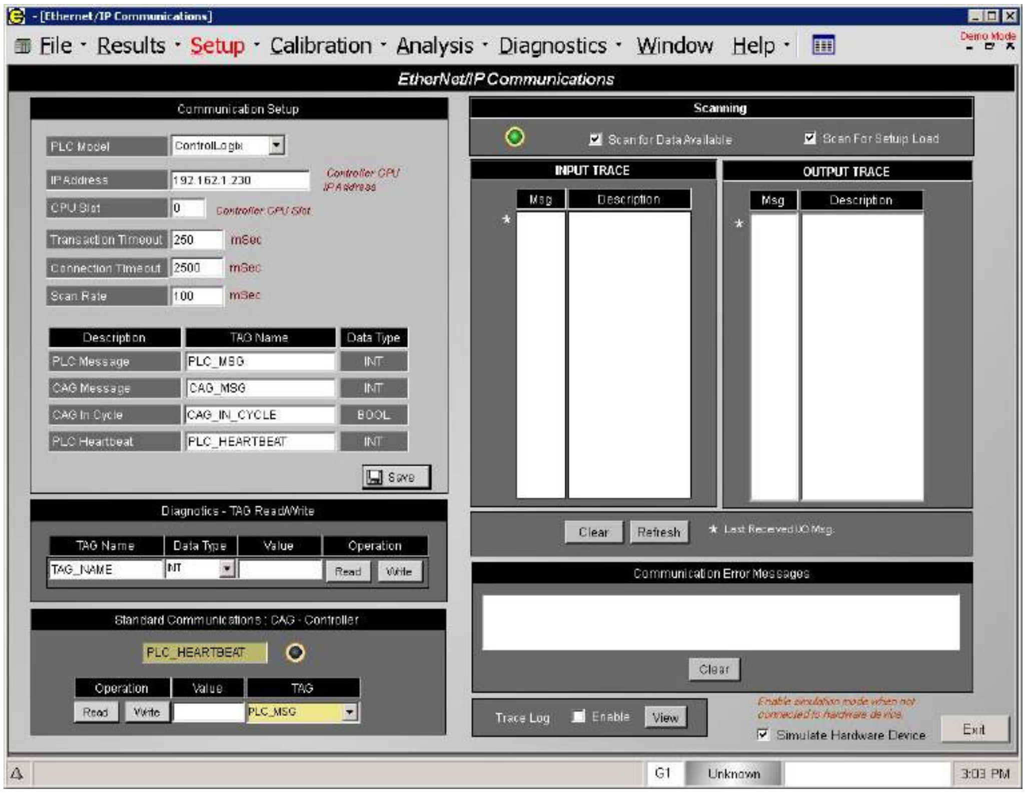


2. Set the CAG Ethernet IP address to the same Ethernet sub-net as the PLC Controller's Ethernet IP address.

   For example: **Controller**: 192.168.1.230, **CAG**: 192.168.1.233.

   The CAG Ethernet IP address is set in the Windows embedded "Control Panel" under "Network Connections". ***Note: Drive Protection must first be disabled before CAG Ethernet IP address is changed (see APPENDIX B for instructions on setting the CAG IP Address).***

3. Set the Controller Ethernet IP address and CPU Slot in the EPIC software (Ethernet IP Comm. screen)


[Ethernet/IP Communications]
File
Results
Setup
Calibration
Analysis
Diagnostics
Window
Help
Demo Mode
EtherNet/IP Communications
Communication Setup
PLC Model
ControlLogix
IP Address
192.162.1.230
Controller CPU IP Address
CPU Slot
0
Controller CPU Slot
Transaction Timeout
250
mSec
Connection Timeout
2500
mSec
Scan Rate
100
mSec
Description
TAG Name
Data Type
PLC Message
PLC_MSG
INT
CAG Message
CAG_MSG
INT
CAG In Cycle
CAG_IN_CYCLE
BOOL
PLC Heartbeat
PLC_HEARTBEAT
INT
Save
Diagnotics - TAG Read/Write
TAG Name
Data Type
Value
Operation
TAG_NAME
INT
Read
Write
Standard Communications : CAG - Controller
PLC_HEARTBEAT
Operation
Value
TAG
Read
Write
PLC_MSG
Scanning
Scan for Data Available
Scan For Setup Load
INPUT TRACE
OUTPUT TRACE
Msg
Description
Msg
Description
Clear
Refresh
Last Received I/O Msg.
Communication Error Messages
Clear
Trace Log
Enable
View
Enable simulation mode when not connected to hardware device.
Simulate Hardware Device
Exit
G1
Unknown
3:03 PM

5.4. EPIC CAG EtherNet/IP Gage Data (Optional)

The EPIC CAG™sytems are capable of writing measurement data (Check measurement results, Part Status, Sort Class, etc..) to Allen Bradley PLC controller. The measurement data is written to controller Tags on the PLC. The Tag names are programmable in EPIC CAG™ software. The Tag names must match the name of an existing Tag residing in the PLC.

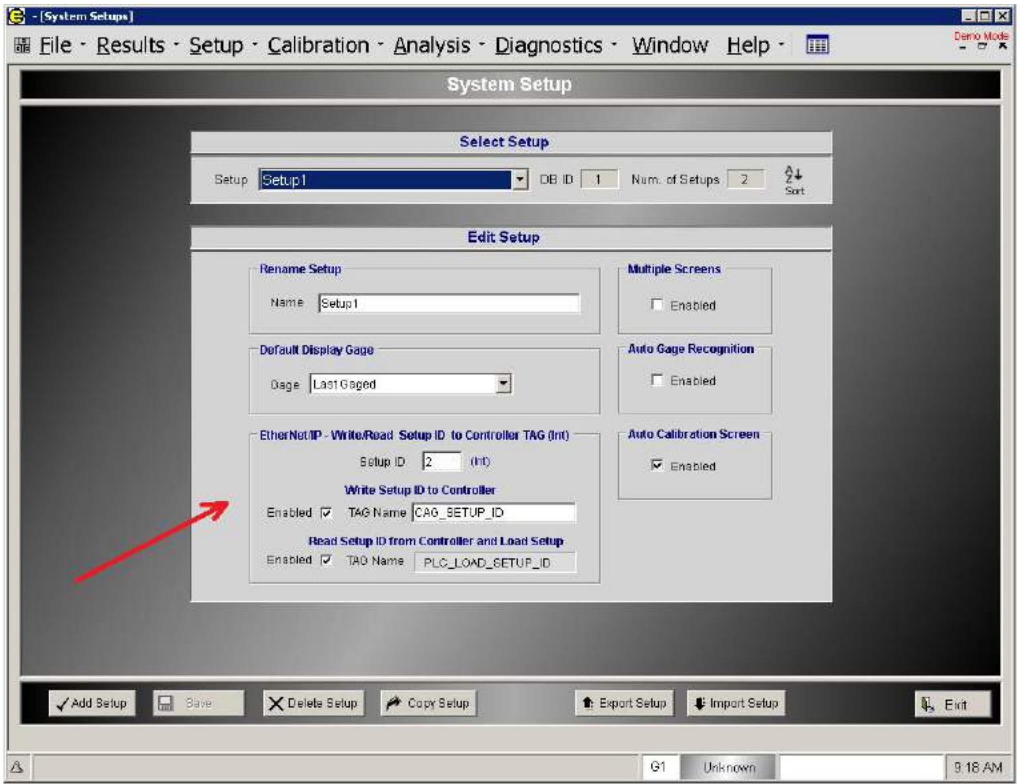
Below is a list of available measured results (Gage Data) that can be setup to write to EtherNet/IP Tags:
Setup ID - value indicating the current loaded Setup.
Part Status - value indicating the part status of the last measured part.
Check Result - measured value of an individual Check from the last measurement cycle.
Check Status - value indicating the status of an individual Check from the last measurement cycle.
Sort Class - value indicating the Sort Class of the part from the last measurement cycle.
Alarm Message - value indicating that an alarm has been triggered.

Note: There are **duplicate** methods of writing some of the Gage Data to EtherNet/IP Tags when both the "EtherNet/IP Gage Data" option and the "Stanadard EtherNet/IP Communications (Section 3.2)" option are used. For example, Part Status is written to an EtherNet/IP tag as part of the "Standard EtherNet/IP Communication". Part Status can also be enabled to be written to a different EtherNet/IP tag as part of the "EtherNet/IP Gage Data" option.

Setup ID (Programmed in System Setup Screen)

Write Setup ID to Controller:
If the EtherNet/IP option is installed a user programmed Setup ID will be written to a "TAG" on connected PLC controller. If this option is enabled, the Setup ID will be written to the PLC controller when the Setup is loaded and at the completion of a measurement cycle. The Setup ID Tag must be defined as a Controller Tag of Integer data type on the PLC controller.

Read Setup ID from Controller and Load Setup:
If this option is enabled, a predefined controller tag "**PLC_LOAD_SETUP_ID**" will be scanned and value will be read when the value has changed. If the read tag value contains a valid Setup ID corresponding to an existing Setup that Setup will be loaded automatically. The "**PLC_LOAD_SETUP_ID**" Tag must be defined as a Controller Tag of Integer data type on the PLC controller.

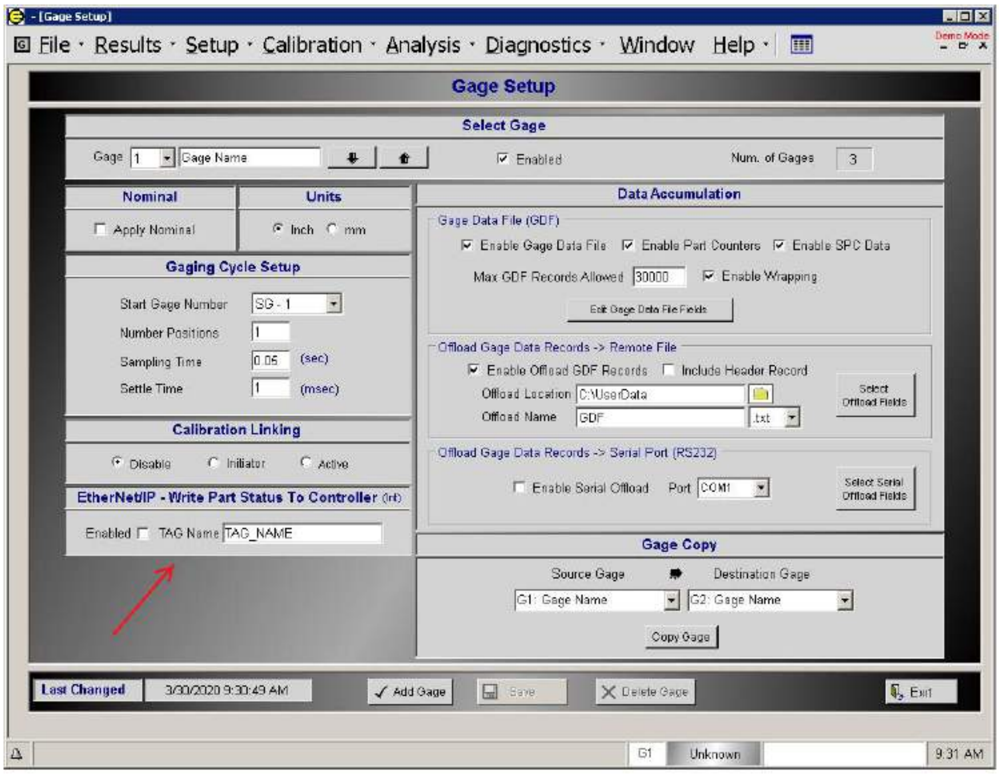


- [System Setups]
File · Results · Setup · Calibration · Analysis · Diagnostics · Window Help ·
Demo Mode
System Setup
Select Setup
Setup
Setup1
DB ID
1
Num. of Setups
2
Sort
Edit Setup
Rename Setup
Name
Setup1
Multiple Screens
Enabled
Default Display Gage
Gage
Last Gaged
Auto Gage Recognition
Enabled
EtherNet/IP - Write/Read Setup ID to Controller TAG (Int)
Setup ID
2
(Int)
Write Setup ID to Controller
Enabled
TAG Name
CAG_SETUP_ID
Read Setup ID from Controller and Load Setup
Enabled
TAG Name
PLC_LOAD_SETUP_ID
Auto Calibration Screen
Enabled
Add Setup
Save
Delete Setup
Copy Setup
Export Setup
Import Setup
Exit
G1
Unknown
9:18 AM

Part Status (Programmed in Gage Setup Screen)

Write Part Status to Controller:
If the EtherNet/IP option is installed the part status can be written to "TAG" on connected PLC controller at the completion of a measurement cycle. The part status will be written to the controller Tag at the completion of the measurement cycle. The part status Tag must be defined as a Controller Tag of Integer data type on the PLC controller.

Integer value written to PLC
0 = Unknown
1 = Accept
2 = Reject
3 = Rework1
4 = Rework2
5 = Rework3
6 = Flyer



Check Result (Programmed in Check Setup Screen)

Write Check Result to Controller: If the EtherNet/IP option is installed the Check result can be written to "TAG" on connected Allen Bradley PLC controller at the completion of a measurement cycle. The Check result Tag must be defined as a Controller Tag of Real data type on the PLC controller.

NOTE: The individual Check results can be setup to write to individual Tags or and array of Tags.

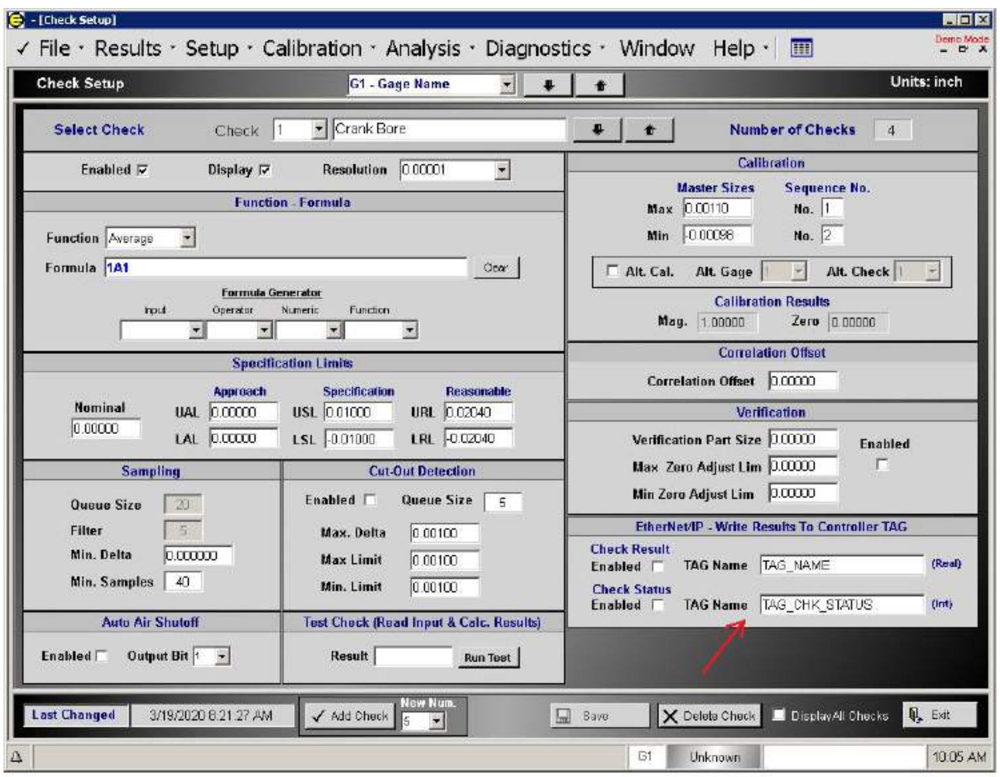
Example: Tag: Chk1_Result, Chk2_Result, etc… or Array Tags: Chk_Result[0], Chk_Result[1], etc…

Allen Bradley Controller - RSLogix 5000 - Tags for Check Result

Write Check Status to Controller: If the EtherNet/IP option is installed the Check status can be written to “TAG” on connected Allen Bradley PLC controller at the completion of a measurement cycle. The Check status ag must be defined as a Controller Tag of Integer data type on the PLC controller.

Check Status (values written to Tag)

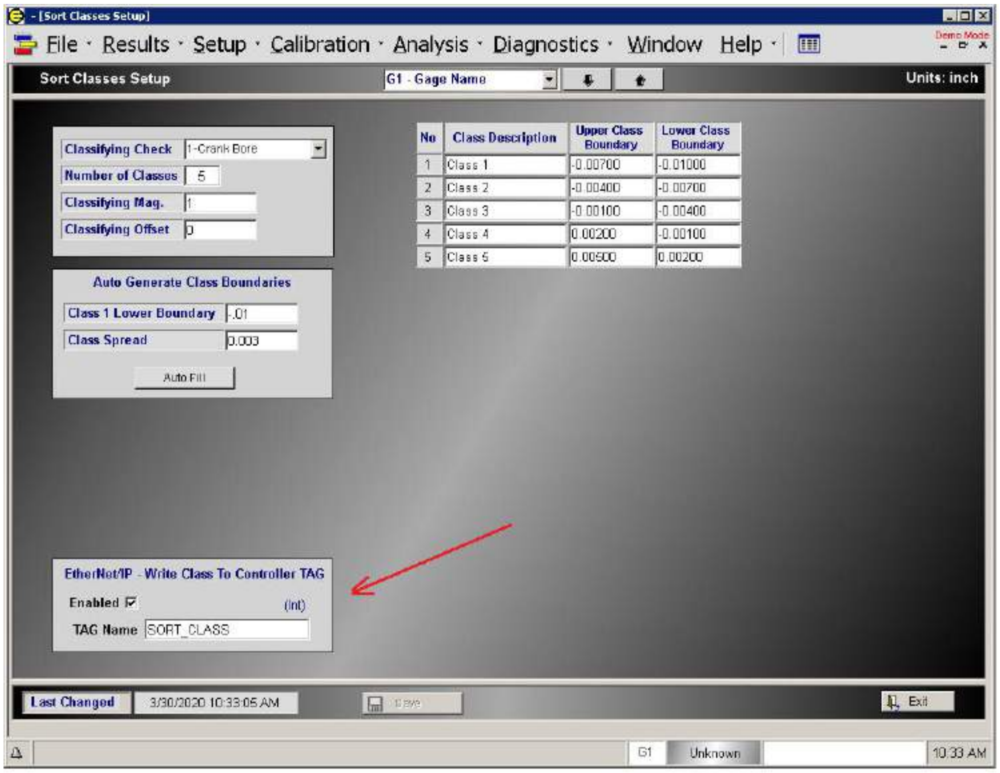
Unknown = 0	
Within Spec = 1	Within Specification Limit
Over UAL = 2	Over Upper Approach Limit
Under LAL = 3	Under Lower Approach Limit
Over USL = 4	Over Specification Limit
Under LSL = 5	Under Specification Limit
Over URL = 6	Over Reasonable Limit
Under LRL = 7	Under Reasonable Limit
Sat Input = 8	Saturated Input used in formula



Sort Class (Programmed in Sort Classes Setup Screen)

Write Sort Class to Controller: If the EtherNet/IP option is installed, the Sort Class number can be written to a “TAG” on connected Allen Bradley PLC controller at the completion of a measurement cycle. The Sort Class TAG must be defined as a controller tags on the PLC of “Integer” data type.

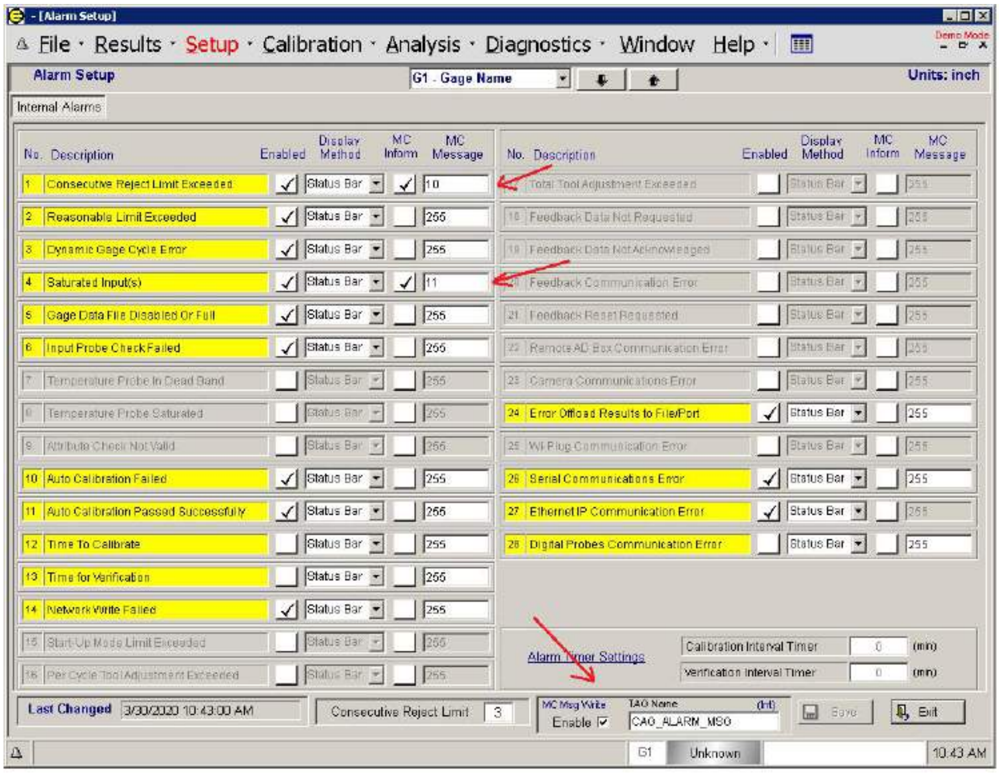
The value written to the tag will be the sort class number, for example if the Sort Class was determined to be “Class 3” a value of “3” will be written to the tag.



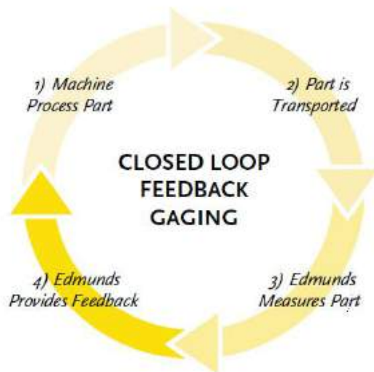
Alarm Message **(**Programmed in Alarm Setup Screen)

Write Alarm Message to Controller: If the EtherNet/IP option is installed this option is available. If “MC Msg Write” is enabled the system will write the MC Alarm programmed message number to the specified machine control PLC Tag. The Alarm TAG must be defined as a controller tags on the PLC of “Integer” data type.

In the example show in the below image, if alarm 1 “Consecutive Reject Limit Exceeded” is triggered the Machine Control Message (MC = 10) will be written to the PLC controller tag “CAG_ALARM_MSG”.



6. SECTION : Feedback Setup and Operations



The EPIC CAG system can be configured to compute machine tool offsets and transmit the offsets to the machine for tool adjustments. One Gage setup can provide feed back for multiple machines and multiple offsets can be programmed for each machine.

The final offset that goes to the machine for a given tool will be made up of components from two sources. The first source is the running average of a measured feature minus a set point. The second source is a combination of the other offsets generated for this cycle.

This will handle cases where some variables affect others in the machine. It becomes apparent that if this second source is utilized, the order of offset calculation becomes critical and must be taken into account by the user when defining the offset algorithm.

The offset calculation is a function of one running average multiplied by a compensation factor and up to three other offsets, each with a multiplier.

The compensation algorithm operates in two modes. The first mode is called "START UP" mode. The second is called "RUN" mode.

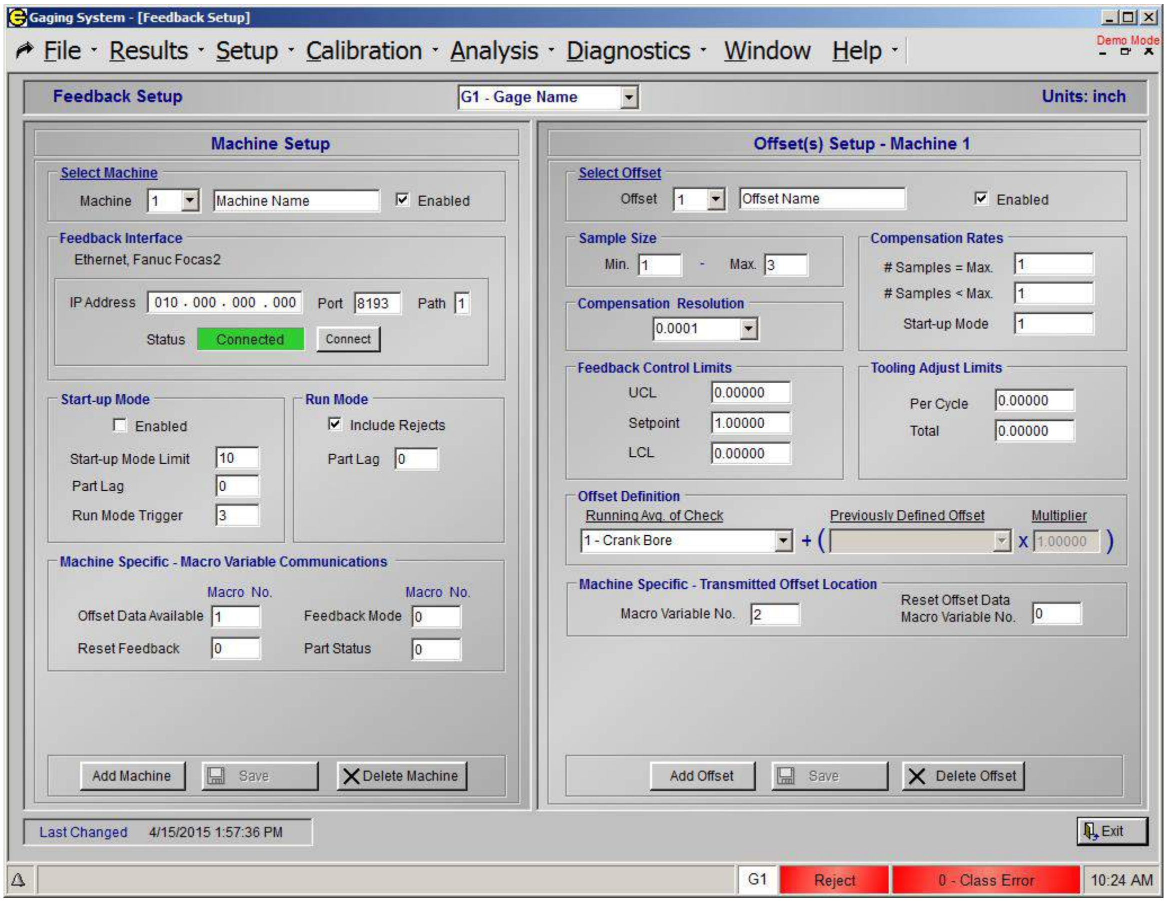
The Start Up mode is entered on demand by the machine or manually by the operator. Upon entering this mode, all running averages are reset. The CAG provides a separate set of running averages compensation factors that will be used while in this mode.

When the system is in the Start Up mode it will include rejected parts in the feedback calculations. When in the run mode the rejected parts are not included in the calculations.

The CAG will stop the process if the system stays in start up mode for more than an adjustable number of pieces.

The CAG will stop the process in Run Mode if an adjustable number of consecutive rejects are measured.

6.1. Feedback Setup Settings



6.1.1. Machine Setup

Machine Selection

Machine - Selection for Machine and programmable machine name.
Enabled - Enables feedback for the selected machine.

Feedback Interface

The EPIC system is capable of interfacing with many types of machine controls. The EPIC system will be configured at the factory with the feedback interface required to communicate to the specified machine control. This section of the machine setup will include setup required to interface with the specific machine being configured. The following is a list of the current standard feedback interfaces (see also *Section 5 Feedback Interfaces*):

Standard Interfaces

Parallel I/O
Edmunds Serial (RS232)
Okuma Serial (RS232)
Okuma Thinc (Ethernet)
GE Focus2 (Ethernet)

Allen Bradly EtherNet/IP
Ethernet File Transfer
Plus - Minus Comp (dedicated IO)

Start-up Mode

Enable - Enables a machine to use a Start-up mode

Start-up Mode Limit - Maximum number of consecutive parts allowed to be gaged in Start-up mode. If this limit is exceeded an alarm is triggered and feedback will not be calculated. The alarm can be programmed to send a shutdown.

Part Lag (Start-up) - Number of parts following a compensation that will not be included in the new running average.

Run Mode Trigger - Number of consecutive gaged good parts that must be measured in the Start-up Mode before advancing to Run Mode.

Run Mode

Include Rejects - Enabled allows feedback to be calculated on rejected parts in Run Mode.

Part Lag (Run Mode) - Number of parts following a compensation that will not be included in the new running average.

Machine Specific

This section of the machine setup will include specific setup required to interface with the specific machine being configured for (see *Section 5 Feedback Interfaces)*

Add Machine - Add additional feedback Machine to the current select Gage setup.

Save - Save the current Machine setup. The Save button will be red when changes have been made but not yet saved.

Delete Machine - Delete the current Machine setup and all Offset setup associated with the Machine.

6.1.2. Offset Setup

Select Offset

Offset - Selection for offset and programmable offset name.
Enabled - Enables feedback for the selected offset.

Sample Size

Min - Minimum number of parts that must be gaged before feedback data can be computed for an offset.
Max - Maximum number of parts that can be used to compute feedback data.

Compensation Rates

 # Samples = Max - Compensation rate applied to the running average when the following conditions exist:

- The Gage is in Run Mode.
- The running average exceeds 1 of the Feedback Control Limits.
- The number of Samples accumulated for the offset is equal the Max Sample Size.

Samples < Max - Compensation rate applied to the running average when the following conditions exist:

- The Gage is in Run Mode.
- The running average exceeds 1 of the Feedback Control Limits.
- The number of Samples accumulated for the offset is equal or greater than the Min Sample Size.

 # Start-up Mode - Compensation rate applied to the running average when the following conditions exist:

- The Gage is in Start-up Mode.
- The running average exceeds 1 of the Feedback Control Limits.
- The number of Samples accumulated for the offset is equal or greater than the Min Sample Size.

Feedback Control Limits

UCL - The Upper Control Limit is a trigger point for computing compensation data for a given offset. If the Running Average minus the set point is greater than the Upper Control Limit and the accumulated # of samples is equal to or greater than the Min Sample Size then Feedback data will be computed for that offset and transmitted back to the Machine.

Setpoint - The Setpoint is a value that is subtracted from the running average before the running average is evaluated against the UCL and LCL Limits. This feature allows the offset to correct to a value other than nominal.
Example: A dimension that is measured right after being machined may be larger, do to heat expansion, than when the part is cooled. In this case, it may be desirable to control the dimension to a Setpoint greater than nominal to compensate for the heat expansion.

LCL - The Lower Control Limit is a trigger point for computing compensation data for a given offset. If the Running Average minus the Setpoint is less than the Lower Control Limit and the accumulated # of samples is equal to or greater than the Min Sample Size then Feedback data will be computed for that offset and transmitted back to the Machine.

Compensation Rate - The resolution of the machine tool being compensated is entered here.

Feedback Control Limits

Per Cycle - The Per Cycle Tooling Adjust Limit is the maximum allowed adjustment on any given measurement cycle. This protects the Machine from over compensation. If the limit is exceeded an alarm is triggered which can be programmed to send a shutdown command.

Per Cycle - The Total Tooling Adjust Limit is the maximum allowed adjustment since the last tool change (feedback reset). The computed compensation data for an offset is totaled and compared against this limit. If the Limit is exceeded an alarm is triggered which can be programmed to send a shutdown command.

Offset Definition

Running Avg. of Check - The measured part feature (Check) that the running average will be performed on for an offset.

Previously Defined Offset - An offset can be a function of another offset. This is useful when the other offset computed for the same measurement cycle will affect the amount of compensation this is to be applied for this offset (this is not common).

Multiplier - The percentage of the previously defined offset that will be added or subtracted to the running average during the measurement cycle.

Machine Specific

This section of the offset setup will include specific setup required to interface with the specific machine being configured for (see *Section 5 Feedback Interfaces)*

6.2. Feedback Operation

In this section the operation of the Edmunds Feedback will be demonstrated through a several examples. Note that many of the screens shown in the examples are of the “Feedback Monitor” screen . The “Feedback Monitor” screen allows the operator to view the compensation amounts and rates for the process (see *Section 1.5.7 Feedback Monitor*).

6.2.1. START-UP MODE:

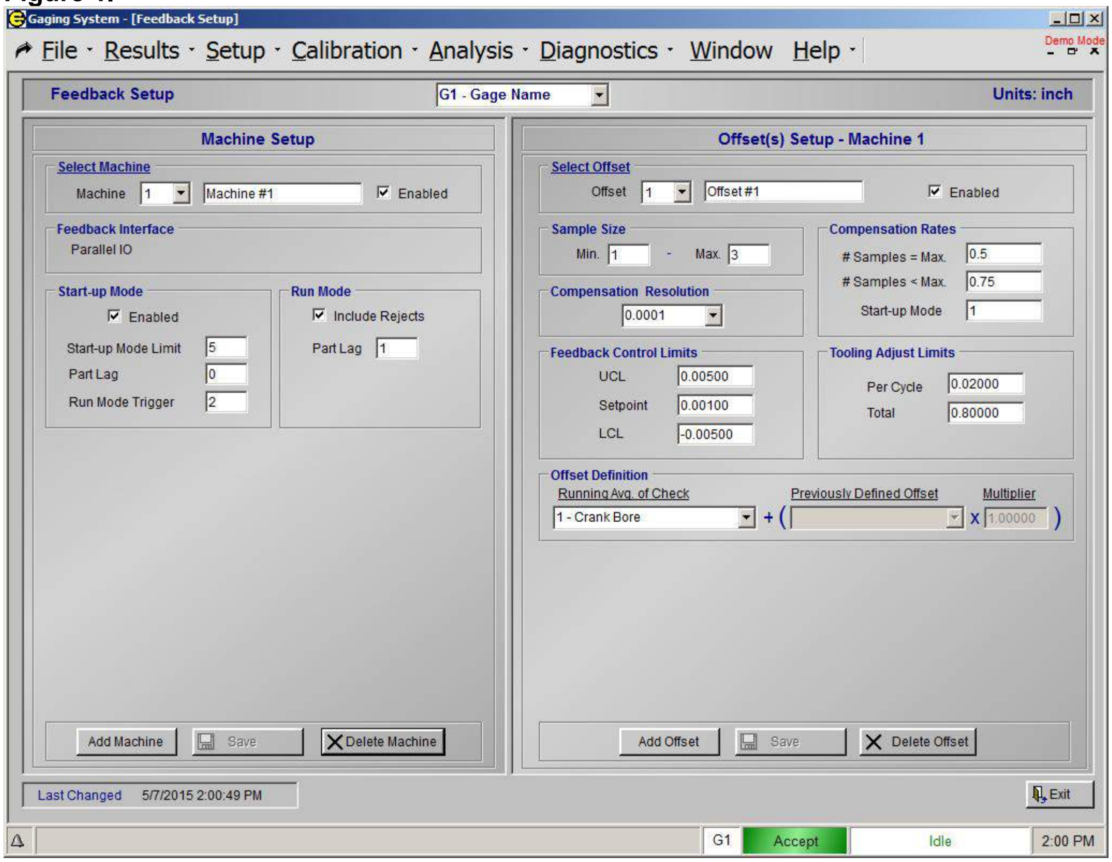
Start-up mode is used to quickly bring the production process under control and produce acceptable parts. Start-up mode differs from run mode in two important ways:

1) A separate, start-up mode compensation rate is used to allow for a different rate of feedback than during run mode.

2) Because reject parts are likely to be produced during start-up mode, they are also included in the running average used to calculate feedback.

If start-up mode is utilized and enabled, and feedback is reset, start-up mode is entered and all accumulated data, such as tooling adjustments and part counters, are cleared. The following example uses one offset defined as Offset #01 to illustrate start-up mode operation (see Figure 1).

Figure 1.



Gaging System - [Feedback Setup]
File Results Setup Calibration Analysis Diagnostics Window Help
Demo Mode
Feedback Setup
G1 - Gage Name
Units: inch
Machine Setup
Select Machine
Machine 1 Machine #1 Enabled
Feedback Interface
Parallel IO
Start-up Mode
Enabled
Start-up Mode Limit 5
Part Lag 0
Run Mode Trigger 2
Run Mode
Include Rejects
Part Lag 1
Add Machine
Save
Delete Machine
Offset(s) Setup - Machine 1
Select Offset
Offset 1 Offset #1 Enabled
Sample Size
Min. 1 - Max. 3
Compensation Resolution
0.0001
Compensation Rates
Samples = Max. 0.5
Samples < Max. 0.75
Start-up Mode 1
Feedback Control Limits
UCL 0.00500
Setpoint 0.00100
LCL -0.00500
Tooling Adjust Limits
Per Cycle 0.02000
Total 0.80000
Offset Definition
Running Avg. of Check
Previously Defined Offset
Multiplier
1 - Crank Bore
1.00000
Add Offset
Save
Delete Offset
Last Changed 5/7/2015 2:00:49 PM
Exit
G1
Accept
Idle
2:00 PM

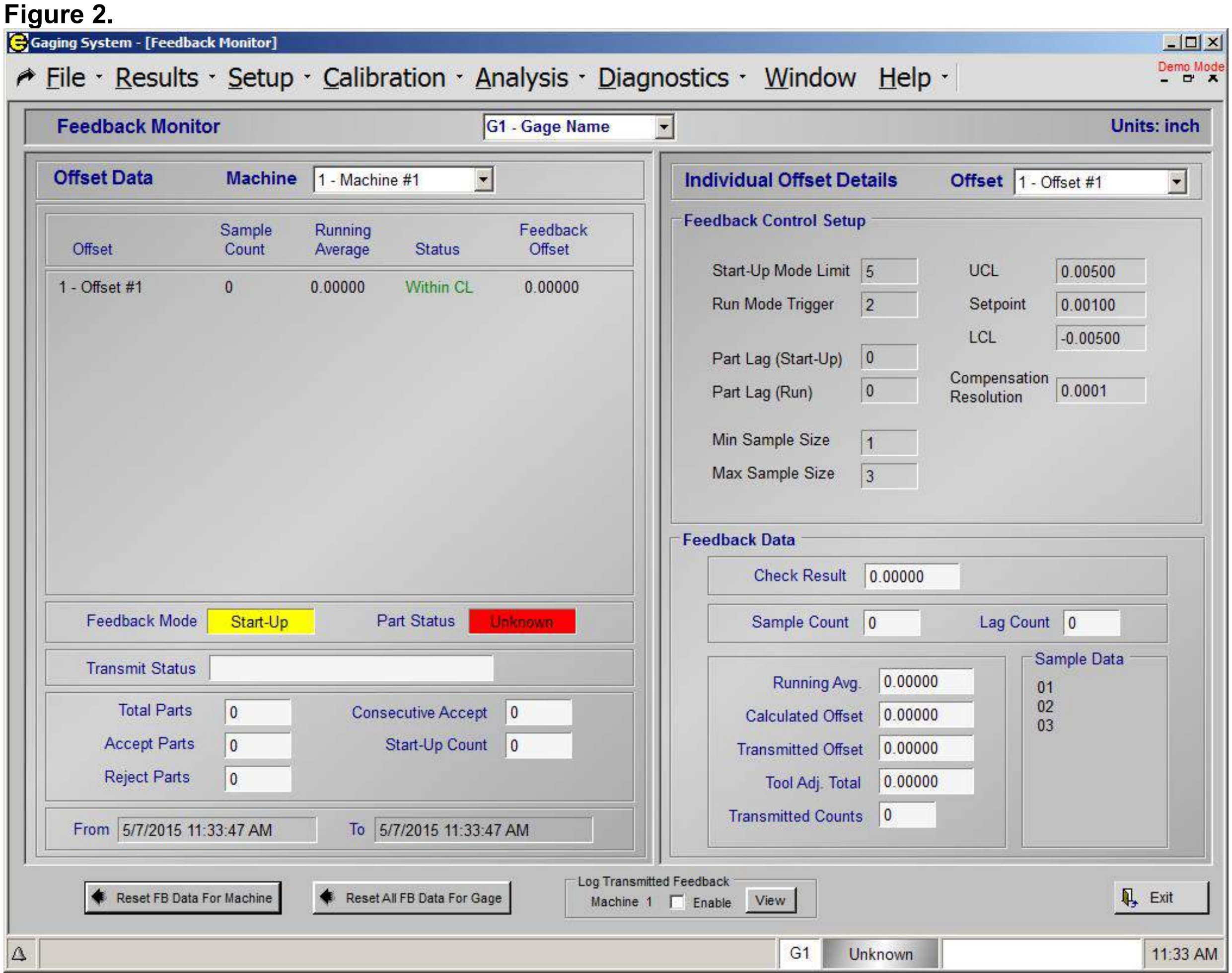
1. **Start-up Mode - initialized**

   On power-up, or when resetting the feedback data in *Feedback Monitor* screen , the feedback data is initialized to the values shown in Figure 2. The part status is “Unknown” and Check result values is 0.000.

   The part counters and sample count are set to 0. The lag count is set to the user defined start-up mode part lag, 0, because after reset, it is assumed that there are no parts waiting to be gaged between the machine and the CAG and, therefore, there is no lag. Initializing the part lag in this manner allows the CAG to include the first part gaged in the feedback algorithm.

   The feedback mode is set to Start-Up mode, and the running average, calculated and transmitted offsets, tool adjustment total, and sample data are all set to 0.

Figure 2.



2. Start-up - First Part (Reject)

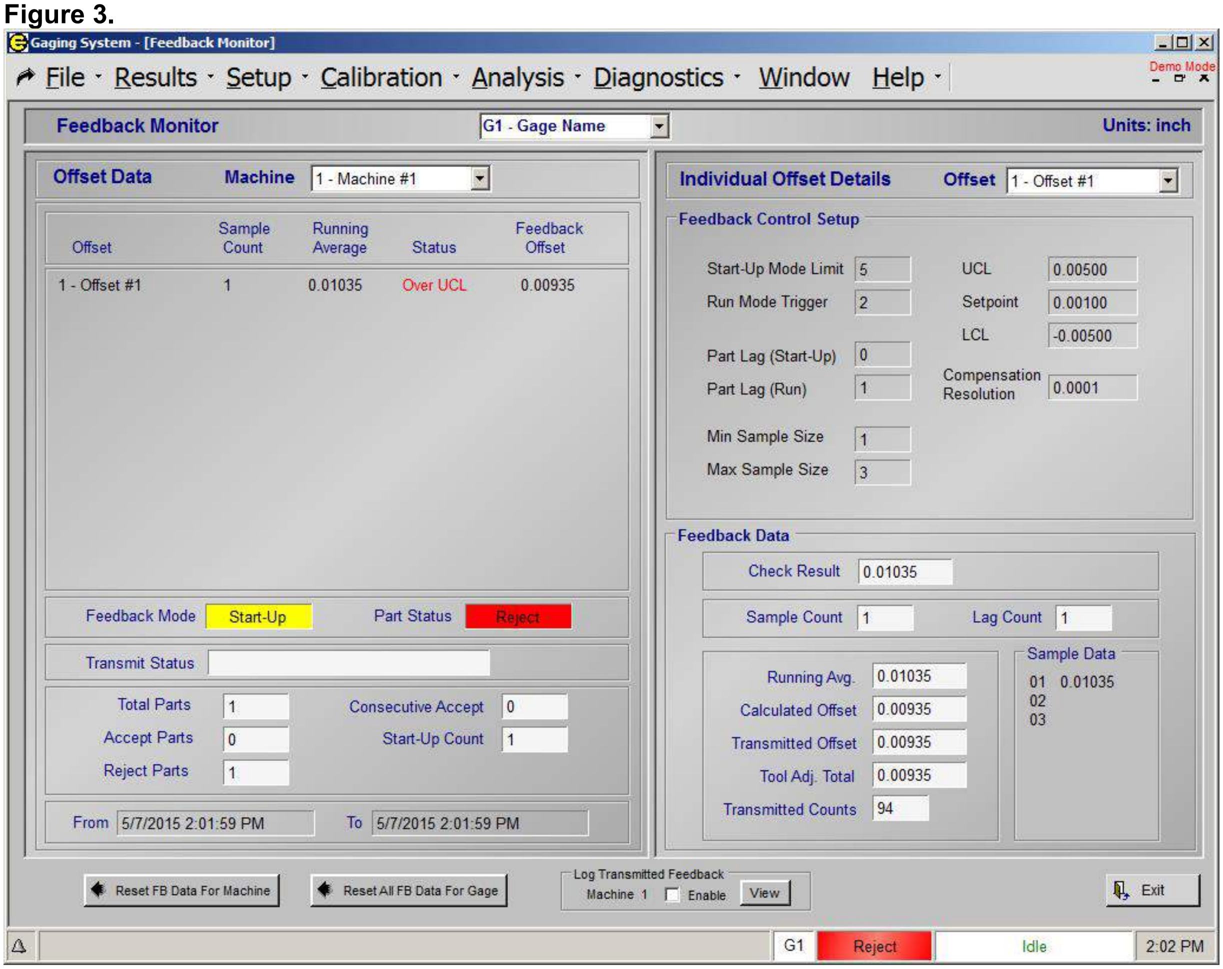
The first part is gaged, the part status is *Reject*, and the Check result is +0.01035. The feedback data is updated as shown in Figure 3.

The part counters were updated as follows: **Total Parts** was incremented from 0 to 1 because a part was gaged, **Consecutive Accept** remained unchanged because the part status was not Accept, and **Start-Up Count** was incremented from 0 to 1 because the part was gaged in START-UP mode.

The sample counters were updated as follows: ***Sample Count*** was incremented from 0 to 1 because the Check result was included in the sample data (Reject parts are used in START-UP mode only), and **Lag Count** was incremented from 0 to 1 because the Lag Count was less than or equal to the user defined start-up mode lag count.

The feedback mode is Start-Up because the **Consecutive Accept** counter, 0, is less than the run mode trigger, 2. The running average, +0.01035, is the average of the sample data. The calculated offset, +0.00935, is the running average minus the setpoint value, +0.00100, multiplied by the start-up mode compensation rate, +1.00000. Feedback is transmitted because the running average exceeds the upper feedback control limit UCL, +0.00500, and the sample count, 1, is greater than or equal to the min sample size, 1.

Figure 3.



3. Start-up - Second Part (Accept)

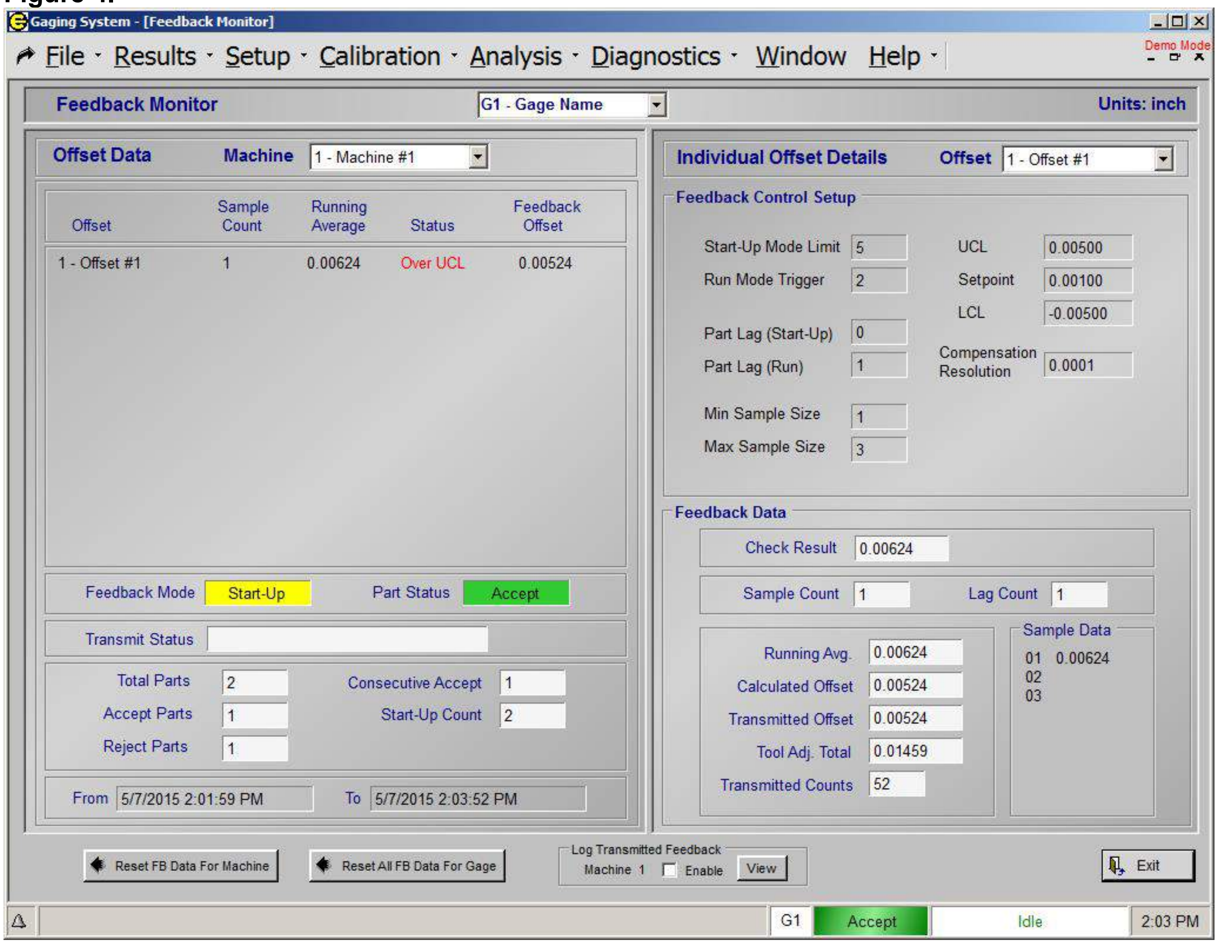
The sample count, lag count, and sample data are reset to 0 when the next part is gaged, because feedback was transmitted on the last gage cycle.

The next part is gaged, the part status is *Accept*, and the Check result is +0.00624. The feedback data is updated as shown in Figure 4.

The part counters were updated as follows: **Total Parts** was incremented from 1 to 2 because a part was gaged, **Consecutive Accept** was incremented from 0 to 1 because the part status was Accept, and **Start-Up Count** was incremented from 1 to 2 because the part was gaged in Start-Up mode.

The sample counters were updated as follows: **Sample Count** was unchanged because the lag count, 0, was less than the start- up mode part lag, 1, and then **Lag Count** was incremented from 0 to 1.

Figure 4.



4. Start-up Mode - Third Part (Accept)

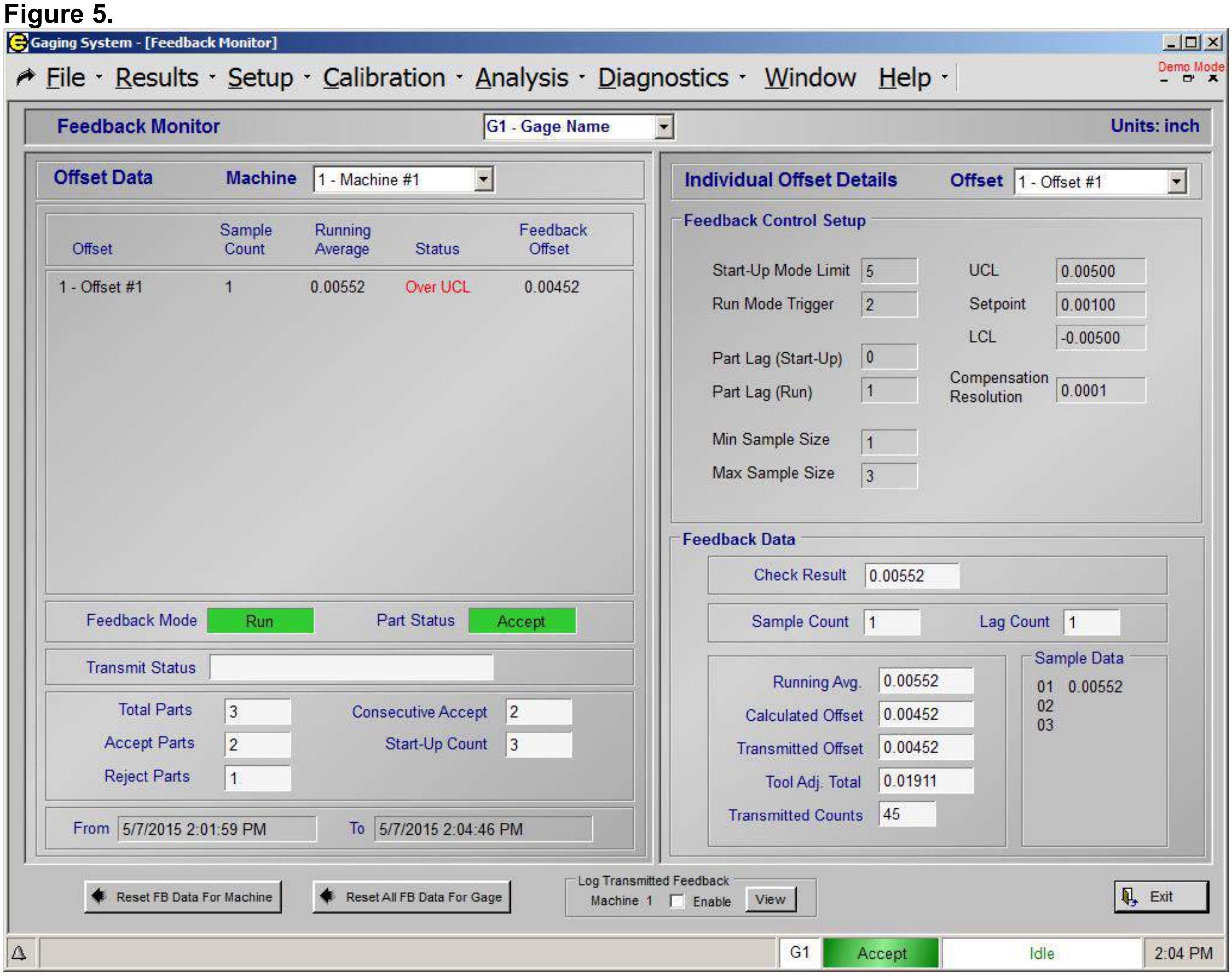
The third part gaged is Accept, and the Check result is +0.00552. The feedback data is updated as shown in Figure 5.

The part counters were updated as follows: **Total Parts** was incremented from 2 to 3 because a part was gaged, **Consecutive Accept** was incremented from 1 to 2 because the part status was Accept, and **Start-Up Count** was incremented to 3 because the part was gaged in **Run** mode.

The sample counters were updated as follows: **Sample Count** was incremented from 0 to 1 because the Check result was included in the sample data, and the **Lag Count** was incremented from 1 to 2 because the Lag Count ,1, was not greater than the user defined start- up mode lag count, 1.

The feedback mode displays **RUN** because the **Consecutive Accept** counter (2) was greater than or equal to the run mode trigger and it will be in Run mode for the next cycle. The running average, +0.00552, is the average of the sample data. The calculated offset, +0.00452, is the running average minus the setpoint value, +0.00100, multiplied by the start- up mode compensation rate, +1.00000. Feedback is transmitted because the running average exceeds the upper feedback control limit UCL, +0.00500, and the sample count, 1, is greater than or equal to the min sample size, 1.

Figure 5.



6.2.2. RUN MODE:

Run mode is used to continuously control the production process to produce acceptable parts as close to the set point as possible. Run mode is entered when the consecutive good counter equals the run mode trigger, and can only return to Start-up mode in three ways:

1) Turn power off and on again.
2) Reset the feedback data through "Reset FB Data" on "Feedback Monitor" screen.
3) Special software to communicate with an external source that instructs the EPIC CAG to reset the feedback data.

EXAMPLE:
This is a continuation of the previous example, with the same feedback setup as in the Start-Up mode section. It will continue from the last gage cycle described in START-UP mode step 5. above, and the feedback data from Figure 5.

1. Run Mode - First Part (Accept)

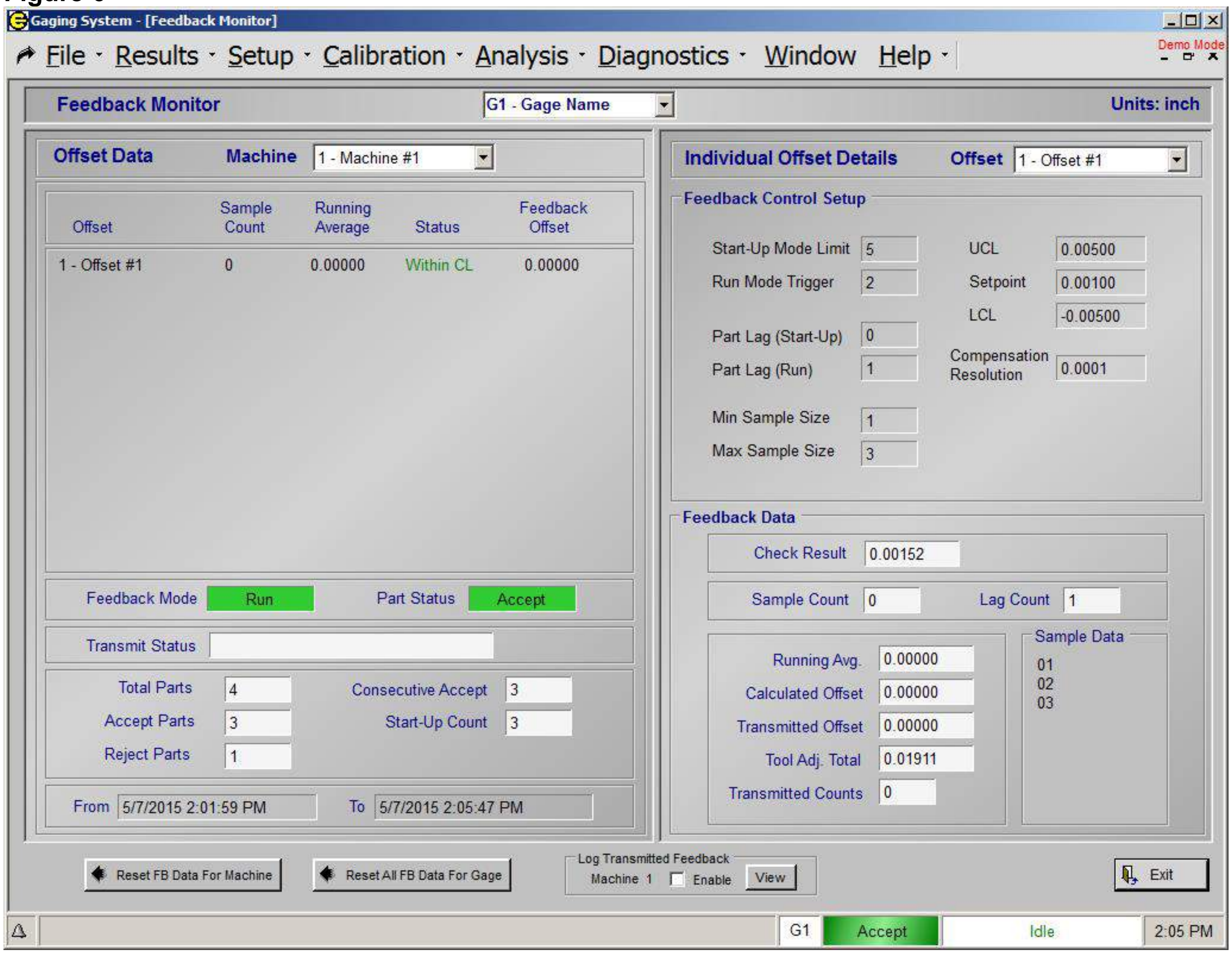
The sample count, lag count, and sample data are reset to 0 when the next part is gaged, because feedback was transmitted on the last gage cycle. The next part is gaged, the part status is Accept, and the Check result is +0.00152. The feedback data is updated as shown in Figure 6.

The part counters were updated as follows: **Total Parts** was incremented from 3 to 4 because a part was gaged, **Consecutive Accept** was incremented from 2 to 3 because the part status was Accept, and Start-Up Count was unchanged.

The sample counters were updated as follows: **Sample Count** was unchanged because the **Lag Count**, 0, was less than the run mode part lag, 1, and then **Lag Count** was incremented from 0 to 1.

NOTE: No Feedback was Calculated/Transmitted because the 1 part Lag (Lag Count set to 1).

Figure 6


Gaging System - [Feedback Monitor]
File Results Setup Calibration Analysis Diagnostics Window Help
Demo Mode
Feedback Monitor
G1 - Gage Name
Units: inch
Offset Data
Machine
1 - Machine #1
Offset
Sample Count
Running Average
Status
Feedback Offset
1 - Offset #1
0
0.00000
Within CL
0.00000
Feedback Mode
Run
Part Status
Accept
Transmit Status
Total Parts
4
Consecutive Accept
3
Accept Parts
3
Start-Up Count
3
Reject Parts
1
From 5/7/2015 2:01:59 PM
To 5/7/2015 2:05:47 PM
Individual Offset Details
Offset
1 - Offset #1
Feedback Control Setup
Start-Up Mode Limit 5
Run Mode Trigger 2
Part Lag (Start-Up) 0
Part Lag (Run) 1
Min Sample Size 1
Max Sample Size 3
UCL 0.00500
Setpoint 0.00100
LCL -0.00500
Compensation Resolution 0.0001
Feedback Data
Check Result 0.00152
Sample Count 0
Lag Count 1
Running Avg. 0.00000
Calculated Offset 0.00000
Transmitted Offset 0.00000
Tool Adj. Total 0.01911
Transmitted Counts 0
Sample Data
01
02
03
Reset FB Data For Machine
Reset All FB Data For Gage
Log Transmitted Feedback
Machine 1
Enable
View
Exit
G1
Accept
Idle
2:05 PM

2. Run Mode - Second Part (Accept)

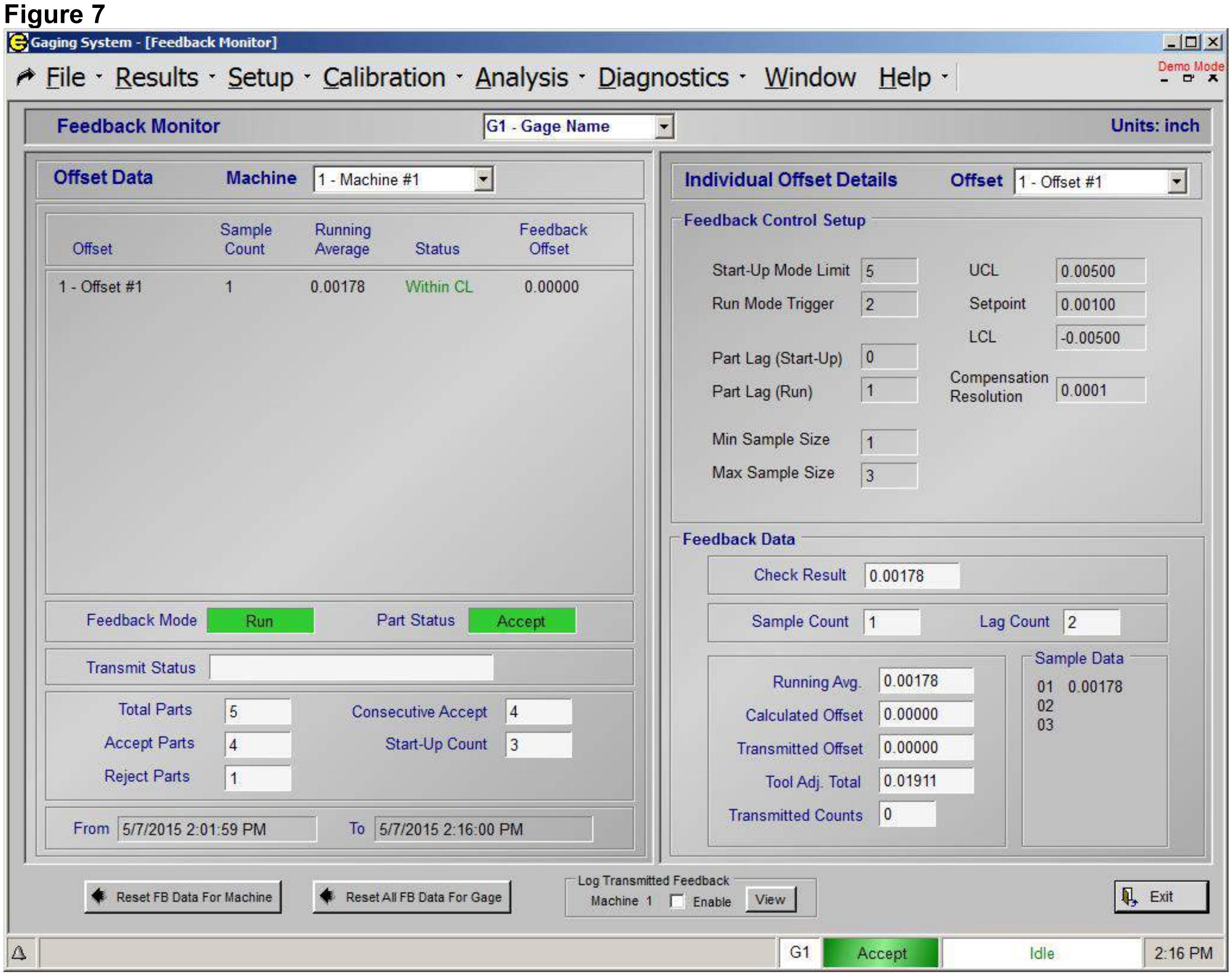
The next part is gaged, the part status is Accept, and the Check result is +0.00178. The feedback data is updated as shown in Figure 7.

The part counters were updated as follows: **Total Parts** was incremented from 4 to 5 because a part was gaged, **Consecutive Accept** was incremented from 3 to 4 because the part status was Accept, and Start-Up Count was unchanged.

The sample counters were updated as follows: **Sample Count** was incremented from 0 to 1 because the Check result was included in sample data, and LAG COUNT was incremented from 1 to 2 because the **Lag Count**, 1, was not greater than the user defined run mode lag count, 1.

The running average, +0.00178, is the average of the sample data. **Feedback is not transmitted because the running average does not violate the feedback control limits**, -0.00500 and +0.00500, and therefore, the calculated offset and transmitted offset are zero.

Figure 7



3. Run Mode - Third Part (Accept)

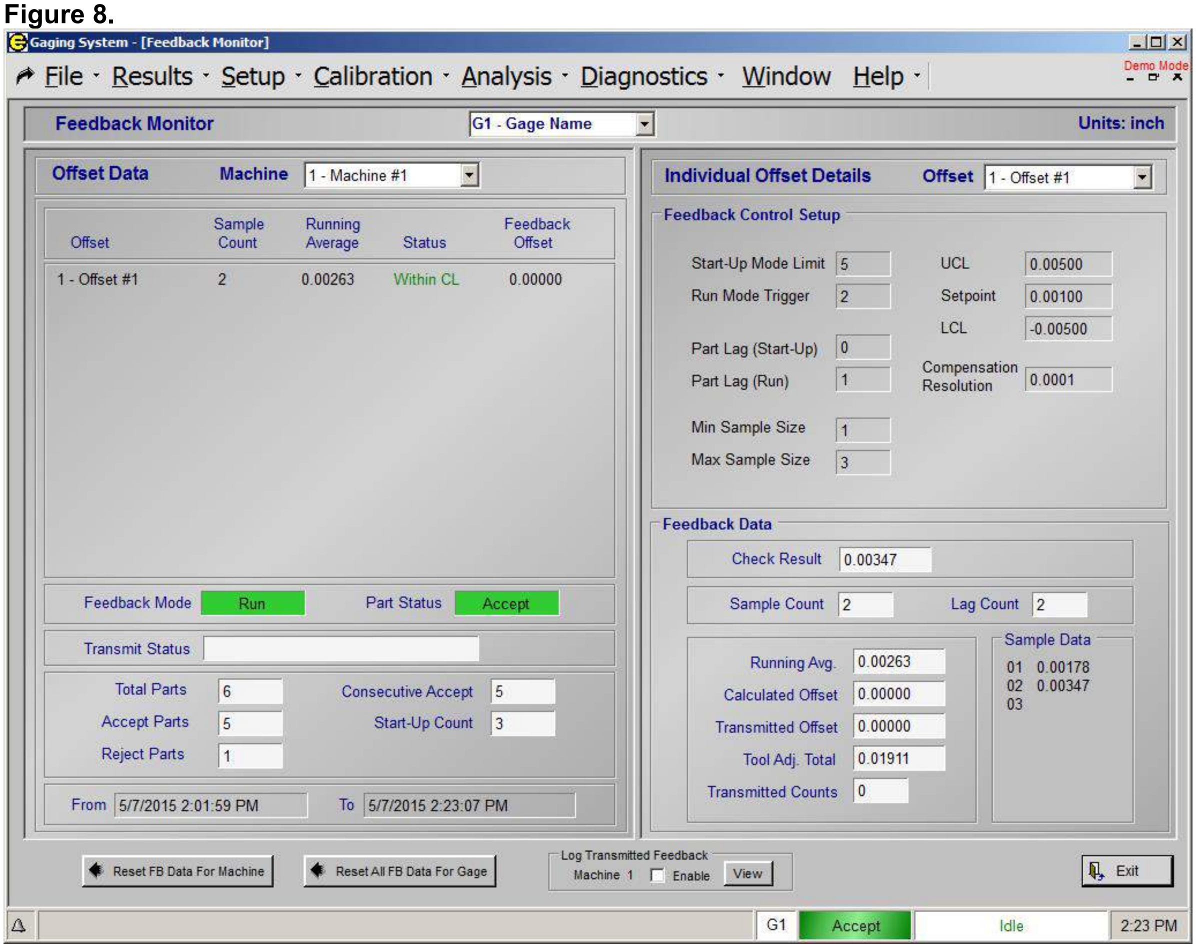
The next part is gaged, the part status is Accept, and the Check result is +0.00347. The feedback data is updated as shown in Figure 8.

The part counters were updated as follows: **Total Parts** was incremented from 5 to 6 because a part was gaged, **Consecutive Accept** was incremented from 4 to 5 because the part status was Accept, and Start-Up Count was unchanged.

The sample counters were updated as follows: **Sample Count** was incremented from 1 to 2 because the Check result was included in the sample data, and Lag Count remained unchanged.

The running average, +0.00263, is the average of the sample data. **Feedback is not transmitted because the running average does not violate the feedback control limits**, -0.00500 and +0.00500, and therefore, the calculated offset and transmitted offset are zero.

Figure 8.



4. Run Mode - Fourth Part (Accept)

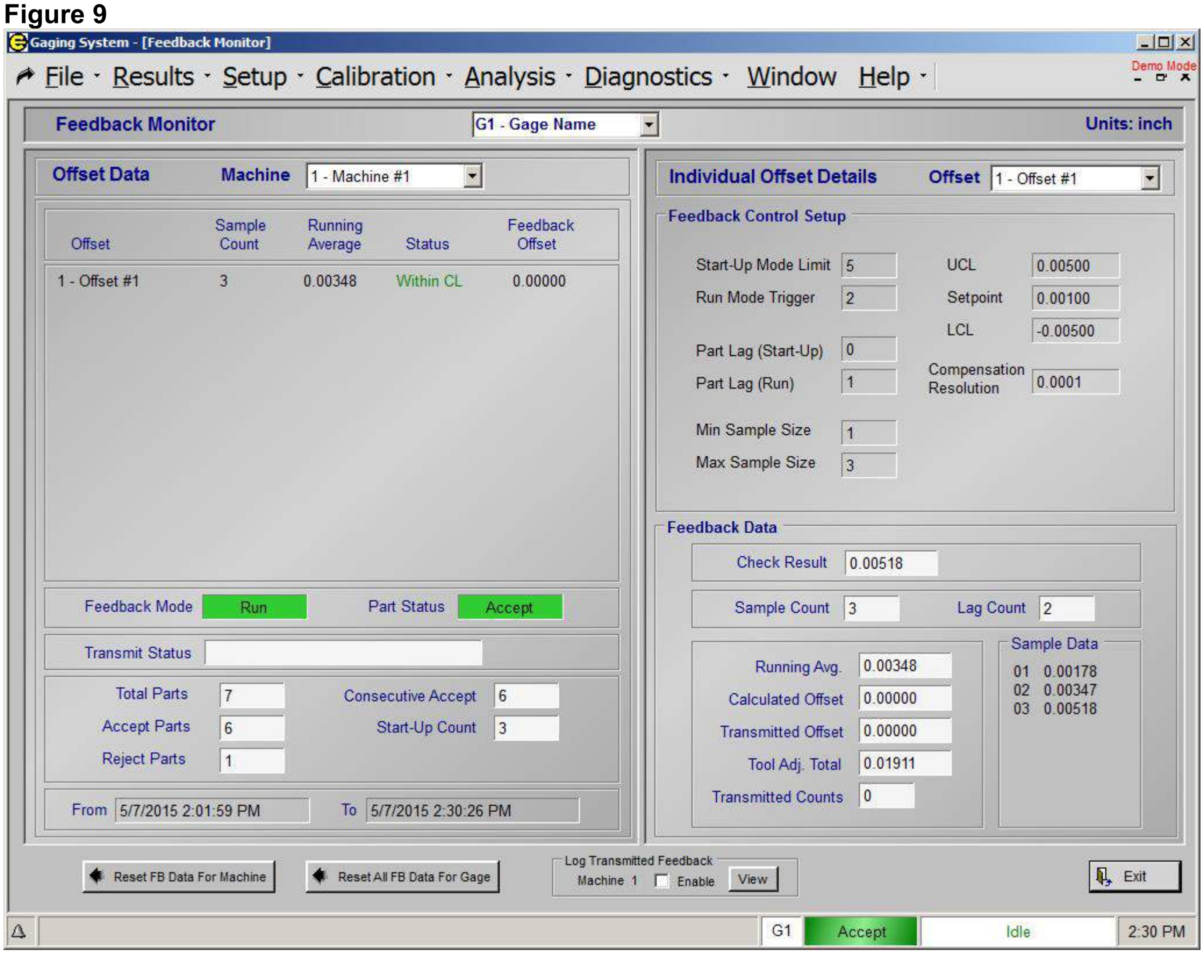
The next part is gaged, the part status is Accept, and the Check result is +0.00518. The feedback data is updated as shown in Figure 9.

The part counters were updated as follows: **Total Parts** was incremented from 6 to 7 because a part was gaged, **Consecutive Accept** was incremented from 5 to 6 because the part status was Accept, and Start-Up Count was unchanged.

The sample counters were updated as follows: **Sample Count** was incremented from 2 to 3 because the Check result was included in the sample data, and Lag Count remained unchanged.

The running average, +0.00348, is the average of the sample data. **Feedback is not transmitted because the running average does not violate the feedback control limits**, -0.00500 and +0.00500, and therefore, the calculated offset and transmitted offset are zero.

Figure 9



5. Run Mode - Fifth Part (Accept)

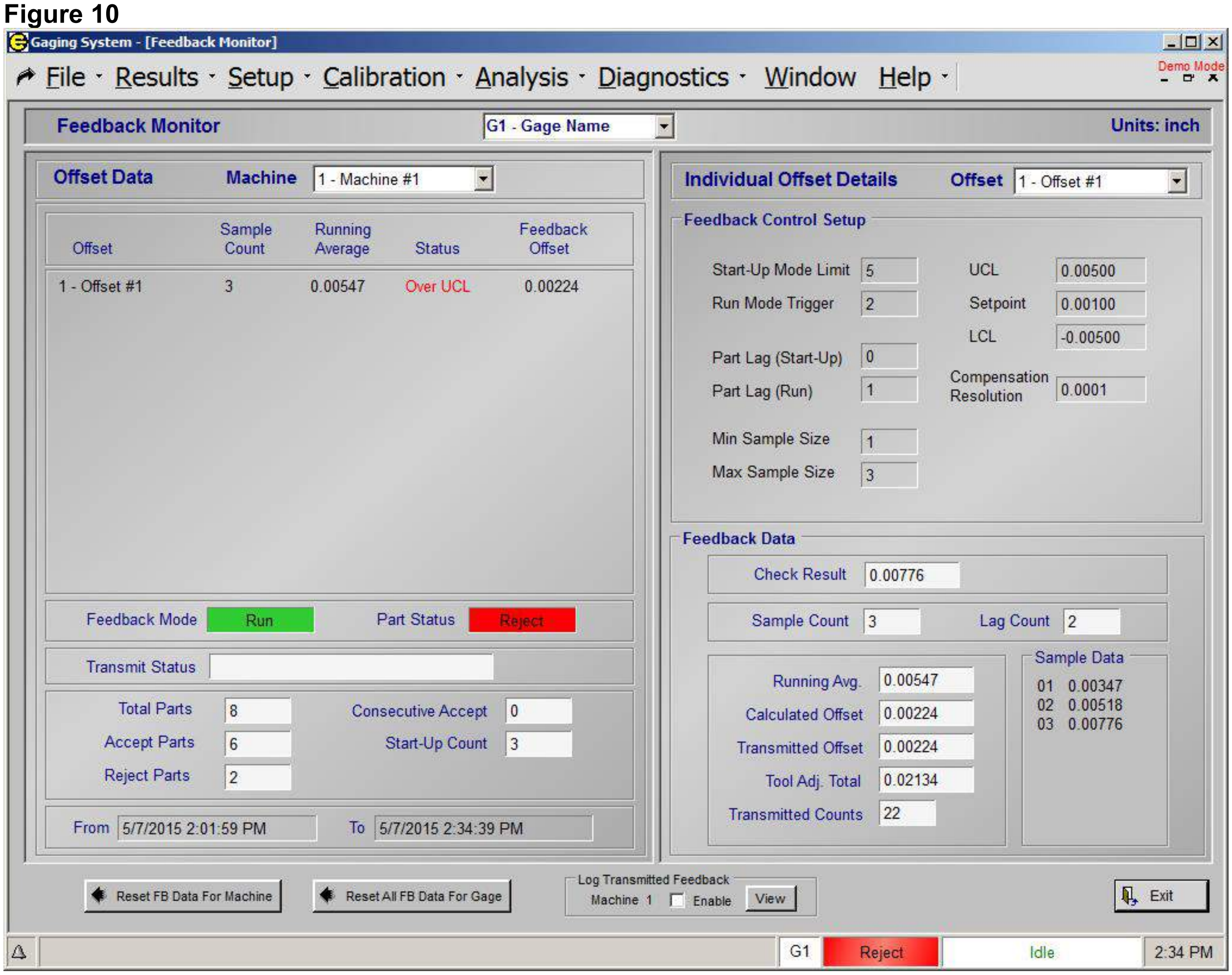
The next part is gaged, the part status is Accept, and the Check result is +0.00776. The feedback data is updated as shown in Figure 10.

The part counters were updated as follows: **Total Parts** was incremented from 7 to 8 because a part was gaged, **Consecutive Accept** was incremented from 6 to 7 because the part status was Accept, and Start-Up Count was unchanged.

The sample counters were updated as follows: **Sample Count** was unchanged because it already equals the max sample size of 3, and Lag Count remained unchanged.

The running average, +0.00547, is the average of the sample data. The calculated offset, +0.00224, is the running average minus the setpoint value, multiplied by the #SAMPLES = MAX compensation rate of +0.50000. ((0.00547 - 0.00100) * 0.50000) = 0.00223. Feedback is transmitted because the running average exceeds the upper feedback control limit UCL, +0.00500, and the sample count, 3, is greater than or equal to the min sample size, 1.

Figure 10



7. SECTION : Feedback Interfaces

7.1. G.E. Fanuc FOCAS2 Interface

7.1.1. Introduction and Interface Protocol:

The Focas2 interface between the EPIC CAG™ and the G.E. Fanuc control will require an Ethernet connection and the G.E. Fanuc control's "Custom Macro" option. Either the embedded Ethernet or the Fast Ethernet option (J909) can be used on the G.E. Fanuc control. The IP address, Port number and Path of the Fanuc Control are programmable values within the EPIC software running on the CAG. The EPIC CAG can be programmed to read and write to macro variable addresses located in the G.E. Fanuc control.

Feedback compensation parameters defined on the CAG™ can have an associated macro variable address assigned as part of the setup.

In practice, the EPIC CAG™ will complete a measurement cycle and use the new data to determine if Tool Compensation is required.

The EPIC CAG™ will solicit the Fanuc Control macro variable "Data Available" to determine if the previous Tool Compensation data has been read. A value of 1.0 indicates that the previous data has not been read by the Machine Tool Macro. The Machine Tool is responsible to reset this variable to 0.0 after reading the Tool compensation offset macro variables. The EPIC CAG™ will solicit this variable once per measurement cycle. If the previous data has not been read by the Machine Tool then the EPIC CAG™ will not solicit this variable again until the completion of the next measurement cycle. The running average will not be reset.

If the "Data Available" variable equals 0.0 then the previous data has been read by the Machine Tool Macro.

The EPIC CAG™ will update the Tool Compensation Offset Macro variables with the new compensation values. If compensation is not required for any given offset, then a value of 0.0 will be written. The EPIC CAG™ will update the "Data Available" macro variable to a value of 1.0 after the new compensation data has been written.

A "Machine Feedback Reset" macro variable can be assigned in the EPIC CAG™ to indicate a Tool change. The Machine Tool will set this variable to 1.0 whenever a tool change occurs. The CAG™ will solicit this macro variable at the beginning of a measurement cycle to determine if the accumulated feedback data for all offsets should be reset. The CAG™ will set the "Feedback Reset" variable to 0.0 at the completion of the reset.

An "Offset Feedback Reset" macro variable can be assigned in the EPIC CAG™ to indicate an individual Offset Date reset is required. The Machine Tool will set this variable to 1.0 whenever the Offset data is required to be reset. The CAG™ will solicit this macro variable at the beginning of a measurement cycle to determine if the accumulated feedback data should be reset. The CAG™ will set the "Offset Feedback Reset" variable to 0.0 at the completion of the reset.

This interface can accommodate up to 16 Machine Tool Offsets. A maximum of 34 macro variables will be required: Data Available, Machine Data Reset, Offset #1 thru Offset #16, Offset Data Reset #1 thru #16.

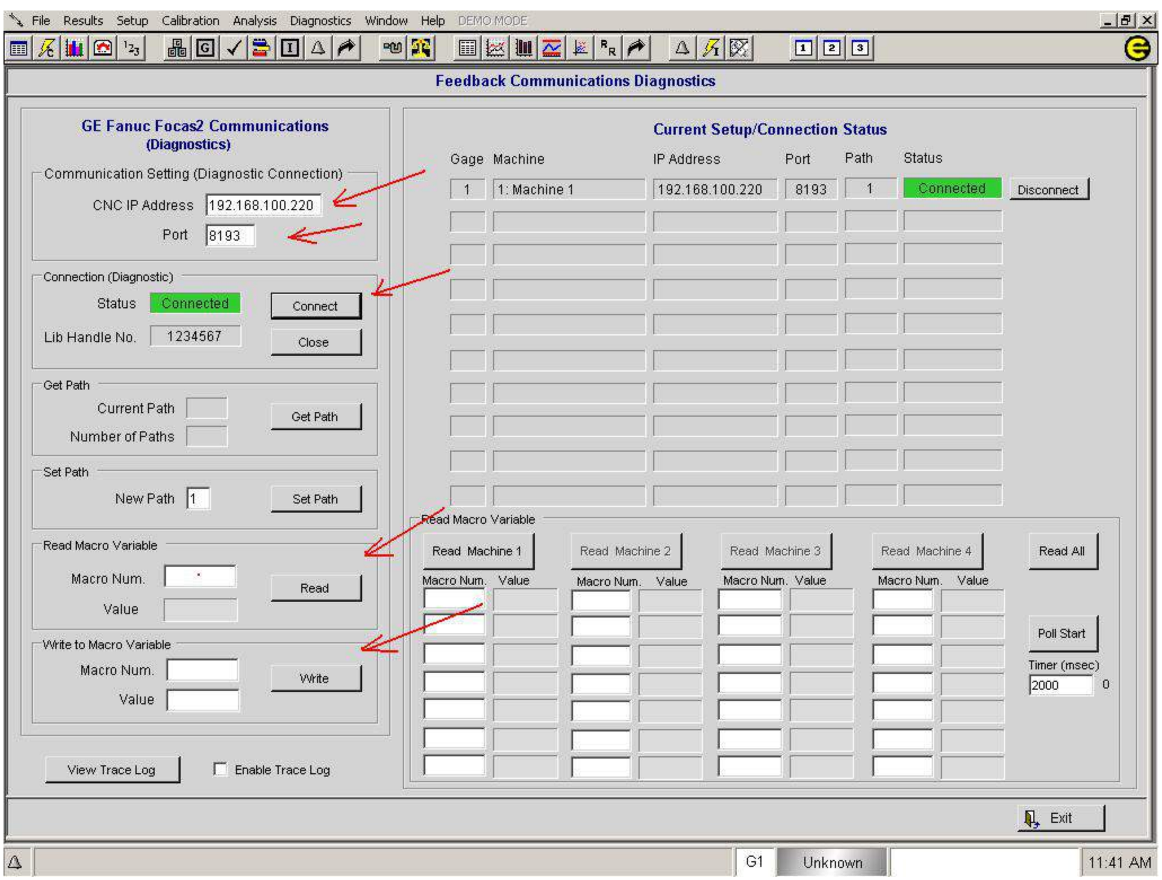
7.1.2. Initial Setup and Establishing Communications:

System Requirements:

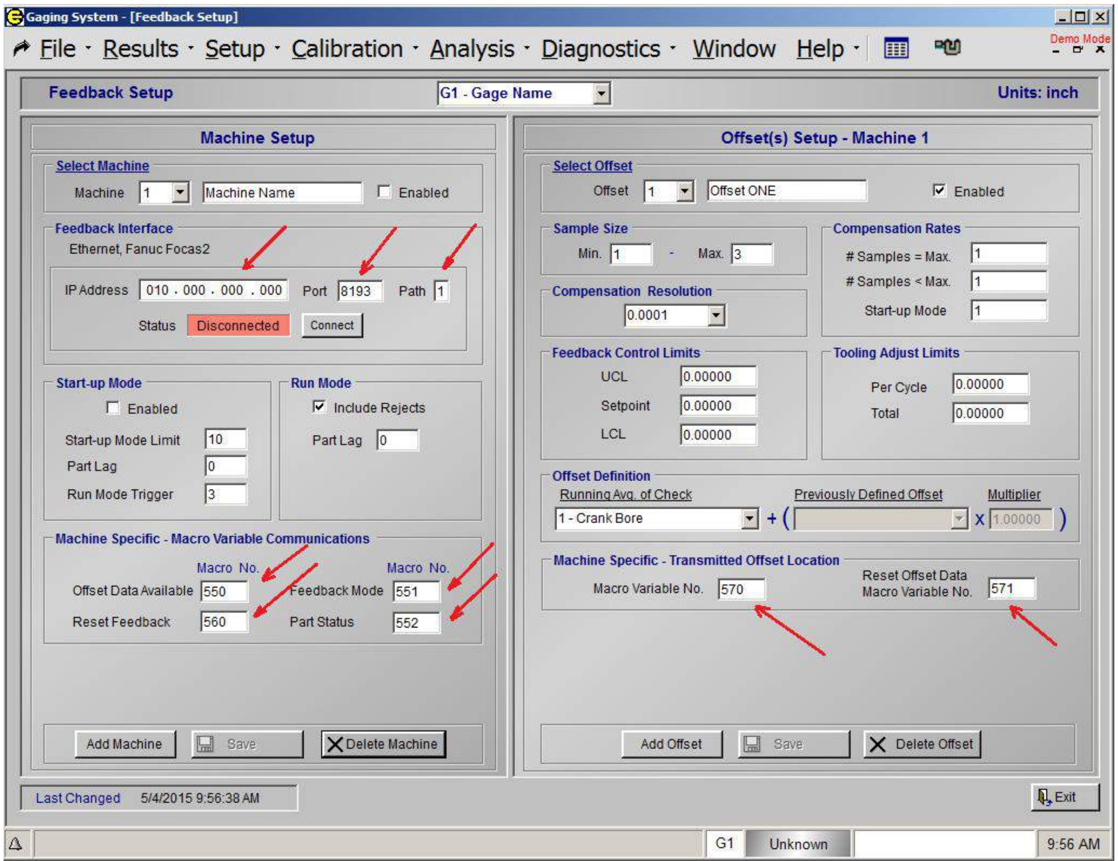
-Edmunds EPIC CAG™: Optional Focas2 Feedback module installed.

-G.E. Fanuc controller with Fanuc control's "Custom Macro" option and either the embedded Ethernet or the Fast Ethernet option (J909).

1. Determine/Report the IP Address, Port and Path of the Fanuc controller.
2. Set the IP Address of the EPIC CAG™ unit. The IP Address of the CAG unit will need to be compatible with the Fanuc controller (first three sets of numbers in the addresses need to match) Example: Fanuc controller IP Address: 192.168.100.220, CAG™ unit IP Address: 192.168.100.221. See (**APPENDIX B)** for instructions on setting the CAG IP Address.
3. Test the communications using EPIC Feedback Communications Diagnostics screen:
   a. Enter menu "Diagnostics" – "Feedback Communications" in the EPIC software.
   b. Enter the CNC IP Address (address of the Fanuc Controller) and Port number.
   c. Click on the "Connect" button. Status should display "Connected" if communication was established. If connection fails, verify IP Addresses and Port number of both the Fanuc controller and the EPIC CAG™ and also verify the Ethernet cable is connected correctly.
   d. Test Write/Read of data to the controller macro variables. In the "Write Macro Variable" box, enter macro number and value to write. Click on "Write" button. Read back that value by entering the macro number in the "Read Macro Variable" box and click on the "Read" button.



7.1.3. Focas2 Feedback Setup In EPIC Software:



7.1.3.1. Machine Specific - Macro Variable Communications

Offset Data Available - Macro variable number on host Fanuc Controller (Machine). A non-zero value will be written to this macro variable when offset data is available. The host machine will read this variable, if the value is non-zero, the offset data will be read and applied. The macro variable value will then be set to zero by the host machine.

Reset Feedback - Macro variable number on host Fanuc Controller (Machine). A non-zero value will be written to this macro variable when offset data is available. The host machine will read this variable, if the value is non-zero, the offset data will be read and applied. The macro variable value will then be set to zero by the host machine.

Feedback Mode - Macro variable number on host Fanuc Controller (Machine). The Feedback Mode (Startup or Run) will be written to this marco variable when feedback data is available.
Run Mode = 1
Start-up Mode = 2
If Macro variable number is zero '0', Mode will not be written (disabled)

Part Status - Macro variable number on host Fanuc Controller (Machine).The Part Status will be written to this marco variable when feedback data is available.
Unknown = 0
Accept = 1
Reject = 2
Flyer = 3
If Macro variable number is zero '0', Status will not be written (disabled)

7.1.3.2. Machine Specific - Transmitted Offset Locations

Macro Variable No. - Macro variable number on host Fanuc Controller (Machine). The Feedback Offset value will be written to this macro variable. The value in the macro variable will be used to adjust the tooling offset in the machine.

Reset Offset Data Macro Variable No. - Macro variable number on host Fanuc Controller (Machine). The value of this marco variable will be read, if it is non-zero offset sample data will be reset. If macro variable number is set to zero, variable will not be read (reset function disabled).

7.1.4. Example Macro Program for Reading Feedback Offsets.

Note: this program should be used for reference only, actual variable number will differ.

Macro Variable numbers used in the following example program:
Data Available: 550
Offset #1: 570
Offset #2: 572
Offset #3: 574
Offset #4: 576
Offset #5: 578
Reset Feedback: 560

Tool Wear Offset Variables:
Tool Offset #1: 2001
Tool Offset #2: 2002
Tool Offset #3: 2003
Tool Offset #4: 2004
Tool Offset #5: 2005

```
:9500(EDMUNDS GAGE - FB MACRO)
(REV.A, 09/29/11)

(TEST FOR FEEDBACK)
(LOOK AT DATA AVAL)
IF[#550EQ1.0]GOTO210
```

```
GOTO220

N210
(SET FEEDBACK OFFSET'S)
(ADD NEW OFFSET TO TOOL OFFSET)
(OFFSET #1)
#2001=[#2001+ #570]
(OFFSET #2)
#2002=[#2002+ #572]
(OFFSET #3)
#2003=[#2003+ #574]
(OFFSET #4)
#2004=[#2004+ #576]
(OFFSET #5)
#2005=[#2005+ #578]

 (RESET - DATA AVAIL.)
#550=0

(RESET EDMUNDS OFFSET VARIABLE)
#570=0
#572=0
#574=0
#576=0
#578=0
GOTO999

N220
(TEST FOR TOOL CHANGE)
(CODE HERE TO DETERMINE IF TOOL CHANGE AND RESET FEEDBACK NEEDED)
*
*
*
*
(IF RESET NEEDED – RESET FEEDBACK ALL TOOLS)
#560=1.0
#570=0
#572=0
#574=0
#576=0
#578=0

GOTO 999
N999
M99
```

7.2. Edmunds AB EtherNet/IP Feedback Interface

CAG (EPIC) <-- --> Allen Bradley ControlLogix Controller (PLC)

7.2.1. Introduction and Interface Protocol:

The EtherNet/IP interface between the Edmunds CAG and the ControlLogix control will require an Ethernet connection. The IP address and CPU slot of the ControlLogix control are programmable values within the EPIC software running on the CAG. The Edmunds CAG can be programmed to read and write to Tag variables located in the ControlLogix control.

Feedback compensation parameters defined on the CAG can have an associated Tag names assigned as part of the setup.

In practice, the Edmunds CAG will complete a measurement cycle and use the new data to determine if Tool Compensation is required.

The Edmunds CAG will solicit the ControlLogix control Tag “Data Available” to determine if the previous Tool Compensation data has been read. A value of 1.0 indicates that the previous data has not been read by the Machine Tool Macro. The Machine Tool is responsible to reset this Tag to 0.0 after reading the Tool compensation offset Tag variables. The Edmunds CAG will solicit this variable once per measurement cycle. If the previous data has not been read by the Machine Tool then the Edmunds CAG will not solicit this variable again until the completion of the next measurement cycle. The running average will not be reset.

If the “Data Available” Tag equals 0.0, then the previous data has been read by the Machine Tool.

The Edmunds CAG will update the Tool Compensation Offset Tag variables with the new compensation values. If compensation is not required for any given offset, then a value of 0.0 will be written. The Edmunds CAG will update the “Data Available” Tag to a value of 1.0 after the new compensation data has been written.

A “Machine Feedback Reset” Tag can be assigned in the Edmunds CAG to indicate a Tool change. The Machine Tool will set this Tag to 1.0 whenever a tool change occurs. The CAG will solicit this Tag at the beginning of a measurement cycle to determine if the accumulated feedback data for all offsets should be reset. The CAG will set the “Feedback Reset” Tag to 0.0 at the completion of the reset.

An “Offset Feedback Reset” Tag variable can be assigned in the Edmunds CAG to indicate an individual Offset Date reset is required. The Machine Tool will set this Tag to 1.0 whenever the Offset data is required to be reset. The CAG will solicit this Tag at the beginning of a measurement cycle to determine if the accumulated feedback data should be reset. The CAG will set the “Offset Feedback Reset” Tag to 0.0 at the completion of the reset.

This interface can accommodate up to 16 Machine Tool Offsets. A maximum of 34 Tag variables will be required: Data Available, Machine Data Reset, Offset #1 thru Offset #16, Offset Data Reset #1 thru #16.

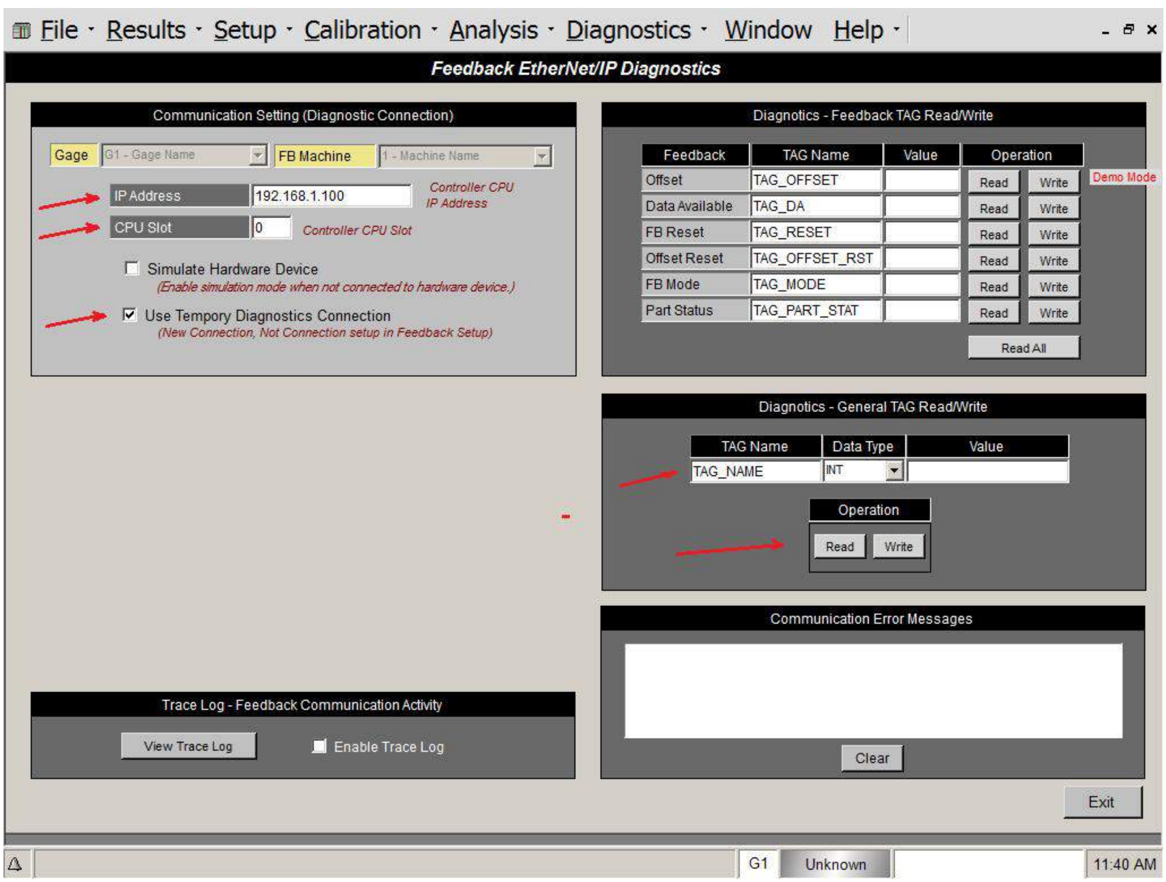
7.2.2. Initial Setup and Establishing Communications:

System Requirements:

-Edmunds EPIC CAG: Optional AB EtherNet/IP Feedback module installed.

-AB ControlLogix Controller

4. Determine/Report the IP Address and CPU slot of the ControlLogix controller.
5. Set the IP Address of the EPIC CAG unit. The IP Address of the CAG unit will need to be compatible with the ControlLogix controller (first three sets of numbers in the addresses need to match) Example: ControlLogix controller IP Address: 192.168.100.220, CAG unit IP Address: 192.168.100.221. See (**APPENDIX B)** for instructions on setting the CAG IP Address.
6. Test the communications using EPIC Feedback EtherNet/IP Diagnostics screen:
   a. Enter menu "Diagnostics" – "Feedback AB EtherNet/IP Diag" in the EPIC software.
   b. Enter the CNC IP Address (address of the AB ControlLogix Controller) and CPU Slot number.
   c. Select "Use Temporary Diagnostics Connection"
   d. Test Write/Read of data to the controller Tag variables. In the "Diagnostics – General TAG Read/Write" box, enter Tag name and value to write. The Tag variable must exist on the controller. Click on "Write" button. Read back that value by entering the "Read" button.



7.2.3. AB EtherNet/IP Feedback Setup In EPIC Software:

TAG Usage:

Offset Data Avail: TAG Name associated with TAG on Machine Control PLC Controller.
A non-zero value will be written to this Tag when offset data is available.
The host machine will read this Tag, if the value is non-zero, the offset data will be read and applied.
The Tag value will then be set to zero by the host machine.

Reset Feedback: TAG Name associated with TAG on Machine Control PLC Controller.
A non-zero value will be written to this Tag when offset data is available.
The host machine will read this Tag, if the value is non-zero, the offset data will be read and applied.
The Tag value will then be set to zero by the host machine.

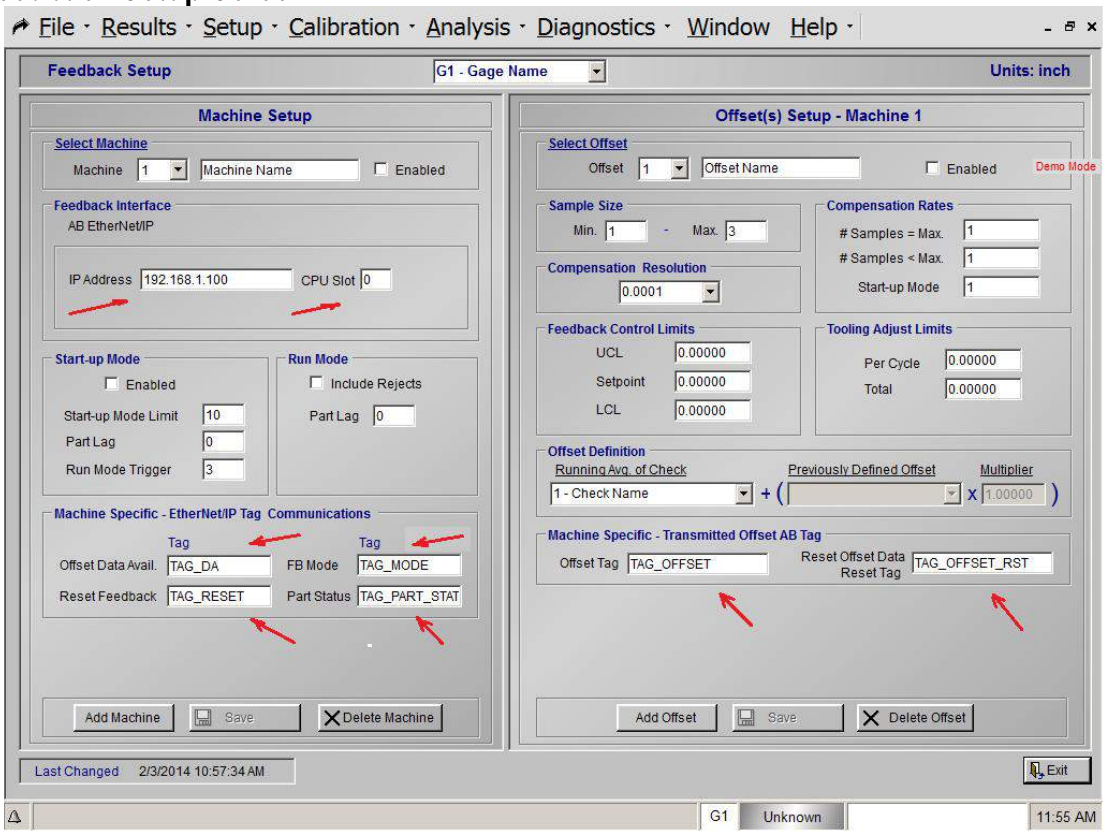
FB Mode: TAG Name associated with TAG on Machine Control PLC Controller.
The Feedback Mode (Startup or Run) will be written to this Tag when feedback data is available.
Run Mode = 1
Start-up Mode = 2
If the Tag Name is set to "None", the mode will not be written.

Part Status: TAG Name associated with TAG on Machine Control PLC Controller.
The Part Status will be written to this Tag when feedback data is available.
Unknown = 0
Accept = 1
Reject = 2
Flyer = 3
If the Tag Name is set to "None", the Status will not be written.

Offset Tag: TAG Name associated with TAG on Machine Control PLC Controller.
The calculated feedback offset value will be written to this Tag. The value in the Tag will be used to adjust the tooling offset in the machine.

Reset Offset Data: TAG Name associated with TAG on Machine Control PLC Controller.
The value of this Tag will be read, if it is non-zero offset sample data will be reset.
If the Tag Name is set to "None", the Tag will not be
read (reset function disabled).

Feedback Setup Screen



7.3. Edmunds - Okuma Thinc Feedback Interface

7.3.1. Introduction and Interface Protocol:

The Okuma Thinc interface between the Edmunds CAG™ and the Okuma P200/P300 control will require an Ethernet connection and the Okuma control running the Okuma Thinc API drivers and Edmund-Okuma Server application. The IP address and Port number of the Okuma control are programmable values within the EPIC software running on the CAG.™ The Edmunds CAG™ can be programmed to read and write to common variables located in the Okuma control.

Feedback compensation parameters defined on the CAG can have an associated common variable number assigned as part of the setup.

In practice, the Edmunds CAG™ will complete a measurement cycle and use the new data to determine if Tool Compensation is required.

The Edmunds CAG™ will solicit the Okuma control common variable "Data Available" to determine if the previous Tool Compensation data has been read. A value of "1" indicates that the previous data has not been read by the Okuma Macro. The Okuma is responsible to reset this variable to "0" after reading the Tool compensation offset common variables. The Edmunds CAG™ will solicit this variable once per measurement cycle. If the previous data has not been read by the Okuma then the Edmunds CAG™ will not solicit this variable again until the completion of the next measurement cycle. The running average will not be reset.

If the "Data Available" common variable equals "0" then the previous data has been read by the Okuma Macro.

The Edmunds CAG™ will update the Tool Compensation Offset common variable with the new compensation values. If compensation is not required for any given offset, then a value of "0" will be written. The Edmunds CAG will update the "Data Available" common variable to a value of "1" after the new compensation data has been written.

A "Machine Feedback Reset" common variable can be assigned in the Edmunds CAG™ to indicate a Tool change. The Machine Tool will set this variable to "1" whenever a tool change occurs. The CAG™ will solicit this common variable at the beginning of a measurement cycle to determine if the accumulated feedback data for all offsets should be reset. The CAG™ will set the "Feedback Reset" variable to "0" at the completion of the reset.

An "Offset Feedback Reset" common variable can be assigned in the Edmunds CAG™ to indicate an individual Offset Date reset is required. The Machine Tool will set this variable to 1.0 whenever the Offset data is required to be reset. The CAG™ will solicit this common variable at the beginning of a measurement cycle to determine if the accumulated feedback data should be reset. The CAG™ will set the "Offset Feedback Reset" variable to 0.0 at the completion of the reset.

This interface can accommodate up to 16 Machine Tool Offsets. A maximum of 34 common variable will be required: Data Available, Machine Data Reset, Offset #1 thru Offset #16, Offset Data Reset #1 thru #16.

7.3.2. Initial Setup and Establishing Communications:

System/Software Requirements:

- Edmunds EPIC CAG™ with Okuma Thinc feedback option.
- Okuma P200/P300 control
- Okuma Thinc API drivers installed on Okuma controller
- Edmunds-Okuma Server application installed on Okuma controller.

1. Install the Edmunds-Okuma Server application on the Okuma controller. See (**Section 3.3.4 below)** for the Edmunds-Okuma Server setup instructions.

2. Determine/Report the IP Address, Port of the Okuma controller.

3. Set the IP Address of the EPIC CAG unit. The IP Address of the CAG™ unit will need to be compatible with the Okuma controller (first three sets of numbers in the addresses need to match) Example: Okuma controller IP Address: 192.168.100.220, CAG unit IP Address: 192.168.100.221. See (**APPENDIX B)** for instructions on setting the CAG IP Address.

4. Test the communications:

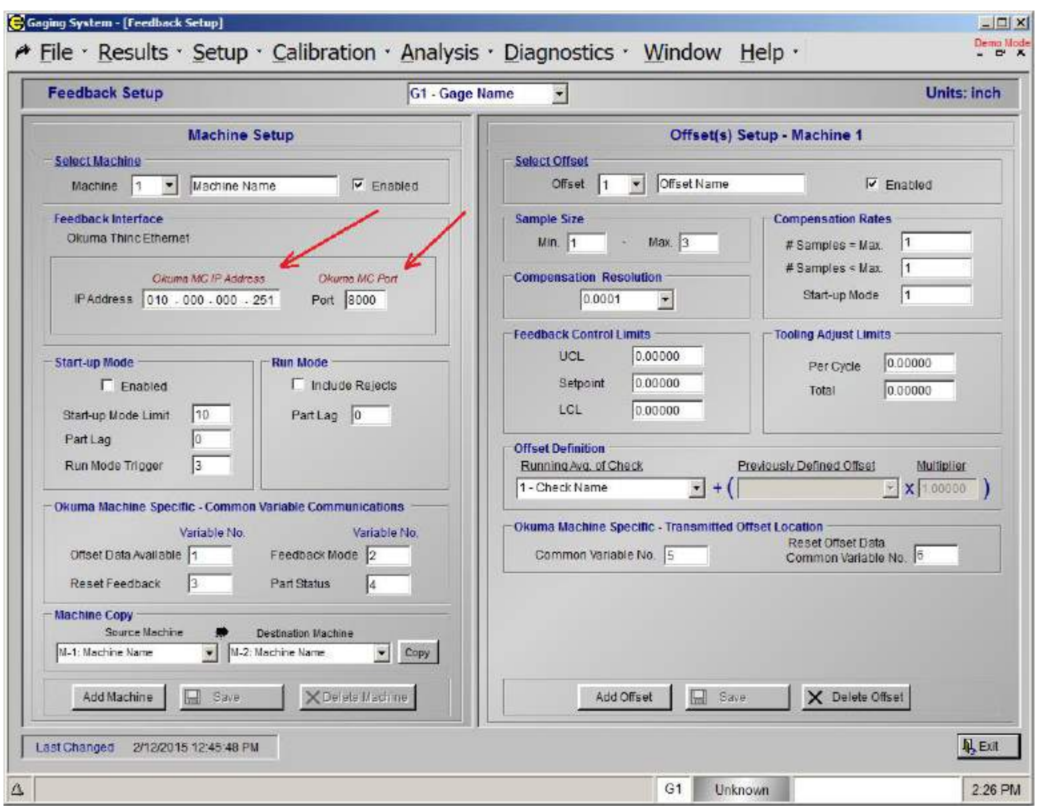
a) Enter menu "Setup" – "Feedback Setup" in the EPIC software.

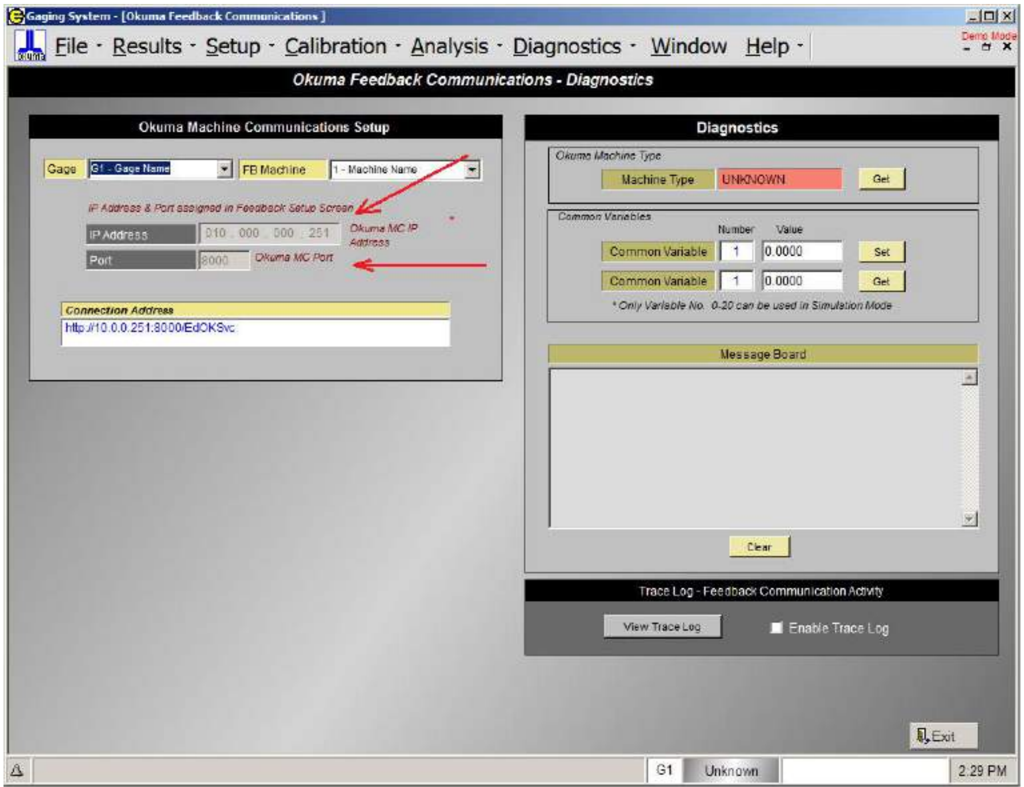
b) Enter the Okuma IP Address and Port number. Select SAVE.

c) Enter menu "Diagnostics" – "Okuma Feedback Diagnostics" in the EPIC Software.

d) Click on the "Get" button in the "Okuma Machine Type" box. Machine Type should display "Lathe" or "Machine Center".

e) Test Set/Get of data to the controller common variables. In the "Common Variables" box, enter common variable number and value to write. Click on "Set" button. Read back that value by entering the common variable number and click on the "Get" button.





7.3.3. Okuma Thinc Feedback Setup In EPIC Software:

Okuma Common Variable Usage:

Offset Data Avail: Common variable number associated with common variable on Okuma controller.
A non-zero value will be written to this common variable when offset data is available.
The Okuma control will read this common variable, if the value is non-zero, the offset data will be read and applied. The common variable value will then be set to zero by the Okuma control.

Reset Feedback: Common variable number associated with common variable on Okuma controller.
A non-zero value will be written to this common variable when offset data is available.
Okuma control will read this common variable, if the value is non-zero, the offset data will be read and applied.
The common variable value will then be set to zero by the Okuma control.

FB Mode: Common variable number associated with common variable on Okuma controller.
The Feedback Mode (Startup or Run) will be written to this common variable when feedback data is available.

Run Mode = 1
Start-up Mode = 2
If the common variable is set to "0", the mode will not be written.

Part Status: Common variable number associated with common variable on Okuma controller.
The Part Status will be written to this common variable when feedback data is available.
Unknown = 0

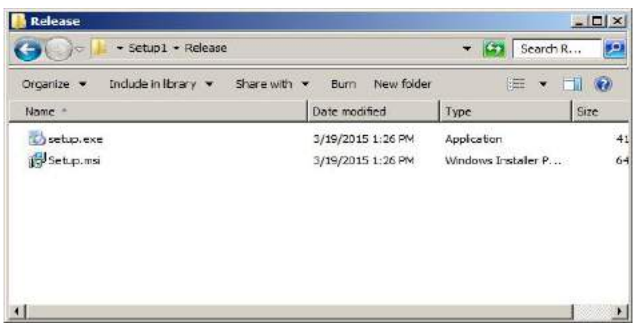
Accept = 1
Reject = 2
Flyer = 3
If the common variable is set to "0", the Status will not be written.

Offset Tag: Common variable number associated with common variable on Okuma controller. The calculated feedback offset value will be written to this common variable. The value in the common variable will be used to adjust the tooling offset in the machine.

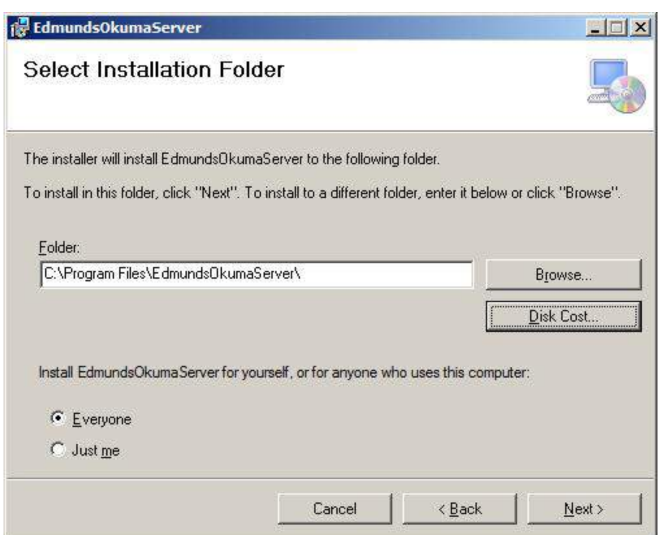
Reset Offset Data: Common variable number associated with common variable on Okuma controller. The value of this common variable will be read, if it is non-zero offset sample data will be reset. If the common variable number is set to "0", the common variable will not be read (reset function disabled).

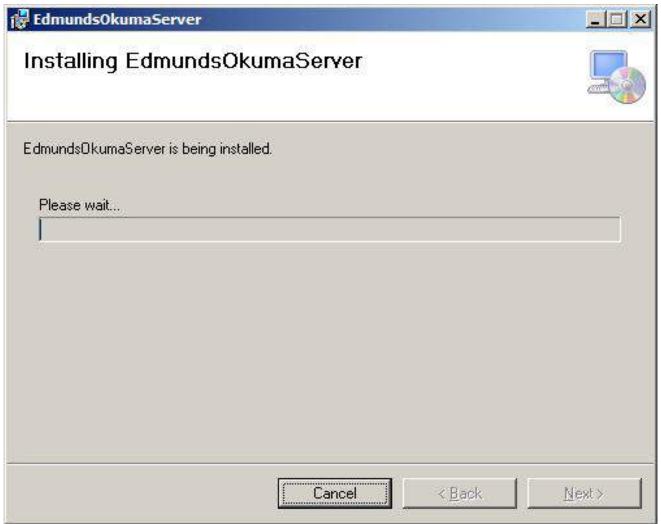
7.3.4. Edmunds-Okuma Server setup Instructions .

1. Installation of the Edmunds-Okuma Server application on the Okuma Controller (P200/P300).
    a. Run the Setup.exe

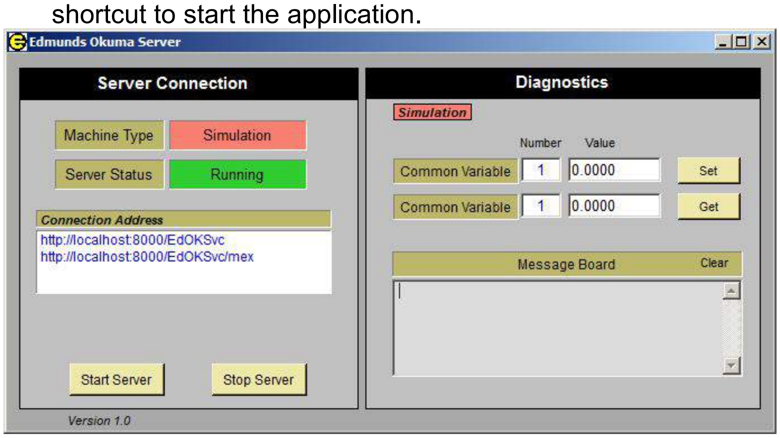


    b. Follow install prompted instructions





c. After setup is complete an icon will be located on desktop, “Edmund-Okuma Server”. Click on shortcut to start the application.



d. Insure the “Server Status” is “Running”. The application can be minimized to the status bar.

The server application will need to remain open and server “Running” to allow feedback communication from the Edmunds EPIC CAG.

7.3.5. Example Macro Program for Reading Feedback Offsets.

Note: this program should be used for reference only, actual variable number will differ.

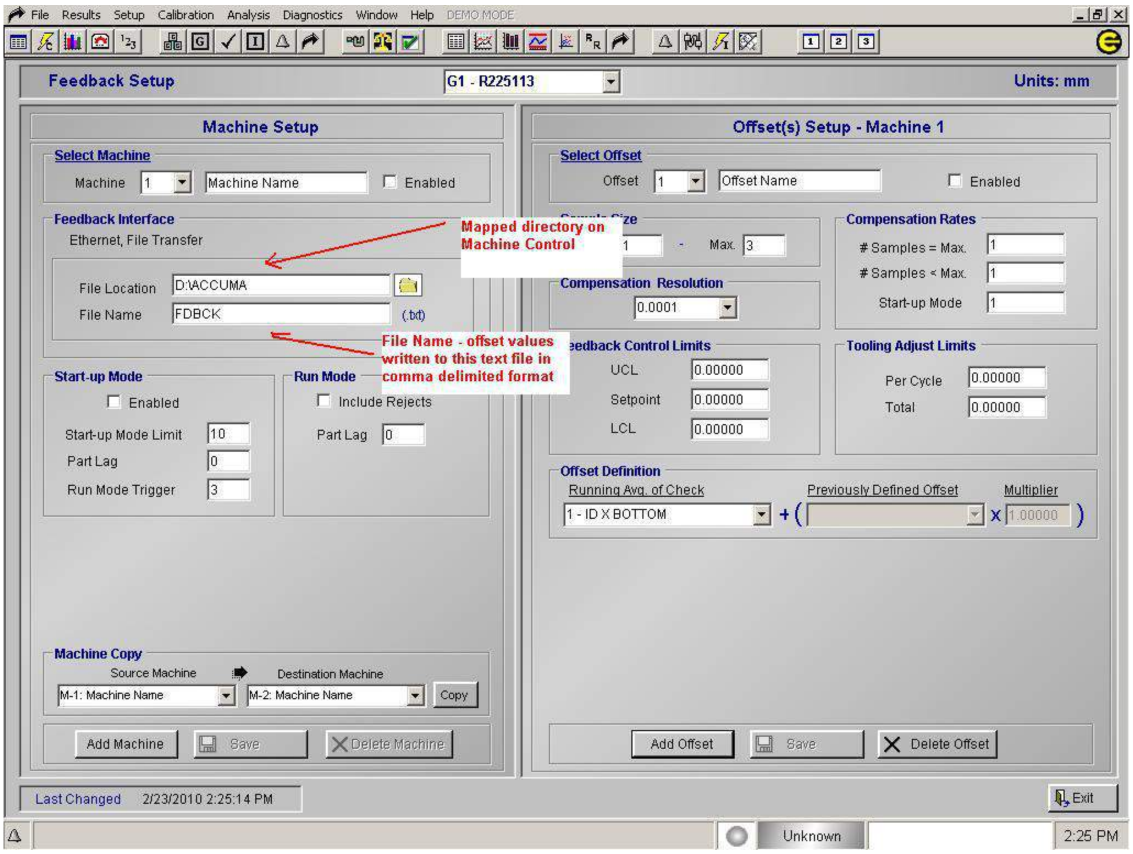
Common Variable numbers used in the following example program:
Data Available: V100
Offset #1: V1
Offset #2: V2
Offset #3: V3
Offset #4: V4
Offset #5: V5
Offset #6: V6
Reset Feedback: V101

```
OGAGE (OKUMA EDMUNDS GAGE VARIABLE ADJUSTMENT)
(*** VARIABLES ***)
(V100 = NEW DATA AVALABLE 0/1)
(V101 = RESET FEEDBACK 0/1)
(VTWOX[**] = TOOL WEAR OFFSET X)
(VTWOZ[**] = TOOL WEAR OFFSET Z)
(V1 = EDMUNDS GAGE FEED BACK X TOOL 1)
(V2 = EDMUNDS GAGE FEED BACK Z TOOL 1)
(V3 = EDMUNDS GAGE FEED BACK X TOOL 2)
(V4 = EDMUNDS GAGE FEED BACK Z TOOL 2)
(V5 = EDMUNDS GAGE FEED BACK X TOOL 3)
(V6 = EDMUNDS GAGE FEED BACK Z TOOL 3)


(*** SYSTEM CHECKS ***)
IF [VMLCK EQ 1] NRTS    (CHECK IF MACHINE LOCK IS ACTIVE)
IF [VRSTT EQ 128] NRTS (CHECK IF SEQUENCE RESTART IS ACTIVE)
IF [V100 EQ 0] NCK1        (CHECK FOR NEW DATA)
GOTO NSET


NSET (*** PERFORM ADJUSTMENTS ***)

(*** TOOL OFFSET 1 ***)
VTWOX[1]=VTWOX[1]+V1 (X AXIS ADJUSTMENT)
VTWOZ[1]=VTWOZ[1]+V2 (Z AXIS ADJUSTMENT)
()
(*** TOOL OFFSET 2 ***)
VTWOX[2]=VTWOX[2]+V3 (X AXIS ADJUSTMENT)
VTWOZ[2]=VTWOZ[2]+V4 (Z AXIS ADJUSTMENT)
()
(*** TOOL OFFSET 3 ***)
VTWOX[3]=VTWOX[3]+V5 (X AXIS ADJUSTMENT)
VTWOZ[3]=VTWOZ[3]+V6 (Z AXIS ADJUSTMENT)
()
V100=0 (RESET DATA FLAG)
(*** RESET GAGE VARIABLES ***)
```

```
V1=0
V2=0
V3=0
V4=0
V5=0
V6=0
GOTO NRTS (GOTO END OF ROUTINE)

NCK1    (CHECK FOR NEW TOOL FLAG)
V101=1 (SET RESET DATA FLAG)

CNT=20 (NUMBER OF TOOL GROUPS)
CTR=1   (COUNTER FOR FIRST TOOL GROUP)

NLOOP (PARSE THROUGH TOOL GROUPS)
IF [VTLCN[CTR] EQ 0] NRST (CHECK NUMBER OF MACHINED WORK PIECES)
M331 (BUFFER PROHIBIT)
IF [[CTR+1] GT CNT] NRTS (CHECK FOR LOOP OVERSHOOT)
(ELSE)
CTR=CTR+1 (INCREMENT THE COUNTER)
GOTO NLOOP (GOTO LOOP)

NRST (RESET TOOL GAGE DATA)
V101=1 (SET RESET DATA FLAG)
(*** RESET GAGE VARIABLES ***)
V1=0
V2=0
V3=0
V4=0
V5=0
V6=0

NRTS RTS (END OF SUB ROUTINE)
```

7.4. EPIC Feedback – Ethernet File Transfer (EFT)

EPIC Software Feedback Setup Screen:
Feedback offsets are written to a file in a mapped directory on the machine control or network computer. If the file does not exist, the file will be created and the offset record will be written to the file. If the file exists the offset record will be appended to the file.



File Format

Ethernet File Transfer format

Feedback offset records will be offloaded to a comma delimited text file on a mapped network drive. If the file does not exist, the file will be created and the offset record will be written to the file. If the file exists the offset record will be appended to the file.

Record Format:
Offset1,Offset2,Offset3,... <CR><LF>

Example:
0.00012,-0.00015,0.00038

7.5. EPIC Standard Serial Feedback (RS232)

Overview:

The following is a description of the serial data offload protocol between an Edmunds EPIC CAG system and a Machine Tool.

The data offload will be a solicited serial data transfer from the CAG to the Machine Tool over an RS-232 serial port. RS-232 control lines are not used in this protocol. The only lines that will be utilized are: TXD, RXD, Signal Ground and the Shield. Baud, parity, stop bits and bits per character are all programmable values in the EPIC system in the Serial Port Setup screen.

The calculated compensation data are referred to as part offsets, is sent to the Machine Tool by request. The Machine Tool will request the data from the CAG by transmitting a DC1 (11H) character to the CAG. The CAG will respond with the data.

The Machine Tool will respond with a DC3 (13H) character if the data was received successfully. If the data was not received successfully the cell controller will re-transmit the DC1 (11H) character. If the CAG does not receive the DC3 (13H) character within 5 seconds of receiving the DC1 (11H) character, a communication error message will be displayed on the CAG screen.

The CAG will reset the offset data when it receives the DC3 (13H) character.

Data Packet:

The data packet offloaded will contain the packet length, part status, number of offsets, and offset results. A detailed description of the packet follows:

Field #	Description	Length		
1	STX	1		
2	packet length	3		
3	part status	1		
4	# of offsets	2		
5	offset #1 result	10		
6	offset #2 result	10	:	:
7	ETX	1		
8	bcc	1		

STX – The start of text character, 02 Hex, or simply 02H, signifies the beginning of the packet.

Packet Length – The length is a three byte ASCII field representing the number of bytes in the packet from the first byte, the STX, to the last byte, the bcc, inclusive. For example, if there are 50 bytes from STX to the bcc, then the packet length is 30H, 35H, 30H.

Part status – A single byte representing the status of the part measured. There are three possible values for the part status:

Hex Value	ASCII	Status
47H	"G"	Good, Accept
42H	"B"	Bad, Reject
52H	"R"	Rework

# of offsets – A two byte field representing the number of check results to be offloaded. The valid range for this field is 1 (30H, 31H) to 16 (31H, 36H)

Offset #1 data – The actual check result, in ASCII, for Check number 1. The offset result is a ten byte field containing the sign, Check value with decimal point, and padded with spaces, if necessary, to the right to fill the tem byte field.

For example, if the offset result is –0.12345, then the ten byte filed would contain the following bytes:

Byte #	Hex Value	ASCII
1	2DH	"-"
2	3OH	"0"
3	2EH	"."
4	31H	"1"
5	32H	"2"
6	33H	"3"
7	34H	"4"
8	35H	"5"
9	20H	" "
10	20H	" "

Offset #n data – Check number n's result, in the same ten byte field format as described under "offset #1 data" above. Each offset result is sent in this same format.

ETX – End of text character, 03H, signifies the end of the packet, with only the bcc to follow.

bcc – Exclusive OR of all bytes in packet from the packet length to ETX, inclusive.

Example:

The following is an example of a typical automatic measurement cycle and data transmission. Assume the data transmission is from the CAG with the following data:

Part Status = REJECT
# of Offsets = 2
Offset #1 = +0.011
Offset #2 = -0.005

The offsets are calculated by the CAG with the following conditions:

Offset #	Units	Comp Resolution
1	mm.	0.001
2	mm.	0.001

The packet length is calculated with the following formula:

Packet length = (#offsets x 10) + 9
= (2 x 10) + 9
= 29 decimal

The Machine Tool solicits the measurement data from the CAG by sending the following byte:

Byte #	Hex value	ACSII	Description
1	10H	DC1	

The response sent by the CAG to the Machine Tool consists of the following packet:

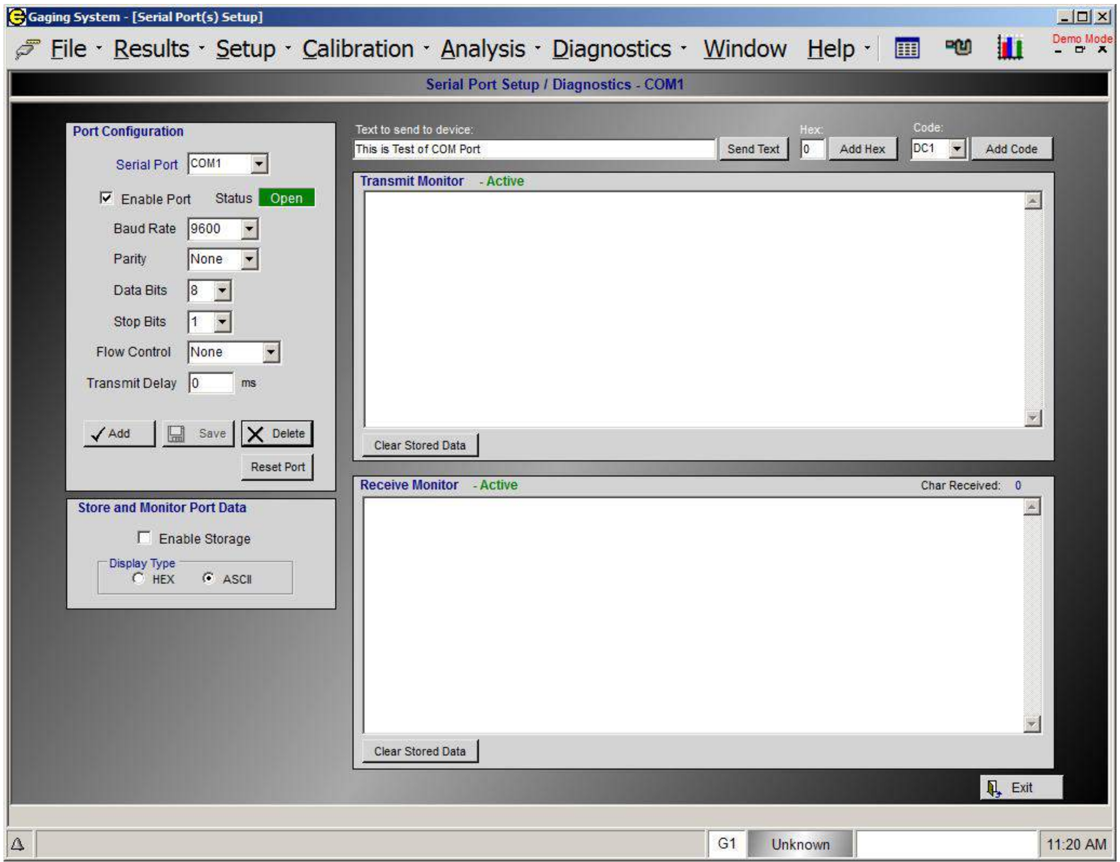
Byte #	Hex value	ACSII	Description
1	02H		STX, Start of Text
2	30H	“0”	Packet length (100)
3	32H	“2”	Packet length (10)
4	39H	“9”	Packet length (1)
5	42H	“B”	Bad, Reject part
6	30H	“0”	Number of offsets (10)
7	32H	“2”	Number of offsets (1)
8	2BH	“+”	--+
9	30H	“0”	|
10	2EH	“.”	| Offset Result for
11	30H	“0”	| Offset #1, padded
12	31H	“1”	+- with four spaces at
13	31H	“1”	| the end:
14	20H	“ ”	|
15	20H	“ ”	|
16	20H	“ ”	|
17	20H	“ “	--+
18	2DH	“-“	--+
19	30H	“0”	|
20	2EH	“.”	| Offset result for
21	30H	“0”	| Offset #2 padded
22	30H	“0”	+- with four spaces at
23	35H	“5”	| the end:
24	20H	“ ”	|
25	20H	“ ”	|
26	20H	“ ”	|
27	20H	“ “	--+
28	03H		EXT, End of Text
29	7Eh		bcc

Assuming the packet was received successfully by the Machine Tool, the response by the Machine Tool to the Edmunds CAG consists of the following byte:

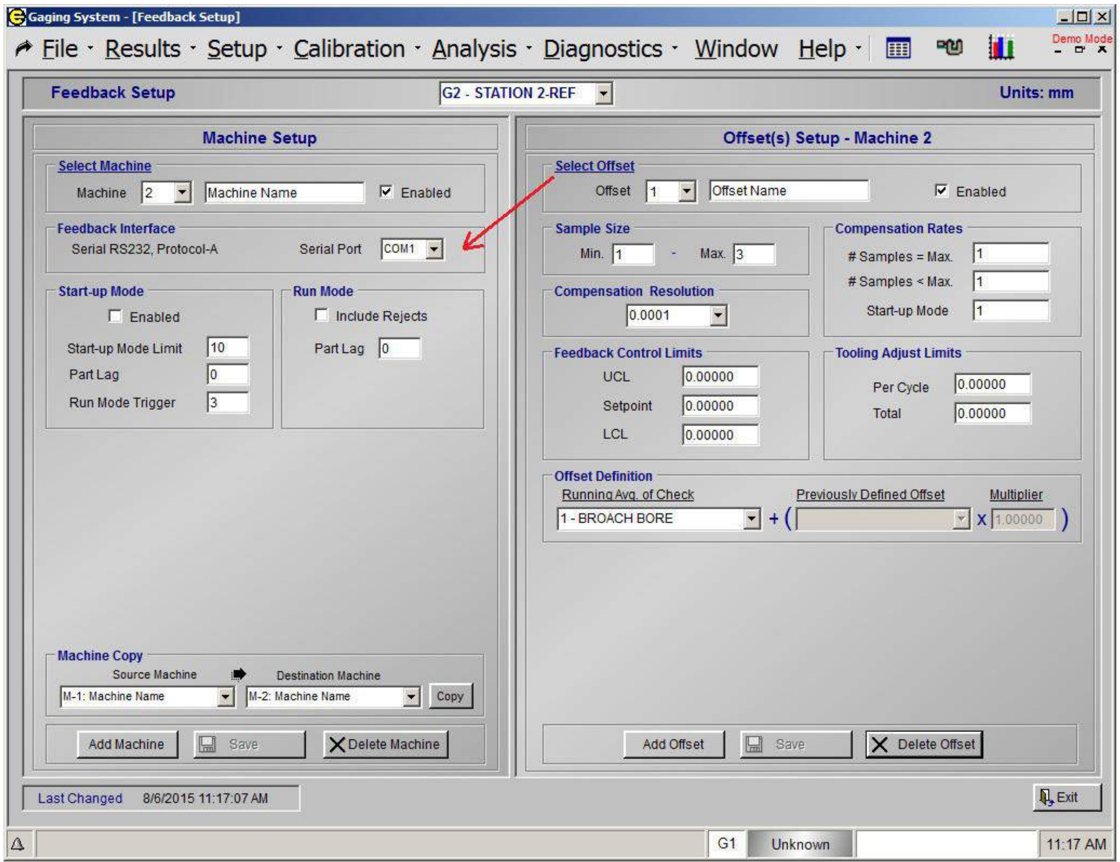
Byte #	Hex value	ACSII	Description
	1	13H	DC3

EPIC Software Setup for Serial Feedback:

The EPIC CAG serial port needs to be enabled and configured to interface with the Machine Tool. The serial port baud rate, parity, stop bits and bits per character are all programmable values in the EPIC system in the Serial Port Setup screen.



The serial port used to communicate with the Machine Tool is selected in the Feedback Setup screen (see below).



8. SECTION: Temperature Compensation

8.1. Temperature Compensation Overview

The calibration of a gage and the measurement of parts have many factors that affect system accuracy. One of the most important factors to be considered is temperature. Under optimum conditions, the Gage would be calibrated and parts measured at 68° Fahrenheit. Reality dictates that gages operate under "shop floor" conditions and parts are measured during various stages of the manufacturing cycle.

The EPIC CAG™ has the capability to provide temperature compensation for gage calibration and part measurement. This permits gage mastering and measurement of parts when they exit a machine tool or other external process, regardless of the process temperature. An offset is computed by the EPIC CAG™ based upon the part temperature, master temperature, tooling temperature and predefined coefficients of expansion for each component. This offset is then added to the parts gaged readings and the corrected part size is displayed.

The amount of offset is dependent upon a range of factors – part material, master material, part thickness etc. In order to provide the proper coefficient of expansion for each, a temperature compensation study is performed on each component: part, master and tooling. Once the study is completed, the coefficients of expansion for each component are stored in the EPIC CAG™ and retrieved as needed.

The actual formula for temperature compensation is:
(Initial gaged readings) + (tooling compensation) + (part compensation) + (master compensation) = Compensated gaged readings.

The part checks that require compensation are selectable in the EPIC software program. Each part Check that is to receive temperature compensation is associated with a temperature probe set. A probe set consists of two (2) input channels. One input channel is utilized to measure the part temperature while the other measures the tooling temperature.

In operation, the operator would master the gage utilizing the calibrated masters. A correction offset for each applicable Check is computed by the EPIC to compensate for any variations in the master's size due to temperature. The offset is based upon the master temperature, tooling temperature and the predefined coefficients of expansion for the master and tooling.

Master Offset = $[\text{Coeff}_{\textbf{master}} \times (\text{temp}_{\textbf{master}} - 68°)] + [\text{Coeff}_{\textbf{tool}} \times (\text{temp}_{\textbf{tool}} - 68°)]$

The temperature compensation master offsets will be applied during normal gaging in the same manner as the Mag and Zero offsets are applied.

During gage operation, the part would be measured in the normal gage cycle. . A correction offset for each applicable Check is computed by the EPIC for temperature compensation. The offsets are based upon the part temperature, tooling temperature and the predefined coefficients of expansion for the part and tooling.

Part Offset = $[\text{Coeff}_{\text{part}} \times (\text{temp}_{\text{part}} - 68°)] + [\text{Coeff}_{\text{tool}} \times (\text{temp}_{\text{tool}} - 68°)]$

The temperature compensation part offsets will be applied during normal gaging in the same manner as the Mag and Zero offsets are applied.

The corrected final gage readings would be displayed and part status would be determined based on the corrected readings.

8.2. Steps to Setting up the EPIC CAG™ Temperature Compensation .

1. Setup the means of acquiring part and tooling temperatures (Temperature Probe Setup screen)

   a. Select number of probe sets. A typical probe set will be (1) probe for part and (1) probe for tooling.

   b. Name probe sets as desired menu (see Section 1.3.9 Temp. Probe Setup)

   c. The probe sets will have to be assigned input channels. The input channel is the input on the temperature amplifier card that the temperature probe will be plugged into (see Section 1.3.9 Temp. Probe Setup).

   d. The probe sensors allow for entering input channel dead band. The dead band allows the CAG™ to determine if the temperature probe has failed. The dead band is 99.5 – 100.5 degrees Fahrenheit. If your measuring environment is in this area you will want to set the dead band to 0.0 degrees (see Section 1.3.9 Temp. Probe Setup).

   e. The probe sensors allow for entering temperature settle time (see Section 1.3.9 Temp. Probe Setup)

2. Enable the type of temperature compensation. The manner in which the gage is to be operated is designated in this menu. There are (3) types of temperature compensation. Gage mastering automatically selects the proper compensation type during the master cycle (see Section 1.3.9 Temp. Probe Setup).

   a. Part – This selection should be utilized whenever temperature compensation is desired during gage operation or when performing an R & R study on parts.

   b. Master As Part - This selection should be utilized whenever an R & R study is performed on masters only or need to add the correct compensation to the master when measuring it as a part.

   c. Disabled - This selection disables temperature compensation.

3. Assign the probe sets to Checks. For a part Check to receive temperature compensation a probe set has to be assigned (see Section 1.3.9) .

At this point the system will be setup for temperature compensation given that a temperature compensation study has been performed and the coefficients of expansion have been determined and entered in the system (see following for temperature compensation study).

8.3. Manual Temperature Composition Study

Use the following procedure to calculate the values of the master, part, and tooling coefficients that can be entered in menu “Check Setup -Temperature Compensation”

Begin by determining the coefficient for the Max Master.

NOTE: While performing the temperature study for the master or part the tooling must be maintained at a constant temperature.

Use the following procedure to determine the coefficient for the Max master and then repeat the procedure for a sample part.

1) Disable all temperature compensation in menu: Setup - Temp. Probe Setup.

2) Measure the Max master in the gage, with the master and tooling at ambient, and record gaged size readings for all temperature compensated checks as well as master and tooling temperatures.

3) Heat the Max master to a temperature of approximately 100 – 105 °F.

4) Record the master temperature outside of the gage. Put the master into the gage and run a measurement cycle. Remove the master from the gage. Select menu: “Results” and record gaged size readings for all temperature compensated Checks as well as master and tooling temperatures.

5) Perform the procedure a few times as the temperature of the master decreases in approximately 5 degree increments.

6) Calculate the individual Master coefficient by dividing the change in size by the change in temperature of the master from the ambient readings to the reading of the heated part. (Ambient Size – Heated Size) / (Ambient Temp - Heated Temp) for each check.

7) Calculate the Average Master Coefficient for each Check.

8) Enter the Average Master Coefficient for each compensated check in the appropriate location in menu “Check Setup -Temperature Compensation”.

Use the following procedure to determine the coefficient for the tooling.

NOTE: While performing the temperature study for the tooling the master must be maintained at a constant temperature.

---

3) Enable all temperature compensation in menu Setup - Temp. Probe Setup. Select “Master As Part”.

2) Measure the Max master in the gage, with the master and tooling at ambient, and record gaged size readings as well as master and tooling temperatures.

3) Heat the tooling to a temperature of approximately 90 – 95 °F.

4) Record the master temperature outside of the gage. Put the master into the gage and run a measurement cycle. Remove the master from the gage. Select menu “Results” and record gaged size readings for all temperature compensated checks as well as master and tooling temperatures.

5) Perform the procedure a few times as the temperature of the tooling decreases in approximately 5 degree increments.

9) Calculate the Tooling coefficient by dividing the change in size by the change in temperature of the tooling from the ambient readings to the reading of the heated tooling (Ambient Size – Heated Size) / (Ambient Temp - Heated Temp) for each check.

10) Enter the coefficient in the appropriate location in menu “Check Setup -Temperature Compensation”.

11) Master the gage with all components at ambient.

12) Heat the Max Master and do a gage R&R as the master cools down. This will show how the gage repeats with varying temperatures. If the gage R & R is acceptable then the Master coefficient is good.

13) Repeat the process but heating the tooling and keeping the master the same temperature. Do a Gage R&R and if the R%R is acceptable then the tooling coefficient is good.

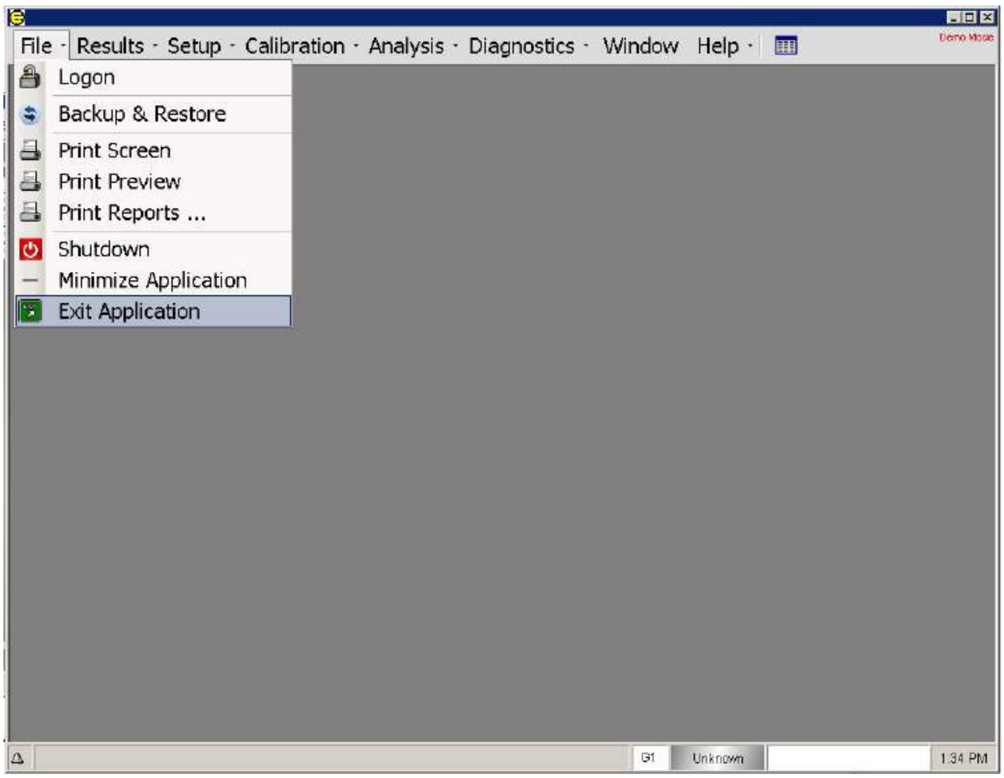
14) Enable the temperature compensation in menu Setup - Temp. Probe Setup and select “Part”.

15) Heat the part up and do a Gage R & R as the part cools down. If the R & R is acceptable than the part coefficient is good.

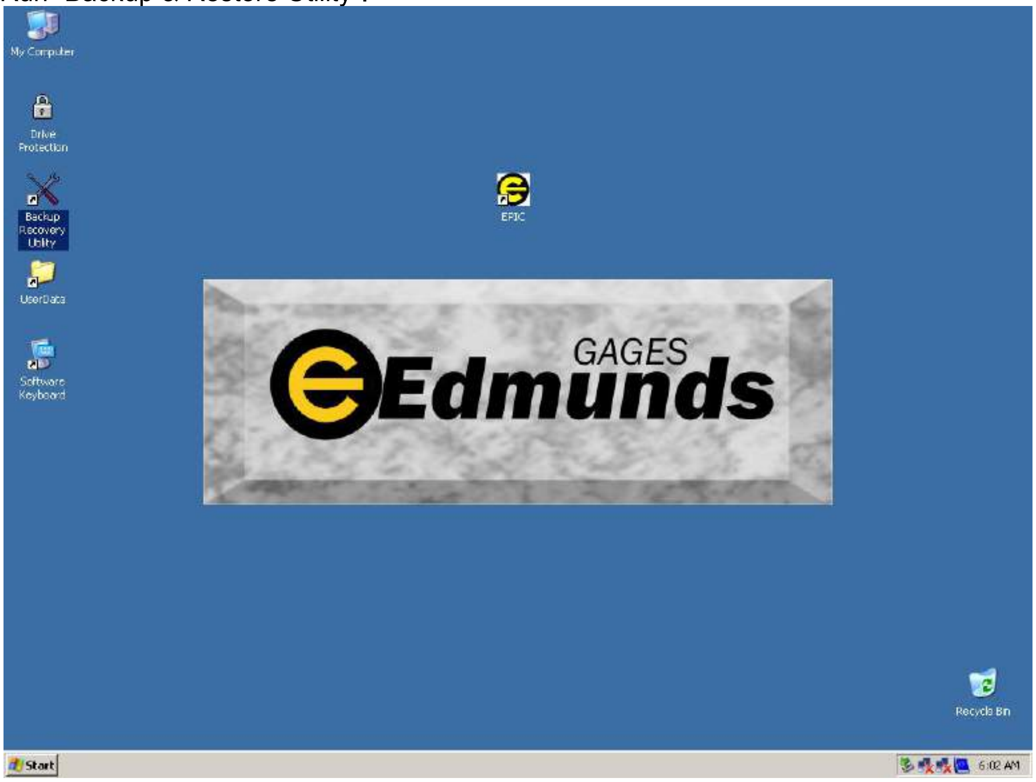
9. SECTION : Backup/Restore EPIC System

9.1. Backup EPIC System to USB Compact Flash Drive

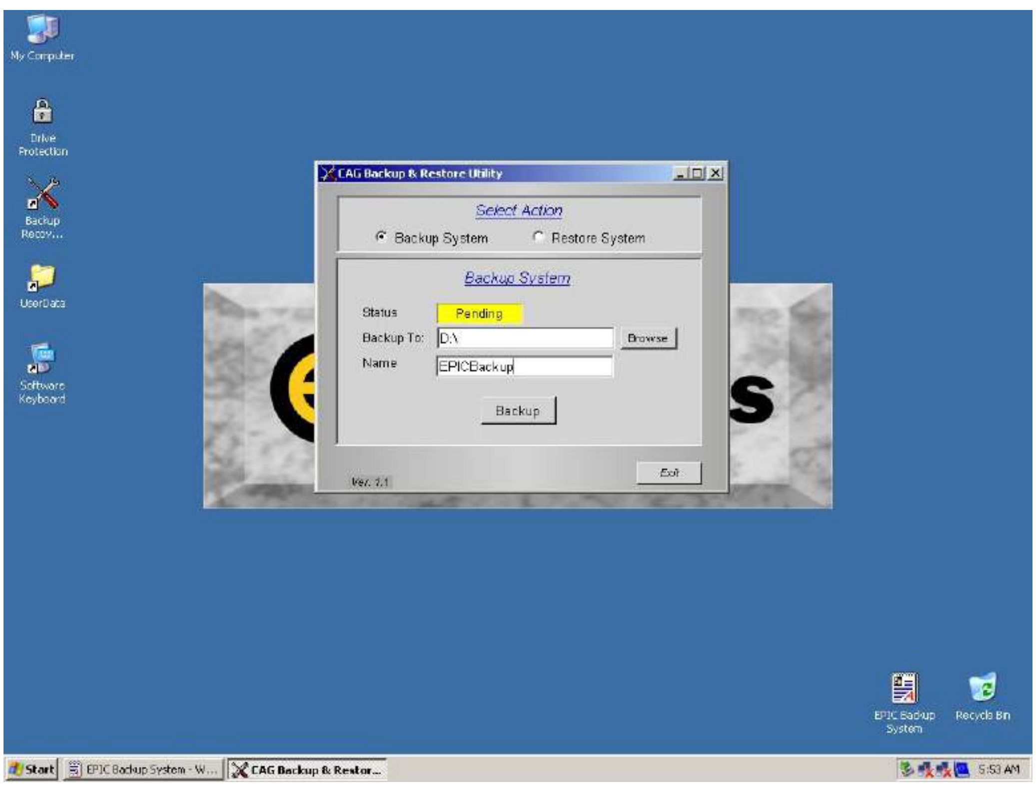
1. Insert USB Memory Stick into USB port on the side of CAG™ unit.
2. Exit EPIC application, menu “File” – “Exit Application”



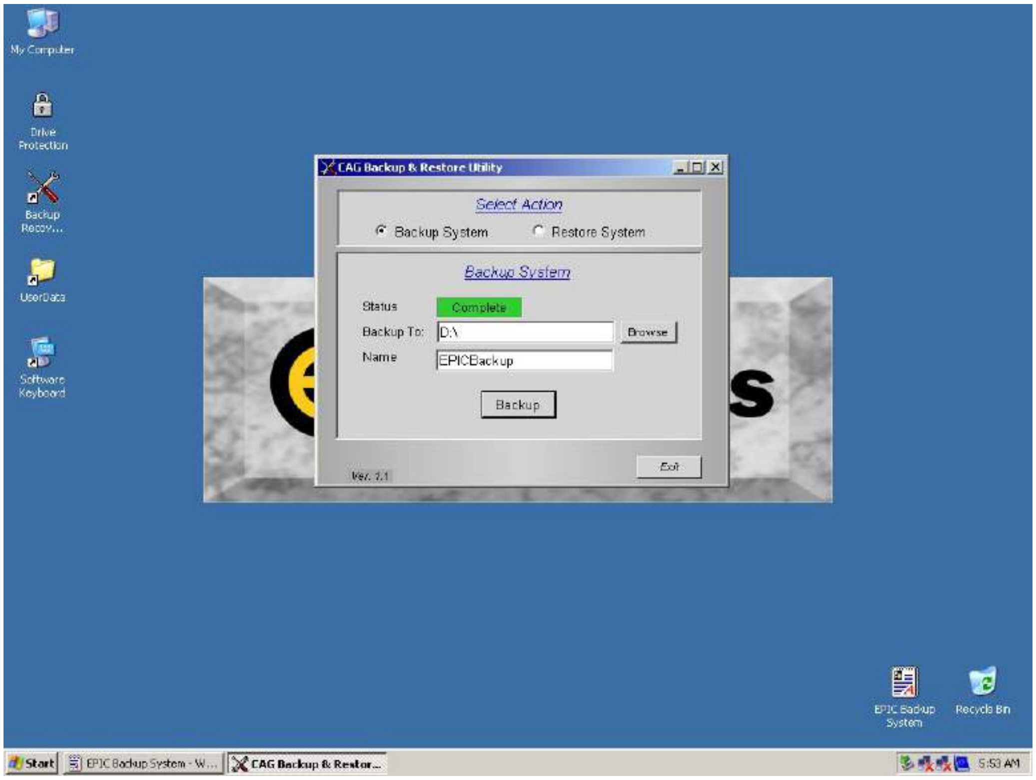
3. Run “Backup & Restore Utility”.



4. Browse for or enter the drive letter of the USB memory stick in the “Backup To:” location.
5. Enter a name in the “Name” location. The EPIC system files will be copied to a folder with this name on the USB memory stick.

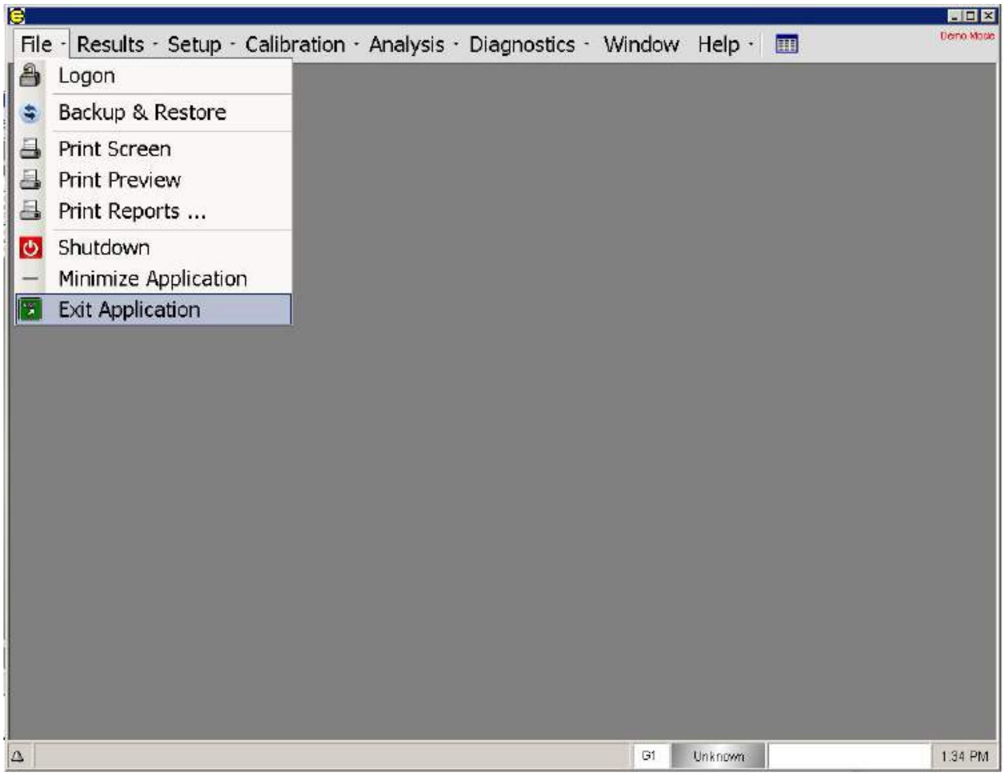


6. Select “Backup” and the EPIC system will be copied to USB memory stick.

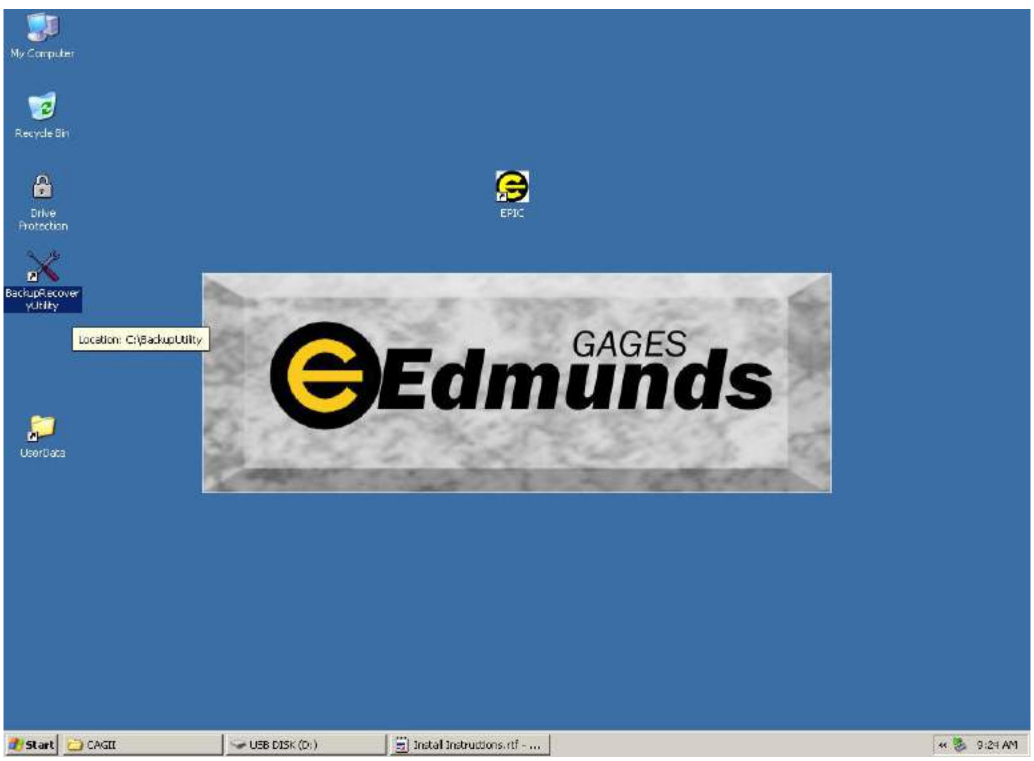


9.2. Restore EPIC system From USB Compact Flash Drive

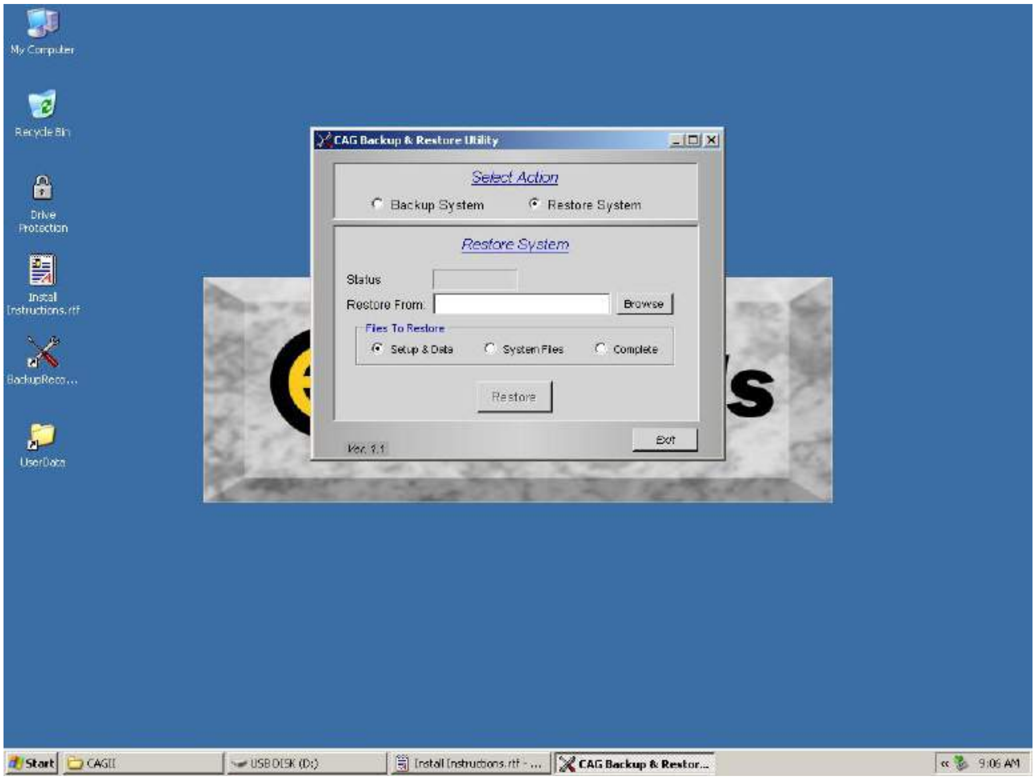
1. Exit EPIC application: menu "File" - "Exit Application"



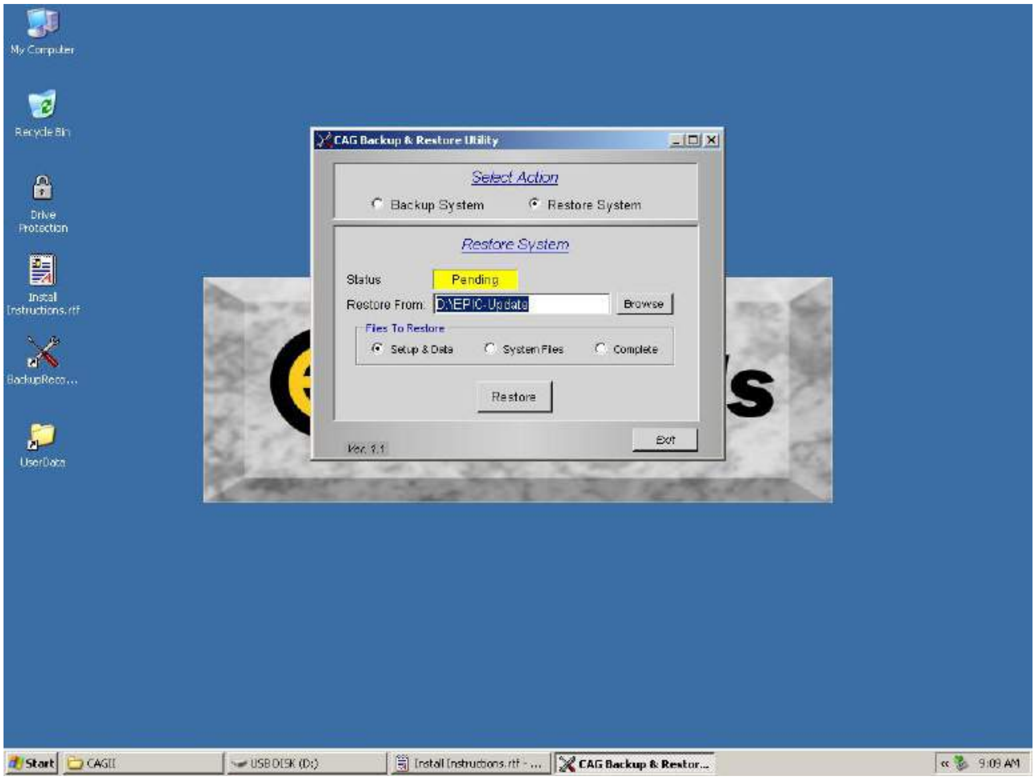
2. Insert USB flash drive into USB port.
3. Run "BackupRecoverUtility" - click on icon located on desktop.



4. Select "Restore System" under "Select Action"



5. Enter the "Restore From" path by selecting "Browse" button and locate directory containing the backup on the USB flash drive. The path should be look something like this, "D:\EPIC-Backup"

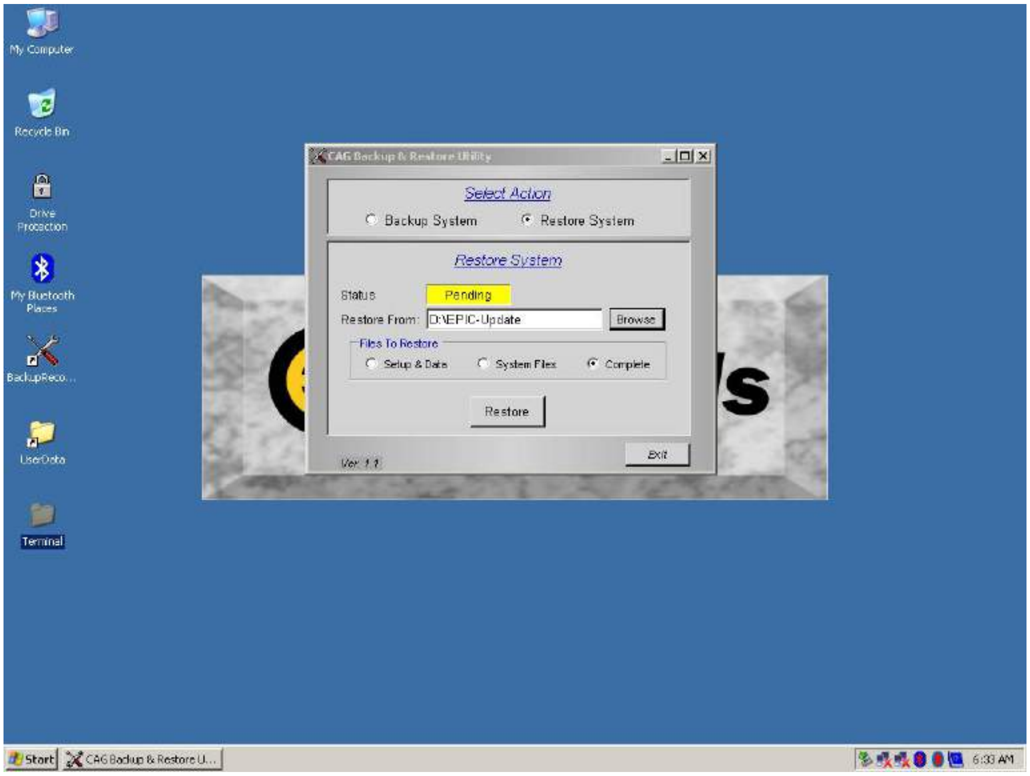


6. Select “Files To Restore”

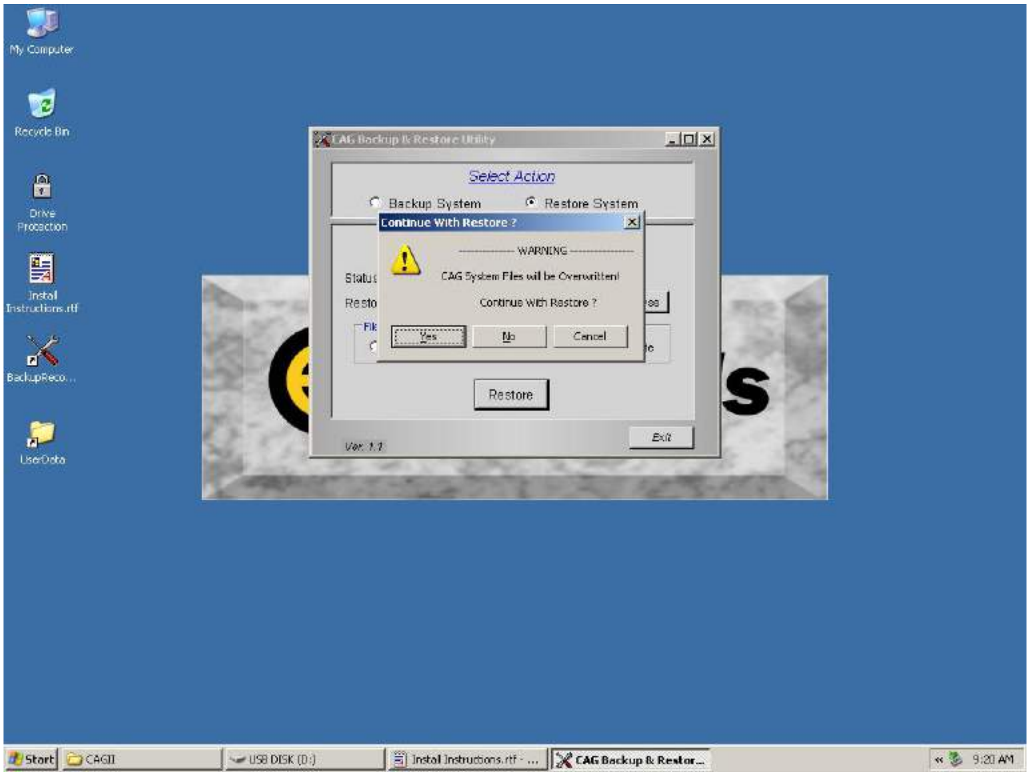
a) Setup & Data - this will restore the Setup(s) and the measured data.

b) System File - this will restore the system file only that run the applicaton, not the user entered Setup and measured data.

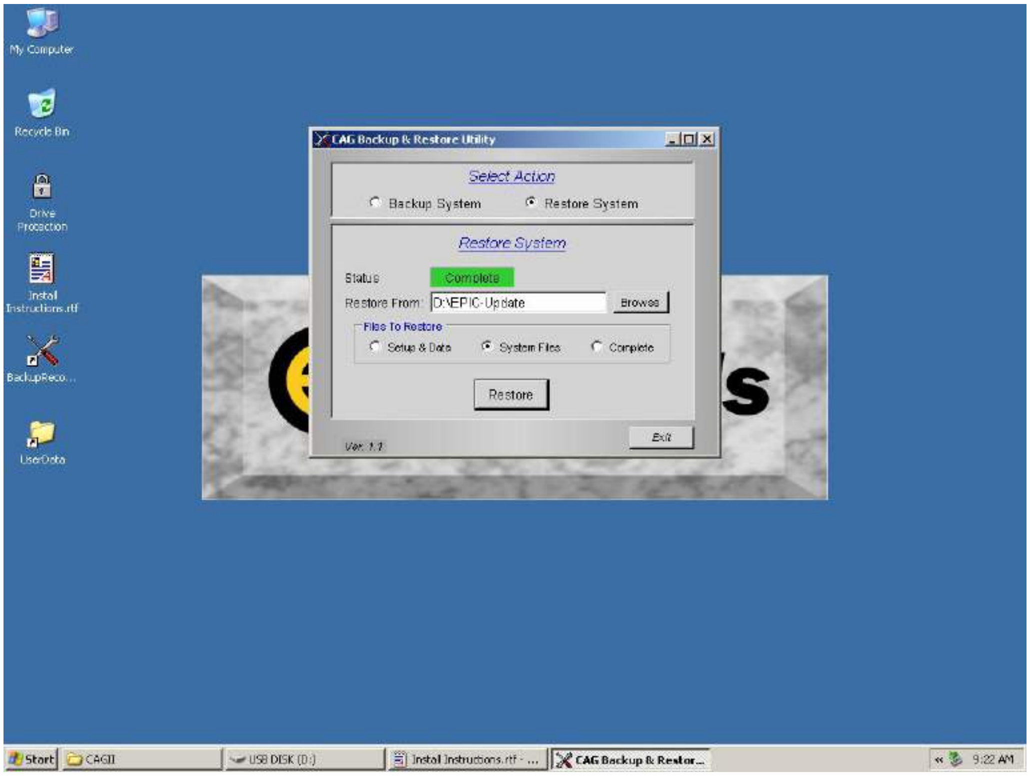
c) Complete - this will restore the complete EPIC system including System File, Setup(s) and measured data.


My Computer
Recycle Bin
Drive Protection
My Bluetooth Places
BackupReco...
UserData
Terminal
CAG Backup & Restore Utility
Select Action
Backup System
Restore System
Restore System
Status
Pending
Restore From:
D:\EPIC-Update
Browse
Files To Restore
Setup & Data
System Files
Complete
Restore
Ver. 1.1
Exit
Start
CAG Backup & Restore U...
6:33 AM

7. Select the "Restore" button and select "Yes" to overwrite system files.

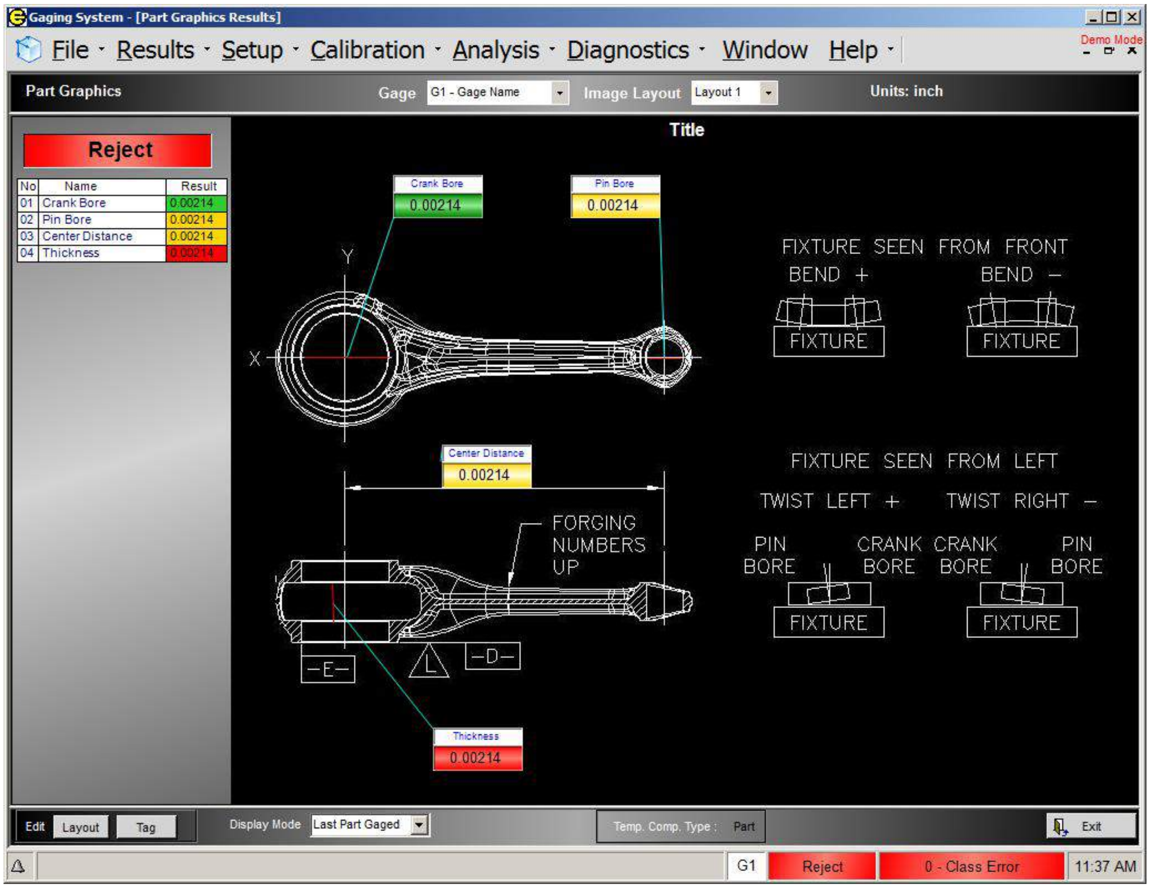


8. After restore "Complete", exit BackupRestoreUtility and start EPIC application.



10. SECTION: Part Graphics

The Part Graphics screen is a results screen that can be customized to display part graphics with live measurement results. A graphical image of the part and the features (Checks) being measured can be displayed.



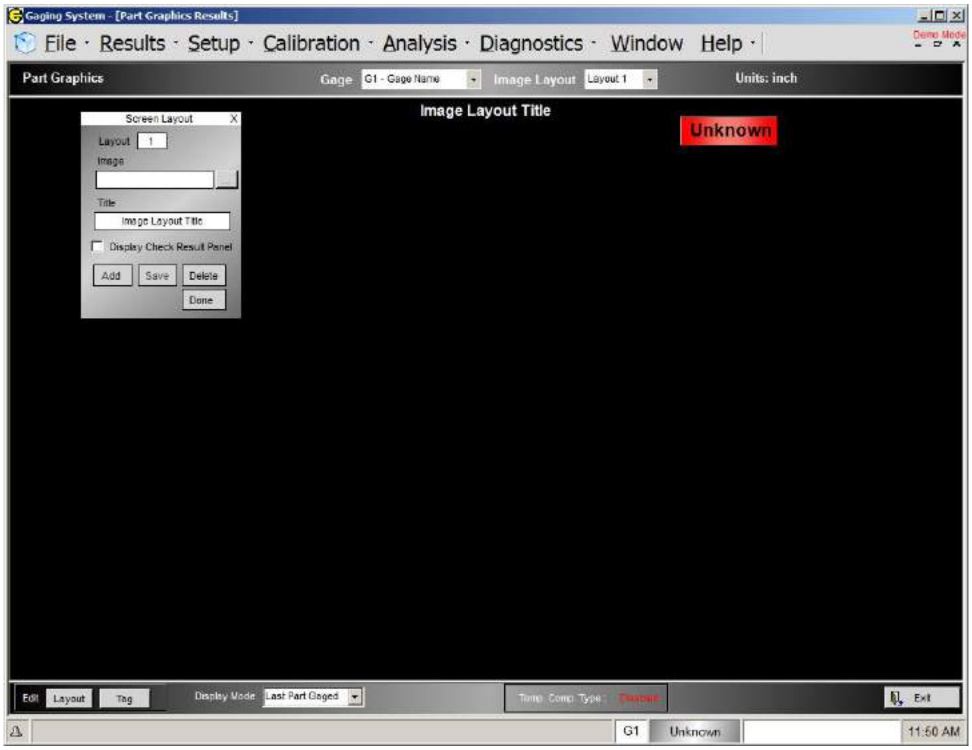
Setting Up a Graphics Screen

1. **Creating Image file.**
   a) Image Format - JPG image format.
   b) Size -
      i. 1000 pixels x 620 pixels (if Result panel NOT displayed) .
      ii. 900 pixels x 620 (if Results panel displayed)
   c) Location on EPIC-CAG - The image file must reside in the following directory on EPIC system:
   C:\Edmunds Gages\CAGSU\DataBases\PartGraphics

2. **Create a Layout** - The Layout contains everything used to display the custom graphics screen including the part graphics image, Check results Tags, Titles and Results panel options. Multiple layouts can be created for a give Gage Setup.
   a) Select the Layout button in bottom left corner.

b) A “Screen Layout” edit box will appear. Using the edit box, an existing Layout can be modified or a new Layout can be added. Select the “Add” button to add a new Layout (see Figure 1). Note that each Layout is given a number.

Figure 1

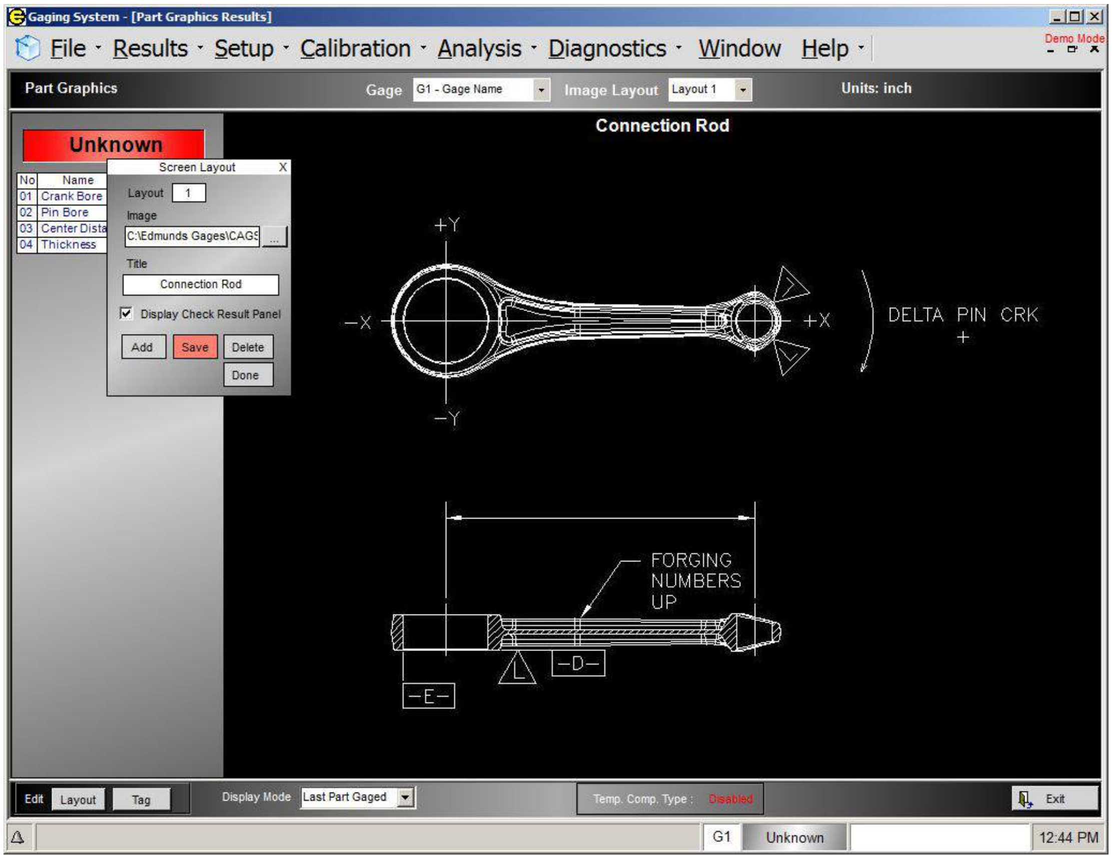


c) Select the Image to be displayed by selecting the browse button next to the Image text box.

d) Enter a title for the Layout in the Title text box.

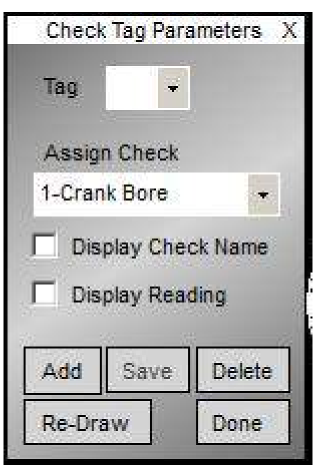
e) Select “Display Check Results Panel”. This will display all the features (Checks) setup in the system along with part status. The results will be updated at the completion of a measurement cycle.

f) Select Save and Done.



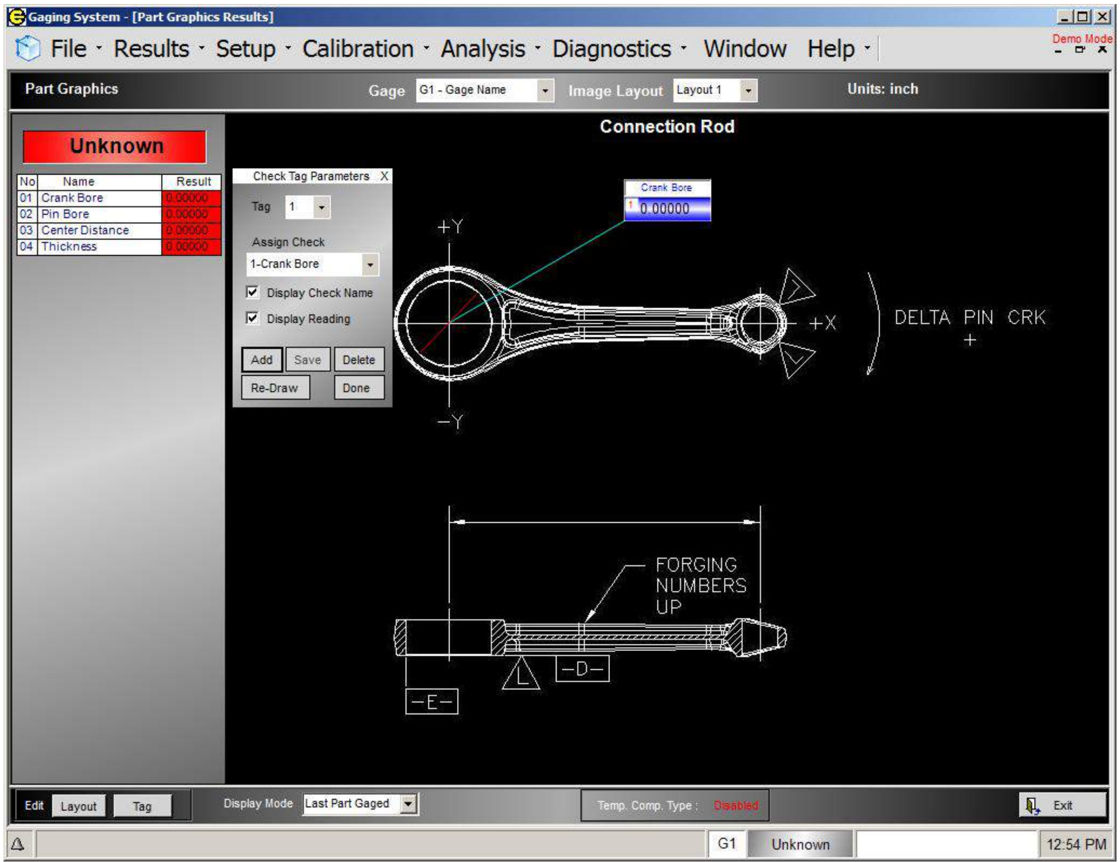
3. **Add Tags** - Tags are used to display Check results. Multiple Tag can be created for a Layout. Tag can be place anywhere on the image.

   a) Select the Tag button on the bottom left of the screen. A “Check Tag Parameters” edit box will appear. Using the edit box, an existing Tag can be modified or a new Tag can be added.



   b) Add Tag: Select the “Add” button to add a new Tag. When the “Add” button is selected a new Tag is added and the system is then in draw mode. In draw mode, the first thing that will be draw in a Red line used to indicate the dimension or location of measurement. To start drawing the Red dimension line, position cursor at the start of the desired location and press and hold down the right mouse button. Then drag the mouse to the end location. When the mouse button is release, a Tag will automatically be displayed with a leader line to the middle of Red dimension line. Move the Tag by moving the mouse, click the right mouse button when the Tag is in the desired location.

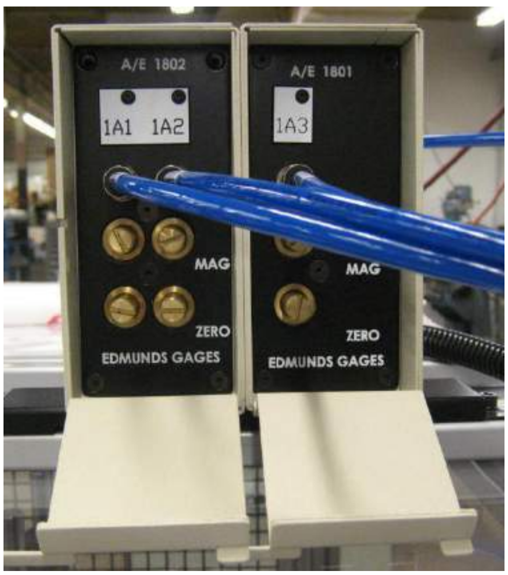
c) Assign Check: Select the "Assign Check" drop-down box to assign a Check to the added Tag.
d) Display Check Name: To display the Check name as part of the Tag select the "Display Check Name" check-box.
e) Display Reading: To display the Check result reading as part of the Tag select the "Display Check Name" check-box.
f) Select "Save"
g) Select "Done" to finish or "Add" to add another Tag.



11. SECTION: Air Check Setup (Mag & Zero)

Use the following procedure to set mag and zero for all air circuits (A/E transducers). This procedure must be followed before the gage is calibrated. The A/E transducers typically need to be adjusted to the maximum & minimum sizes of the calibration masters for every input channel being used. The max and min sizes of the masters can be found on the master certification sheets. In some cases, the air probes may be manufactured close enough that manual adjustment may not be required.

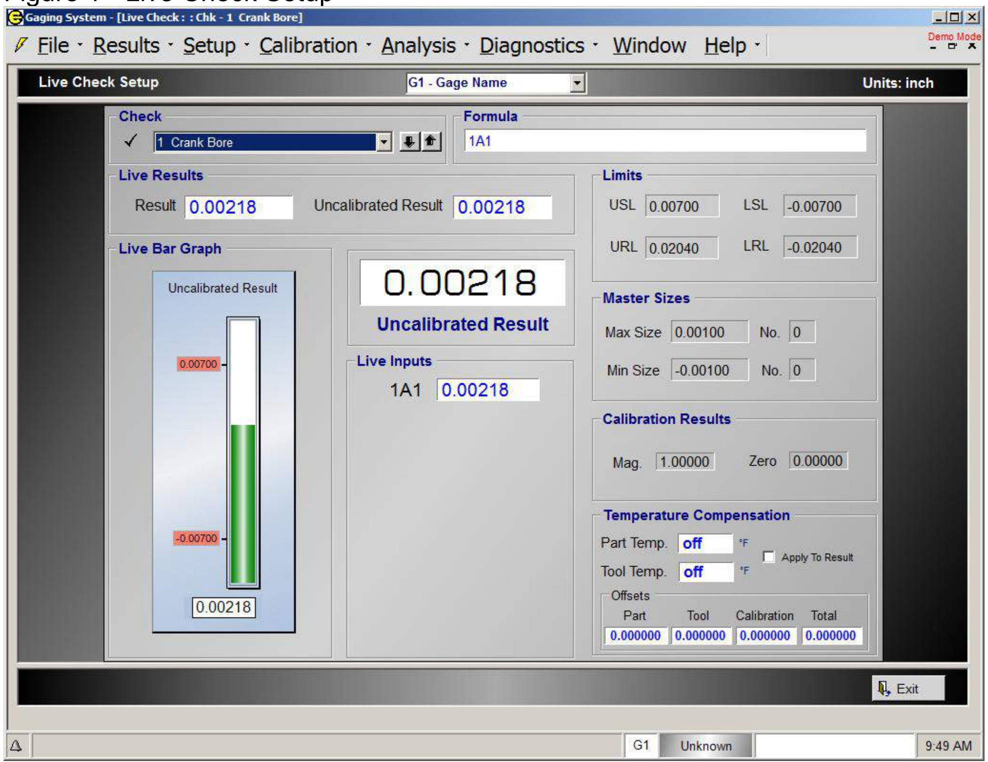
<u>Air Electronic Transducer Assembly</u>



<u>Adjusting Pneumatic Mag & Zero</u>

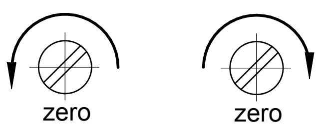
1.0 On the EPIC readout select the **"Results"** menu and then select **"Live Check".** Select the Check associated with the air circuit from the drop-down menu. Monitoring of the "Uncalibrated Result" should be used in the setup procedure. Click on the "Uncalibrated Result" reading in the Live Results box. This will display the "Uncalibrated Result" in the zoomed reading window and on the bar graph (see Figure 1 below).

Figure 1 - Live Check Setup



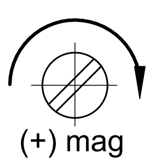
1.1 If first time setup, turn both mag (M) & zero (Z) screws carefully clockwise until they stop and unscrew both counterclockwise 2 ½ full turns as start point. If not, proceed to step 1.2

1.2 Max size - place the max size master on the air gage covering the nozzles. Turn the (Z) zero screw until digital reading is close or equal to max master size.

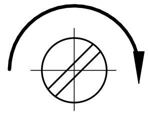


1.3 Min size - remove the max size master and place the min size master on the air gage covering the nozzles. If the digital reading is close or equal to the min master size, proceed to software calibration. Repeat steps 1.1 & 1.2 for the other inputs. If not, proceed to step 1.4.

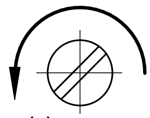
1.4 Min size, adj mag (spread too short) - If the digital reading for the min master size is larger than it should be, the spread is "short", mag adjustment is required.



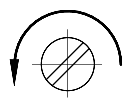
1.5 Turn the (M) mag screw CW 1/4 turn. Then turn the (Z) zero screw in the same direction as the (M) mag screw was just turned until the digital reading is close to or equal to the min master size.



1.6 Min size, adj mag (spread too long) - If the digital reading for the min master size is smaller than it should be, the spread is “long”, mag adjustment is required.

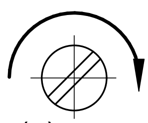


1.7 Turn the (M) mag screw CCW 1/4 turn . Then turn the (Z) zero screw in the same direction as the (M) mag screw was just turned until the digital reading is close to or equal to the min master size.

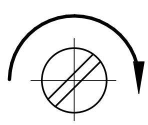


1.8 Max size - remove the min size master and place the max size master on the air gage covering the nozzles. If the digital reading is close or equal to the max master size, proceed to software calibration. Repeat steps 1.2 thru1.7 for other inputs. If not, proceed to step 1.9.

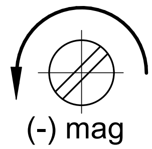
1.9 Max size, adj mag (spread too short) - If the digital reading for the max master size is smaller than it should be, the spread is “short”, mag adjustment is required.



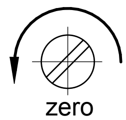
2.0 Turn the (M) mag screw CW 1/4 turn. Then turn the (Z) zero screw in the same direction as the (M) mag screw was just turned until the digital reading is close to or equal to the max master size.



2.1 Max size, adj mag (spread too long) - If the digital reading for the max master size is larger than it should be, the spread is “long”, mag adjustment is required.

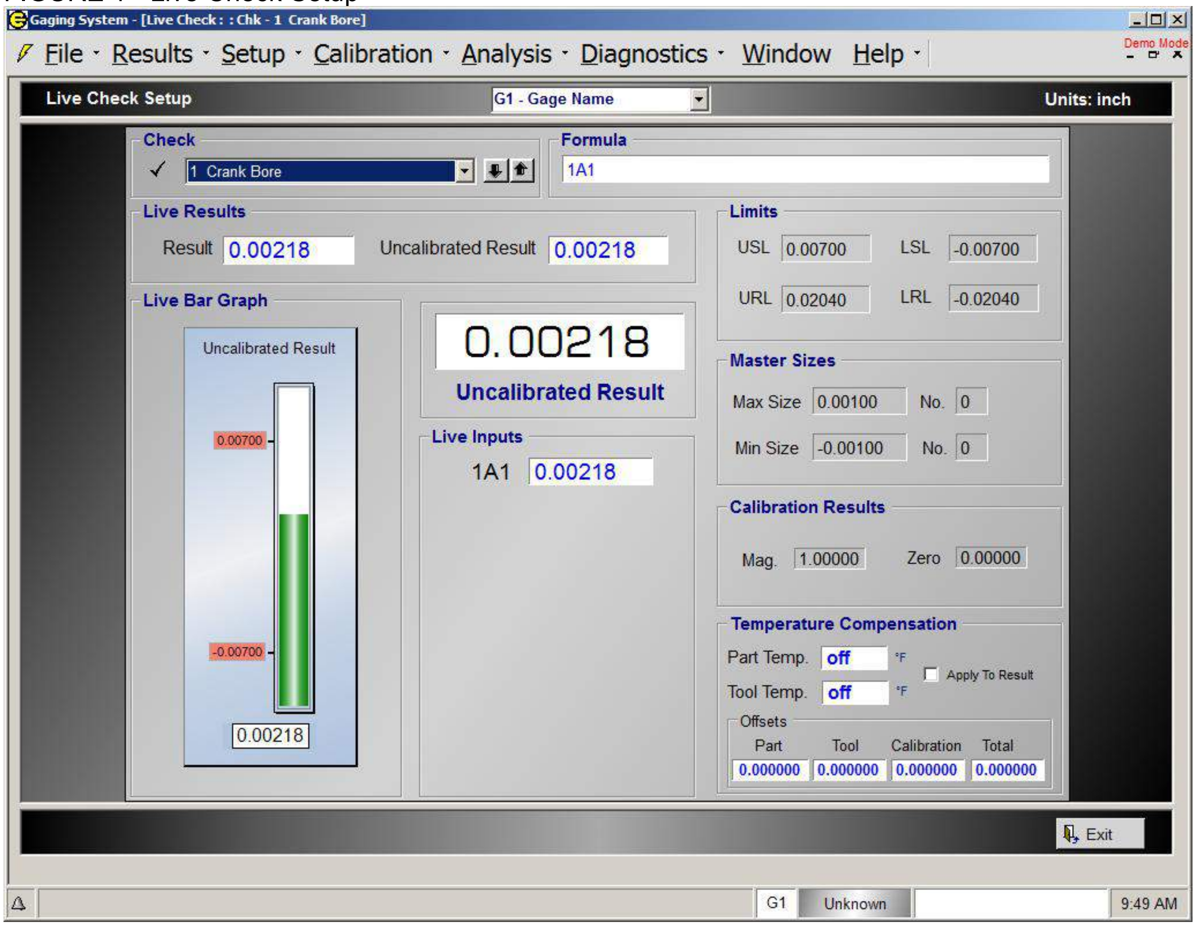


2.2 Turn the (M) mag screw CCW 1/4 turn . Then turn the (Z) zero screw in the same direction as the (M) mag screw was just turned until the digital reading is close to or equal to the max master size.



2.3 Repeat steps 1.3 thru 1.8 by switching both masters as required until the max and min sizes display correctly. Once completed proceed to the “software calibration”.

FIGURE 1 - Live Check Setup



12. SECTION: Drive Protection

12.1. Drive Protection Overview

The EPIC CAG™ is a specialized computer based product used for the purpose of dimension measurement, and the association of measurement results and analysis in relation to production processes.

The EPIC CAG™ uses an Edmunds designed, single board computer that operates from an industrial flash card as its main hard drive, and on board RAM for immediate access of the Windows™ Embedded operating system, the EPIC software application, and all the data generated from dimensional measurement functions.

The EPIC CAG™ has built in drive and data protection to insure absence of system failures due to operating system file corruption. EPIC CAG™ incorporates a useful Microsoft Windows™ feature called File Base Write Filters (FBWF) into the Windows™ Embedded operating system that allows the ability to protect the drive (compact flash) from write access. Instead of writing directly to a disk, disk writes are redirected into RAM cache called an overlay. The data that has been stored in the RAM overlay will not persist if the unit is powered down or power is lost. Some files such as gaging result data are allowed to be written directly to disk for permanent storage.

The major benefit of FBWF is that changes to the operating system files are written to the RAM overlay and not to permanently stored to the disk. If the system files become corrupt, they are not written to the disk. Thus, upon next reboot, the system files will be restored.

FBWF can also help protect against unintended or malicious changes to the system. If a virus or malware is installed, it will be written to the RAM overlay and not written to the disk. On next reboot, the malicious software will not persist.

The features of FBWF are also beneficial in preventing accidental tampering of the EPIC CAG™ system. For instance, if a user alters some of the files or configuration data, the user could simply reboot the unit to return back to a original state.

The FBWF also extends the life of compact flash media. Flash-based storage media has a finite number of erase cycles before erase blocks wear out. This means that there is a finite life span for a compact flash drive. Since FBWF redirects files writes into RAM this can decrease the amount of data being written to disk; thus, extending the life span of disk.

12.2. Disable & Enable Drive Protection

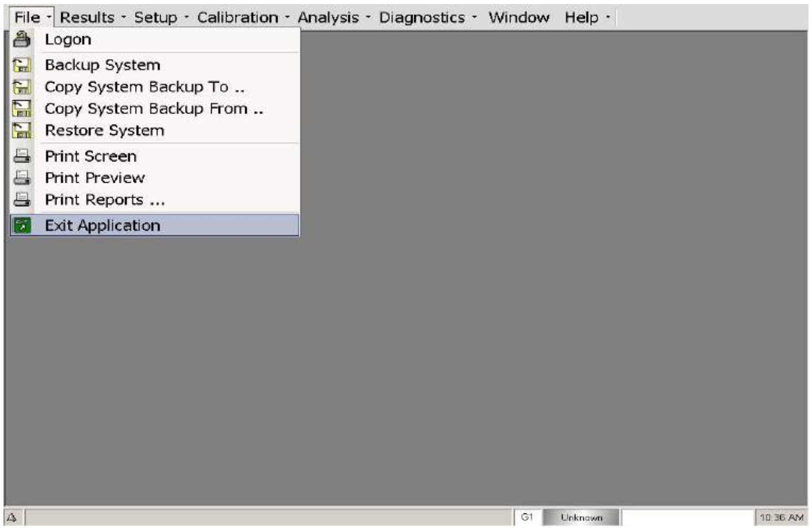
If changes to the Windows™ Embedded operating system need to be made the drive protection will need to be disabled for those changes to be made permanent. There is a utility that can be accesses from the Windows desktop that allows the uses to Enable/Disable drive protection.

Examples of when Drive Protection needs to be Disabled:

- Changing the system Ethernet IP Address
- Changing system network settings
- Changing system Date/Time
- Calibrating Touch Screen.

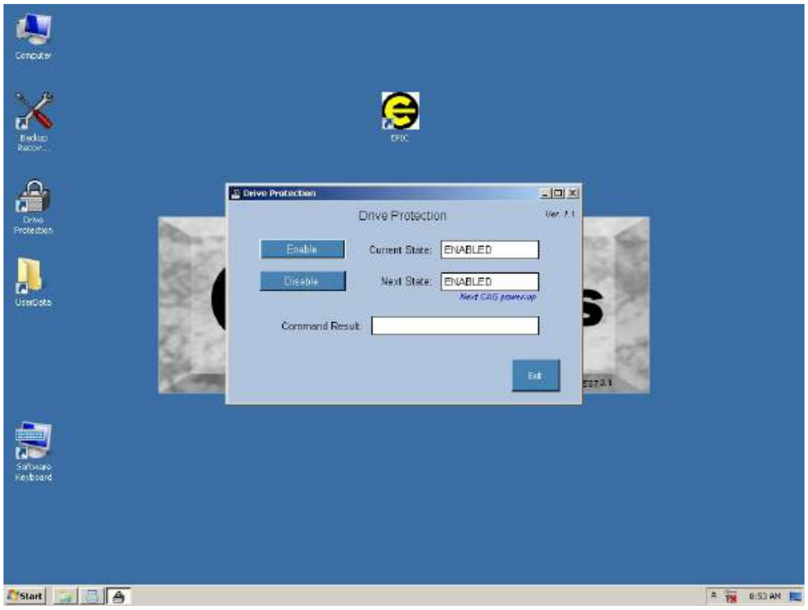
12.2.1. Disable Drive Protection (Instructions)

1. Exit EPIC application to get to the Windows desktop.

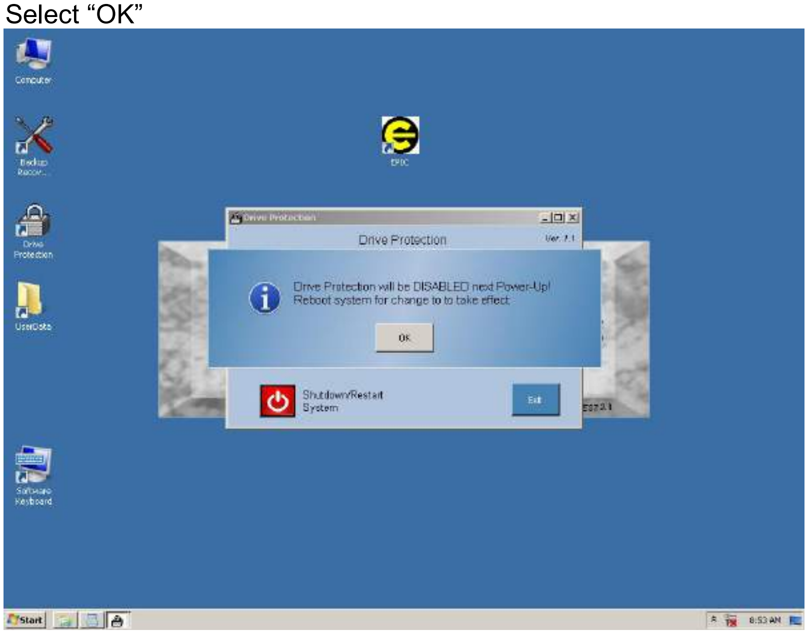


2. Select “Drive Protection” icon to stat the drive protection utility.

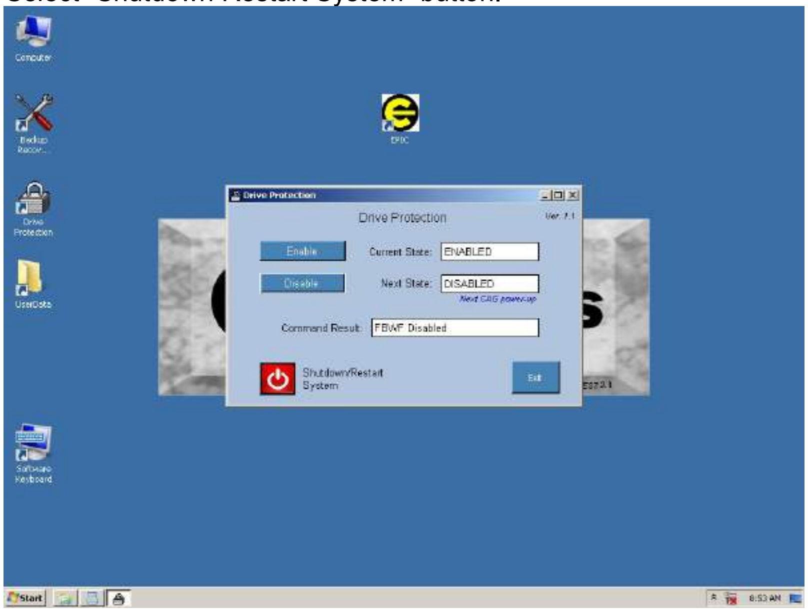
3. Select “Disable” button on the Drive Protection screen.



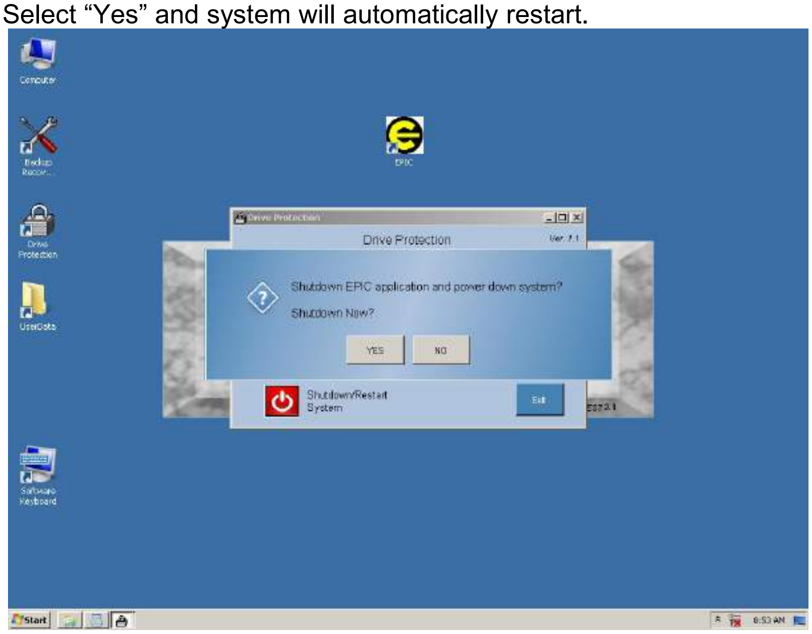
4. Select “OK”



5. Select “Shutdown Restart System” button.

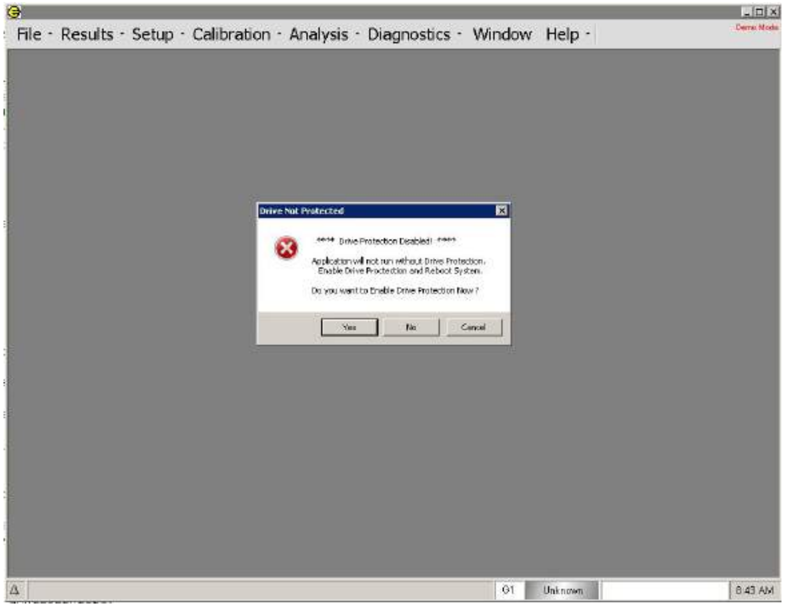


6. Select “Yes” and system will automatically restart.



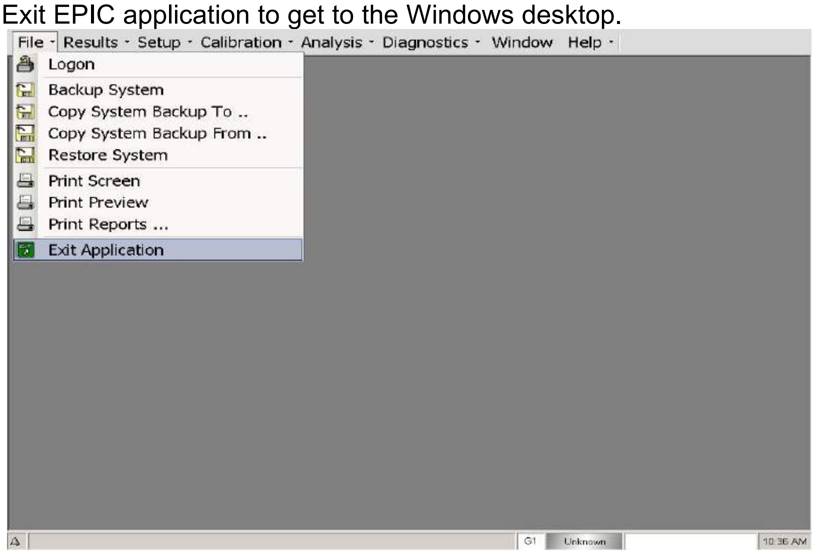
7. After the system restarts, the EPIC application will attempt to start but will not run because driver protection is disabled. Select “No” at prompt to not enable drive protection. The EPIC application will then close. Drive protection is now disabled and changes to the Windows embedded operating system can permanently be made.

NOTE: *The EPIC application will* ***NOT Run*** *if Drive Protection is Disabled.*



12.2.2. Enable Drive Protection (Instructions)

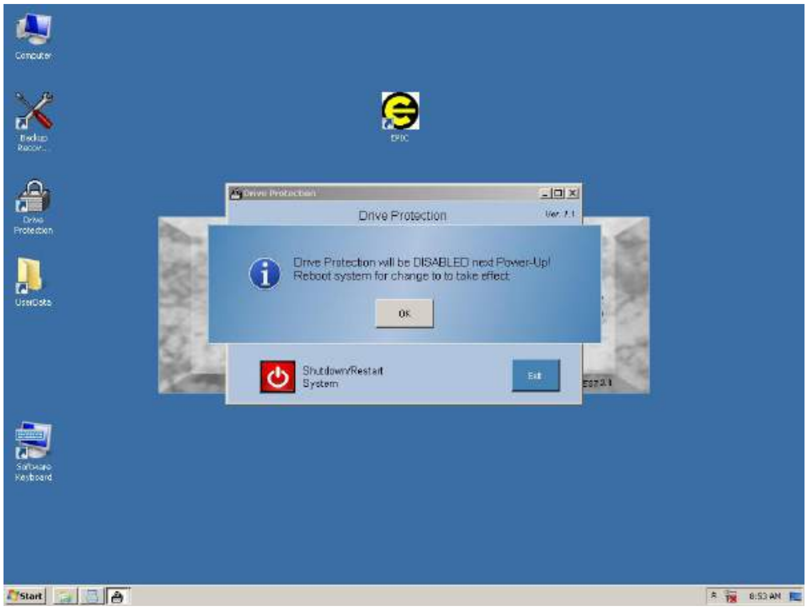
1. Exit EPIC application to get to the Windows desktop.



2. Select “Drive Protection” icon to stat the drive protection utility.

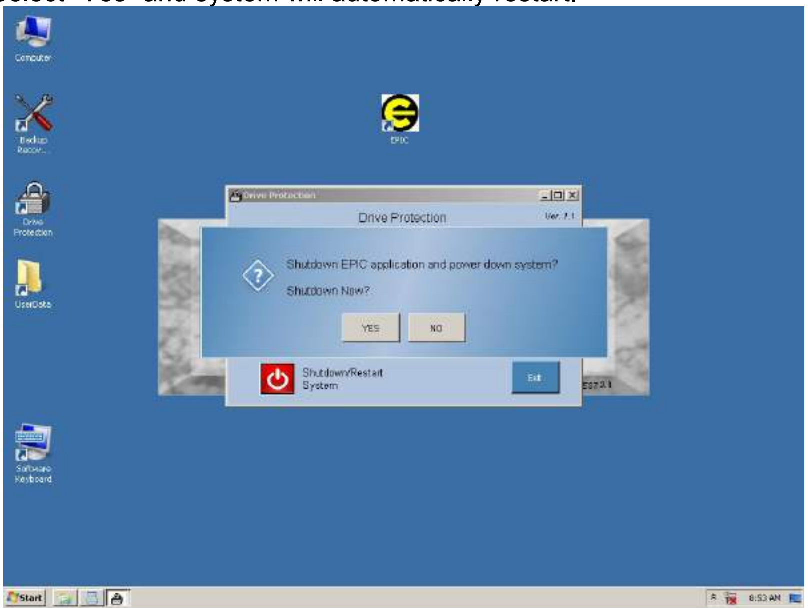
3. Select “Enable” button on the Drive Protection screen.

4. Select “OK”



5. Select “Shutdown Restart System” button.

6. Select “Yes” and system will automatically restart.



7. After the system restarts, driver protection will be enabled and the EPIC application will start.

13. SECTION: Troubleshooting

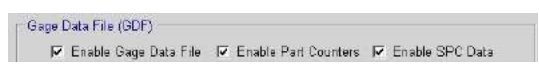
EPIC CAG SYSTEM		
Description	**Probable Cause**	**Recommended Action**
Display is Blank after power-up	No Line Power	Check 120 VAC input power Inspect power cable connection Check fuse in power entry module
	Improper Video Connection or Failed Video Monitor	Inspect video monitor connection and power. Temporarily connect or replace the video monitor connected to VGA port of the CAG. If temporary connected monitor works, contact Edmunds Gages for monitor replacement.
	Hardware Failure	Contact Edmunds Gages for repair
Error Message at power-up preventing EPIC system from starting.	The following error message at start-up indicates the CAG drive (C-Fast or Compact Flash card) can not be read. EFI Shelol version 2.31 [21216.18] Current running mode 1.1.2 map:Cannot find required map name Press ESC In 5 seconds to skip startup.nsh, any other key to continue Shell>_	Ensure that the CAG drive (C-Fast or Compact Flash card) is securely seated in connector-holder on motherboard. Contact Edmunds Gages for assistance. CAG drive (C-Fast or Compact Flash card) is corrupt. Contact Edmunds Gages for replacement.
	Operating System Corrupt or Corrupt/Failed CAG drive (C-Fast or Compact flash card)	Contact Edmunds Gages. New CAG drive (C-Fast or Compact Flash card) may be required.
	If error generated while loading EPIC application, the EPIC software application may be corrupt. The error reported may give an indication if the programmed setup, stored results or system files are the cause.	Restore EPIC System using backup. See SECTION 7: Backup/Restore EPIC System. If a current backup is not available for restore contact Edmunds Gage.
Error Message generated in the EPIC application.	System Error	See Section 13.1 EPIC System Software Errors

<table>
<tr><th colspan="3">GAGING CONSIDERATIONS</th></tr>
<tr><th>Description</th><th>Probable Cause</th><th>Recommended Action</th></tr>
<tr><td rowspan="3">System will not gage (measurement cycle)</td><td>Gage is not enabled</td><td>Enable Gage in Gage Setup screen.

</td></tr>
<tr><td>Not receiving external Start Gage signal</td><td>Verify the system is receiving the external Start Gage signal by viewing the “Input Trace” on the IO Diagnostics screen. If the Start Gage signal is not coming into the “Input Trace” verify the external source of the signal and the communication interface.

Verify the system will gage using the on-screen Start Gage pushbutton. If the system does gage using the on-screen Start Gage pushbutton, this will confirm that the external Start Gage signal should be focused on as the problem.

</td></tr>
<tr><td>Wrong “Start Gage Number” assigned to Gage setup.</td><td>Verify the correct “Start Gage Number” is assigned to the correct Gage setup in the Gage Setup screen.

</td></tr>
<tr><td rowspan="2">Gage Results not being stored in Gage Data File (GDF)</td><td>Gage Data File (GDF) disabled</td><td>Enable Gage Data File in Gage Setup screen.

</td></tr>
<tr><td>Reasonable Limits exceeded.</td><td>If any one of the measured Check results exceeded the Reasonable Limits the results will not be stored in the Gage Data File for that measurement cycle.
Verify the Check status in the Results screen. If the Check status for any one of the Checks is “Over URL” or “Under LRL” the results will not be stored in the GDF.</td></tr>
</table>

	Gage Data File (GDF) Full.	If the number of stored records has reached the “Max GDF Records Allowed” and Wrapping is not Enabled the results will not be stored. The “Max GDF Records Allowed” is set in the *Gage Setup* screen.  The GDF can be reset in the *Gage Data File* screen

13.1. EPIC System Software Errors

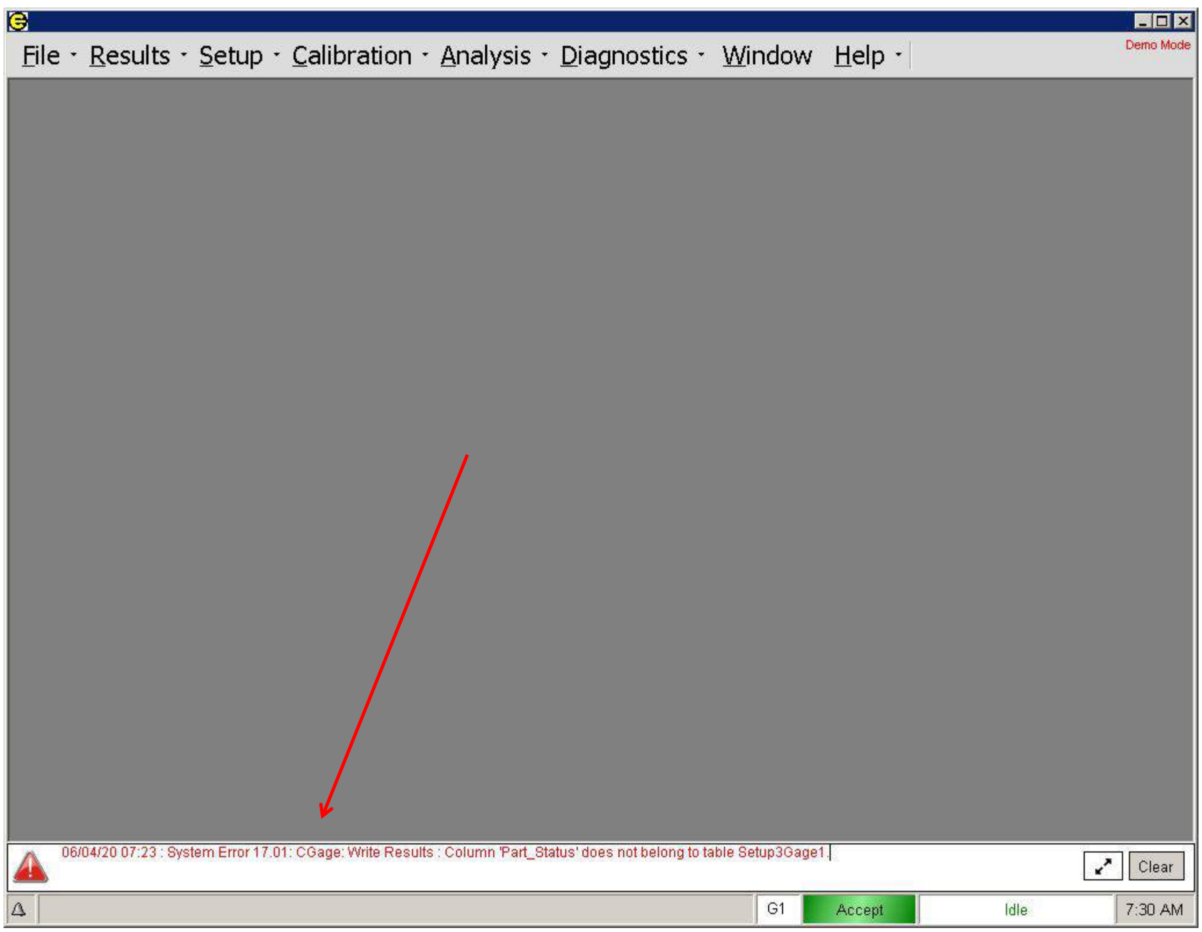
EPIC System Software errors and exceptions messages are displayed when a function in the system can not be performed. The exception causes the system to abruptly stop processing the function it was performing. EPIC system software errors are displayed at the bottom of the main screen. Displayed system error messages must be cleared before the next measurement cycle can be performed.

The displayed system error message contains the following information::

- Date and Time the error occurred
- Error number
- Description of what the system was doing when error occurred
- Where the error was generated in the system code.
- Description of the system error.

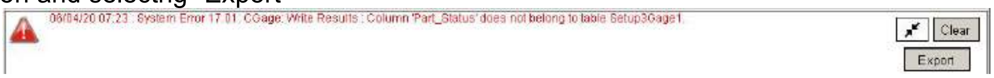
If the entire contents of the error message can not be viewed, the expand button can be selected to increase the error display box.

NOTE: The system will NOT perform a measurement cycle until the System Error is Cleared.

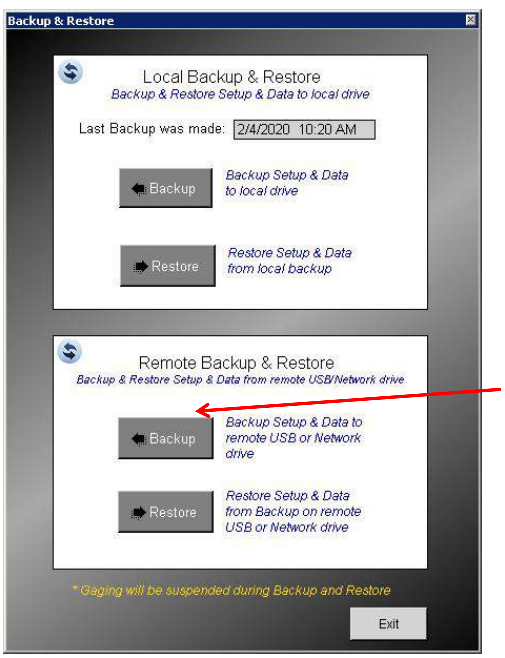


13.1.1. Steps to Recover from System Error:

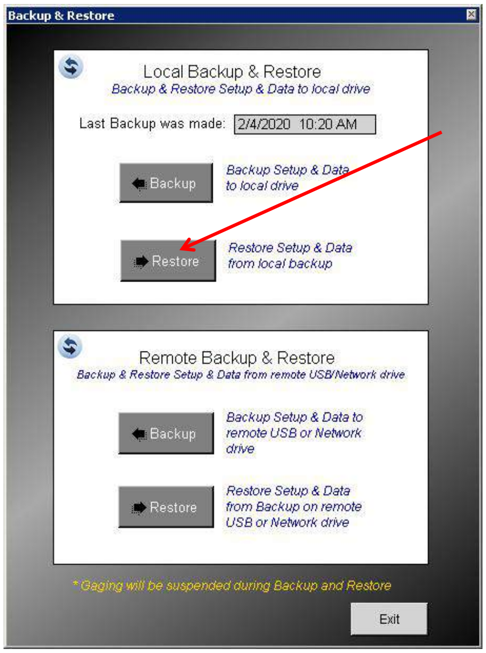
1. Document the error message. The system error message can be exported to a text file by selecting the expand button and selectng “Export”



2. Clear the system error by selecting the “Clear” button.
3. Perform the function/action that caused error (run system as normal) and if error reoccurs proceed to next step.
4. Restart the EPIC CAG, select menu: File-Shutdown and toggle power button OFF then ON. When system in restarted, perform the function that caused the error and if error reoccurs proceed to next step.
5. Reset stored results and restart system.
    a) Reset the Gage Data File (GDF) for all Gages from the Gage Setup screen, see section “*1.5.1 Gage Date File (GDF)*”. Note: all stored results will be lost during a reset. The results can be exported “Export Data” before the reset is performed if desired.
    b) Reset the part counters for all Gages from the Part Counters screen, see section “1.2.5 Part Counters”.
    c) Restart the EPIC CAG, select menu: File-Shutdown and toggle power button OFF then ON. When system in restarted, perform function that caused the error and if error reoccurs proceed to next step.
6. Restore Setup and Data from local backup.
    a) Before a restore from backup is performed it is good practice to backup the current system to a separate location just in case the current setup settings are overwritten or changed inadvertently during the restore. Insert a USB memory stick in USB port of CAG, this will be used to store the remote backup. Go to menu: ***File - Backup & Restore***. Select “**Backup**” under **“Remote Backup & Restore**” and browse to the USB memory stick drive and select OK (see *Section 1.1.2.3 Backup Remote)*.



    b) Restore Setup and Data from Local Backup. Go to menu: ***File - Backup & Restore***. Verify that the date and time of the last backup is acceptable. Any setup changes or results stored later than the Last Backup date and time will be lost. Select “**Restore**” under **“Local Backup & Restore**” (see *Section 1.1.2.2 Restore Local Backup*) .



c) After the restore is complete, perform function that caused the error and if error reoccurs proceed to next step.

7. Contact Edmunds Gages technical support.

APPENDIX A - Performance/Process Capability Calculations

Performance Capability

Performance Capability indices Pp and Ppk are normally used when determining the possibilities of a process to produce within specified requirements and where the sampling of parts is made in the form of a large sample taken on one occasion

Pp

Pp is a Performance index. It is the relationship of the process distribution to the established spec limits. Typically a process is considered capable when the Pp is 1.33 or greater. Pp uses the actual standard deviation calculation from all samples in the active data set to determine performance

Pp = (USL - LSL) / (6 * StdDev)

Pr

Pr is the Performance ratio. Pp uses the actual standard deviation calculation from all samples in the active data set to determine performance.

Pr = (6 * StdDev) / (USL - LSL)

Ppk

Ppk is the Performance index. It is a measure of how centered the process distribution is. Pp uses the actual standard deviation calculation from all samples in active data set to determine performance.

Ppk = Min[(USL - Xbarbar),(Xbarbar - LSL)] / (3 * StdDev)

Process Capability

Process Capability indices Cp and Cpk are normally used when determining the capability of a continuous production process and where the sampling of parts is made continuously during the production

Cp

Cp is Process Capability. Capability is the relationship of the process distribution to the established spec. limits. Typically a process is considered capable when the Cp is 1.33 or greater.
Cp uses the estimated standard deviation calculation base on subgroup size and samples in the XR chart subgroups.

Cp = (USL - LSL) / (6 * StdDevEst)

Cr

Cr is the Capability ratio.

Cr = (6 * StdDevEst) / (USL - LSL)

Cpk

Cpk is the Process Capability index. It is a measure of how centered the process distribution is. A process is considered capable when the Cpk is 1.33 or greater.

Cpk = Min[(USL - Xbarbar),(Xbarbar - LSL)] / (3 * StdDevEst)

Machine Capability

Machine Capability indices Cm and Cmk are used when determining the ability of a production machine to produce, for example as acceptance test of new equipment. The sampling of parts is made in a short period of time without changes in machine settings. All efforts are make to try to isolate the influence on the machine from other factors

Cm

Cm is Machine Capability. Machine Capability is the relationship of the process distribution to the established spec. limits. Typically a process is considered capable when the Cm is 1.33 or greater. Cm uses the estimated standard deviation calculation base on subgroup size and samples in the XR chart subgroups.
Cm = (USL - LSL) / (6 * StdDevEst)

Cr

Cr is the Machine Capability ratio.
Cr = (6 * StdDevEst) / (USL - LSL)

Cmk

Cmk is the Machine Capability index. It is a measure of how centered the process distribution is. A process is considered capable when the Cmk is 1.33 or greater.
Cmk = Min[(USL - Xbarbar),(Xbarbar - LSL)] / (3 * StdDevEst)

Standard Deviation

Std Dev = Sqrt[(sum(X1-Xbar) / (n-1)]

Standard Deviation Estimate
Estimated Standard Deviation(Std Dev Est). The estimate of the standard deviation of a stable process using the dispersion statistics associated with the sub-grouped samples taken from the XR Chart Data.

Std Dev Est = Rbar / d2

d2 Constants
Subgroup Size (N)

N	d2
1	1.128 (Rbar moving range average)
2	1.128
3	1.693
4	2.059
5	2.326
6	2.534
7	2.704
8	2.847
9	2.97

Xbarbar

Xbarbar: Average (Mean) of the average of each subgroup
Xbarbar = ($\bar{X}1$ + $\bar{X}2$ + $\bar{X}3$ + .. $\bar{X}n$)/n

Xbar

X-bar: Average (Mean) of all readings
X-bar = (X1 + X2 + X3 + .. Xn)/n

RBar

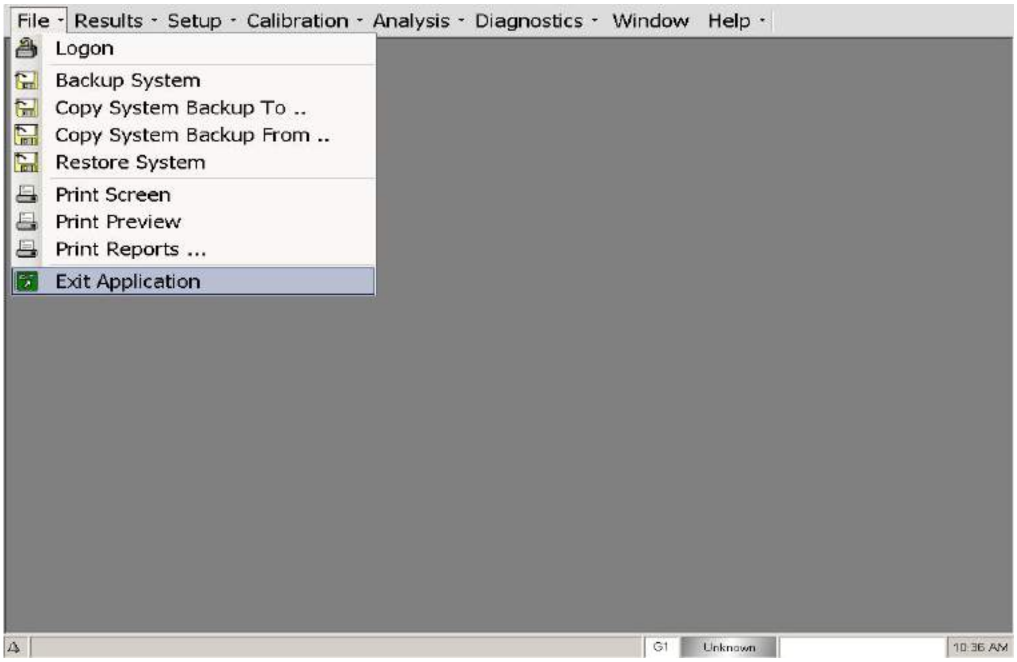
R-bar: Average range of all the range values (Xmax-Xmin) for each subgroup

R-bar = (R1 + R2 + R3 + .. Rn)/n

R = (Xmax - Xmin)   from subgroup values

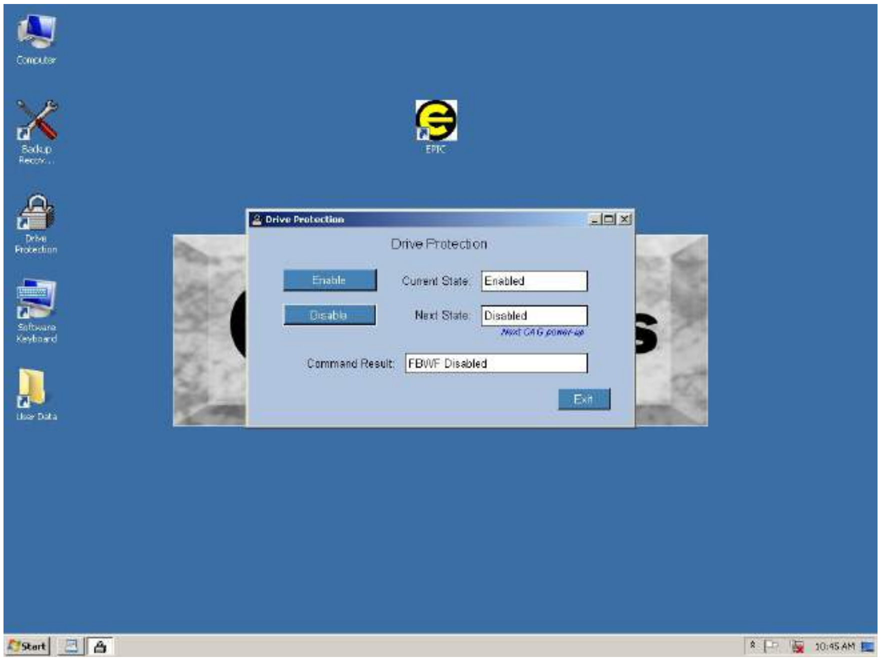
APPENDIX B - Setting Ethernet IP Address of EPIC CAG unit

1. Exit the EPIC application



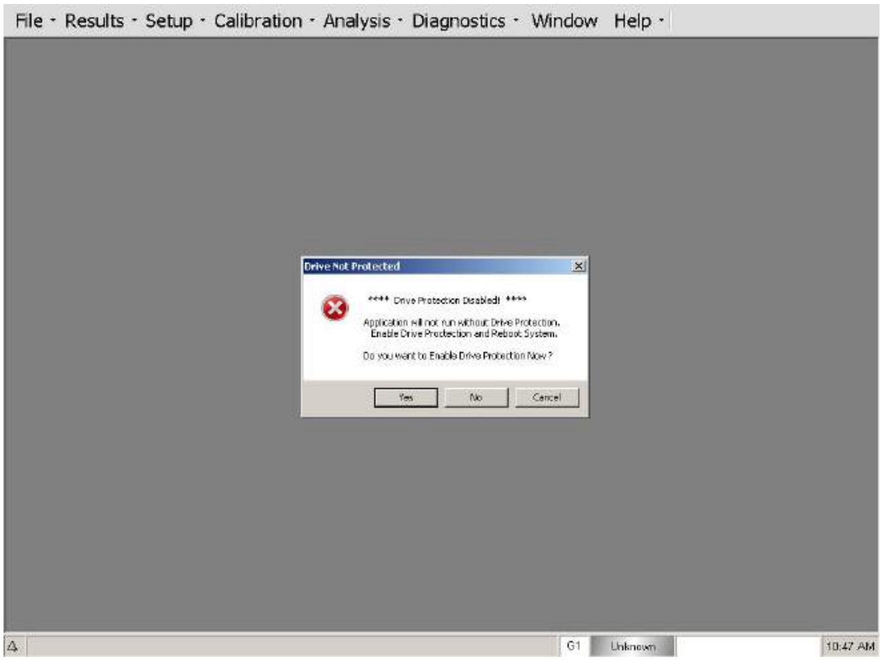
2. Click on “Drive Protection”

3. Click on “Disable”. Need to reboot system.

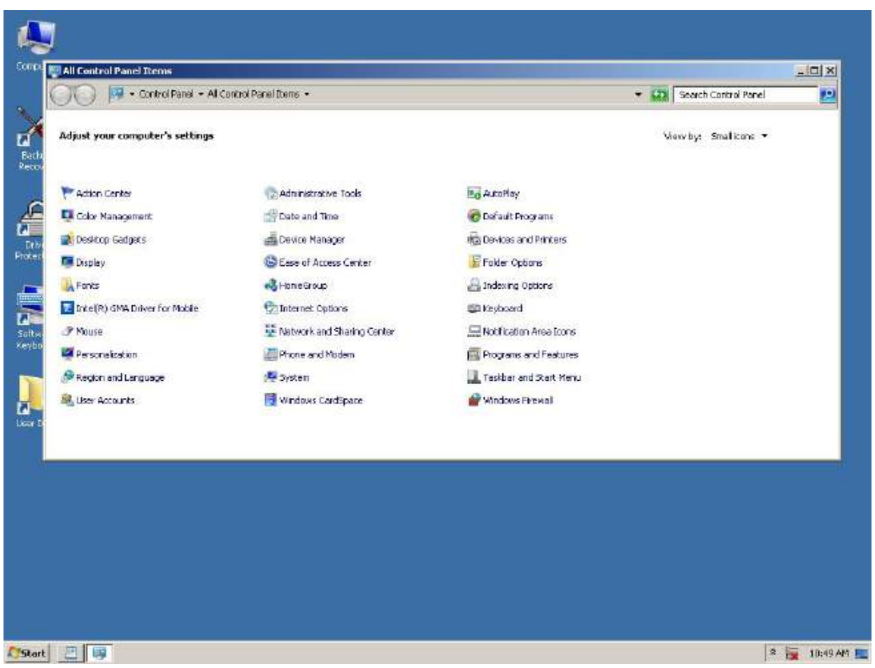


4. Shutdown system (reboot)

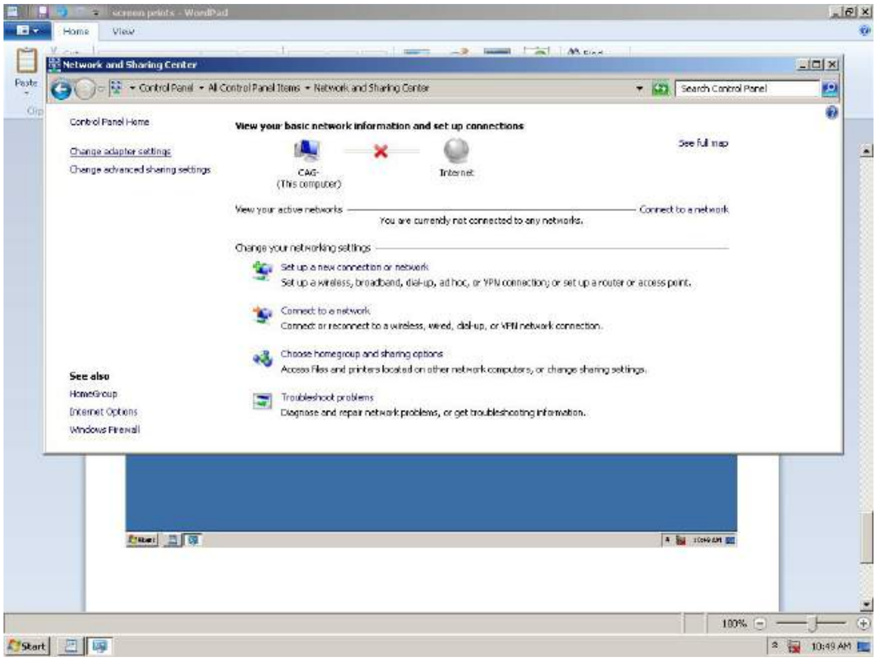
5. When system powers up the EPIC application will display error message. The EPIC application will not run if drive protection is disabled. Select “NO” , t he system will then exit to Windows Desktop.



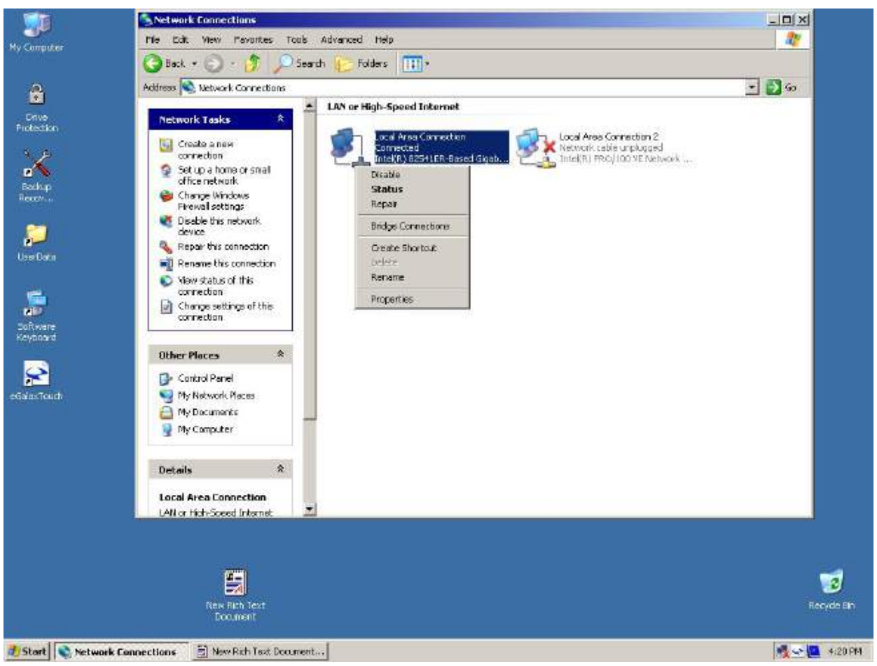
6. From the Desktop, click on the “Start” button then select “Settings” then “Control Panel”. Once in the “Control Panel” select “Network and Sharing Center”.



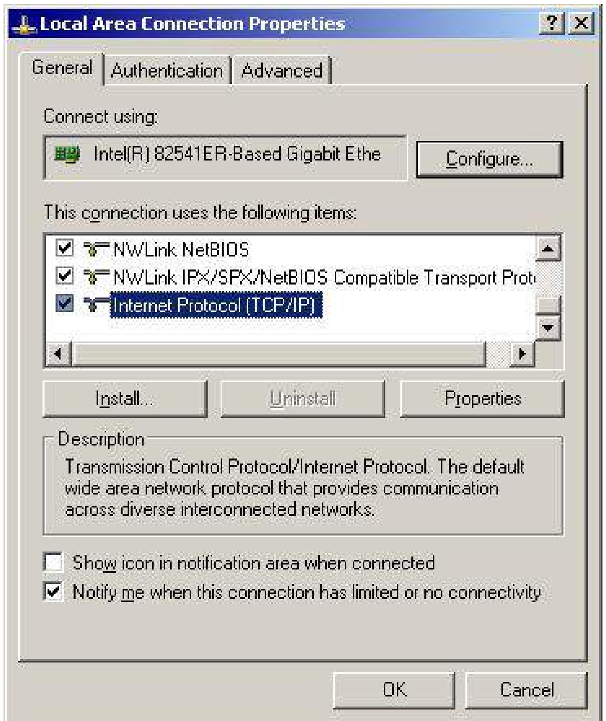
7. Select “Change adapter settings”.



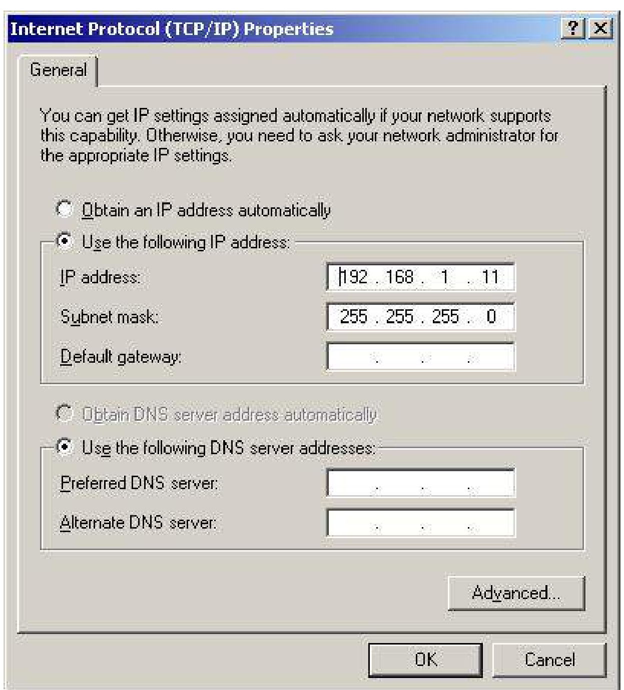
8. Right click mouse button on “Local Area Connection” and select “Properties”.



9. Select “Internet Protocol (TCP/IP)”.

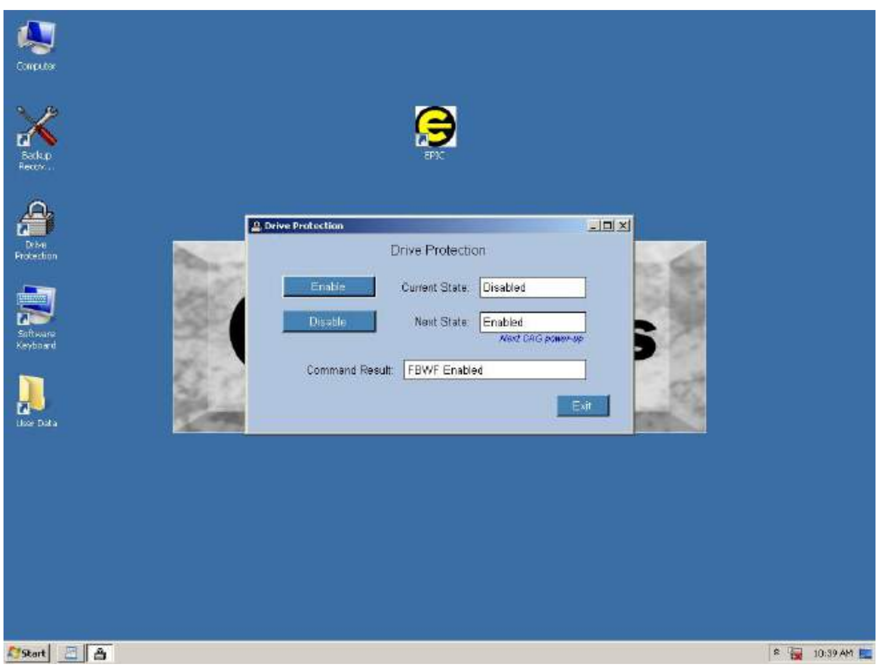


10. Set the “IP address” and “Subnet mask” as needed. Select OK when done.



11. Click on “Drive Protection”

Click on “Enable.   Need to reboot system.



13. Shutdown system (reboot).   Complete

APPENDIX C - EPIC Software Activation

The EPIC Software requires an Activation Code to prevent a software shutdown from occurring. Each system is preset with a number of days the system will run until shutdown. The number of days until system shutdown can be viewed in the “About” screen (see Figure 1).   When the system is within seven (7) days of shutdown a red warning alarm will display every hour stating the system is not activated and will shutdown in a number of hours (see Figure 2). If the system has is shutdown, the user can still navigate to all the screens but the system will not perform a measurement cycle or calibration cycle and live input readings will be disabled. When the system is shutdown, a warning alarm will be displayed every hours stating the system is is not activated (see Figure 3).

Figure 1. Help - About Screen - System Not Activated

Figure 2. System Not Activated - Alarm

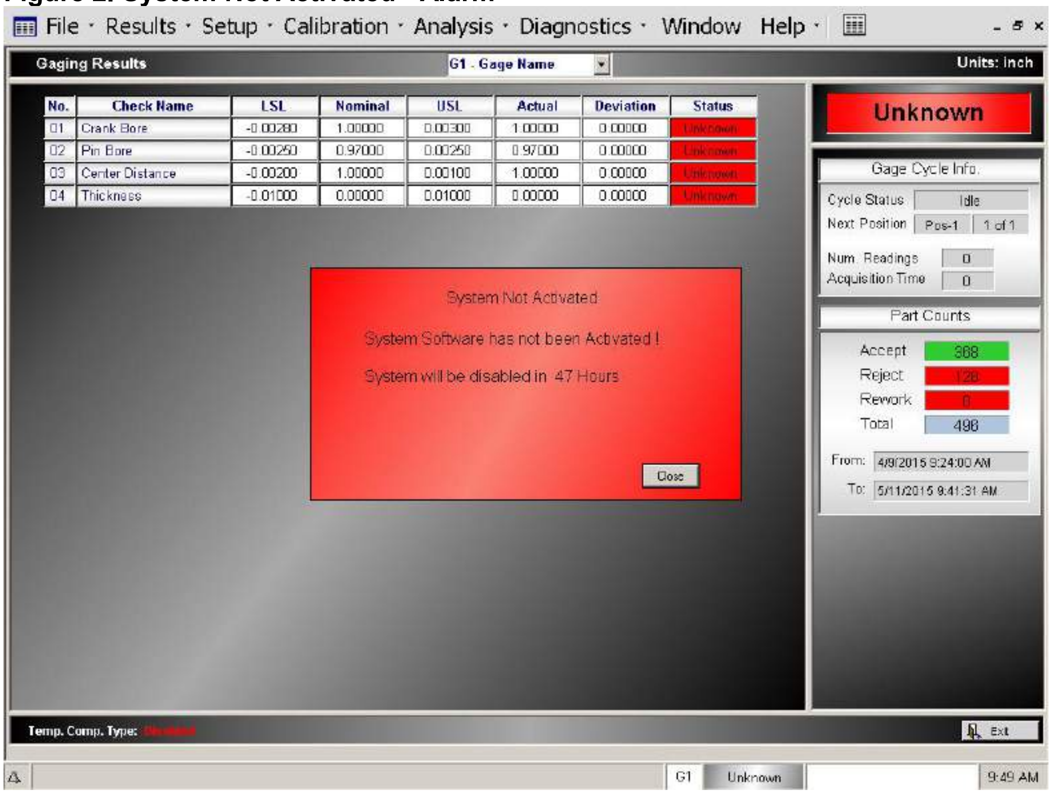
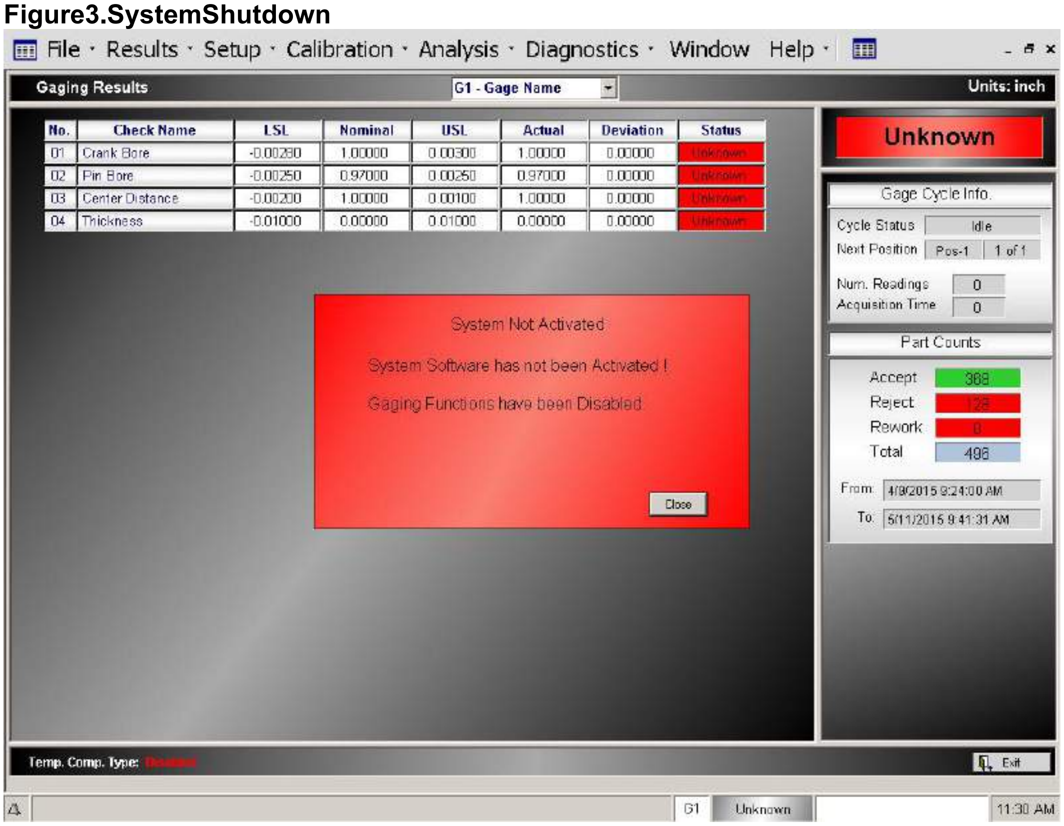


Figure3.SystemShutdown



Activating EPIC System:

1. Open the About screen (menu: Help - About)
2. Enter Activation code supplied by Edmunds Gages.
3. Select the “Activation” button (see Figure 4)
4. A message box will be displayed stating Software Activated.
5. When the system is Activated the About screen will no longer display activation box (see Figure 5).

Figure 4

Figure 5

APPENDIX D - Gage R&R Calculations

XBar and R (ARM) Method

ARM methods R&R calculations are in accordance with Automotive Industry Action Group (AAIG) (2010), MSA (Measurement System Analysis Reference Manual), Fourth Edition, pages 116-123.

The calculations used for the ARM R&R are presented in the following sections.

Range

$\overline{R}_a = \text{Avg Range Appraiser A}$

$\overline{R}_b = \text{Avg Range Appraiser B}$

$\overline{R}_c = \text{Avg Range Appraiser C}$

$$\overline{\overline{R}} = (\overline{R}_a + \overline{R}_b + \overline{R}_c)/3 = \text{Average Range of all Appraisors}$$

Average (Readings)

$\overline{X}_a = \text{Avg Appraiser A}$

$\overline{X}_b = \text{Avg Appraiser B}$

$\overline{X}_c = \text{Avg Appraiser C}$

$$\overline{\overline{X}} = (\overline{X}_a + \overline{X}_b + \overline{X}_b)/3 = \text{Average of all appraisers}$$

SV (Study Variation)

Study variation is a multiplier used in study variation calculations. The default multiplier is 5.15, which is the number of standard deviations needed to capture 99% of the process measurements. A 99% spread is on considered to represent the full spread of measurement error. A 99.7% spread is represented by a multiplier of 6, which is +-3σ and represents the full spread of a “normal” curve.

Repeatability - Equipment Variation (EV)

$$EV = \overline{\overline{R}} * K_1 * SV$$

K_1 is dependent on the number of trials (r) and the number of parts times the number of operators (g) which is assumed to be greater than 15.

TRIALS	2	3
K_1	0.8862	0.5908

Equipment Variation as percentage of part tolerance

%EV = (EV/Tolerance)100

Equipment Variation as percentage of total variation (TV)

%EV = (EV/TV)100

Reproducibility - Appraiser Variation (AV)

$$\text{AV} = \sqrt{\left(\overline{X}_{DIFF} \times K_2 \times SV\right)^2 - \left(EV^2 / nr\right)}$$

$\overline{X}_{DIFF} = \text{Max}\overline{X}_i - \text{Min}\overline{X}_i$ ($\overline{X}_i$ is the average of all readings for a single operator.)

n = number of parts

r = number of trials

K_1 is dependent on the number of trials (r)

appraisers	2	3
K_2	0.7071	0.5231

If a negative value is calculated under the square root sign, the appraiser variation (AV) defaults to zero (0).

Appraiser Variation as percentage of part tolerance

%AV = (AV/Tolerance)100

Appraiser Variation as percentage of total variation (TV)

%AV = (AV/TV)100

Repeatability and Reproducibility (R&R)

$$R\&R = \sqrt{EV^2 + AV^2}$$

Appraiser Variation as percentage of part tolerance

%R&R = (R&R/Tolerance)100

Appraiser Variation as percentage of total variation (TV)

%R&R = (R&R/TV)100

Part Variation (PV)

$$PV = R_p \times K_3 \times SV$$

$$R_p = \mathrm{Max}\overline{X}_p - \mathrm{Min}\overline{X}_p$$

R_p is defined as the range of $\overline{X}_p$ values where $\overline{X}_p$ is average across all trials and operators of a single part tested.

Samples	2	3	4	5	6	7	8	9	10
K3	0.7071	0.5231	0.4467	0.403	0.3742	0.3534	0.3375	0.3249	0.3146

Appraiser Variation as percentage of part tolerance

%PV = (PV/Tolerance)100

Appraiser Variation as percentage of total variation (TV)

%PV = (PV/TV)100

Total Variation (TV)

$$TV = \sqrt{\left(R\&R^2 + PV^2\right)}$$

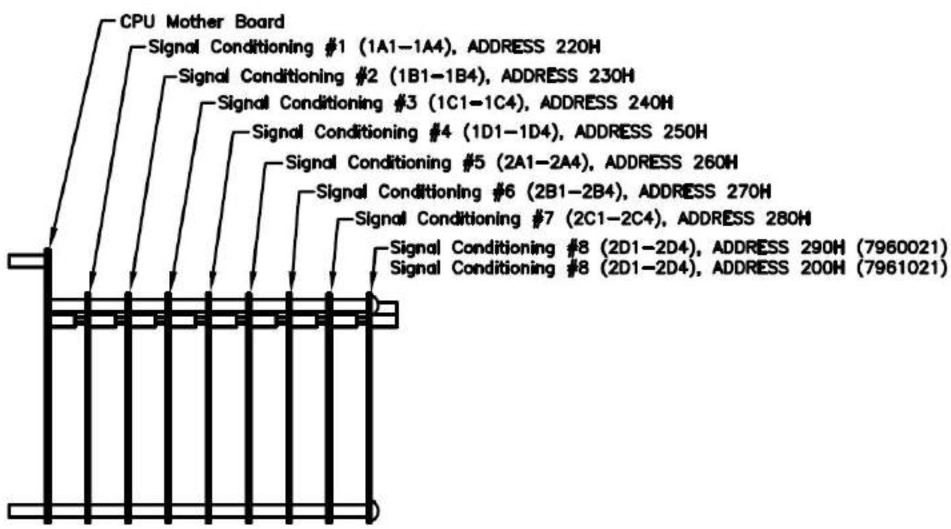
ANOVA Method

ANOVA methods R&R calculations are in accordance with Automotive Industry Action Group (AAIG) (2010), MSA (Measurement System Analysis Reference Manual), Fourth Edition, pages 116-123.

APPENDIX E - 4 Input Channel Add On - Hardware & Software Setup

Adding additional inputs to an EPIC CAG unit requires additional hardware and software setup change. Input signals are processed thru a PC104 Signal Conditioning Card (S/C Card) mounted on the EPIC CAG CPU Motherboard. Each S/C Card contains 4 Input Channels and the EPIC CAG can support up to 8 S/C Cards providing for a total of 32 Inputs.

PC104 BOARD STACK POSITIONS



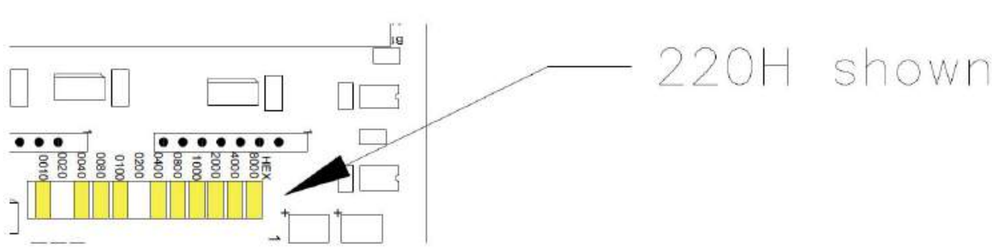
Components Required

Adding additional inputs to EPIC CAG requires the following hardware components:

① PC104 Signal Conditioning Card, Board #4110957-BM
② Ribbon Cable 24", #7960615
③ Connector Panel, #7960710
④ DIN PCB Assembly, #4110963-BM

Assembly Instructions

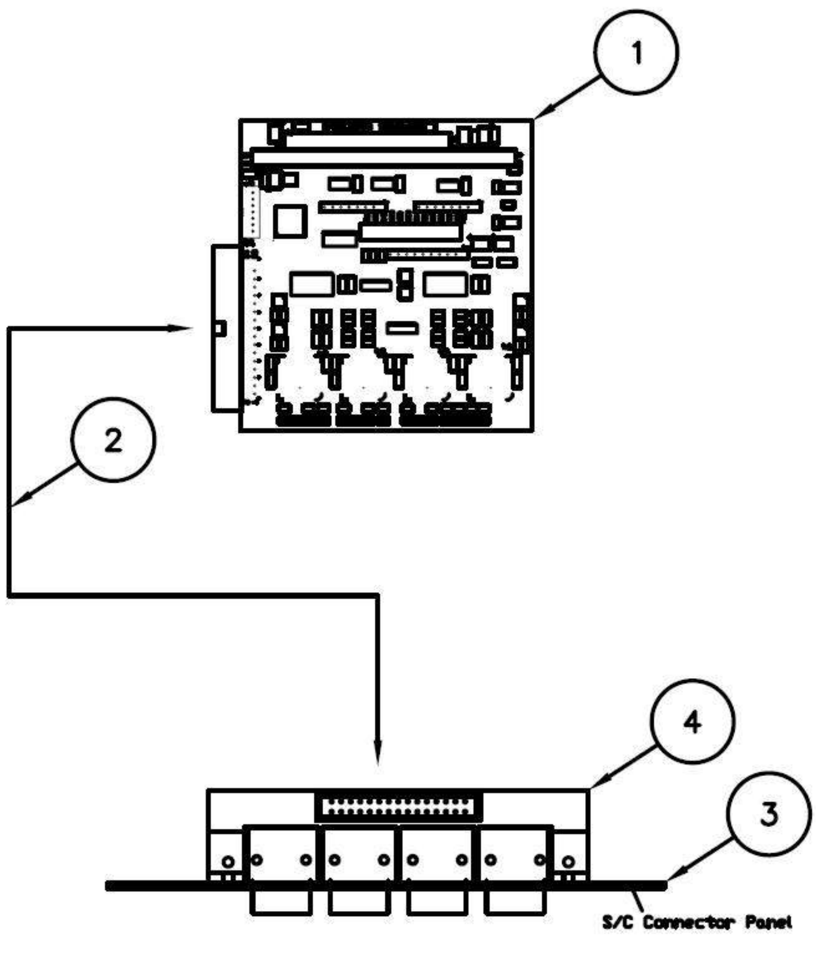
1. Verify that the S/C Card is set for the correct address. Each S/C Card requires a unique address that is set with a series of jumpers located on the board. The jumpers are removed to add up to the desired address, for example to set board address to 220H (board #1), jumpers 0200 and 0020 are removed adding up to 220H. To set board address of 250H (board #4), jumpers 0200, 0040 and 0010 are removed adding up to 250H.

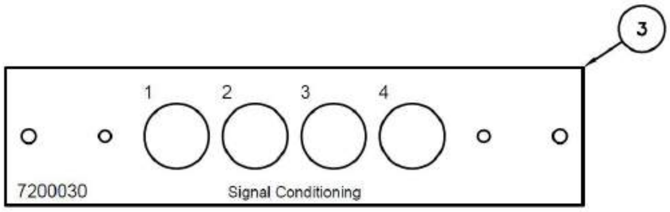


S/C Card #1 : Address 220H (1A1- 1A4)
S/C Card #2 : Address 220H (1B1 - 1B4)
S/C Card #3 : Address 230H (1C1 - 1C4)
S/C Card #4 : Address 240H (1D1 - 1D4)
S/C Card #5 : Address 250H (2A1 - 2B4)
S/C Card #6 : Address 260H (2B1 - 2B4)
S/C Card #7 : Address 270H (2C1 - 2B4)
S/C Card #8 : Address 200H (2D1 - 2B4)

2. Attach Ribbon Cable ② to Signal Conditioning Card ① and DIN PCB Assembly ④.
3. For signal conditioning board 1-4, mount Connector Panel ③ to the left side of the CAG enclosure.
4. For signal conditioning board 5-8, mount Connector Panel ③ to the right side of the CAG enclosure.
5. Mount Signal Conditioning Card on the CPU Motherboard PC104 stack.

PC104 SIGNAL CONDITIONING



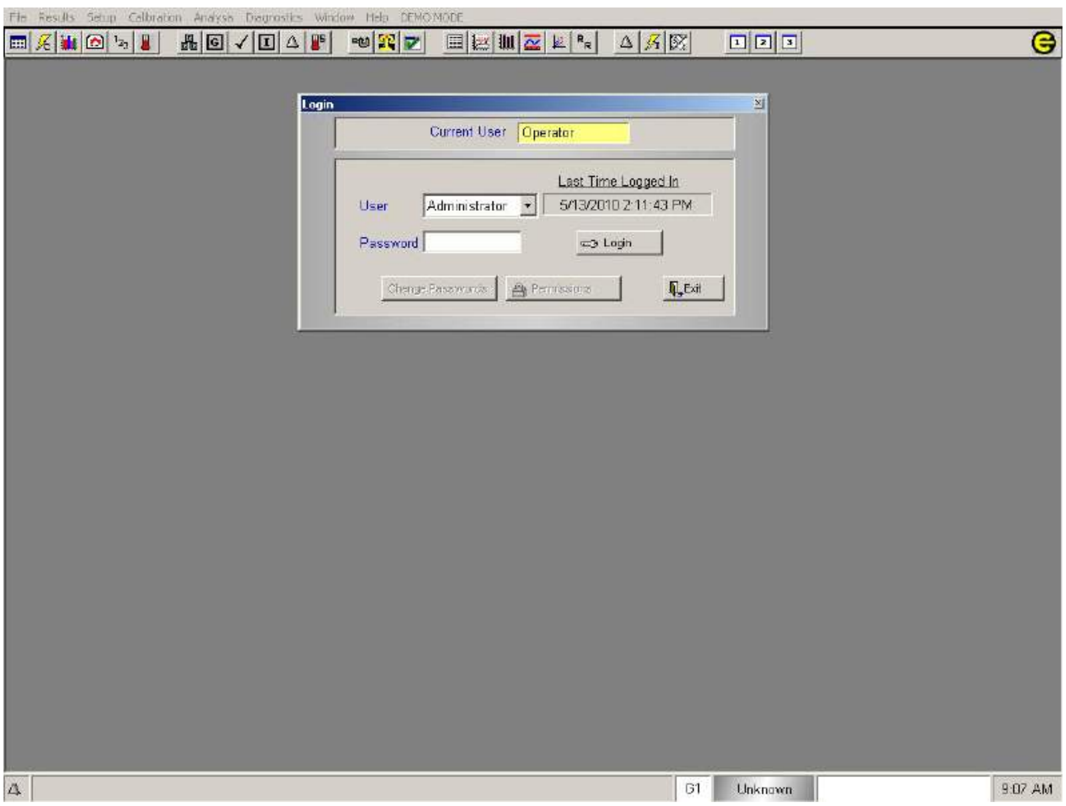


Software Setup Instructions

Change number of Inputs in EPIC software.

The number of inputs needs to be changed (increased) to equal the total number of inputs including the new inputs added.

1. Logon as Administrator (menu: File – Logon)



2. Change the number of inputs
    a. Go to “Inputs Setup” screen (menu: Setup – Inputs Setup)
    b. Click on “Number Inputs” on bottom of screen.
    c. Select the desired number of inputs from drop down box.
    d. Save and then exit EPIC application and restart.