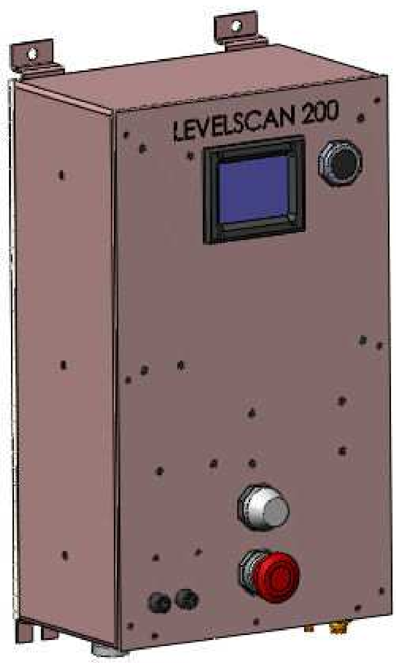
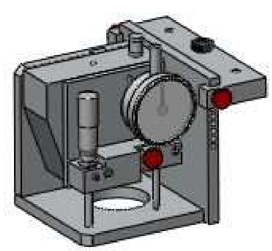
Credence Engineering Incorporated

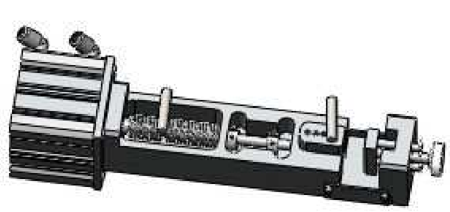
LEVELSCAN 200®

Fluid Process Level Controller

OPERATING INSTRUCTION MANUAL







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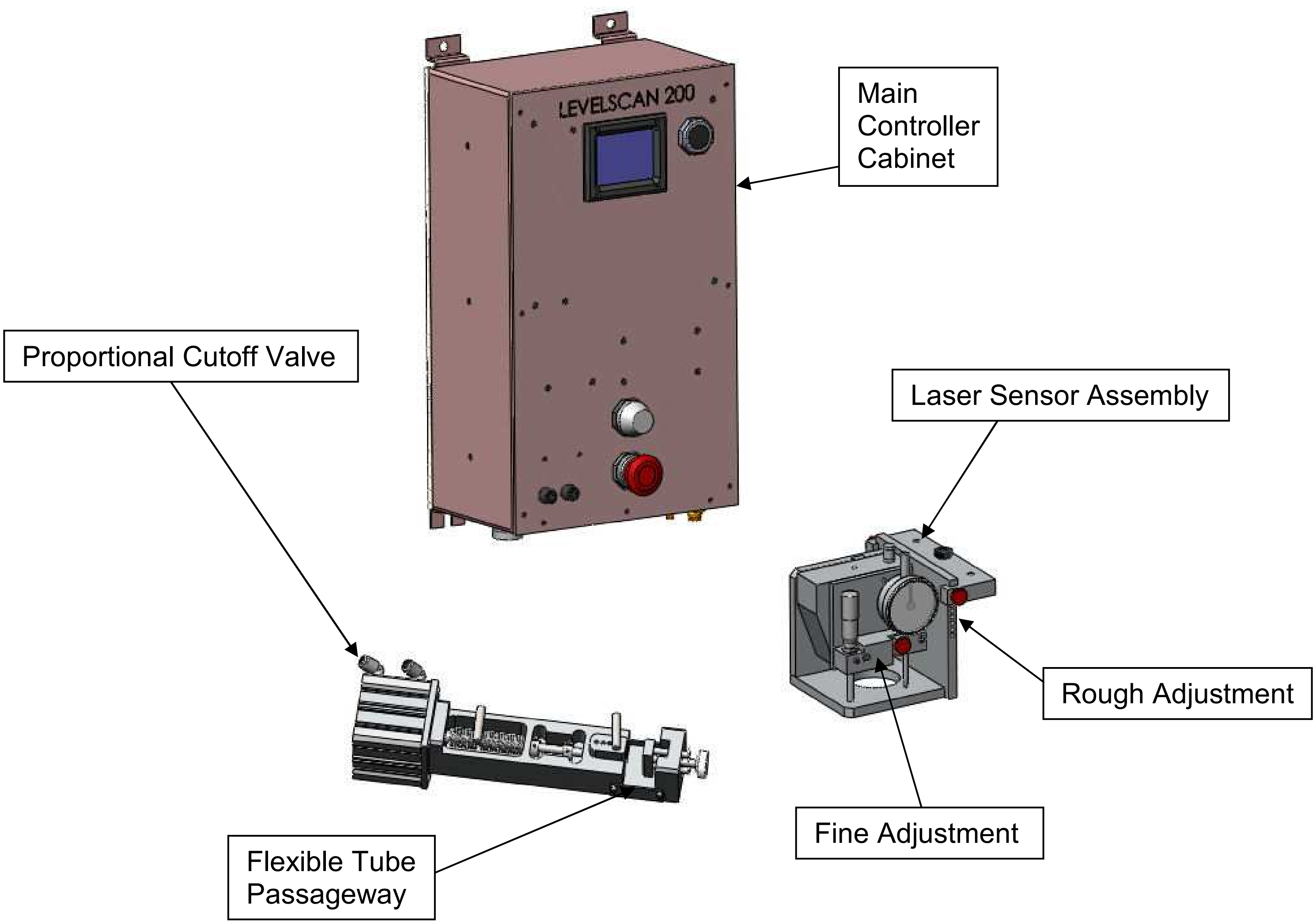
SYSTEM DEFINITION

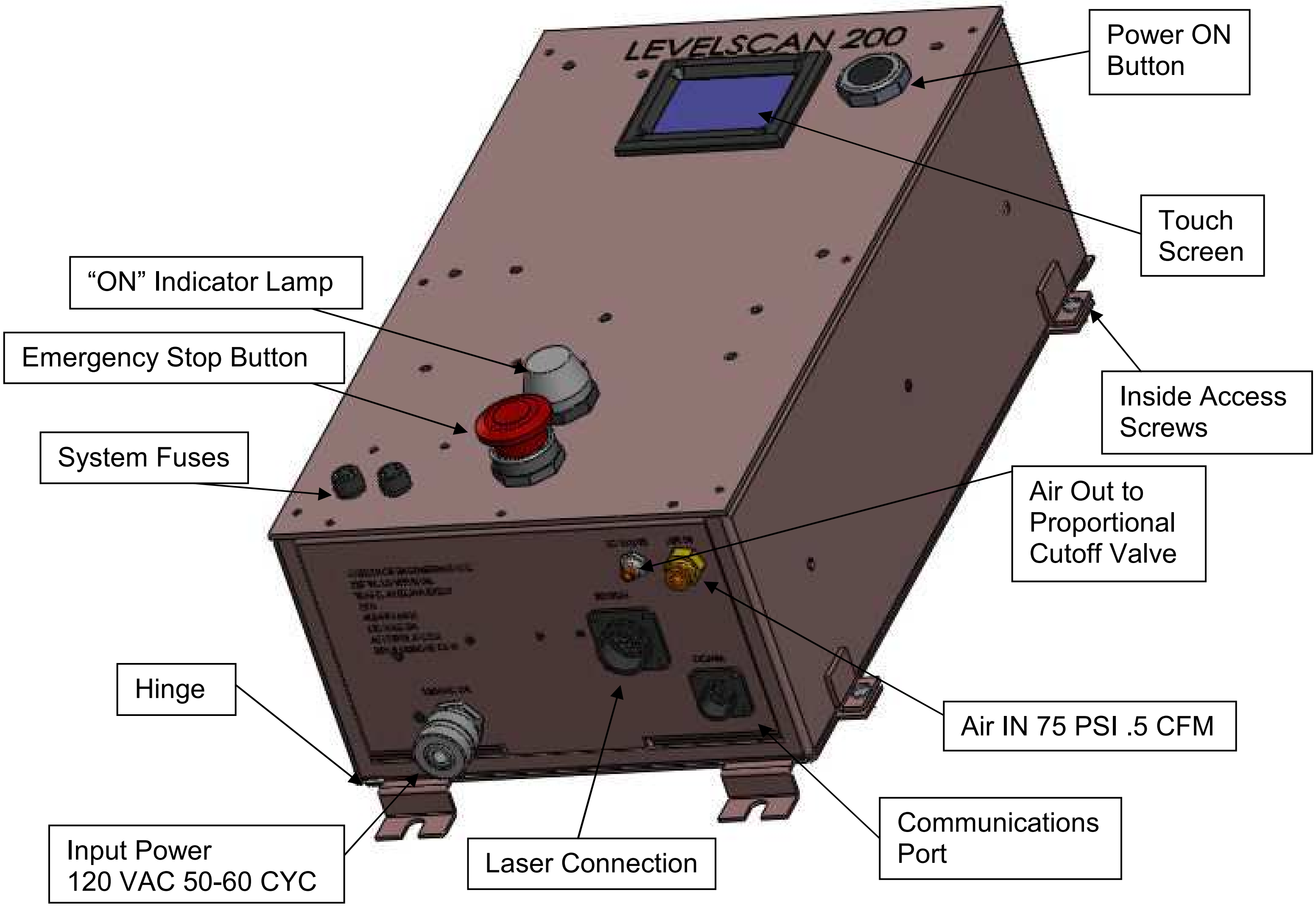
It is a well known fact that the number one key variable in maintaining consistent dry tape thickness is by controlling the level of the slurry within the reservoir to a very constant depth. The LSH 200 Level Control System is a sophisticated system that controls the level of the slurry within the casting reservoir up-stream from the Doctor Blade using a patented process that incorporates a laser sensor, a proportional air regulator and a patented proportional cutoff valve. The LSH 200 system consists of a main controller cabinet, a laser sensor height adjustment, and a supply tube proportional cut-off valve.

The Laser Sensor Assembly (LSA) is mounted onto a customer provided beam that positions the LSA directly above the slurry in the casting reservoir. The LSA provides vertical adjustment of the sensing laser with respect to the slurry being cast in both a rough and fine adjustment. The LSA sends accurate distance data to the Main Control Cabinet (MCC). The MCC processes the input measurements in a real-time fashion and outputs a corresponding air pressure to the Proportional Cutoff Valve (PCV). Flexible tubing carries the slurry from a pressurized slurry tank through the PCV and injects the slurry into the casting reservoir. The PCV is mounted as close to the reservoir as practical and it provides the real-time flow control of the slurry to the reservoir. The MCC is a potential spark generator and must be mounted as far as practical from the volatile vapors.



Functional units

Main Control Cabinet:

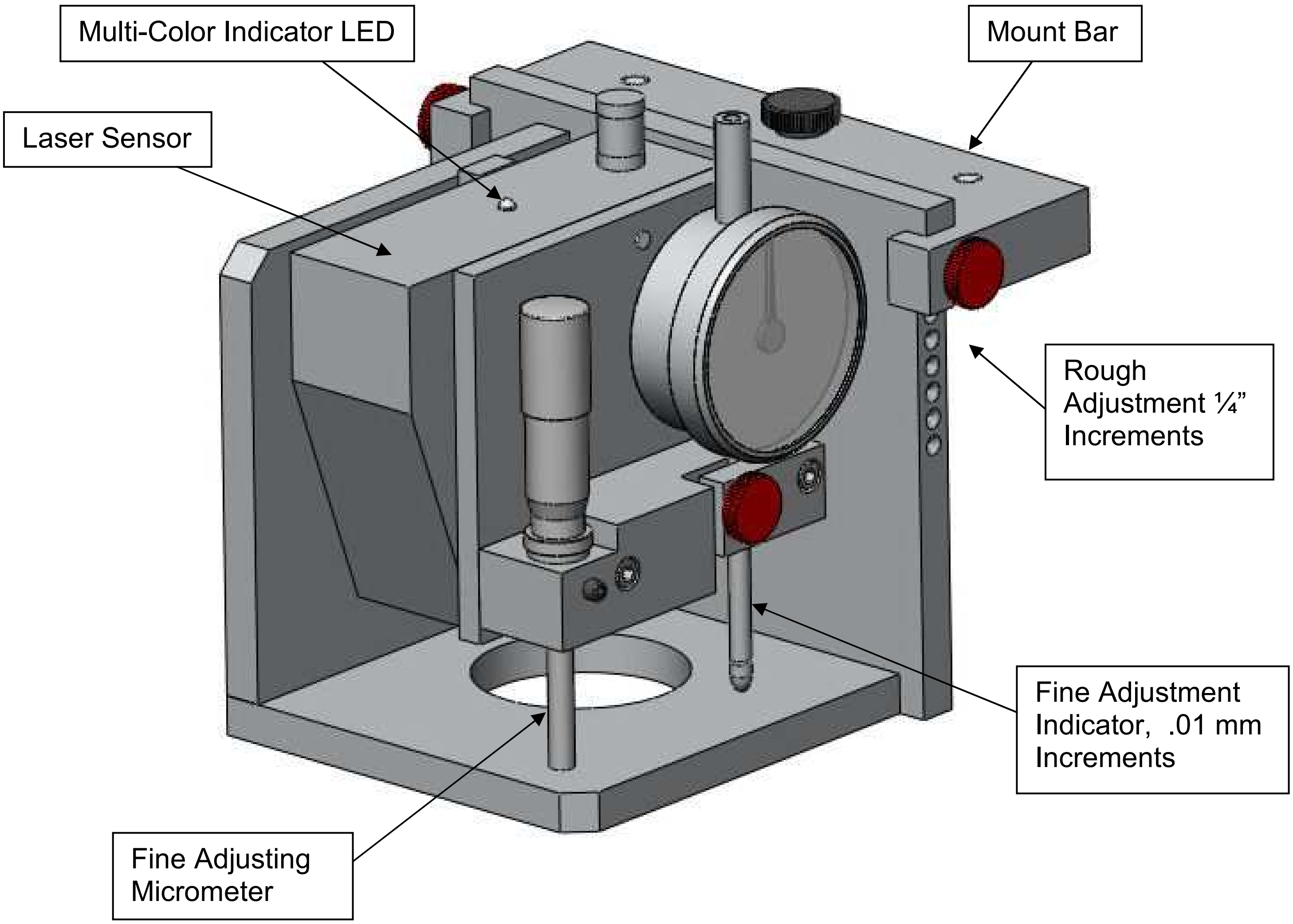


The Main Controller cabinet houses the system micro-controller, proportional air regulator, bypass/main air cutoff valve, touch-screen display, start switch, ON Indicator, digital power supply, alarm and E-stop. The cabinet has an AC inlet using a standard plug for easy installation and a Main Air inlet.

The touch-screen display is used both for data entry and controlling specific functions within the controller. The touch-screen LCD display provides operator feedback for setting up the system and for viewing how the system is operating. In auto mode, it displays Real-time slurry level, and Output level in .001 mm increments. In the PID mode, the various PID variables functions are scrolled and modified. In Manual Mode the pinch valve can be manually opened or closed to any percentage of flow between zero and 100%.

The built-in alarm unit provides audible indication of alarm conditions such as: Low level, high level and overfill conditions.

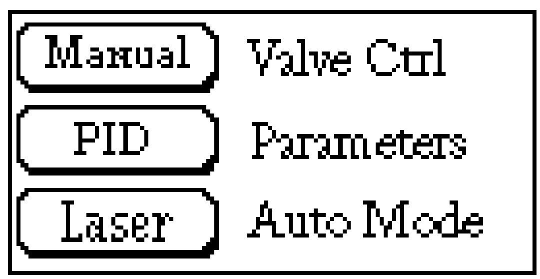
Laser Sensor Assembly:

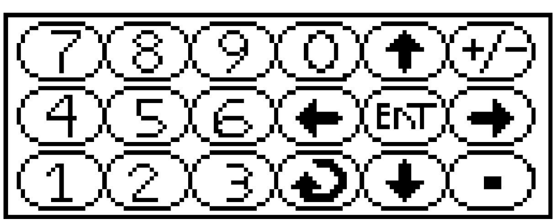


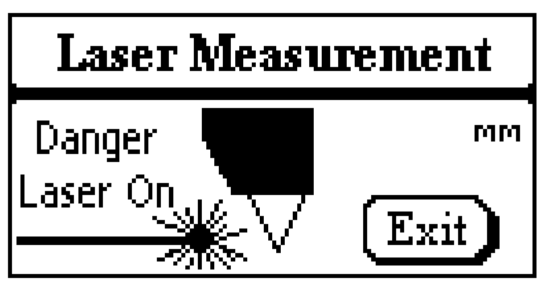
The Laser Sensor Assembly unit has a Laser Scanning Sensor mounted on a vertical precision slide. Within the assembly is a fine-adjustment consisting of a micrometer for moving the laser up or down and a dial indicator to display the relative adjustment. The entire assembly is mounted in a Mount Bar that has built into it a rough vertical adjustment for moving the entire assembly up or down to get it within the desired range. Once in the rough range, the micrometer is used to fine tune the vertical position of the laser head. The Laser Sensor has a 120 mm standoff distance from the Laser Head to the sensing point. The measurement range is +/- 20 mm from that point. With the rough adjustment full down and the fine adjustment full up the Laser Sensor Assembly should be mounted to a height of 8” (204 mm) from the casting belt to the mount Bar mounting surface. With the rough adjustment full down and the fine adjustment full up, this puts the Laser at its proper standoff distance of 120 mm. There is plenty of flexibility in the system so if this is off a little it won’t matter much. This gives you 1.75” rough adjustment to go higher and 25 mm adjustment within any selected range. Companies typically set the laser standoff distance right at the belt surface and raise it up from there from ½” to 1” and control to that ½” or 1”. The laser measurement range is +/- 20 mm so if you set the standoff distance 20 mm above the belt and control from there the slurry will always be in the laser measurement range up until it goes to a depth of 40 mm, at which time, the upper limit will set off an alarm and close the PCV until the level drops back into a safe range.

Display unit:

The Touch-Screen display has four screens as follows:

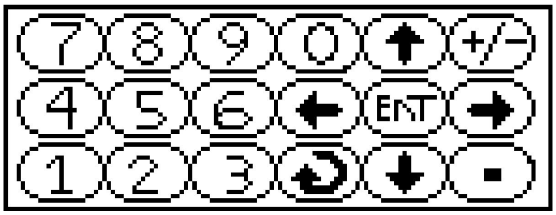






The display unit is a touch-screen LCD unit and is used to operate the Level Control System. When the system comes up the LEVELSCAN Screen displays for three seconds and then automatically switches to the Three-choice menu screen. The three Modes are: **Manual, PID and Laser**. To enter a particular Mode you touch the respective Mode from the main menu.

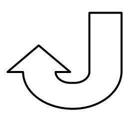
Manual Mode



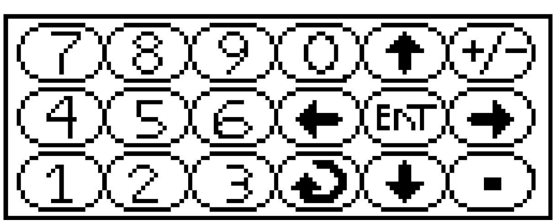
In the Manual Mode you manually control the percentage of valve flow. The percentage shown on the screen is the amount of the total possible flow that the valve can allow to flow. A higher percentage will result in a lower voltage output to the proportional regulator which will output a lower air pressure which will result in the bias springs retracting the valve ram reducing the pinch on the tube allowing more flow through the tube. Conversely, a lower percentage shown on the screen will result in a higher voltage output from the proportional regulator which will output a higher air pressure which will result in an advancing of the valve ram causing more pinch on the tube allowing more flow through the tube.

To increase the valve flow, touch the “UP” arrow and hold your finger in that position while the percentage value increases. Release your finger when the value reaches the desired value.

To decrease the valve flow, touch the “DOWN” arrow and hold your finger in that position while the percentage value decreases. Release your finger when the value reaches the desired value.

To exit the menu, touch the  (Return) button.

PID Mode



In the PID Mode you enter values for the three variables that are used by the micro-controller PID Function. The three variables used in any PID process are the “P” (Proportional), the “I” Integral, and the “D” Derivative. These three variables control different aspects of the process and work together to provide a “Smart” process that can almost anticipate system changes. These variables cannot be dictated from a book, nor can they be derived from any formula. They must be derived from experience through understanding of their respective effect on the process and through experimentation to achieve a PID system that responds the way you want and controls the way you want. You can have a very “Tight” process where the controller reacts swiftly to the slightest process change or you can have, on the other end of the spectrum, a process that is “Soft” that does not react to minor fluctuations and reacts slowly to process trends. You can also develop anything in between.

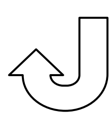
The following is from the PID Primer by ESS and has been modified to reflect a level control process.

PID stands for Proportional, Integral, and Derivative. The following explanations describe PID as it applies to the precise control of a **process**. A **process,** in this case, is a level in a reservoir that is being controlled at or driven to a precise distance. PID is a control method or mode that has three functions or variables. The *proportional* action dampens process response. The *integral* corrects for **droop**. **Droop** is the difference in level between the process **set point (zero)** and the actual process level. The **set point** is the desired process level or control point. The *derivative* minimizes **overshoot** and **undershoot**. **Overshoot** is the amount in distance units that the process level exceeds the set point before the **process stabilizes**. **Process stabilization** is achieved when the set point and process levels are equal over a defined period of time. **Undershoot** is the amount in distance units that the process level falls below the set point (zero) before the process stabilizes.

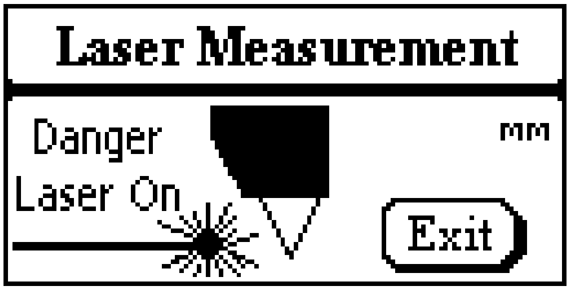
Proportional is the **control output** effort in proportion to the error from set point. A **control output** is a signal action delivered in response to the difference between set point and actual process level. The output controls the pinch valve action. The proportional range is referred to as a “band” and is usually measured in distance units. If a **proportional band** of .2 mm is applied to a process that is .5 mm below set point, the valve output would be 2.5 percent. The lower the proportional band, the higher the **gain**. **Gain** is the amount of amplification used in an electrical circuit. Proportional band is sometimes referred to as gain. The **proportional band** or **PB** is a range in which the proportioning function of the controller is active. The PB units are usually expressed in millimeters.

Integral is a control action that automatically eliminates droop or **offset**. **Offset** is the same as droop and is the difference in level between the process level and the set point. Droop or offset is a typical result when using proportional control. Integral is also known as “**Reset**”.

Derivative is the rate of change in the process level. Large values prevent overshoot but can cause sluggishness. It is also known as “**Rate**”.

To exit the PID Mode, touch the  (Return) button.

Laser Mode

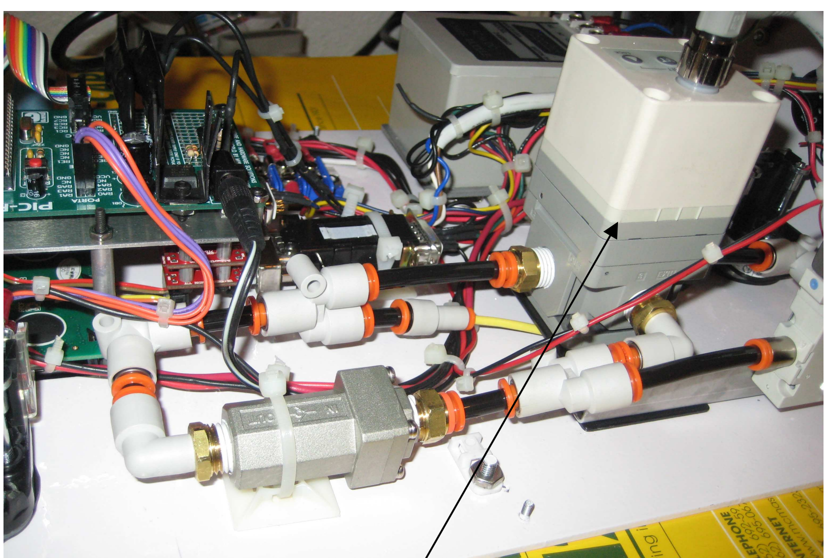


The laser Mode is also the automatic mode where the system is using the laser to take actual level measurements and processes the measurement through the PID Function to automatically calculate an output that results in a correction to the system to attempt to drive the level to the control point.

In the LS-200 the set point is always zero. You can set “Where” zero is with respect to the casting belt, but the system will always try to bring the level to zero. This zero is also the center point of the laser measurement range. The laser has a total range of 40 mm, 20 mm above zero and 20 mm below zero. The most accurate measurements are within +/- 3 mm of zero, which is the “Green” zone.

If the valve is set up correctly, the laser system will systematically drive the slurry level to the zero point.

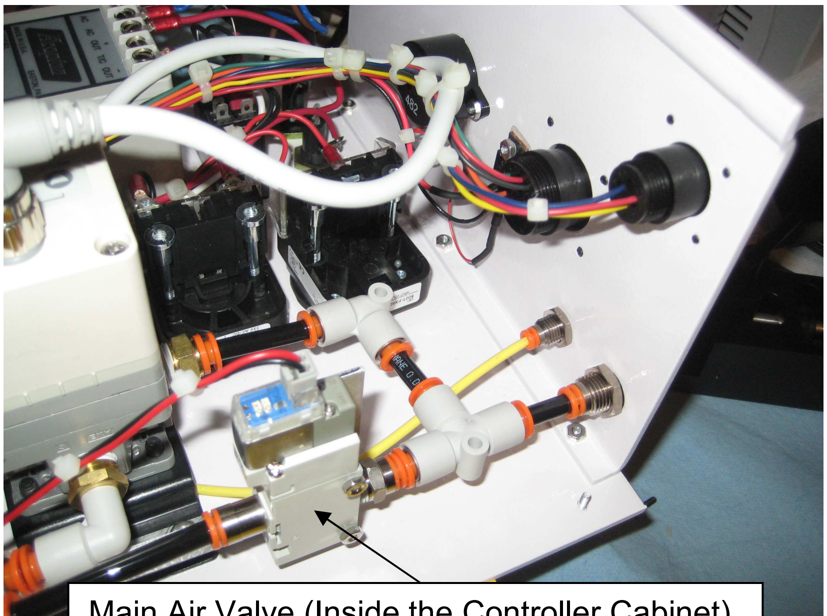
Proportional regulator valve (Inside Control Panel):



Proportional Regulator (Inside the Controller Cabinet)

The controlling output unit is a proportional air-regulating valve. This valve uses a 0-5 volt DC signal from the Micro-controller PID function to proportionally vary the air pressure to the proportional cut-off valve (PCV), which in turn regulates the flow of process fluid.

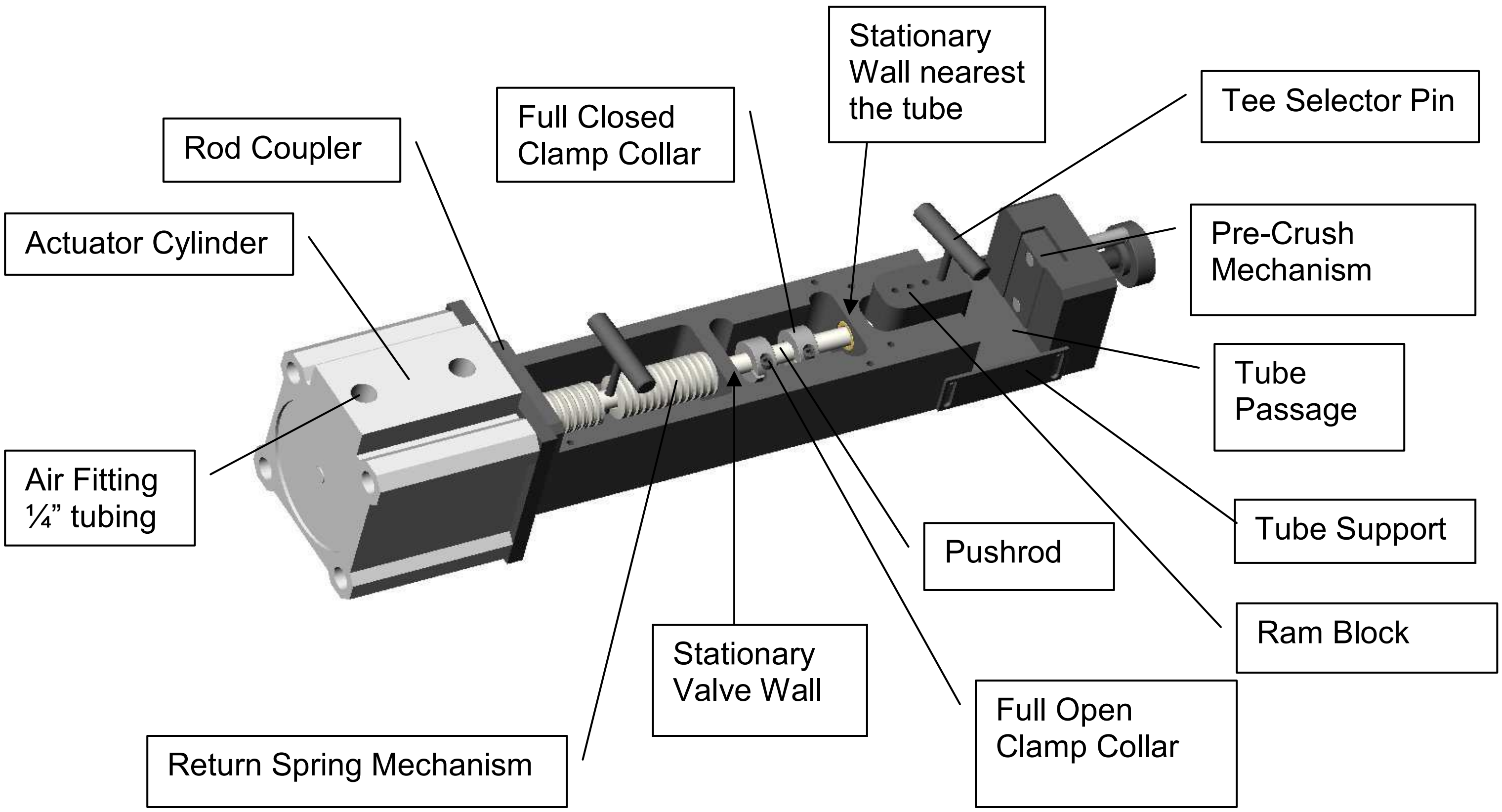
Main Air Bypass valve (Inside Control Panel):



Main Air Valve (Inside the Controller Cabinet)

A bypass valve is used to insure that, in the event of a regulator valve failure, the PCV will close. If the power to the controller is shut off, this normally open valve will supply air to the PCV. It will also be shut off if the overfill sensor is activated.

Proportional Cut-off Valve (PCV):



The Proportional Cut-off valve consists of an actuator cylinder, pushrod, Ram block, Pre-Crush Mechanism and return spring mechanism. The function of this valve is to proportionally control the amount of flow of process fluid by receiving a controlled amount of air pressure from the control unit. Increased air pressure causes increased pinch-off of the slurry supply tube, which reduces flow from the valve and decreasing air pressure increases flow from the valve. The Ram Block of the PC valve applies pressure to the flow tube and proportionally blocks the flow of process fluid.

Installation

The main controller must be mounted remote to the casting process to prevent any potential spark generating devices from being in close proximity to any volatile atmosphere.

The system requires 110VAC .5A, 75 PSI air @ .5 CFM. It is helpful to have an accessible air regulator to be able to vary the system air pressure.

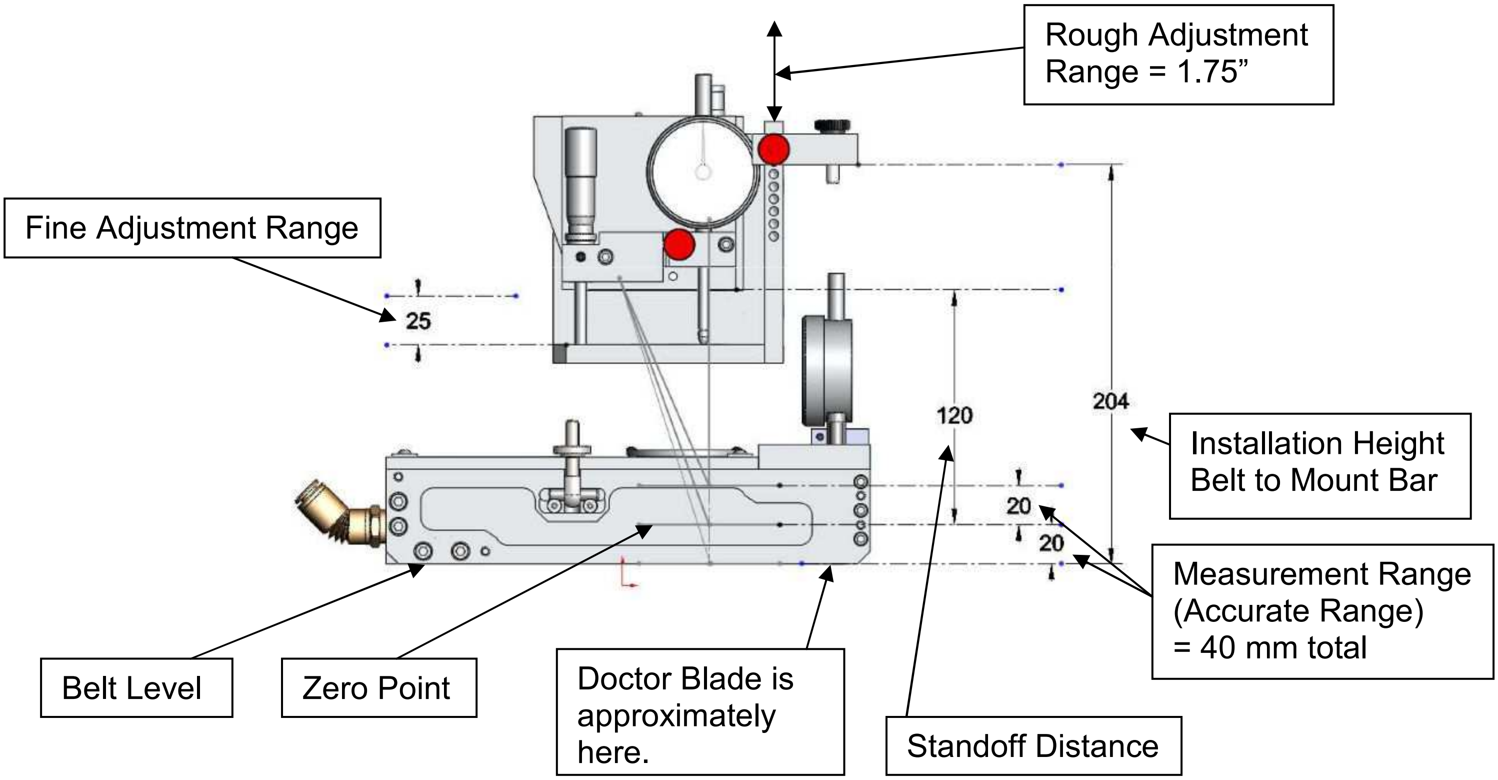
The Proportional Cut-off Valve must be mounted in close proximity to the casting slurry reservoir.

The Laser Sensor Assembly is mounted onto the casting machine 204 mm above the belt to sense the slurry level within the reservoir. The level is controlled prior to the Doctor Blade assembly.

Operation

Laser Sensor setup:

Determine the level that you want the controller to maintain within the slurry reservoir. Remember, that the laser sweet spot, or zero, or center of control is 120 mm below the bottom face of the laser head. The LED is green when laser is sensing the measured surface to be at the 120 mm (=/- 3 mm) distance. With the laser head set high, or above that 120 mm distance, with the rough adjustment, when the system is turned on, the LED on top of the laser head will be blue or red. Incrementally lower the rough adjustment until the LED just turns green. Raise the rough adjustment up one (1) increment. The LED should be blue. Adjust the fine adjustment to lower the laser until the LED just turns blue. Continue down and watch the laser height readout on the display. When it reaches zero this is the center of the 40 mm total range or the 120 mm standoff position. At this point the laser will control the level to right at the belt level. Now adjust the rough adjustment up by the desired depth that you want to maintain. If you want to maintain a depth of 1” than raise the rough adjustment up 4 increments. IF you desire a level in between the rough adjustments then, first set the dial indicator to zero. Then make rough adjustments to the desired rough range. Make the final adjustment using the fine adjustment. Re-zero the indicator. You now have the laser sensor at your desired height. Remember, if you have adjusted the laser to where the 120 mm distance is above the belt by more than 20 mm, you will have a situation where the lower limit will alarm until the level has raised in the reservoir above the 140 mm point. You will have to use the manual mode to open the valve to let slurry into the reservoir until the LED is in the blue range. The system will seek the center of the green range from there.



Determining the optimum tube size:

It is important to choose a tube diameter, which allows ample flow, to supply the desired cast thickness and width using from 5 to 15 PSI air pressure in the slurry vessel. Higher pressure causes higher slurry velocity, which causes turbulence and contributes to the inability of the system to settle resulting in inaccurate control. Tubing too large in diameter, on the other hand, requires shorter stroke for the PCV to shut off the slurry flow. This reduces valve resolution and causes the system to over shoot. A “rule-of-thumb” is that for a desired cast (thickness, width and belt speed) a tube pre-crushed by ½ the ID should just outrun the cast at a vessel pressure of 10 to 15 PSI. You will have to experiment to determine the optimum tube diameter for your process.

A method for determining tube diameter is as follows:

Through simple experimentation we can determine the correct tube size. We determine this by running a cast with the tube we have in mind. We place the tube in the proportional cut-off valve and squeeze the tube using the pre-crush mechanism. We watch the level within the slurry box and notice whether the level within the slurry reservoir raises or lowers over time once we squeeze the tube by 1/2 of the inner diameter. If the level continues to rise at a fast pace then the tube is too large. If the level lowers, then the tube is too small. We want a tube diameter that allows slow steady increase in level with the tube crushed in half.

Proportional Cut-Off Valve Setup:

The cut-off valve is fitted with a series of disc springs (Belleville Washers) setup in alternating position. Each spring is capable of allowing .010” (.264 mm) displacement @ 56 PSI air pressure. The number of springs selected is determined by the required stroke distance of the valve. An example of this concept is as follows: Suppose you determined that you needed a 16mm tube with a 12 mm ID to provide ample flow at low vessel pressure for your casting process. You also determined, by experimentation, that the 12 mm ID tubing, when used in your casting process, achieved a pre-crush distance of 4 mm. The resultant ID distance is 12 mm – 4 mm or 8 mm resultant distance. This 8 mm is the Valve Stroke distance. We then take the 8 mm and divide it by .264 mm to get 30 springs. You then separate 30 springs and insert the Tee pin so that only 30 springs are providing bias for the valve. This will provide .264 mm X 30 or 7.92 mm of valve travel. This is adequate to provide good level control for this set of parameters.

The tube is placed in the valve tube passage area and the valve is pressurized to minimum psi to get the Tee pin to snug up the springs against the stationary valve wall, but not compress them. This is the fully open position. Move the full open clamp collar to the left toward the air cylinder till it is against the stationary wall. Tighten the clamp collar clamping screw. Pressurize the valve to 56 psi. This is the fully closed position. Adjust the pre-crush mechanism to just pinch off the tube completely. You may have to move the Tee pin in the Pinch Ram to get the face of the ram at an adequate start position so the tube can be crushed properly within the travel range of the pre-crush mechanism. Slide the fully closed clamp collar up against the stationary wall nearest the tube. Tighten the clamp collar clamping screw. This prevents over-crushing of the tube, which can result in pre-mature tube failure. This procedure limits the valve travel to the pre-crushed condition to fully off and maintains a full 56 PSI (Total system output) for the full range of operation. If greater or lesser amounts of travel are needed, use the same procedure to calculate the total number of springs to isolate.

The proportional cut-off valve is now ready.

Review: Procedure for setting up the Proportional Cut-Off Valve:

1) Determine the tube size required for the cast. Carefully match it to the process cast. If the tube size is too large, the amount of valve ram-travel to go from ample flow to full closed will be only a small fraction of the diameter of the tube. This will reduce the resolution of the valve and cause the system to over-shoot. If the tube is too small, it will not keep up with the demand of the system. A good rule-of-thumb is that a tube squeezed by half of its inner diameter should flow enough to supply the cast.
2) Determine the pre-crush distance of the tube to where the flow is just beginning to be reduced

3) Calculate the required valve stroke distance (resultant ID remaining when at the pre-crush position or initial tube ID less the pre-crush distance)
4) Calculate the number of springs required for that stroke distance (# of springs = Stroke distance/.33 mm)
5) Separate that number of springs and insert the Tee pin to isolate them.
6) Pressurize the valve with minimum pressure to snug the springs.
7) Set the fully open "FO" position of the ram by sliding the FO clamp collar to the left and tightening it against the stationary wall.
8) Increase the air to the valve to 56 psi.
9) Set the fully closed "FC" position valve by sliding the FC clamp collar to the right and tightening it against the right-most stationary wall.
10) Adjust the ram block position so the pre-crush mechanism has enough travel to completely shut off the tube.
11) Adjust the pre-crush mechanism so the tube is completely shut off.

Another Example setup:

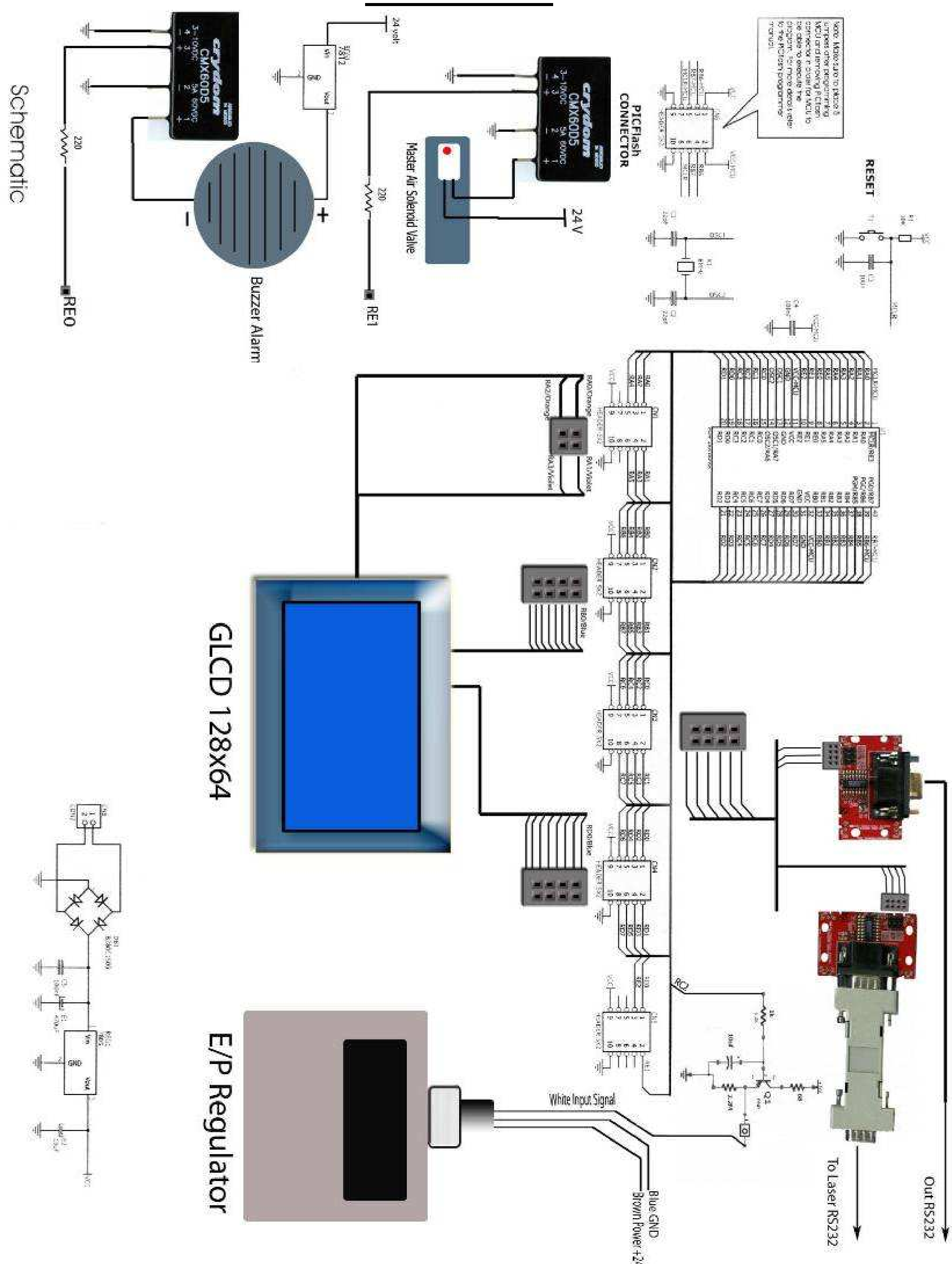
In this example we do not run the casting machine to determine the pre-crush distance. We place the tube into the tube passageway and let the loose end of the tube hang over a bucket. We apply 5 to 15 psi to the casting vessel and watch the flow of slurry out of the tube into the bucket. We then start closing down the pre-crush mechanism to start squeezing the tube. We notice the point where the flow of slurry just begins to slow down. At this point we stop the slurry flow and measure the distance between the ram block and the face of the pre-crush mechanism, using a dial or digital caliper. This distance subtracted from the original OD of the tube is the pre-crush distance. We then subtract that distance from the original ID of the tube and the resultant distance is the remaining amount that the tube must be crushed to be completely shut off.

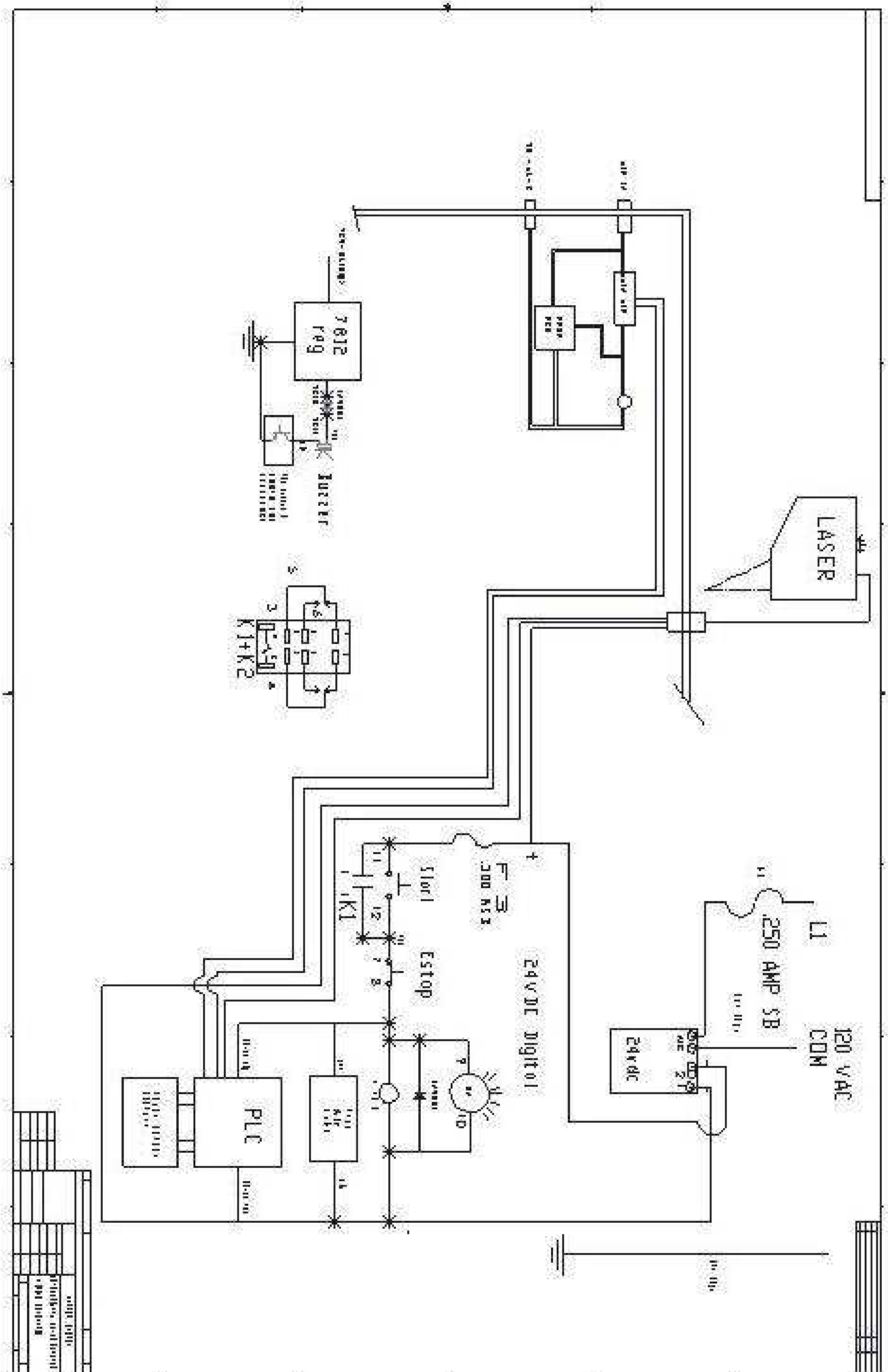
In this example suppose we started with a 20 mm OD tube and suppose the distance that we measured between the ram block and the pre-crush mechanism was 11 mm. The distance that the tube was crushed is 20 mm – 11 mm or 9 mm. We ten take the 9 mm and subtract it from the original tube ID (20 mm – 3mm – 3 mm = 14 mm – 9 mm) or 5 mm. This is the stroke distance of the valve.

Then:

a.) Calculate the number of springs required for 5 mm valve stroke. (5 mm / .33 mm = 15.15 mm or 15 springs)
b.) Count out and isolate 15 springs and insert the Tee pin.
c.) Pressurize the valve to snug the springs and clamp the FO clamp in place.
d.) Pressurize the valve to 56 psi and clamp the FC clamp in place.
e.) Place the tube into the tube passageway and set the pre-crush mechanism so the tube is completely shut off.
f.) Your valve is set up and ready to go.

Schematics


Schematic
CMX60D5
24 volt
Buzzer Alarm
RE0
RE1
Master Air Solenoid Valve
24 V
PICFlash CONNECTOR
RESET
GLCD 128x64
E/P Regulator
White Input Signal
Blue GND
Brown Power +24
To Laser RS232
Out RS232


7812
reg
Buzzer
K1+K2
LASER
F3
Start
K1
Estop
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PLC
L1
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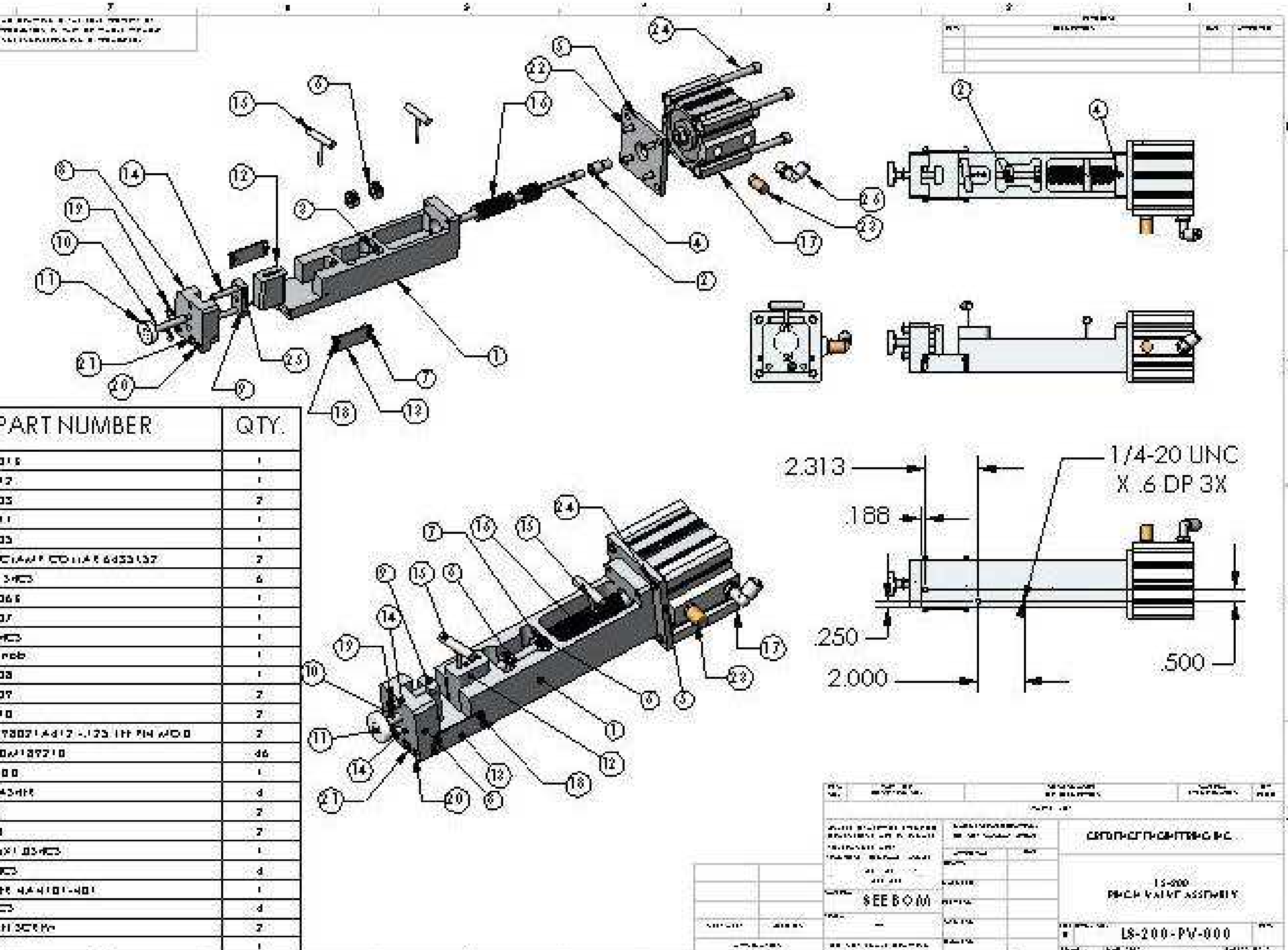
120 VAC
COM
24vdc



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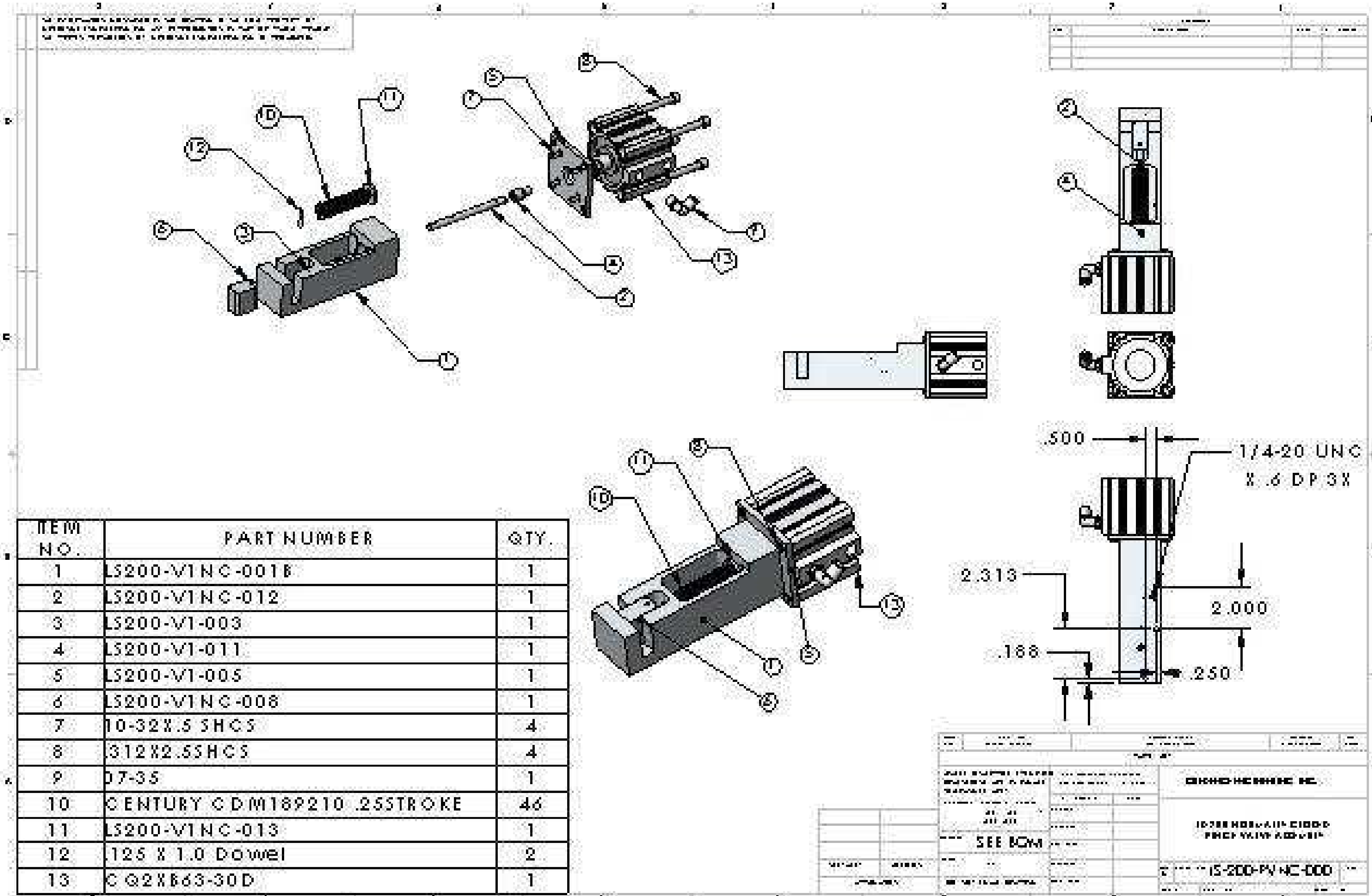
1	13700-V1-001B	1
2	13700-V1-012	1
3	13700-V1-003	2
4	13700-V1-011	1
5	13700-V1-005	1
6	MCMASTER CLAMP COLLAR 6435K12	2
7	4-40 X .375 SHCS	6
8	13700-V1-006B	1
9	13700-V1-007	1
10	.312X1.75SHCS	1
11	5-16 SHCS knob	1
12	13700-V1-008	1
13	13700-V1-009	2
14	13700-V1-010	2
15	MCMASTER 98071A417 -.125 HT PIN MOD	2
16	CENTURY COM187210	46
17	CD2X563-300	1
18	#4 FLAT WASHER	4
19	RR1200-25	2
20	.25X1 Dowel	2
21	CAPTIVE .25X1.05SHCS	1
22	10-32X.5 SHCS	4
23	SMC MUFFLER AN101-401	1
24	.312X2.25SHCS	4
25	#4 X .125 SET SCREW	2
26	KQ1107-333	1



ITEM NO.	PART NUMBER	QTY.
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3	LS200-V1-003	1
4	LS200-V1-011	1
5	LS200-V1-005	1
6	LS200-V1NC-008	1
7	10-32X.5 SHCS	4
8	.312X2.5SHCS	4
9	D7-35	1
10	CENTURY CDM189210 .25STROKE	46
11	LS200-V1NC-013	1
12	.125 X 1.0 Dowel	2
13	CQ2XB63-30D	1

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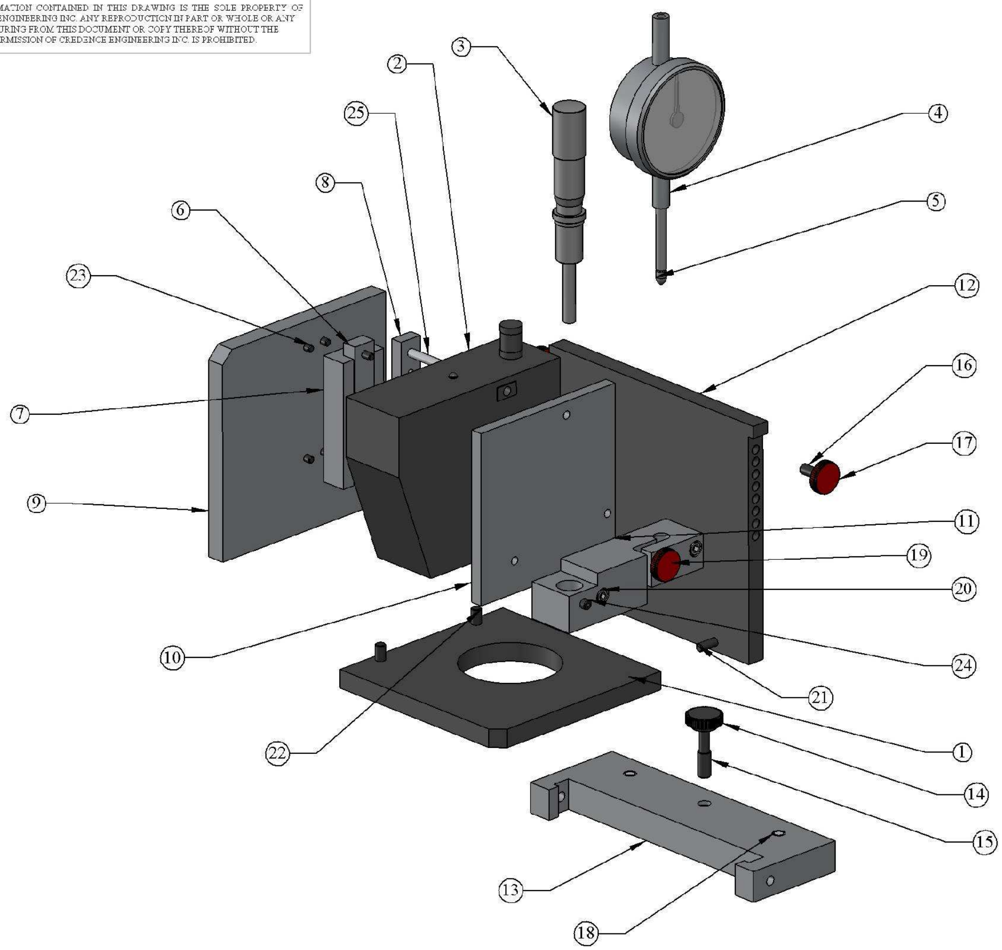

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

ITEM NO.	PART NUMBER	QTY.
1	HARROP 003-01-007	1
2	MTI LASER HEAD LTC-120-40-SA	1
3	STARRETT V263MRL	1
4	MITUTOYO 30mm x .01mm gr 21-781-0 DIAL INDICATOR BODY	1
5	INDICATOR SHAFT 30mm	1
6	MCMASTER STAGE 6257K25 BASE	1
7	MCMASTER STAGE 6257K25 SLIDE	1
8	LASER HEAD MOUNT BLOCK	1
9	SLIDE MOUNT	1
10	INDICATOR MOUNT BASE	1
11	INDICATOR-MIC MOUNT BLOCK	1
12	SENSOR BACK PLATE	1
13	SENSOR HANGER BLOCK	1
14	.25SHCSKnob BLACK	1
15	CAPTIVE .25X1.0SHCS	1
16	MOD 10-32X.5SHCS	2
17	#10SHCSKnob	3
18	.25X1.0Dowel	2
19	10-32X.75SHCS	1
20	8-32 X 1.00 SHCS	2
21	8-32x.625 shcs	4
22	10-32X.5 SHCS	2
23	6-32X.375 SHCS	6
24	10-32X.25 SOC SET SCREW	1
25	8-32X2.0 ss BHCS	2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
.XX ±.01 .XXXX ±.001
.XXX ±.003 ANGLES ±.5°

MATERIAL
FINISH
SPECIAL PROCESS
DO NOT SCALE DRAWING

APPROVALS | DATE
DRAWN
RESP ENG
MFG ENG
QUAL ENG

CREDENCE ENGINERERING, INC.

PART NAME
HARROP SENSOR ASSY

SIZE B SCALE SHEET OF
DWG. NO. REV.

NEXT ASSY | NEXT ASSY
WHERE USED

Specifications

No.	Description	Range/Limits/Tolerance
1.	Tube Size	¼-1 1/16
2.	Fluid Viscosity	100 cps - 10,000 cps
3.	Compressed Air Requirement (Clean)	75psi .5 cfm
4.	Electrical	110V AC 2A
5.	Level Accuracy (Depends on Viscosity)	± .012”
6.	Minimum Process Flow Requirement	1.5 oz/min.

Recommended Spares

1. 1 ea Captive Thumb Screw for Sensor Assembly Mounting
2. 2ea thumb screw assembly for Coarse Z adjust mechanism
3. 1 ea Micrometer Z adjuster
4. 1ea 25mm dial indicator
5. 2ea Fuse for A/C
6. 2ea Fuse for 24 VDC
7. 1 ea thumb screw assembly for indicator clamp
8. 2ea 4-40 socket head cap screws for valve stops
9. Thumb screw assembly for valve pre-crush mechanism
10. 2 ea Tee Pins
11. 12 ft. 1/8” tubing
12. 20ft ¼” tubing