

GRAPHIC GAGE "EUROGAGE"  
COMPUTERIZED FREELONGTH CONTROL SYSTEM

Built by:

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## 1.0 DESCRIPTION OF FEATURES

1.1 Length Control System The Graphic Gage is a microprocessor based controller and probe for measuring the spring free length deviation from a target mean free length while coiling. When used with a pitch controller and sorting chute, the Graphic Gage makes pitch adjustments based upon statistical data to correct for free length variation, and sorts the springs according to selected free length tolerances into three or five categories.

Some of the features of the Graphic Gage include:

- graphic LCD (liquid crystal display)
- patented feedback calculation
- temperature stabilized probe
- three and five way sorting capability
- broken tool detection
- quota shut down
- rotary probe control
- statistical printouts
- auto zero
- simple menu set up and programming

The Graphic Gage enables the operator to make scrap reduction simple.

1.2 Length Measurement Each spring is measured many times prior to cut off. These measurements are sorted from the longest to the shortest. The length is calculated from the average of the center of these measurements. This patented measuring method increases the accuracy of spring length measurements and reduces the effects of electrical noise and mechanical vibration.

1.3 Pitch Correction: The operator selects from two pitch control methods: "AUTO", or "%TOL".

1.3.1 AUTO: In this mode the gage makes a proportional adjustment based upon the variation from the target mean free length. The adjust knob is set for an initial setting by the operator. A good place to start is with the dot on knob set at the 12:00 o'clock position or midway of its travel. All the way counterclockwise provides minimum adjustment. All the way clockwise provides maximum adjustment.

Each pitch adjustment is checked to determine if the correct adjustment was made. If the correction was too great, the amount of pitch adjustment decreases a little. If the correction was too small, the amount of pitch adjustment increases a little. The gage also monitors the three sigma of the last 30 springs coiled. Each pitch adjustment is limited to a fraction of this 3 sigma value. This is called flyer rejection and improves centering.

The adjust knob setting is only a target setting. The best internal pitch adjustment calculation is automatically maintained to reduce free length variation to obtain the best yeild. The

Eurogage stabilizes to provide the best good spring yield in 50 to 100 coiled springs. The gage continually optimizes the pitch correction calculation to compensate for changes in the wire or the coiling process.

1.3.2 %TOL (Barrier Avoidance): In % tolerance mode the amount of the adjustment and the frequency of adjustment is based upon the position of the adjust knob and the "%TOL" value in the setup mode. A fixed adjustment to center the process is triggered whenever the spring length exceeds the % of sort tolerance set in setup. The amount of adjustment is determined by the setting of the adjust knob. With the adjust knob turned all the way counterclockwise the gage makes very small adjustments. With the knob turned all the way clockwise, the gage makes very large adjustments. The smallest amount of adjustment is usually the best to center the process.

"%TOL" is selected over "AUTO" only when running low performance material or on coilers with mechanical problems. Use "AUTO" first, as auto mode usually provides a better yield.

1.4 Five way sorting: This feature allows sorting the good springs into 3 groups, and sorting the bad springs into 2 groups. It is becoming a very popular feature as it allows for grinding to closer tolerances than ever before. Good group tolerances can be even (33% each), or center weighted (25% long, 50% center, & 25% short) with respect to the overall tolerance.

Example: The gage is set for 5 way sorting at 33%. If the total "good" spring tolerance is +/- 0.012", then the 0.024" total tolerance is divided into three good spring groups of 0.008" each. Shorts are anything shorter than -0.012", longs and anything longer than 0.012" and the remaining groups are -0.012" to -0.004", -0.004" to 0.004" and 0.004" to 0.012". As in the case of three way sorting, the two outer groups, long and short, may have very long and very short springs. Consequently, the outer groups are sometimes thrown away or manually 100% inspected. The three inner groups can be easily ground.

## 2.0 DESCRIPTION OF ACCESSORIES

2.1 Graphic Gage: This is the main control unit that all accessory equipment, such as sorting chutes, pitch controllers, etc. connect to. It contains all operational controls such as on/off, configure, and set up. Portions of the Eurogage are protected under U.S. patent #4,719,586 and copyrights.

2.2 Temperature Stabilized Probe: The Graphic Gage uses a noncontact capacitive measuring probe. The internal temperature of the probe is kept at a constant, thus reducing drift due to fluctuating outside temperatures. This measuring device has a micrometer at one end and a threaded barrel at the other end. A cable with a six pin plug extends from the probe for connecting to the Graphic Gage's "PROBE" output socket.

2.3 Rotary Probe Assembly: An optional rotary probe holder with a heavy duty rotary noncontact capacitive measuring probe can plug directly into the Graphic Gage. The probe rotates out of the way before cutoff, which eliminates the spring hitting the tip end. A brush wipe can be added for cleaning the tip after each spring.

2.4 Probe Tip: The probe tip threads onto the end of the probe. The O.D. of the probe tip is chosen to be slightly larger than the O.D. of the spring. Refer to the chart on page 14 of the manual for recommended tip sizes and standoff distances from tip to spring.

2.5 Special Probe Tips: Probe tips that are not one of our 7 standard sizes, 1/8", 1/4", 3/8", 1/2", 5/8", 3/4", and 1", are available upon request.

2.6 Probe Holder: The probe holder holds the temperature stabilized probe. This bracket is adjustable so the probe tip can be in a fixed position on the coiler and centered in front of the coiled springs.

2.7 Pitch Controller Assembly: The complete assembly includes a pitch drive motor, and necessary hardware to make automatic adjustments to the pitch control mechanism on coilers. There are several sizes and types of pitch controllers available. Standard systems are available for most coilers. Special controller systems are designed as needed. A cable connects the pitch drive motor to the Graphic Gage "ADJUST" output socket.

2.8 Read Switch Assembly: The assembly includes a magnet mounted on a lock collar, hall-effect magnetic (read) switch with cable having a three pin plug for connecting to the "READ" socket on the gage back panel, and hardware for mounting the switch inside the coiler. The magnet mounts on any shaft that makes one

revolution per spring. The read switch is positioned to detect the magnet. A read signal is sent to the Graphic Gage after the spring is coiled, but prior to cut off.

2.9 Stainless Steel Three Way Sorting Chute: This chute sorts springs into three groups, short, long, and good. The chute comes complete with all the necessary cabling and plugs for connecting to the Graphic Gage's "SORT" output socket. This chute is available in two throat sizes, 4"x4" and 4"x8".

2.10 Stainless Steel Five Way Sorting Chute: This chute sorts springs into five groups. The total good spring length tolerance is divided into three good groups. This chute is available in two different throat sizes, 4"x4" and 4"x8". The chute connects to the gage via two cables. These cables connect to the Graphic Gage "SORT" and "AUX OUT" output sockets.

2.11 Coiler Kill (safety): The coiler kill kit includes two 3 pin sockets and relay mounted on a pc board, and a 3 pin cable. It is designed to turn off the coiler if one of the following occurs: (1) a number of consecutive bad springs are coiled, (2) broken tooling or wire has been detected, or (3) a quota of good springs are coiled.

The 3 pin cable connects to the Graphic Gage via the "AUX OUT" output socket.

When using a five way chute with coiler kill, the two pin plug from the chute is connected to one of the sockets on the coiler kill board. The 3 pin plug from the coiler kill cable is plugged into the "AUX OUT" socket.

### 3.0 NAMES AND FUNCTIONS OF CONNECTORS AND SWITCHES

3.1 PRINTER: The 25 pin connector on the Moyer printer cable plugs into this receptacle. (Moyer printer cable and Eurogage can be used with most Epson Compatible printers)

3.2 SER I/O: Used to connect a data collection device directly into the Graphic Gage. A nine pin connector plugs into this receptacle.

3.3a FUSE 5A: 5 amp (117VAC 60hz model) 250 volt

3.3b FUSE 2.5A: 2.5 amp (240VAC 50hz model) 500 volt

3.4a 117 VAC LINE: The main power connector that requires using the supplied grounded plug. In plants with extreme electrical noise, extra grounding may be required. (117 VAC 60hz model)

3.4b 240 VAC LINE: The main power connector which requires using the supplied grounded plug. In plants with extreme electrical noise, extra grounding may be required. (240 VAC 50hz model)

3.5 ADJUST (117/240 VAC): The three pin plug from the pitch drive motor plugs into this socket.

3.6 SORT (117/240 VAC): The three pin plug from the air valve, three way sorting chute, or the five way sorting chute plugs into this socket.

3.7 AUX 1 (117/240 VAC): The two pin plug from the five way sorting chute or the three pin plug from the coiler kill cable plugs into this socket.

3.8 AUX 2 (117/240 VAC): The two pin plug from the rotary probe air valve plugs into this socket.

3.9 PROBE: The six pin plug from probe cable plugs into this socket.

3.10 READ: The three pin plug from the read switch cable plugs into this socket.



3.11 Contrast Knob: This is used to adjust the contrast of the LCD display.

3.12 Adjust Knob: In run mode, it is used to control the amount of pitch adjustment. In test mode, it is used to help test the gage and probe for proper functional operation.

3.13 Sort Knob: In run mode, it is used to set sort time. Changing the sort time also changes rotation time when the rotary probe is used. In test mode, it is used to help test the gage and probe for proper functional operation.

3.14 LCD (Liquid Crystal Display): The LCD displays data and menus for running productions, set-up, configure, and hardware tests.

3.15 Key Pad: The Key Pad is used to select options from menus, and to enter options and numbers. (The MODE key changes displays and brings up menus.)

## 4.0 RECEIVING and INSTALLING THE Graphic Gage

4.1 Unpacking: Before accepting the shipment from the carrier, inspect all cartons for signs of damage. If you suspect that a carton is damaged, open the carton in front of the carrier's representative and check the contents. Each component will be shipped with approved packing. Go thru each carton carefully and check against the packing list to be sure no parts are lost in the packaging materials. In all cases, report any missing parts or damage to the carrier and Moyer Process and Control Co., Inc. immediately.

4.2 Installation: WARNING: Do not connect power cord until instructed.

4.2.1 Gage Placement: Place the Graphic Gage in a location so the operator has good access and visibility to the front of the gage. Avoid putting the gage where it will be subjected to excessive shock, falling, oven heat and the like. Place the gage where its use will not subject the operator to danger from moving machine parts. Normal coiler vibration should not be considered excessive.

4.2.2 Installing the Probe & Holder: Coil a spring by hand until wire feed quits. Put the probe thru the 1" hole on the probe holder. Slide the probe forward so the collar is gripping the probe at the back, close to flange of the outer cylinder toward the micrometer. The micrometer should be readable. Tighten the collar around the probe using the 1/4-20 screw.

Locate the base of the probe holder on the coiler in an area that won't interfere with the fall of the springs after cut off, or with the operator during tooling changes, and so the probe measuring end is in front of the coiled spring. Mark the location of the holes on the coiler thru the probe holder base. Drill and tap holes on the coiler as marked for 1/4-20 screws. After tapping, file the coiler face to remove any burrs, then mount the probe holder base to the coiler.

Select a probe tip that is slightly larger than the O.D. of the coiled spring. Make sure that the brass spring is in the probe tip before screwing it onto the probe. Screw the probe tip

tightly onto the probe (finger tight sufficient.) Refer to section 5 page 14 of the manual for tip size selection and distance between the end of the spring and the probe tip. Using the probe holder sliding block, position the probe tip in front of the coiled spring. Make sure the tip is on the same axis of the spring and the tip covers the O.D. of the spring. Tighten the 1/4-20 cap screws on the probe holder sliding block. Be sure to tape the probe cable to the probe holder. Connect the six pin plug to back of the gage in the socket marked "PROBE". Route the probe cable so that it is out of harms way. Note: The probe must be held rigid. Any movement of the probe will affect the free length measurement.

The Moyer temperature stabilized probes are interchangeable between any Graphic Gage, Mean Machine or PJM 1000 gaging system. They require no calibration, matching, or tuning for a particular gage.

4.2.3 Installing the Read Switch: The read switch assembly consists of a magnet mounted on a lock collar, and a read switch mounted in a mounting bracket. Mount the magnet to any shaft that makes one complete revolution per spring. Mount the switch and bracket so that nothing will hit it and so that the magnet will pass 0.030" <0.7mm> to 0.080" <2mm> from the flat on the switch once each spring. Position the read switch and magnet so that the read signal will be made after the wire quits feeding but before cut off.

NOTE: On most segment type coilers, the read signal should take place at the midpoint between end of feed and cut off. On escapement coilers, high speed coilers, or when using the rotary probe, the read must take place as soon as the wire quits feeding.

Coil a spring by hand slowly to insure that the magnet does not hit anything. Cut off the spring. Connect the read switch three pin plug to the socket on the back of the gage marked "READ".

With no other accessories plugged into the gage, plug in the power cable and turn the gage on. Coil a spring by hand and check the read signal. Some of the LEDs should blink when a read signal is received by the gage. Verify that the blink is at the correct point in the coiling cycle. Turn the gage off.

4.2.4 Installing the Pitch Control Motor: NOTE: Due to the variety of coilers the following procedure may vary and the type of mounting hardware may be different than listed here. However, the basic principals still apply. If you have any question regarding this, contact customer service for assistance. Telephone: (219) 495-2405 Fax: (219) 495-1290.

4.2.4.1a Single Coiling Point Systems: The pitch controller assembly consists of pitch motor, flex shaft, adaptor nut and gearbox. On some coilers the pitch motor is directly connected to the pitch pull rod. Remove the locking nut from the pitch rod on the coiler. Check the pitch rod threads for cleanliness and rough spots. If necessary, clean threads by using a die to ensure smooth movement of the adaptor nut on the pitch rod.

Screw adaptor nut onto pitch rod. Connect the flex shaft to the gear box's input shaft. Set the gear box's hollow shaft over the nut on the pitch rod. Position the flex shaft so that the end of the flex shaft which attaches to the pitch drive motor will be in the proper position to mount it to the pitch drive motor. Tighten the two set screws in the gear box hollow shaft to the nut. Adjust the height of the pitch drive motor using the two legs on the base of the pitch drive motor housing so the flex shaft is parallel to the coiler. Fasten the flex shaft to the pitch drive motor.

Position the pitch drive motor so the flex shaft does not hit anything and has a very slight curve. This curve helps the flex shaft act as a torque arm. Using the mounting holes in the two pitch drive motor legs, mark the coiler. Slide the pitch drive motor housing out of location and drill clearance mounting holes for 10/32 screws. Be sure to use lock washers or locking nuts to prevent hardware from coming loose and falling into the coiler mechanism. Proceed with 4.2.4.2.

4.2.4.1b Dual Coiling Point Systems: The pitch controller

assembly consists of pitch motor, universal, and threaded rod (often supplied with the coiler). Usually the pitch motor replaces the fine pitch adjustment knob. Remove the existing knob, detent, and universal. Check the pitch rod threads for cleanliness and rough spots. If necessary clean threads by using a die to ensure smooth movement.

Install the universal on the end of the threaded rod. Reinstall the threaded rod back on the elliptical pitch adjustment bushing. Position the pitch control motor so it's output shaft aligns with the end of the threaded rod. Be sure that there is room for the system to adjust through it's entire range. Attach the motor to the coiler using the proper screws, and tighten the universal to the motor shaft using the set screws.

4.2.4.2 Checkout: Connect the three pin plug from pitch drive motor to the socket on the back of the gage marked "ADJUST". Turn the gage on. Place the gage in "SET UP" mode by pressing the mode key. Check for correct motor direction by pressing the "1" (in) and "2" (out) buttons. If the motor turns the wrong direction, reverse the switch on the motor. When a gear box reducer is use motor direction can also be reversed by mounting the flex shaft to the other input shaft on the gear box reducer. Unplug power.

4.2.5 Installing the Sorting Chute: Position the chute so the back of the funnel is as close to the front of the coiler as possible. This is usually beneath the cut off mechanism. Align the chute so the springs, after cut off, fall into the throat portion of the chute without bouncing out.

Fabricate a mounting bracket that connects the chute to the coiler in the correct position.

Connect the three pin plug on the three way chute to the socket on the back of the gage marked "SORT".

The five way chute has two cables to connect to the gage. Connect the three pin plug into the socket on the back of the gage marked "SORT". Connect the two pin plug into the socket on the back of the gage marked "AUX OUT".

When using a five way chute with coiler kill, the two pin plug is connected to one of the sockets on the coiler kill pc boards. The three pin socket on the coiler kill board is attached to the "AUX OUT" using a supplied cable.

## 5.0 USING THE GRAPHIC GAGE

The gage must be taken through a series of steps before first use. Step #1 is to configure the gage. In configure, the least often changed gage options are set. Step # 2 is to set up the gage. This step is used to set the sort limits and enter parameters on the spring you are coiling. Step #3 is running the gage during production. The last step is to analyze the results and improve the process.

### 5.0.1 GENERAL INSTRUCTION

The "MODE" key: This key has different functions, on power up, to change from screen to screen while running the gage.

SELECTING OPTIONS: Move the "->" cursor to select the option that you want to perform. NOTE: This does not execute the option. The "->" cursor moves from option to option. Any option may be selected with either the "UP" or "DOWN" key. The "ENTR" key executes the selected option.

ENTERING NUMBERS: For entering or changing a number, an underline cursor will highlight the last digit of the number. The "CLR" or "ESC" key will remove that digit and move the remaining digits 1 place to the right, while filling the left with '0'. The '0' thru '9' keys will shift the number one place left and insert the digit pressed. The "UP" and "DOWN" keys increase and decrease the number by one. You must press "ENTER" when finished changing a numeric value. The gage will hold it's memory if turned off, and only erases a previous set up when it is turned on while pressing and holding the "MODE" key on the key pad.

## 5.1 Configuring your Graphic Gage

5.1.1 ENTERING CONFIGURE: Turn the gage on. Press and release the "MODE" key once. Use the "UP" or "DOWN" key to move the cursor to CONFIGURE option. Press and release the "ENTER" key. The gage is now in "CONFIGURE" menu. You can select an option by using the "UP" or "DOWN" keys to move the cursor to that item. This menu will allow you to set or change the following options:

5.1.2 SORTING: Three or five way sorting is changed by moving the cursor to the option and pressing the "ENTER" key.

5.1.2.1 LIMIT: Control limit type is changed by moving the cursor to the option and pressing the "ENTER" key.

5.1.3 DWELL: Coiler dwell is changed between short (non-segment) and normal (segment) by moving the cursor to the option and pressing the "ENTER" key.

5.1.4 BAUD: RS232 baud rate is changed between 1200 and 9600 by moving the cursor to the option and pressing the "ENTER" key.

5.1.5 UNIT: The Unit of measurement is changed between Metric and Inch by moving the cursor to the option and pressing the "ENTER" key. All data and settings convert so that you need not reset the gage.

5.1.6 ROTATION: The Rotary probe rotation time is changed by moving the cursor to the option and pressing the "ENTER" key. Then enter what % of sort time the probe should rotate away from the spring. (25% to 33% is usually good)

5.1.7 MCS SPC: MCS time & SPC time is changed by moving the cursor to the option and pressing the "ENTER" key when one of these options are selected. Then enter the time you want. (seconds and minutes are on the display)

5.1.8 TOOL SAFE: Broken tool detection option is turned on and off by moving the cursor to "TOOL SAFE" and pressing the "ENTER" key.

5.1.9 REJECT SAFE: The Coiler kill number is changed by moving the cursor to the option and pressing the "ENTER" key. Enter the number of consecutive bad springs you want to shut the coiler off at. 0 will disable the option.

5.1.10 DATE TIME: The Date and Time are changed by moving the cursor to the option and pressing the "ENTER" key. Enter new values as needed.

## 5.2 Setting And Running The Graphic Gage

5.2.1 ENTERING SETUP: For the first set up, or for setting up a new job, turn on the power while pressing and holding the "MODE" key. The gage will display the "SET UP" options menu. Release the "MODE" key. Let the gage with probe plugged in, warm up for approximately three minutes.

5.2.2 GAP: Place probe the recommended standoff distance from spring using the following chart, as a starting point:

Spring O.D.		Recommended Tip size	Initial Standoff
0.062" to .125"	[1.6mm to 3.2mm]	1/8" [3.17mm]	.065" [1.65mm]
0.125" to .250"	[3.2mm to 6.4mm]	1/4" [6.35mm]	.125" [3.17mm]
0.250" to .375"	[6.4mm to 9.5mm]	3/8" [9.52mm]	.200" [5.08mm]
0.375" to .500"	[9.5mm to 12.7mm]	1/2" [12.7mm]	.275" [6.98mm]
0.500" to .625"	[12.7mm to 15.9mm]	5/8" [15.9mm]	.350" [8.89mm]
0.625" to .750"	[15.9mm to 19.1mm]	3/4" [19.1mm]	.450" [11.4mm]
0.625" to 1.00"	[15.9mm to 24.4mm]	1" [25.4mm]	.650" [16.5mm]

5.2.3 ZERO: Press the "ENTER" key. The gage will automatically zero the electronics and the scale % should display 000%.

5.2.4 GAP CHECK: Turn the probe micrometer clockwise the desired sort distance. If the % of scale is between 15% and 50%, proceed. If it is below 15%, the probe may be too far away from the spring, move the micrometer in closer to the spring. If it is more than 50%, the probe may be too close to the spring, move the micrometer out further away, rezero and go back to step 5.2.3.

5.2.5 SORT LONG: Select "SET SORT" option and press the "ENTER" key. This will lock in the sort long length. If 5-way sorting, the gage automatically divides the total tolerance into three good groups.

5.2.6 SORT SHORT: Return the micrometer to the zero position and continue turning counter clock wise to the sort short length. Press the "ENTER" key again. Your sort distances are now calibrated. Return the micrometer to the zero position.

5.2.7 OFFSET: Select "OFFSET" option and press "ENTER" to change the offset value. The gage considers a perfect spring as 0 length. To display and print the actual length of the spring, enter that length in the offset value, otherwise enter 0.

5.2.8 TOLERANCE: Select "TOLERANCE" option and press "ENTER" to change the sort tolerance value. This tells the gage how the length variation relates to the electronic signals from the probe.

5.2.9 TECHNIQUE: Select "TECHNIQUE" either Auto or % and press "ENTER" to change the type of pitch correction. You will probably use "AUTO" the most. Don't be afraid to experiment with it to see how it works.

5.2.10 QUOTA: Select "QUOTA" and press "ENTER" to set or change a shut off production quota. When the coiler kill is wired to the coiler, this will automatically shut off the coiler when the

required number of parts are coiled.

5.2.11 CLEAR COUNTS: Select "CLEAR COUNTS" and press "ENTER" to clear or reset the good and bad spring counters to 0.

5.2.12 CONFIGURE: Select "CONFIGURE" and press "ENTER" to view or change any of the configure options or parameters. (refer to previous section for more detail)

5.2.13 SORT TIME: Set the "SORT" knob for the amount of time the air or flappers on a chute are to be activated. For example, if you are running at 60 parts per minute, a correct setting would be at mid scale.

5.2.14 PITCH ADJUST: Set the "ADJUST" knob to control the pitch adjustment time. Start with the dot on the knob at mid scale if using "AUTO" feed back. Otherwise start it at a low value.

5.2.15 RUN: Press the "MODE" key to return to the main run screen. Cut off the spring used to set up. Measure this spring and correct the probe for it's actual length.

Start coiling springs. Catch a spring close to the length you want as indicated on the LCD. Compare it's actual measured length to your target length. Correct the probe if necessary by moving the micrometer the amount that the spring differs. Repeat if necessary.

5.2.16 PITCH CORRECTION: Occasionally you may want to increase or decrease the amount of correction for further scrap reduction. The gage has built in self improvement, so coil 50 to 100 springs before you change the "ADJUST" knob setting. You will find the section on Statistical Process Control very helpful in determining if the adjust knob setting needs changed. Please be sure to read that section.

5.2.17 STATS: To do a Machine Capability Study (MCS), press and hold the "\*" for just over one second (printer required). When the MCS is done the gage will automatically continue taking Statistical Process Control Study (SPC) samples. To pause the SPC press and release the "ESC" or "CLR" key. The printer feeds one line. To continue a paused study press and release the "\*" or "STAT" key. To abort the studies before done, press and hold the "ESC" or "CLR" key until the printer ejects the page.

5.2.18 SERIAL DATA: To turn the serial port on and off when using a data collector system, in main run mode, the "UP" and "DOWN" keys are used. Start sending data thru the serial port by pressing the "UP" key. Stop the flow of data by pressing the "DOWN" key.

## 6.0 Statistical Terms

6.1 Normal Distribution: A normal distribution is represented by a bell shaped curve which has few points (or measured spring lengths) at either end and the majority of the points (spring lengths) in the middle. If a line is drawn through the middle to the base line, the two parts should be similar in shape

and nearly equal in area in order to be called a normal distribution. The Graphic Gage measures the "Normality" of the production using the Geary's test for normality, or "Z". This can be important as calculated process limits at mean + 3 sigma and mean - 3 sigma are only valid if the process forms a normal distribution. In most all cases a properly running coiler and gage will coil parts whose lengths form a normal distribution.

6.2 Standard Deviation or Sigma: Standard deviation is a term used in statistics to describe the spread of data within a distribution. As manufacturers, we want this spread to be as little as possible from the middle or mean. It is also called Sigma. The Graphic Gage calculates this spread several different ways. It calculates and displays the spread of the last 30 springs each time a spring is measured in order to make a smarter adjustment. It also calculates the process spread in the Machine Capability Study using both the classic sum of the squares method (3sigma(v) on the printout) and the simpler approximation using Ranges (3sigma(r) on the printout). One is effected more by trend than the other, so together they are helpful in determining adjustment effectiveness.

6.3 Mean or Average: The Mean or Average of a process is the value calculated by adding up all the lengths and dividing by the number of lengths added together. The Graphic Gage calculates the Mean of the last 30 springs each time a spring is measured in order to make a smarter adjustment. It calculates and displays the mean of the last five springs (Xbar) for the operator, and it calculates the Mean of each five spring sample for the Xbar and R Chart print outs. This is called Xbar which means average of X values. The X represents an individual measurement in statistics. The Mean of the parts are calculated and printed in a Machine Capability Study (MCS) and Statistical Process Control study (SPC).

6.4 Range or R: Range, or R, is another way of measuring the spread of data sampled from a distribution. The Range of a sample is the difference between the longest measurement in the sample and the shortest measurement in the sample. The Graphic Gage calculates and displays the range of the last 5 springs (R), and prints the Range, or R, of each five part sample in it's studies.

6.5 Control: A process being in or out of statistical

control generally refers to its' predictability, not the amount of adjustment made to the process. In fact if one thinks of the gage and coiler as one machine, an adjustment is something an operator does to the probe micrometer or coiling point, not something that the gage does to the pitch mechanism. Gages don't actually adjust, they maintain and operators adjust. In control means predictable.

One of the most important aspects of Statistical techniques is that they offer a way to determine if a process is of predictable quality and is consistent. By analyzing samples taken at various times from a production of springs, a determination can be made if something has changed and/or if the parts are still the same. As some statistical terms are related, more information about control is given in "6.6 Charting".

6.6 Charting: The gage is capable of using natural, modified natural, and modified control limits. For purpose of explanation, we will assume natural limits. "UCLx" is the upper control limit of the Xbar values. "LCLx" is the lower control limit of the Xbar values. "UCLr" is the upper control limit of Range values. The concepts of Xbar & R charting are as follows :

6.6.1 Sample statistics (Xbar and R) taken from a random distribution of parts have a relationship to the statistics of the distribution from which they were taken. Or another way of saying this is that the overall quality of a distribution of parts from which samples are taken can be determined by sample statistics.

6.6.2 After enough samples have been taken from a distribution of parts, limits (UCLx, LCLx, & UCLr) can be calculated. Also the statistics mean and standard deviation of the distribution of parts can be estimated. This is part of what a Machine Capability Study does.

6.6.3 As additional samples are taken from the distribution their statistics should never exceed the limits calculated by the Machine Capability Study. This is part of what a Statistical Process Control study does.

6.6.4 Additional analysis is also often done by looking for trends and shifts in the actual chart. Because of it's closed loop adjustment technique, the Graphic Gage will seldom, if ever, allow a noticeable trend or shift to occur so it will only be mentioned here. If further study is desired a good book on industrial quality control is best used here.

If all the Xbar and R values calculated from samples taken from the production distribution fall within the calculated control limits (UCLx, LCLx, & UCLr) then the process is "IN CONTROL". It is in fact predictable and it will probably continue to run the same with all Xbar and R values within the control limits as long as nothing changes. Conversely something has probably changed if an Xbar or R value has exceeded a control limit.

## 7.0 Statistical Studys

7.1 MCS Overview: The machine capability study is a short term study using statistics to determine if a machine is running parts which have a normal distribution, are in control, and are capable of meeting the print requirements. When a machine capability study is done, data is collected into subgroups. The data is then analyzed using Xbar and R charts.

7.2 MCS Features: The Graphic Gage produces a print out titled "Machine Capability Study". Refer to the examples found just after the section "Is The Process Capable?". It has the following features:

- (1) A place at the top to record information about the job.
- (2) Date in day/month/year (military) format.
- (3) Time of day using a 24 hour clock.
- (4) "Mode": the first 2 digits of mode represent the position in which the adjust knob was set. 0 equals full counter clockwise and 99 equals full clockwise. The letter "P" means proportional "auto" feedback and "B" means "%tol" feedback. The last two digits represent the internal gage adjustment value.
- (5) "Good" is the number of good springs coiled since the counters were cleared.
- (6) "Yield" is the % of good springs coiled since the last sample was taken.
- (7) "Ranked Data" is the actual lengths of the sample, sorted from longest to shortest. The sample is the last five unsampled springs coiled, at the instant the sample is taken. The Graphic Gage will not allow individual spring lengths to be sampled more than once, and the samples are always contiguous (taken one after another) even at the fastest possible coiling speeds. This is important if Xbar and R charting is to be effective.
- (8) "Xbar" is the average length of the sample.
- (9) "Range" is the spread of the sample lengths.
- (10) "Overall yield" is the % of good springs coiled since the set up.
- (11) "Study yield" is the % of good springs coiled during the study.
- (12) "Mean" is the average of the 100 springs sampled in the study.
- (13) "3sigma(v)" is three times sigma calculated using the sum of the squares (variance) and represents long term variation.
- (14) "Min\_x" is the shortest measurement in the study.
- (15) "Max\_x" is the longest measurement in the study.
- (16) "Z" is the Geary's test for normality value. If a distribution is to be considered normal it should be between +1.96 and -1.96.
- (17) "Avg\_dev" is the average deviation calculated from the study.
- (18) "3sigma(r)" is three times sigma calculated using ranges and represents short term variation.

- (19) "UCLx" is the upper control limit for Xbars.
- (20) "Lclx" is the lower control limit for Xbars.
- (21) "Rbar" is the average of the sample ranges.
- (22) "Uclr" is the upper control limit for the ranges.
- (23) "CPK" is an index of process quality.
- (24) "r/v" is the ratio of  $\sigma(r)$  over  $\sigma(v)$ . It is a handy tool to monitor adjustment effectiveness.
- (25) "Xbar chart" is a standard Xbar chart. It has fine spacing of Xbar values and the added 50% interval with count used to monitor adjustment effectiveness.
- (26) "Range chart" is a standard Range chart with fine spacing.
- (27) "Histogram" is a true histogram as opposed to a frequency distribution. It has ideal interval spacing and the median two datum are indicated by "MM" for easy interpretation.
- (28) The last line of the study analyzes the study for centering, control, and normality. Because some customers did not like the word 'normal' we use the word 'Gaussian' (they mean the same thing)

7.3 SPC Overview: A process capability study is the long term study of the sample data taken by the Graphic Gage and plotted against the machine capability studies control limits to see if the process is remaining in control and is predictable. The Graphic Gage titles it's process capability study "Process Xbar & R Chart". It contains the same data and features as the Machine Capability Study except control limits do not change. It uses the limits as calculated in the most recent Machine Capability Study.

## 8.0 Interpretation of Statistical Printouts

The Graphic Gage is designed to provide some very useful information on the LCD and via the printer. This section explains standard SPC data as well as some Moyer additions. There are examples in the Appendix.

8.1 Adjust setting: The best setting of the "Adjust" control can be determined from the printouts. The ratio  $r/v$  ( $\sigma(r)/\sigma(v)$ ) should be greater than 0.80 but less than 1.00. If this ratio is greater than 1.00 then the gage is probably over controlling. If this ratio is less than 0.80 then the gage is probably under controlling.

The number of times "X" is printed between the two broken lines on the Xbar chart is printed at the right end of the second broken line in the Xbar chart printout. It should be 9, 10, or 11. If the count is 12 or greater then the gage is probably over controlling. If the count is 8 or less then the gage is probably under controlling. The broken lines are titled "50%" because half of the 20 Xbar values should fall between them.

Examine the last two digits of the mode column. Check to see if this value is getting larger, getting smaller, or staying the same. This value represents the gage's internal correction value. If the gage thinks it is over controlling this value will be getting smaller. If the gage thinks it is under controlling this value will be getting larger.

If the  $r/v$  ratio and the number of Xbars between the 50% confidence lines on the Xbar chart indicate the gage is over controlling, and the last two digits of the mode column is staying the same or getting bigger, then turn the "Adjust" knob on the front of the gage counter clockwise to reduce the control level. Wait fifty or more springs and run another Machine Capability Study to see the results.

If the  $r/v$  ratio and the number of Xbars between the 50% confidence lines on the Xbar chart indicate the gage is under controlling, and the last two digits of the mode column is staying the same or getting smaller, then turn the "Adjust" knob on the front of the gage clockwise to increase the control level. Wait fifty or more springs and run another Machine Capability Study to see the results.

The exact amount to increase or decrease the "Pitch" knob setting is a combination of experience and trial and error. It should also be noted that too little control can sometimes result in Xbar values above the UCLx line or below the LCLx line on the Xbar chart. Too much control can sometimes result in R values which are above the UCLr line on the Range chart.

Once you've generated a Machine Capability Study which shows a proper level of adjustment, it is then time to examine a few other items on the study.

8.2 Control Test: If the bottom line indicates that the

process is in control and centered, then no corrective action is indicated.

If the process is not centered then a severe feedback problem exists. For some reason, the feedback from the gage is not centering the process over a large number of parts. You may have a defective linkage, loose set screw, damaged pitch rod thread, bent pitch rod or pitch tool, bad flex shaft, or even a broken gage. Refer to the trouble shooting section in the back of the manual to help locate the problem.

If the process is centered but not in control, and you have tried varying the adjustment control with no help, then the process is truly Out of control.

Out of control conditions usually require some corrective action. Things to check would include, but not be limited to:

- (1) wire quality
- (2) worn, loose, or incorrect tooling
- (3) unpowered payoffs
- (4) incorrect feed roll pressure
- (5) machine problems

When a process is out of control, it is safe to say there is a cause for it. If that cause is corrected or eliminated the process will run with an improved quality. Therefore Xbar & R charting is a powerful tool for process improvement.

8.3 Capability Test: If the statistics indicate that the parts are all within the quality requirements, the process is considered "Capable" of producing all good parts. A process may be "Capable" but not in "Control", or it may be in "Control" but not "Capable". A coiler may coil predictable springs with a maximum length variation of only +/-0.002 inch, but if the print requires +/-0.001 inch it is not capable. If an out of control process is capable, try using modified control limits, if allowed.

What if the process is not capable?

(1) Employ sorting to eliminate non conforming parts. The Graphic Gage with a chute or air valve is capable of sorting springs into three or five groups according to length. Sorting to eliminate nonconforming parts is common. If the load is a very important print requirement, and if length tolerances have been established which will ensure good loads, it may be adequate to just sort or reject springs outside of these tolerances. Some rejected springs may be salvageable, but the limits ensure all nonsorted springs are good.

(2) Employ sorting to subdivide the process. The Graphic Gage with the proper chute, may sort your springs into five groups. If the amount of grind is a very important print requirement, and if relatively wide length tolerances have been established to hold the loads, and if the amount of length variation is too much for a consistent grind, it may be adequate to sort the springs into five groups. Each group can be ground separately. In this case five way sorting has been used to reduce the variation in the free length of

a sub process of unground springs for controlling the quality of grind. Consequently, one big hard to manage process has been split into several smaller easier to manage processes.

(3) Attempt to tighten or improve the process at another step. This action may require using half tolerance wire, a powered dereeler, in line heat treating, a set removal operation, heat setting, or a Moyer Computerized Grinder Length controller. Usually manual or automatic 100% sorting should be considered a last resort and only rarely necessary.

NOTE: Problems can arise from sorting and are often due to the nature of truncated normal distributions. Sometimes problems are real, such as when stackup arises because too many parts are close to, but not exceeding the print tolerance. Problems may be imaginary, such as when final inspection calculates process limits using usual techniques and estimate that some parts must be out of tolerance. However, extensive manual inspection finds no unacceptable parts.

## 9.0 Hardware Test / Troubleshooting

If trouble should ever arise with the Graphic Gage, there are several methods that one can use to locate and correct problems. The Hardware Test mode of the Graphic Gage is one method for troubleshooting the gage. This mode will allow an operator to test the LEDs, switches, AC outputs, printer and serial port, and probe. To use the gage's hardware Test mode, follow these steps:

9.1 Entering Test: Turn off the gage. Press and hold the "MODE" and "0" key while turning on gage. Release the "MODE" and "0" key after 2 seconds or when the LCD displays "HARDWARE TEST". The gage is now setting up the graphic character set. While it is doing this, the LCD will display "PLEASE WAIT" and a character in the upper right corner on the LCD will be changing very fast. Use this time to adjust the "CONTRAST" knob from limit to limit. The LCD should go from blank to black. Now adjust it for a proper viewing contrast.

9.2 Output Check: Turn the "SORT" knob from limit to limit. The "SORT =" display on the LCD should change as you do this. Select the "test outputs" menu item. WARNING!! If the control motor is hooked up, use care not to damage the coiler. Use the "SORT" knob to select an output to test then press the "ENTER" key. The proper LED should light and the output should activate while the "ENTER" key is pressed. Repeat for other outputs you wish to test.

9.3 Zero Check: While watching "ADJUST =" display on the LCD, turn the "ADJUST" knob from limit to limit. The displayed value should go smoothly from about 0 to about 4095. At some point (if a probe is attached) you should be able to manually center the "PROBE" display value using the "ADJUST" knob. At that time, the "P-P =" should be between 98 and 102 and the "noise" should be very low, 10 or less, 1 or 2 not uncommon. The "P-P =" value represents the peak to peak drive on the mm3r1 board. It must function correctly for the probe touch detection to work properly. Touch the Probe guard (the outer brass ring). The "P-P =" should drop below 85. Using the "ADJUST" knob, set the "PROBE" value to about 8100 then touch the probe tip. The "PROBE" value should go below -8100 and "P-P =" should drop below 85.

9.4 Printer Check: Select "test printer" and press "ENTER" to test the printer output, cable, and printer with "AbCd 0123456789."

9.5 rs232 Test: Select "test rs232" and press "ENTER" to test the RS232 (serial) output, cable, and terminal with "AbCd 0123456789."

If you get this far, it is probably NOT your gage, but it could be an incorrect Configure or Setup. Feel free to call with any questions.

Example 1

Observations:

The last two digits of the mode start at 29 and go down to 9 very quickly and stay there.

The process is centered.

18% scrap.

The r/v is too high (1 or greater).

Too many Xbar values between +/- 50% on Xbar chart.

1 Range (sample 9) is out of control and it's sample holds the shortest measured individual part.

Conclusions:

The gage has reduced the internal control to a minimum value which was used during the bulk of the samples. Never the less, the process shows two, possibly three, indications of over control. They are the r/v value, the 13 Xbars within +/- 50% on the Xbar chart, and the out of control Range. The out of control Range by itself might mean a specific cause was at work, but when viewed in light of the other two indications, probably reflects the results of excessive control.

Probably the adjustment knob needs to be turned down to improve this process. I doubt that enough improvement can be obtained to eliminate the need of a sorting chute or air sorting, but some additional scrap reduction is probably possible. Try setting the knob to about 1/2 of what it is now. That should be about 1/4 of the knob's rotation, and should print in the first two numbers of Mode about 25. Repeat the study.

## Example 2

### Observations:

The last two digits of the mode start at 74 and go up to 98 very quickly and stay at 98 or 99.

The process is centered.

18% scrap.

The r/v is too low (.8 or less).

Too few Xbar values between +/- 50% on Xbar chart.

Two Xbars (samples 18 & 20) are out of control.

Process seems binodal (two bumps in histogram) and not normal (Z value > 1.96).

### Conclusions:

The gage has increased the internal control to a maximum value which was used during the bulk of the samples. Never the less, the process shows two, possibly three, indications of under control. They are the r/v value, the three Xbars within +/- 50% on the Xbar chart, and the out of control Xbars.

The out of control Xbars are probably connected to the cause of the binodal distribution and possibly not due to the aparent under control.

Because this gage uses a type of proportional control, and because r/v value is so low, the binodal distribution is probably not due to the gage. There are two possible ways to go. First try to locate and eliminate the cause of the binodal distribution and repeat the study. Second, assuming time doesn't permit or you are unsuccessful, turn up the adjustment knob to improve the process. Enough improvement can probably be obtained to eliminate the need of a sorting chute or air sorting. Try setting the knob at about 1 1/2 to 2 of what it is now. That should be about 3/4 to full knob rotation, and should print in the first two numbers of Mode about 75. Repeat the study .

### Example 3

#### Observations:

The last two digits of the mode start at 62, go up to 74 and stay steady.

The process is centered.

13% scrap.

Correct number of Xbar values between +/- 50% on Xbar chart.

r/v value good.

Process seems slightly flat topped (see histogram) but the process is probably normal (Z value between +/- 1.96).

#### Conclusions:

The process is in control, centered, and probably normal.

It exhibits no signs of over or under control.

This example is probably running about as good as it can. The scrap rate here shows sorting is necessary (I'm assuming it was set up to maintain process tolerances).