# CALIBRATION AND CORRECTIVE MAINTENANCE MANUAL for MODEL 6290 TANK GAUGING SYSTEM

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**SCIENTIFIC INSTRUMENTS, INC.**
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# 1 INTRODUCTION

This manual provides procedures for calibration and corrective maintenance for the Model 6290 (M6290) Tank Gauging System. The manual begins with a description of the overall system to give maintenance personnel a system overview. The system is then broken up into components and a theory of operation is given for the drive system, the level system, the temperature system, and the density system.

The troubleshooting guide lists potential problems and possible solutions. Faults are separated into various categories according to the system affected.

Parts replacement procedures are first given for the control unit, which contains the stepping motor and most of the electronics for the system. Following are sections for accessing the mechanical unit and replacing parts in the mechanical unit.

The primary diagnostic and maintenance tool for the M6290 is the Hand Held PC (HHPC). The HHPC displays a great deal of diagnostic information and provides the only means for setting system parameters and entering calibration data. In addition, the HHPC may be used to control the M6290 from the tank top, which greatly facilitates maintenance activities.

Throughout the manual, reference is made to the Hand Held PC User Interface manual, which contains exact instructions for inputting data and performing certain operations. In fact, the details of some procedures are contained only in that manual. While operation of the Hand Held PC is important for performing maintenance operations, exact instructions are best left in the Hand Held PC User Interface manual where complete information is given on the operation of the Hand Held PC; that information is not duplicated here. After a period of time working with the HHPC, it should not be necessary to refer to that manual as often, and most maintenance operations can be performed by only consulting this manual.

The drawing section of the system manual includes wiring diagrams, schematic diagrams, and P/C assembly drawings of the printed circuit boards. These will be referred to at various points in maintenance operations.

# 2 SYSTEM OVERVIEW

## 2.1 SYSTEM COMPONENTS

The M6290 consists of a computer-based control unit and a mechanical unit. The two operate as a unit to position a multi-sensor probe assembly suspended within the liquid storage tank.

The control unit is housed in a flameproof box below the mechanical unit and contains the stepping motor and the electronics necessary to operate the mechanical unit. The electronic components include the control module, zener barriers, the motor driver, the power supply, and the power conversion card. The interface with the control room is limited to communication links and power control.

The mechanical unit houses the probe assembly and the drive cable used to transport the probe. The mechanical unit also contains the take-up reel, which receives the cable as the probe is being raised. Other components in the mechanical unit include the arc plate, which prevents the cable from being stressed as it makes the turn into the tank, and the spring motor, which keeps tension on the cable. The gear reduction box is used to transfer torque from the motor to the drive gear, which drives the cable.

The brain of the control unit is the control module, consisting of five PC104 format cards. These are the CPU card, the I/O card, the signal conditioning card, the level sense card, and the interconnect card. Signals from the temperature sensor, the level sensors, and the density meter are fed into the signal conditioning card. The signal conditioning card processes the waveforms and transmits basic sensor information to the CPU card, where remaining calculations are performed. The control module controls all system operations.

The probe assembly in the mechanical unit contains a bottom reference switch, upper and lower level sensors, a temperature sensor, and the density meter. All system components located inside the tank can be completely removed from the tank for inspection and/or maintenance at any time.

## 2.2 THEORY OF OPERATION

The M6290 takes its reference from the floor of the tank in order to obtain the most accurate liquid level readings. The first important operation after power up is to establish a bottom reference. When the system is first powered up and this reference has not been established the current probe position will be marked as “Uncal”. The system incorporates a unique memory feature such that the last position of the probe is stored when power is lost, but it is always possible that outside forces have physically moved the probe and its cable during its power-off condition. Therefore the position of the probe is always marked as “Uncal” when the system is powered up. Bottom reference must be re-established to remove this indication.

The system can be set so that it will automatically re-establish its bottom reference after a power loss, or it can be set so that it will power up in the manual mode so that no action is taken.  The setting for this choice is described in the Hand Held PC User Interface manual.  If the system is not set to re-establish bottom reference automatically, it is only necessary to initiate a calibration run to re-establish bottom reference.  The probe will travel to the bottom of the tank and then back up to liquid level, after which it will return to the Auto mode.

Since the temperature sensors and density meter are contained in the probe, the M6290 can take readings at various points in the tank and create a profile of the liquid or vapor.  The “Profile” mode is used for creating a profile of the liquid.  "Top Scan” can be used to sample sections of liquid or vapor.  More details about these modes of operation are given in the Operation manual (090-248) and the Hand Held PC User Interface manual (090-252).

Profile information can be transmitted to a host computer via the Modbus interface or to a PC running the Data Acquisition software.  Profiles can be initiated manually or set to run periodically, as requested by the operator.

There are a number of alarms which can alert the operator to various conditions. Some of these relate to current conditions at liquid level and some relate to data collected during a profile.  These alarms are described in more detail in the Operation manual and the Hand Held PC User Interface manual.

# 3 SYSTEM COMPONENTS

As the primary function of the M6290 is to measure level, temperature, and density, understanding these subsystems should be given special attention. Even more basic is the drive system; this will be discussed first.

## 3.1 DRIVE SYSTEM

The M6290 performs measurement of level by driving the probe to the bottom of the tank and then up to liquid level. Therefore, proper drive system operation is crucial for accurate measurement of liquid level.

### 3.1.1 DRIVE SYSTEM COMPONENTS

The electronic portion of the motor drive mechanism consists of the control module, the motor driver, and the motor driver power supply. The mechanical portion consists of the stepping motor, the gear train assembly, the take up reel assembly, and the helical drive cable. Related components are the bottom reference switch and the reel feedback switch.

### 3.1.2 THEORY OF OPERATION

#### 3.1.2.1 MOTOR DRIVE PULSES

Based on the mode of operation and the status of the level sensors, the control module CPU determines the direction and speed that the probe should be moved. A series of drive pulses (with a direction of up or down) are sent to the motor driver. These stepping pulses are then sent by the motor driver to the stepping motor as high current drive pulses. Because the motor operates from DC voltages, the rotation direction of the motor is determined by the polarity of these drive pulses.

Through the gear train assembly, the motor rotates the helical drive gear, which in turn causes the helical drive cable to move in one direction or the other. If the CPU generates a "drive down" pulse train, the driving mechanism pulls the helical cable from the take-up reel and lowers the probe into the tank. If a "drive-up" pulse train is generated, the driving mechanism pulls the probe upward inside the tank. A constant tension spring mechanism turns the take-up reel, thus allowing it to accept the helical cable being driven onto it.

The control module keeps track of the pulses sent to the motor, and through a conversion constant (level scale), position is calculated from these pulses. As described below, a reel feedback switch signals the control module as to whether the reel is turning or not. It is important to properly maintain the drive system, since any obstruction or slippage could result in inaccurate level readings.

#### 3.1.2.2 BOTTOM REFERENCE

A mechanical switch assembly signals the control unit when the probe is in contact with the tank floor. When the bottom is reached, a sliding shroud which is attached to the switch moves and actuates the switch. The switch then shorts the upper level sensor. The change in voltage is detected by a voltage comparator on the signal conditioning card. (The voltage detector must be properly set for the bottom reference circuit to work properly. This setting is described in the HHPC User Interface manual.)

When the control module senses a "Probe at Reference" condition, it ceases downward movement of the helical drive cable, sets the probe position display to the preset bottom reference value, and indicates "Bottom Reference" to the user interface.

The bottom reference value is the height of the level sensors above the bottom of the probe. This value is added to the probe position so that a true liquid level is reported.

#### 3.1.2.3 INTERLOCK

An "Interlock" value is input via the HHPC, which causes the probe to be stopped near the top of the tank as it is being driven upward so it cannot accidentally be driven into the mechanical assembly.

#### 3.1.2.4 REEL FEEDBACK

Since the drive mechanism is located at the top of tank, and is therefore impossible for the operator to monitor, a feedback circuit is employed in order to tell the control unit that the take-up reel is rotating and the motor is driving the helical cable in a normal manner. This is accomplished via a series of 24 magnets that are located along the top outside edge of the take-up reel. When the take-up reel rotates (as the probe is being driven up or down) the magnets pass beneath and activate a magnetic switch. The control module CPU "reads" the opening and closing of this magnetic switch. If the take-up reel is not turning when it is required, the control module CPU aborts the motor driving routine and indicates a "Reel Alarm". This would indicate a potential problem that requires attention.

### 3.1.3 DRIVE SYSTEM CALIBRATION (LEVEL SCALE)

Liquid level is computed according to the following relationship:

L = NS x LS, in which

L = computed liquid level,

NS = number of steps of stepping motor required to raise the probe assembly from the bottom of the tank to the liquid/vapor interface, and

LS = level scale value.

Thus, the "level scale" value establishes the amount of change in level for each step of the stepping motor.

A possible initial value for the level scale value is 0.063153, which means that it requires approximately 16 steps to drive the cable 1 mm. Computations for position and level are performed in metric units. If position and level are to be reported in English units, the quantities are converted accordingly.

If the current level scale value does not yield the correct probe position, the level scale value must be changed. The following procedure, therefore, is critically important in that it establishes the proper level scale value to assure accurate liquid level measurement and display. Although it is a relatively straightforward procedure, it should be performed with care to yield valid results.

The procedure involves the comparison of the displayed probe position value to a pre-established reference height above the tank floor (i.e., a "benchmark"), when the probe assembly has been manually driven to that location. If the probe position and benchmark values agree, the system is properly calibrated. If they do not, a corrected level scale value must be computed and inserted.

The principal difficulty in the entire procedure is establishing an accessible benchmark and obtaining an accurate height measurement to that mark. A marker applied to the viewing window of the probe enclosure will serve the purpose. An accurate height measurement from the tank floor to that mark is absolutely essential.

The procedure should be done in the following manner. First drive the probe down to the bottom of the tank to re-establish bottom reference. Then drive the probe back up to the benchmark established on the probe enclosure. If the position reading is correct, the procedure is complete. If not, a new level scale must be calculated; multiply the old level scale by the ratio of the new position to the old position as follows:

New Level Scale = (New Position /Old Position) x (Old Level Scale)

Enter the new level scale using the Hand Held PC and the position should be displayed as the corrected value. The exact procedure for entering the level scale value is found in the Hand Held PC User Interface section of the manual.

## 3.2 LEVEL SYSTEM

Provided that the drive system is functioning properly, the level system components provide for accurate measurement of liquid level.

### 3.2.1 COMPONENTS OF LEVEL SYSTEM

The level measurement system consists of the level sensors, the control module, the zener barriers, and the drive system. The level system and the drive system are integrally related.

### 3.2.2 THEORY OF OPERATION

The liquid level sensors are the heart of the level detection system. They operate on the principle that heat will dissipate more efficiently in a liquid than in a vapor environment. An electrical current is passed through the sensors which have a negative temperature coefficient (i.e. the resistance increases as the temperature decreases). When the sensor contacts liquid, heat is transferred from the sensor to the liquid, the sensor is cooled, and the sensor resistance (and therefore the voltage drop across it) increases rapidly. As the sensor travels into the vapor (since vapor does not carry the heat away as efficiently) the current passing through it causes it to "self heat", thereby decreasing its resistance and causing the voltage to drop. The control unit uses these differences in the sensor voltages to determine if the sensors are in liquid or vapor. By vertically spacing the level sensors approximately 3/8" (9 mm) apart (or more in the case of excessive tank turbulence), the control unit can recognize liquid level at the point where the lower level sensor is "in liquid" and the upper level sensor is "in vapor".

### 3.2.3 LEVEL SENSOR CALIBRATION

Since each cryogenic medium has different characteristics, the level sensors must be calibrated in the actual cryogenic medium before they can properly indicate the interface between liquid and vapor. During the calibration process, the reference voltage is adjusted until the sensor voltage is approximately 2.5 V. The sensor voltages can be displayed using the “Basic Units” display of the Hand Held PC. The procedure for calibrating the level sensors is described in the Hand Held PC User Interface manual.

It is important when calibrating the level sensors that the probe be near the bottom of the tank, but not on the bottom. The bottom reference switch shorts out the upper level switch making it impossible to perform a proper calibration. The procedure for this operation is detailed in the commissioning section of the system manual.

## 3.3 TEMPERATURE SYSTEM

### 3.3.1 COMPONENTS OF TEMPERATURE SUB SYSTEM

The components of the temperature system include the temperature sensor, the conductors in the helical cable, the take-up reel circuit board, the cable assembly to the control unit, zener barriers, the zener barrier cable, and the control module.

### 3.3.2 THEORY OF OPERATION

The temperature of the liquid in the tank is determined by means of a four-leaded precision platinum resistance temperature device (RTD) located in the probe assembly. This is a 100 ohm +/-0.1% @ 0 °C element, with calibration traceable to the National Institute of Standards and Technology (NIST). Through the use of a one milli-amp DC excitation current, a voltage is developed across the sensor that is proportional to temperature. The resulting voltage is digitized by an analog to digital converter on the signal conditioning card and is converted to resistance. This information is fed to the control module CPU, which compares the resistance value to data tables kept in memory. Temperature is calculated and is made ready for a query by a host computer or the Hand Held PC.

Since the drive mechanism allows the probe assembly to be moved from the floor of the tank to the liquid/vapor interface and beyond, discrete temperature readings can be obtained throughout the entire height of the liquid, and actually at any height in the tank.

### 3.3.3 TEMPERATURE CALIBRATION

Calibration of the temperature system is comprised of two parts. First, the signal conditioning card is calibrated to read resistance correctly. This is actually a calibration of the A/D converter and is described in the Hand Held PC User Interface manual in the signal conditioning card section.

After the signal conditioning card is calibrated to read resistance correctly, the proper calibration constants must be entered in the control module for the particular temperature sensor being used. These constants are listed on the configuration worksheet supplied with the system, and the process for entering these values is described in the Hand Held PC User Interface manual in the “Edit Parameters” section of the Control Module User Interface chapter.

## 3.4 DENSITY SYSTEM

### 3.4.1 COMPONENTS OF DENSITY SYSTEM

The system components necessary for density measurement are the density meter (located in the probe assembly), a "maintaining amplifier" (mounted to the drive cable supply/take-up reel in the mechanical unit), and the associated electronic circuitry and software in the control unit necessary to measure the signal frequency and calculate the density.

### 3.4.2 THEORY OF OPERATION

The density meter houses a thin-wall cylinder that is set and maintained in circumferential oscillation by the remote maintaining amplifier. The liquid completely surrounds both the inside and outside surfaces of the oscillating cylinder. Thus, the liquid is also maintained in oscillation, its resonant frequency being dependent upon the total mass of the oscillating system. Frequency of cylinder oscillation is detected by an integral pick-off coil in the density meter package. A variable frequency square wave signal is sent by the maintaining amplifier to the control unit and is received on the signal conditioning card. It then passes through a wave shaper where it is transformed into a usable signal and passed on to a counter. The microprocessor on the signal conditioning card measures the frequency of this signal. This information is fed to the control module CPU, which based on the calibration data for that particular density meter/maintaining amplifier combination, calculates the current density.

Density is computed according to the following relationship:

$$d = 2( D_0 ) ( T / T_0 ) ( 1 + K ( T / ( 2T_0 ) ) ),$$

where

$d$ = Measured density in $kg/m^3$ (or $lb/ft^3$ in the English system),
$D_0$ = Meter constant in $kg/m^3$,
$t$ = Output signal period at density (d), in µs,
$T_0$ = Output signal period in vacuum, in µs,
$T$ = $t - T_0$, and
$K$ = Calibration constant.

### 3.4.3 DENSITY CALIBRATION

Calibration of the density meter is ensured by entering the correct calibration constants from the configuration worksheet into the control module using the HHPC. This procedure is described in the HHPC User Interface manual.

# 4 POSSIBLE SYSTEM FAULTS

Following are charts of possible system faults along with possible causes and suggested remedies. Each system's components are listed at the beginning of the appropriate section. Each chart is ordered with the most basic faults first. It should be verified that the more basic fault does not exist before trying to troubleshoot another fault farther on in the list.

## 4.1 SYSTEM POWER

**Power System Components**

24 V Power Supply in Control Room, Tank Gauge Interface Module (TGIM), Field Wiring, Power relay, 110 or 220 VAC at top of tank, Circuit Breaker, Service Bypass Power Switch, Power Supply, Transformer (for Motor Driver only).

| **Symptom(s)** | **Possible Cause/Remedy** |
|---|---|
| Green LED (D8) on TGIM Card not illuminated | Verify 24 V is applied to TGIM.<br><br>If 24 V okay, check/replace TGIM fuse. |
| HHPC does not turn on when plugged into the TGIM. | Verify 24 V is applied to TGIM.<br><br>Check HHPC cord.<br><br>If 24 V okay, check/replace TGIM fuse. |
| 28 V Power LED not lit. (This LED is controlled by power from the tank top.) | Make sure power switch is on to apply power to tank top equipment.<br><br>Check A/C power to tank top equipment.<br><br>In the control unit, verify that the power relay cable is connected to the interconnect card.<br><br>Check that field wiring carrying power control signals is intact.<br><br>Check operation of the power relay inside the control unit. |
| Turning power switch off in the control room does not extinguish 28 V power LED. | The service bypass power switch may be on in the control unit; turn it off. |

## 4.2 CONTROL MODULE OPERATION

The control module consists of the CPU card, the I/O card, the signal conditioning card, the level sense card, and the interconnect card.

| **Symptom** | **Possible Cause/Remedy** |
|---|---|
| +5 V Power LED (D4) not on | Check A/C power. Measure voltages on power conversion card. If +5 V is not present for the control module, check/replace the power conversion card and/or the power supply. |
| SCC-CPU light not blinking | SCC-CPU LED should blink when powered-up after a short delay (1 or 2 seconds). If LED does not blink, replace control module. |
| CM-CPU light not blinking | CM-CPU LED should blink when powered-up after a longer delay (10 to 15 seconds).<br><br>If LED does not blink, program may be stopped to allow program updates. Try resetting the processor or power cycling the system.<br><br>Program may be set for remote update. Wait 5 minutes for program to start. If it does not start, contact factory to change setting via modem. |
| Control module resets periodically, interrupting profiles and changing status to "Uncal." | Check +5 voltage supply. Check all wiring connections, tighten connectors and wiring attached to connectors. |

## 4.3 SIGNAL CONDITIONING CARD

| **Symptom** | **Possible Cause/Remedy** |
|---|---|
| No response from signal conditioning card | Verify that communications are not interrupted due to HHPC plugged into signal conditioning card. Verify all power supply voltages. If problem is not resolved, replace control module. |

## 4.4 COMMUNICATIONS

### Communication System Components

CPU Card, Serial I/O Card, Interconnect Card, Field Wiring, RS485 Repeaters, TGIM.

| **Symptom** | **Possible Cause/Remedy** |
|---|---|
| When plugged into User Link on TGIM, HHPC powers up, but no response from system. | Verify that 28 V power LED is lit. If power LED is lit, it will be necessary to go to tank top to continue troubleshooting. Open control unit and plug HHPC into control module. If no response there, follow instructions below. |
| HHPC powers up when plugged into Host Link, but no response from system. | Each Host link may be configured for use with Modbus or for the HHPC. In addition, the baud rate is variable. Plug into the User link and configure for the HHPC. Baud rate must be 9600. |
| No response from system when plugged into control module at tank top. | Verify that CM-CPU and SCC-CPU LED's are blinking. If LED's are not blinking, continue troubleshooting under Control Module Operation. If LED's are blinking and still no response, replace control module. |

## 4.5 DRIVE SYSTEM

### Drive System Components

CPU Card, Interconnect Card, Wiring, Motor Driver, Transformer, Power Supply, Motor, Coupling, Drive Shaft, Gear Box, Drive Wheel, Back-up Wheel, Helical Drive Cable.

| **Symptom** | **Possible Cause/Remedy** |
|---|---|
| Probe position does not change on display. (System does not drive.) | Drive disable may be set – system will not drive if this setting is on. See HHPC manual.<br><br>Bottom reference switch may be activated – system will not drive down with bottom reference closed.<br><br>Probe may have reached interlock value – system will not drive up above interlock value.<br><br>Reel alarm may have occurred; continue below. |
| Reel alarm; position value changes but the motor does not attempt to turn.<br><br>(The position value will change before a reel alarm occurs, but not after. The reel alarm must be cleared before the system will attempt to drive again.) | Cable from interconnect card to motor driver may be disconnected. Re-connect cable.<br><br>Simulator mode may be set – system will not drive in simulator mode.<br><br>Motor driver module or power supply may be bad. Change motor driver. Check motor driver power supply.<br><br>There may be a physical drive problem; continue below. |
| Reel alarm; the motor attempts to turn (causing a chattering noise), but the drive cable does not move. | The motor coupling may be loose. Tighten screws in motor coupling.<br><br>There may be an obstruction of some kind in the mechanical unit. Check for physical obstructions. Check gear box, drive wheel, back-up wheel. |
| Reel alarm; the motor is turning and the | The reel feedback switch may not be |

| | |
|---|---|
| drive cable is moving freely. | adjusted. Check reel feedback switch operation.<br><br>The reel feedback signal may not be carried to the control module. Check for reel feedback signal at control module with voltmeter. |

## 4.6 REEL FEEDBACK SYSTEM

**Reel Feedback System Components**

Magnetic switch, wiring, zener barrier, wiring, interconnect card, CPU Card.

| **Symptom** | **Possible Cause/Remedy** |
|---|---|
| Magnetic switch does not open and close when take-up reel turns. | Switch may be too far away or too close to the take-up reel. Adjust until it opens and closes for each magnet. |
| Reel feedback alarm is not registered during reel alarm test. | Reel feedback alarm may be disabled. This is indicated by “RA Disable” on HHPC display. In normal system operation, it should be enabled. |

## 4.7 LEVEL SYSTEM

### Level System Components

Level Sensors, Conductors In Helical Cable, Take Up Reel Circuit Board, Cable Assembly To Control Unit, Zener Barriers, Zener Barrier Cable, Interconnect Card, Level Sense Card, Signal Conditioning Card, CPU Card.

| Symptom | Possible Cause/Remedy |
|---|---|
| Probe does not track liquid level. | The system must be in “Auto” to track liquid level. Verify that the mode is not set to “Manual”.<br><br>Verify that the drive system is working properly.<br><br>The level sensors may not be working properly; continue below. |
| Level sensors do not respond when moving from liquid to vapor. | Level sensors may not be calibrated. Perform level sensor calibration.<br><br>Level sensors may be open or shorted. The short or open could be in the sensor itself (least likely), in the wiring, or in the zener barriers. |
| Level readings are inaccurate. | Check that the drive system gives an accurate position value. The level scale value controls the position calculation and should be set to match the configuration worksheet. |
| Level readings are unstable. | If the probe is constantly seeking liquid level, the level sensors may be too close to each other; there should normally be a separation of 3/8$^{th}$ inch. |
| Probe stops randomly when finding liquid level, or performing a profile or calibration. | It may be that the control module is resetting periodically; continue troubleshooting in the control module operation section. |

## 4.8 TEMPERATURE SYSTEM

### Temperature System Components

Temperature sensor, conductors in helical cable, take-up reel circuit board, cable assembly to control unit, zener barriers, zener barrier cable, interconnect card, signal conditioning card, CPU card.

| Symptom | Possible Cause/Remedy |
|---|---|
| Display Reads 999.99 | Temperature sensor is open. Confirm temperature sensor resistance and back-up A/D voltage on “Basic Units” display of HHPC. The normal value for temperature sensor resistance in LNG is about 34 ohms. The Backup A/D normally indicates 0.035 volts. |
| Display Reads -555.55 | Temperature sensor is shorted. Confirm temperature sensor resistance and back-up A/D voltage on “Basic Units” display of HHPC. If the back-up A/D voltage is near 30 mV (for LNG temperatures), it indicates a problem with the main A/D converter. Replace the control module. |
| Inaccurate Readings | The calibration parameters for the temperature sensor may not be set properly. Check that the calibration data matches the configuration worksheet. |
| Reading are unstable. | Unstable readings may be due to poor connections or poor grounding. Check to make sure that all connections are tight and ground connections are secure. |

## 4.9 DENSITY SYSTEM

### Density System Components

Density Meter, Conductors In Helical Cable, Take Up Reel Circuit Board, Cable Assembly To Control Unit, Zener Barriers, Zener Barrier Cable, Interconnect Card, Signal Conditioning Card, CPU Card.

| Symptom | Possible Cause/Remedy |
|---|---|
| Display Reads 9999.99 | No density signal – verify all connections. Check power supply for density meter. |
| Display reads 000.00, or readings are inaccurate. | Verify that calibration data matches configuration worksheet. |
| Reading are unstable. | It is normal for readings to be unstable when the probe is first introduced into the tank and the probe has to cool down. This is due to boiling of the liquid.<br><br>Unstable readings may be due to contamination in the tank (perlite).<br><br>If the probe was exposed to the atmosphere while still cold and condensation developed, the probe may be iced up. It will be necessary to bring the probe back up to ambient temperatures and dry it thoroughly. |

# 5 CONTROL UNIT PARTS REPLACEMENT

The control unit may be opened with power applied only if no gas is present. Local safety procedures must be followed. Before removing any components, A/C power must be removed. It is recommended to physically remove power from the control unit by turning off the circuit breaker that provides A/C power. To open the control unit, remove the 6mm socket bolts holding the cover in place and carefully lower the cover. Verify that power has been disconnected by measuring A/C mains with a voltmeter.

## 5.1 CONTROL MODULE

The control module may be replaced without removing any other components. Before removing the control module, disconnect the cables specified below. The pictorial of the Interconnect Card may be used as a reference (150-385).

1) Remove the cable at P6 (to the zener barriers), P4 (to the power conversion card), P12 (to the motor driver), and P3 (to the 12 V disconnect power relay).

2) Loosen the 4 screws holding the control module. (On the bottom side, be careful not to confuse the screws with the screws holding the safety barrier/control module mounting plate.)

3) Carefully pull the control module out, taking care not to disturb surrounding components.

4) To reinstall the control module, carefully position it so that the 4 screws line up with their respective sockets. The connector P4 should be at the top with the 2 RJ11 sockets at the bottom. If correct orientation is not observed, it will not be possible to insert the screws.

5) After tightening the 4 screws, replace the 4 cables disconnected in the first step.

## 5.2 ZENER BARRIERS

The zener barriers may be replaced individually without removing any other components, or they may be removed as a unit by removing the safety barrier/control module mounting plate, as described below, after removing the control module. Be sure to note that there are several types of barriers in each system and they must not be interchanged.

To remove zener barriers individually, first remove the wires attached to each barrier. Insert a flat screwdriver between the plastic casing and the lower screw terminal on the left side of the barrier and apply slight pressure toward the zener barrier. (Push the handle toward the barrier.) The barrier should pop out. To remove all the zener barriers as a unit, remove the safety barrier/control module mounting plate as described below.

To reinstall a zener barrier, engage the right side of the barrier first on the mounting rail, then apply slight pressure on the left side of the barrier until it snaps in place.

## 5.3 SAFETY BARRIER/CONTROL MODULE MOUNTING PLATE

The safety barrier/control module mounting plate may be replaced after removing the control module. To remove the safety barrier/control module mounting plate, first remove the black and blue earth ground wires from the zener rail. Loosen the 4 screws holding the mounting plate and lift it out. The safety barrier/control module mounting plate may be removed with the zener barriers still attached.

If it is necessary to completely remove the safety barrier/control module mounting plate, it will of course be necessary to remove all connected wiring.

## 5.4 POWER SUPPLY

Before replacing the power supply, it is first necessary to remove the control module and the safety barrier/control module mounting plate.

1) Remove the cables attached to CON1 and CON2 of the power supply.
2) Extract the conductors running through the cable harnesses on the side of the power supply.
3) Remove the outer 4 screws holding the power supply mounting plate (not the 4 inner screws holding the power supply PC board) and lift the power supply out, taking care not to smear the thermal coating on the bottom side of the power supply on other components in the box.
4) Remove the cable guide harnesses from the old power supply and attach them to the new power supply.
5) Coat the bottom with thermal coating.
6) Position the power supply on the base plate and replace the 4 screws that hold the power supply to the base plate.
7) Reinsert the cables into the cable harnesses.
8) Reconnect the cables attached to CON1 and CON2.

## 5.5 MOTOR DRIVER

To replace the motor driver, it is first necessary to remove the control module and the safety barrier/control module mounting plate.

1) Remove the wires from J2-100 on the motor driver.
2) Remove the wires from J1-100 on the right side of the motor driver.

3) Remove the 2 screws holding the motor driver in place and pull the motor driver out, taking care not to smear the thermal coating on the bottom of the motor driver on other components in the control unit.

4) Attach the wires from the motor and the power supply to J1-100 of the motor driver.

5) Apply thermal coating to the bottom of the motor driver.

6) Position the motor driver and replace the 2 screws that hold the motor driver to the base plate.

7) Reconnect the wires to J2-100.

## 5.6 POWER CONVERSION CARD

The power conversion card is mounted to the component mounting bracket and may be replaced without removing any other components. To replace the power conversion card, remove the attached cables and remove the 4 screws that hold it to the mounting bracket. Replace with the new card, reinsert the screws, and connect the cables removed above.

## 5.7 POWER FUSES

The two power fuses are mounted on the component mounting bracket and may be replaced without removing any other components. To replace a fuse, use a medium-size regular screwdriver to apply slight pressure to the fuse holder and turn counter clockwise approximately ¼ turn. The fuse holder should emerge from the socket.

Replace the fuse in the fuse holder, insert the holder into the socket, and apply slight pressure with the screwdriver while turning clockwise. The fuse holder should engage after approximately ¼ turn.

## 5.8 POWER TERMINAL STRIP

The power terminal strip is mounted on the component mounting bracket and may be replaced without removing any other components. To replace the power terminal strip, remove the cover, disconnect the wires that are attached to the terminal strip and remove the screws that hold the strip in place. Replace the terminal strip with the new one, reinsert the screws, and reconnect the wires to the terminal strip. Also replace the cover that goes on the terminal strip.

## 5.9 COMPONENT MOUNTING BRACKET, POWER SWITCH

The component mounting bracket may be removed without removing any other components. To remove the bracket, pull off the cable harnesses to the power conversion card and loosen the 3 screws holding the component mounting bracket to the motor mounting bracket.

If it is necessary to remove the bracket completely, it will be necessary to disconnect all attached wires. If it is only necessary to remove the bracket to gain access to other parts, then it may be possible to swing the bracket over to the side and rest it on a bolt from the cover inserted on the right side and leave the wiring connected.

## 5.10 POWER SWITCH, BRIDGE RECTIFIER, CAPACITOR, POWER RELAY

The component mounting bracket holds the service bypass power switch, the bridge rectifier, the capacitor, and the power relay on the interior side of the bracket. These components may be replaced after removing the component mounting bracket, as described above.

## 5.11 TRANSFORMER

To replace the transformer, it is first necessary to remove the control module, the safety barrier/control module mounting plate, and the component mounting bracket.

1) Remove the ground wire attached to the base-plate of the control unit above the power supply.

2) Pull the connector off CON1 of the power supply.

3) Remove the screws holding the transformer to the base-plate and pull the transformer out. It will be necessary to cut tie wraps holding the transformer wires in the wiring bundle.

4) Disconnect the wires holding the transformer to the other components.

5) Connect the wires attached to the new transformer where the wires from the old transformer were disconnected.

6) Route the wires with the wire bundles and use tie wraps to hold them in place.

7) Position the transformer over the screw holes and replace the screws holding the transformer to the base plate.

8) Replace the cable to CON1 of the power supply.

9) Re-attach the ground wire to the base plate above the power supply.

## 5.12 MOTOR

The motor is a very robust stepping motor and very seldom needs to be replaced. All other related systems should be carefully checked prior to replacing the motor.

To replace the motor, it is first necessary to remove the control module, the safety barrier/control module mounting plate, and the component mounting bracket.

1) Loosen the screws holding the motor coupling in place until the coupling is loose.

2) Disconnect the wires connecting the motor to the motor driver.

3) Loosen the 4 bolts holding the motor to the motor mounting bracket and remove the motor. Use care, since the motor is quite heavy. Keep the motor coupling at hand for use in the next step.

4) Position the coupling on the drive shaft and put the new motor in position.

5) Connect the wires to the motor driver.

6) Replace the 4 bolts that hold the motor to the motor mounting bracket, but do not tighten. Slide the motor back and forth until it is properly aligned with the drive shaft. This is best determined by observing the brass spacer rings in the center of the motor coupling gaps; there should be even spaces on each side of the brass rings. In addition, the motor coupling should be able to slide freely up and down when the motor is properly aligned.

7) Tighten the 4 bolts holding the motor in place.

8) Tighten the screws in the motor coupling while being careful to observe that the screws are aligned with the flat spots on the drive shaft. It may be necessary to partially tighten the screws and then turn the drive shaft with the motor coupling until the screws can be tightened on the flat sides of the motor shaft.

# 6 MECHANICAL UNIT ACCESS PROCEDURES

## 6.1 TANK INTERFACE ASSEMBLY

The interface between the Model 6290 mechanical assembly and the storage tank consists of a pinch valve and a ball or gate valve. The pinch valve is required in case it is necessary to perform maintenance on the system while the probe and cable are still in the tank. The pinch valve may be closed on the cable, sealing off the tank so that the cover on the mechanical unit can be removed for maintenance or repair.

## 6.2 ACCESS PROCEDURES

**WARNING!**

**Since gas is contained in the mechanical unit housing, local safety precautions must be taken during any work that requires access to the mechanical unit.**

The housing is open to the tank during normal operation, and therefore contains gas vapor. Before the housing cover is removed, it must be isolated from the tank interior. Two valves are provided for this purpose, a pinch valve and a gate valve. During normal operation the probe drive cable passes through both these valves, therefore precautions must be taken before closing them. Damage will result if the gate valve is closed before the probe is above it!

**WARNING!**

**It is strongly recommended that local procedures require that the gate valve be chained and locked open to prevent inadvertent closing.**

The pinch valve may be closed with the probe in or out of the tank as long as the probe is above or below the pinch valve. The probe will be crushed if the pinch valve is closed on the probe. Under normal conditions, the probe should be driven up into the probe housing before the pinch valve is closed. If the drive mechanism is jammed, the pinch valve may be closed on the drive cable without damaging the drive cable to gain access to the drive mechanism. Do not attempt to drive the probe with the pinch valve closed.

## 6.3 MECHANICAL DRIVE COVER REMOVAL

1) Set the Interlock value in the control unit to a value equal to or above the maximum height of the probe enclosure. Failure to do this will result in the probe reaching interlock, which will stop the probe from driving up before it is above the pinch valve.

2) Station an observer on the top of the tank to view the probe when it enters the probe enclosure. This is the only sure way to know when the probe has reached the top of the tank.

3) Drive the probe up using the manual mode until the probe is in the probe enclosure. The center of the probe should be approximately at the center of the viewing window. The probe is approximately 18 inches long. The probe safety label is located in the center of the probe and may be used as an indicator of probe location.

**WARNING!**

**Any attempt to close the pinch valve with the probe not either above or below the valve will result in damage to the probe.**

4) Close the pinch valve. If the valve was all the way open, it should take about 17 turns to close the valve.

5) Allow the probe to warm up to ambient temperature for at least 4 hours. This will prevent condensation and icing when the probe is exposed to the atmosphere.

6) Loosen the bolts holding the drive mechanism housing cover in place and check to see if gas is leaking from the housing. The housing will be filled with gas vapor, but if the pinch valve is closed properly, there should be no pressure or noticeable gas flow. If gas is escaping, determine the cause and correct prior to proceeding. Remove all of the bolts holding the housing cover and lift the cover off.

### 6.4 PROBE REMOVAL

1) Remove the positive stop rod from over the probe enclosure.

2) Lift the probe out of the probe enclosure and lay it on the base of the mechanical housing.

### 6.5 CABLE REMOVAL

While it is possible to work on the probe when it is still on the tank, it is often easier to remove the probe/cable assembly and take it to a shop area for further work. This eliminates the necessity of soldering wires on top of the tank. Some of the parts inside the probe are quite small and can be difficult to work with, especially in adverse weather conditions.

**WARNING!**

**The drive cable should be treated very carefully at all times and not kinked in short bends. A “C” clamp or similar device is needed for this procedure.**

1) Remove the cable from the drive gear by removing the backup wheel that holds the cable against the gear.

2) Lift the probe off of the mechanical housing, unwinding the cable by rotating the take-up reel.

3) Continue to unwind the drive cable from the take-up reel making sure the cable is kept in large loops and is not tangled until the cable clamp is reached.

4) Fasten the take-up reel with a “C” clamp or some similar device so that it cannot turn once the drive cable is completely removed. Keep in mind that it is spring-loaded and will spin if not securely fastened.

5) Remove the cover on top of the take up reel to reveal the electrical connections for sensor leads.

6) Disconnect all of the electrical connections to the end of the drive cable at the terminal blocks on top of the take-up reel.

7) Remove the clamp holding the end of the drive cable to the take-up reel and remove the cable.

8) Wind the cable in large loops to facilitate transporting it to a shop area.

## 6.6 GEAR TRAIN REMOVAL

1) Loosen the set screws in the coupling just below the right angle drive.

2) Disconnect the cable from the drive gear by removing the backup wheel that holds the drive cable against the drive gear.

3) Remove the 4 gear train mounting bolts that attach to the legs holding the gear train.

4) Lift gear train from support legs.

## 6.7 PROBE DISASSEMBLY

All of the sensing elements are located in the probe assembly. The following procedure should be followed to gain access to those sensing elements if necessary.

1) Loosen the bottom reference switch actuator.

2) Remove the 4 screws at the top of the probe shroud.

3) Slide the lower shroud off of the probe, exposing the sensors.

NOTE: The mechanical fit of the shroud is very close. Care should be taken not to damage the shroud in any way or it may be difficult to fit it back again.

4) Loosen the set screws in the collar around the upper shroud.

5) Slide the collar up the cable. Note that 2 cable clamps will be loose at this time and may fall out. They should be removed when they are exposed.

6) Remove the 2 screws from the top of the upper shroud.

7) Remove the upper shroud exposing the sensor cup.

8) Remove the 4 screws from the sensor mounting cup cover.

9) Carefully pull back the cover from the top of the sensor cup to reveal the electrical connections between the drive cable and the sensors.

## 6.8 REEL DISASSEMBLY

In order to gain access to the sensor wires for trouble shooting purposes, it is necessary to remove the cover to the reel assembly. This will reveal the density maintaining amplifier and the end of the drive cable. Under normal circumstances, it is not necessary to further disassemble the take up reel.

# 7 MECHANICAL UNIT PARTS REPLACEMENT

## 7.1 DRIVE CABLE

1) Follow the access and probe removal procedures including Probe Disassembly. This will reveal the connections at the end of the cable to the probe sensors. Refer to drawing 050-194.

2) Carefully unsolder all of the connections at the end of the cable that attach to the terminal posts. Note that some of the sensor wires are very small and can be easily damaged.

3) Remove the sensor cup cover by loosening the set screws on either side.

4) Two cable clamps holding the cable to the sensor cup cover will now be loose and should be removed.

5) Slide sensor cup cover off of the end of the cable.

## 7.2 LEVEL SENSOR

1) Follow the access and removal procedures detailed in the Probe Disassembly section. This will reveal the connections to the level sensor.

**WARNING!**

**Note that there is a vertical separation between the upper and lower level sensor. This separation must be maintained. The upper sensor must be higher than the lower sensor or the system will not function properly.**

2) Carefully unsolder the wires going to the level sensor that is to be removed. Note that the wires are quite small and can be easily damaged, so great care should be used when working with these wires.

3) Loosen the compression fitting holding the level sensor and remove the sensor.

4) When replacing the new sensor, make sure the bottom tip of the upper sensor is about 1/4" (6 mm) higher than the bottom tip of the lower sensor.

## 7.3 TEMPERATURE SENSOR

1) Follow the access and removal procedures detailed in the “Mechanical Unit Access Procedures” section above including “Probe Disassembly.” This will reveal the connections to the temperature sensor.

2) Unsolder the temperature sensor leads making sure not to damage any of the other sensor leads.

3) Loosen the compression fitting holding the temperature sensor.

4) Loosen the safety wire holding the bottom of the temperature sensor.

5) Remove the temperature sensor and replace with a new element.

## 7.4 DENSITY METER

NOTE: The density meter (in the probe) and the density maintaining amplifier (just inside the take up reel) are a matched pair and must be replaced together.

1) Follow the access and removal procedures detailed in the Mechanical Unit Access Procedures section above including Probe Disassembly. This will reveal the connections to the density meter.

2) Unsolder the density meter leads taking care not to damage the other sensor leads. Also, take care to note the proper connections so that the new meter may be wired in exactly the same way. All sensor leads are color-coded and should be matched exactly.

3) Remove the 2 flat head screws holding the mounting straps to the sensor-mounting block.

4) Remove the mounting straps from the density meter and place them on the new density meter.

5) Install the meter back on the sensor-mounting block, connect wires and reassemble.

6) Replace the density maintaining amplifier which is mounted inside the take up reel with the one supplied with the new density meter.

## 7.5 BOTTOM REFERENCE SWITCH

1) Follow the access and removal procedures detailed in the “Mechanical Unit Access Procedures” section above to the point of removing the probe.

2) Remove the probe shroud as described in the “Mechanical Unit Access Procedures” section above. This will reveal the bottom reference switch.

3) Loosen screws holding the switch and remove.

4) Unsolder the 2 wires leading to the switch.

5) Connect the new switch. Note that the connections are to the common and normally open terminals.

6) Reassemble and adjust the switch following the procedure below.

## 7.6 BOTTOM REFERENCE SWITCH ADJUSTMENT

As described previously, this switch is located within the probe assembly. Referring to drawing 040-372 and 050-236 will aid in following the adjustment procedure. Adjustment of the switch to provide proper operation is provided for by means of a locking screw and an associated slot in the lower shroud.

The procedure for making this adjustment is as follows:

1) Extract the probe assembly from the tank.

2) Connect an ohmmeter across the upper sensor.

   NOTE: A convenient connection point is between TB1-1 and TB1-2 of the Drive Cable Interface Board (see drawing 050-236).

3) With reference to drawing 040-372, locate the lower shroud at its midpoint of travel over the slide block.

4) Loosen the actuator screw approximately one (1) turn.

5) Slide the actuator up or down, as applicable, until the ohmmeter indicates that the "bottom reference" switch has closed.

6) Lock the actuator screw.

7) Move the lower shroud between its upper and lower limits and check that switch closing and opening occurs at the mid-point of travel. Re-adjust the actuator, if necessary.

8) Lower the probe assembly into the probe enclosure.

   **NOTE: The probe must be completely dry before being reintroduced into the tank or the system may not function correctly!**

9) Replace the cover on the drive mechanism.

10) Activate the system and manually drive the probe assembly down and up inside the probe enclosure to verify proper operation of the "probe at reference" circuit.

11) Re-enter the initial interlock value.

12) Open the pinch valve fully.

13) Activate the system and initiate the calibration mode.

## 7.7 MECHANICAL UNIT COVER GASKET

1) Follow procedures for removal of cover.

2) Remove old gasket.

3) Beginning at the top of one end, insert new gasket in slot using silicon adhesive to hold in place.

4) Replace cover and check carefully for leaks.

## 7.8 REEL FEEDBACK SWITCH

1) Open the mechanical enclosure.

2) Before replacing switch, check adjustment very carefully. Switch should be approximately ¼ " (3 mm) above take up reel at all points when rotated. At times, it may be rotated or moved in a horizontal direction to gain improved performance.

3) Disconnect wires from terminal block.

4) Loosen screw holding switch to bracket and remove switch.

5) Mount and connect new switch.

## 7.9 TAKE-UP REEL SPRING MOTOR

**SPECIAL NOTE:**

**IMPORTANT!**

***Replacing the spring is more difficult than it first appears. Besides its natural tendency to snap to its unloaded state, other problems associated with the stainless steel rope and helical drive cables can cause major problems.***

- The spring motor is attached to the larger reel with two screws and free wound onto the smaller reel.

- The spring is usually shipped in a free wound condition with mounting holes exposed on the outside wrap. It must be re-wound on itself so the mounting holes are on the inside.

### 7.9.1 DISASSEMBLY

- In order to remove the old spring and install the new one, the entire take-up reel must be allowed to rotate an additional 2 to 3 turns in a counterclockwise direction. This can be accomplished by following the procedure:

1) Rotate magnetic feedback switch out of position.

2) Remove 2 wraps of helical drive cable over top of the take-up reel.

3) Allow spring to re-coil cable onto reel.

4) If spring mounting screws are still not visible, one additional wrap may need to be removed and re-coiled.

- Tension of spring must be maintained on stainless wire rope (#5) until mounting screws are visible.

5) Tape (masking or equivalent) wire rope in place on both spools. The rope must not be allowed to fall off the spindle (major problems if this occurs).

6) Remove spring mounting hardware.

***CAUTION!***

***The springs natural state is to reverse wind on the small reel and will snap the moment the screws are removed.***

7) Remove the old spring from the small free turning reel.

### 7.9.2 INSTALLATION

1) Wind new spring onto small reel by feeding end onto spool while turning clockwise. Continue until the entire spring is mounted and two mounting holes are on outer wrap.

2) Feed the free end of spring behind larger reel and heading toward the front in a clockwise direction.

3) While holding the spring in position aligning the mounting holes, install both mounting screws.

### 7.9.3 REEL CORRECTION

This is to pre-load the spring and return the 2 to 3 coils of helical cable to the take up reel.

1) Remove the tape from the wire rope reels.

2) Rotate the large cable take-up reel clockwise one (1) turn by pulling on the helical drive cable.

3) Rewind one turn of cable by looping over top of reel.

4) Repeat 1 or 2 more times depending on the number of turns removed in the disassembly process.

5) Reposition the magnetic switch over the magnet and test for proper operation.