SCIENTIFIC INSTRUMENTS

SI-7000 Online Informational Catalog

Cryogenic Temperature Sensors and Instruments • Aircraft Temperature Probes • LNG Tank Gauging
Engineering and Design Services

4400 W. Tiffany Drive, West Palm Beach, Florida 33407 USA • P: (561) 881-8500 • F: (561) 881-8556
info@scientificinstruments.com • www.scientificinstruments.com

Version 2. Updated 7/29/2021

SCIENTIFIC INSTRUMENTS

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SCIENTIFIC INSTRUMENTS

SI-7000

The New SI-7000 LTD Tank Gauge System

The leader in Rollover Prevention in LNG Storage Tanks

The latest generation SI Gauge model SI-7000 is the industry's leading solution for level, temperature, and density profiling in LNG & LPG storage tanks. The third generation LTD from Scientific Instruments is designed to detect stratification and to provide the DCS and other host the data necessary for rollover prediction and prevention, as well as for fiscal calculations. The LTD provides real-time and averaged measurement data that is used to monitor conditions inside the tank. This data also provides early warnings to plant operators, thus empowering them to make smart decisions and to take control of situations before becoming dangerous emergencies.

PROVEN TECHNOLOGY

Accuracy & Reliability
Dedicated Sensors for Level, Temperature and Density embeded into a single housing / Probe

INNOVATION

Smart Electronics
Single Control Module, easily accessible for service & maintenance

RELIABILITY

Reliable Mechanical Drive
Robust 316 SS Vertical-Gear-Drive mechanism (VGD) & 304 SS Chain

CONNECTIVITY

Flexible Connectivity
Standard RS-485 MODBUS

About us

Scientific Instruments was founded in 1967 by Aeronautical Engineer Jack Hoey and Physicist Gib Halverson. Their core competence focussed on precision cryogenic thermometry. Their accomplishements include creating the first Germanium Resistance Thermometer (GRT) used by NASA for Apollo missions.

In 1975 they also invented / patented the first LTD system. An intelligent system comprising of multi-sensors embedded into a single probe capable of measuring Level, Temperature and Density inside LNG Storage Tanks.

Current CEO Leigh Ann Hoey has been successfully leading & transforming the company while proceeding her Father's legacy

Why Choose us

- Original inventor of the first LTD in 1975, globally recognized as the "SI Gauge"
- Market Leader, with more than 500 units installed in LNG Storage Tanks around the world.
- Market focus, providing LNG and Cryogenic Measurement solutions since 1967.
- Global sales and technical support. Providing Turn-Key Tank Gauge Solutions

4400 W. Tiffany Dr.
West Palm Beach, FL 33407

P 561-881-8500
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sales@scientificinstruments.com
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SI-7000 Specifications

Level
- Range: 56 m (longer check w/factory)
- Resolution: < 1 mm
- Accuracy: < ±2 mm
- Top and Bottom reference

Temperature
- Sensor Range: -200°C to +50°C
- Resolution: 0.01
- Accuracy: ±0.1°C

Density
- Oscillating Spool
- Range: 400 to 1000 kg/m3
- Resolution: 0.01 kg/m3
- Accuracy: ±0.5 kg/m3

Electrical
- Power Supply
- 85-264 VAC, 47-63 Hz, 150 W

Communications
- (2) Standard RS-485 MODBUS

Sensor Isolation
- Intrinsically Safe

Physical
Maximum Operating Pressure
- 400 mbarg (for higher, consult factory)

Protection Class
- Designed to meet IP65

Mounting Flange
- Standard 6" ANSI 150#RF (more available upon request)

Sensor Drive
- Stainless Steel Chain

Housing Material
- 316 Stainless Steel

Safety Certification
- IECEx / ATEX , cml Ex , PESO, UL / CSA

Seismic Rating
- Designed to meet 3.0G (testing required)

Stilling Well
- With or Without (Consult Factory)

Isolation Valves
- External Pinch Valve (Required)

Ambient Temperature
- - 40°C to +60°C

Dimensions
- 125 (50) × 76 (30) × 37 (15) cm (in.)
- Weight: 180 (396.8) kg(lbs.)

OUR GLOBAL INSTALLED BASE SINCE 1976 **

**Includes new and previous LTD versions
Quantities vary

SCIENTIFIC INSTRUMENTS

Cryogenic Temperature Sensors and Instruments • Aircraft Temperature Probes • LNG Tank Gauging

Engineering Design Services, Integrated Solutions and Technical Services

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.: IECEx SEV 19.0035X

Issue No: 0

Certificate history:
Issue No. 0 (2019-09-11)

Status: **Current**

Page 1 of 3

Date of Issue: **2019-09-11**

Applicant: **Scientific Instruments**
4400 West Tiffany Drive
West Palm Beach
FL 33407
United States of America

Equipment: **Tank Gauging System**
Optional accessory:

Type of Protection: **d, i, h**

Marking:

Electrical Compartment: Ex db [ia IIC Ga] IIB T4 Gb

Mechanical Compartment: Ex h IIC T4 Ga

Probe Assembly: Ex ia IIC T4 Ga

Approved for issue on behalf of the IECEx Certification Body: Martin Plüss

Position: Manager Product Certification

Signature:
(for printed version)

Date: 2019-09-11

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3. The Status and authenticity of this certificate may be verified by visiting the Official IECEx Website.

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CH-8320 FEHRALTORF
Switzerland

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IECEx Certificate of Conformity

Certificate No:	IECEx SEV 19.0035X	Issue No: 0
Date of Issue:	**2019-09-11**	Page 2 of 3
Manufacturer:	**Scientific Instruments** 4400 West Tiffany Drive West Palm Beach FL 33407 **United States of America**	

Additional Manufacturing location(s):

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:

The apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

IEC 60079-0 : 2011 Edition:6.0	Explosive atmospheres - Part 0: General requirements
IEC 60079-1 : 2014-06 Edition:7.0	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC 60079-11 : 2011 Edition:6.0	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
ISO 80079-36 : 2016 Edition:1.0	Explosive atmospheres - Part 36: Non-electrical equipment for explosive atmospheres - Basic methods and requirements
ISO 80079-37 : 2016 Edition:1.0	Explosive atmospheres - Part 37: Non-electrical equipment for explosive atmospheres - Non electrical type of protection constructional safety "c", control of ignition source "b", liquid immersion "k"

*This Certificate **does not** indicate compliance with electrical safety and performance requirements other than those expressly included in the Standards listed above.*

TEST & ASSESSMENT REPORTS:

A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in

Test Report:

CH/SEV/ExTR19.0036/00

Quality Assessment Report:

GB/BAS/QAR14.0004/04

IECEx Certificate of Conformity

Certificate No: IECEx SEV 19.0035X Issue No: 0

Date of Issue: **2019-09-11** Page 3 of 3

Schedule

EQUIPMENT:

Equipment and systems covered by this certificate are as follows:

Tank Gauging System

Type: SI-7000

Tank Gauging System, model SI-7000 is a process monitoring instrument capable of monitoring liquid media (including LNG and other fuels) in tanks to 200' depth.

Additional information see Annexe

SPECIFIC CONDITIONS OF USE: YES as shown below:

Specific Conditions of Use" / "Schedule of Limitations":

Flameproof joints are not intended to be repaired.

Annex:

IECEx SEV 19.0035 Annexe Issue 0.pdf

SCIENTIFIC INSTRUMENTS

SI-7000

Tank Gauging System

DCS Modbus
Interface Specification

SCIENTIFIC INSTRUMENTS, INC.
4400 W. Tiffany Dr. West Palm Beach, FL 33407 U.S.A.
020-701 Rev B

Table of Contents

1 General Description

This document defines a limited implementation of the Modbus protocol for the Scientific Instruments SI-7000 LTD. This document should provide programmers with the details necessary to prepare and test the user interface on a host computer.

The LTD is a tank gauging system designed to measure level, temperature and density in large tanks of cryogenic liquids (e.g. liquid natural gas). A probe is driven up and down in a tank to collect temperature and density data, as specified by the operator. The data is stored in memory for output to the host computer on demand. The programmer should read and be familiar with the Operation Manual for the LTD, as the basic system operation information is not duplicated here.

In the general Modbus specification, certain characteristics are fixed, such as frame format and frame sequence. Other characteristics are variable, including the type of interface (e.g. RS232, RS485), baud rate, parity, number of stop bits and transmission mode (ASCII or RTU). In the LTD implementation of the Modbus interface, the interface type is RS485. (To interface with the host computer using RS232, a converter must be used.) The baud rate is fixed at 9600 baud, and the other parameters are odd parity, 8 data bits, and 1 stop bit. The transmission mode used is RTU.

The Modbus interface allows the host computer access to the LTD's current mode of operation, the direction and speed of the probe, individual system status and alarm bits, profile data, and current tank conditions. The mode of operation can be controlled via Modbus, and the probe can be driven manually at several different speeds.

Output of level, temperature, and density will be scalable in future firmware versions.

In the last section, programming suggestions are given to assist the programmer in handling important information and status bits appropriately.

Note:

The minimum time for the Command/Request from Host (PC) to Device (LTD) should be 1 Second.

2 Data Addressing & Data Definition

A number of Modbus functions are utilized in the LTD Modbus interface. Function 1 is used to read system mode, motor drive direction, and speed, while Function 5 is used to set them. Function 2 is used to read individual status and alarm bits. Function 3 is used to read profile and alarm configuration registers and Function 6 makes it possible to set them. Function 4 allows the host computer to read sensor data from the LTD.

When more than one tank is connected to a host computer, each tank must be addressed and scanned individually. The Device ID is the Tank ID of each system, as explained below in the Communication Settings section of the Hardware Specifications.

2.1 Mode, Speed (Digital Output or Input, 1 Bit) (Functions 1, 5)

Mode, Speed Base Address = 0001
Maximum Legal Address = 0016

The bits are defined as follows:

Parameter	Address
Manual	00001
Calibrate	00002
Auto	00003
Profile	00004
Reserved	00005
Reserved	00006
Reserved	00007
Reserved	00008
Stop	00009
Up Slow	00010
Up Medium	00011
Up Fast	00012
Down Slow	00013
Down Medium	00014
Down Fast	00015
Reserved	00016

The information shown above gives the current LTD mode of operation and the probe's movement and can be accessed using Function 1. These are individual bits, not registers. Any of these quantities may be set using Function 5 with the same address.

Bits 1 – 5 indicate the current mode of operation. Each mode is mutually exclusive, so that if one bit is set, the others are cleared. When using Function 5 to change the system mode, it is only necessary to set the bit corresponding to the new mode. It is not necessary (or possible) to manually clear the bit corresponding to the old mode.

Bits 9 – 15 indicate the probe's direction and speed of travel. Again, each drive speed is mutually exclusive, so if the host computer sets one bit using Function 5, the others are automatically cleared.

These bits may be read to determine current system status at any time without any effect on the system mode of operation, but it should be noted that manually setting any of the bits relating to the probe's direction and speed of travel will halt any profile activity or liquid level tracking that is taking place and put the system in the Manual drive mode. The system will continue indefinitely in this mode until it is set back to "Auto", "Cal", or "Profile." The system will not be able to perform any of its automatic functions while it remains in the Manual mode. One suggestion to bring attention to this condition would be to indicate the manual mode in red to alert the operator that this is not the normal mode of operation. The "Auto" mode, on the other hand, could be indicated in green, since this is the normal mode of operation where liquid level will be tracked continuously.

2.2 Status, Alarms (Digital Input, 1 Bit) (Function 2)

The main purpose of this document is to provide the information necessary for a programmer to develop a user interface for the LTD on a host computer.

Status Base Address = 10001
Alarms Base Address = 10017
Maximum Legal Address = 10032

2.2.1 Status Bits

The status bits provide important information about system operation and are essential for verifying that data reported by the LTD is current and valid. Each status bit (or status indicator) is given along with its address. They are defined as follows:

Status Indicator	Address	
Bottom Reference	10001	
Lower Level Sensor	10002	
Upper Level Sensor	10003	
Interlock	10004	
Profile Complete	10005	
Metric	10006	
Reserved	10007	
Reel Alarm Disable	10008	
Reel Alarm	10009	
Probe Un-calibrated	10010	
Reserved	10011	
Interval Timer	10012	
Probe At Liquid Level	10013	
Reserved	10014	
Reserved	10015	
Reserved	10016	

Some of these status indicators provide information that is more important than others for plant operators to see. The ones that are essential and should definitely be reported in any custom user interface are Bottom Reference, Lower Level Sensor, Upper Level Sensor, Interlock, Reel Alarm, Probe Un-calibrated, Interval Timer, and Probe At Liquid Level. The others are optional, as explained below.

Bottom Reference is activated whenever the bottom reference switch is closed, indicating that the probe is on the bottom of the tank. **Lower Level Sensor** and **Upper Level Sensor** are set whenever the sensors are in liquid. These are important for observing the physical conditions around the probe and verifying where it is in the tank.

Interlock is set whenever the probe is at the maximum allowed probe position; the probe will not drive up any more when it reaches Interlock. It usually indicates some kind of error condition if the probe reaches Interlock during normal operation, since the probe should be at liquid level or below. This could also happen if an operator drives the probe up manually.

When **Reel Alarm** is set, it shows that a physical drive problem has occurred. This indicates the need for investigation by maintenance personnel and is absolutely essential for monitoring proper operation of the equipment.

Probe Un-calibrated is activated whenever it is possible that the current probe position is not correct. This status indicator is also important, since it means that the liquid level value reported may be incorrect as well.

When **Interval Timer** is set, it indicates that the system will perform profiles automatically at the programmed interval. If not set, profiles can be run manually.

Probe At Liquid Level is set whenever the system is in Auto and the probe is at the liquid/vapor interface. This means that the level reported is current.

The status indicator, **Profile Complete**, may be of more importance to the programmer than to the operator. When this indicator is cleared, the LTD is in the process of running a profile. When this indicator is set, it means that the profile is complete and the data can be collected and analyzed. The remaining status indicators are not normally needed by operators, but they are useful for someone checking the complete status of the equipment. **Reel Alarm Disable** should not normally be set, because this overrides a safety feature in the equipment that could prevent possible damage in the event of equipment failure. Having an alarm tied to this indicator would help prevent it from being set without operator knowledge. The status indicator, **Metric**, will be set if values are reported in metric units, and cleared if values are reported in English units. Once this is set, it should not need to be changed.

2.2.2 Alarms

The alarm bits relate to conditions of liquid in the tank and are important with respect to plant operation. Each alarm is given along with its address. The alarms are defined as follows:

Alarm	Address	
Low Density	10017	
High Density	10018	
Low Temperature	10019	
High Temperature	10020	
Low, Low Level	10021	
High, High Level	10022	
Low Level	10023	
High Level	10024	
Profile Temperature Deviation	10025	
Profile Density Deviation	10026	
Reserved	10027	
Reserved	10028	
Profile Low Temperature	10029	
Profile High Temperature	10030	
Profile Low Density	10031	
Profile High Density	10032	

2.3 Profile & Alarm Control (Analog Output or Input) (Functions 3, 6)

Functions 3 and 6 are used to read and control profile settings and product alarm settings. This makes it possible for operators to completely control the profiles and change alarm settings from the DCS.

2.3.1 Addressing

Base Address = 40001
Maximum Address = 40023

Parameter	Address
Profile First Point	40001
Profile Increment	40002
Profile Dwell Time	40003
Reserved	40004
Reserved	40005
Reserved	40006
Reserved	40007
Reserved	40008
Reserved	40009
Automatic Profile Interval	40010
Automatic Profile Enable	40011
Automatic Profile Hour	40012
Automatic Profile Minute	40013
Low Density Alarm Set Point	40014
High Density Alarm Set Point	40015
Low Temperature Alarm Set Point	40016
High Temperature Alarm Set Point	40017
Low Low Level Alarm Set Point	40018
High High Level Alarm Set Point	40019
Low Level Alarm Set Point	40020
High Level Alarm Set Point	40021
Temperature Deviation Alarm Set Point	40022
Density Deviation Alarm Set Point	40023

2.3.2 Definition

When a profile is initiated, the probe drives to the tank bottom and starts the profile there. **Profile First Point** is the first programmed point at which the probe will stop on the way up to take temperature and density measurements. (Actually it is the second point in the profile, since the first point is always at the bottom of the tank.)

Profile Increment is the distance that is added to the first point and each successive point to determine where to stop and take readings on the way back to the surface of the liquid.

Profile Dwell Time is the time in seconds that the probe will pause at each point to allow readings to stabilize before recording the value.

A profile can be started manually by switching the mode to Profile Mode. Alternatively, a profile can be run automatically at either a fixed time each day or at regularly repeated intervals.

Automatic Profile Interval designates the number of minutes between each successive profile run (after the first profile starting at **Automatic Profile Hour** and **Automatic Profile Minute**).

Automatic Profile Enable designates whether profiles will be run automatically or not. A value of 0 disables automatic profiles. A value of 1 causes profiles to be initiated at the programmed time each day and at the interval chosen. If only one profile is desired per day, the interval should be 1440 minutes (to start it the next day at the same time). The first profile (after enabling the feature) will be at the time defined in **Automatic Profile Hour** and **Automatic Profile Minute**.

The remaining quantities set the alarm limits for low and high density values, temperature values, liquid level, and temperature and density deviations. **Temperature Deviation Limit** is the amount of change in temperature from one point to the next in a profile that will cause an alarm. **Density Deviation Limit** is the amount of change in density from one point to the next in a profile that will cause an alarm.

2.3.3 Scaling

In the LTD implementation of the Modbus specification for Functions 3, 4, and 6 the values are communicated to the DCS using 16 bit signed or unsigned integers, so it must be decided what each integer will represent. Each quantity is scaled between high and low limits for the value being reported, along with high and low scale values. These limits are currently fixed. (In a future firmware version it will be possible to change them, and the proper values for each site will be established during commissioning if not previously set.)

Separate scaling factors are set for level, temperature, and density. The following table defines the scaling.

	Low Limit	High Limit	Low Scale	High Scale	Value to be reported from LTD	Value Sent to DCS
Level (m)	0 m	65.000 m	0	65000	15.000 m	15000
Temperature	-327.68	327.67 °C	-32768	32767	-160.00	-16000
Density (kg/m^3)	0	655.35 kg/m^3	0	65535	450.00	45000
Level (ft)	0 ft	200.00 ft	0	60000	100.00 ft	30000
Temperature	-327.68	327.67 °F	-32768	32767	-256.00 °F	-25600
Density (lb/ft^3)	0	65.535 lb/ft^3	0	65535	27.500	27500

For Level (in metric units), the 16-bit integer value in the Modbus register would read directly in millimeters of liquid level as an unsigned integer. Each count of the Modbus integer would represent 1 mm. For temperature (both English and metric), each count would represent 100th's of a degree in each respective scale, and would be reported as a signed integer.

When reading or writing quantities relating to level (such as Profile First Point, Profile Increment, and High Level Alarm Set Point), use the scaling factors for Level. This applies both to quantities received and transmitted. Quantities received from the host computer are interpreted according to the current scaling values in effect. Dwell times are in seconds.

2.4 Sensor Data, Profile Data (Analog Input) (Function 4)

The current conditions in the tank at the location of the probe and information about the condition of the tank during the last profile are given by the sensor data and profile data quantities.

2.4.1 Addressing

Base Address for Sensor Data = 30001
Maximum Legal Address = 30620

Parameter	Address
Current Probe Position	30001
Current Temperature	30002
Current Density	30003
Liquid Level	30004
Reserved	30005
Number of Points	30006
Profile Month	30007
Profile Day	30008
Profile Hour	30009
Profile Minute	30010
Current Hour	30011
Current Minute	30012
Current Second	30013
Reserved	30014
Reserved	30015
Reserved	30016
Reserved	30017
Reserved	30018
Reserved	30019
Reserved	30020
Profile Probe Position Point 0	30021
Profile Temperature Point 0	30022
Profile Density Point 0	30023
Profile Probe Position Point 1	30024
Profile Temperature Point 1	30025
Profile Density Point 1	30026
Profile Probe Position Point n	30021 + (3 * n)
Profile Temperature Point n	30022 + (3 * n)
Profile Density Point n	30023 + (3 * n)
Profile Probe Position Point 199	30618
Profile Temperature Point 199	30619
Profile Density Point 199	30620

Note: The term “profile probe position” is used instead of “profile level,” because in this document, level is usually used to indicate the actual liquid level. Only the last point in a regular profile is actually at “liquid level.”

2.4.2 Definition

Current Position, Current Temperature, and **Current Density** are the current values where the probe is now, whether at the bottom of the tank or at liquid level. **Liquid Level** holds the most recent liquid level reading. If the probe is beneath the surface, such as during a profile, the liquid level reading will not be updated until the probe returns to the surface. The status indicator "At Liquid Level" (described in a previous section) is used to show when the value reported is up to date.

Number of Points contains the number of profile points collected during the last profile. The number of points is determined by the location of the programmed starting point, the increment added, and liquid level. The first point in a profile is always the bottom of the tank. The next point is programmable, and is usually set to an whole number such as 1 m, and then a programmable increment is added (also normally 1 m). This puts profile points at whole numbers, such as 1 m, 2 m, 3 m, etc. The probe moves up, collecting data until liquid level is reached (or the maximum number of points is reached, causing the profile to terminate prematurely). The last point is normally at liquid level.

The maximum number of points allowed is 500 (0 to 499). To limit the number of points to a lower value, set the profile increment so that at maximum liquid level, the number of points will not exceed the desired limit. For example, if maximum liquid level is 30 m and the profile increment is 1 m, the maximum number of points would be 31 (including the bottom reference point) and the total number of registers needed for position, temperature and density would be 93 (31 x 3).

Profile Month, Profile Day, Profile Hour, and **Profile Minute** show the date and time when the first profile point is collected. **Current Hour, Current Minute, and Current Second** show the current system time. One way to constantly verify communications with the LTD is to monitor the system time and verify that it is always changing. If it stops changing, an alarm should be generated.

The probe position, temperature, and density for each point collected in a profile are available at the addresses shown. Data in registers beyond the number of points collected will be zero.

2.4.3 Scaling

The scaling for Function 4 values is controlled by the same parameters that are used for values in Functions 3 & 6. Please refer to that section for more information about scaling.

3 Hardware Specifications

3.1 General

A host computer may be connected directly to the LTD using the RS485 field wiring. A site-wiring diagram is generally provided for each site. In order to establish communications, there are a number of data parameters that must be set properly.

3.2 Communication Settings

In one possible configuration, the LTD is connected to the Tank Gauge Interface Module (TGIM). The TGIM serves as a power switch and power indicator for the gauge and a connection point for all field wiring. It is usually located in the control room or in a field equipment room. There are normally 2 communication links, and these may be used for communication with a host computer. They are referred to as Host 1 and Host 2.

The LTD communication links use RS485. To interface with the host computer using RS232, a converter must be used. The default baud rate is 9600 baud, and this cannot be changed at this time. The other parameters are odd parity, 8 data bits, and 1 stop bit. The transmission mode used is RTU.

The Modbus protocol requires the use of an address. The Tank ID in the LTD may be set using the touch screen user interface, and also serves as the Modbus address. If more than one LTD is connected on the same data bus, it is important to set a unique address for each unit.

4 Programming Suggestions

4.1 Introduction

To completely understand the operation of the LTD, the programmer should read the Operation Manual. While not all of the information is duplicated here, many relevant details are given to assist in the programming task. Below are some suggestions on how to use the information available from the LTD.

The primary uses of the LTD are 1) to obtain accurate liquid level information, and 2) to obtain temperature and density profile information that will enable the detection of unsafe layering conditions. Layers detected by the LTD are indicated by the Temperature and Density Deviation alarms.

The relative importance of the various status bits has been covered in the section above where the addresses of the status bits are given. Refer to that section for a better understanding of which indicators are most important for the operators to see.

4.2 Finding Liquid Level

After powering on the LTD, accurate liquid level information is available only after the probe has touched the bottom of the tank and been driven back to the liquid/vapor interface. When the system is powered off, the last known probe position and liquid level are stored in non-volatile memory, and the same values are recalled when the system is powered on, but the “Un-cal” indication appears, since it is possible that these values are no longer correct.

To clear the “Un-cal” indicator, it is necessary to touch the bottom of the tank. This will automatically set the probe position to the value that should be displayed at the bottom of the tank.

The LTD can be set to remain in Manual Mode or go directly into Cal Mode on power up. If it remains in Manual, a calibration should be initiated manually and after that it will remain in Auto Mode, measuring liquid level. With a system commissioned in a tank with liquid, that should be all that is necessary. The LTD will automatically go through the steps to find liquid level, switch to Auto mode and monitor the liquid level.

4.3 Profile Information

A profile is initiated by placing the controller into the Profile mode. This may be done via the touch screen user interface, the automatic interval timer, or a command sent from a host computer. Point 0 is always the bottom point, and the liquid level is the last point. The number of points collected is given in the "Number of Points" variable. The probe is stopped at each point for a specified wait time (called “dwell time”) for stabilization. Temperature and density are measured, and then the probe is driven to the next point. The unit is returned to the AUTO mode when the profile is completed.

As a profile is being collected, the “Number of Points” variable is incremented after each new point. Using this variable makes it possible to import only valid data points. When the probe first touches the bottom of the tank at the beginning of a new profile all the previous data points in memory and the “Profile Complete” status indicator are cleared. When the profile is complete and all data is available, the “Profile Complete” status indicator is set.

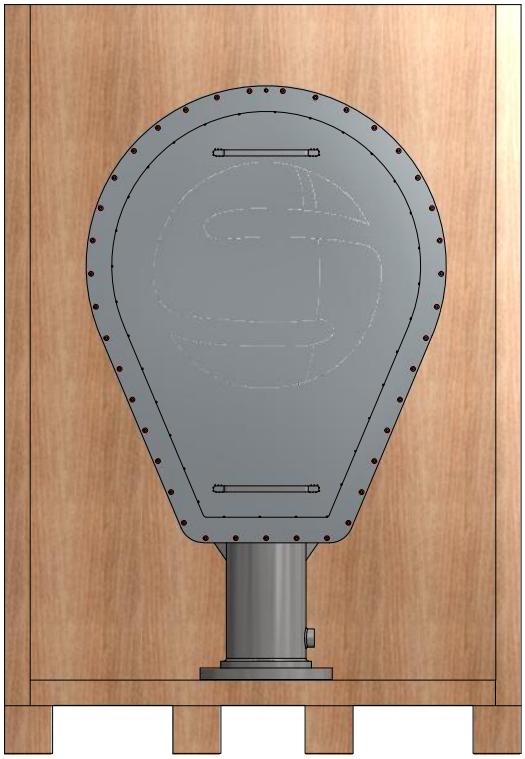
4.4 Profile Graphing

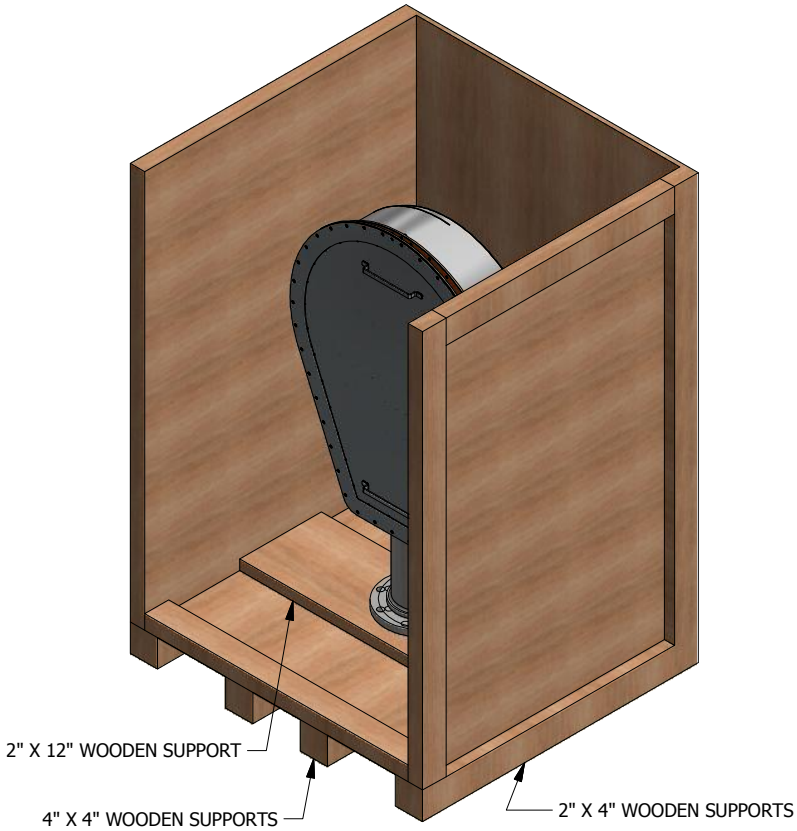
The easiest way to see stratification of temperature and density in a tank of liquid is by graphing the data. In order for this graph to be meaningful, it must have a high resolution. The expected changes in the data are small, and the graph must be able to show those changes. It is recommended that the range of temperature and density be chosen carefully. One way to achieve the correct scaling is to make the values read at the first point at the bottom of the tank as the center of the graph, and then plot a deviation from those values as the level increases. On most LNG tanks, it should be suitable to show a deviation from the center of 5 kg/m^3 or 0.3 lb/ft^3.

REVISION HISTORY						
ECR No.	REV	DESCRIPTION	REV. BY:	DATE:	APPR. BY:	DATE
N/A	-	Initial Release	AS/WWJ	4/2/18	WWJ	4/2/18

TYPICAL PACKAGING CONSTRUCTION

SI-7000 ASSY SHOWN





STORAGE REQUIREMENTS

PACKAGING IS DESIGNED FOR INSIDE STORAGE BUT MAY BE KEPT OUTSIDE IN A COVERED AREA FOR A SHORT PERIOD.
CRATES ARE MARKED WITH INTERNATIONAL SYMBOLS TO INDICATE PROPER HANDLING.

CRATE CONSTRUCTION

ALL ITEMS SHIPPED IN WOODEN CRATES. THE CRATES ARE CONSTRUCTED FROM 5/8" THICK PLYWOOD USING 2" X 4" LUMBER FOR SUPPORT AT ALL CORNERS AND EDGES AS REQUIRED. ADDITIONAL 2" X 4" AND 2" X 12" LUMBER IS USED AS REQUIRED FOR INTERNAL BRACING.
THE CRATE IS ALSO BANDED WITH STEEL STRAPS.

PACKAGING

TOP OF TANK ASSEMBLIES:
THE MECHANICAL ASSEMBLY IS PURGED WITH NITROGEN AND SEALED.
THE ELECTRONIC ENCLOSURE MOUNTED TO THE MECHANICAL ASSEMBLY IS PURGED WITH NITROGEN GAS AND DESICANT PLACED INSIDE THE COVER.

PACKAGING

CONTROL ROOM ELECTRONICS/MANUALS:
ALL ITEMS ARE SECURELY PACKED IN A CARDBOARD BOX AND THEN VACUUM-SEALED IN A PLASTIC BAG.
SPARE PARTS, IF ORDERED WITH THE SYSTEM ARE ALSO PACKED INSIDE A PLASTIC BAG AND VACUUM SEALED.

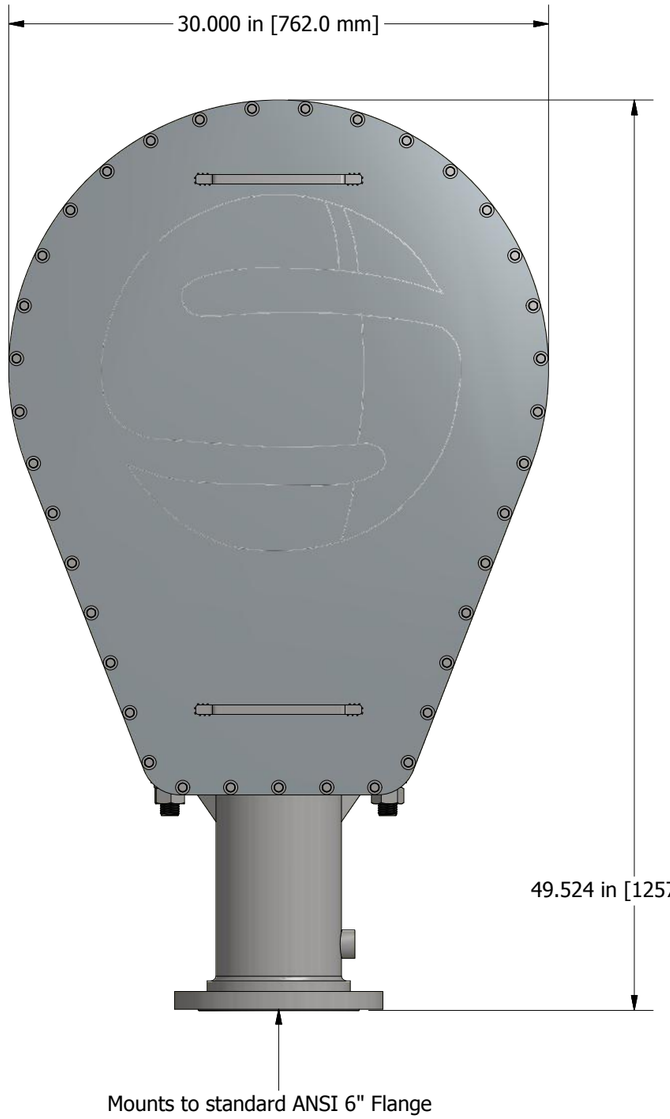
Schedule Drawing
No modifications permitted without reference to the Notified Body

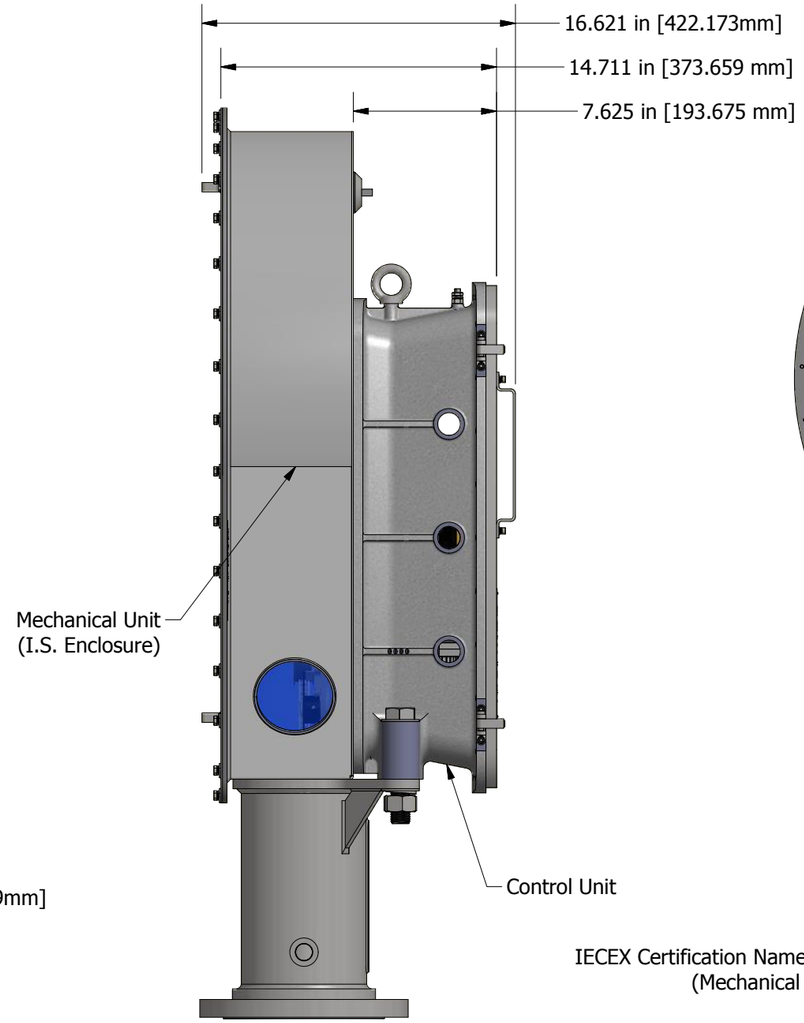
APPROXIMATE WEIGHT AND DIMENSIONS

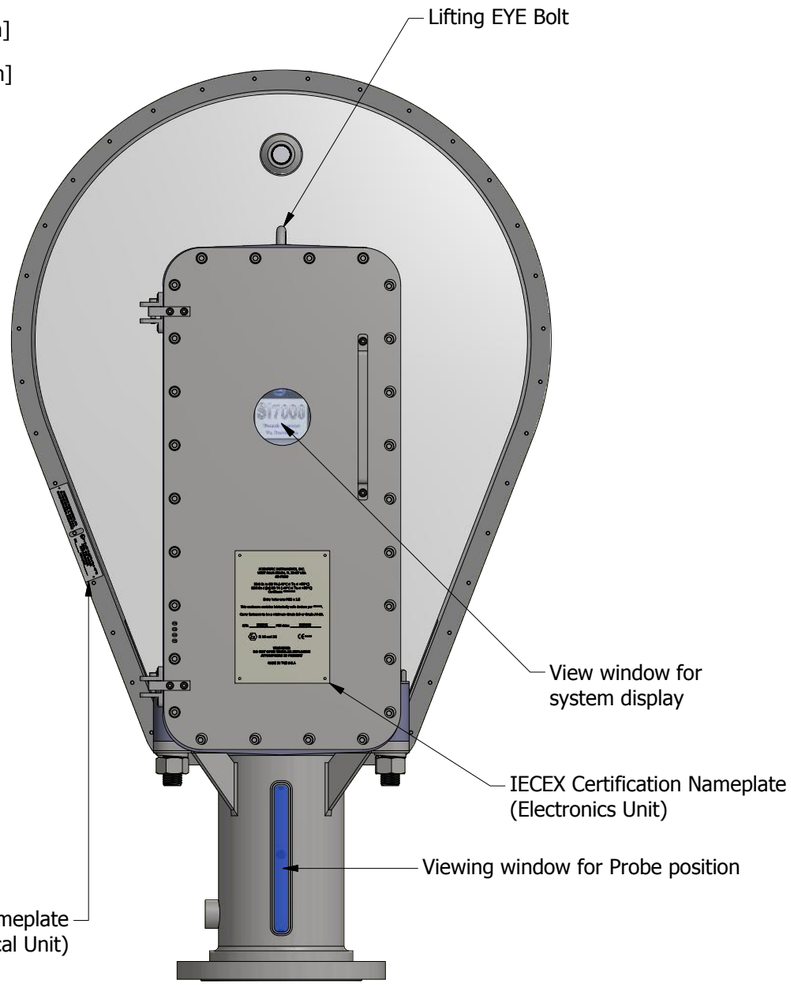
SI-7000 ASSY_____(INCH [MM]) 40L X 40W X 60H [1016L X 1016W X 1524H]
NET WEIGHT_____ (LBS [KG]) 393 [178]
GROSS WEIGHT_____ (LBS [KG]) 600 [273]

SCIENTIFIC INSTRUMENTS INC. 4400 W. TIFFANY DR. WEST PALM BEACH FLORIDA. 33407 USA			DRAWN: GTN DATE: 6/22/2016 APPROVED BY: KN DATE: 4/28/17
MTL: N/A	FINISH: N/A	TITLE: SI-7000 STANDARD PACKAGING SPECIFICATIONS	
Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/16 Ang. +/- ½° Corners +/- .010	SIZE: A / FSCM NO. 53547	DWG No 025-119	REV: -
	SCALE: NTS		SHEET 1 OF 1

REVISION HISTORY						
ECN	REV	DESCRIPTION	REV BY	DATE	APPROVED	DATE
-	-	INITIAL RELEASE	GTN	4/20/2017	KN	4/20/2017
10900	A	ADDED PAGES 2-4	JR	5/15/2018	KN	5/15/2018

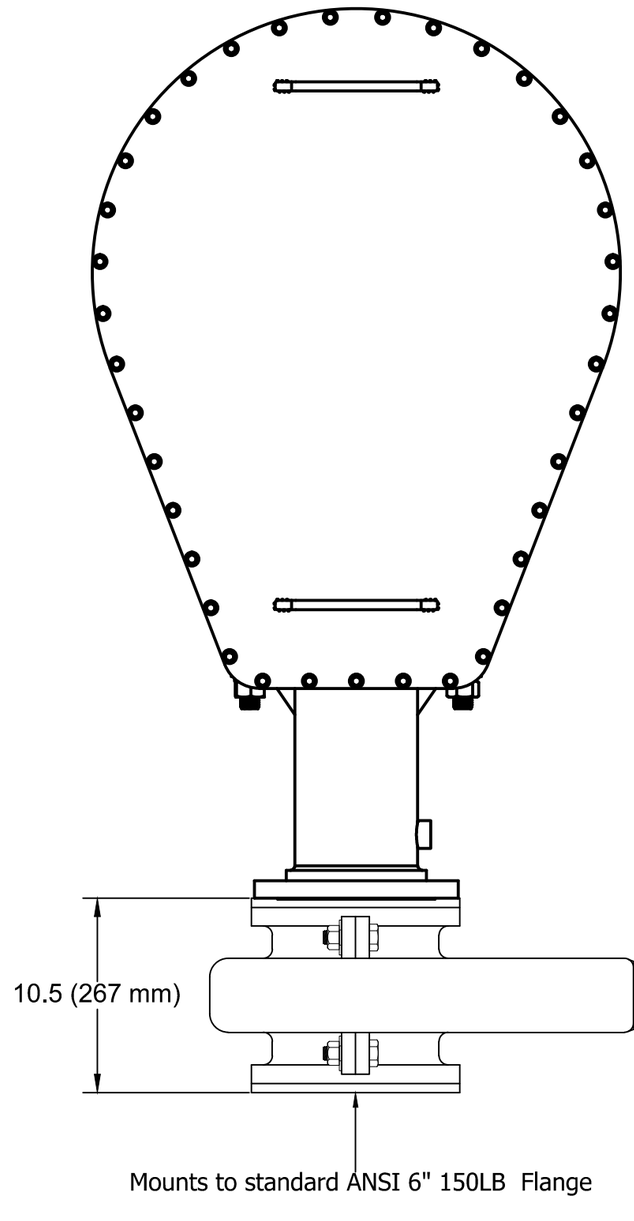


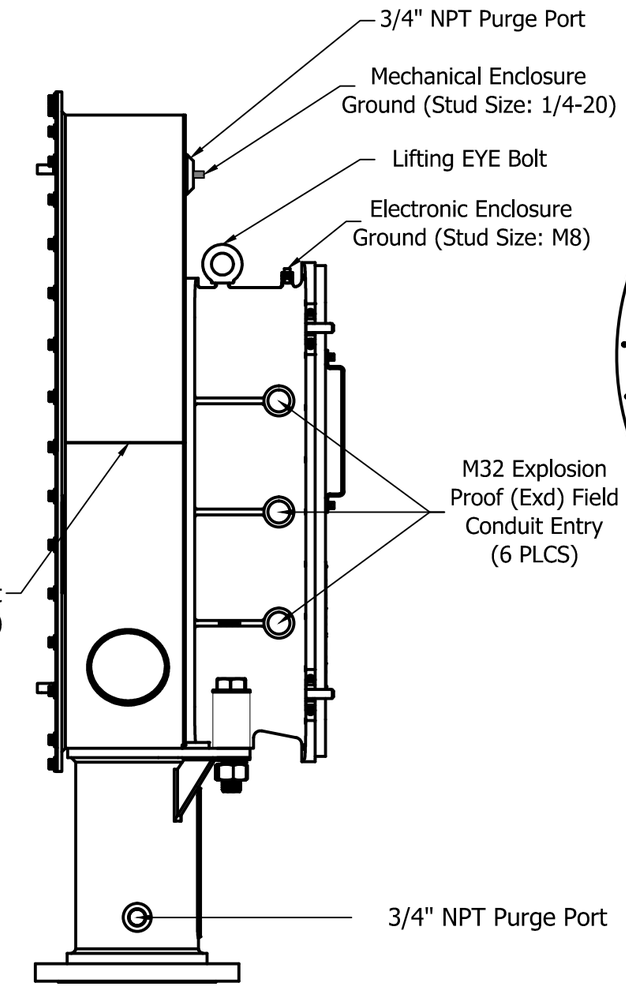


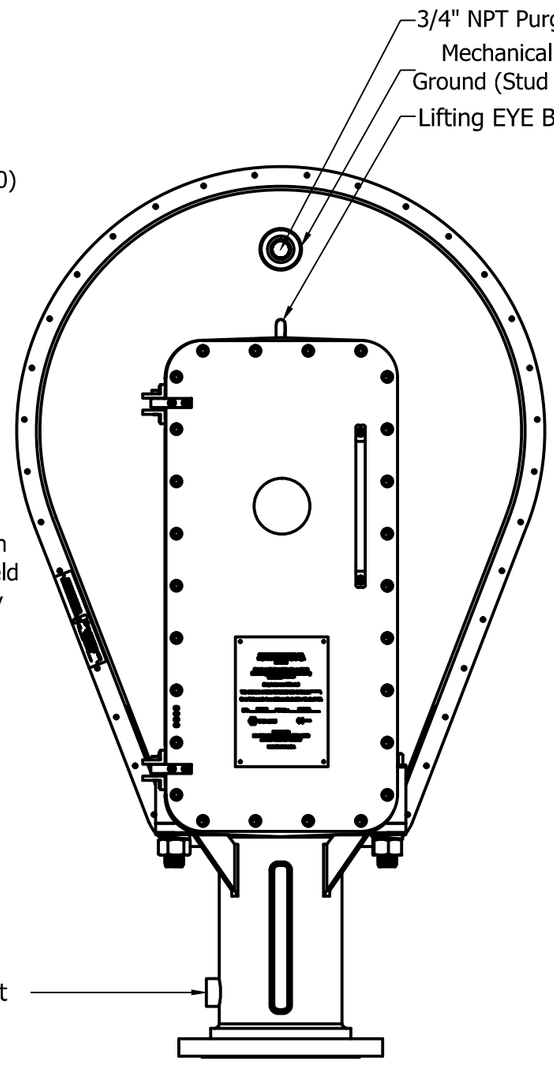


NOTE:
Exposed surfaces may be stainless steel or a protective finish not greater than 0.2mm in thickness.
UON all given dimensions are +/- .5 in [12.7mm]

SCIENTIFIC INSTRUMENTS INC. 4400 W. TIFFANY DR. WEST PALM BEACH FLORIDA. 33407 USA			DRAWN: GTN DATE: 4/20/17 APPROVED: KN DATE: 4/20/17
MTL: N/A	FINISH: N/A	TITLE: SI-7000 General Arrangement	
Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/16 Ang. +/- ½° Corners +/- .010	SIZE: B FSCM NO. 53547 SCALE:	DWG No 040-7000	REV: A SHEET 1 OF 4





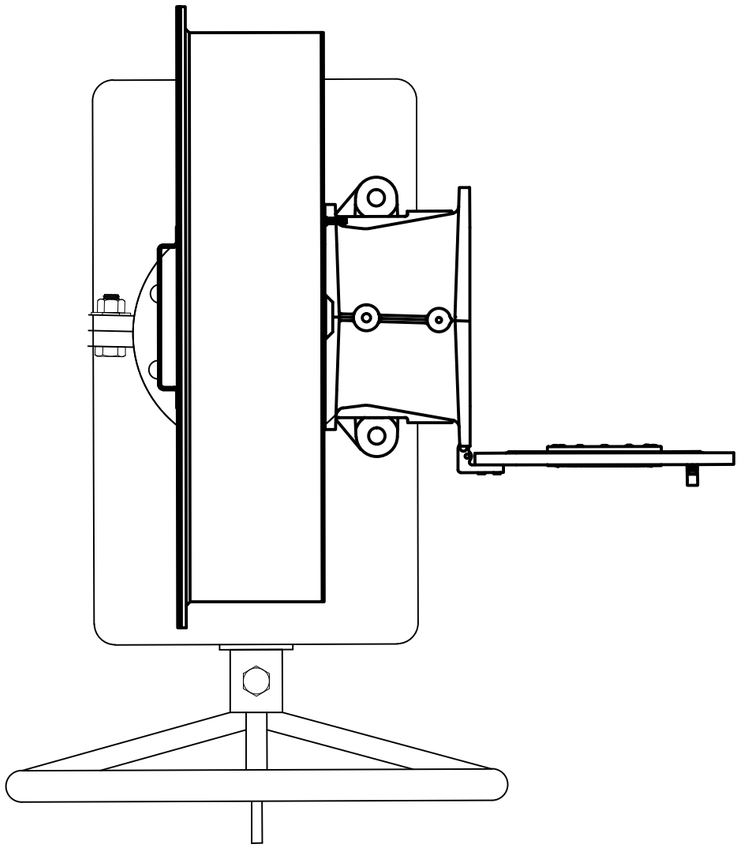


NOTE:
1. The orientation of the pinch valve ideally should be 90 degrees or ±45 degrees to the face of the mechanical enclosure.

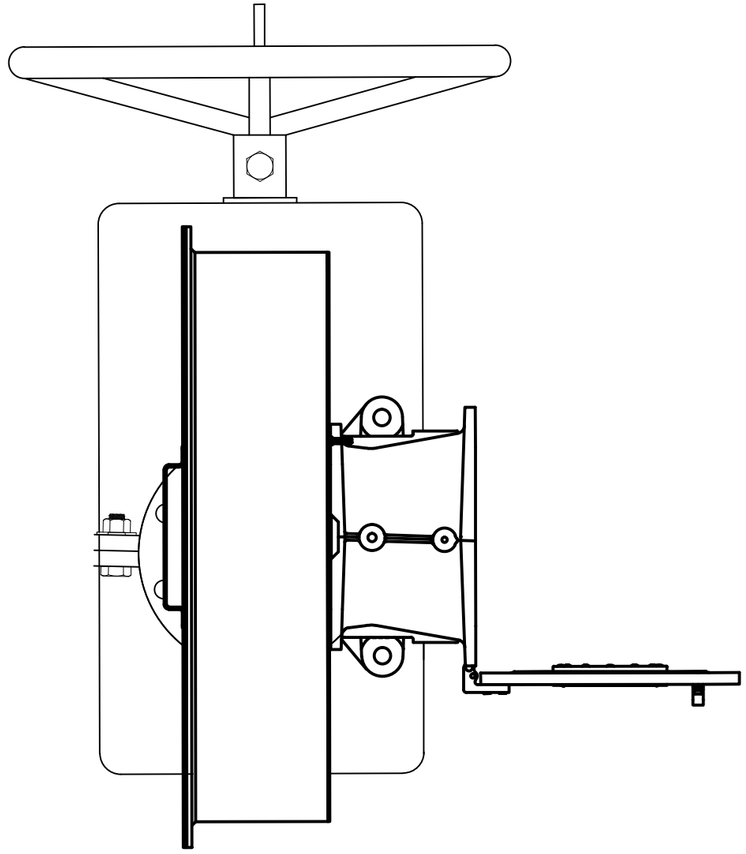
SCIENTIFIC INSTRUMENTS INC. 4400 W. TIFFANY DR. WEST PALM BEACH FLORIDA 33407 USA			
MATERIAL: N/A	FINISH: N/A	TITLE: SI-7000 General Arrangement - with Pinch Valve	
Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/16 Ang. +/- 1/2° Corners +/-.010	SIZE B / FSCM NO. 53547	Dwg. No. 040-7000	REVISION: A
	SCALE: NTS		SHEET: 2 OF 4

TOP VIEW

OPTION A

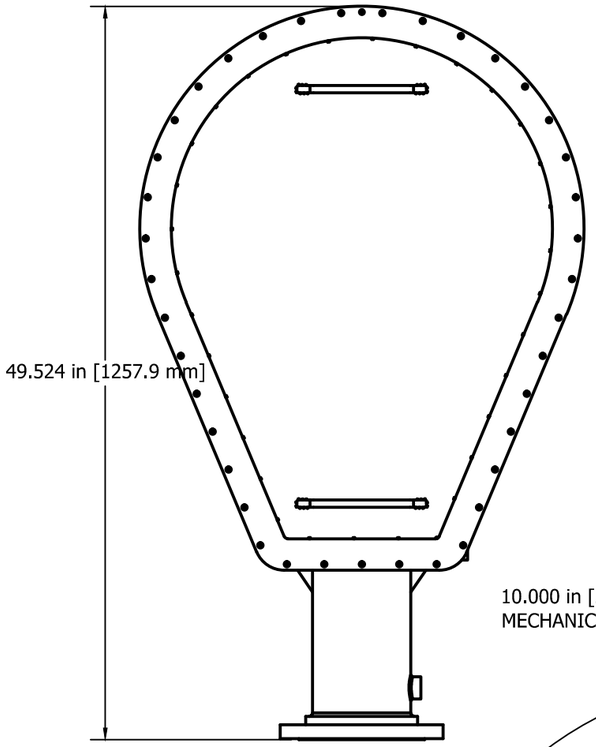


OPTION B

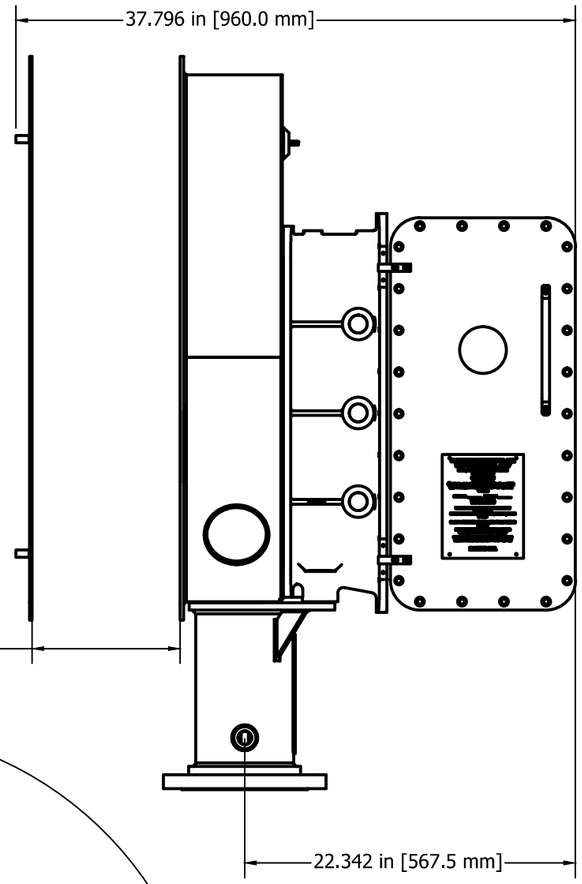


ATTENTION: Shown above are the two possible orientations when mounting and SI-7000 with a pinch valve. Option A and B ensure proper contact angle with the chain. No other positioning is acceptable.

SCIENTIFIC INSTRUMENTS INC. 4400 W. TIFFANY DR. WEST PALM BEACH FLORIDA 33407 USA			
MATERIAL: N/A	FINISH: N/A	TITLE: SI-7000 General Arrangement - with Pinch Valve	
Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/8 Ang. +/- 1/2° Corners +/-.010	SIZE B	FSCM NO. 53547	Dwg. No. 040-7000
	SCALE: NTS		REVISION: A
			SHEET: 3 OF 4



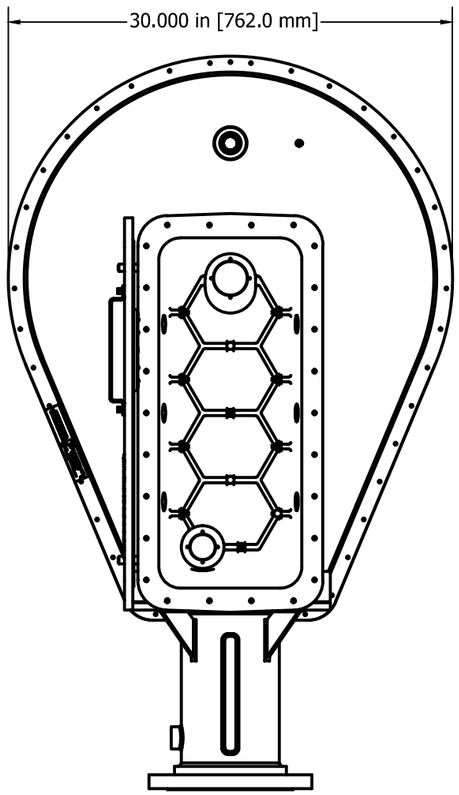
49.524 in [1257.9 mm]



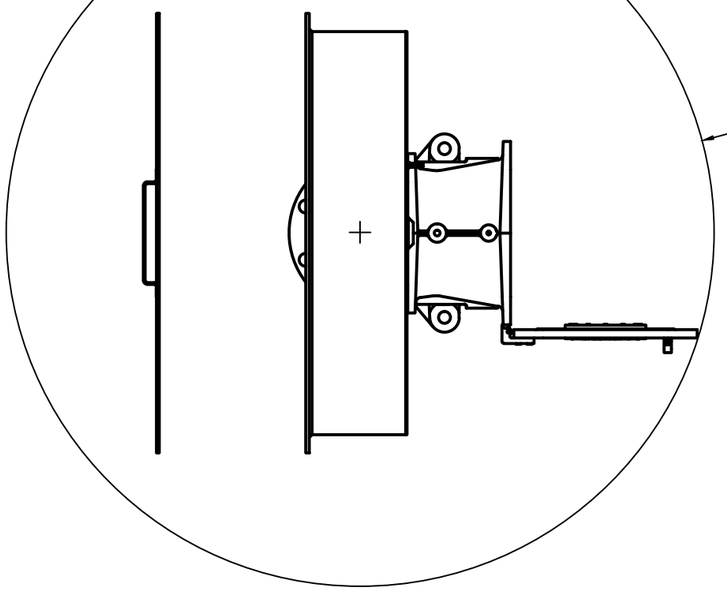
37.796 in [960.0 mm]

10.000 in [254.0 mm]
MECHANICAL LID REMOVAL CLEARANCE

22.342 in [567.5 mm]



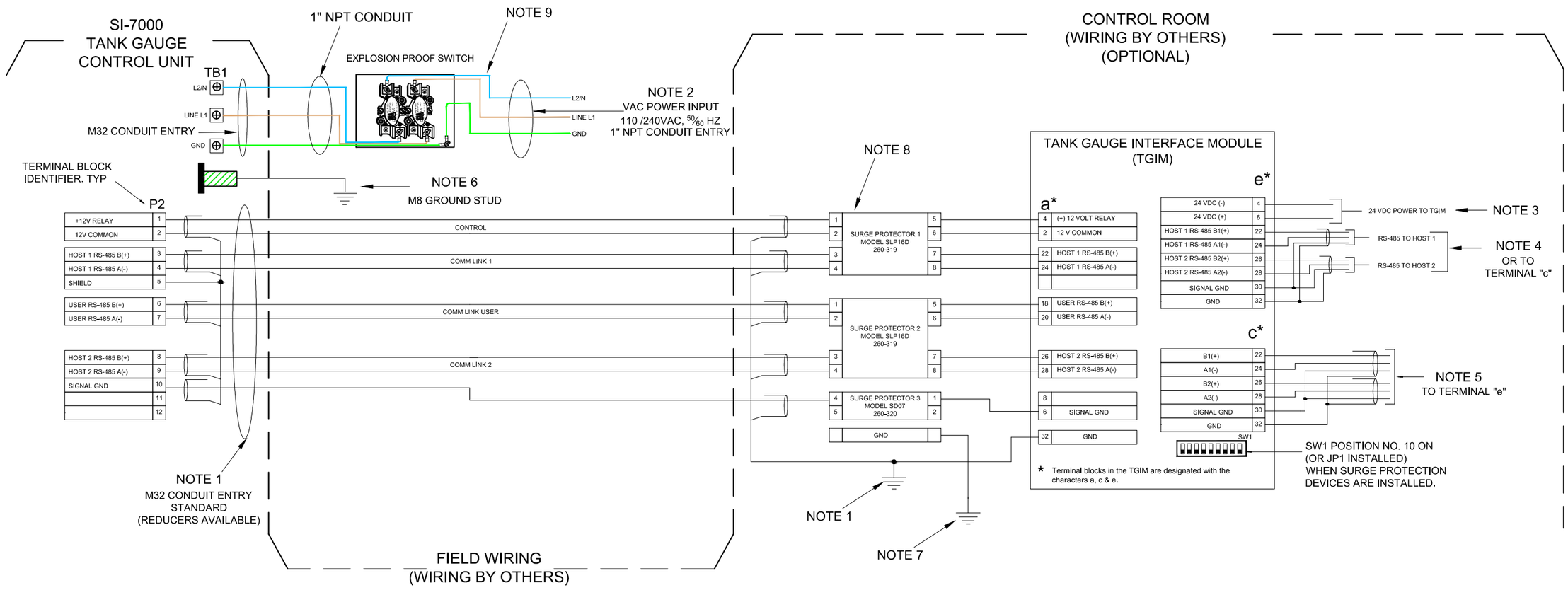
30.000 in [762.0 mm]



45.26 [1149.6]
MIN LID OPENING CLEARANCE DIAMETER

SCIENTIFIC INSTRUMENTS INC. 4400 W. TIFFANY DR. WEST PALM BEACH FLORIDA 33407 USA			
MATERIAL: N/A	FINISH: N/A	TITLE: SI-7000 General Arrangement - Required Clearance	
Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/16 Ang. +/- 2° Corners +/-..010	SIZE B	FSCM NO. 53547	Dwg. No. 040-7000
	SCALE: NTS		REVISION: A
			SHEET: 4 OF 4

ECN	LTR	Description	Re□ By	Date	Appr.	Date
10799	B	Wiring for explosion proof on/off switch corrected/ Revision was corrected	KN	02/24/17	KN	02/24/17
10853	C	Change voltage from +28VDC to +3.3VDC, new surge protector model SD07 P/N 260-320 and add Earth GND.	□R	10/31/17	KN	10/31/17
10932	D	Delete +3.3VDC from P2 and TGIM. Added page 2 and new wiring, for explosion proof switch. Changed pin 5 from earth ground to shield and move signal ground from pin 12 to 10.	□R	01/11/1□	KN	01/11/1□



NOTES:

1. FIELD COMMUNICATIONS AND CONTROL WIRING FROM LTD CONTROL UNIT TO CONTROL ROOM SHALL BE A 6 PAIR CABLE OF STRANDED WIRE 18 AWG (0.8 mm²) TYPICAL. EACH PAIR SHALL HAVE A DRAIN WIRE AND BE INDIVIDUALLY TWISTED AND SHIELDED. INSTALLER SHALL TERMINATE DRAIN AND SHIELD WIRES TO A KNOWN GROUND AT CONTROL ROOM.
2. VAC CABLE SHALL BE A TWO (2) CONDUCTOR WITH GROUND. INSTALLER SHALL VERIFY THAT THE VOLTAGE DROP FROM THE SOURCE TO THE CONTROL UNIT IS EQUAL TO OR LESS THAN 5% OF THE SPECIFIED VOLTAGE.
3. 24 VDC INPUT POWER, TWO (2) CONDUCTOR CABLE 18 AWG (0.8 mm²) TYPICAL.
4. RS-485 COMM LINE TO HOST COMPUTER, DCS OR MANAGEMENT SYSTEM. ALSO USED FOR MULTI-DROP COMM TO TERMINAL "c" OF PREVIOUS TGIM IN A MULTI TANK SYSTEM. TWO CONDUCTOR TWISTED, SHIELDED WITH DRAIN WIRE. 18 AWG (0.8 mm²).
5. TGIM RS-485 MODBUS COMMUNICATION WIRING LINK TO TERMINL "e" OF THE NEXT TGIM IN A MULTI TANK SYSTEM, AS APPLICABLE. INSTALLER SHALL PROVIDE A TWO PAIR CABLE 20 AWG (0.5 mm²), EACH PAIR SHALL BE HAVE A DRAIN WIRE AND BE INDIVIDUALLY SHIELDED.
6. HIGH INTEGRITY EARTH CONNECTION. PROVIDE A 10 AWG (4 mm²) WIRE (FOR IMPEDANCE < 1 OHM TO MAIN POWER SYSTEM EARTH POINT).
7. PROVIDE A 10 AWG (4 mm²) WIRE TO ELECTRICAL SYSTEM GROUNDING.
8. SURGE PROTECTOR DEVICES: MTL INC. MODEL NO. SLP16D, SD07 OR EQUIVALENT.
9. EXPLOSION PROOF ON/OFF SWITCH SI PART #: 450-702

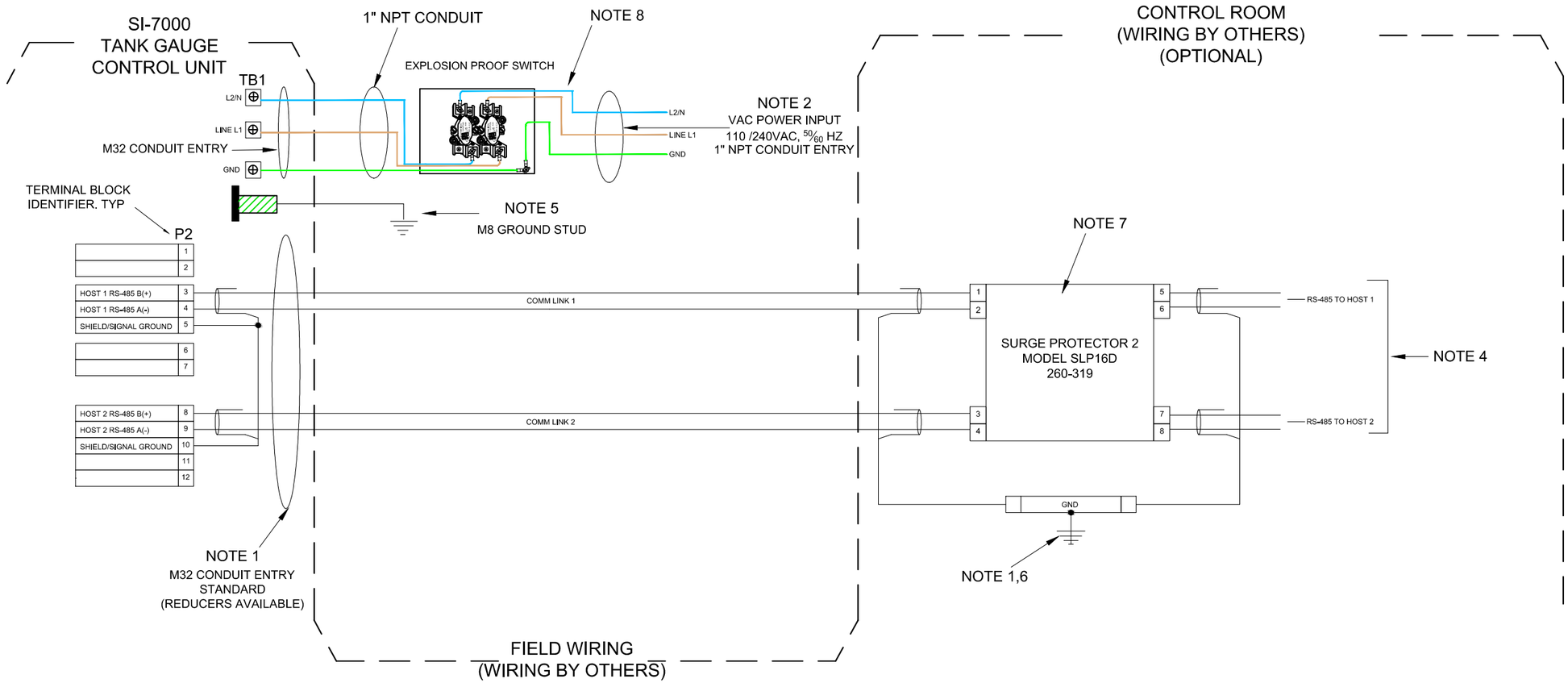
Related Drawing
No modifications permitted without reference to the Authori□ed Person

SCIENTIFIC INSTRUMENTS INC.
4400 W. TIFFANY DR. WEST PALM BEACH
FLORIDA 33407 USA

DRAWN: KN DATE: 8/11/16
APPROVED: KN DATE: 8/12/16

MATERIAL: SEE B.O.M.
FINISH: N/A
TITLE: SI-7000 Field Wiring Diagram w/ Field Surge Protectors and TGIM

Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/8 Ang. +/- 1/2° Corners +/- .010
SIZE B
FSCM NO. 53547
Dwg. No. 050-235-7000
REVISION: D
SCALE: NTS
SHEET: 1 OF 2



REFER TO Dwg. No. 050-701
FOR CONNECTION DETAIL

NOTES:

1. FIELD COMMUNICATIONS AND CONTROL WIRING FROM LTD CONTROL UNIT TO CONTROL ROOM SHALL BE A 2 PAIR CABLE OF STRANDED WIRE 18 AWG (0.8 mm²) TYPICAL. EACH PAIR SHALL HAVE A DRAIN WIRE AND BE INDIVIDUALLY TWISTED AND SHIELDED. INSTALLER SHALL TERMINATE DRAIN AND SHIELD WIRES TO A KNOWN GROUND AT CONTROL ROOM.
2. VAC CABLE SHALL BE A TWO (2) CONDUCTOR WITH GROUND. INSTALLER SHALL VERIFY THAT THE VOLTAGE DROP FROM THE SOURCE TO THE CONTROL UNIT IS EQUAL TO OR LESS THAN 5% OF THE SPECIFIED VOLTAGE.
3. 24 VDC INPUT POWER, TWO (2) CONDUCTOR CABLE 18 AWG (0.8 mm²) TYPICAL.
4. RS-485 COMM LINE TO HOST COMPUTER, DCS OR MANAGEMENT SYSTEM. TWO CONDUCTOR TWISTED, SHIELDED WITH DRAIN WIRE. 18 AWG (0.8 mm²).
5. HIGH INTEGRITY EARTH CONNECTION. PROVIDE A 10 AWG (4 mm²) WIRE (FOR IMPEDANCE < 1 OHM TO MAIN POWER SYSTEM EARTH POINT).
6. PROVIDE A 10 AWG (4 mm²) WIRE TO ELECTRICAL SYSTEM GROUNDING.
7. SURGE PROTECTOR DEVICES: MTL INC. MODEL NO. SLP16D, OR EQUIVALENT.
8. EXPLOSION PROOF ON/OFF SWITCH SI PART #: 450-702

SCIENTIFIC INSTRUMENTS INC. 4400 W. TIFFANY DR. WEST PALM BEACH FLORIDA 33407 USA			**Related Drawing** No modifications permitted without reference to the Authori□ed Person
MATERIAL: SEE B.O.M.	FINISH: N/A	TITLE: SI-7000 Field Wiring Diagram w/o TGIM	
Tolerance .00 +/-.015 .000 +/-.005 Frac. +/- 1/16 Ang. +/- 2° Corners +/-.010	SIZE B	FSCM NO. 53547	Dwg. No. 050-235-7000
	SCALE: NTS		REVISION: D
			SHEET: 2 of 2

SCIENTIFIC INSTRUMENTS

SI-7000

Tank Gauging System

Installation & Commissioning Manual

SCIENTIFIC INSTRUMENTS, INC.
4400 W. Tiffany Dr. West Palm Beach, FL 33407 U.S.A.
090-7000-1 Rev A

TABLE OF CONTENTS

1 INTRODUCTION

The SI-7000 Tank Gauging System monitors the level, temperature, and density of the cryogenic liquid in a large storage tank and is typically controlled and monitored by a PC based operator interface and/or DCS user interface in the control room. The SI-7000 consists of two sections, mechanical and electrical. The mechanical section consists of the chain reel enclosure and probe enclosure. This section contains all of the mechanical components, except the drive shaft gear box, required to lift and lower the probe assembly in the tank and shall be considered a Zone 0 environment. For most installations this section will not need to be accessed. The electrical section consists of the electrical enclosure and contains all the electronics and drive shaft gear box. The electrical section housing is an explosion-proof container and shall be considered a Zone 1 environment. This section is where the input power and communications are physically connected to the SI-7000. For a more detailed explanation of the components in these sections and their function please refer to the “SI-7000 Operational Manual” (090-7000-2). The probe enclosure is mated to the bottom of the chain reel enclosure, and the chain reel enclosure and electrical enclosure are mated back to back

Figure 1 Chain reel & probe enclosures

Figure 2 Chain reel enclosure w/o Cover

Figure 3 SI-7000 Side View

Figure 4 Electrical Enclosure

Figure 5 Electrical Enclosure w/ door open

Figure 6 SI-7000 transparent side view

This manual provides information necessary to install the system at a typical location. A site-specific mechanical installation drawing and field wiring diagram may be provided along with this manual for clarification of details at an atypical location.

The complete power-up, system testing, and calibration are accomplished during commissioning activities at a later time and only with the presence of a factory representative. Please refer to the “SI-7000 Operational Manual” (090-7000-2) for more detailed instructions on these activities. However, initial power-up and basic system functionality testing are included in this manual and may be performed if SI personnel are present.

2 WARNINGS, CAUTIONS, AND NOTICES

Scientific Instruments, Inc. is not liable for any injuries, death, or damages caused during the installation of the SI-7000. It shall be the installer's or customer's responsibility to ensure the operation is performed in a safe manner and complies with all government, local, and governing agency regulations.

 **WARNING:** All applicable government, local, and governing agency regulations shall be strictly adhered to. Failure to do so could result in death or serious injury.

 **WARNING:** The conductive grounding paths for lightning shall be achieved in such a way, that warming up, ignitable sparks alternatively spray sparks cannot become the ignition source of the explosive atmosphere. Failure to do so could result in death, serious injury, or extensive property damage.

 **WARNING:** Care must be taken to ensure equipment used to lift the SI-7000 is adequate for the weight as well as any sudden jolts from crane movement. Failure to do so could result in death, serious injury, or extensive property damage.

 **WARNING:** Care must be taken to ensure adequate clearances are maintained between structures, other equipment, and personnel when lifting and moving the SI-7000 into position. Failure to do so could result in death, serious injury, or extensive property damage.

 **WARNING:** No connections shall be made to the upper left entry port due to the location of the internal intrinsic safety circuitry.

 **CAUTION - PINCH POINT:** Care must be taken when positioning the SI-7000 on the mounting flange and all personnel shall keep their hands clear as the SI-7000 is lowered into place. Failure to do so may result in serious injuries as fingers may be crushed or severed.

NOTICE: All installation instructions in this manual shall be followed. Failure to do so may result in damage to the SI-7000, void the warranty, or cause installation delays.

NOTICE: Do not remove the protective foam from the probe enclosure until the SI-7000 is being attached to the tank's mating flange. Remove the protective foam will allow the probe to impact the walls of the probe enclosure while the SI-7000 is being moved and lifted into place.

3 INSTALLATION REQUIREMENTS

These are the minimum requirements for installation that Scientific Instruments suggests. If these minimum requirements are not met and there is a safety risk, Scientific Instruments personnel shall not engage in installation activities.

- An available 6” 150 pound flange mounted on a 6” minimum pipe providing unobstructed access to the tank interior. This flange should be capable of supporting 400 pounds (181.4 kg) without causing damage to the flange or surrounding structures.
- A minimum of 1m of clearance around the flange. The equipment should not be mounted where it is difficult to operate the A/C power disconnect switch.
- Crane and qualified operator.
- Two personnel to guide SI-7000 into position.
- One qualified personnel for mechanical and electrical installation.
    - General understanding of relevant electrical engineering.
    - Understanding of and ability to read and assess engineering drawings.
    - Practical understanding of explosion protection principles and techniques.
- Stable temporary or permanent working platform.

Other Notes:

- Since the SI-7000 is always mounted outside on the tank, there are no additional ventilation requirements.
- There are no requirements relating to sound levels.
- No assembly is required before installing the SI-7000.
- The safety of any system incorporating the SI-7000 is the responsibility of the assembler of the system.
- Scientific Instruments does not currently provide any accessories for the SI-7000.

4 PRE-INSTALLATION CHECK LISTS

These items need to be verified prior to the SI-7000 being installed. Failure to meet these requirements can adversely affect the operation of the SI-7000, cause severe damage to equipment, or create installation delays.

4.1 SI-7000 INSTALLATION TOOL AND HARDWARE

Only a few basic tools are required to install the SI-7000. This checklist should be completed prior to climbing to the top of tank.

- Tools, Site supplied
    - ☐ 2ea 1⅛” Wrench
    - ☐ 1ea 6mm Hex T-handle
    - ☐ 1ea Reversible Screwdriver Set (#2 Philips & 9/32 In. slotted)
    - ☐ Torque wrench (10ft/Lbs.-150ft/Lbs.)
    - ☐ 1ea 1⅛” Socket, ⅜” drive
    - ☐ 1ea ½” to ⅜” drive adapter
    - ☐ 1ea ½” Socket, ⅜” drive
    - ☐ 1ea 6mm Hex bit socket, ⅜” drive

- Hardware, Scientific Instruments supplied
  - 1ea Explosion proof external AC power switch
  - 16ea ¾-10x2.5” Stainless steel bolt
  - 4ea ¾” Stainless steel nut (Extra on Blind Flange)
  - 16ea ¾” Stainless steel lock washer
  - 16ea ¾” Stainless steel washer
  - 4ea ¾-10x3” Stainless steel bolt (Extra on Blind Flange)

4.2 INTERNAL TANK REQUIREMENTS

- Was the tank cleaned before it was closed and sealed? Excess rust, dust particles, perlite, or other foreign particles that are left in the tank could stick to the density meter over time and begin to affect density readings.
- Can the probe assembly move vertically in an unrestricted manner from the drive mechanism all the way to the bottom of the tank or stilling well? Any obstructions may cause the probe assembly to become stuck and result in damage to the probe assembly, chain, and/or drive mechanism.
- Is the probe assembly’s path away from any pumps or filling lines that would produce high liquid flow or turbulence? High liquid flow or turbulence may result in damage to the probe assembly or inaccurate density and/or level measurements.
- If a stilling well is used, is it plumb and of adequate size to ensure that the probe does not contact the stilling well’s inner surface? Contact with the inner surface may cause unpredictable operation and place additional stress on the drive system resulting in premature failure of components.

4.3 EXTERNAL TANK REQUIREMENTS

- Is a stable work platform in place? This may be a permanent or temporary structure; however SI strongly suggests that a permanent work platform be installed.
- Is adequate safety equipment in place and serviceable?
- Is the mating flange where the SI-7000 will be mounted clean and free of damage and debris?
- Is the gasket that will be used between the mating flange and SI-7000 clean and serviceable?
- Will the hand-wheel of the isolation valve obstruct access to the mechanical or electrical enclosures? If it will obstruct access, can the mechanical enclosure cover still be removed and the electrical enclosure door opened?
- If a pinch valve is used, is it installed so that it closes on the flat sides of the chain as much as possible and that the hand wheel does not prevent opening the electrical enclosure door or the ability to remove the mechanical enclosure cover? Misalignment of the pinch valve may prevent it from sealing properly and allow excessive gas to escape during maintenance and may also hinder personnel from having access to one side of the SI-7000.

4.4 ELECTRICAL AND COMMUNICATIONS

- ☐ Has a place been chosen for the external power switch within sight of the SI-7000?
- ☐ Are the electrical power and communication cable conduits ready to be connected to the SI-7000? The SI-7000 may be mounted without the cable conduits in place. However, the installation will not be considered complete until these connections are made.
- ☐ Is the electrical power supply to the SI-7000 locked out/tagged out? If not, this shall be done prior to the power conductor being attached to the SI-7000.

5 SI-7000 UNPACKING AND INSPECTION

The SI-7000 is designed for ruggedness and use in severe conditions, but care should still be used when moving or lifting the unit. SI has designed a custom container so that the SI-7000 will arrive ready to be installed. However, the unit should still be inspected for any damage that may have occurred during shipping.

1. Ensure shipping crate is upright on a flat, stable, and relatively level surface.
    a. If the crate rocks back and forth then it shall be shimmed to hold it steady.
2. Ensure the shock and tilt indicators have not been activated.

    a. Notify SI if the indicators have been activated and provide photos if possible.
3. Inspect shipping crate for any visible signs of damage.
    a. Notify SI of any damage and provide photos if possible.
4. Remove the crate top, internal horizontal supports, and side panels.

Figure 7 SI-7000 mounted on crate bottom

5. Thoroughly inspect the SI-7000 for any signs of damage.
    a. Notify SI of any damage and provide photos if possible.

6. Attach lifting straps to eyelet on top of the electrical enclosure and apply a slight lifting force.

Figure 8 SI-7000 with lifting strap attached

7. Use a 1/2” wrench to remove the 4 lag screws holding the SI-7000 to the crate bottom.

6 INSTALLATION

REF: Appendix A, Bolt Tightening Worksheet and other site specific drawings supplied.

NOTICE: DO NOT remove the protective foam from the probe enclosure until the SI-7000 is being attached to the tank’s mating flange. Removing the protective foam will allow the probe to impact the walls of the probe enclosure while the SI-7000 is being lifted into place

1. Verify that the pinch valve has been installed following the instructions in section 4.3.

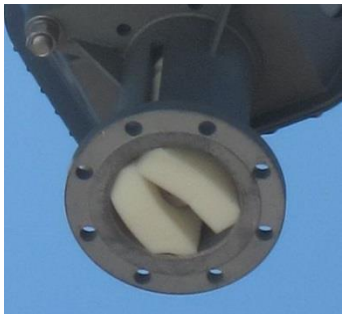


Figure 9 Protective foam holding probe in place

2. Lift SI-7000 to top of tank taking without causing it to swing excessively.

Figure 10

3. Position SI-7000 over mounting flange.

Figure 11 Guiding SI-7000 into position

4. Remove Blind Flange & disregard the 3/4bolts & nuts. Keep flat & lock washers to use w/the ¾-10x2.5” bolts provided w/the Pinch Valve for mounting.

5. Remove protective foam from the probe enclosure.

Figure 12 Remove probe protective foam

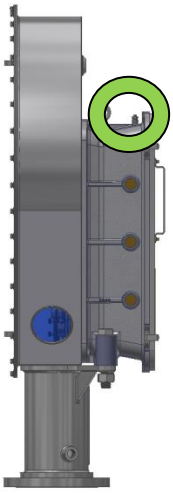
6. Lower SI-7000 onto the Pinch Valve flange ensuring the holes are aligned and pinch points are kept clear.

Figure 13 Aligning SI-7000 with mating flange

7. Use 8 sets of the ¾" SS hardware included w/the Pinch Valve to mount the SI-7000 to the Pinch Valve flange. See Appendix A for detailed instruction.

Figure 14 Installing mounting hardware

8. Connect an earth bonding cable to the ground lug on top of the electrical enclosure in such a way that a bolt lightning of a 30m can be controlled.



7 CONNECTING SYSTEM WIRING

WARNING: ALL THREADED ENTRIES TO ELECTRICAL ENCLOSURE FOR VAC POWER INPUT AND/OR COMMUNICATIONS, SUCH AS CABLE GLANDS, CONDUIT FITTINGS, PLUGS FITTED TO ELECTRICAL ENCLOSURE SHALL BE RATED FOR USE IN EXPLOSIVE ATMOSPHERES.

THERE IS A WIDE SELECTION OF CABLE GLANDS, AND THREADED ENTRIES AVAILABLE WITH APPROVALS AND CERTIFICATES COVERING INTERNATIONAL AND LOCAL WIRING CODES. THEREFORE IT IS THE RESPONSIBILITY OF THE INSTALLER TO ENSURE THAT CABLE GLANDS, THREADED PLUGS AND/OR CONDUIT FITTINGS ARE Ex APPROVED FOR THE ZONE AND AREA CLASSIFICATION WHERE THE SI-7000 WILL BE INSTALLED. CONSULT THE MANUFACTURER FOR ADDITIONAL INFORMATION.

REF: Appendix B Drawing 050-7000-1 Typical Installation Wiring Diagram

All unused wires and shields should be terminated to ground in the control room only. Proper grounding and shield connections must be made to minimize noise levels on the communication lines. No connections shall be made to the upper left entry port due to the location of the internal intrinsic safety circuitry. Connecting to this will void the SI-7000's intrinsic safety certification.

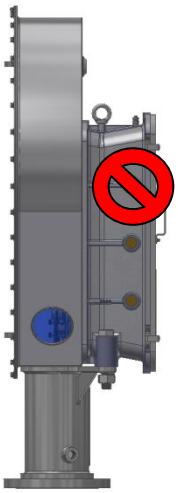


Figure 15 Unused upper left entry port

7.1 OPENING ELECTRICAL ENCLOSURE DOOR

Extreme care must be taken not to scratch or mar the flame path surfaces while working inside the electrical enclosure. A protective covering is used during assembly and shipping and should remain in place until the installation is completed. Any scratches or damage to the flame path void the enclosure's explosion proof certification.

- Loosen all bolts holding the enclosure's door shut.
- Open door fully.
- Insert latching pin to hold the door in the open position.

7.2 AC POWER INPUT & GROUND

AC power lines shall be connected to the SI-7000 using either the lower right or lower left entry port with the lower right port being the preferred option. The SI-7000 has been designed for use with 18 AWG to 10 AWG power lines and an 8 AWG Earth ground.

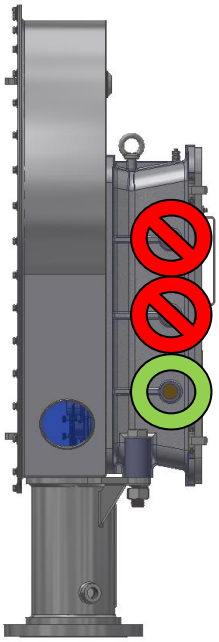


Figure 16 Lower left-side AC entry port option

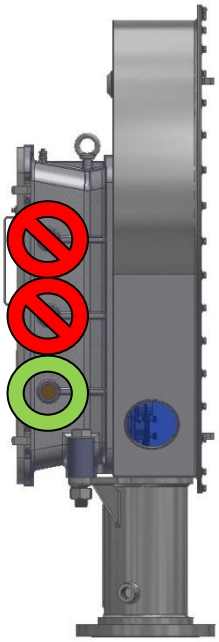


Figure 17 Lower right-side AC entry port option

1) Ensure AC power source is locked out / tagged out.
2) Ensure external AC power switch is in the off position.
3) Connect appropriate cable gland and conduit to entry port.
4) Pull in enough wire so that the AC power lines can be routed to the power terminal strip and the Earth ground wire can be routed to the grounding stud at the top of the enclosure with adequate service loops for both.
5) Crimp the appropriate ring lug connectors to the ends of the wires.
6) Remove the two screws on the power terminal strip cover to access the connection terminals.
7) Connect the AC power lines as shown in the wiring diagram.
8) Reinstall the power terminal strip cover.
9) Connect the earth ground terminal to the tank ground using wiring practices in accordance with all local regulations.

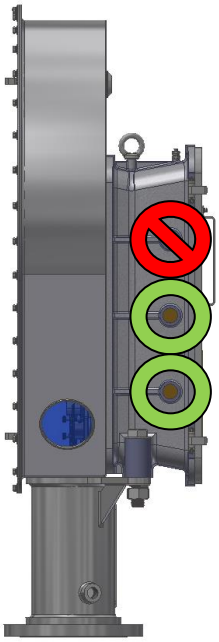
   Note:

   ¾” NPT conduit entries are standard. Other approved sizes are available upon request

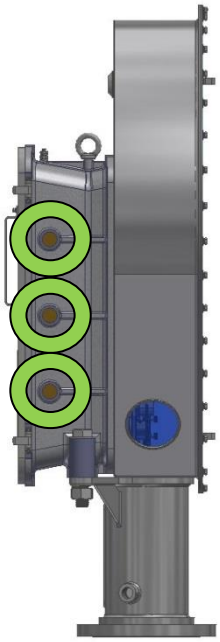
7.3 SIGNAL WIRING CONNECTIONS

Signal lines can be connected to the SI-7000 using any entry port other than the upper left port and the entry port being used for the AC power. For ease of internal routing, the center right port is the preferred option. Care should be taken not to route the signal wires in close proximity to the AC power lines.

The SI-7000 has been designed for use with 22 AWG to 18 AWG signal lines, and wire gages up to 14 AWG may be used. However, due to limited space it is recommended that smallest possible gage wire be used. All signal wire connections are made via a single connector (J2) on the main controller assembly (150-601) inside the electrical enclosure. The mating connector (Phoenix Contact #1863259) that will be attached to the signal wires has been inserted on the main controller. A spare connector has also been included in the installation kit. Ferrules are not required, but it is strongly suggested that they be used. SI recommends the following Phoenix Contact sleeved ferrules, but any similar ferrules may be used: 22AWG – 3203024, 20 AWG – 3200687, 18 AWG – 3200690, 16 AWG – 3200755, 14 AWG – 3200522.



3 Left-side signal entry port options



4 Right-side signal entry port options

1. Install appropriate cable gland into entry port.
2. Pull in enough wire so that the signal lines can be routed to the connector on the main controller assembly with an adequate service loop.
3. If used, crimp ferrules to the ends of the wires.
4. Remove mating connector from the main controller assembly.
5. Connect the signal lines to the connector as shown in the wiring diagram.
6. Plug connector into main controller assembly (J2).

7.4 CLOSING ELECTRICAL ENCLOSURE DOOR

Extreme care must be taken not to scratch or mar the flame path surfaces while working inside the electrical enclosure. Any scratches or damage to the flame path void the enclosure's explosion proof certification.

- If the “Initial Power Up” (Step 8.1) has not been completed, ensure the AC power switch in the “OFF” position.
- Remove the protective covering from both sides of the flame path.
- Clean flame path surfaces with alcohol wipes provided in kit to remove any residual adhesive.
- Apply a 1/8” bead of vacuum grease all the way around the enclosure side flame path, one near the outer edge and one near the center.
- Remove pin holding the door in the open position.
- Close door fully.
- Tighten all bolts on the enclosure door with the Allen wrench provided .
- Torque bolts to 20ft/lbs.
- Wipe off any silicone lubricant that has been squeezed out from the flame path.

8 COMMISSIONING

NOTE: If the SI-7000 is used in a manner not specified by Scientific Instruments, the protection provided by the equipment may be impaired.

Initial power up and commissioning shall only be performed by or with Scientific Instruments personnel. Applying power to or operating the SI-7000 prior to Scientific Instruments personnel inspecting the installation will void the warranty and Scientific Instruments will not be liable for any damage to the equipment.

8.1 INITIAL POWER UP

1. Ensure the SI-7000 power switch is in the “OFF” position.
2. Remove AC power lock out/tag out.
3. Move the SI-7000 power switch to the “ON” position.
4. Check the following on the main controller.
    - Red “A/C” power LEDs are on. If not, try the following:
        - Ensure AC power is being supplied to the controller assembly.
        - Ensure power plug is full inserted into socket .
    - Green “FUSE” LEDs are on. If not, try the following:
        - Check fuses in AC plug module (spare fuses are included in kit).
    - Green “PWR” LED is on. If not, it is most likely the following:
        - DC power supply is not functioning, replace controller assembly.
    - LCD is on and displaying the main menu. If not,
        - Remove controller assembly and ensure LCD is fully connected.
        - If still no success, the LCD or CPU is not functioning, replace controller assembly.
5. Continue to the next test or move the SI-7000 power switch to the “OFF” position.

8.2 MOTOR DRIVER TEST

1. Ensure the SI-7000 power switch is in the “ON” position.
2. On the touch screen LCD navigate to the Motor menu.
3. Touch the down arrow once.
    - The motor should begin to lower the probe assembly at its slowest speed.
4. Touch the down arrow a second time.
    - The motor should increase to its medium speed.
5. Touch the down arrow a third time.

- The motor should increase to its maximum speed.

6. Touch the down arrow a fourth time.
    - The motor should return to its medium speed.
7. Touch the stop button.
    - The motor should stop and hold the probe at its current position.
8. Touch the up arrow once.
    - The motor should begin to lift the probe assembly at its slowest speed.
9. Touch the up arrow a second time.
    - The motor should increase to its medium speed.
10. Touch the up arrow a third time.
    - The motor should increase to its maximum speed.
11. Touch the up arrow a fourth time.
    - The motor should return to its medium speed.
12. Allow the motor to lift the probe to the parked position.
    - The motor should automatically stop and hold the probe in the parked position.

8.3 BENCH MARKING

1. Ensure the SI-7000 power switch is in the “ON” position.
2. On the touch screen LCD navigate to the Motor menu.
3. Touch the down arrow once.
    - The motor should begin to lower the probe assembly at its slowest speed
4. Observe the chain movement through the probe enclosure window and stop the motor when the designated marking on the chain is aligned with a reference point. Record the step count.
    - Motor should stop and hold the probe at the current location
5. Touch the down arrow three times.
    - The motor should begin to lower the probe assembly
6. Observe the chain movement through the probe enclosure window and stop the motor when the second marking on the chain is aligned with the reference point. Record the second step count.
7. Calculate the level scale. Consult with factory for details.
8. Touch the up arrow three times.

- The motor should begin to lift the probe assembly.

9. Allow the motor to lift the probe to the parked position.
    - The motor should automatically stop and hold the probe in the parked position.

8.4 COMMUNICATIONS

1. Ensure the SI-7000 power switch is in the “ON” position.
2. Ensure the green “COM” LED(s) are on.
3. From the control room send a command to lower the probe.
    - The motor should begin to lower the probe assembly .
4. From the control room send a command to stop the motor.
    - The motor should stop and hold the probe at its current position.
5. From the control room send a command to lift the probe.
    - The motor should begin to lift the probe assembly.
6. Allow the motor to lift the probe to the parked position.
    - The motor should automatically stop and hold the probe in the parked position.

APPENDIX A

BOLT TIGHTENING WORK SHEET

Location/Identification:_____ Nominal Bolt Size: _____

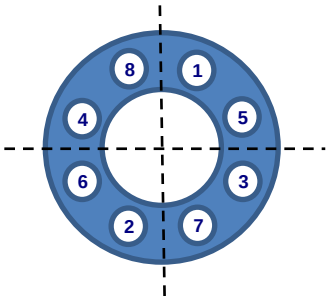
Surface Finish on Flange:_____ Lubricant Used:_____

Note: Bolt lubrication greatly affects the torque values used when installing gaskets. To achieve the same gasket compression, a much higher torque value is required for a dry bolt versus using an effective lubricant such as molybdenum disulfide. Lubricant should not be applied to the gasket or flange faces as a release agent.

(Initial each step)

_____1. Ensure system is at ambient temperature and depressurized.
_____2. Visually examine and clean flanges, bolts, nuts and washers.
_____3. Lubricate bolt, nut, and flange facings on the nuts surfaces.
_____4. Insert bolt from the bottom of the mounting flange and hold it in place.
_____5. Place the washer and then the lock washer on the end of the bolt.
_____6. Install nut on end of bolt and hand tighten.
_____7. Repeat steps 3 to 6 for remaining seven hardware sets
_____8. Use the torque values and cross-pattern sequence below to tighten hardware (each tightening sequence 1 through 8 constitutes a “round”).
_____9. Check gap around the circumference between each of these rounds, measured at every other bolt. If the gap is not reasonably uniform around the circumference, make the appropriate adjustments by selective bolt tightening before proceeding.

- **Round 1** - Torque to 30 ft-lbs.
- **Round 2** - Torque to 60 ft-lbs.



_____10. Final Rotational Round - 100% of Final Torque (same as Round 3 above). Use ROTATIONAL, clockwise tightening sequence, starting with Bolt No. 1, for one complete round and continue until no further nut rotation occurs at 100% of the Final Torque value for any nut.

NOTE: Short-term bolt preload loss can occur between four to twenty-four hours after initial tightening due to bolt relaxation. SI suggests repeating step 10 at least twenty-four hours after the initial “Final Rotation Round” and/or just prior to commissioning.

Name: _____ Signature: _____ Date: _____

SCIENTIFIC INSTRUMENTS

SI-7000

Tank Gauging System

Operational Manual

Part A

SCIENTIFIC INSTRUMENTS, INC.
4400 W. Tiffany Dr. West Palm Beach, FL 33407 U.S.A.
090-7000-2A Rev -

Record of Revisions						
Rev	RFEA #	Description	Rev by	Date	Appr by	Date
-		Initial Release	KN	8/21/19	KN	8/21/19

1 INTRODUCTION

1.1 GENERAL DESCRIPTION

The Scientific Instruments, Inc. SI-7000 is a state of the art electro-mechanical system designed to measure liquid level, temperature, and density in cryogenic liquids, including liquid natural gas (LNG), propane, and butane. The system has been designed with an emphasis on reliability, modularity, and ease of maintenance and operation. With its computer-controlled operation, the SI-7000 gives operators access to critical data necessary for intelligent and safe operation of the plant.

In addition to providing an accurate measure of the liquid level in a tank, the SI-7000 provides for precise measurement of temperature and density throughout the tank by positioning a multi-sensor probe assembly at any height in the tank. This makes it possible to obtain a profile that gives an accurate representation of the current conditions in the tank. This information is crucial for the safe storage and handling of cryogenic liquids, since they are subject to layering, and over time, possible "rollover" conditions.

1.2 APPLICATION

A significant safety concern in the storage of cryogenic liquids such as LNG is a phenomenon known as "rollover." If this occurs, pressures inside the storage tank may rise to excessive levels. The tanks are equipped with safety vent valves that are designed to keep the pressures from rising to levels that could cause structural damage. However, when these valves operate, gas is vented to the atmosphere at an uncontrolled rate, which is an additional safety concern.

Rollover occurs under certain conditions as stratified LNG comes to equilibrium. Stratification occurs when the product in the tank forms in layers with different densities and different temperatures. Sudden mixing of LNG in any storage tank occurs as two or more layer densities approach equality. Any heat trapped in the system is released rapidly during mixing, generating a vapor which may exceed the venting capability of the tank.

By periodically taking a profile of the tank, the Scientific Instruments SI-7000 can detect stratification and possible rollover conditions and generate an alarm signaling the need for operator intervention. Operators can then take preventative measures (such as mixing the liquid or moving it to another tank).

1.3 SYSTEM CONFIGURATION

The integrated touch screen LCD is the primary interface used for setting all system parameters. The system configuration may also be changed remotely via a Modbus serial communication interface.

2 SYSTEM SPECIFICATIONS

2.1 CERTIFICATION STANDARDS

IEC 60079-0:2011, IEC 60079-1:2014, IEC 60079-11:2011, EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 60079-11:2012, ISO 80079-36, ISO 80079-37, IEC/EN61010-1:2010

2.2 EQUIPMENT MARKINGS

Electrical Compartment: II (1) 2 G Ex db [ia IIC Ga] IIB T4 Gb (-20°C ≤ Ta ≤ + 50°C)
Mechanical Compartment: II 1 G Ex h IIC T4 Ga (-20°C ≤ Ta ≤ + 50°C)
Probe Assembly: II 1 G Ex ia IIC T4 Ga (-200°C ≤ Ta ≤ +50°C)

2.3 MEASUREMENT CAPABILITY

Level:

Range	56 m
Resolution:	1 mm
Accuracy:	±2 mm

Temperature:

Range	-200° C to +50° C
Resolution:	0.01° C
Accuracy:	± 0.1° C

Density:

Range	400 to 1000 kg/m^3
Resolution:	0.01 kg/m^3
Accuracy:	± 0.5 kg/m^3
Profile Points:	250+

Sensor Isolation: Internal I.S. Barriers

2.4 ELECTRICAL

Operational Voltage:	85-240 VAC
Certified Operational Voltage:	120-240 VAC
Frequency:	50-60 Hz
Power Draw:	I_{max}: 3.15 A
Overvoltage:	Category III
Pollution:	Degree 1

2.5 COMMUNICATIONS

Standard:	(2) Standard RS485 / MODBUS Protocol
Optional:	4-20mA, Fiber Optic, HART & Ethernet

2.6 MECHANICAL

Explosion Group of Ex Atmosphere: IIC

Housing Mat:	Stainless Steel
Dimensions:	125 cm x 76 cm x 37 cm
Weight:	180 kg
Ambient Temp:	-40°C to +60°C
Safety Certs:	IECEx
Protection class:	Designed to meet IP65
Seismic Rating:	Designed to withstand 3.0 g
Drive Chain:	SS304
Mounting:	6” ANSI 150#RF Flange
Op. Pressure:	400 mbar
Stilling Well:	Not Required
Isolation Valve:	Required
Pinch Valve:	Required

2.7 INTERNAL CONNECTIONS

All internal connectors have a flammability rating of V-0. Skipped designators have been removed from the design. Not all connections are used, and some may not be present on the assembly.

SI-7000 Controller Assembly

- J1 Mains Power Input (Universal AC Input)
- J2 Field Wiring Input (RS485)
- J6 Reel Encoder Input
- J8 Motor Power Output
- J10 Probe Interface Module (PIM)
- J14 JTAG Programing (manufacturer use only)
- J22 Alternative 28 VDC – 48 VDC Power Input

Probe Interface Module (PIM)

- J1 SI-7000 Controller Assembly
- J2 Slip-ring
- P1 Primary Earth Ground
- P2 Optional Earth Ground

3 WARNINGS, CAUTIONS, AND NOTICES

Scientific Instruments, Inc. is not liable for any injuries, death, or damages caused during the operation of the SI-7000. It shall be the customer’s responsibility to ensure all operations and maintenance are performed in a safe manner and complies with all government, local and governing agency regulations

WARNING: All applicable government, local, and governing agency regulations shall be strictly adhered to. Failure to do so could result in death or serious injury

WARNING: External power supply shall be disconnected via switch or circuit breaker prior to opening the electronics enclosure lid or removing the mechanical enclosure cover. Failure to do so could result in death, serious injury, or extensive property damage

WARNING: Care must be taken to ensure adequate clearances are maintained between structures, other equipment, and personnel when lifting and moving the SI-7000 into position. Failure to do so could result in death, serious injury, or extensive property damage

WARNING: Possibility of cryogenic burns! If the SI-7000 is installed on tanks with cryogenic liquids (such as LNG), when the probe is lifted for maintenance it must be given time to reach ambient temperatures to avoid cryogenic burns when handling the probe. It usually takes more than 4 hours to reach ambient temperature. When the temperature indicated on the touch screen main display reaches ambient temperature, it should be safe to open the mechanical unit.

WARNING: The SI-7000 is not for intended oxygen service

WARNING: Do not open when an explosive atmosphere is present.
Maximum experimental safe gap (MESG) of gas/air mixture ≥ 0,05 mm

CAUTION - PINCH POINT: Care must be taken when closing the SI-7000 electronics enclosure lid and all personnel shall keep their hands clear. Failure to do so may result in injuries as fingers may be pinched.

SPECIAL CONDITIONS OF USE: Flameproof joints are not intended to be repaired.

NOTICE: There are no consumable materials associated with using the SI-7000.

NOTICE: During normal operation there are no surfaces which can cause burns due to high temperatures. If the equipment fails in a manner not covered in the service manual, please consult with Scientific Instruments before touching the equipment.

NOTICE: Instructions for cleaning the probe are given in the service manual. This is the only whetted part that may require periodic cleaning. The drive chain does not need to be cleaned, and no un-whetted parts require periodic cleaning. In the range of applications, the instrument is designed for, no decontamination is required.

NOTICE: All operation instructions in this manual shall be followed. Failure to do so may result in damage to the SI-7000 and void warranty.

SCIENTIFIC INSTRUMENTS

SI-7000

Tank Gauging System

Operational Manual

Part B

SCIENTIFIC INSTRUMENTS, INC.
4400 W. Tiffany Dr. West Palm Beach, FL 33407 U.S.A.
090-7000-2B Rev A

Record of Revisions						
Rev	RFEA #	Description	Rev by	Date	Appr by	Date
-		Initial Release	KN	8/21/19	KN	8/21/19
A		Updated Photos	JR	11/16/20	KN	11/16/20

TABLE OF CONTENTS

1 THEORY OF OPERATION

1.1 OVERVIEW

The SI-7000 controller receives input from the sensors in the mechanical unit and sends signals to control the motor depending on the current mode of operation. This controls the movement of a multi-sensor probe assembly suspended within the tank. Two level sensors inside the probe indicate to the controller whether the probe is in liquid, in vapor or at the interface between liquid and vapor. The controller monitors the signals from the temperature sensor and the density meter, and continuously calculates updated information for transmittal to a host computer.

The system has several modes of operation to accommodate maintenance activities and daily operation. The system may be programmed to perform a profile at regular intervals (as determined by customer requirements) to provide updated information about the conditions in the tank. When not performing a profile, the system is usually set to track liquid level, providing the most up-to-date reading of liquid level.

1.2 LIQUID LEVEL

The liquid level sensors produce different voltages depending on whether they are in liquid or vapor. The controller uses these differences in the sensor voltages to determine their state. By vertically spacing the level sensors a short distance apart, the controller can "recognize" liquid level at the point where the lower level sensor is "in liquid" and the upper level sensor is "in vapor".

1.3 TEMPERATURE

The temperature sensor is a four-leaded platinum element with a resistance of 100 Ω at 0 degrees centigrade. Using a one-milliamp excitation current, a sensor voltage is developed across the sensor proportional to its resistance. This voltage is digitized by an analog to digital converter and compared to data tables in the controller. The appropriate temperature is calculated and constantly updated as the temperature changes.

1.4 DENSITY

The density meter and its associated maintaining amplifier output to the controller a signal whose frequency is proportional to density. The controller determines the frequency of this signal and using a density conversion formula along with calibration parameters for the particular density meter, calculates the density of the medium into which the densitometer is submerged.

1.5 BOTTOM REFERENCE SWITCH

A mechanical switch assembly is employed to signal the controller when the probe is in contact with the tank floor. When the controller senses this "Probe at Reference" condition, it ceases downward movement of the probe and sets the probe position to the pre-programmed bottom reference value. The bottom reference value accounts for the distance of the level sensors from the bottom of the probe.

1.6 TOP REFERENCE SWITCH

A second mechanical switch assembly is employed to signal the controller when the probe has reached the top of the probe chamber. When the controller senses this "Probe at Top" condition, it ceases upward movement of the probe. This provides an easy method of parking the probe at the top in preparation for maintenance activities.

1.7 OPERATIONAL MODES

The system can be operated in any one of five principal modes using the touch screen interface pictured below. The available modes are Automatic (Auto), Calibration, Profile, Zoom Scan, and Manual. The most commonly used modes in daily operation are Auto and Profile. Manual is used normally only for maintenance activities. The Calibration mode can be used after maintenance activities. When power has been removed. It will quickly find bottom reference again and then return to Auto mode at the surface, or whenever it is desirable to re-establish the liquid level.

1.7.1 AUTOMATIC MODE (AUTO)

When the system is placed into Auto, the controller causes the probe to locate and track the liquid/vapor interface. The system is at the interface when the lower sensor is in liquid and the upper sensor is in vapor. The Automatic mode is the normal mode of operation; all alarms are reported, and profile runs can start automatically if they are programmed. The system returns to Auto upon completion of a profile run or a calibration run (described below).

1.7.2 CALIBRATION MODE (CAL)

When Cal mode is selected, the controller drives the probe to the bottom of the tank to establish bottom reference and then back to the liquid level interface, upon which the system is returned to Auto. A calibration is most often used after a power loss or after certain maintenance activities. When power is lost, the last probe position is stored, but it is assumed that the probe may have been moved manually while power was off (such as during maintenance activities), so on power-up the system is marked as not being calibrated.

1.7.3 PROFILE MODE

In the Profile mode, temperature and density readings are taken from the bottom of the tank up to liquid level, providing operators with an accurate representation of the current conditions in the tank.

When the Profile mode is started, the probe is driven to the tank floor where it re-establishes bottom reference. At the bottom, the probe pauses for a programmed delay time to allow conditions in the tank around the probe to stabilize. After the prescribed delay, position, temperature, and density readings are taken, and then the probe is driven up, stopping at programmed increments to collect temperature and density data. The same delay occurs at each point to allow readings to stabilize. The profile is terminated when the maximum number of points is taken or liquid level is found.

The parameters that control a profile may be entered via the LCD interface or over the Modbus serial interface.

After all readings are taken, the data is analyzed and alarms are generated as applicable. The system is returned to Auto after completion of the profile. In this manner, a complete profile of the tank is collected and stored for output to a host computer.

NOTE: The SI-7000 was designed to perform profiles when liquid is fully at rest and stabilized. Do NOT attempt to perform a profile while loading or unloading liquid in the tank. Loading LNG either top or bottom creates turbulence, swirls, and insatiability in liquid. High power compressors are used during unloading, this process also creates low level turbulence and instability in the liquid. For best

accuracy and results profiling must be scheduled a day before or after the loading or unloading process. Consult factory for more information.

1.7.4 ZOOM SCAN MODE

This feature is not implemented at this time.

1.7.5 MANUAL MODE

The Manual mode is used whenever it is desirable to take control of the probe and give specific commands to drive up or down. This would occur most often during maintenance activities. The probe may be stopped so that it will not track liquid level, or it may be driven up or down in fast, medium, or slow.

NOTE: No alarms are reported in the Manual mode and the liquid level reading is not updated. It is important to realize that the system will remain in the Manual mode indefinitely until it is returned to Auto by an operator or by maintenance personnel.

1.8 POWER UP CONDITION

The SI-7000 takes its reference from the floor of the tank; therefore, it is important to re-establish this bottom reference after power up. If this reference has not been established, the current probe position will be marked as "Uncal".

The system can be set so that it will automatically reestablish its bottom reference after a power loss, or it can be set so that it will power up in Manual with the motor stopped. This setting (“Change to Start in Auto” or “Change to Start in Manual”) is found in the Configuration section accessed via the LCD interface. If it is set to start in Auto mode, it will first find the tank bottom and then return to liquid level.

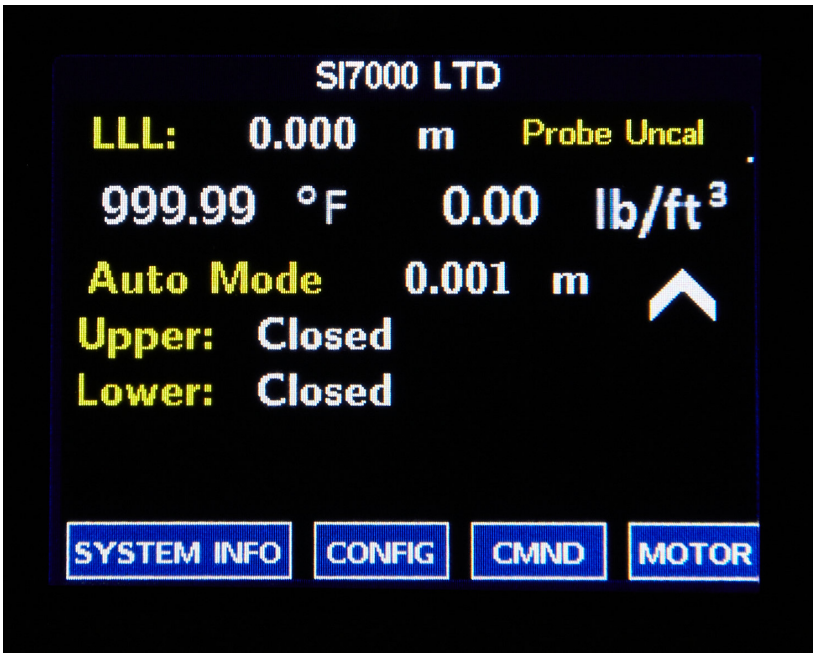
If the system is not set to reestablish bottom reference automatically, it is only necessary to start a Cal run (enter Calibration Mode). The probe will travel to the bottom of the tank, re-establish bottom reference and then return to liquid level, where it will return to the Auto mode.

2 OPERATOR INTERFACE

Information about the system status is usually transmitted to a host computer (or DCS) in the Control Room using the Modbus protocol. The information available includes the current mode of operation, direction and speed of travel of the probe, current values for the position, liquid level, temperature, and density, profile data, and various status indications and alarms, but the programming and implementation of an optional DCS operator interface for the SI-7000 may be different at each site, therefore some of the features described below may not appear. The sections below describe what is available on the SI-7000 LCD screen.

2.1 HOME SCREEN

The home screen is the default display when the gauge is powered on. This screen displays the level, temperature, and density, along with other key parameters.



The current values for position, temperature, and density are the values measured where the probe is located at the moment. If the density is at a very low value (at or equal to zero), it is possible that the probe is in vapor instead of liquid.

The current value for liquid level should also be displayed if it has been established after power-up. If it has not yet been found, it will be zero or the last recorded value. Note that the liquid level can only be guaranteed to be correct when the probe is actually at liquid level. This is indicated by the "At Liquid Level" indicator as described below. In addition, to guarantee an accurate liquid level there should be no "Probe Uncal" status indication (also described below).

There are a number of status indicators that are very important to system operation and must be understood to get a complete picture of the current conditions.

The most basic indicators are the upper and lower level sensors, along with the bottom reference switch and top limit switch. The bottom switch is wired across the lower level sensor, and the top limit switch is wired across the upper sensor. Thus each sensor has 3 possible states:

- Closed: The corresponding switch is closed and the sensor is shorted, so it is not possible to indicate liquid or vapor.

- Liquid: The corresponding switch is open and the sensor is in liquid. (This will be indicated by L-LIQ for the lower sensor, and U-LIQ for the upper sensor.)

- Vapor: The corresponding switch is open and the sensor is in vapor. (This will be indicated by L-VAP for the lower sensor, and U-VAP for the upper sensor.)

When the probe if fully submersed, both switches will be in liquid. If the probe is completely out of liquid, both sensors should indicate vapor. If the probe is at the interface (liquid level), the lower sensor should be in liquid, and the upper sensor should be in vapor.

The SI-7000 measures level with respect to the bottom of the tank, so to report an accurate liquid level, it must first establish the location of tank bottom. If this reference has not been established, the current probe position will be marked as "Uncal". The system saves its last position when power is lost. However, since it is possible that maintenance personnel have physically moved the probe and its cable during a power loss, the position of the probe is always marked as "Uncal" when the system is first powered up. Bottom reference must be reestablished to clear this condition.

The "Probe Uncal" indicator will also come on if the probe position decreases below where bottom reference was found previously without finding bottom reference there again.

The SI-7000 provides a number of alarms to alert operators to abnormal or potentially dangerous conditions. Some of the alarms relate to current conditions and some relate to conditions found in the tank during a profile run.

2.1.1 REEL ALARM

If the Reel Alarm indicator is on, it indicates that the mechanical unit reel is not turning, and it could be indicative of a mechanical failure in the drive mechanism or an obstruction in the tank. Maintenance personnel should investigate.

2.1.2 PROBE AT LIQUID LEVEL

"Probe at Liquid Level" should be on when the system is in its Auto mode of operation and is at liquid level. If this indicator is not on, the operator cannot be assured that the current liquid level reading is correct. If the probe is beneath the surface or it is up in the vapor, there is no way of knowing if liquid level is changing.

2.1.3 LEVEL ALARMS

Probably the most important alarmed parameter relating to current conditions is level. There are several different level alarms: a low level alarm, a low low level alarm, a high level alarm, and a high high level alarm. Each alarm level setting should be determined by operations personnel and programmed accordingly.

2.1.4 TEMPERATURE AND DENSITY ALARMS

The other alarms relating to current conditions are the high and low temperature alarms and the high and low density alarms. In most environments, these alarms are not critical, since it is the deviation alarms that are normally used to detect abnormal variations of temperature and density in the profile of the tank, not the high and low alarms.

2.1.5 DEVIATION ALARMS

During a profile run, temperature and density data are collected at each programmed stop point. At the end of the run, the data points are analyzed. If the temperature deviation between one point and the next point is greater than the programmed alarm value, the temperature deviation alarm is set. Similarly, if the density variation from one point to the next is greater than the alarm threshold value, the density deviation alarm is set. These alarms are not cleared until another profile run is made, and it is verified that the alarmed condition no longer exists.

The deviation alarms are very important, since a variation in density or temperature could indicate layering or stratification, which if left unchecked could lead to a potential rollover condition.

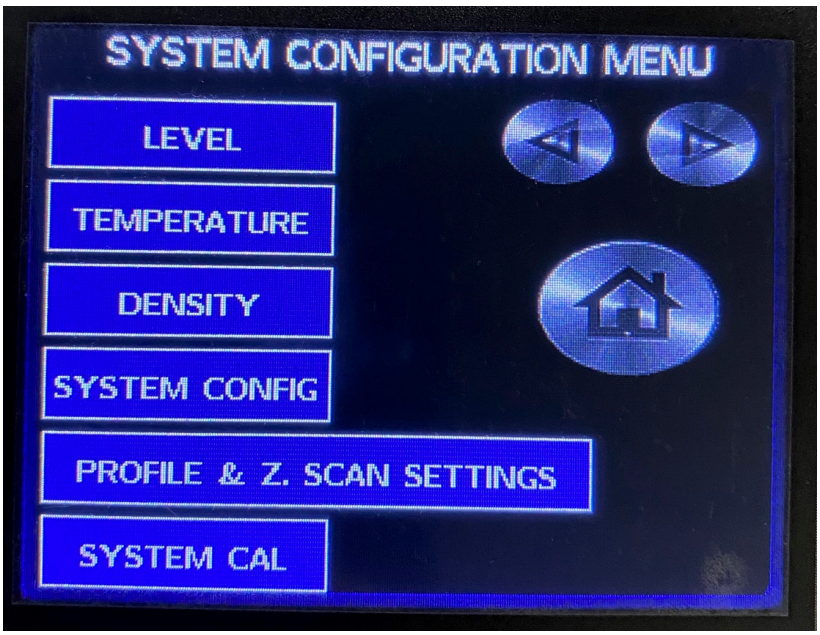
2.1.6 ALARM FUNCTIONALITY IN MANUAL MODE

NOTE: It is very important to understand that when the system is in its Manual Mode of operation, no alarms will be reported, even if alarm conditions exist. For the system to report alarms, it must be in the Auto mode. The system will immediately switch to Auto mode after a Profile or Cal run.

2.2 SYSTEM INFO

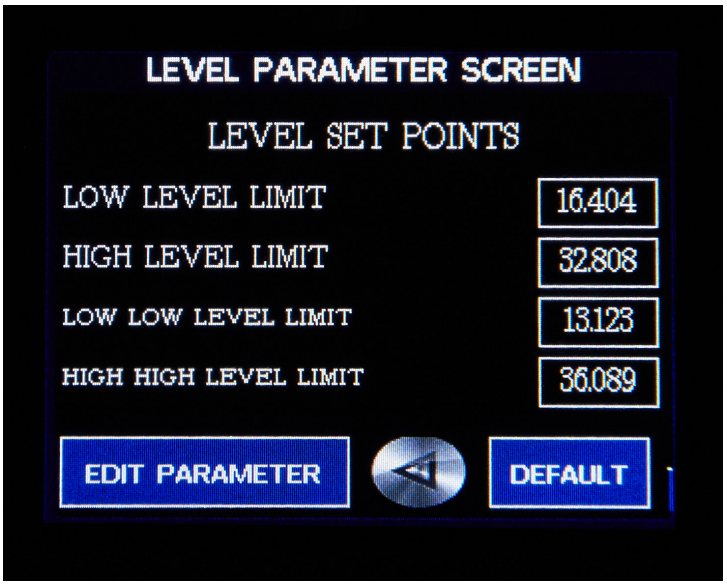
This screen displays the software revision and the Tank ID.

2.3 SYSTEM CONFIGURATION MENU



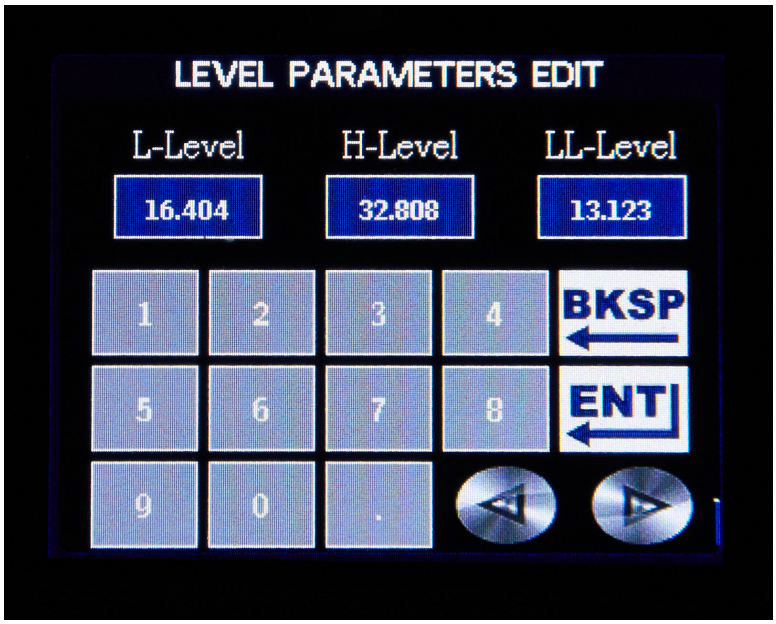
Pressing CONFIG on the main screen brings up the System Configuration Menu. This allows access to parameters that can be changed via the LCD touch screen display.

2.3.1 LEVEL



One of the primary functions of the LTD is to measure the level of the liquid in a storage tank. If the level falls below the low limits or rises above the high limits, alarms are generated. The set points for these alarms are set in this menu.

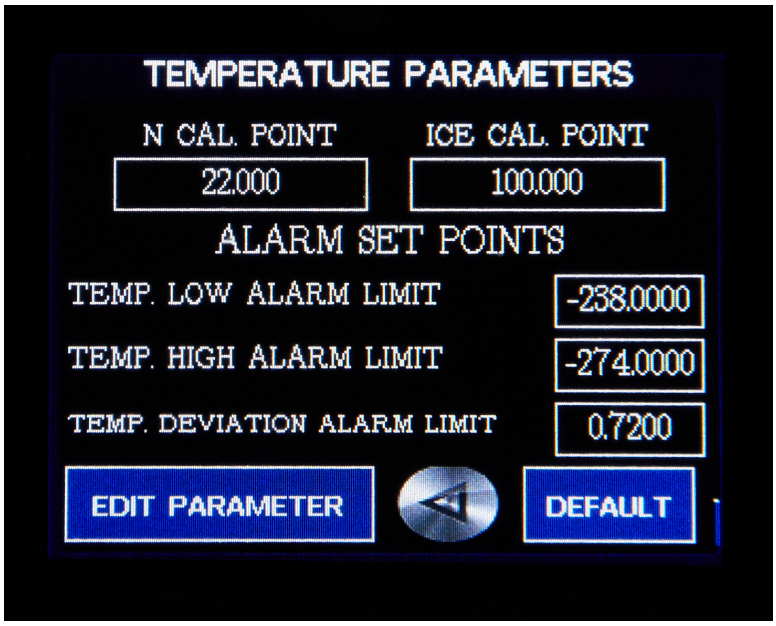
To change the values, push on the “Edit Parameter” button. A new screen will appear allowing the values to be changed.



To change the levels, touch the blue squares and then enter the desire reference. When all the levels are entered, click enter and save.

Use the right arrow to access the fourth parameter.

2.3.2 TEMPERATURE



The temperature sensor in the SI-7000 is mounted inside the density meter. Each sensor is theoretically a 100 Ω platinum resistance thermometer (PRT), but the resistance can vary slightly from the theoretical value. Before each one is shipped, a calibration process is performed, and the exact value is measure in ice and nitrogen. The resulting values are included on the calibration certificate for each density meter.

The SI-7000 electronic circuits are calibrated to measure resistance accurately, so once the correct values are entered for the sensor being used, the instrument can display temperature within the tolerance stated in the system specification.

Temperature Measurement Range: -200°C to +50°C

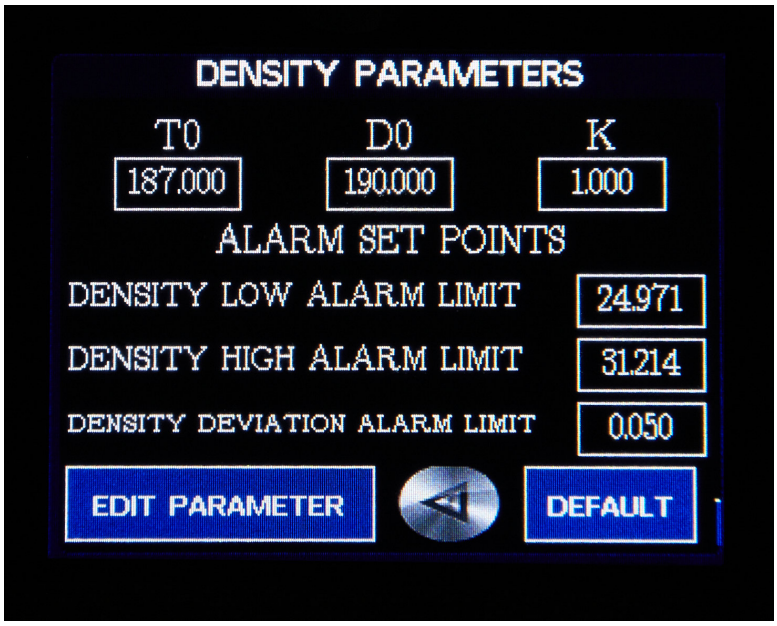
Error (over-range): 999.99°C

Error (under-range): -555.55°C

Low Temperature and High Temperature alarms can be triggered at set points determined by the customer and are entered in Kelvin.

The Deviation alarm is a very important alarm that is used to determine if the tank is stratified or not. In a profile, if there is a difference from one point to the next greater than the Deviation alarm limit, a Temperature Deviation (TD) alarm is triggered. This alarm will remain active until another profile is performed and the condition is cleared.

2.3.3 DENSITY



The density meter is a calibrated device. Before each one is shipped, a calibration process is performed, and three coefficients are determined and included on the calibration certificate for each density meter.

The SI-7000 electronic circuits are designed to measure frequency accurately, so once the correct values are entered for the density meter, the instrument can display density within the tolerance stated in the specification.

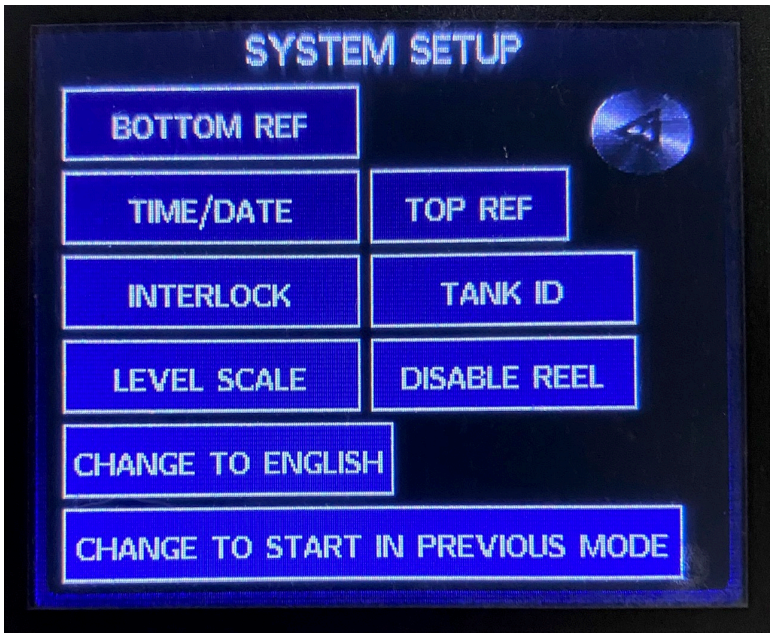
Density Measurement Range: 400 kg/m^3 to 600 kg/m^3

Error (over-range): 9999.99 kg/m^3

Low Density and High Density alarms can be triggered at set points determined by the customer and are entered in kg/m^3.

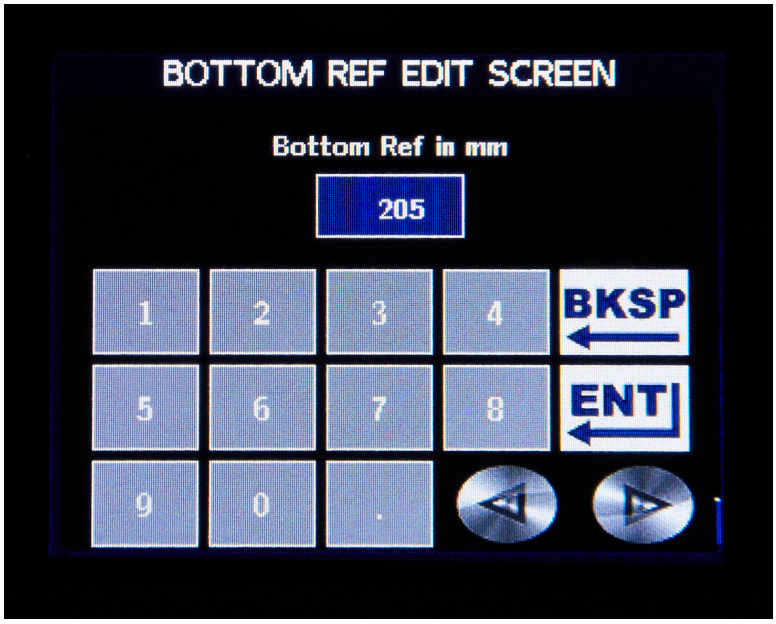
The Deviation alarm is a very important alarm that is used to determine if the tank is stratified or not. In a profile, if there is a difference from one point to the next greater than the Deviation alarm limit, a Density Deviation (DD) alarm is triggered. This alarm will remain active until another profile is performed and the condition is cleared.

2.3.4 SYSTEM



The System Menu provides access to a number of sub menus.

2.3.4.1 BOTTOM REFERENCE



The SI-7000 measures level with respect to the bottom of the tank, and it touches bottom at the beginning of every Cal run and Profile. When the probe touches tank bottom, the motor pulse count is set to zero.

The height of the lower level sensor above the bottom of the probe is added to the pulse count to establish an accurate position of the lower level sensor.

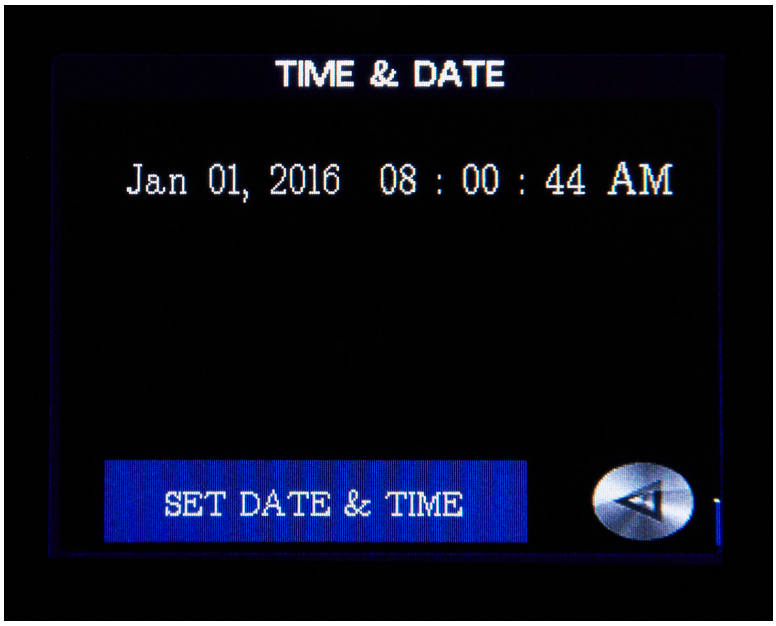
To change the bottom reference, touch the blue square and then enter the desire reference. Click enter and save.

2.3.4.2 TANK ID

For installations with multiple tanks, the Tank ID distinguishes one tank from another. This is also the Modbus Address.

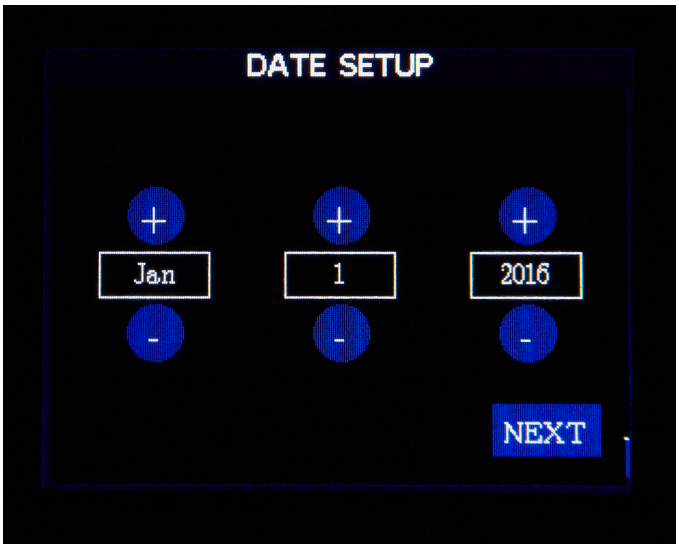
To change the Tank ID “Address”, touch the blue square and then enter the desire ID “Address”. Click enter and save.

2.3.4.3 TIME/DATE



The SI-7000 maintains a record of the date and time and keeps the time for up to one month after power is turned off. If the controller is powered off for more than one month, it may be necessary to reprogram the current date and time.

To change the date and time, push the button with that label. A new screen opens with an option to set the date.



After specifying the correct date, push Next, and another screen opens with an option to set the current time. Push Done when finished.

2.3.4.4 LEVEL SENSOR CAL CLOSED

This is for internal use, and a password is required.

2.3.4.5 MICROCONTROLLER CAL

This is for internal use, and a password is required.

2.3.4.6 LEVEL SENSOR CAL LIQUID

This is for internal use, and a password is required.

2.3.4.7 UNITS OF MEASURE (METRIC/ENGLISH)

This button gives the option to change to the other system of measure. If the system is currently in metric, the button will display an option to Change to English. If the system is in English units, the button will display an option to change to metric.

2.3.4.8 100 OHM CAL

When this menu is selected, a verification message is displayed.

“Calibrate at 100 OHM?”

This is for internal use, and should only be performed when instructed to do so by the technical support department. Press “No” to exit the menu without calibrating.

2.3.4.9 NITROGEN TEMPERATURE CAL

When this menu is selected, a verification message is displayed.

“Calibrate at Nitrogen temperature?”

This is for internal use, and should only be performed when instructed to do so by the technical support department. Press “No” to exit the menu without calibrating.

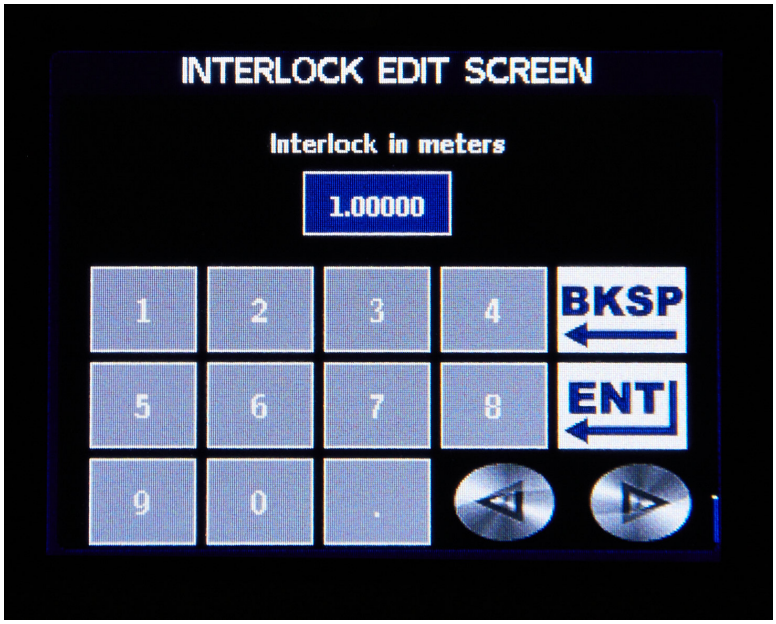
2.3.4.10 LEVEL SCALE

The formula for level is as follows:

Level = Motor Pulses * Level Scale + Bottom Reference

So Level Scale is the calibration value that relates pulses to actual probe position. A calibration is done at the factory, and Level Scale value is determined and then recorded on a site specific Configuration Worksheet. The value shown here should match the value in that Configuration Worksheet.

2.3.4.11 INTERLOCK



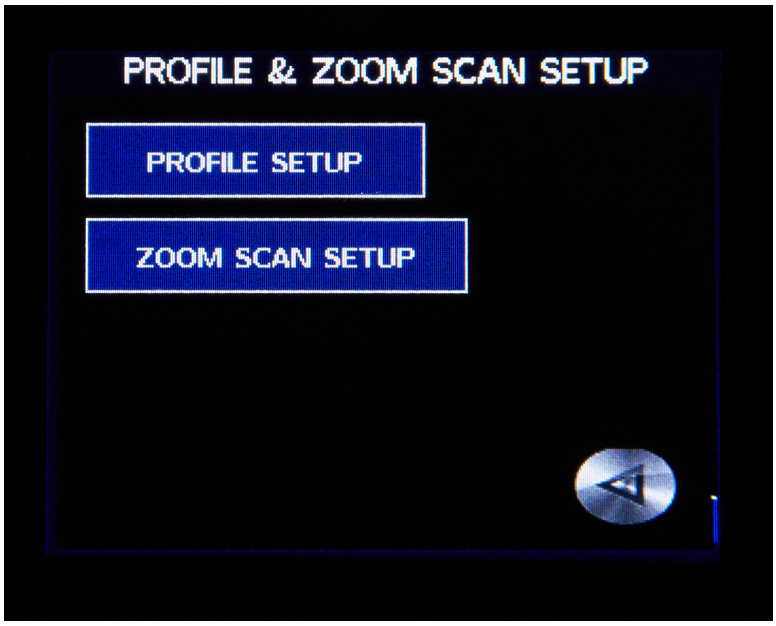
Interlock is the high limit for probe movement. It is normally set to keep the probe down in the cold part of the tank. If the Interlock indicator in the DCS or PC User Interface is on, it means that the probe has reached the highest position allowed. Unless the probe was raised to that point manually, this is an abnormal situation and maintenance personnel should investigate.

To change the interlock, touch the blue square and then enter the desire interlock. Click enter and save.

2.3.5 COM SETTINGS

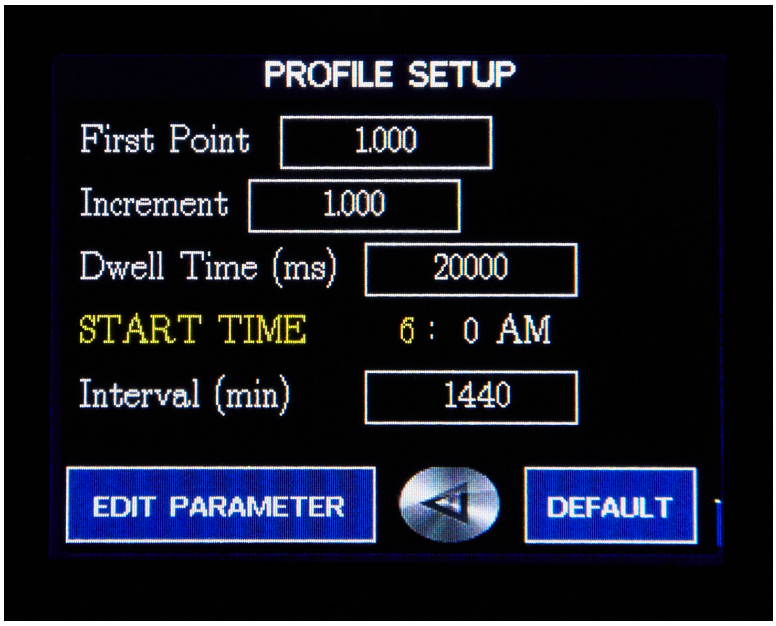
This menu is not supported at this time.

2.3.6 PROFILE & ZOOM SCAN SETTINGS



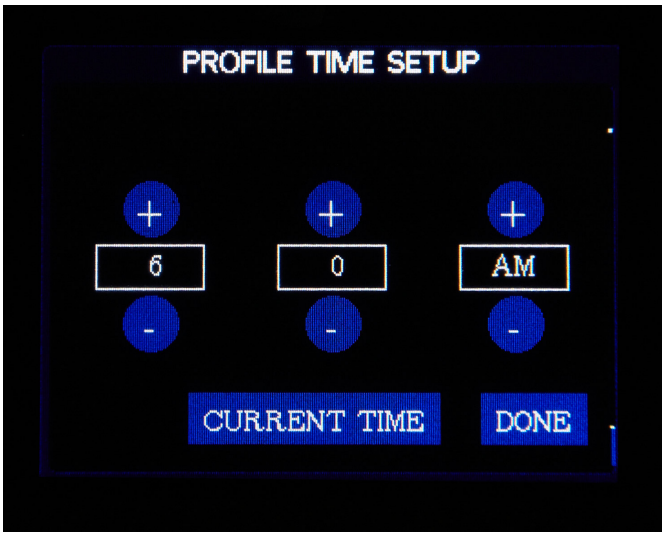
This menu has two sub menus.

2.3.6.1 PROFILE SETUP



One of the most important features of the SI-7000 is the ability to collect data at various points in the tank. A profile starts at the bottom of the tank and points are taken in the upward direction until the maximum number of points is reached or liquid level is found. This menu allows customization of the profile that is taken.

The actual first point of the profile is taken at the tank bottom. The first programmable point is specified in the field, “First Point.” As the probe moves off the bottom, it will first stop at this point, and then the Increment will be added to calculate the next stop point. The Dwell Time is the time in milliseconds that the probe will wait at each point before taking readings. The Interval is the amount of time in minutes before the next profile will be taken.



The time setup screen makes it possible to choose the exact time when the profile will start. Note that the profile run will not start if the system is in Manual when the programmed time arrives, but will start if the system is in Auto, Calibrate, or Profile.

2.3.6.2 ZOOM SCAN SETUP

This menu is not implemented at this time.

2.3.7 START MODE (AUTO/MANUAL)

When the system is powered on, the power up state is programmable. It can either remain in Manual Mode, waiting for instructions, or it can go directly into Auto Mode and measure liquid level. During maintenance, it is usually set to stay in Manual. In normal operation it can be changed to start in Auto.

If it is currently set to start in Manual, the button will show the option to change to start in Auto. If it is set to start in Auto, the button will show the option to start in Manual.

2.4 COMMAND MENU

The Command Menu allows the current LTD mode to be changed.

Pressing **Manual Mode** will cause the probe to go to Manual Stop. It will remain in this mode indefinitely, waiting for operator commands.

If you push the **Level Calibration** button, the probe will move to the tank bottom to re-establish the bottom reference, and then it will return to the liquid level.

The **Auto Mode** button will return the LTD to normal Auto mode, where it continuously tracks liquid level.

Push **Start Profile** to initiate a new profile, moving to the bottom of the tank, and then back to liquid level, collecting data at the programmed stop points.

Zoom Scan is not implemented at this time.

Use the Back button to return to the previous menu.

2.4.1 MANUAL MODE

In Manual mode the probe is under operator control. Pressing the Up arrow one time starts the probe moving up slowly. Press it again to change to medium speed and press it a 3rd time to change to high speed.

Likewise, pressing down one, two, or three times puts it in slow, medium, or fast speed moving down.

The Stop button should be pressed before changing directions to avoid jerking the chain and probe.

2.4.2 LEVEL CALIBRATION

Pressing Level Calibration starts the probe moving down to the tank bottom. After it reaches the tank bottom it will return to liquid level. After the calibration button is pushed, the display returns to the normal display.

2.4.3 AUTO MODE

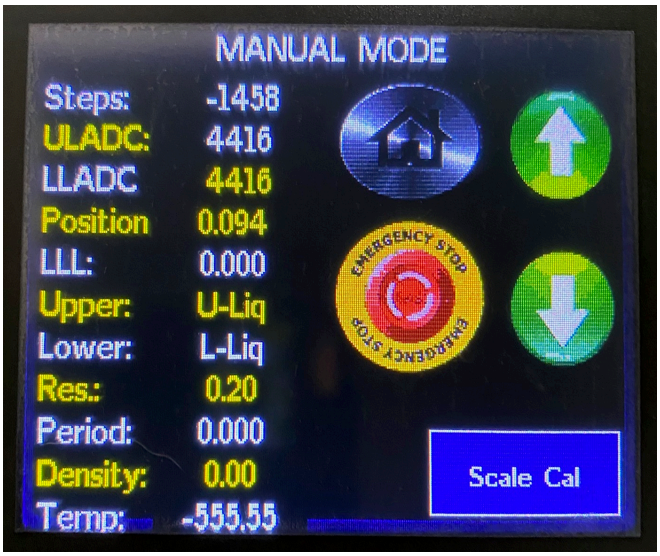
Pressing Auto Mode puts the LTD in Auto, and the probe will return to liquid level from wherever it is, and it will track liquid level continuously. After the Auto Mode button is pushed, the display returns to the normal display.

While in Auto, the probe usually drives in slow to track liquid level, but it can accelerate to a faster speed as needed.

2.4.4 START PROFILE

Pressing Start Profile starts the probe moving down to the tank bottom. After it reaches the tank bottom and collects data at the first point, it begins moving up, stopping to collect data at the programmed stop points along the way. When it reaches liquid level, the last point will be taken, and the profile will complete. After the Start Profile button is pushed, the display returns to the normal display.

2.5 MOTOR



Pressing MOTOR brings up a screen that shows detailed diagnostic information related to the motor drive function and other system parameters.

3 TECHNICAL ASSISTANCE

For technical assistance, please contact Scientific Instruments via telephone, fax, mail, or email.

Scientific Instruments
4400 W. Tiffany Dr.
West Palm Beach, FL 33407
U.S.A.

Telephone: +1 (561) 881-8500
Facsimile: +1 (561) 881-8556
Email: support@scientificinstruments.com
Website: www.scientificinstruments.com

4 DISCLAIMER

WARNING: Only personnel **certified by Scientific Instruments, Inc.** are authorized to execute the activity of installation, commissioning, or any type of work/maintenance on the model SI-7000 LTD gauge. Unauthorized activity on the SI-7000 LTD gauge will negate warranty. Scientific Instruments, Inc. assumes no responsibility for injury, loss or damage to person or property caused by unauthorized activity. Any questions please contact us at email fieldservicetechs@scientificinstruments.com or Phone: (800)466-6031.

SCIENTIFIC INSTRUMENTS

SI-7000

Tank Gauging System

Service Manual

SCIENTIFIC INSTRUMENTS, INC.
4400 W. Tiffany Dr. West Palm Beach, FL 33407 U.S.A.
090-7000-3 Rev -

TABLE OF CONTENTS

1 INTRODUCTION

The SI-7000 Tank Gauging System monitors the level, temperature, and density of the cryogenic liquid in a large storage tank and is typically controlled and monitored by a PC based operator interface and/or DCS user interface in the control room. The SI-7000 consists of two sections, mechanical and electrical. The mechanical section consists of the chain reel enclosure and probe enclosure. This section contains all of the mechanical components, except the drive shaft gear box, required to lift and lower the probe assembly in the tank and shall be considered a zone 0 environment. For basic service this section will not need to be accessed. The electrical section consists of the electrical enclosure and contains all the electronics and drive shaft gear box. The electrical section housing is an explosion-proof container and shall be considered a Zone 1 environment. This section is where the input power and communications are physically connected to the SI-7000. For a more detailed explanation of the components in these sections and their function please refer to the “SI-7000 Operational Manual” (090-7000-2). The probe enclosure is mated to the bottom of the chain reel enclosure, and the chain reel enclosure and electrical enclosure are mated back to back

Figure 1 Chain reel & probe enclosures

Figure 2 Chain reel enclosure w/o Cover

Figure 3 SI-7000 Side View

Figure 4 Electrical Enclosure

Figure 5 Electrical Enclosure w/ door open

Figure 6 SI-7000 transparent side view

This manual provides information necessary to service the system at a typical location. A site-specific mechanical installation drawing and field wiring diagram may be provided along with this manual for clarification of details at a typical location.

Please refer to the “SI-7000 Operational Manual” (090-7000-2) for more detailed instructions on other activities.

2 WARNINGS, CAUTIONS, AND NOTICES

Scientific Instruments, Inc. is not liable for any injuries, death, or damages caused during operation and servicing of the SI-7000. It shall be the customer's responsibility to ensure all operations and maintenance are performed in a safe manner and comply with all government, local and governing agency regulations.

 **WARNING:** All applicable government, local, and governing agency regulations shall be strictly adhered to. Failure to do so could result in serious injury and/or death.

 **WARNING:** External power supply shall be disconnected via switch or circuit breaker prior to opening the electronics enclosure lid or removing the mechanical enclosure cover. Failure to do so could result in serious injury, death, or extensive property damage

 **WARNING:** Possibility of cryogenic burns! If the SI-7000 is installed on tanks with cryogenic liquids (such as LNG), when the probe is lifted for maintenance it must be given time to reach ambient temperatures to avoid cryogenic burns when handling the probe. It usually takes more than 4 hours to reach ambient temperature. When the temperature indicated on the touch screen main display reaches ambient temperature, it should be safe to open the mechanical unit.

 **WARNING: Do not open when an explosive atmosphere is present.** Maximum experimental safe gap (MESG) of gas/air mixture ≥ 0.05 mm

 **CAUTION - PINCH POINT:** Care must be taken when closing the SI-7000 electronics enclosure lid and all personnel shall keep their hands clear. Failure to do so may result in injuries as fingers may be pinched.

NOTICE: There are no consumable materials associated with using the SI-7000.

NOTICE: During normal operation there are no surfaces which can cause burns due to high temperatures. If the equipment fails in a manner not covered in the service manual, please consult with Scientific Instruments before touching the equipment.

NOTICE: Instructions for cleaning the probe are given here. This is the only whetted part that may require periodic cleaning. The drive chain does not need to be cleaned, and no un-whetted parts require periodic cleaning. In the range of applications the instrument is designed for, no decontamination is required.

NOTICE: All operation instructions in this manual shall be followed. Failure to do so may result in damage to the SI-7000 and void warranty.

NOTICE: All service instructions in this manual shall be followed. Failure to do so may result in damage to the SI-7000 and/or other nearby equipment.

NOTICE: All service shall be performed by qualified personnel.

NOTICE: Fuses shall be changed by qualified personnel.

NOTICE: Lock-out tag-out procedures shall be followed during service.

3 OVERVIEW

In general, a system inspection and routine maintenance session will begin in the Control Room, evaluating the performance of the system while the probe is still in the liquid. This provides an opportunity to observe any existing problems and performance problems, allowing corrective action to be taken once the probe is out of the liquid.

After that inspection, the probe will be raised to the probe enclosure and allowed to warm. While the system is warming up, the Mechanical Unit cannot be opened, but the Electronic Unit can be checked during that time. When the probe has reached ambient temperature, the mechanical unit may be opened and the internal components can be checked.

4 GUIDELINES FOR MAINTENANCE

Refer to site specific drawings for more information about field wiring and installation.

4.1 PREPARATION

Before beginning the maintenance procedures, it is recommended to check to see if firmware updates are required. If firmware updates are required, these may need to be completed first.

4.2 POSSIBLE MATERIALS NEEDED

- Vacuum grease
- Grease for pinch valve
- Can of compressed air or clean instrument air

4.3 CALIBRATION OF DENSITY METER

Some customers are concerned about absolute accuracy in density measurement. These customers should return the density meters to the manufacturer every three to five years, depending on how concerned they are with absolute accuracy. Absolute accuracy is not required for detection of stratification. To detect stratification, the system only needs to observe a relative density difference in the tank.

Calibration of the density meter is not included in normal routine maintenance procedures. Please contact the factory for details.

4.4 CALIBRATION OF TEMPERATURE MEASUREMENT

Calibration of temperature measurement consists of two parts: 1) Calibrating the electronics, and 2) Calibrating the temperature sensor. Since the temperature sensor is internal to the density meter, calibration of the temperature sensor can be requested when the density meter is returned to Scientific Instruments. It is possible to perform calibration of the electronics for temperature measurement on site only if the correct test equipment is available. (This would include a decade box, precision DVM, connecting cables.) Please contact the factory for details.

Temperature calibration can also be done every three to five years, depending on how concerned the customer is with absolute accuracy of temperature measurement. Normally,

absolute accuracy is not critical. Stratification is detected by observing relative changes in temperature.

Calibration of temperature measurement is not included in normal routine maintenance procedures. Please contact the factory for details.

4.5 OPENING ELECTRICAL ENCLOSURE DOOR

To perform maintenance activities, it will be necessary to open the electrical enclosure door. Extreme care must be taken not to scratch or mar the flame path surfaces while working inside the electrical enclosure. Any scratches or damage to the flame path void the enclosure's explosion proof certification.

- Loosen all bolts holding the enclosure's door shut with the Allen wrench provided.
- Open door fully.
- Insert pin to hold the door in the open position.

4.6 CLOSING ELECTRICAL ENCLOSURE DOOR

When maintenance activities are complete, the door should be closed. Extreme care must be taken not to scratch or mar the flame path surfaces while working inside the electrical enclosure. Any scratches or damage to the flame path void the enclosure's explosion proof certification.

A basic functionality test should be performed prior to closing the electrical enclosure. If communications with the control room are available these should be tested as well. This allows for discovering any potential problems before the cover is closed.

- Apply a thin bead of silicone vacuum grease all the way around the enclosure side flame path.
- Remove pin holding the door in the open position.
- Close door fully and insert all the bolts.
- Tighten all bolts on the enclosure door with the Allen wrench provided.
- Torque bolts between 18 to 20 lb·ft (24.5 to 27 N·m)
- Wipe off any silicone lubricant that has been squeezed out from the flame path.

4.7 MECHANICAL ENCLOSURE

This section provides guidance for working with the mechanical enclosure.

 **WARNING:** Shafts and bushings (flameproof joints) are not intended to be repaired. Contact Scientific Instruments for replacements of these parts.

NOTICE: Bearings shall be replaced after 10 years of service (90% of rated life). Expected use is 2 hours of continuous mechanical movement per day.

5 PERIODIC MAINTENANCE PROCEDURE

ACTIVITY	REMARKS
On Tank	
Compare current programmable parameters values with Configuration Worksheet.	Note and resolve any discrepancies.
With the probe still in the liquid, observe the operation of the system in Auto at liquid level.	Unless there is turbulence in the tank due to pumping action, the probe should be stable at liquid level with the lower sensor in liquid and the upper sensor in vapor. Constant hunting indicates the need to spread the level sensors apart more.
Check Motor screen and verify all parameters are normal. Observe any alarms present.	
Check for proper values for temperature and density on home screen.	For LNG, temperature is typically between -157°C (-251°F) and -163°C (-261°F), and density is usually between 425 kg/m3 (26.5 lb/ft3) and 470 kg/m3 (29.3 lb/ft3). This is only a functional check. Re-calibration of temperature and re-calibration of density are more complex procedures, and are not included in this procedure.
Drive the probe to the bottom of the tank in manual.	
Raise the probe a little and verify that both sensors indicate liquid.	It is only necessary to raise the probe a little. (The bottom reference switch must not be closed, since it shorts the lower level sensor.)
Start a level calibration and check that the system finds level properly.	The probe should stop quickly when it reaches liquid level.
Drive probe up until it stops at the upper limit switch. Disable drive when the probe reaches the top.	Disabling the drive mechanism prevents the probe from being driven back down into liquid by mistake.
Wait for the probe to warm to ambient temperatures before opening the mechanical unit. Proceed with electronic unit checkout procedure.	In warm weather, the probe should reach ambient temperature in about 4 hours. The mechanical unit cannot be opened during this time, but the electronic unit may be opened. It is not necessary to close the pinch valve while the probe is warming.
Pinch Valve	
After verifying that the probe is at the top limit switch, check that the pinch valve operates freely. (Do not close the pinch valve yet.)	Verify that the top of the probe is at the upper limit switch before closing, otherwise the probe may be damaged! Rotate hand wheel 5 turns clockwise, then 5 turns counter-clockwise. If equipped with a grease fitting, lubricate with quality grease.
Electronic Unit Checks	
Check the value recorded for driving to the top. Close the pinch valve firmly.	The top stop value should correspond closely with the value in the Configuration Worksheet.

ACTIVITY	REMARKS
Drive the probe down to touch the pinch valve.	This verifies bottom reference operation at ambient temperature.
Leave the probe resting on the pinch valve.	This ensures there is enough slack in the cable when opening the system.
Power off.	
Check that terminals within the electronic unit enclosure are free of corrosion and foreign matter, and are secure.	Check that connectors and terminal screws are tight and no corrosion is present.
Inspect for any sign of deteriorating components.	
Check exposed hardware to be sure it is tight.	
Check connection to motor to make sure the connection is tight.	
Mechanical Unit (after warm up period)	
Loosen bolts in the mechanical unit cover and allow system to depressurize.	If the gas flow does not stop after 15 seconds, close the pinch valve a little tighter.
Remove cover and perform visual inspection of interior components.	
Remove applicable hardware and lift probe out of enclosure. Lay it on a suitable working surface.	
Remove the probe shroud, switch assembly, and screen.	
Inspect the density meter to make sure it is clean and dry and fastened securely to probe cone.	If necessary, clean with compressed air. If it is necessary to use a liquid cleaner, any moisture on the probe must be allowed to dry before returning the probe to liquid.
Inspect level sensors to make sure they are free of debris and foreign material.	
Record spool number of density meter.	Check to see that it matches the Configuration Worksheet.
Re-install the probe shroud, switch assembly, and screen.	
Check all for proper operation, especially the bottom switch.	It is very important that the bottom switch function properly. Verify this carefully.
Return the probe to the probe enclosure and reinstall hardware.	
Inspect chain and sprocket for excessive wear.	If any signs of serious abrasion are evident and drive problems have been reported, carry out a full inspection of the drive chain over its entire length. NOTE: The chain must be handled properly, or it can be adversely affected during the inspection.
Clean drive mechanism interior and remove any foreign matter	
Check decoder for reel feedback signal.	

ACTIVITY	REMARKS
Closing Mechanical Unit	
Apply a small amount of vacuum grease to the gasket, and apply anti-seize compound to cover bolts. Re-install cover.	
If the system is powered on, power off.	The next step involves venting gas. There should be no exposed active electronics during this step.
Follow site procedures to purge the instrument.	There are lower and upper purge ports.
When purging is complete, make sure all purge openings are secure and tight.	Check that no gas leaks are evident around cover joints. If leaks cannot be stopped, it may be necessary to replace the mechanical unit gasket.
When no gas remains in the area, open Electrical Unit (or power on again).	
Open the pinch valve fully and drive the system down in Manual.	Use high speed. There is no need to stop at the liquid interface. Monitor the system as it drives to make sure it drives smoothly.
Raise the probe a little and verify that sensors read liquid.	
Start a level calibration.	This is the quickest way to return the probe to liquid level. Wait for the Cal Run to finish.
After the probe reaches liquid level, verify that it stops quickly.	
Closing Electronic Unit	
Apply a small amount of silicon grease to sealing surfaces of the electronic unit to protect from environmental effects.	
Apply grease or anti-seize compound to socket bolts and close the electronic unit.	
Run a profile. (If the user interface allows, this may be started from the Control Room.)	This will provide density and temperature profile values for the host computer.
Update Configuration Worksheet.	Make sure all values are up-to-date.
Optional PC Interface	(if PC was provided by SI)
Check that communications cable is fastened securely	
Take backup, etc.	
Check past profiles, if available.	While waiting for the probe to finish its movements, it's a good time to check profile history, if available. Look for any abnormalities in profile data.

6 BASIC FUNCTIONALITY TESTING

6.1 POWER UP

1. Ensure the SI-7000 power switch is in the “OFF” position.
2. Remove AC power lock out/tag out.
3. Move the SI-7000 power switch to the “ON” position.
4. Check the following on the main controller.
    - Red “A/C” power LEDs are on. If not, try the following:
        - Ensure AC power is being supplied to the controller assembly.
        - Ensure power plug is full inserted into socket .
    - Green “FUSE” LEDs are on. If not, try the following:
        - Check fuses in AC plug module (spare fuses are included in kit).
    - Green “PWR” LED is on. If not, it is most likely the following:
        - DC power supply is not functioning, replace controller assembly.
    - LCD is on and displaying the main menu. If not,
        - Remove controller assembly and ensure LCD is fully connected.
        - If still no success, the LCD or CPU is not functioning, replace controller assembly.
5. Continue to the next test or move the SI-7000 power switch to the “OFF” position.

6.2 MOTOR DRIVER TEST

1. Ensure the SI-7000 power switch is in the “ON” position.
2. On the touch screen LCD navigate to the Motor menu.
3. Touch the down arrow once.
    - The motor should begin to lower the probe assembly at its slowest speed.
4. Touch the down arrow a second time.
    - The motor should increase to its medium speed.
5. Touch the down arrow a third time.
    - The motor should increase to its maximum speed.
6. Touch the down arrow a fourth time.
    - The motor should return to its medium speed.
7. Touch the stop button.
    - The motor should stop and hold the probe at its current position.
8. Touch the up arrow once.
    - The motor should begin to lift the probe assembly at its slowest speed.

9. Touch the up arrow a second time.
    - The motor should increase to its medium speed.
10. Touch the up arrow a third time.
    - The motor should increase to its maximum speed.
11. Touch the up arrow a fourth time.
    - The motor should return to its medium speed.
12. Allow the motor to lift the probe to the parked position.
    - The motor should automatically stop and hold the probe in the parked position.

6.3 CHECKING LEVEL CALIBRATION

1. Ensure the SI-7000 power switch is in the “ON” position.
2. On the touch screen LCD navigate to the Motor menu.
3. Touch the down arrow once.
    - The motor should begin to lower the probe assembly at its slowest speed
4. Observe the chain movement through the probe enclosure window and stop the motor when the designated marking on the chain is aligned with a reference point. Record the step count.
    - Motor should stop and hold the probe at the current location
5. Touch the down arrow three times.
    - The motor should begin to lower the probe assembly
6. Observe the chain movement through the probe enclosure window and stop the motor when the second marking on the chain is aligned with the reference point. Record the second step count.
7. Calculate the level scale. Consult with factory for details.
8. Touch the up arrow three times.
    - The motor should begin to lift the probe assembly.
9. Allow the motor to lift the probe to the parked position.
    - The motor should automatically stop and hold the probe in the parked position.

6.4 COMMUNICATIONS TEST

1. Ensure the SI-7000 power switch is in the “ON” position.
2. Ensure the green “COM” LED(s) are on.
3. From the control room send a command to lower the probe.
    - The motor should begin to lower the probe assembly .
4. From the control room send a command to stop the motor.
    - The motor should stop and hold the probe at its current position.
5. From the control room send a command to lift the probe.
    - The motor should begin to lift the probe assembly.
6. Allow the motor to lift the probe to the parked position.
    - The motor should automatically stop and hold the probe in the parked position.

Systems Warranty Policy

Scientific Instruments, Inc. (SII) warrants its LTD tank gauging system against all defects in material and workmanship for a period of (24) months from the date of shipment of goods from SII dock, at 4400 West Tiffany Drive, West Palm Beach, Florida.

SII shall not be liable for damages caused by raw materials, designs of work methods instructed by the Purchaser or incompatibility of the Purchaser's equipment with SII products. SII shall not be liable for damages caused by negligence of a contracting party or a third party and not for damages caused by the use of SII product for other purposes than it is intended.

Sub-assemblies not of SII manufacture, but as part of an SII system, such as software, printers, terminals, modems, etc., are warranted in accordance with the terms of sales as extended by the product supplier.

SII shall not be liable for indirect losses and pure financial losses, lost profit or other consequential economic losses.

Should a defect become apparent within this warranty period, SII or properly trained and certified personnel will perform field repair at the customer's facility. Transportation costs and living expenses for the required field service personnel shall be borne by the customer, at cost.

In the event of failure of sub-assemblies or components which can be physically returned to SII, all warranty repairs/replacements will be made at no charge, provided that the customer pays all freight costs, foreign duties, etc., incurred in returning such sub-assembly or components to SII. Any U.S.A. duties or fees imposed upon products entering this country will be paid by SII.

This warranty policy is considered null and void if the installation and commissioning of the system is not performed by SII personnel, or personnel formally trained and certified by SII. A Certificate of Training will be issued by SII when independent contractors or consultants have successfully completed such training.

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