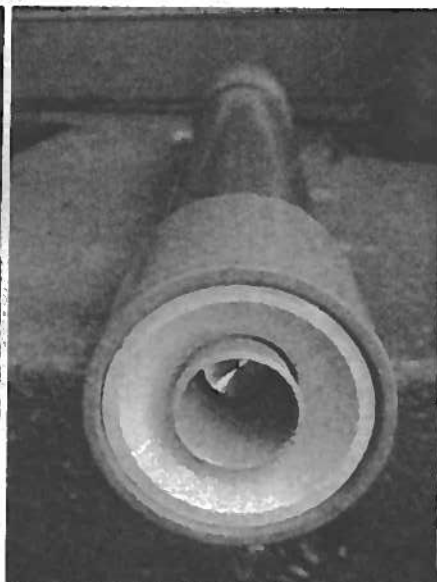
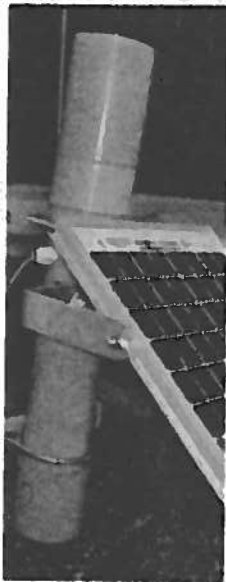


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FINAL REPORT
HARLINGEN IRRIGATION DISTRICT'S
AGRICULTURAL WATER CONSERVATION
GRANT FROM THE
TEXAS WATER DEVELOPMENT BOARD
FOR
INNOVATIVE TECHNOLOGIES FOR
AGRICULTURAL WATER MANAGEMENT
AND FLOW MEASUREMENT



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Attachments

- Low Cost Automatic Gates for Irrigation Canals
- Low Cost RTU for Water Level Measurement
- Low Cost RTU for Soil Moisture Measurement

TWDB-ITA Project overview

The Harlingen Irrigation District received a grant from the Texas Water Development Board in October of 2008 to develop low cost alternatives to canal automation and control. The primary purpose of the proposed project was to develop, document, and demonstrate low-cost alternatives for canal gate automation, water level measurement, and soil moisture management. The technologies developed have applicability to all surface water irrigation districts in Texas. All of the technologies are currently commercially available in many variations, but all have very significant costs and/or use limitations. The technologies are based on existing designs partially developed by the U.S. Bureau of Reclamation, the University of Delaware, or the Irrigation Training and Research Center in California. Each of the previous existing designs have limitation of cost or functionality and are not well documented.

This project modified designs to meet specific requirements of Texas irrigation systems. The District built five gates, five level sensors, and five soil moisture LCRTUs and tested each device in a real world situation by installing and integrating the devices into the District's existing telemetry system. This report contains fully documented engineering drawings, parts list, installation instruction, maintenance and calibration instructions, and vendor list for parts. All of the software developed to operate the devices is based on open-source code and available from the District. A more detailed account of the development of the devices is located within this report. Overall the devices have worked as designed and are in use in the Harlingen Irrigation District as well as other Districts across the state.

Auto-Gate

The Auto gate design is based on a Bureau of Reclamation (BOR) design used in the hydraulic lab located in Denver CO. The design was modified to mount the gate to a canal check structure and to be operated with a simple 12volt linear actuator. This report contains a more detailed description of the gate assembly and technical aspects in the attachment labeled "Low Cost Automatic Gates for Irrigation Canals".

The gate had a few challenges in the design and production phase. For instance with the 12 volt actuator we needed to reduce the friction coefficient of the gate to the frame in order to move the gate with a large head of water against it. This was done by applying a product from Crown Plastics called DuraSurf. DuraSurf is a UHMW plastic with an adhesive on one side making the attachment to the gate surface much stronger than a mechanical attachment. The DuraSurf was attached to the gate where the frame mates to the gate door. By doing this the friction was greatly reduced allowing the gate to move freely under a heavy load with a 12 volt actuator. With the low voltage actuator the gate can be powered with alternate forms of energy. Many of the canal check structures are

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located in remote areas where grid electricity is not available or very expensive to install. The Auto-Gate and its control components can be powered with solar or wind generators as well as A/C power from the grid. This enables the placement of automatic gates in areas where a traditional automatic gate controller's power requirements would be cost prohibitive. Using the information in this report a reliable automatic gate can be produced and installed for less than \$10,000.

The design and installation of the project's five auto-gates allowed the district to test and verify the gates for operation and reliability. The success of the testing lead to the District applying for, and receiving a Water Smart grant from the Bureau of Reclamation. The grant allowed the District to install 25 more gates creating a fully automated system on the District's main canal.

The canal automation has given the District greater control over water deliveries and potential wasted water events. The gates can be configured many ways: in standalone mode, with upstream and downstream control, and multi-gate mode, with upstream and downstream control, with telemetry. The gates used in standalone mode are an effective way to maintain upstream water levels preventing canals from over flowing. This is very important when operating a canal at a critical level to enable delivery of sufficient irrigation water. As a multiple gate system with the gates communicating via telemetry the District can deliver, monitor and control water moving through the canals more efficiently. This in turn uses less man power to move the same amount of water and alerts the operators to potential problems along the canal preventing instances of wasted or accidently spilled water.

The District predicts the gates to have a life span of 20 years or more depending on the environment. Very little maintenance is required as the only moving parts are lubricated by water. The actuator has a life span of 5 to 8 years if kept protected from the elements. The District made pvc covers for all of the actuators to keep them protected from the rain and the sun. We did experience premature failure on the units that were not protected in this manner.

The Gate was exhibited at the Texas Irrigation Expo in October 2010. Upon viewing the gate and seeing the benefits the El Paso

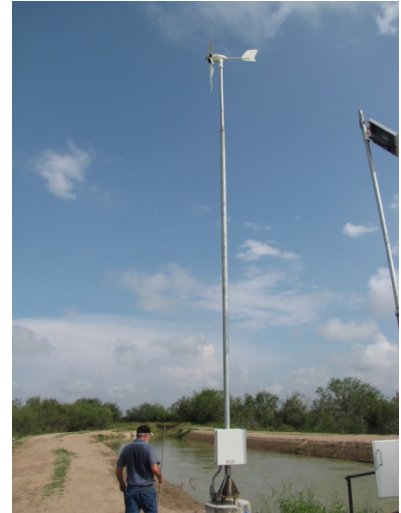


Figure 1 Wind Generator at first gate site



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Irrigation District installed 10 gates built by the Harlingen Irrigation District and expects to build and install more as they improve their district over the next several years. This same gate design was selected for use in the Lower Colorado River Authority's canal automation project partially funded by a Water Smart grant from the Bureau of Reclamation.

The Gate has proven to be a success in this District and has become the gate of choice in others as well. The District will continue to improve the gate as needed and assist other irrigation districts in their canal automation projects as requested.

Level Sensor and Remote Telemetry Unit

The need to monitor canal levels in remote areas of irrigation districts is of utmost importance when trying to minimize waste and improve irrigation deliveries. AW Blair Engineering through this grant developed and built a low cost remote telemetry unit (LCRTU) capable of monitoring water levels and communicating that level to a central location for monitoring. The LCRTU is made from off the shelf components and an interface board developed to combine a PIC processor and a spread spectrum radio into one unit. The unit housing was then constructed from readily available components to enable the installation and operation in various environments. Details of the LCRTU are found in this report in the attachment titled “Low Cost RTU for Water Level Measurement”.



Figure 2 LCRTU and Extended Antenna

The Harlingen Irrigation District has installed three of these units in remote areas of the District and interfaced them with the District’s existing telemetry system. These areas would normally only be checked once or twice daily. The LCRTU is configured to report levels every fifteen minutes. This information is then sent to the District’s web site, where an alert can be sent to the canal operator when the canal is in an overflow state, greatly reducing the amount water that would normally be lost.

This device coupled with a simple telemetry system could greatly improve a district’s efficiency and save countless acres of water lost due to overfilled canals. The remote monitoring of canal levels can reduce time and fuel expenses associated with manual monitoring of a canal system.

Soil Moisture Monitor and Remote Telemetry Unit

AW Blair modified the Low Cost Remote Telemetry Unit to read soil moisture data from two soil moisture devices and transmit that data to a central location for monitoring. The two soil moisture devices chosen were the Decagon HS 10 and the AquaSpy Aqua Blue sensor. Both sensors performed well in the testing phase and were chosen for their known reliability. A more detailed description of the devices is located in the attachment titled “Low Cost RTU for Soil Moisture Measurement”.



Figure 4 Digi/MDS Relay Unit

The District installed three devices in the fields of local farmers and at the Flow Meter Calibration facility. The devices performed well in all three places until the crop reached a height that blocked communication with the base radio. This can be overcome with the installation of a taller antenna mast at the field site. While the soil moisture device worked well at reading the soil moisture the ability to relay that information back to the District headquarters was a major hurdle. The challenges experienced with the LCRTU were primarily communication. The Digi X-10

radios are very good radios but require a clear line of sight in order to get the transmission distance advertised. When the units are placed in the field under a crop canopy or on a canal bank adjacent to trees the line of sight is greatly diminished. The communication problem was overcome by using a high gain yagi antenna and placing it on an extended mast. Communication was also improved by placing relay stations throughout the district that mated the Digi radio to a MDS radio. The MDS radio is the radio used in the District's main telemetry system. By using these relay units the District is able to place a LCRTU anywhere in the district and communicate data back to the main office.

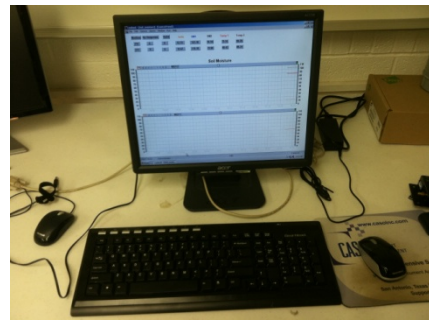


Figure 3 Mini PC Base Station

A system based on a mini PC is being used in support of the Agricultural Water Conservation Initiative at one of the on farm demonstration sites. This system could be placed in a grower's office or home and coupled with the Digi base radio to allow for the collection of soil moisture data within a 3 mile radius of the base station. This is an inexpensive alternative to some of the products on the market today.

The District plans to expand its telemetry system using the LCRTU to offer soil moisture monitoring to all of the growers within the District. The implementation of these devices across the District's 20,000 irrigated acres will aid in the scheduling of irrigation and the conservation of water within our District.

Water Savings

Water savings can be accomplished through various applications of the devices produced by this project. The use of level sensors in remote areas has enabled our district to monitor canal overflow weirs that in the past were only monitored once or twice daily. These overflow weirs have the capability to flow in excess of 3 cfs. This would equate to a loss of 3 to 6 acre feet per day depending on when the overflow was corrected. These canals normally would reach the critical level 8 to 10 times in an irrigation season. With the installation of the LCRTUs and our telemetry system, remote over flow weirs are

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monitored every 15 minutes. This means the canal level is adjusted immediately upon receiving an alert of the canal being in a critical condition saving the District an estimated 30 to 60 acre feet in a season. If you combine the monitoring ability of the LCRTU and the Auto-gate's ability to maintain the canal at a specified elevation you can eliminate 99% of water losses that occur due to the canal being over full. The use of the Auto-gate with a telemetry system also enables the remote operation of the gate which in turn will save labor and energy by eliminating the need to travel to the remote site to adjust the gate.

The Soil moisture monitoring device developed with this project can be configured for district wide or a private farmer application. This could encourage farmers to move toward irrigation scheduling with monitoring soil moisture. The use of soil moisture monitoring has the potential to reduce water use for irrigation from 20-70% depending on the application.

Financial Summary

The project was expected to cost \$498,000 to design and build five Auto-Gates, five Low Cost RTU Level Sensors and five Low Cost RTU Soil Moisture measurement devices. The project was completed under budget by approximately \$60,000. Figure 5 illustrates the budget and actual expenses incurred during the project.

Expense Item	Approved Budget	Actual Expenses
Salary	\$ 113,500.00	\$ 49,739.74
Fringe	\$ 23,835.00	\$ 8,864.91
Travel	\$ 5,716.00	\$ 421.84
Supplies&Equip less than\$500	\$ 40,134.00	\$ 33,028.67
Capital Equipment over \$500	\$ 10,000.00	\$ 8,932.13
Subcontracting Services	\$ 304,695.00	\$ 334,352.57
Reproduction	\$ 150.00	\$ -
Overhead	\$ -	\$ -
Totals	\$ 498,030.00	\$ 435,339.86
Task Expenses		
Task A- Auto Gates	\$ 171,948.00	\$ 178,815.75
Task B- Water Level Telemetry	\$ 189,162.00	\$ 133,925.76
Task C- Soil Moisture Management	\$ 136,920.00	\$ 122,598.36
Totals	\$ 498,030.00	\$ 435,339.86

Figure 5 Budget Proposed vs. Actual

Attachment 1

Low Cost Automatic Gates for Irrigation Canals

Prepared for the

Harlingen Irrigation District



Under a Texas Water Development Board Grant

Innovative Technologies for
Agricultural Water Management
and Flow Measurement

September 27, 2010

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APPENDICES

A Gate construction details

- Elevations
- Sections
- Details
- Gate details

B Actuator

- Basic dimensions and specifications
- Actuator arm parts breakdown
- Actuator motor/gear parts breakdown
- Parts list
- Wiring diagram
- Limit switch adjustment
- Part number code

C Automatic gate controller

- Wiring schematic
- Parts list
- Test sheet

D NEMA enclosure vandal box

- Elevations
- Sections
- Parts details

1. Introduction and Overview

Flow in irrigation canal systems is controlled by gates that can be raised or lowered to change water levels and hence flow rate. Traditionally, gates have been raised or lowered manually and then left in position to achieve a target flow rate for a desired time period. This is a labor intensive and time consuming process, and is often done only at the beginning and end of the time period.



Figure 1. Various manual gates requiring an operator to raise and lower them.

Automating canal gates enables them to be raised or lowered without visiting the site, and can also enable frequent adjustments to be made to maintain flow rates within a target range as water levels fluctuate within the system. Automatic gates are commercially available, but are often too expensive to be economically viable.

This project has resulted in the design of automatic gates that can be readily manufactured locally, assembled, and installed. All parts for the gates are available commercially off-the-shelf. The primary sub-assemblies of the system are:

1. The gate assembly itself
2. The actuator, including motor and controls for raising and lowering the gate

Optionally, water level sensors, telemetry and control hardware (such as SCADA) can be used for full automation, enabling the gate to be raised or lowered as required.

Figure 2 shows an example of a 3 ft wide by 4 ft tall canal sluice gate constructed of mild steel. This design is based on a USBR gate. The autogate modifies this design to:

- make the gate more reliable
- handle larger sizes with the associated greater forces needed for operation
- operate on solar power (DC)
- provide push-button up/down control

The primary difference between the system developed for this project and commercially available systems is cost.

Each of the primary components are described separately in the following sections, with parts lists, drawings and supporting information included in appendices. Figure 3 illustrates the individual components required for full automation and remote operation.

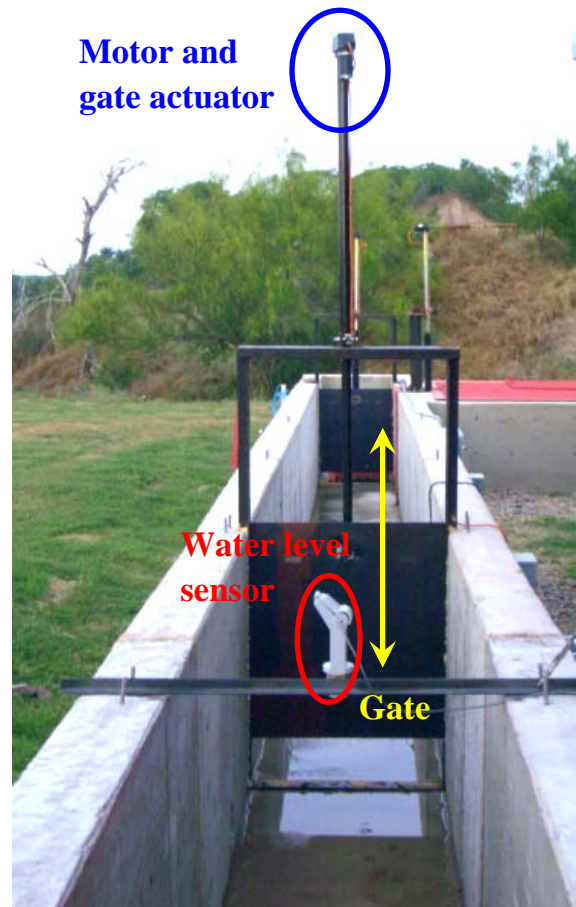


Figure 2. Typical sluice gate with actuator and water level sensor.

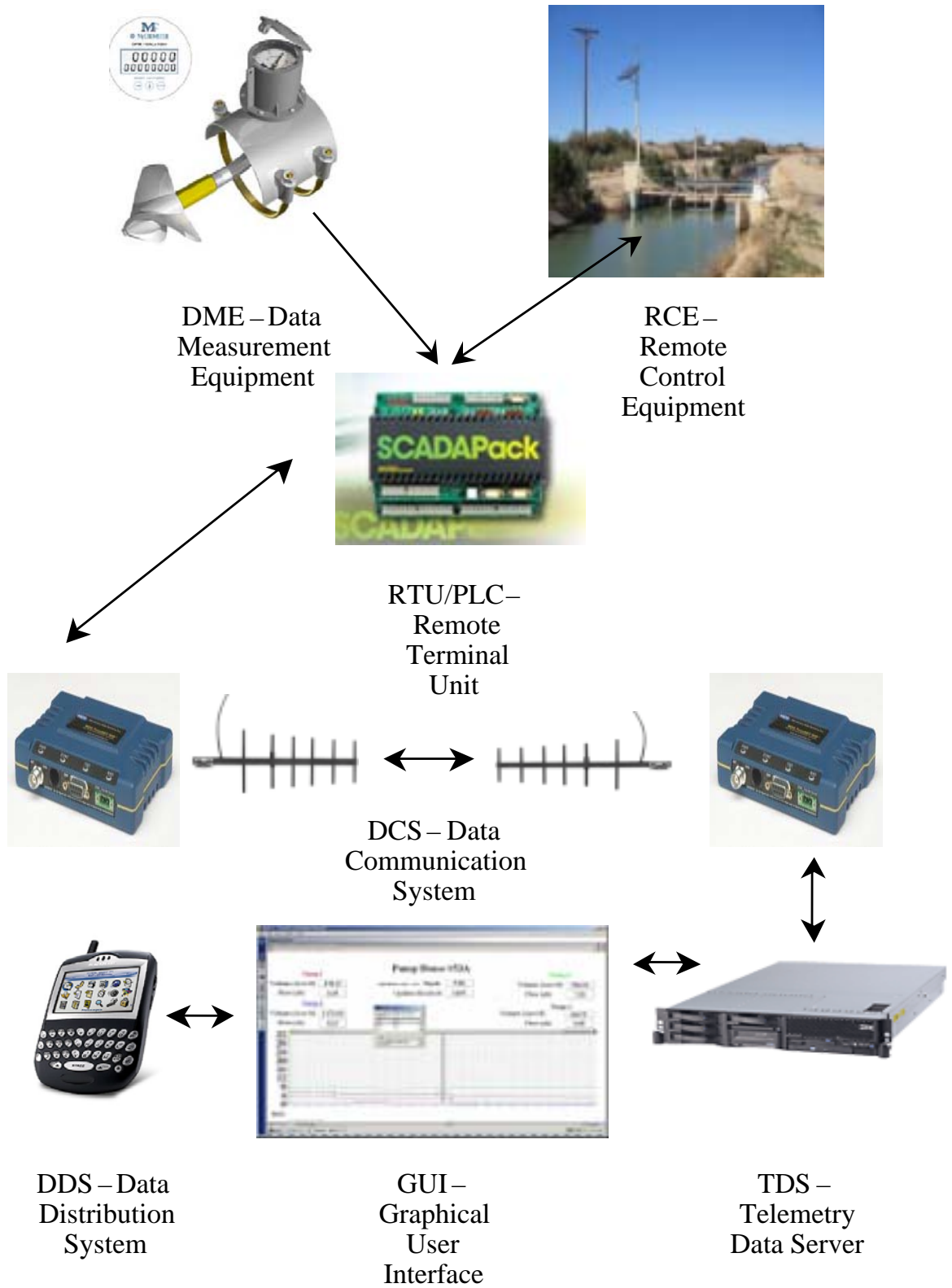


Figure 3. Major components of an automatic gate system.

2. Gate description

The gate assembly is fabricated of aluminum secured with welding or bolts, and can be made individually in custom sizes to fit existing canals.

2.1 Gate

The gate itself is constructed of 3/8 inch aluminum plate reinforced horizontally with 2 inch x 2 inch aluminum angle bolted to the plate with 1/2 inch stainless steel bolts. The gate can slide smoothly up and down within the aluminum frame using a bearing surface and seal provided by Ultra High Molecular Weight (UHMW) plastic strips.

(www.crownplastics.com)

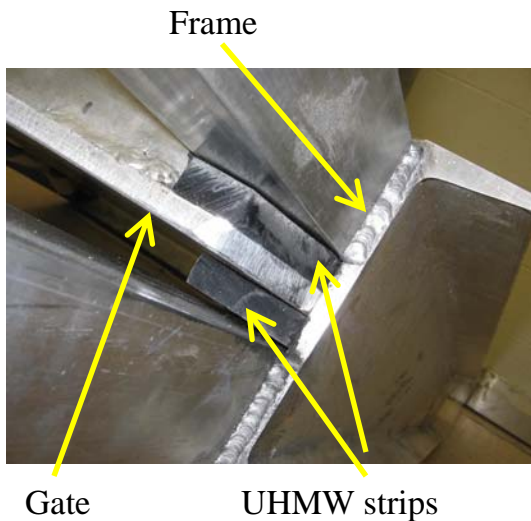
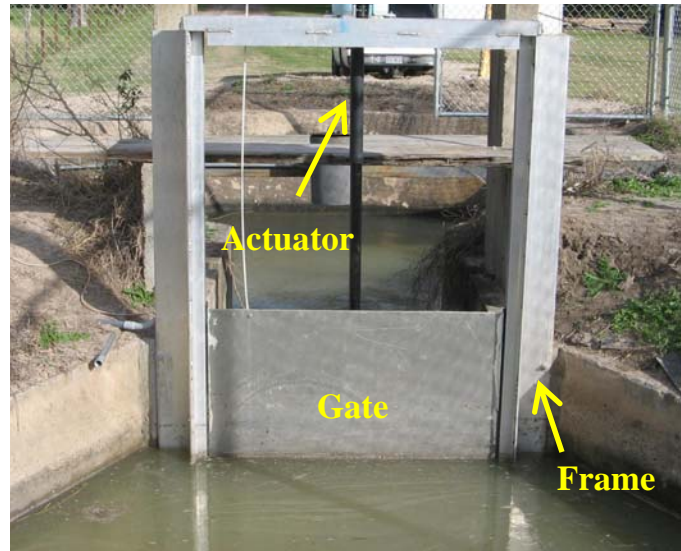


Figure 4
Right top and bottom: a gate assembly showing the gate itself and the frame in which the gate can slide up or down.
Above: detail showing gate, frame and UHMW sealing/bearing strips.



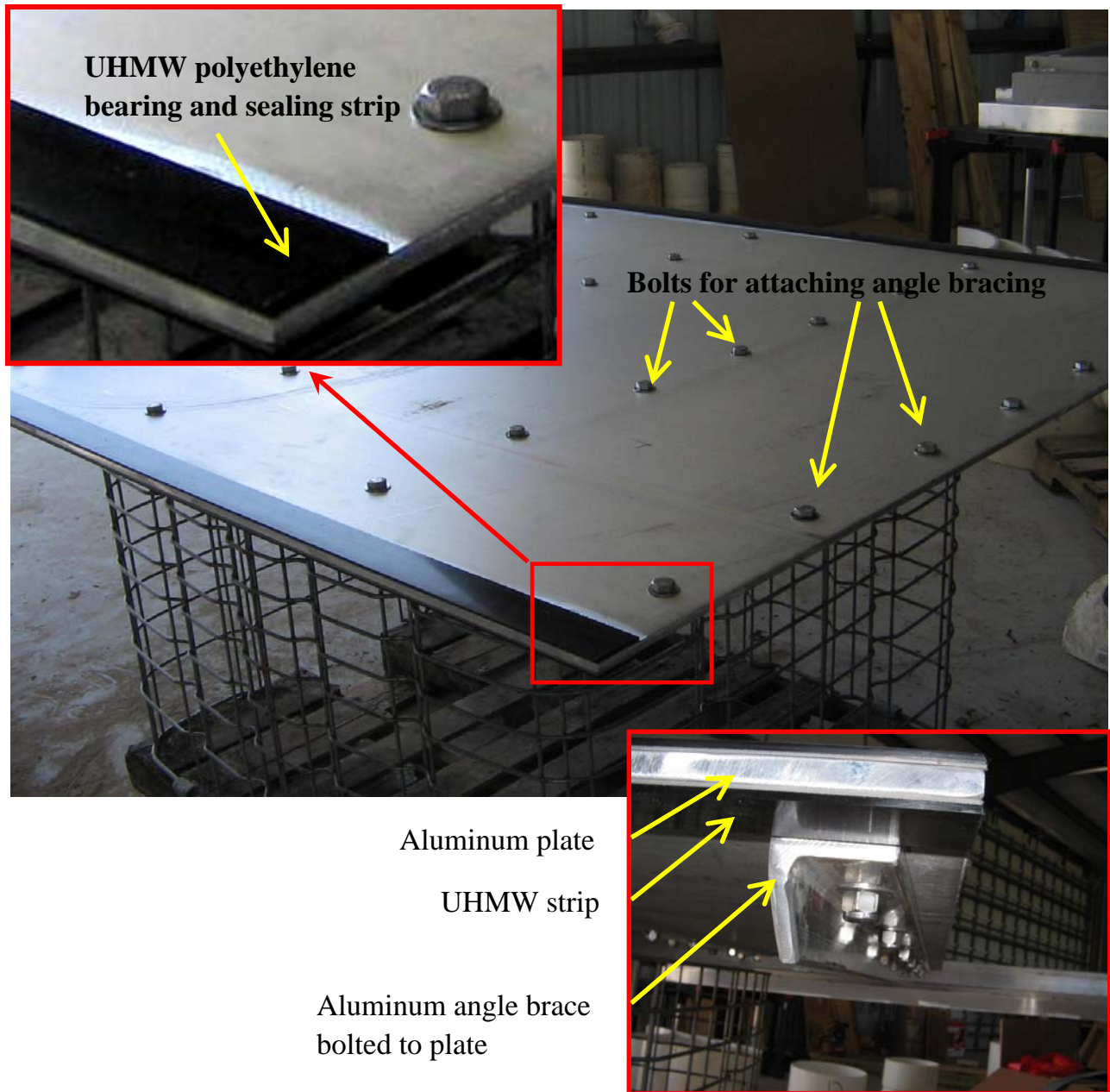
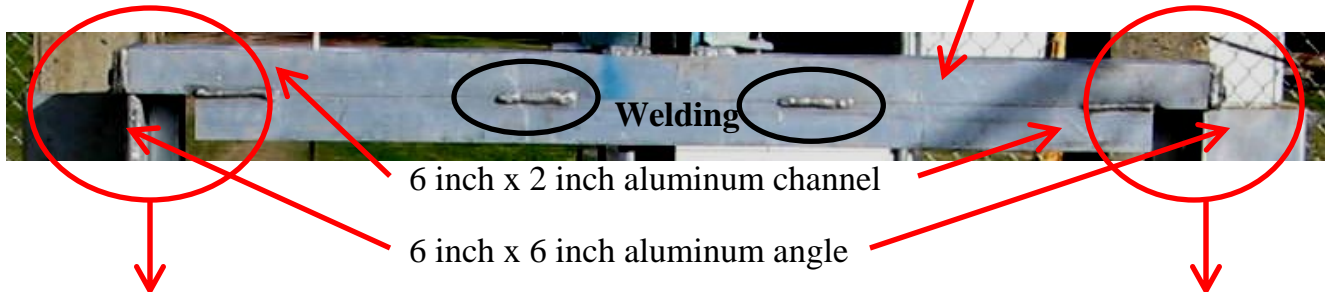


Figure 5. Fabrication of gate from aluminum plate. The inset at top left shows the UHMW bearing/sealing strip fixed to both sides (upstream and downstream) of the vertical edges that contact the frame. The inset at bottom right shows the underneath of the plate to which 2 inch x 2 inch aluminum angle bracing is bolted.

2.1.1 GATE FRAME

The frame in which the gate fits is constructed of 6 inch aluminum angle and channel welded and bolted together. The vertical path in which the gate slides is constructed of 2 inch aluminum angle.

Further details of the gate path are shown in figure 6. The bottom of the gate frame is constructed of 6 inch x 2 inch channel as shown in figure 7.



2 inch x 2 inch aluminum angle



6 inch x 2 inch aluminum end plate

Figure 6. Horizontal top of gate frame using 2 lengths of 6 inch x 2 inch aluminum channel welded together and supported on vertical 6 inch x 6 inch aluminum angle (top). Two lengths of 2 inch x 2 inch aluminum angle are welded to each vertical support to form the path in which the gate slides (bottom left). An end plate and bolts secure the top frame to the 6 inch x 6 inch vertical support channel and the two 2 inch x 2 inch channels forming the gate path (bottom right).

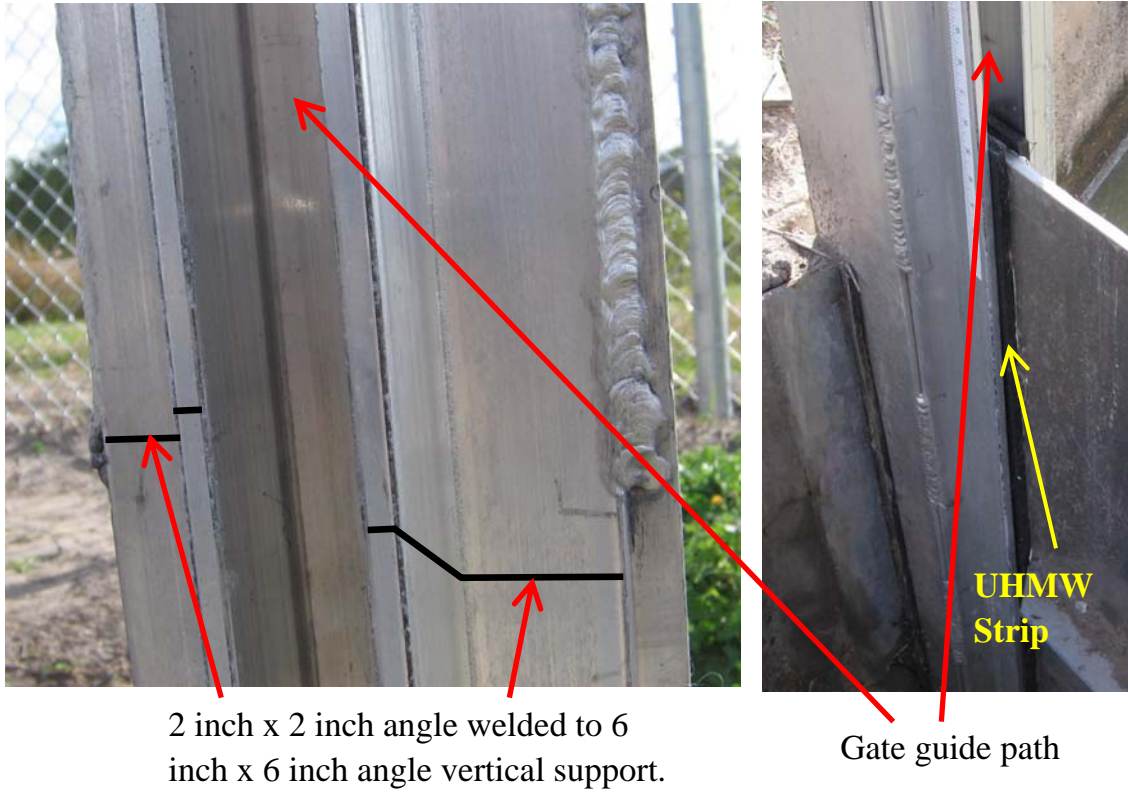


Figure 7. Construction of gate guide path using 2 inch x 2 inch aluminum angle



Figure 8. Construction of bottom of gate frame.

2.1.2 ACTUATOR BRACKETS

There are two brackets to attach the linear actuator to the gate and to the frame. One bracket is welded to the top horizontal beam of the frame, and secures the non-moving part of the actuator. The other bracket is welded to the gate itself and is attached to the moving part of the actuator, enabling it to raise and lower the gate. Both brackets are made from 2 inch x 2 inch aluminum angle.

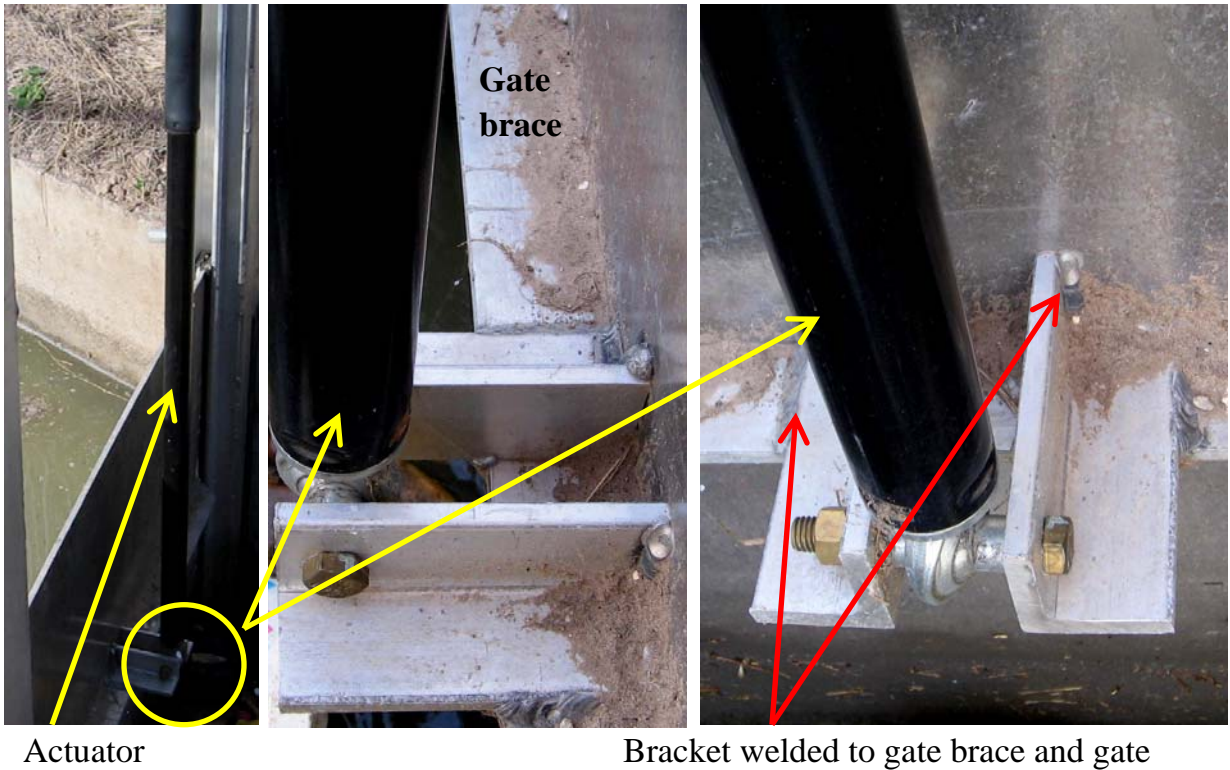


Figure 9. Bracket construction and attachment to the moving part of the actuator and the gate.

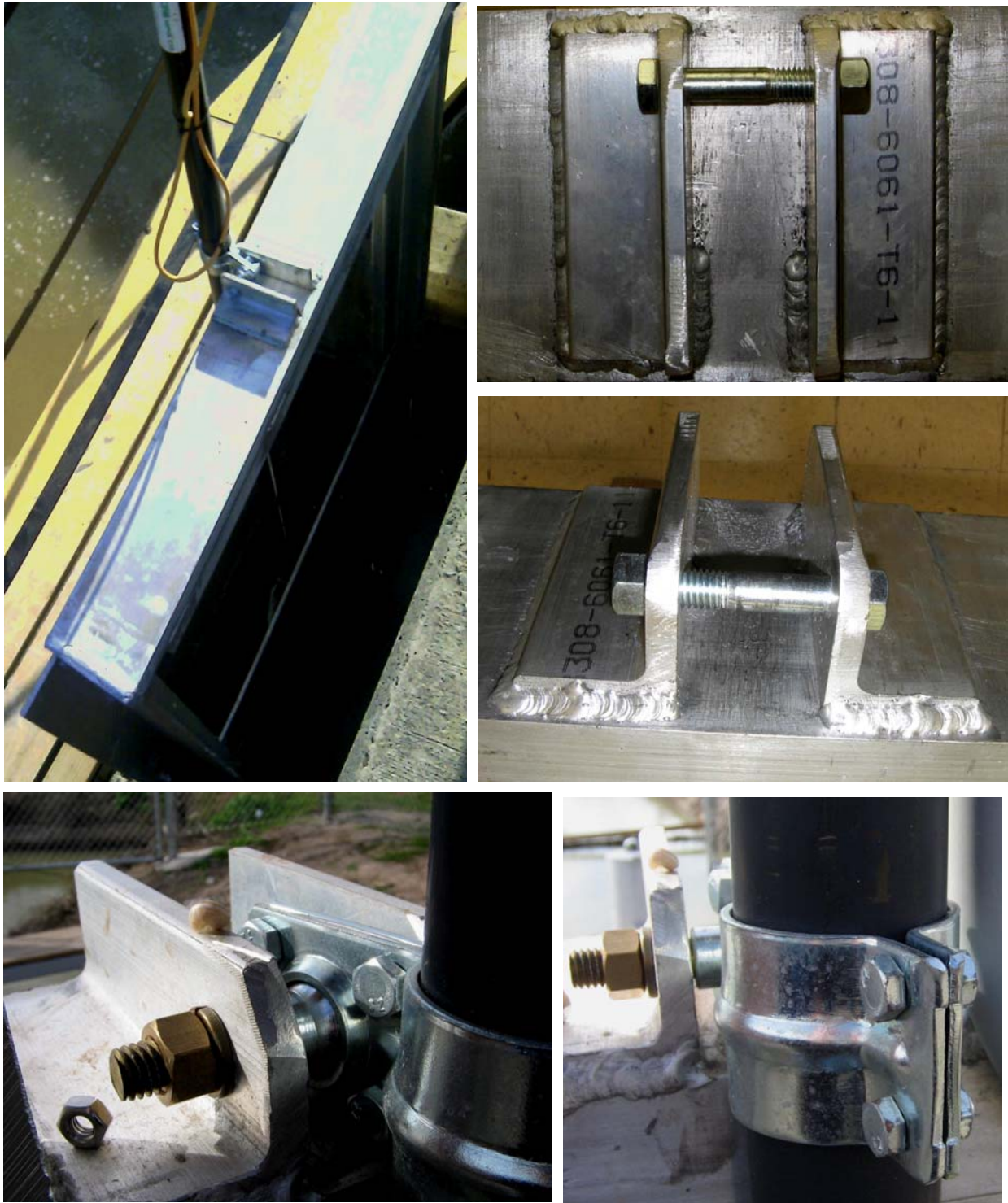


Figure 10. Bracket construction and attachment to the top of the gate frame and the non-moving part of the actuator.

3. Actuator and controls

The actuator is the mechanism that moves the gate up or down. The actuator used is a 12V DC off-the-shelf device found in applications such as “slide-out” room extensions on recreational vehicles. The motor operates a screw assembly that extends or retracts linearly. The mechanical advantage embodied in the screw mechanism enables the application of considerable force at a slow rate of linear movement, attributes that suit the movement of canal gates. The rated load for the actuators used is 1500 lbs force. There are adjustable positive limitations to the minimum and maximum travel, while an internal rheostat enables the position of the actuator between these limits to be determined. Power to operate the motor is supplied using a 12V battery recharged by a solar panel.

3.1 Actuator



Figure 11. Gate actuator showing arm and motor (left), actuator arm position sensor (4-20 ma potentiometer) (Top right) and details of motor (bottom right).

3.1.1 ACTUATOR POSITION SENSOR

As the threaded shaft of the actuator turns, a worm gear drives both a rheostat to determine linear position and a mechanical mechanism to shut off the motor when the limits of travel in either direction are reached. The rheostat outputs a 0-5V signal depending on relative position between the travel limits., but in order to use the signal for automatic control using SCADA, it must be converted to a 4-20 mA signal. This is accomplished with an external potentiometer mounted on top of the actuator enclosure and connected to the internal voltage output signal from the rheostat. The zero output position of the potentiometer as well as the span (range) have external screw adjustments.

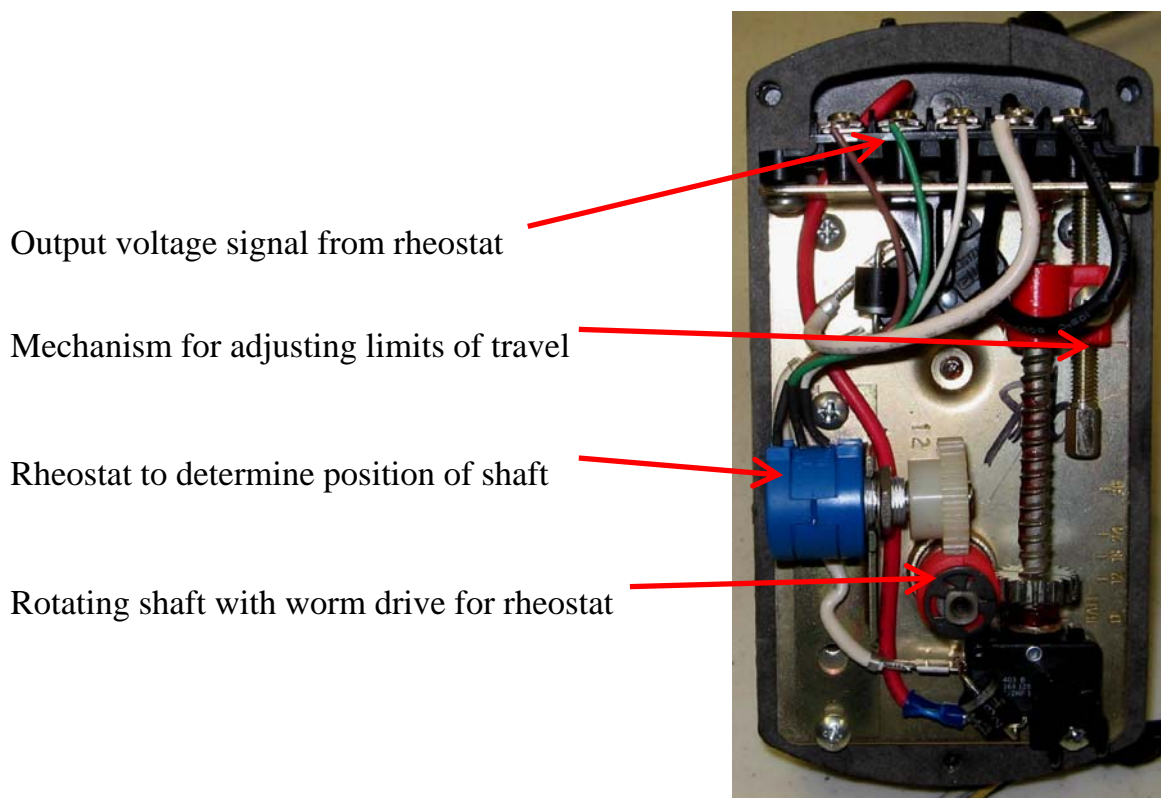


Figure 12. Position sensor and limit adjustment for actuator.

3.1.2 CONTROL BOX

The control box consists of a NEMA enclosure with internal circuitry to operate relays and external controls for manual operation of the gate. A three-position external switch enables selection of off/automatic/manual mode. Two external push-buttons, each with an indicator light, enable the gate to be either raised or lowered when in manual mode.

Each gate requires a set of controls, and more than one set of controls can be incorporated in each control box.

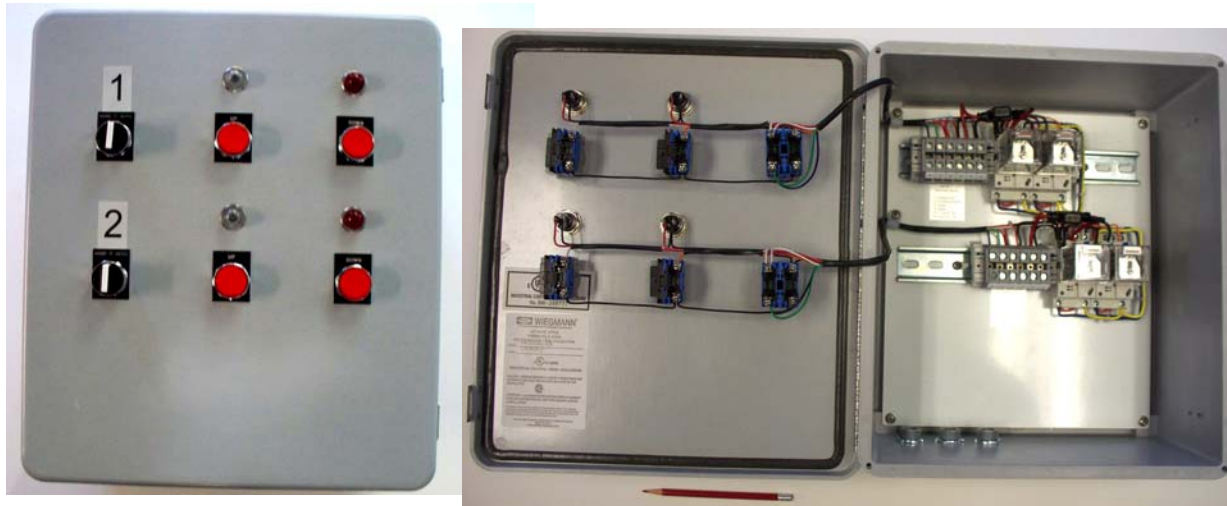


Figure 13. Closed (left) and open (right) gate control box for controlling 2 gates independently.

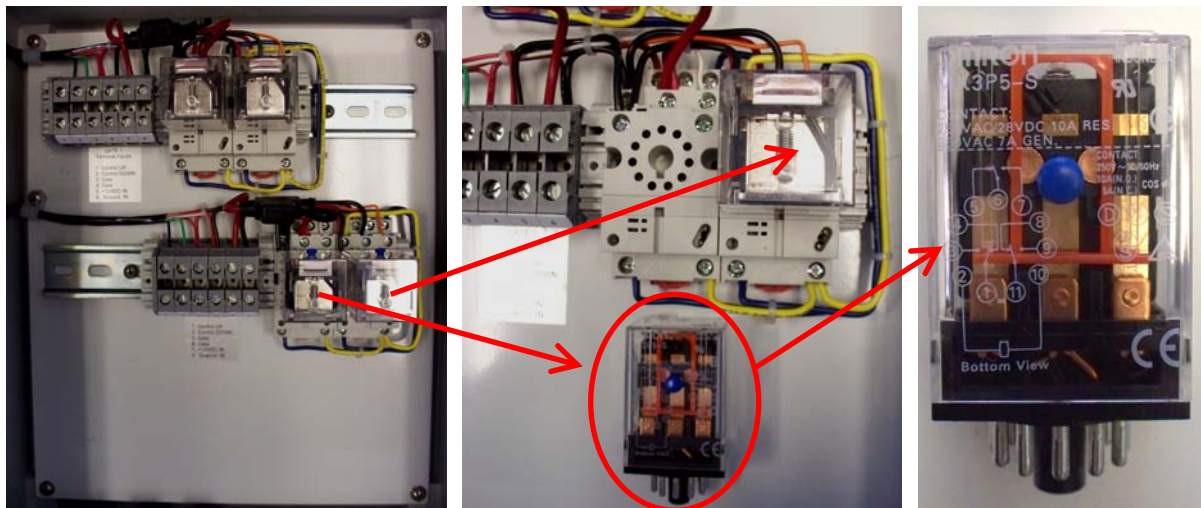


Figure 14. Control panel showing relay circuitry for two gates (left), the two relays required for each gate with one relay removed from the base (middle), and a relay (right).

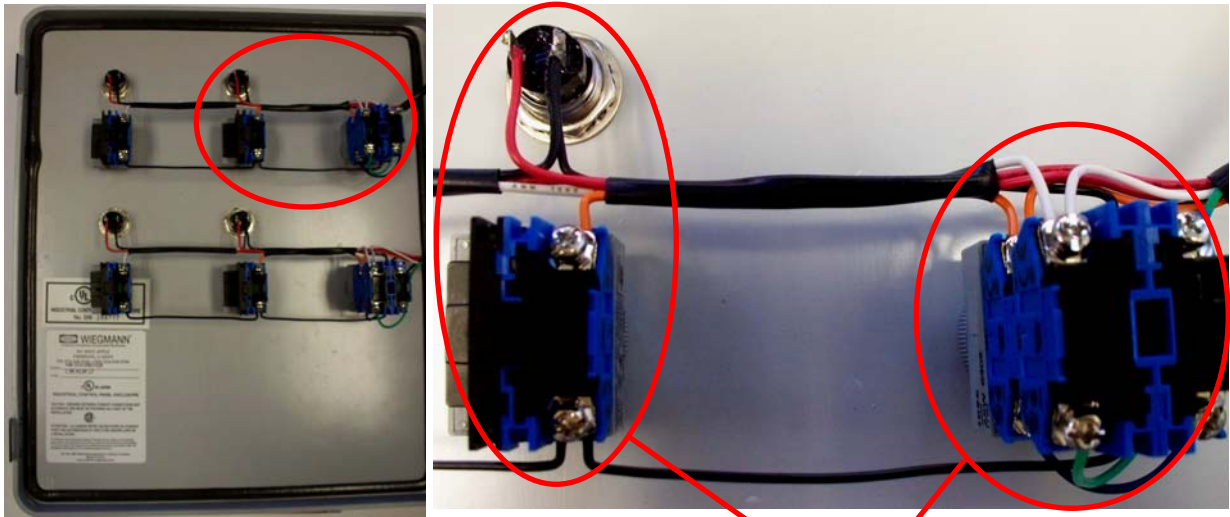
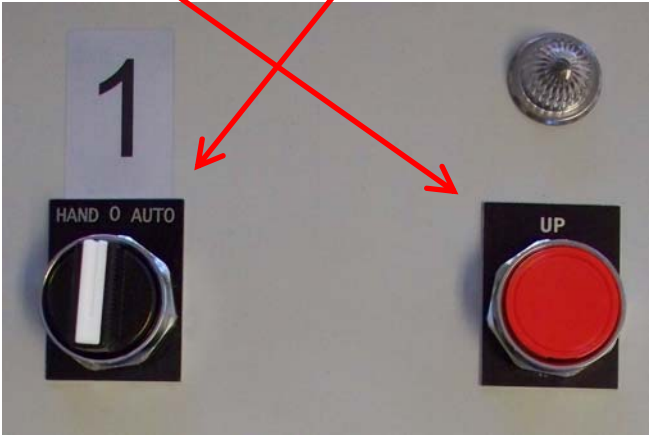


Figure 15. Internal circuitry for external controls and lights (top left), with details of the components for a 3 position switch and an indicator light and control button (top right and bottom right)



Power is supplied by a 12V deep cycle battery that is charged by a 20 Watt solar panel.

4. Automation

The gate can be fully automated by using a sensor (such as for upstream waterlevel) together with a microprocessor based controller, such as SCADA. The incorporation of telemetry also enables remote operation.



Figure 16. A SCADA system capable of automating gate operation in response to input from a sensor such as water level.

APPENDIX A

Gate construction details

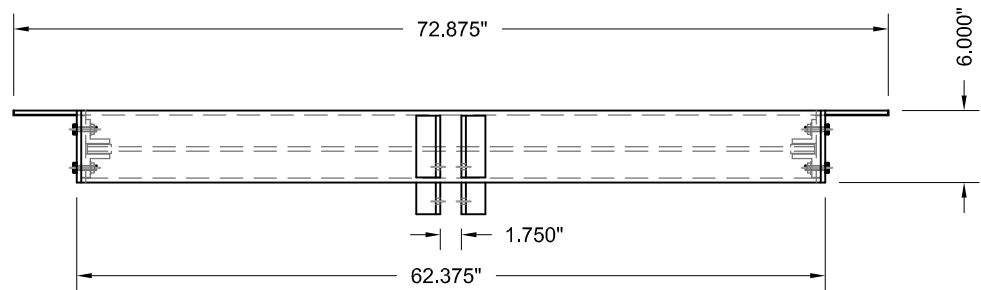
Elevations

Sections

Details

Gate details

TOP VIEW
SCALE 3/4" = 1'



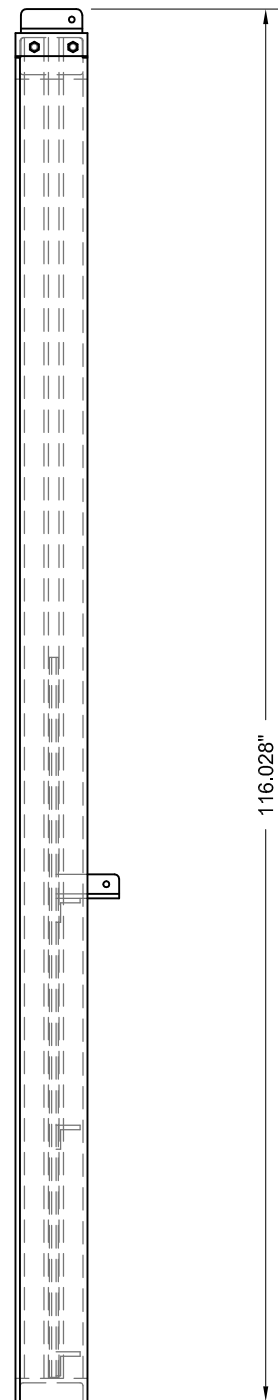
NOTES: GATE FRAME MADE FROM
GRADE 6061 ALUMINUM
2" X 2" ANGLE AND
6" X 1.92' CHANNEL
WELDED WHERE NOTED

GATE MADE FROM 60" X 60.625" X 3/8"
ALUMINUM PLATE WITH 1/8" GAP ON EACH SIDE

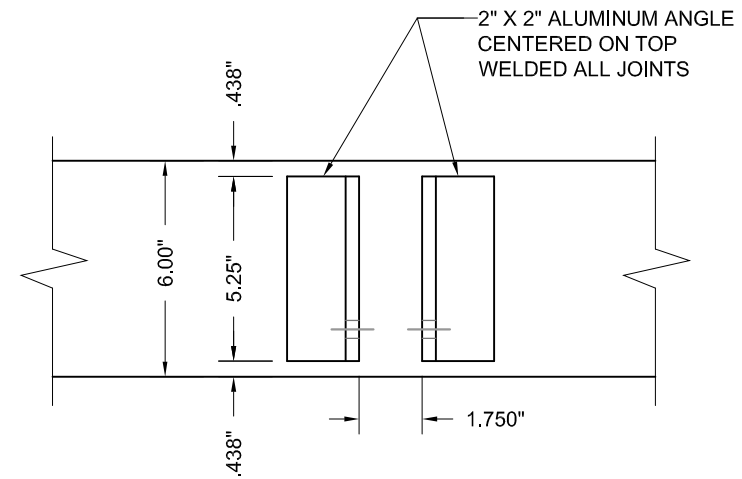
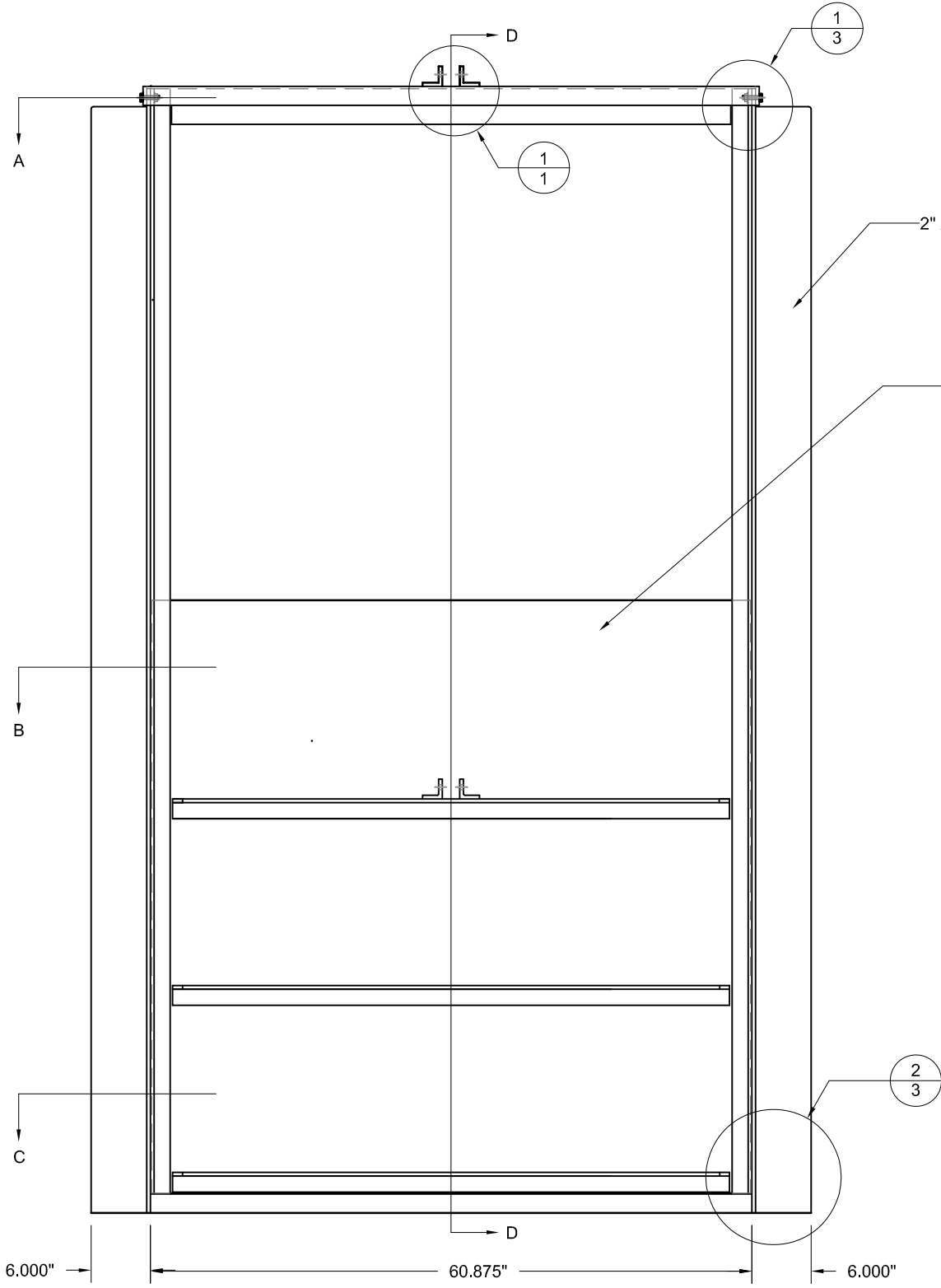
UHMW TO BE 2" X .125" BLACK 3M CVT
LAM-N-HARD PRESSURE SENSITIVE

2" X 2" ANGLE GATE BRACES BOLTED TO GATE
WITH 6 EACH - 1/2" SS BOLTS SPACED 8 1/2" APART

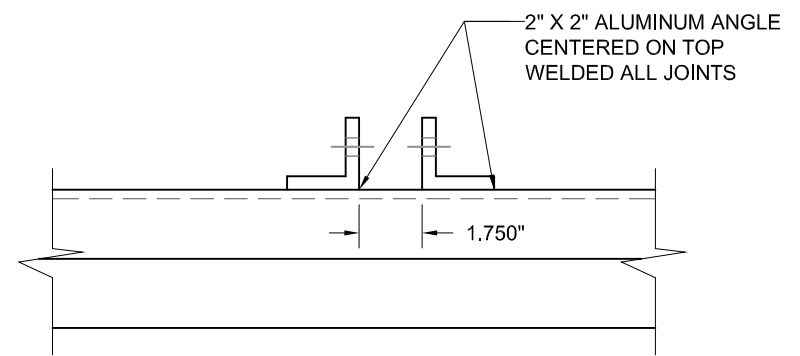
SIDE VIEW
SCALE 3/4" = 1'



FRONT VIEW
SCALE 3/4" = 1'



1/1
1/1
DETAIL TOP ACTUATOR MOUNT / TOP VIEW
SCALE 1 1/2" = 1'



1/1
1/1
DETAIL TOP ACTUATOR MOUNT / FRONT VIEW
SCALE 1 1/2" = 1'

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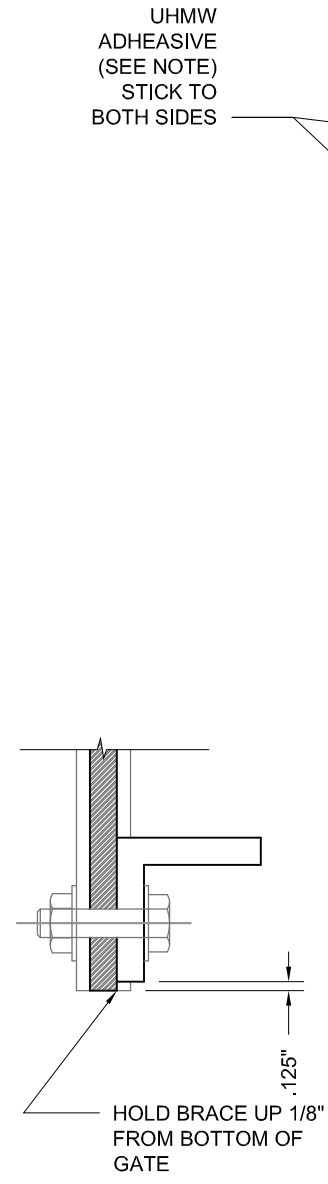
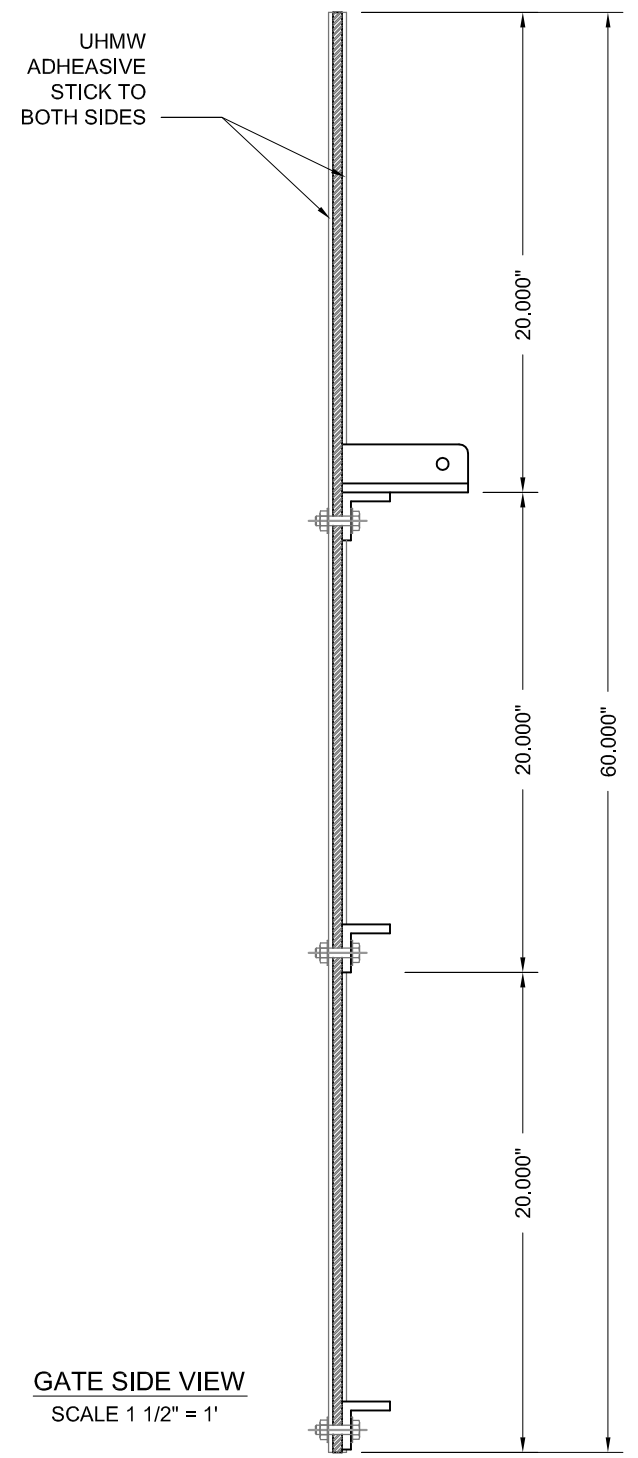
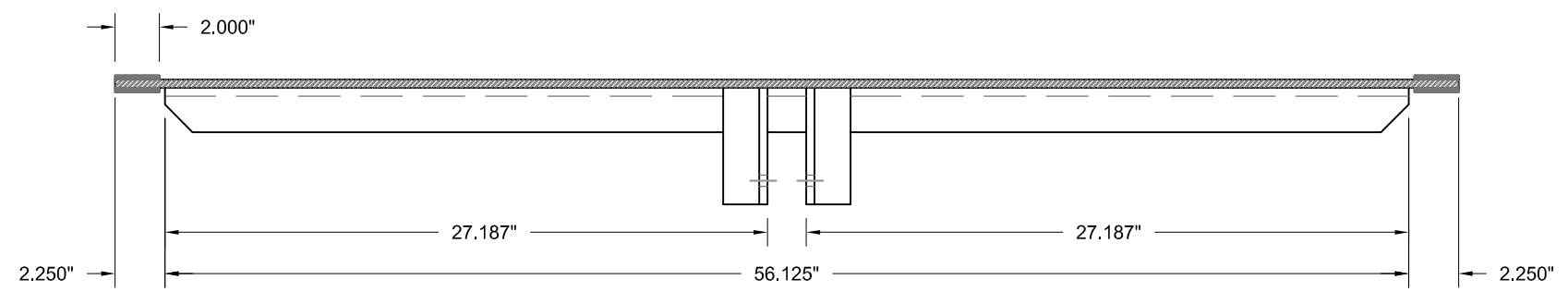
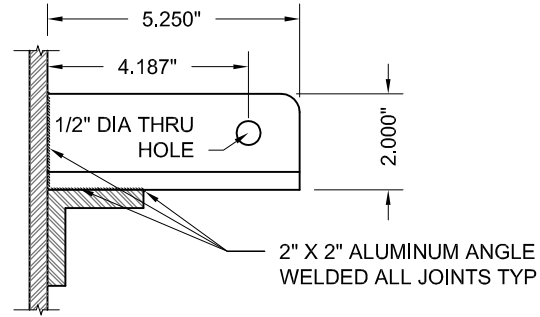
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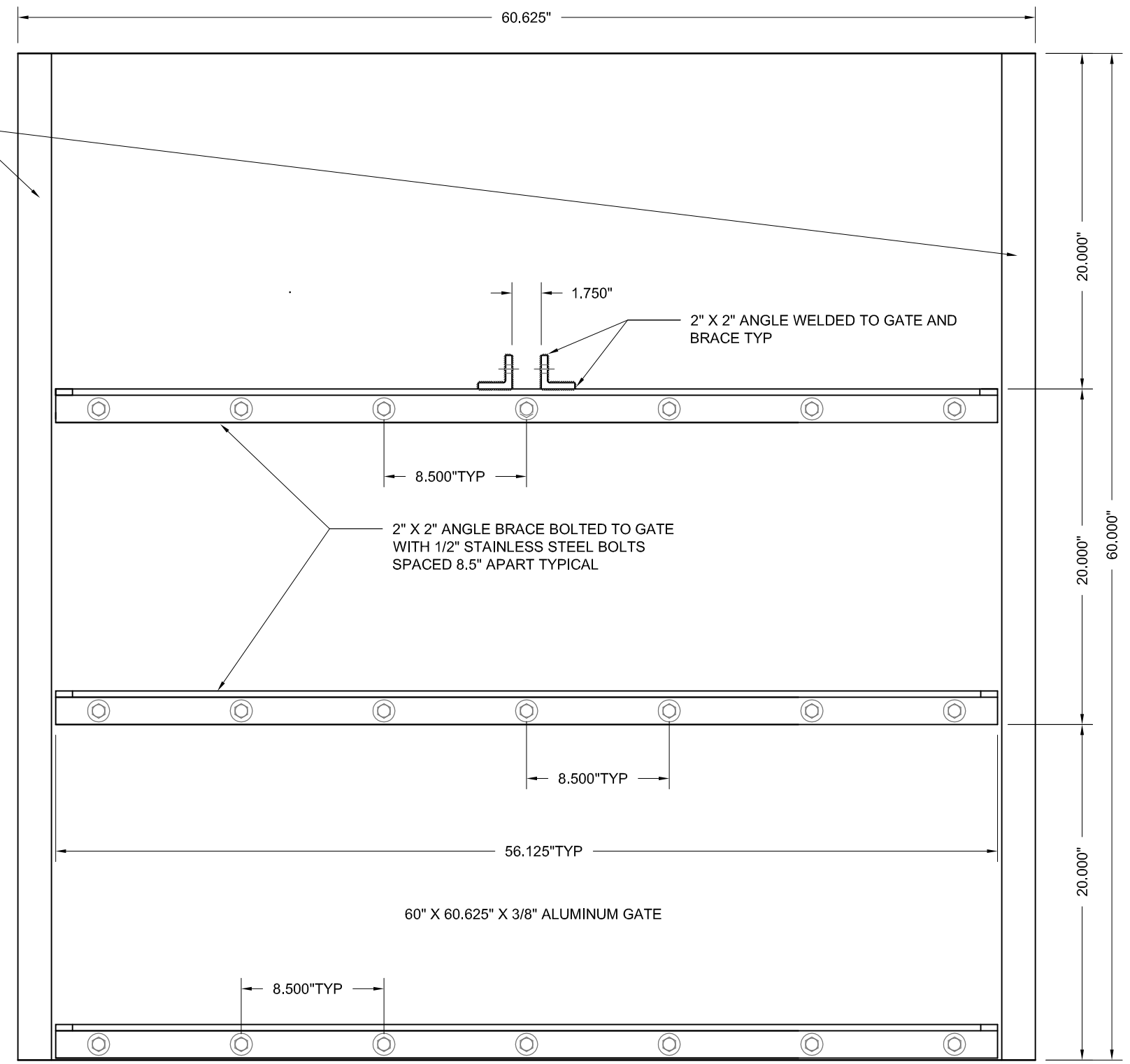
P.O. Box 4615
Austin, Texas 78765-4615
Phone (512) 394-1011
Fax (512) 349-1016

HIDCC#1
TWB - ITA Automatic Gate Controller
GATE CONSTRUCTION DETAILS
ELEVATIONS

DESIGNED:	
APPROVED:	
FILE:	
JOB NO.:	
DATE:	
SHEET	1 OF 4



BOTTOM BRACE DETAIL
SCALE 4 1/2" = 1'



GATE SIDE VIEW
SCALE 1 1/2" = 1'

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GATE CONSTRUCTION DETAILS
GATE DETAILS

DESIGNED:
APPROVED:
FILE:
JOB NO.:
DATE:
SHEET 4 OF 4

APPENDIX B

Actuator

Basic dimensions and specifications

Actuator arm parts breakdown

Actuator motor/gear parts breakdown

Parts list

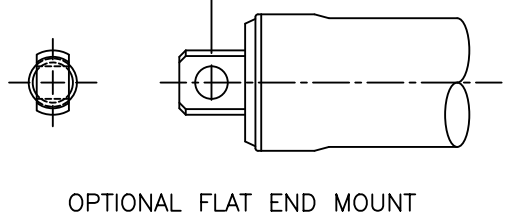
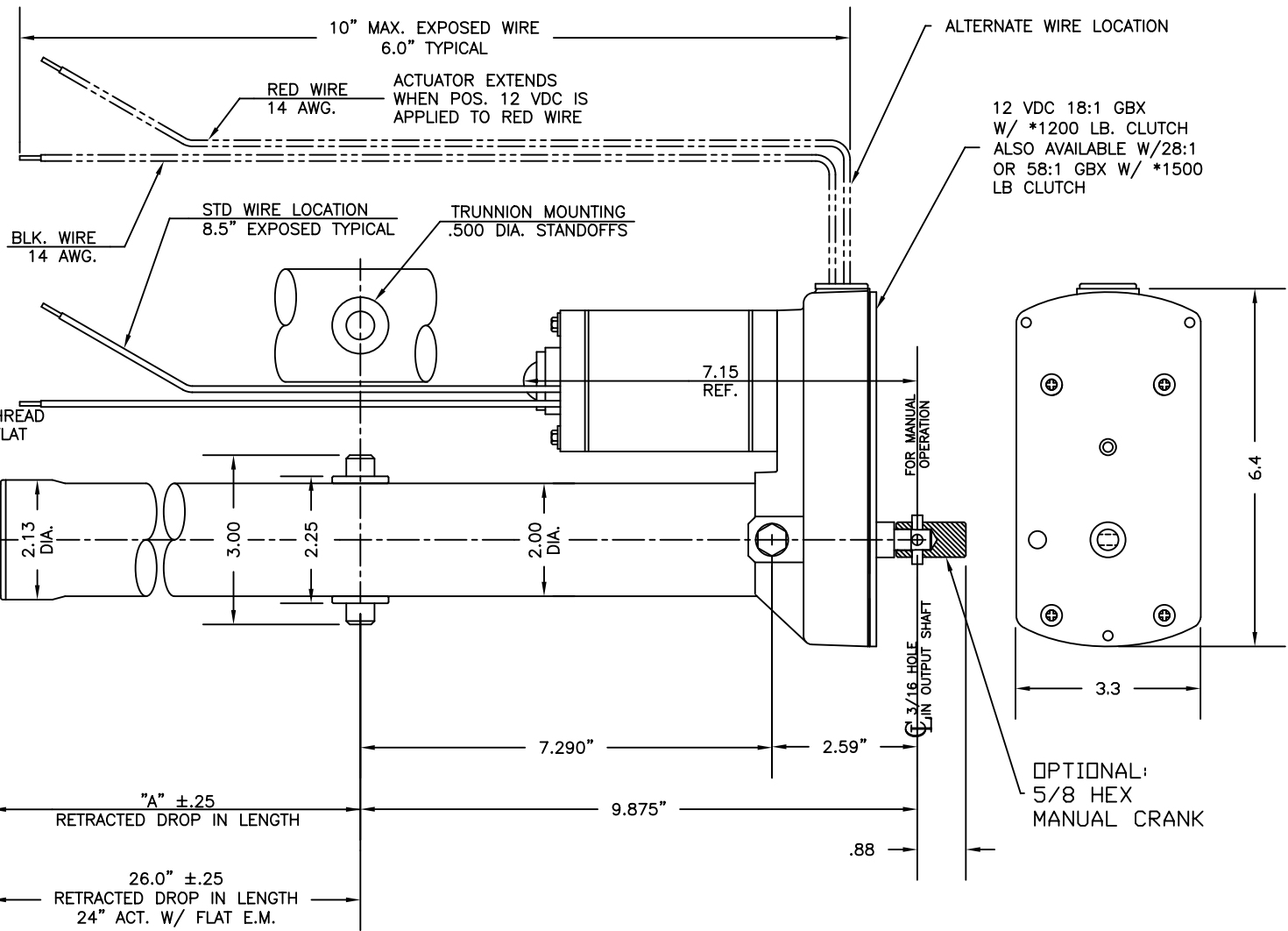
Wiring diagram

Limit switch adjustment

Part number code

TYPICAL 18:1 GBX

LBS. LOAD	NOMINAL AMP DRAW	SPEED I.P.M.
0	5	66
250	9	64
500	11.5	60
750	15.5	55
1000	18.5	50
1250	22.5	45
1500	26	38



STROKE ±.25	"A" ±.25
24"	25.45"
32"	33.45"
36"	37.45"
40"	41.45"
43"	44.45"

MA-821B24L, MA-821B32L,
MA-821B36L, MA-821B40L
& MA-821B43L - STD 18:1
RV SLIDE OUT ACTUATORS
BASIC DIMENSIONS & SPECS

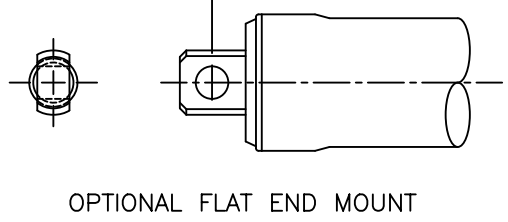
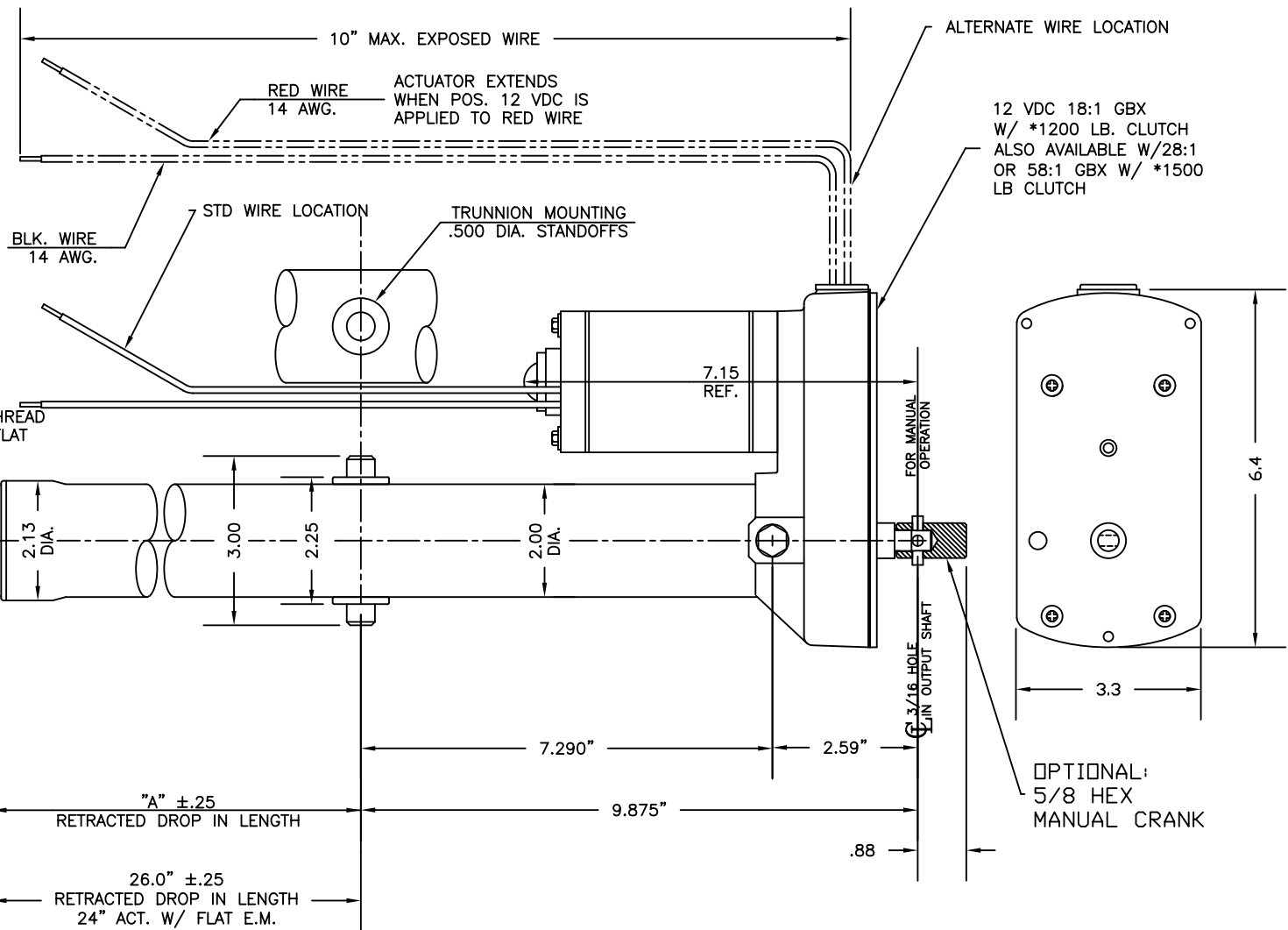
*NOTE: NOMINAL CLUTCH SETTING SET TO NOT BE LESS THAN RATED LOAD THRU LIFE OF ACTUATOR

JAN 2007

VENTURE MFG. CO.
 3636 DAYTON PARK DRIVE
 DAYTON OHIO 45414
 TEL: (937)233-6832
 FAX: (937)233-8485
 WEB PAGE: www.venturemfgco.com

TYPICAL HS 18:1 GBX

LBS. LOAD	NOMINAL AMP DRAW	SPEED I.P.M.
0	10	105
250	13	104
500	20	95
750	28	86
1000	39	73
1250	43	70



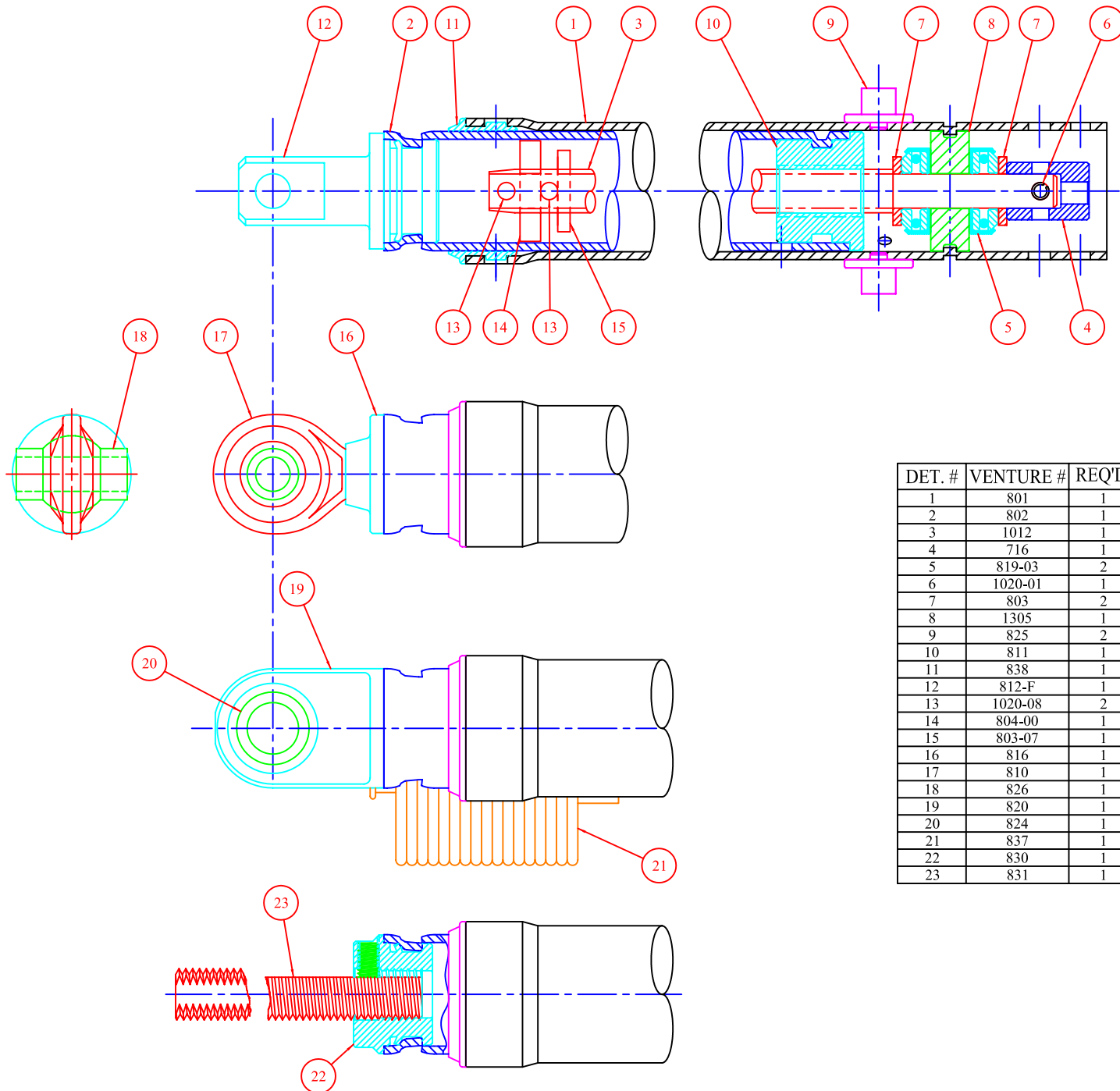
STROKE ±.25	"A" ±.25
24"	25.45"
32"	33.45"
36"	37.45"
40"	41.45"
43"	44.45"

MA-821B24LH, MA-821B32LH,
 MA-821B36LH, MA-821B40LH
 & MA-821B43LH - HS 18:1
 RV SLIDE OUT ACTUATORS
 BASIC DIMENSIONS & SPECS

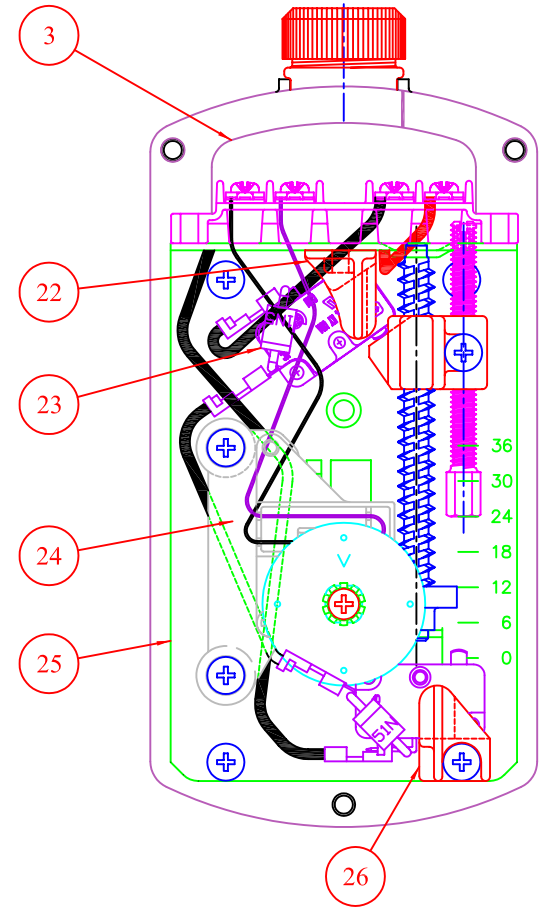
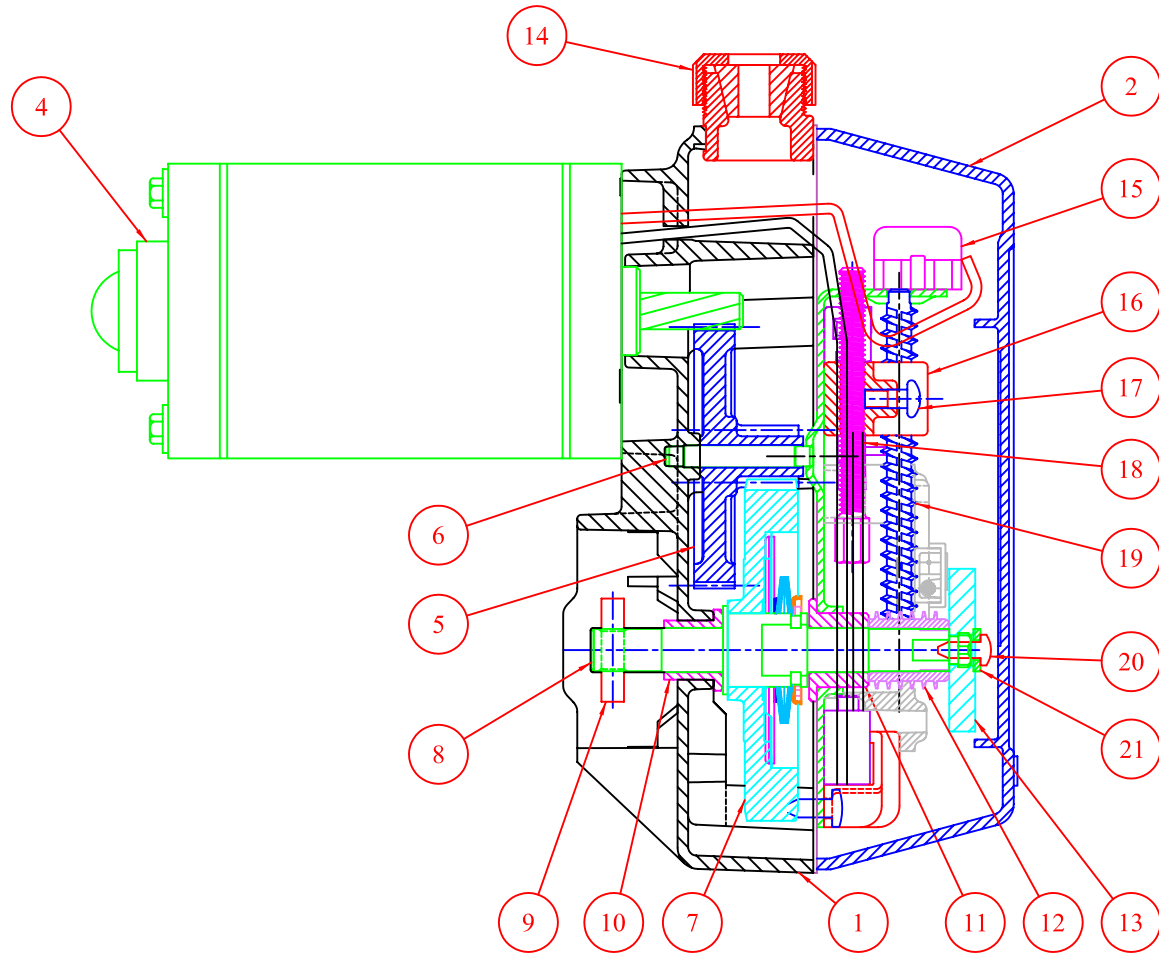
*NOTE: NOMINAL CLUTCH SETTING SET TO NOT BE LESS THAN RATED LOAD THRU LIFE OF ACTUATOR

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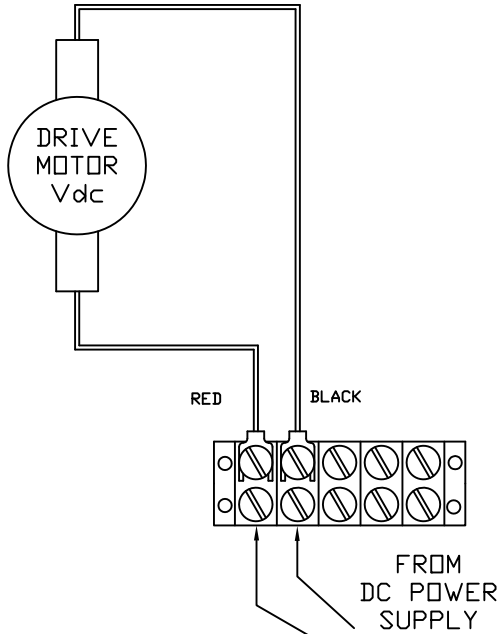
DET. #	VENTURE #	REQ'D.	DESCRIPTION
1	801	1	OUTER TUBE
2	802	1	INNER TUBE
3	1012	1	ACME SCREW
4	716	1	DRIVE COUPLING
5	819-03	2	THRUST BEARING
6	1020-01	1	DRIVE PIN
7	803	2	WASHER
8	1305	1	SPACER
9	825	2	TRUNNION
10	811	1	JACK NUT
11	838	1	TUBE PILOT GUIDE
12	812-F	1	1/2" FLAT END MOUNT
13	1020-08	2	PIN
14	804-00	1	PILOT WASHER
15	803-07	1	WASHER
16	816	1	END MOUNT
17	810	1	1/2" BALL SWIVEL STUD
18	826	1	SWIVEL BALL
19	820	1	3/4" SWIVEL END MOUNT
20	824	1	3/4" BEARING SWIVEL
21	837	1	TUBE BOOT
22	830	1	END MOUNT (STUD TYPE)
23	831	1	THREADED STUD



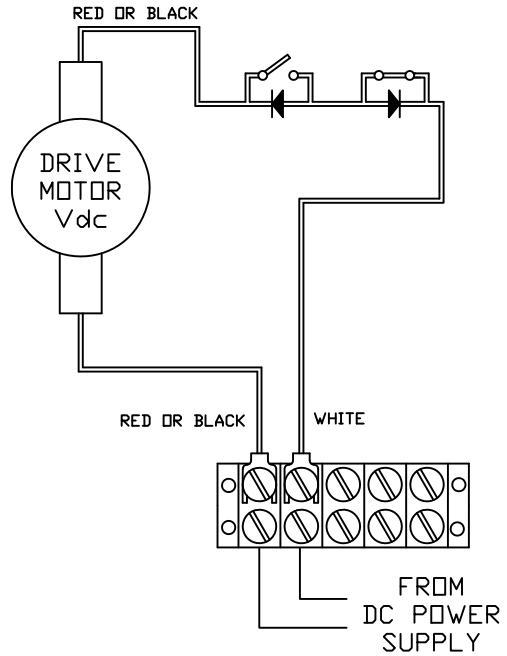
DET. #	VENTURE #	REQ'D.	DESCRIPTION
1	8501	1	GEAR MOTOR HOUSING
2	8502	1	GEAR MOTOR LID
3	8520	1	GASKET
4	8532-08M	1	12 VDC MOTOR
	8532-09A	1	24 VDC MOTOR
	8532-01	1	36 VDC MOTOR
	8532-10A	1	90 VDC MOTOR
	8532-11A	1	110 VDC MOTOR
5	8504-01	1	REDUCTION GEAR FOR 18:1
	8504-02	1	REDUCTION GEAR FOR 28:1
	8504-03	1	REDUCTION GEAR (OVERMOLD) FOR 58:1
	8504-05	1	REDUCTION GEAR (METAL) FOR 58:1
6	8507	1	SHAFT, REDUCTION GEAR
7	8574-00	1	OUTPUT GEAR (PM, CLUTCH) FOR 18:1
	8574-02	1	OUTPUT GEAR (PM, CLUTCH) FOR 28:1
	8574-01	1	OUTPUT GEAR (PM, CLUTCH) FOR 58:1
	8503-04	1	OUTPUT GEAR (NO CLUTCH) FOR 58:1
8	8505-00	1	OUTPUT SHAFT W/OUT CLUTCH (B.S.)
	8505-01	1	OUTPUT SHAFT W/OUT CLUTCH (ACME)
	8575-00	1	OUTPUT SHAFT W/CLUTCH (ACME)
	8575-04	1	OUTPUT SHAFT W/CLUTCH (B.S.)
9	1020	1	SPIROL PIN
10	8514	1	FLANGE BUSHING
11	8514	1	FLANGE BUSHING
12	8509-00	1	DRIVE WORM, R.H. SINGLE START, BLACK
	8509-01	1	DRIVE WORM, L.H. SINGLE START, RED
	8509-02	1	DRIVE WORM, L.H. DOUBLE START, BRASS
13	8524-00	1	MAGNET WHEEL, 4 POLE
	8524-01	1	MAGNET WHEEL, 8 POLE
	8524-02	1	MAGNET WHEEL, 6 POLE
14	8530-00	1	STRAIN RELIEF ASSEMBLY (INCL. BUSHINGS)
15	8525	1	TERMINAL STRIP
16	8511-00	1	LEADSCREW NUT, BLACK
	8511-01	1	LEADSCREW NUT, RED
17	8518-02	1	#8 X .38 LONG P.P.H. SCREW
18	8512	1	ADJUSTING ROD
19	8510-01	1	LEADSCREW, 12 PITCH, ALUMINUM
	8510-02	1	LEADSCREW, 18 PITCH, STL. (BRITE ZINC)
	8510-03	1	LEADSCREW, 8 PITCH, ZINC (STANDARD)
20	8518-04	1	#6 X .38 LONG P.P.H. SCREW
21	803-05	1	#8 EXTERNAL STAR WASHER
22	8516-00	1	LIMIT SWITCH CLIP, RETRACT
23	8526	1	LIMIT SWITCH ASSEMBLY
24	8101-00	1	SUPER SENSOR II
	8102-00	1	HALL EFFECT SENSOR
	8529	1	POTENTIOMETER SENSOR KIT
25	8506	1	GEAR PLATE
26	8517-00	1	LIMIT SWITCH CLIP, EXTEND

MOTOR DIAGRAM

W/O LIMIT SWITCH



WITH LIMIT SWITCH

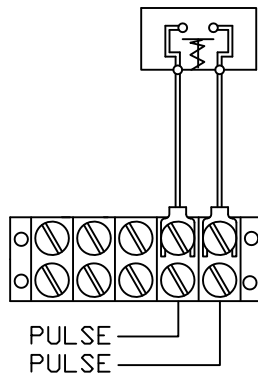


BALL SCREW ACTUATOR ~ RED MOTOR LEAD (+) = EXTEND
 ACME SCREW ACTUATOR ~ RED MOTOR LEAD (-) = EXTEND

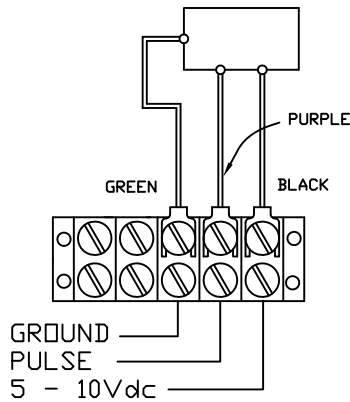
SENSOR OPTIONS

POT RESISTANCE WITH RETRACTION:
 BROWN TO GREEN - MINIMUM
 BROWN TO WHITE - MAXIMUM

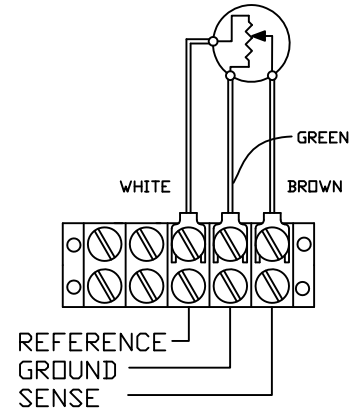
REED SWITCH



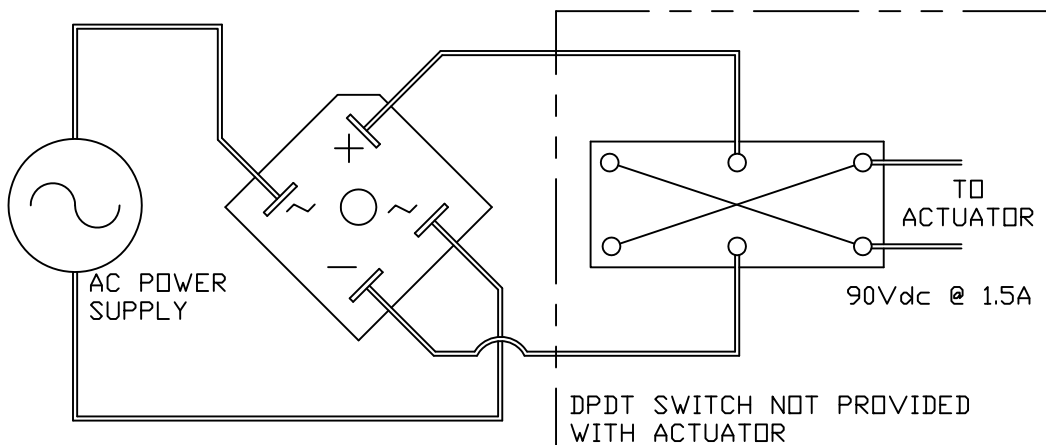
HALL EFFECT



10K POT



110Vac RECTIFIER





Limit Switch Adjustment

Follow directions below to adjust the limit switch settings to your Venture actuator. Your components and installation may vary slightly depending upon your original configuration, but concepts shown here should still apply. This procedure is meant to be performed on a fully-assembled actuator that is almost fully retracted.

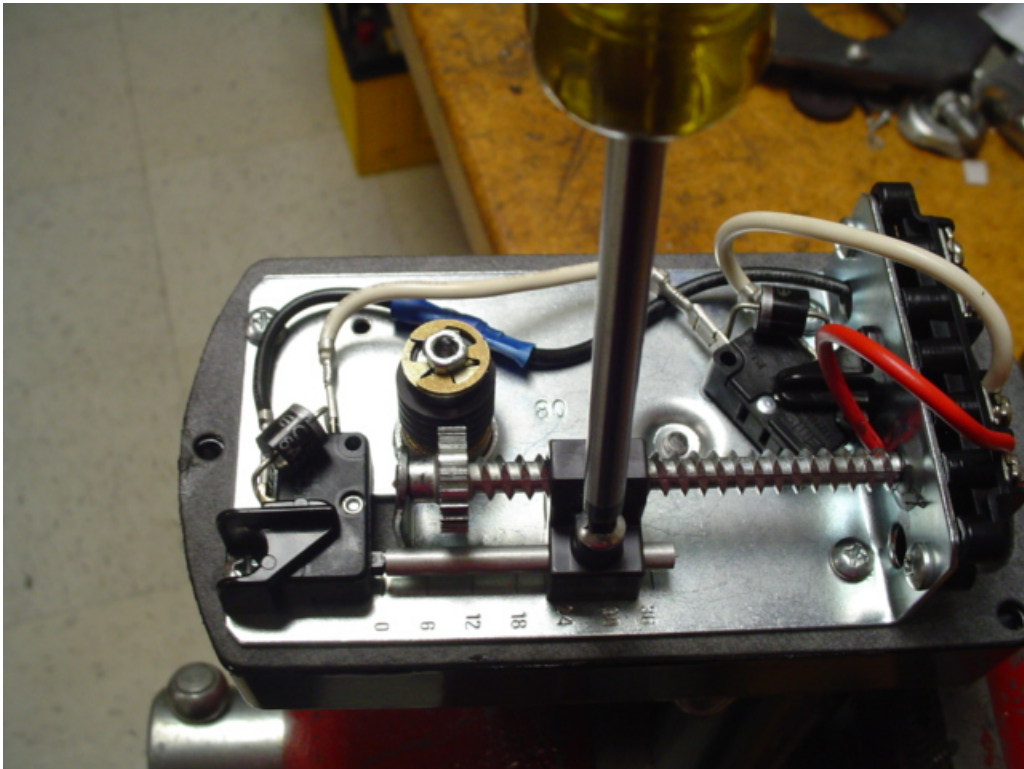
****Units are typically shipped from the factory with the retract switch activated and tube fully retracted, but power supplies vary, so it is always a good idea to reset the retract limit switch using the power supply that will be utilized in operation.****

Insure the inner tube does not rotate during this procedure when actuator is operated under power.

****Warning** Great care should be taken when adjusting the limit switches. If your actuator is supplied without a clutch it is possible to damage the gears if the actuator is over extended or retracted under power.**

Setting the stroke of your actuator

1. If gearbox is not yet attached to actuator tube, do so now. Actuator tube should be almost fully retracted.
2. Extend actuator under power a short distance until Leadscrew Nut has come completely off of "retract" limit switch button.
3. Retract actuator under power until "retract" limit switch shuts off actuator.
 - a. If actuator "bottoms out" before limit switch shuts power off, immediately shut off power and manually extend (unscrew) Inner Tube a couple turns. Re-extend actuator under power, then re-retract under power until limit switch shuts it down (without bottoming it out).
4. After actuator shuts off, screw Inner Tube in manually until it bottoms out, then turn it back out 1 or 2 turns.
5. Now extend actuator under power, shutting it off manually when it reaches your desired stroke or extension point. ***units are typically set in the factory at less than full stroke... It may be necessary to loosen the screw which holds the adjusting rod in position in order to reach the desired extension.***
6. Slide the adjusting rod to where it just activates (you should hear a click) the "extend" limit switch as shown in the photo below. Tighten screw onto the rod.
7. Retract actuator approximately 1 inch [25mm], then extend under power until "extend" limit switch turns the actuator off. Check the extension (stroke) of your actuator and adjust the Stroke Adjust Rod in or out if necessary until your proper setting is achieved.
 - a. Fully extended measurement minus fully retracted measurement is your full-stroke. Adjust rod away from "extend" limit switch to increase stroke, towards it to decrease stroke. *Beware that it takes very little movement of the Stroke Adjusting Rod to make a large change to the stroke. Trial-and-error will be involved. A good hint is to rotate Stroke Adjust Rod to a new point before re-tightening screw, or screw will tend to find previous indentation. It is best to just lightly tighten screw onto rod until final setting is achieved.*
 - b. Numbers stamped onto gearplate may or may not coincide with a rough stroke measurement of your actuator, depending on your configuration. These numbers are for Venture internal use only.



Actuator part number code.

Part number: MA 81433851-48

The part number is composed of the following digits, in sequence:

8	Color (Black)
1	Motor RPM (6800)
4	Gear ratio (58:1)
3	Potentiometer
3	Dual limit switch (open/close)
8	Outer tube diameter (2 inches)
5	Screw size/type (5/8 inches RH Ball)
1	Tube mounting
-48	Stroke length (48 inches)

APPENDIX C

Automatic gate controller

Wiring schematic

Parts list

Test sheet

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NO.	DATE	REVISION	APPVD

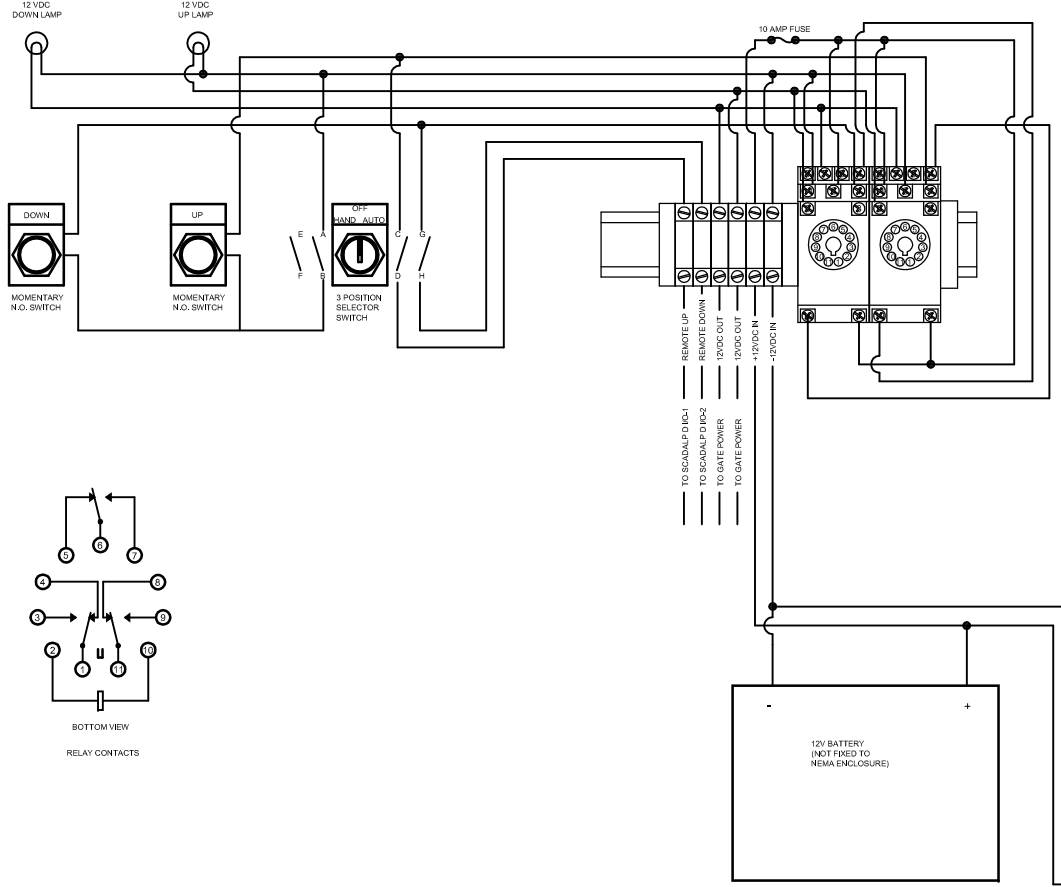
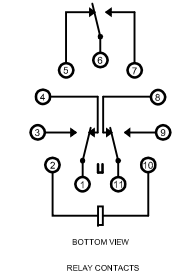
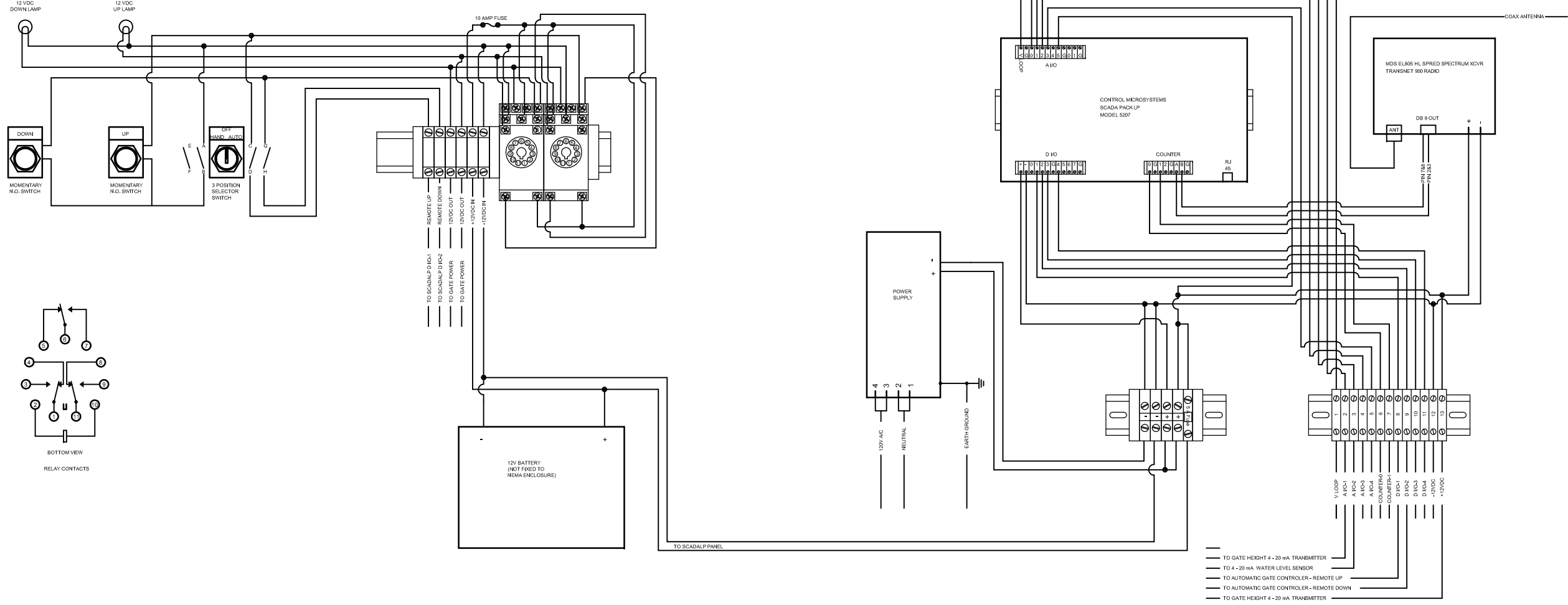
DRAFT
09/27/10

A W BLAIR
ENGINEERING

P.O. Box 4615
Austin, Texas 78765-4615
Phone (512) 394-1011
Fax (512) 394-1016

AUTOMATIC GATE CONTROLLER
WIRING SCHEMATIC

DESIGNED: AWB
APPROVED:
FILE: HIDCC AUTOGATE
JOB NO.:
DATE: JUNE 2010
SHEET 1 OF 1



- TO GATE HEIGHT 4 - 20 mA TRANSMITTER
- TO 4 - 20 mA WATER LEVEL SENSOR
- TO AUTOMATIC GATE CONTROLLER - REMOTE UP
- TO AUTOMATIC GATE CONTROLLER - REMOTE DOWN
- TO GATE HEIGHT 4 - 20 mA TRANSMITTER

AUTOGATE CONTROLER PARTS LIST

Item #	Qty. per Unit	Item	Manufacturer / Model #	Description	Source / Part #	Price Each	Price Per Unit
1	1	Non - Metallic Enclosure, NEMA	Wiegmann / HW-J141206CHQR	NEMA 4 non metallic enclosure 14 x 12 x 6 Hinged	Automation Direct	\$89.00	\$89.00
2	1	Interior Panel	Wiegmann / HW-MP1412CS	White steel Interior mounting panel	Automation Direct	\$12.25	\$12.25
3	2	Relay, 11 pin	OMRON / MK3P5-S-DC12	Plug in Relay, 3PDT, 12 Coil Volts	Granger / 1YDH8	\$8.69	\$17.38
4	2	Relay Socket, 11 pin	Square D / 8501NR62	Din Mount 11 pin Relay Socket	Granger / 5B584	\$21.48	\$42.96
5	2	Down Legend Plate	Altech / 2LP06	Pushbutton Down Legend Plate	Allied / 767-0218	\$1.20	\$2.40
6	2	Up Legend Plate	Altech / 2LP05	Pushbutton Up Legend Plate	Allied / 767-0275	\$1.20	\$2.40
7	2	Hand / Off / Auto Legend Plate	Altech / 2LP36	Hand / Off / Auto Switch Legend Plate	Allied / 767-0229	\$1.20	\$2.40
8	2	Shrink Wrap Tubing 3/16"	3M / FP301 3/16 BK 48"	Black 3/16" Shrink Wrap 48" Length	Allied / 617-0431	\$1.46	\$2.91
9	2	3 pos Selector Switch	IDEC / ASW320	Manual / Off / Auto Switch	Allied / 814-0033	\$17.50	\$35.00
10	4	Push Putton Momentary Switch	IDEC / ABW110-B,G,R	Pushbutton Switch	Allied / 814-0010	\$9.35	\$37.40
11	4	Piggyback contacts	IDEC / HW-C10	Additional contacts for 3 Position Switch	Allied / 814-0201	\$5.57	\$22.28
12	2	Fuse Holder	Cooper Bussmann / HHM	Automotive Inline Fuse Holder	Allied / 740-0934	\$5.18	\$10.36
13	2	Fuse 10 Amp	Cooper Bussmann / ATM-10	Automotive Fast Acting 10 Amp Blade Fuse	Allied / 740-0889	\$1.28	\$2.56
14	4	Pilot Light	Sylvania / 12PSB	Incandescent Miniature Lamp, Slide Base 12V	Allied / 937-9630	\$1.55	\$6.20
15	4	Pilot Light Socket	Sylvania / 30099/32169	Indicator, Panel Mount, Socket	Allied / 937-6098	\$4.53	\$18.12
16	2	Pilot Light Lens / Red	Sylvania / 30120	Fluted, Dome, Lens Cap Red	Allied / 937-6245	\$0.68	\$1.36
17	2	Pilot Light Lens / Clear	Sylvania / 30125	Fluted, Dome, Lens Cap Clear	Allied / 937-6243	\$0.64	\$1.28
18	3	20 Gauge Hook Up Wire / Per Foot	Belden / 9919-009100	20 AWG Stranded Hook Up Wire, White / 100 Ft Roll	Allied / 214-0071	\$39.91	\$1.20
19	3	20 Gauge Hook Up Wire / Per Foot	Belden / 9919-005100	20 AWG Stranded Hook Up Wire, Green / 100 Ft Roll	Allied / 214-0074	\$39.91	\$1.20
20	3	20 Gauge Hook Up Wire / Per Foot	Belden / 9919-010100	20 AWG Stranded Hook Up Wire, Black / 100 Ft Roll	Allied / 214-0072	\$43.18	\$1.30
21	3	20 Gauge Hook Up Wire / Per Foot	Belden / 9919-003100	20 AWG Stranded Hook Up Wire, Orange / 100 Ft Roll	Allied / 214-0077	\$38.43	\$1.15
22	3	20 Gauge Hook Up Wire / Per Foot	Belden / 9919-002100	20 AWG Stranded Hook Up Wire, Red / 100 Ft Roll	Allied / 214-0073	\$39.91	\$1.20
23	2	18 Gauge Hook Up Wire / Per Foot	Belden / 8918-010100	18 AWG Stranded Hook Up Wiew Black / 100 Ft Roll	Allied / 214-0202	\$56.38	\$1.13
24	2	18 Gauge Hook Up Wire / Per Foot	Belden / 8918-002100	18 AWG Stranded Hook Up Wiew Red / 100 Ft Roll	Allied / 214-0203	\$56.38	\$1.13
25	1	Din Rail 35mm x 7.5 x 1m	Altech / 2511120/1m	Din Rail perforated steel zinc	Allied / 502-0156	\$3.75	\$3.75
26	3	Liquidtight Strain Relief 1/2"	Thomas & Betts / 2522	1/2" Hub, 9/16" Throat Strain Relief Connector	Allied / 534-9178	\$5.42	\$16.26
27	2	Cable Clamp	Panduit / CCH25-S10-C	Cable Clamp; .25 max bundle dia; #10 Screw mouint	Allied / 381-1063	\$0.16	\$0.32
28	6	Power Terminal	Entrelec / 11512017	Din Rail Mount Wiring Terminal Block	Gross Automation / 11512017	\$1.17	\$7.02
29	2	Terminal Stop	Entrelec / 39990302	Din Rail Mount Terminal Stop	Gross Automation / 39990302	\$0.69	\$1.38
30	1	Terminal End Cover	Entrelec / 11836816	Wiring Terminal End cover	Gross Automation / 11836816	\$0.24	\$0.24
31	1	Terminal Markers	Entrelec / 23800204	Wiring Terminal Marker Horz 1 - 8 / card of 10 rows	Gross Automation / 23800204	\$6.91	\$6.91
32	4	Stainless Steel Mounting Screws	UNC 18-8 Stainless	Machine Screw, Phillips Pan Head 10-24 x 3/8	Lawson / 91325	\$0.53	\$2.12
					Total Material Expense Per Unit		\$352.56

TEST RESULTS

Automatic Gate Controller

Controller Serial Number: _____

Gate 1 Relay
Manual Mode: _____
Input Voltage: _____

Gate 2 Relay
Manual Mode: _____
Input Voltage: _____

Gate UP Output Voltage: _____

Gate UP Output Voltage: _____

Gate UP Indicator Light: _____

Gate UP Indicator Light: _____

Gate Down Output Voltage: _____

Gate Down Output Voltage: _____

Gate Down Indicator Light: _____

Gate Down Indicator Light: _____

Automatic Mode:
Input Voltage: _____

Automatic Mode:
Input Voltage: _____

Gate UP Output Voltage: _____

Gate UP Output Voltage: _____

Gate UP Indicator Light: _____

Gate UP Indicator Light: _____

Gate Down Output Voltage: _____

Gate Down Output Voltage: _____

Gate Down Indicator Light: _____

Gate Down Indicator Light: _____

Test Date: _____

Test Initials: _____

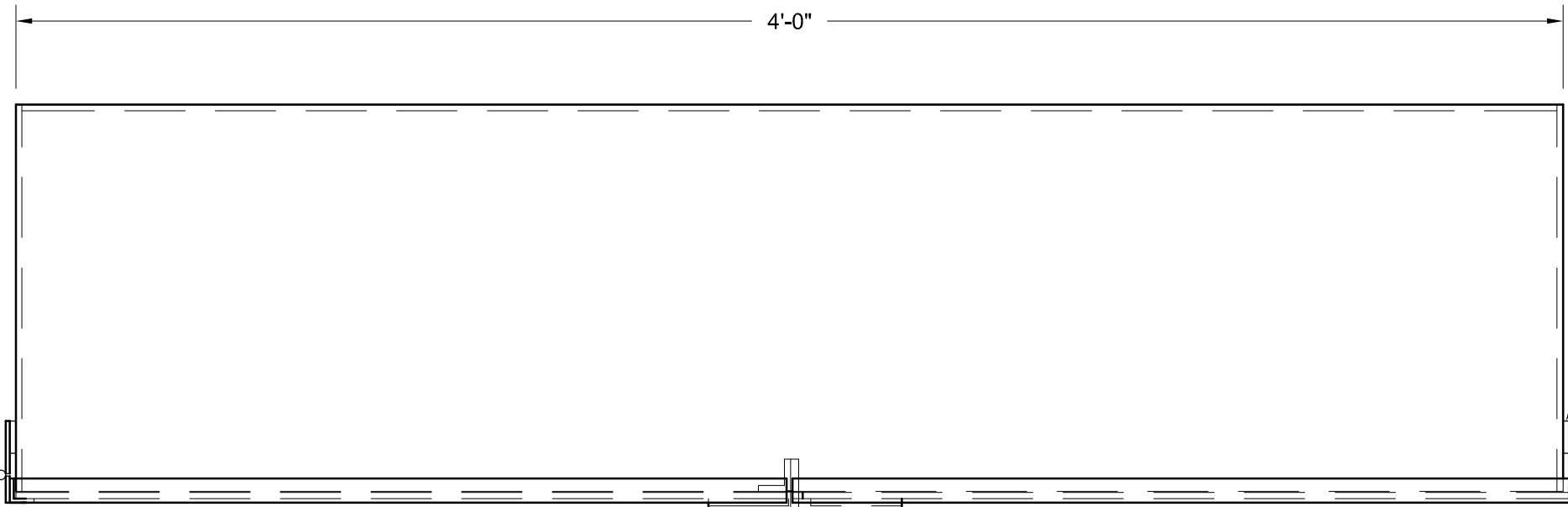
APPENDIX D

NEMA enclosure vandal box

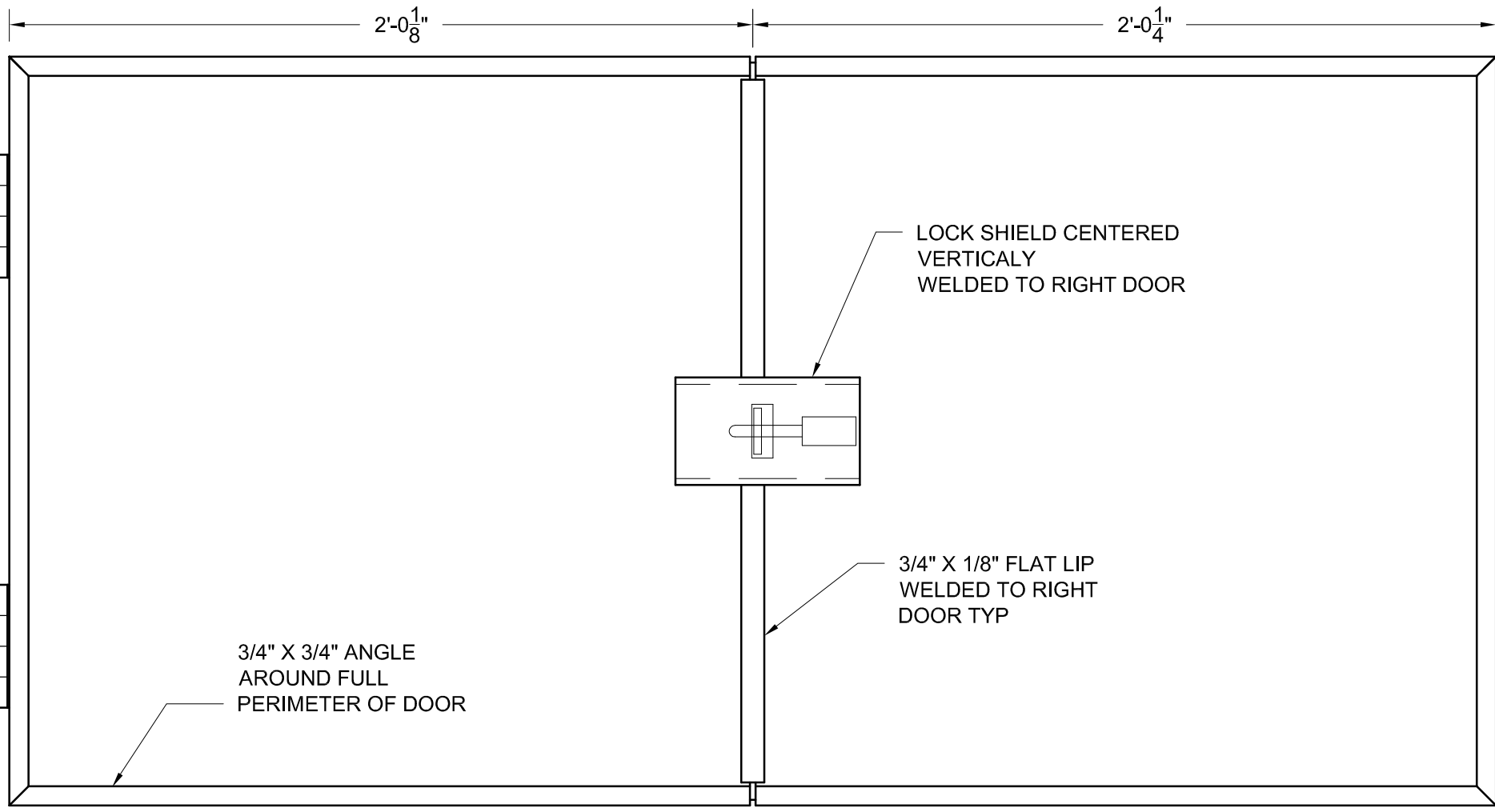
Elevations

Sections

Parts details



TOP VIEW



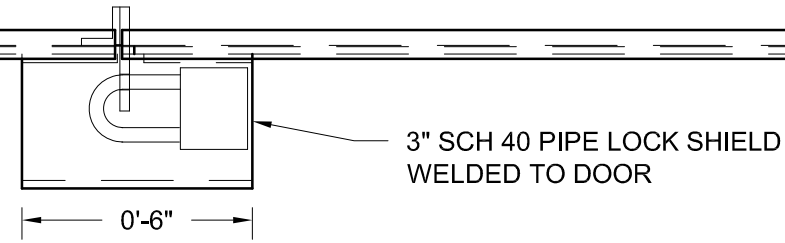
FRONT VIEW

WELDED SPACER
TYP

NOTE: ALL PARTS (TOP BOTTOM, SIDES, BACK, AND DOOR) TO BE 3/16" THICK STEEL PLATE TYP. UNLESS OTHERWISE NOTED.

CONTINUOUS WELD TOP AND SIDES FOR WATER SEAL

QUANTITY REQUIRED (4 EACH)



3" SCH 40 PIPE LOCK SHIELD
WELDED TO DOOR

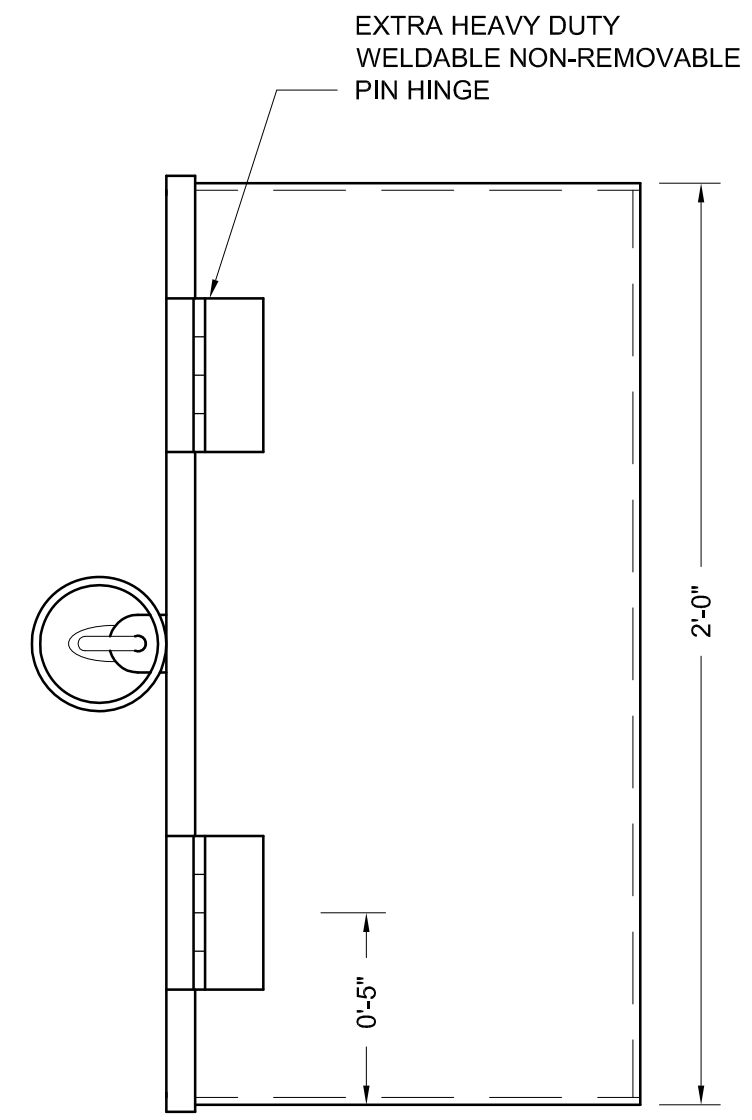
0'-6"

LOCK SHIELD CENTERED
VERTICALLY
WELDED TO RIGHT DOOR

3/4" X 1/8" FLAT LIP
WELDED TO RIGHT
DOOR TYP

3/4" X 3/4" ANGLE
AROUND FULL
PERIMETER OF DOOR

0'-0 1/4"



RIGHT SIDE VIEW

EXTRA HEAVY DUTY
WELDABLE NON-REMOVABLE
PIN HINGE

0'-5"

2'-0"

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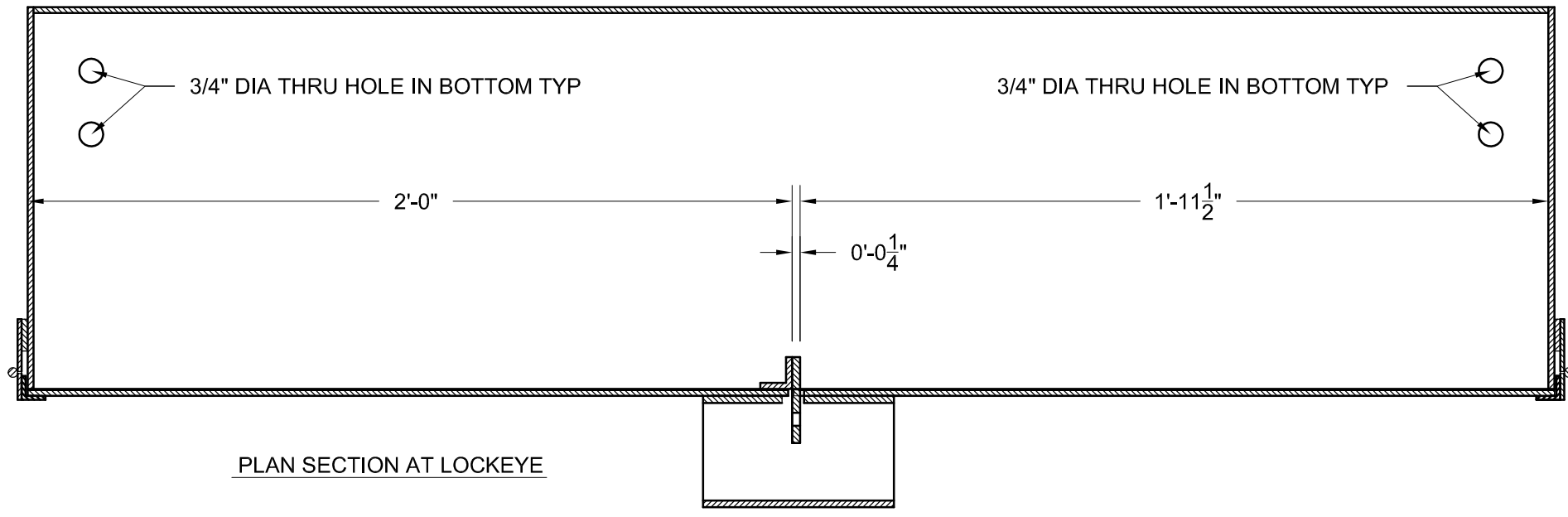
A W BLAIR
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Austin, Texas 78765-4615
Fax (512) 349-1016

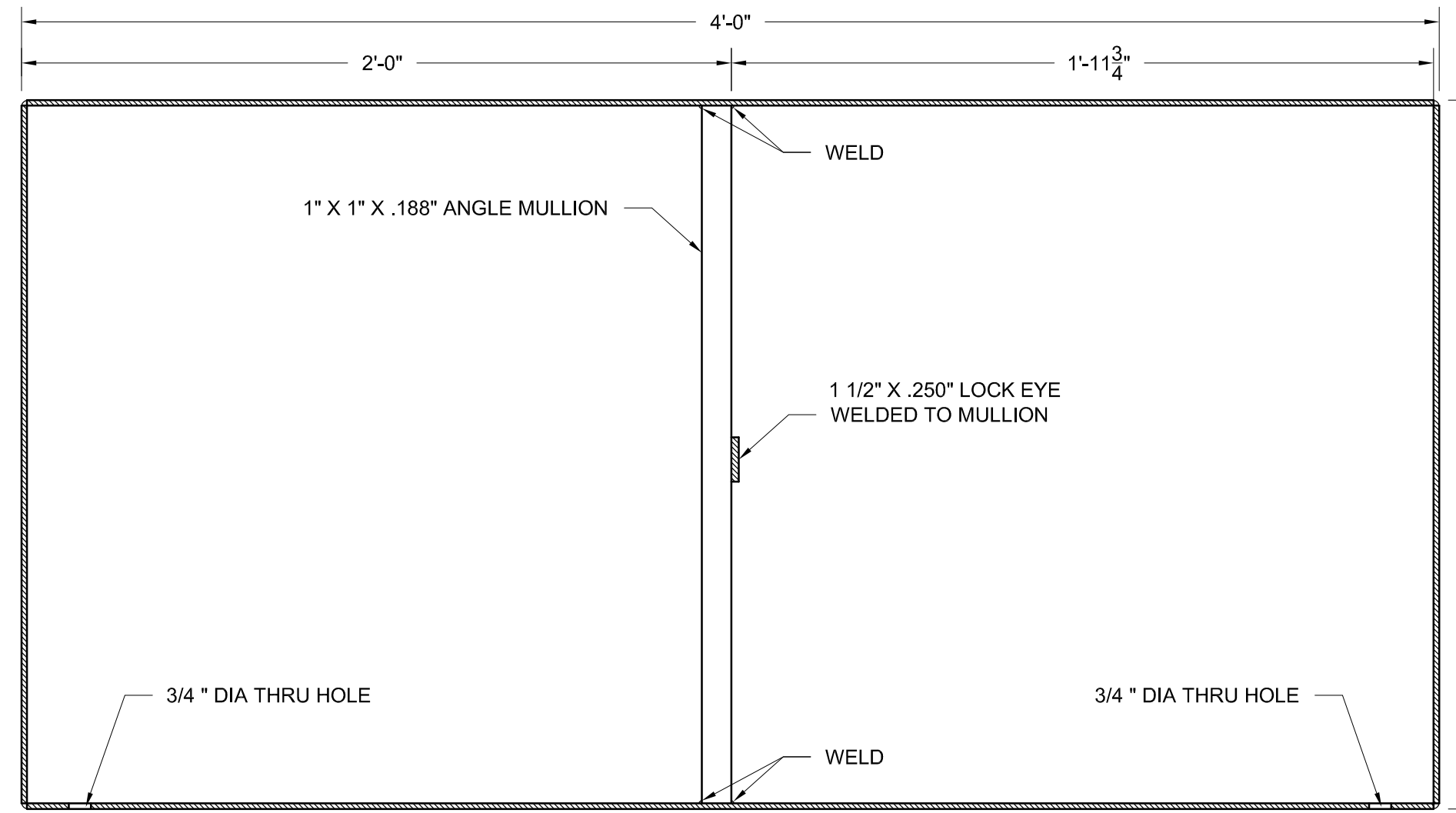
P.O. Box 4615
Phone (512) 394-1011

HIDCC#1
TWB - ITA Automatic Gate Controller
NEMA ENCLOSURE VANDAL BOX
ELEVATIONS

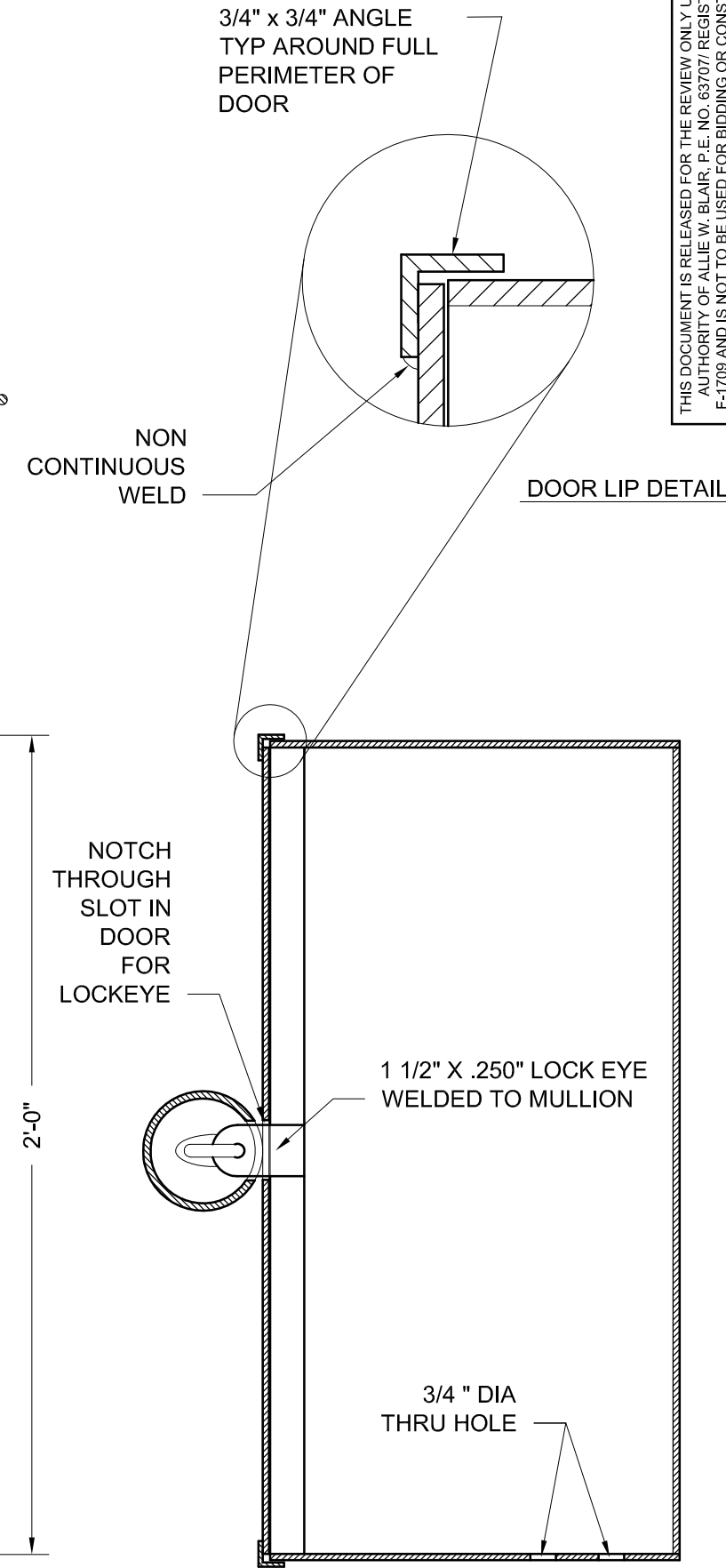
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APPROVED:	
FILE:	
JOB NO.:	
DATE:	
SHEET	1 OF 3



PLAN SECTION AT LOCKEYE



SECTION FRONT



SECTION SIDE

3/4" x 3/4" ANGLE
TYP AROUND FULL
PERIMETER OF
DOOR

NON
CONTINUOUS
WELD

DOOR LIP DETAIL

NOTCH
THROUGH
SLOT IN
DOOR
FOR
LOCKEYE

1 1/2" X .250" LOCK EYE
WELDED TO MULLION

3/4 " DIA
THRU HOLE

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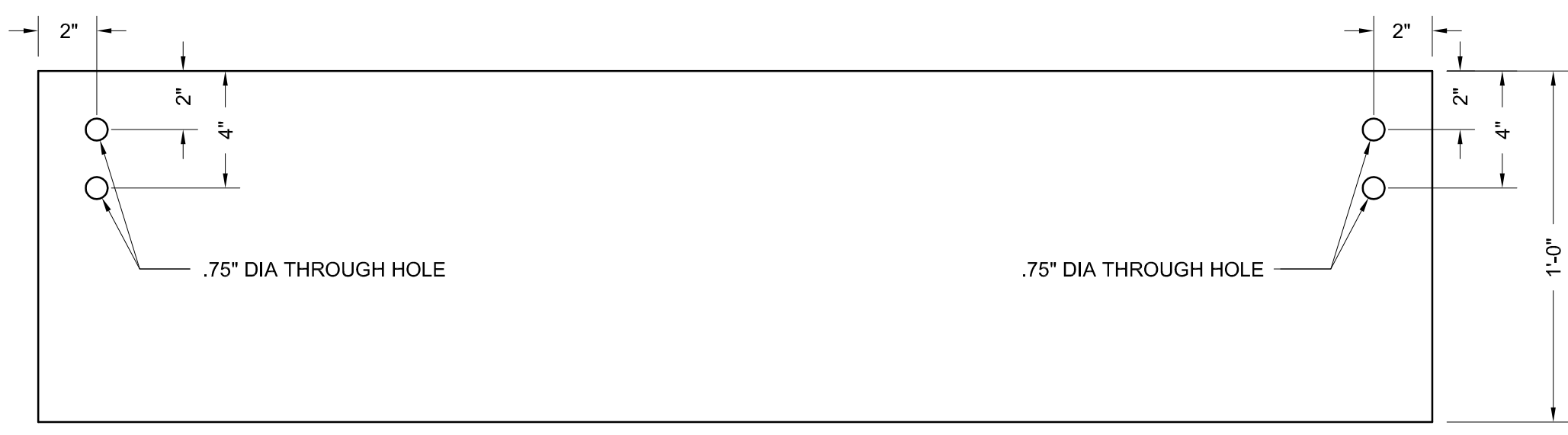
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ENGINEERING

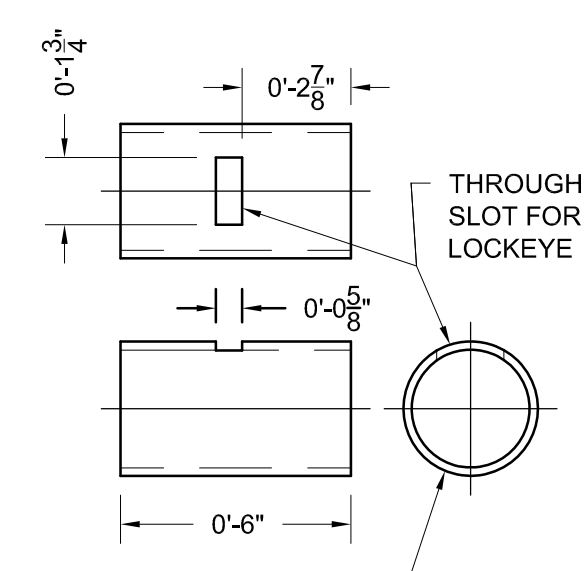
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HIDCC#1
TWB - ITA Automatic Gate Controller
NEMA ENCLOSURE VANDAL BOX
SECTIONS

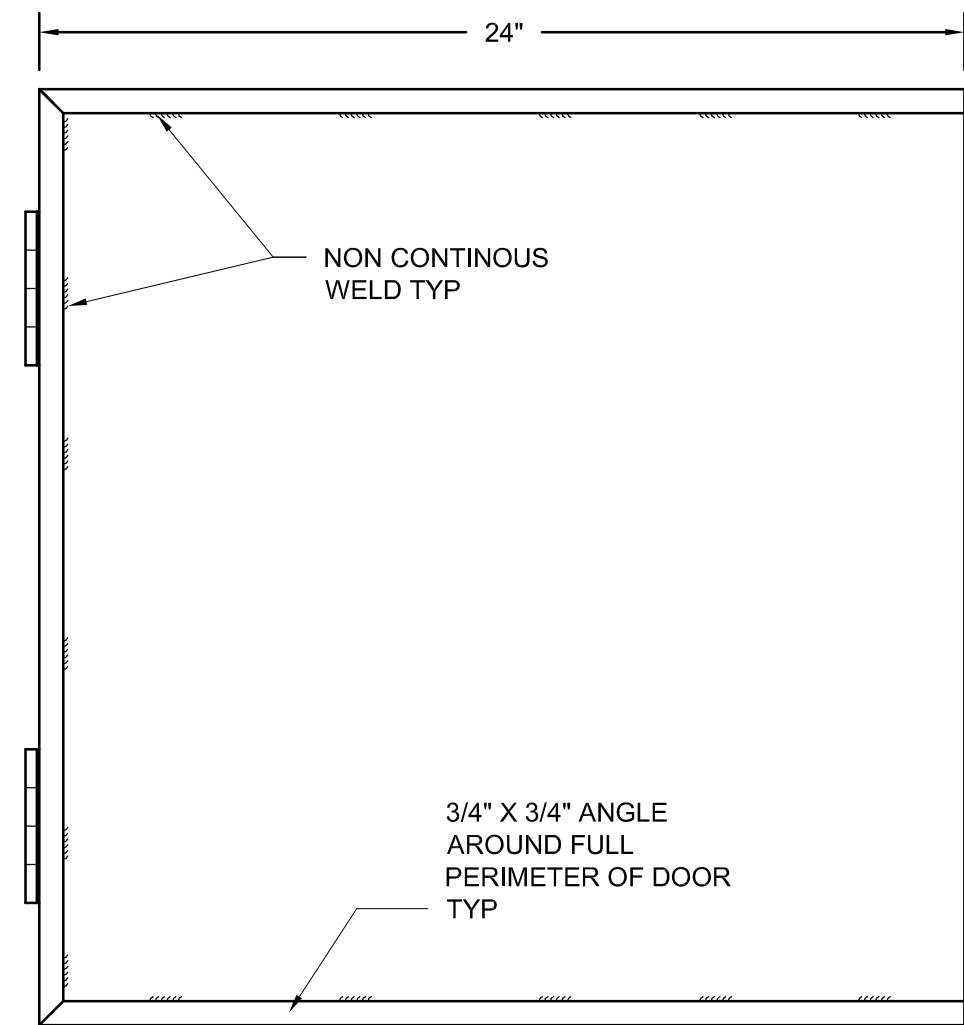
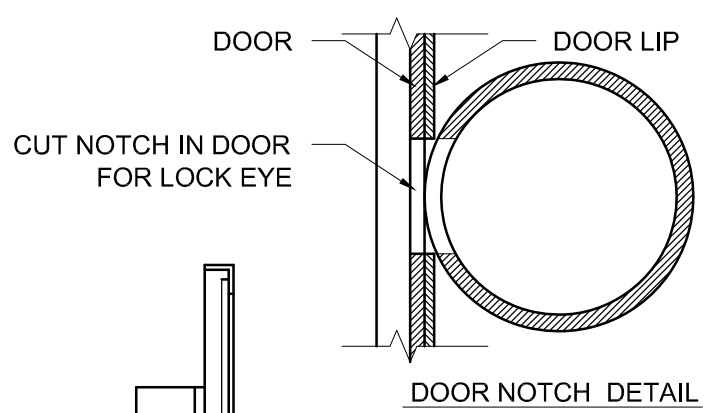
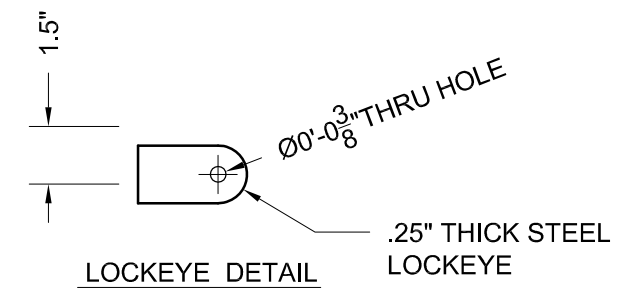
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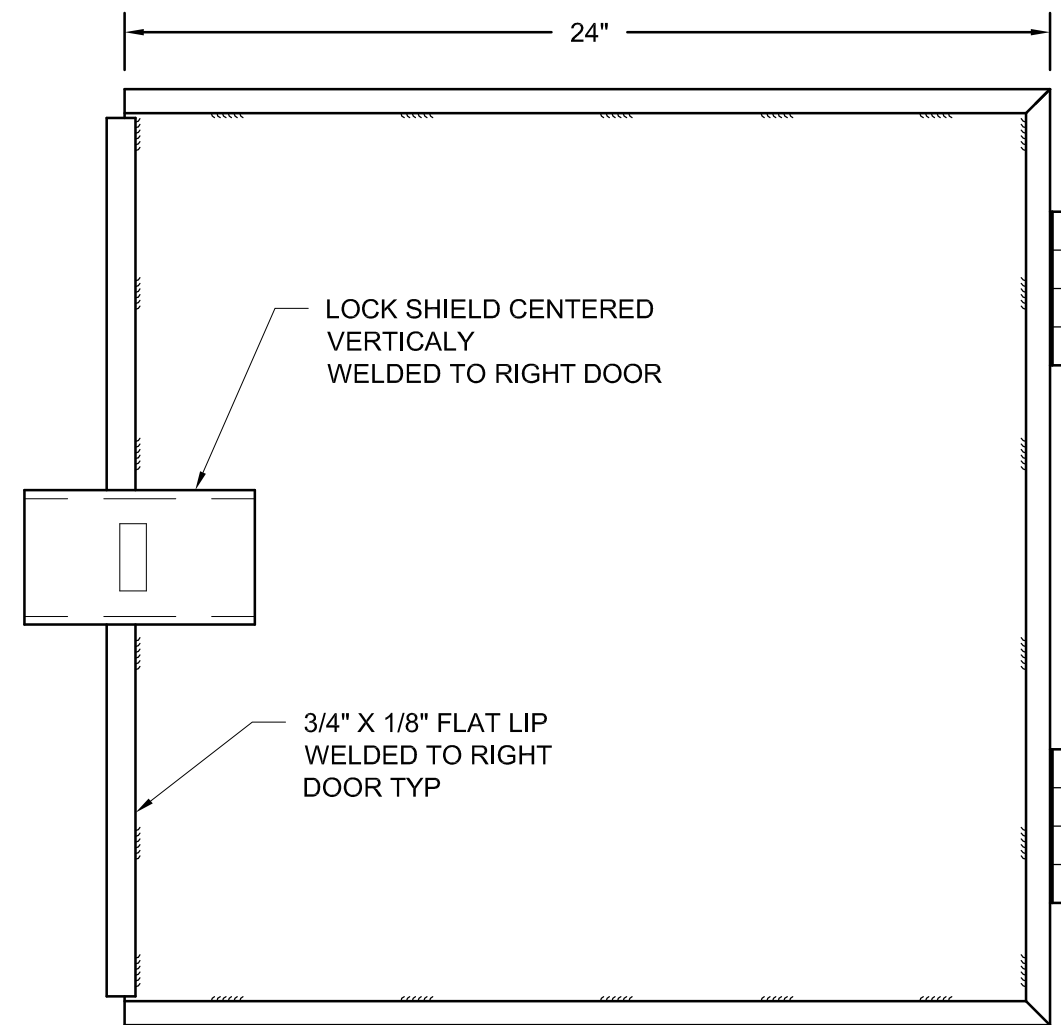
BOTTOM DETAIL



LOCK SHIELD DETAIL



LEFT DOOR DETAIL



RIGHT DOOR DETAL

NOTE: ALL PARTS (TOP BOTTOM, SIDES, BACK, AND DOOR) TO BE 3/16" THICK STEEL PLATE TYP. UNLESS OTHERWISE NOTED.

QUANTITY REQUIRED....(4 EACH)

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HIDCC#1
TWB - ITA Automatic Gate Controller
NEMA ENCLOSURE VANDAL BOX
PARTS DETAILS

DESIGNED:	
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FILE:	
JOB NO.:	
DATE:	
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Attachment 2

Low Cost RTU for Water Level Measurement

Prepared for the
Harlingen Irrigation District



Under a Texas Water Development Board Grant

Innovative Technologies for
Agricultural Water Management
and Flow Measurement

September 27, 2010

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APPENDICES

A LCRTU Enclosure Assembly Details

- Front and side view
- Enclosure section
- Exploded views
- Enclosure details
- Sensor assembly details
- Electrical schematic

B Sample PVC fittings

- Cantex conduit pipe
- Cantex end cap
- Cantex coupling
- Cantex male adapters
- Cantex female adapters
- Mueller bushing
- Pressure fittings

C Sensor

- Sonar range

D Antenna connection components

Male cable end
TNC connector
TNC bulkhead crimp jack

E Power supply components

Battery
Solar panel
Solar panel mount
Solar charge controller

F Electronics

Single board computer
Circuit board V1.12 radio side schematic
Circuit board V1.12 single board computer side schematic

G Parts list

1. Introduction and Overview

Measurements are crucial to the good management of canal systems. However, making measurements, and recording, delivering and analysing the data can be very time consuming and expensive. There is a need for a low cost but reliable system that can make and transmit frequent measurements of values such as the depth of water in a canal. This project has resulted in the design of such a low-cost remote telemetry unit (LCRTU).

Key features include solar-powered operation, the ability to measure analog voltage/current and digital SDI-12 signals, and good radio range.

The major components of the LCRTU are:

1. The enclosure/housing.
2. The power supply system
3. The electronic circuits to read signals and transmit data.

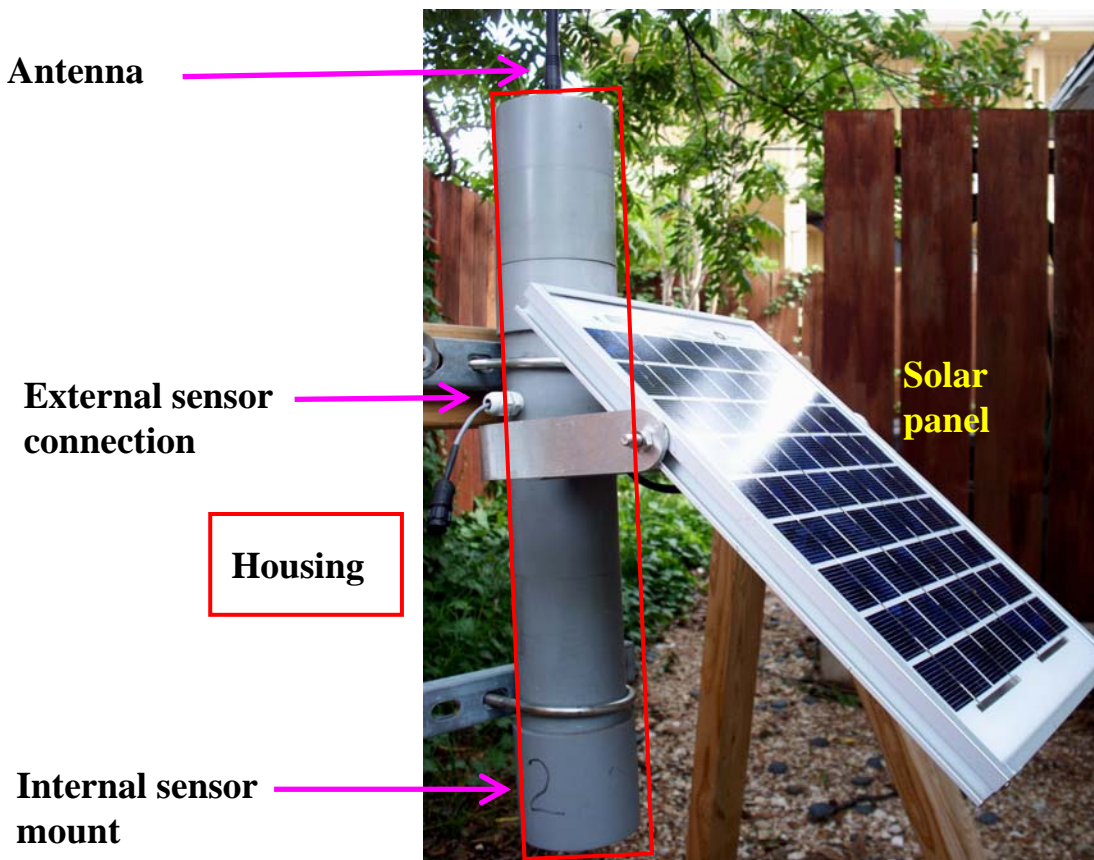


Figure 1. External view of typical LCRTU showing solar panel, antenna, and external sensor connection.

2. Housing/Enclosure

The housing/enclosure contains the electronic components and the power supply (in the form of a rechargeable lead/acid battery). The enclosure should be inexpensive and robust, and not subject to deterioration from sunlight, rainfall and temperature variation. The material used to meet these requirements is UV resistant schedule 40 PVC electrical conduit pipe and fittings, and various non UV resistant PVC plumbing fittings if they are not exposed to sunlight. The fittings take various forms, including male or female threaded connectors. Where appropriate, fittings are permanently joined with solvent welded “slip” joints.

2.1 Pipe

The main body of the enclosure is constructed from 3 inch (internal diameter) conduit pipe, as this size is large enough to contain the electrical components. The pipe is available in 10 ft lengths with one end flared to enable them to be joined together. This flared end section is not used. The pipe can be cut into appropriate lengths using a saw. Figure 2 shows the pipe, which can be purchased from electrical supplies dealers.

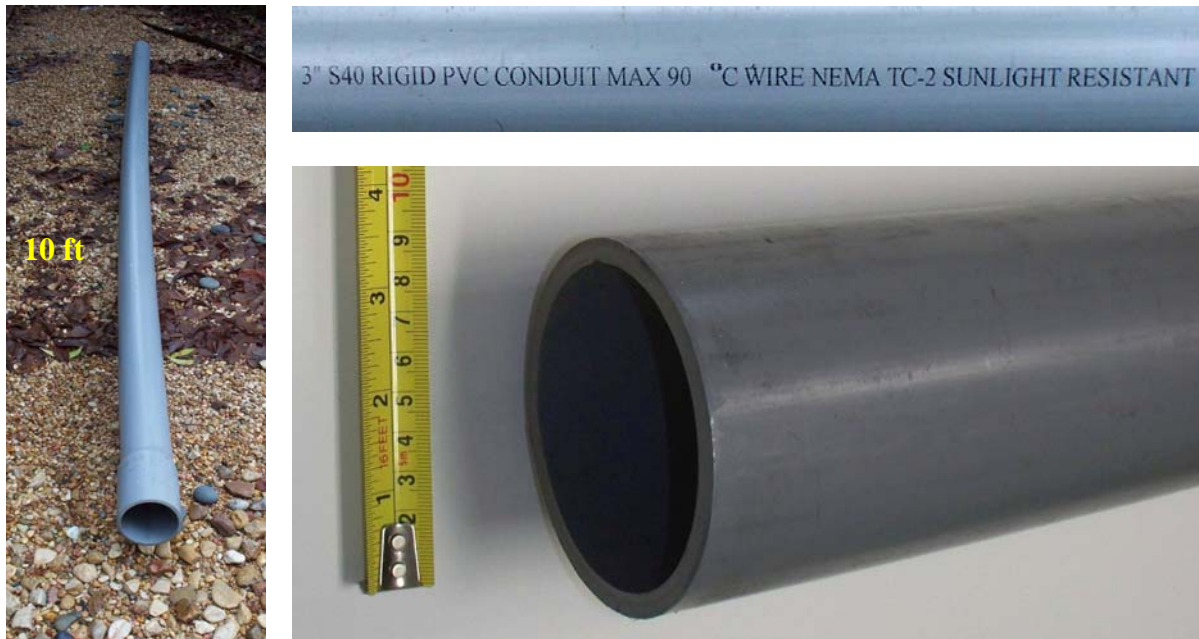


Figure 2. Three inch electrical conduit used for enclosure. A pipe length (top), specifications (middle) and flared end (bottom).

2.2 Pipe fittings

Various standard fittings are used with the pipe to fabricate the top and bottom of the housing/enclosure. The top, to which the antenna is mounted, must be removable so that the electrical components inside can be accessed. The bottom may not need to be removed, and so can be permanently joined to the pipe and configured according to the sensor or other function required. The example used in this manual is for an acoustic distance sensor that has a threaded mounting. Figure 3 shows the top and bottom of the enclosure. Threaded components are used to enable the top to be removed.



Figure 3. LCRTU showing top with antenna (left), top with screw-on cap removed (center) and bottom with downward facing acoustic water level sensor (right).

2.2.1 TOP FITTINGS

The top cap, which is removable, is constructed using a 3 inch slip end cap joined to a 3 inch female threaded/slip connector, both components being UV resistant PVC (figure 4). Figure 5 shows the end cap, through which a hole must be drilled for the antenna mounting hardware. Figure 6 shows the female threaded/slip connector.

The end cap is permanently joined to the female threaded slip/connector using a short length of pipe solvent welded to each piece, as shown in figure 7. The length of this pipe is such that it enables the end cap and the threaded/slip connector to be pushed together after applying solvent to the inside surface of the two pieces.

The end cap can be drilled for the antenna and the antenna screw mount tightened before joining the two pieces (figure 8), but care must be taken that the antenna lead wire does not interfere when they are pushed together. The antenna can also be mounted after joining the two pieces together, but then it is more difficult to reach inside to tighten the antenna mounting screws.

The top of the end cap should be flattened where the antenna mounts so that the mount screw can fit flush. This can be done with a counterbore type wood drill.



Figure 4. Top cap



Figure 5. Three inch end cap viewed from the top (left), and from the bottom (right)

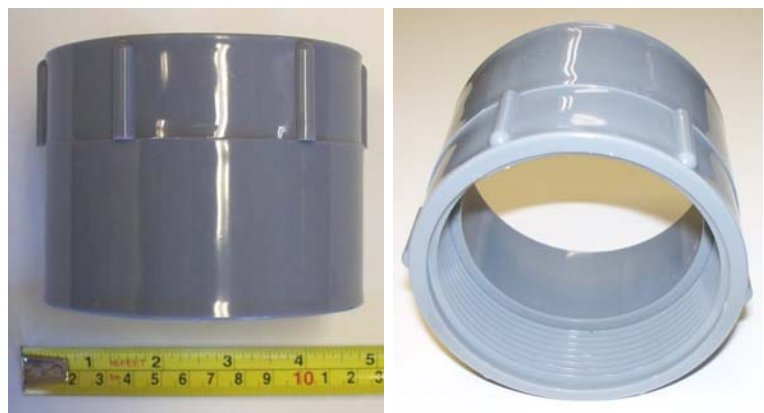


Figure 6. Female threaded/slip connector from the side (left) and from the threaded end (right).

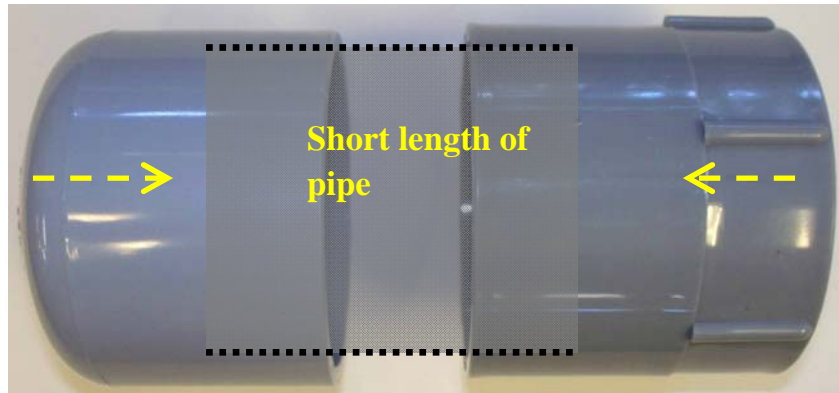


Figure 7. End cap and threaded/slip connector connected with solvent to a short length of pipe.



Figure 8. Antenna and mount on end cap (left), with close up view of mount (top right), and view looking inside the top (bottom right) with the antenna lead.

2.2.2 MAIN BODY OF ENCLOSURE

The main body of the enclosure consists of a length of pipe to which the top and bottom fittings attach (figure 9).

The length of pipe required is determined by the electrical components it encloses, primarily the battery pack. Both the male threaded/slip connector used for the screw-on top and the female slip/slip connector for the bottom are solvent welded to the pipe.

Two internal slots are cut into opposite sides of the pipe and connector to hold the circuit board is held (figure 10).

One or more ports are also installed in the pipe for weatherproof cable connections between internal and external components (figure 11). One port is required for the cable between the external solar panel



Figure 9. Main body of enclosure showing the male threaded/slip connector for the top cap (top right) and the female slip/slip connector for the bottom sensor (bottom right)

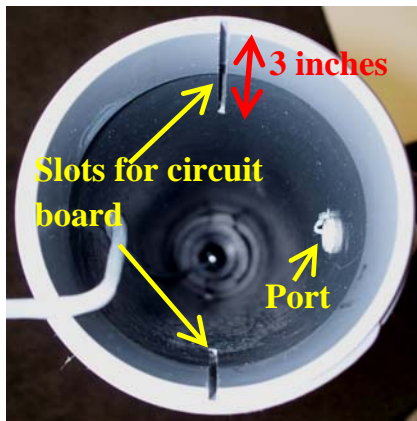


Figure 10. View into top of enclosure

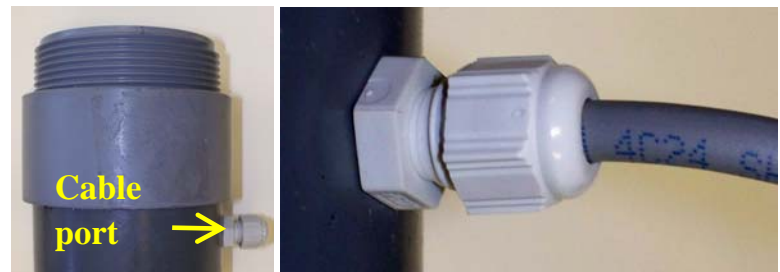


Figure 11. Cable port located near top of enclosure (left) and detail (right).

and the internal battery pack. Other ports can be installed for external sensors such as for soil water content.

2.2.3 BOTTOM SENSOR MOUNT

The bottom sensor mount, such as for the acoustic water level sensor, is constructed from off-the-shelf plumbing/electrical fittings that fit into the bottom female slip/slip connector attached to the pipe (figure 12). These fittings do not need to be resistant to sunlight as they are contained inside the connector.

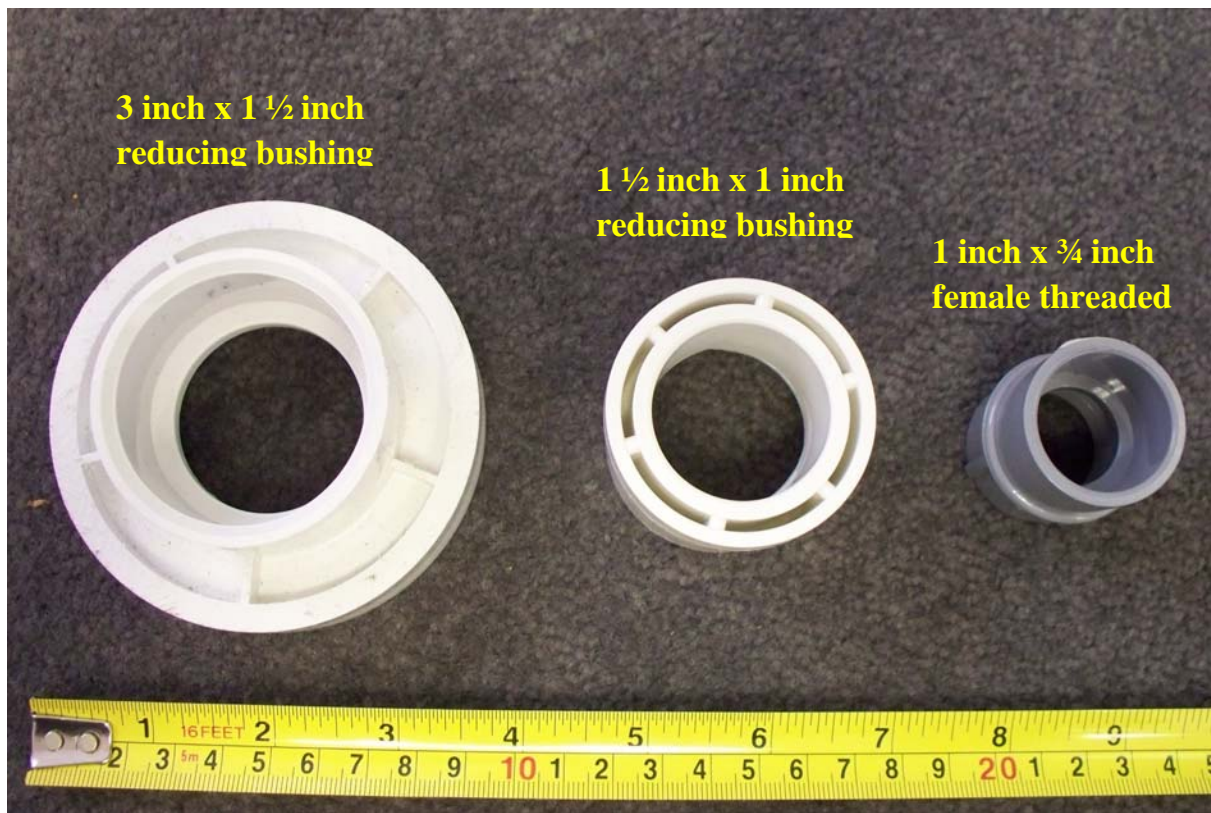


Figure 12. Primary fittings used in making bottom sensor mount.

The 3 inch x 1 ½ inch reducing bushing has to be modified by cutting off approximately half of the outer ring and supports. This reduces the height and enables both it and the enclosure pipe to be solvent welded into one side of the female/female slip connector. Figure 13 shows the part of the bushing that is removed during the modification. A saw can be used to cut through the outer wall without cutting through the inner wall. A chisel can then be used to remove the “fins” between the two walls.

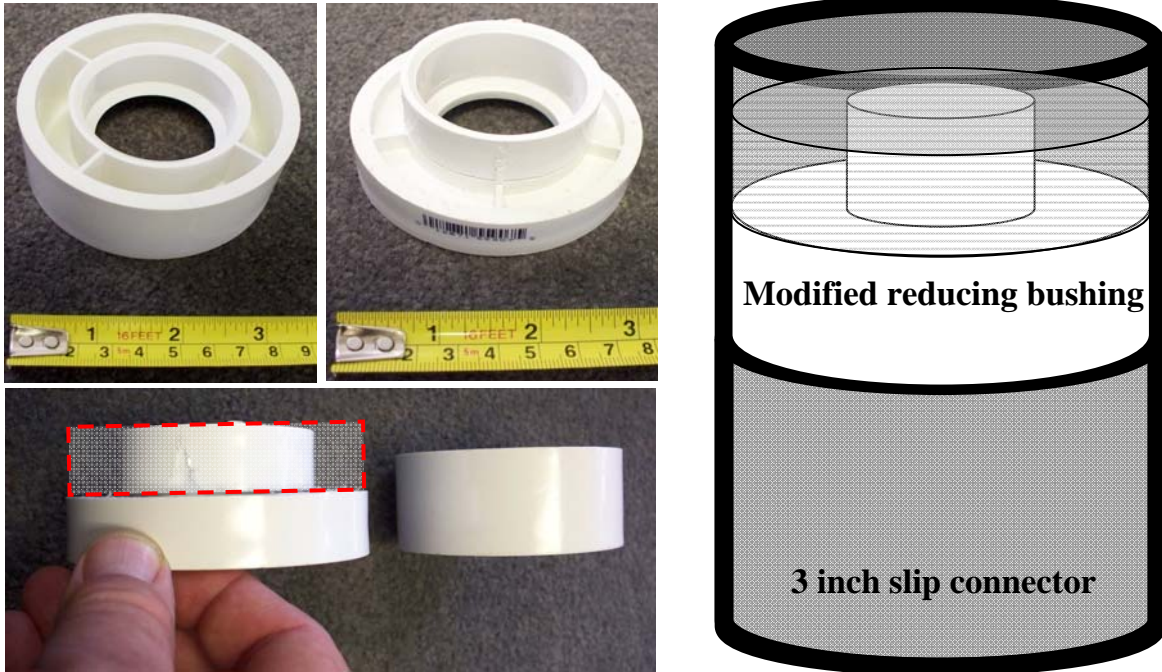


Figure 13. Three inch x 1 ½ inch reducing bushing (top left), and after modification (top center and bottom left). The modified bushing fits into the 3 inch slip connector as illustrated (right).

The 1 ½ inch by 1 inch bushing also has to be modified because it has an internal lip that prevents the 1 inch to ¾ inch adapter from fitting correctly inside it. A small grinding tool (such as a Dremel) can be used to grind off the lip. Figure 14 shows the fitting and where the lip has been ground off.

The final piece is the 1 inch x ¾ inch female threaded adapter into which the water level sensor screws (figure 15). This fitting is solvent welded into the modified 1 ½ inch x 1 inch bushing, as shown in figure 16. Finally, this assembly is solvent welded to the modified 3 inch x 1 ½ inch bushing shown in 13, to create a screw-in mount for the sensor that can be solvent welded into the 3 inch female connector at the bottom of the enclosure (figure 17).

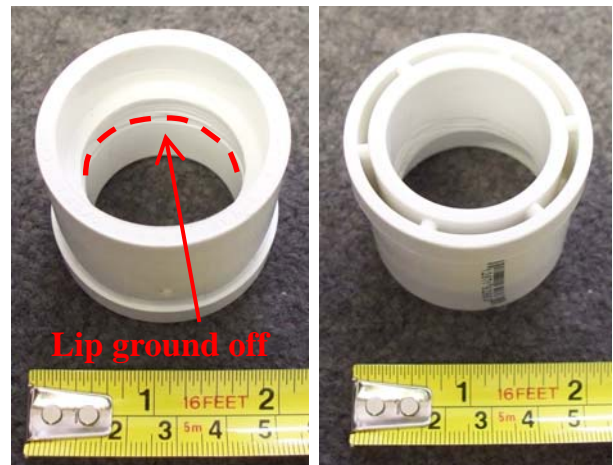


Figure 14. 1 ½ inch to 1 inch reducing bushing, showing where lip has been ground off.



Figure 15. Views of threaded (left) and slip (right) ends of 1 inch slip to 3/4 inch female threaded adapter.



Figure 16. 1 inch slip to 3/4 inch female threaded adapter solvent welded to modified 1 1/2 inch to 1 inch reducing bushing,



Figure 17. The assembly shown in figure 16 solvent welded to the modified 3 inch to 1 1/2 inch reducing bushing shown in figure 13 to create the sensor mount.



Figure 18. The assembly in figure 17 mounted in the 3 inch female/female connector (left), showing the 3/4 inch threaded socket into which the sensor (middle) screws, as shown (right).

Another type of 3 inch x 1 ½ reducing bushing is used as a ring surrounding the sensor. Rather than the modified flat face bushing shown in figure 13, this bushing has an inwardly sloping face enabling the sensor to be recessed. Figure 19 shows the bushing and its use as a surround ring around the sensor, while figure 20 shows the final assembly at the bottom of the enclosure.



Figure 19. Sensor surround ring (left) with sensor (right)



Figure 20. Final assembly of water level sensor with surround ring (left and middle) into the 3 inch female slip connector (right).

3. Power supply system

The LCRTU requires a 12V dc power supply. This is accomplished using an external solar panel to recharge a battery system located inside the enclosure.

3.1 Solar panel

The solar panel (figure 21) is rated at 10 Watts, and is held by an aluminum bracket using bolts that fit into an aluminum channel on each side of the frame. The angle at which the solar panel should be held depends on latitude, and can be adjusted using the bolts. A cable passing through an access port connects the panel to the battery pack inside the enclosure.

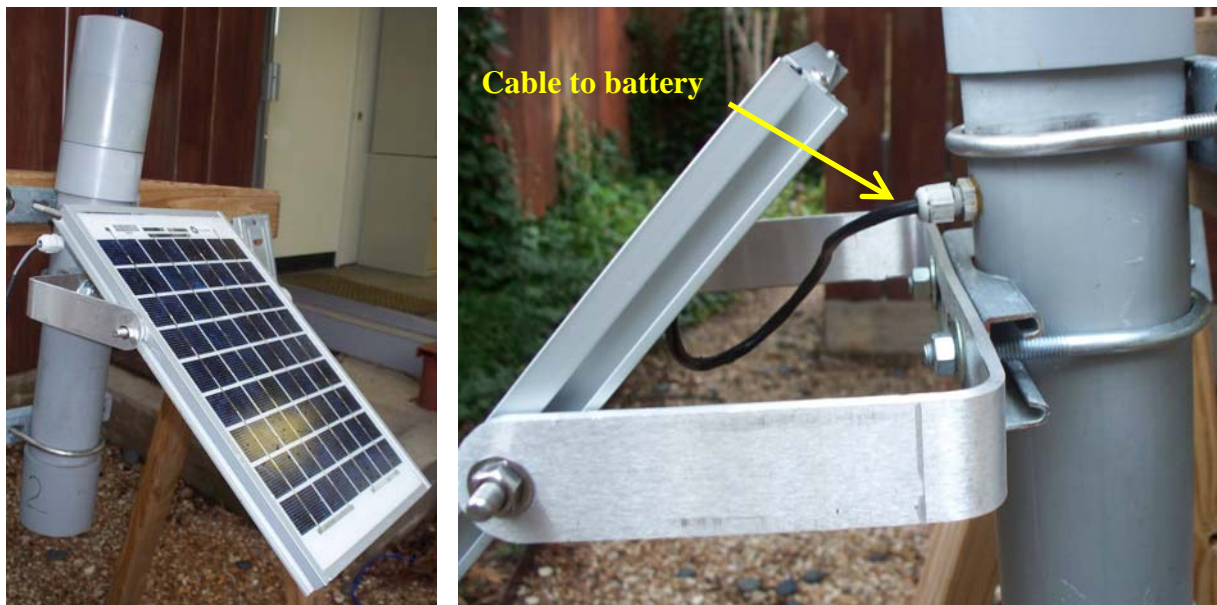


Figure 21. Solar panel (left), with connection to battery and mounting hardware (right)

3.2 Battery pack

The battery pack (figure 22) is a 12V rechargeable lead-acid system that is contained inside the enclosure. Two 6V batteries connected in series and physically joined together using large diameter heat shrink tubing are used in this example. A single 12V battery could also be used. An off-the-shelf voltage regulator circuit board is used between the solar panel and the battery pack.

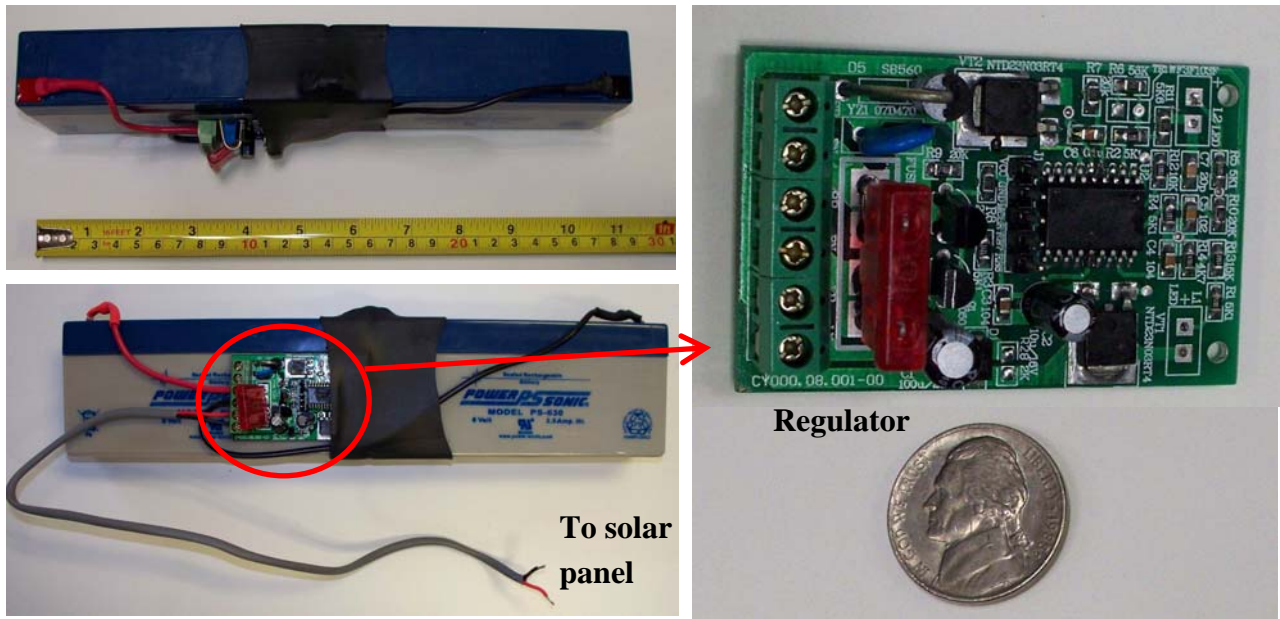


Figure 22. Top and side views of battery pack (top left and bottom left) with detail of regulator (right)

4. Electronics

A custom designed circuit board is used in combination with a radio. The circuit board is a “piggy back” design with one side of the board used for mounting the radio and the other side for mounting the Single Board Computer (SBC) measurement and control circuit. The board fits into the two machined slots in the enclosure (figure 23).

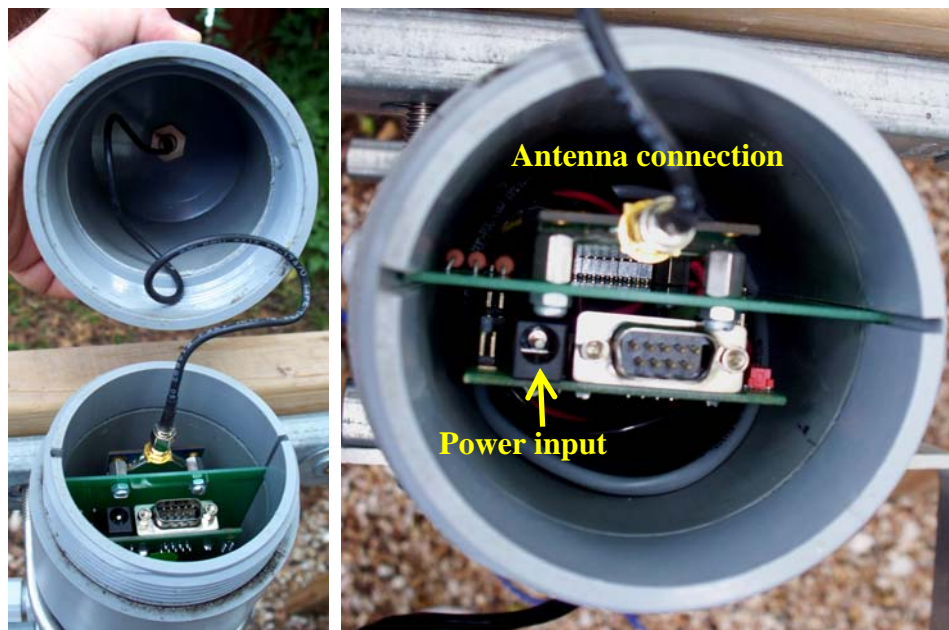


Figure 23. Circuit board in enclosure, with antenna connected through cap (left) and detail (right)

Figure 24 shows a top view of the board with the radio mounted. Four screws secure the radio to the board. Connections to the board are made through a terminal strip. Power from the battery pack is connected to the SBC side of the board. The SBC board is initially programmed using the serial connector and a hardware/software interface.

Figure 25 shows both sides of the circuit board with their respective components unplugged. Connections are made using pin and socket connectors.

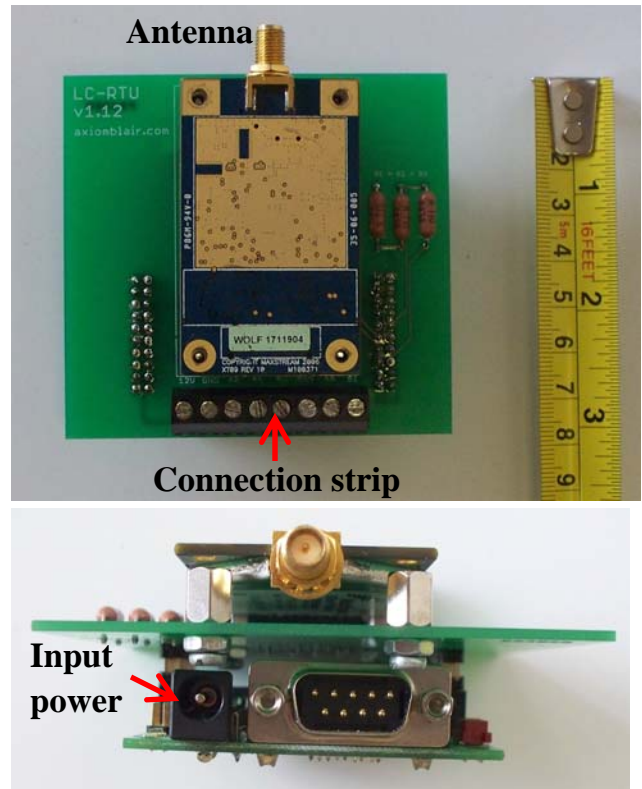


Figure 24. Top view of board showing radio (top), and edge view of board showing radio and measurement circuit sides (bottom).

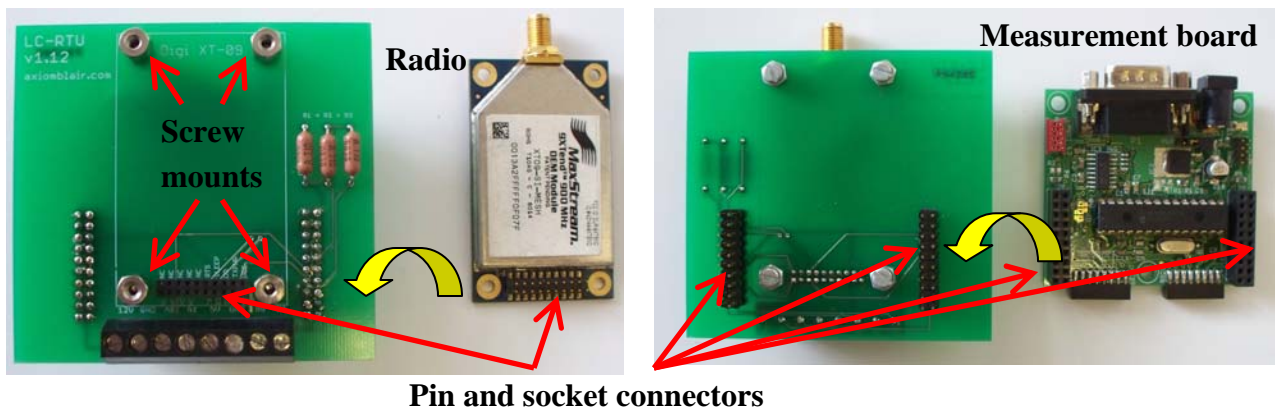


Figure 25. Radio and radio side of board (left) and measurement circuit side of board (right)

Appendices removed.

Contact publicinfo@twdb.state.tx.us to request these items.