MTS®

Level Plus®

DDA Tank Gauge Monitor

Operation Guide and Installation Manual

DDA Tank Gauge Monitor

550421 Revision C

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NOTICE TO USER:

See section 9 of this manual for important information about the installation, setup, and use of this product.

I Introduction

The Level Plus® DDA monitor is an industrial quality microprocessor based data acquisition and display system for use with the Level Plus DDA tank gauges. In its standard form, the monitor performs the following functions:

- Provides intrinsically safe power and communications to the tank gauges (up to 8)
- Displays the following parameters:
  - Product level, volume and mass
  - Interface level and volume
  - Temperature
  - Alarm status
- Provides 8 alarm contact outputs
- Provides 8 isolated 4-20 milliamp analog outputs
- Provides 1 serial asynchronous host communication port (RS485 or RS232)

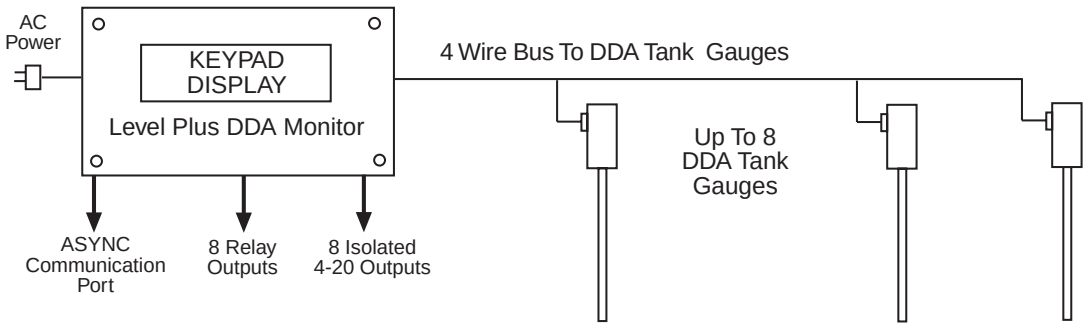


Figure 1. Level Plus DDA System Architecture

2 General Software Information

Advanced software techniques and concurrent operations are used to provide minimum scan times and optimum overall system performance. The SCAN processor runs in background mode scanning each gauge for level and temperature information. Temperature scans occur once per five level scans. In addition, the scan processor performs level, temperature, and volume calculations; alarm processing; and maintenance of the active data arrays. The DISPLAY processor is a foreground operation that transfers the array data to the LCD display. The DISPLAY processor runs under keypad control allowing the user to alter the scan sequence and the type of data being displayed. The COMMUNICATION processor is another background operation that handles all external host communications to the Level Plus monitor. All three operations run independently, allowing immediate access to the data array with no additional over-head imposed on the SCAN processor; thereby, minimizing scan rates and alarm response times. See Figure 2.

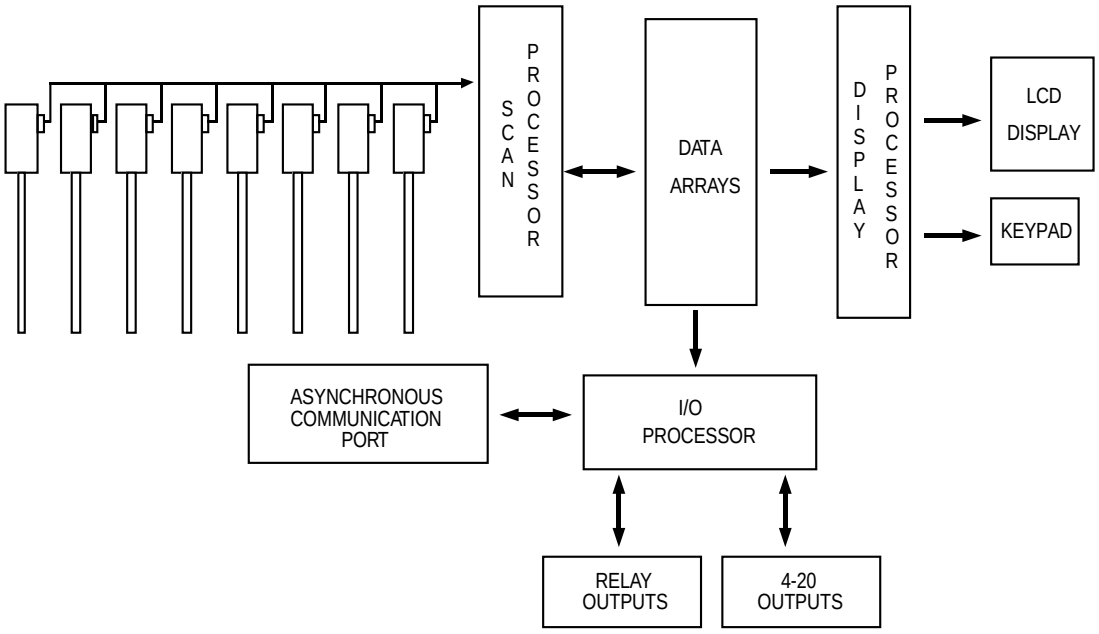


Figure 2. Level Plus DDA Monitor Software Structure

In addition to the advanced processing environment offered by the Level Plus system, the software also supports a high degree of programmability, allowing the user to configure the system to satisfy particular needs. The programming software is user friendly and allows the user to alter many system parameters. Where possible, the software provides error checking on data entered by the user. The software checks for valid assignments and erroneously entered data values. If the software receives an illegal assignment or erroneous value, the entered parameter is rejected and the user is prompted to reenter the correct value. The programmable parameters are described in the following pages.

Display Update Rate

The display update rate is programmable from 1 to 25 seconds. This parameter affects only the display update rate and does not affect the data acquisition scan rate. The software also supports scan override and scan hold functions.

LCD Contrast Ratio

The Level Plus monitor uses a LED backlit, top-view LCD display module. The software allows the user to adjust the optimum contrast ratio (viewing angle).

Communications

The Level Plus monitor is available with either EIA 485 or EIA 232 communications hardware for communications with external host equipment. The user can program both baud rate and communication address parameters.The software also supports a data logger mode allowing gauge data to be sent to a serial interface printer at scheduled intervals.

Security Password

Programming parameters are protected by a 6-digit security access code. This code may be reprogrammed or disabled.

Display Units/Resolution

Both MKS and U.S. customary display units are supported. Available level display units include the following: decimal inches, feet, millimeters, meters or fractional inches. Available temperature display units include degrees Centigrade or Fahrenheit. These are global parameters and affect all gauge data.

Level data resolution is also a programmable parameter, but can be different for each gauge displayed. Level resolutions of 0.1, 0.01 and 0.001 inches can be displayed. Temperature data resolution is also programmable for each gauge in the system. Temperature resolutions of 1, 0.2, and 0.02 degrees Fahrenheit can be displayed.

System Clock

The Level Plus monitor maintains system time with on board real time clock (RTC) circuitry. The RTC uses the power line frequency as a time base offering very high accuracy. In the absence of power, the clock automatically switches over to battery power and a crystal time base. The RTC information (date and time) is printed on all data logger reports and is also accessible via keypad control.

Gauge Parameters

Programmable gauge parameters include the following items: level data resolution, level average factor, level offset, temperature function enable/disable, alarm parameters (see next section) and gauge tag (alphanumeric label). The level data resolution parameter determines the resolution of the data displayed on the LCD (0.1, 0.01 or 0.001 inches). The higher the resolution selected, the longer the system scan delays will be. See the programming section of this manual for additional information about scan delay times. The level average factor determines how many level readings to average together before displaying the data. This function can be useful to smooth level changes due to tank agitation or waves. The level offset function is used to calibrate the displayed level data to the actual measured level in the tank. The level offset value can be directly entered from the keypad or calculated by the system from data acquired from the DDA Tank gauge. The temperature enable/disable function allows temperature scans to be enabled or disabled on a gauge by gauge basis. The alarm parameters are described in the next section. The gauge tag is a seven character programmable label that appears on the LCD display and printer reports to identify tanks with text labels. The default gauge tag is “TANK#X:” where X is the actual tank gauge number in the system (i.e. 1-8).

Alarm Parameters

The Level Plus monitor provides both software and hardware alarm functions. The software alarms are individually programmable and include the following: product low low, product low, product high, product high high, interface high, interface low, temperature high, temperature low, mass leak detect, and general gauge failure (gauge inoperative). Each gauge in the system has independent alarms as described above and can have individual limit settings for each alarm function. All of the software alarms can be assigned to hardware alarms (relay contacts). The Level Plus is available with eight alarm contacts. Any gauge alarm function can be assigned to any relay output. In addition, the software supports multiple assignments and cross assignments of relay outputs (each relay output may represent any combination of software alarm assignments). Programmable dead band (hysteresis) values are also supported for pump/process control applications. All alarm information is maintained in the active data array and may be accessed via remote host communications.

MTS Side Tank Indicator (STI) Support

MTS DDA Side Tank Indicator modules can be connected to the Level Plus monitor system to provide display of tank data at remote locations. The devices are multidropped on the 4-wire MTS DDA network and can be located physically anywhere along the main cable run. See the Side Tank Indicator Operation and Installation manual for additional information about this MTS product.

Analog Output Parameters

The Level Plus monitor is provided with eight isolated analog (4-20 milliamp) outputs. Each output channel can be assigned to any gauge in the system and can be assigned to track any of the three control parameters (product level, interface level, or temperature). Volumetric outputs can also be assigned as analog control parameters. Both the 4 milliamp and the 20 milliamp end points are programmable to allow the user to scale the output values, and inversion of the output channels is also possible. The output channels can also be programmed to indicate a gauge malfunction alarm by driving the outputs to either 4 or 20 milliamps.

Volumetric Parameters

The Level Plus Monitor system includes volumetric correction software, which is useful in many tank gauging applications. The volume software is powerful, fast, and easy to use; providing the user with gross observed volume (GOV), net standard volume (NSV), and net mass information. See the section below labeled VOLUMETRIC SUPPORT for additional information on volume calculations. Programmable volumetric parameters include the following: temperature correction methods (6A, 6B, 6C, 6C MOD, CUST TAB), display units (gallons, liters, barrels, pounds, and kilograms), thermal expansion coefficients or API gravity values, reference temperature (6C MOD only), product density, tank capacities (optional tank information for ullage calculations), and strapping table information. Strapping tables can be up to 100 entries per table (8 tables total) and are accessed via powerful editing software. In addition to basic volume calculations the system incorporates a static mass stabilization (leak detect) function. The user can program the desired mass change limits and can assign software and hardware alarms to each tank. Activation and deactivation of the mass stabilization function is protected through security access codes.

Volumetric Support

The thermal expansion correction software is based upon standards presented in the American Petroleum Institute (API) Standard 2540. The Level Plus software strictly adheres to API guidelines for software implementation, insuring repeatable data accurate to API tables 6A, 6B, and 6C.

Volume information is calculated real time after the level and temperature data is read from each gauge and does not affect the overall scan rate of the system. All volume data is maintained in the active data arrays and is accessible through the host communication interface. In addition, the software provides error checking on the calculated data and

signals the user when volume data is invalid. For example, loss of temperature data or gauge input data that exceeds allowable limits for API table entries would cause invalid volume data. Additional information on error messages and the use of the keypad to display different types of volumetric data can be found in the PROGRAMMING section of this manual.

Volume Calculations

1. GOVP = TOTVOL - INTVOL (two float system)
   GOVP = TOTVOL (one float system)
   GOVI = INTVOL (two float system)
   GOVT = GOVP + GOVI (two float system)
   GOVT = GOVP (one float system)
   GOVU = WORKING CAPACITY - GOVT (one or two float system)

The gross observed volume of the product (GOVP) is equal to the total volume of the tank (TOTVOL) minus the interface volume (INTVOL). The TOTVOL is measured by the product float (the float closest to the flange of the gauge) and the INTVOL is measured by the interface float (the float closest to the tip of the gauge). The level information from the gauge is used along with the tank gauging table or tank equations to calculate the corresponding gross observed volumes.

2. NSVP = GOVP x VCF

The net standard volume of the product (NSVP) is equal to the gross observed volume of the product (GOVP) multiplied by the volume correction factor (VCF). The VCF is calculated from thermal expansion properties of the product (programmed by the user) and the temperature information from the gauge. See item #4 below.

3. MASS = NSVP x DENSITY

The mass of the product (MASS) is equal to the net standard volume of the product (NSVP) multiplied by the density of the product (DENSITY) programmed by the user.

4. VOLUME CORRECTION FACTOR

$$VCF = EXP\{-A(T) \times (t-T) \times [1 + (0.8 \times A(T) \times (t-T))]\}$$

Where:
t = any temperature*
T = base temperature (60 degrees F)
A(T) = coefficient of thermal expansion at base temperature T

Where:
EXP is the exponential function (e^x).

The coefficient of thermal expansion at the base temperature T is related to the density of the product at the base temperature T by:

$$A(T) = [K0 + K1 \times DEN(T)] / [DEN(T) \times DEN(T)]$$

Where:
Density is defined in units of KG/M^3

K0 and K1 are constants related to each product.

* API 2540 states that temperature data is rounded to the nearest tenth (0.1) degree.

API Table Information

This section includes information on the constants used by the software to calculate the volume correction factors and valid ranges for the API (density) and temperature data.

Crude oils (Table 6A)	
Constants: K0 = 341.0957 K1 = 0.0	
Valid temperature ranges	Valid gravity ranges (API)
0 to +300.0 deg F 0 to +250.0 deg F 0 to +200.0 deg F	0.0 to 40.0 deg API 40.1 to 50.0 deg API 50.1 to 100.0 deg API

Generalized products (Table 6B)		
Product type	Constants	Gravity range (API)
Fuel oil	K0 = 103.8720 K1 = 0.2701	0.0 to 37.0
Jet Group	K0 = 330.3010 K1 = 0.0	37.1 to 47.9
Transition Group *	K0 = 1489.0670 K1 = -0.0018684	48.0 to 52.0
Gasolines	K0 = 192.4571 K1 = 0.2438	52.1 to 85.0
Valid temperature ranges		Valid gravity ranges (API)
0 to +300.0 deg F 0 to +250.0 deg F 0 to +200.0 deg F		0.0 to 40.0 deg API 40.1 to 50.0 deg API 50.1 to 85.0 deg API

* For the transition group, A(T) = [K1 + K0 / (DEN (T) x DEN (T))]

Special products using TEC** (Table 6C)	
Valid temperature ranges	Valid TEC ranges
0 to +300.0 deg F 0 to +250.0 deg F 0 to +200.0 deg F	270.0 to 510.0 * 10E-6/deg F 510.5 to 530.0 * 10E-6/deg F 530.5 to 930.0 * 10E-6/deg F

* * TEC is the thermal expansion coefficient of the product being measured.

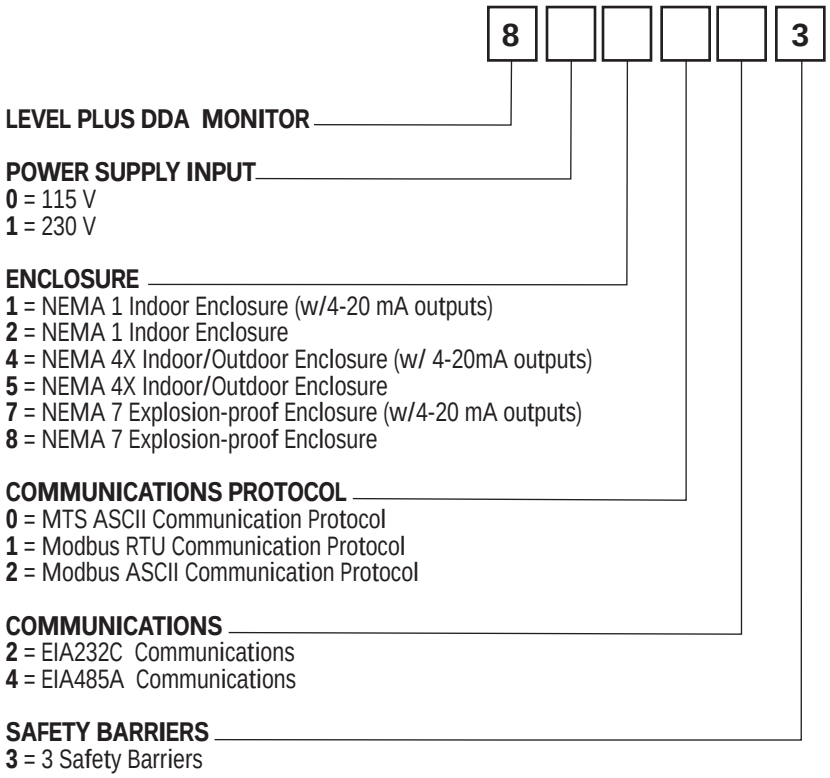
Special products using TEC (Table 6C MOD)	
Valid temperature ranges	Valid TEC ranges
0 to +300.0 deg F	100.0 to 999.0 * 10E-6/deg F

NOTE

Volumetric modes 6C MOD and CUST TAB are not intended for custody transfer applications since they do not follow API standard 2540 exactly. The software for 6C MOD incorporates a moveable temperature reference and allows for a wider range of TEC values.

3 Model Number Information

Model Number: Level Plus DDA Monitor



NOTE

All Level Plus DDA Monitors include:

- *8 alarm contact outputs*
- *EIA485A or EIA232C communications*
- *Factory installed safety barriers to permit DDA tank gauge installation (up to 8) in hazardous areas (Class I, II, III, Division 1, Groups C, D, E, F and G)*
- *Option of (8) 4-20 milliamp outputs*

4 Level Plus Tank Monitor Specifications

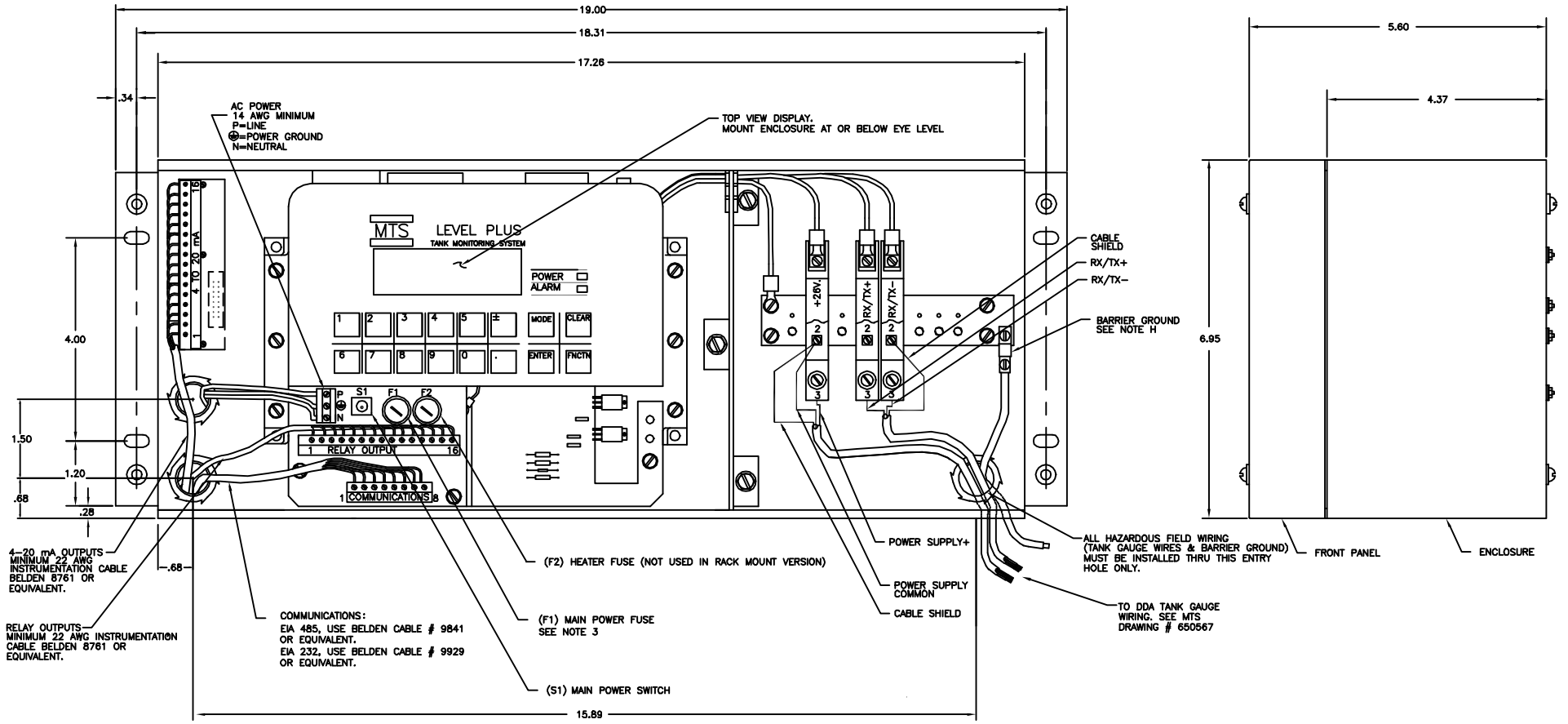
Parameter	Specification
Power Consumption	• NEMA 1: 60 Watts maximum @ 120 VAC, 50/60 Hz, fuse protected • NEMA 4X and 7 (with internal heater): 260 Watts maximum @ 120 VAC, 50/60 Hz, fuse protected • AC power connection includes 2-stage input filter (line-to-line and line-to-ground) and transient protection (line-to-line) 1200 watts maximum.
Operating Temperature:	• NEMA 1: +35 to 135°F (+2 to +54°C) • NEMA 4X and 7: -40 to 135°F (-40 to +54°C)
Relay Contacts	• 3 Amps @ 30 VDC or 250 VAC maximum, NO contacts, continuous duty
4-20 mA Analog Outputs:	• Loop powered, opto-isolated from system ground. • All outputs are reverse polarity protected. • All outputs are transient protected (line-to-line) 600 watts maximum. • Maximum non-linearity + 0.5% F.S. over operating temperature range • 12 bit maximum resolution.
Communication Port	• Industry standard EIA 485 or EIA 232.

5 Monitor Installation and Electrical Terminations

See the following MTS drawings when installing and terminating Level Plus DDA Monitors:

1. 650562 - External wiring NEMA 1 Level Plus DDA Monitor
2. 650615 - External wiring NEMA 4 Level Plus DDA Monitor
2. 650564 - External wiring NEMA 7 Level Plus DDA Monitor
3. 650567 - Field wiring Level Plus DDA Monitor
4. 650561 - Terminal block identification Level Plus DDA Monitor
5. 650511 - Wiring diagram intrinsically safe DDA Liquid Level

Also reference MTS Level Plus DDA Gauge Manual #550164 for additional information about DDA Tank Gauge installation requirements.



NOTES:

1. INSTALLATION MUST CONFORM TO THE APPLICABLE SECTIONS OF THE NATIONAL ELECTRICAL CODE FOR HAZARDOUS LOCATIONS.
2. APPROVED SAFETY BARRIER TYPES INCLUDE:
   FOR POWER CIRCUIT USE
   STAHL TYPE 8901/31−280/165/80
   PER FACTORY MUTUAL−CLASS NO. 3610−1979:
   Voc=30.0V, Isc=175.0mA, Ca=0.3uF, La=5.1mH
   FOR COMMUNICATIONS CIRCUIT USE
   STAHL TYPE 8901/32−093/135/70
   PER FACTORY MUTUAL−CLASS NO. 3610−1979:
   Voc=10.3V, Isc=144.6mA, Ca=7.8uF, La=4.8mH
3. F1 MAIN POWER FUSE: USE .25 AMP FOR 120 VAC OPERATION (WICKMAN # 19374−250mA); .125 AMP FOR 240 VAC OPERATION (WICKMAN # 19374−125mA).

WIRING TO LEVEL PLUS DDA TANK GAUGES:

A. ONLY 8 DDA TANK GAUGE CONNECTIONS ARE ALLOWED.
B. WIRING TO GAUGES MUST CONFORM TO I.S. INSTALLATION DRAWING (MTS # 650511) SEE DDA TANK GAUGE INSTALLATION MANUAL, (MTS # 550164, SECTION 6) FOR ADDITIONAL WIRING INFORMATION.
C. CABLE SHIELDS MUST BE CAPABLE OF CARRYING A MINIMUM CURRENT OF 175 mA CONTINUOUSLY. CABLE WIRES MUST HAVE A MINIMUM INSULATION THICKNESS OF .010 INCHES (0.25 mm).
D. CONNECT CABLE SHIELDS TO TERMINAL #2 ON THE SAFETY BARRIERS.
E. CONNECT THE +26 VOLT DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED +26 V.
F. CONNECT THE RX/TX+ DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED RX/TX+.
G. CONNECT THE RX/TX− DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED RX/TX−.
H. THE SAFETY BARRIER EARTH GROUND CONNECTION MUST BE CONNECTED AT ALL TIMES. IT MUST BE 12 AWG WIRE (OR LARGER) AND MEASURE LESS THAN 1 OHM TO DEDICATED EARTH GROUND (SEPERATE FROM AC POWER GROUND).

REV.	DATE	BY	ECR NO.	DESCRIPTION
A	1−95	RB	2891	RELEASE TO PRODUCTION
P1	4−93	RB		RELEASE TO PRODUCTION

UNLESS OTHERWISE SPECIFIED: .XX = ± .01, .XXX = ± .005, ANGULAR = ± 1°. REMOVE BURRS AND SHARP EDGES .005 MAX. DIM LIMITS HELD AFTER PLATING OR CONVERSION COATING. DRILL DEPTHS ARE TO FULL DIAMETER. TAP DEPTHS ARE MINIMUM FULL THREADS.

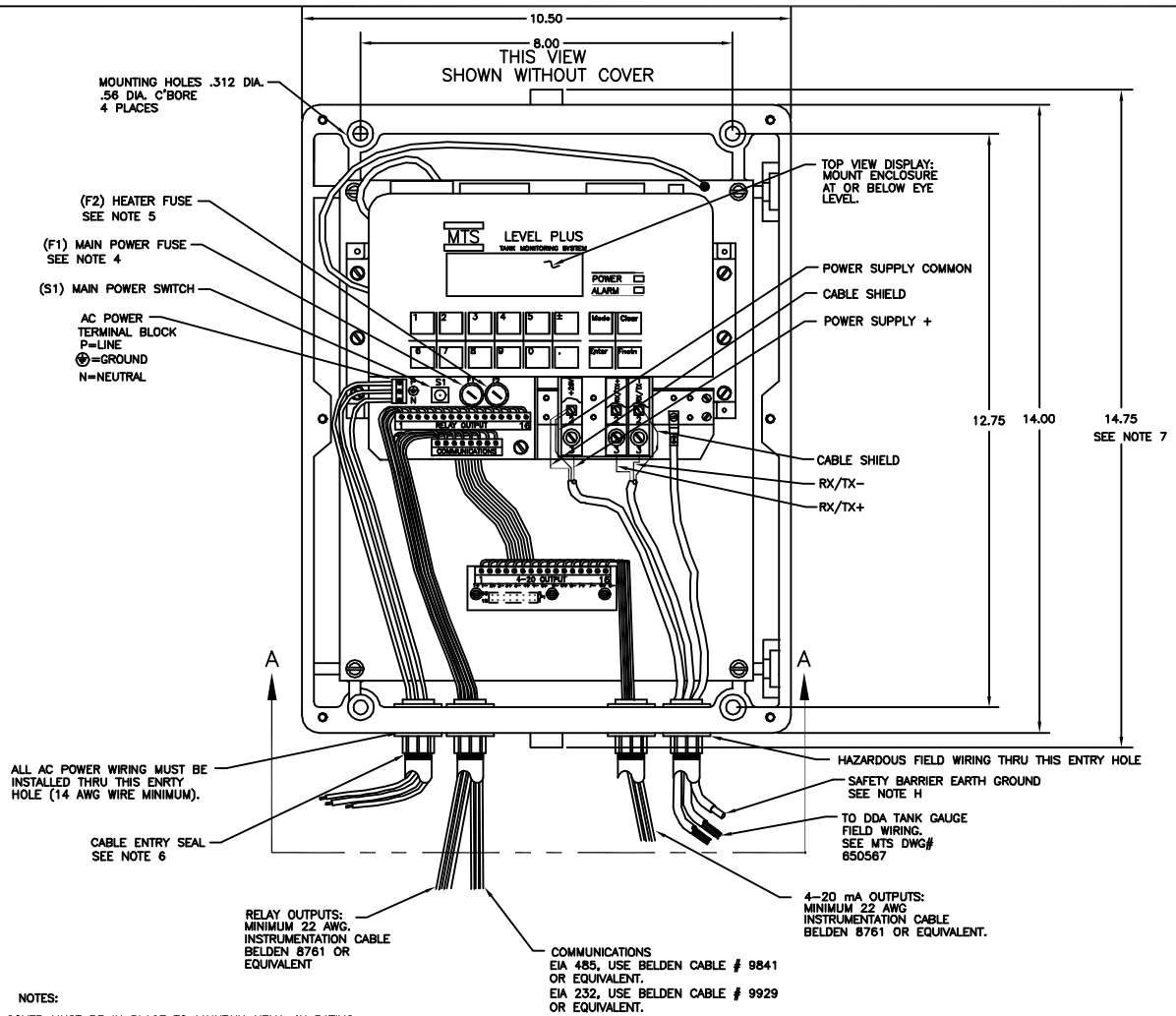
MATERIAL: −−−−−−−−
FINISH: −−−−−−−−
DO NOT SCALE DRAWING

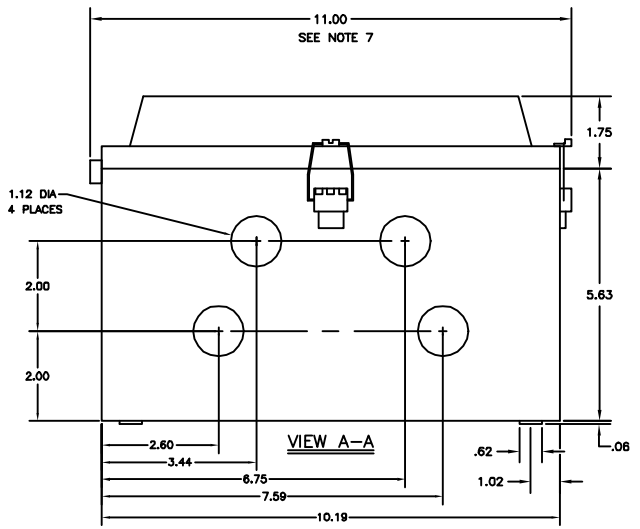
DRAWN: R.BARR 9−27−90
CHK: DATE
ENGR: DATE
QC: DATE
MFG: DATE
SCALE: 1:1
SHEET 1 OF 1

MTS SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE: EXTERNAL WIRING NEMA 1 LEVEL PLUS DDA MONITOR

SYS NO. 650562 REV A





NOTES:

1. COVER MUST BE IN PLACE TO MAINTAIN NEMA 4X RATING.
2. INSTALLATION MUST CONFORM TO THE APPLICABLE SECTIONS OF THE NATIONAL ELECTRICAL CODE.
3. APPROVED SAFETY BARRIER TYPES INCLUDE:
   FOR POWER CIRCUIT USE
   STAHL TYPE 8901/31-280/165/80
   PER FACTORY MUTUAL-CLASS NO. 3610-1979:
   Voc=30.0V, Isc=175.0mA, Ca=0.3uF, La=5.1mH
   FOR COMMUNICATIONS CIRCUIT USE
   STAHL TYPE 8901/32-093/135/70
   PER FACTORY MUTUAL-CLASS NO. 3610-1979:
   Voc=10.3V, Isc=144.6mA, Ca=7.8uF, La=4.8mH
4. F1 MAIN POWER FUSE: USE .25 AMP FOR 120 VAC OPERATION (WICKMAN # 19374-250mA); .125 AMP FOR 240 VAC OPERATION (WICKMAN # 19374-125mA).
5. F2 HEATER FUSE: USE 1.6 AMP FOR 120 VAC OPERATION (WICKMAN # 19374-1.6A); .80 AMP FOR 240 VAC OPERATION (WICKMAN # 19374-800mA).
6. MYERS 3\4 SCRU-TITE HUB (CAT# ST-2) OR EQUIVALENT.
7. OVERALL BOX DIMENSIONS INCLUDE HINGES AND COVER LATCHES.

WIRING TO LEVEL PLUS DDA TANK GAUGES:

A. ONLY 8 DDA TANK GAUGE CONNECTIONS ARE ALLOWED.

B. WIRING TO DDA TANK GAUGES MUST CONFORM TO I.S. INSTALLATION DRAWING (MTS # 650511) SEE DDA TANK GAUGE INSTALLATION MANUAL, (MTS # 550164, SECTION 6) FOR ADDITIONAL WIRING INFORMATION.

C. CABLE SHIELDS MUST BE CAPABLE OF CARRYING A MINIMUM CURRENT OF 175 mA CONTINUOUSLY. CABLE WIRES MUST HAVE A MINIMUM INSULATION THICKNESS OF .010 INCHES (0.25 mm).

D. CONNECT CABLE SHIELDS TO TERMINAL #2 ON THE SAFETY BARRIERS.

E. CONNECT THE +26 VOLT DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED +26 V.

F. CONNECT THE RX/TX+ DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED RX/TX+.

G. CONNECT THE RX/TX- DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED RX/TX-.

H. THE SAFETY BARRIER EARTH GROUND CONNECTION MUST BE CONNECTED AT ALL TIMES. IT MUST BE 12 AWG WIRE (OR LARGER) AND MEASURE LESS THAN 1 OHM TO DEDICATED EARTH GROUND (SEPERATE FROM AC POWER GROUND).

REV.	DATE	BY	DCR NO	DESCRIPTION
A	6-95	RH	2891	RELEASE TO PRODUCTION

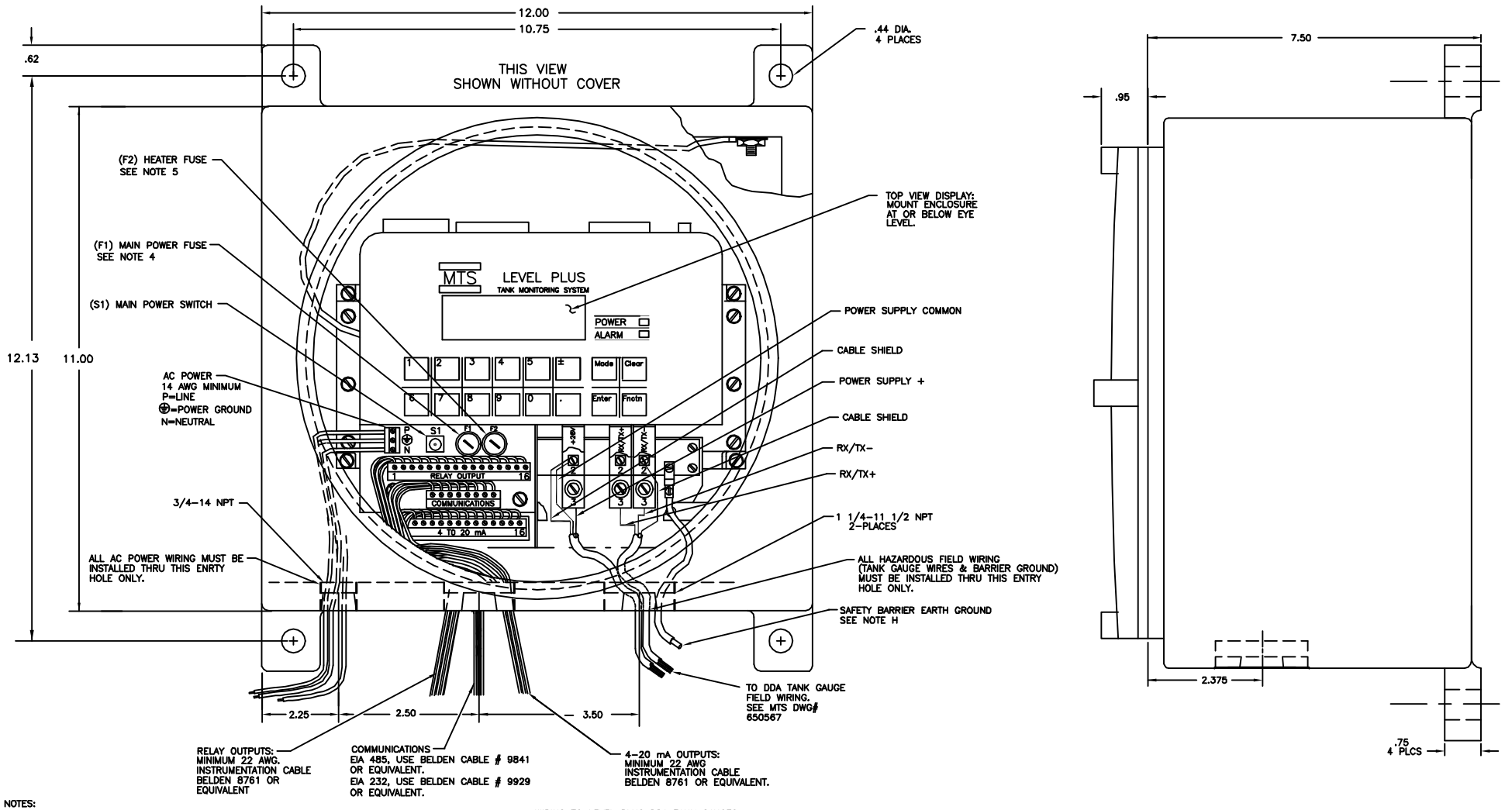
UNLESS OTHERWISE SPECIFIED
.XX = ± .01
.XXX = ± .005
ANGULAR = ± 1°
REMOVE BURRS AND SHARP EDGES .015 MAX
30M LIMITS HELD AFTER PLATING OR CONVERSION COATING
DRILL DEPTHS ARE TO FULL DIAMETER
TAP DEPTHS ARE MINIMUM FULL THREADS

MATERIAL: --------
FINISH: --------
DO NOT SCALE DRAWING
DRAWN: R.BARR DATE 6-12-95
CHK DATE
ENGR DATE
QC DATE
MFG DATE
SCALE: ---
SHEET 1 OF 1

MTS SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE: EXTERNAL WIRING
NEMA 4 LEVEL PLUS
DDA MONITOR

DWG NO. 650615 REV A



NOTES:

1. COVER MUST BE IN PLACE TO MAINTAIN CLASS 1, DIVISION 1, GROUP C & D RATING.
2. INSTALLATION MUST CONFORM TO THE APPLICABLE SECTIONS OF THE NATIONAL ELECTRICAL CODE FOR HAZARDOUS LOCATIONS.
3. APPROVED SAFETY BARRIER TYPES INCLUDE:
   FOR POWER CIRCUIT USE
   STAHL TYPE 8901/31-280/165/80
   PER FACTORY MUTUAL-CLASS NO. 3610-1979:
   Voc=30.0V, Isc=175.0mA, Ca=0.3uF, La=5.1mH
   FOR COMMUNICATIONS CIRCUIT USE
   STAHL TYPE 8901/32-093/135/70
   PER FACTORY MUTUAL-CLASS NO. 3610-1979:
   Voc=10.3V, Isc=144.6mA, Ca=7.8uF, La=4.8mH
4. F1 MAIN POWER FUSE: USE .25 AMP FOR 120 VAC OPERATION (WICKMAN # 19374-250mA); .125 AMP FOR 240 VAC OPERATION (WICKMAN # 19374-125mA).
5. F2 HEATER FUSE: USE 1.6 AMP FOR 120 VAC OPERATION (WICKMAN # 19374-1.6A); .80 AMP FOR 240 VAC OPERATION (WICKMAN # 19374-800mA).

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C. CABLE SHIELDS MUST BE CAPABLE OF CARRYING A MINIMUM CURRENT OF 175 mA CONTINUOUSLY. CABLE WIRES MUST HAVE A MINIMUM INSULATION THICKNESS OF .010 INCHES (0.25 mm).

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F. CONNECT THE RX/TX+ DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED RX/TX+.

G. CONNECT THE RX/TX- DDA TANK GAUGE FIELD WIRING TO TERMINAL 3 OF THE SAFETY BARRIER MARKED RX/TX-.

H. THE SAFETY BARRIER EARTH GROUND CONNECTION MUST BE CONNECTED AT ALL TIMES. IT MUST BE 12 AWG WIRE (OR LARGER) AND MEASURE LESS THAN 1 OHM TO DEDICATED EARTH GROUND (SEPERATE FROM AC POWER GROUND).

REV.	DATE	BY	DCR NO.	DESCRIPTION
A	1-95	RB	2891	RELEASE TO PRODUCTION
P1	4-93	RB		RELEASE TO PRODUCTION

UNLESS OTHERWISE SPECIFIED
.XX = ± .01
.XXX = ± .005
ANGULAR = ± 1°
REMOVE BURRS AND SHARP EDGES .015 MAX
DIM LIMITS HELD AFTER PLATING OR CONVERSION COATING
DRILL DEPTHS ARE TO FULL DIAMETER
TAP DEPTHS ARE MINIMUM FULL THREADS

MATERIAL: --------
FINISH: --------
DO NOT SCALE DRAWING

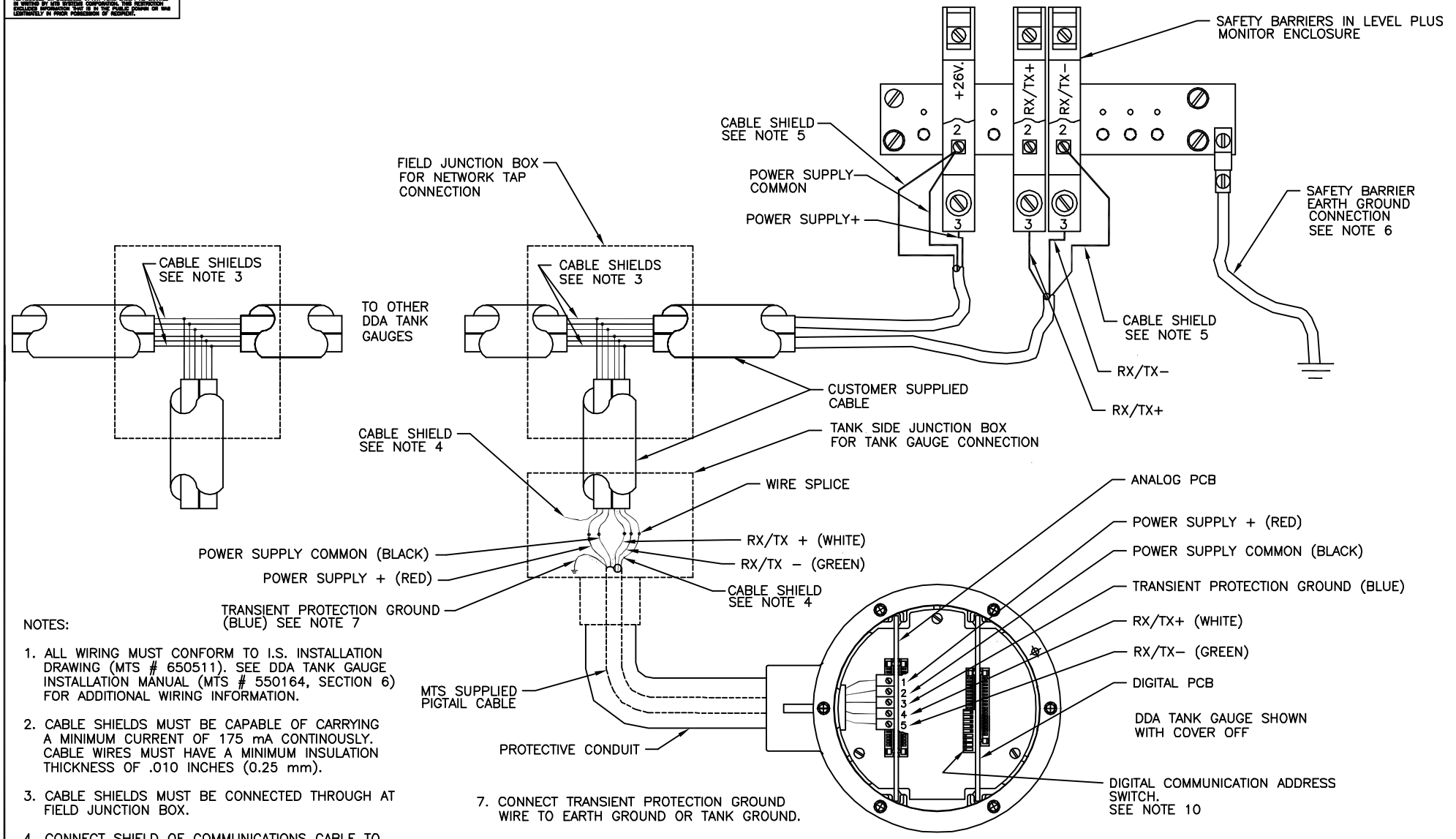
DRAWN R.BARR 4-12-93
CHK
ENGR
QC
MFG
SCALE: ---
SHEET 1 OF 1

MTS SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE: EXTERNAL WIRING NEMA 7 LEVEL PLUS DDA MONITOR

DWG NO. 650564 REV A

MTS PROPRIETARY INFORMATION
THE INFORMATION AND DESIGNED DISCLOSED HEREIN ARE THE PROPERTY OF MTS SYSTEMS CORPORATION AND MAY NOT BE USED, REPRODUCED OR DISCLOSED IN ANY FORM EXCEPT AS GRANTED IN WRITING BY MTS SYSTEMS CORPORATION. THIS RESTRICTION EXCLUDES INFORMATION THAT IS IN THE PUBLIC DOMAIN OR WAS LEGITIMATELY IN PRIOR POSSESSION OF RECIPIENT.



NOTES:

1. ALL WIRING MUST CONFORM TO I.S. INSTALLATION DRAWING (MTS # 650511). SEE DDA TANK GAUGE INSTALLATION MANUAL (MTS # 550164, SECTION 6) FOR ADDITIONAL WIRING INFORMATION.
2. CABLE SHIELDS MUST BE CAPABLE OF CARRYING A MINIMUM CURRENT OF 175 mA CONTINOUSLY. CABLE WIRES MUST HAVE A MINIMUM INSULATION THICKNESS OF .010 INCHES (0.25 mm).
3. CABLE SHIELDS MUST BE CONNECTED THROUGH AT FIELD JUNCTION BOX.
4. CONNECT SHIELD OF COMMUNICATIONS CABLE TO SHIELD OF DDA TANK GAUGE PIGTAIL AT TANKSIDE JUNCTION BOX. DO NOT CONNECT SHIELD OF POWER SUPPLY CABLE AT TANKSIDE JUNCTION BOX.
5. CONNECT CABLE SHIELDS TO EARTH GROUND AT SAFETY BARRIER END ONLY. CONNECT TO TERMINAL # 2 OF SAFETY BARRIERS AS SHOWN.
6. THE SAFETY BARRIER EARTH GROUND CONNECTION MUST BE CONNECTED AT ALL TIMES. IT MUST BE 12 AWG WIRE (OR LARGER) AND MEASURE LESS THAN 1 OHM TO DEDICATED EARTH GROUND (SEPERATE FROM AC POWER GROUND).
7. CONNECT TRANSIENT PROTECTION GROUND WIRE TO EARTH GROUND OR TANK GROUND.
8. THE GROUND SCREW ON TANK GAUGE FLANGE MAY BE USED TO CONNECT GAUGE HOUSING TO EARTH GROUND OR TANK GROUND.
9. DISTANCE FROM FIELD JUNCTION BOX(ES) TO TANKSIDE JUNCTION BOX(ES) NOT TO EXCEED 200 FEET.
10. USER MUST SET COMMUNICATION ADDRESS SWITCH. SEE DDA TANK GAUGE MANUAL # 550164.

REV.	DATE	BY	ECO #	DESCRIPTION
A	4/93	RB	2891	RELEASE TO PRODUCTION

UNLESS OTHERWISE SPECIFIED
.XX = ± .01
.XXX = ± .005
ANGULAR = ± 1°
REMOVE BURRS AND SHARP EDGES .015 MAX
DIM. LIMITS HELD AFTER PLATING OR CONVERSION COATING
DRILL DEPTHS ARE TO FULL DIAMETER
TAP DEPTHS ARE MINIMUM FULL THREADS

MATERIAL

FINISH

DO NOT SCALE DRAWING

DRAWN R.BARR DATE 4/21/93
DOCUMENT OWNER K. PETERSON
PRODUCT LINE DDA LPM
SCALE 1:1 DRAWING SIZE C
SHEET 1 OF 1

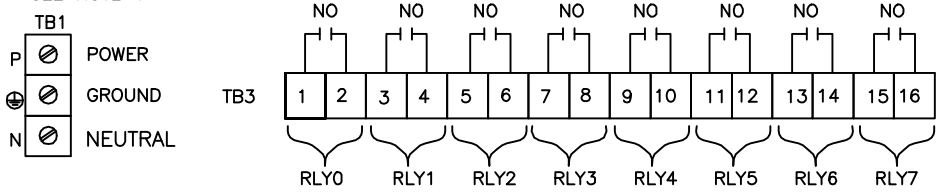
MTS SYSTEMS CORPORATION
SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE
FIELD WIRING
LEVEL PLUS DDA MONITOR

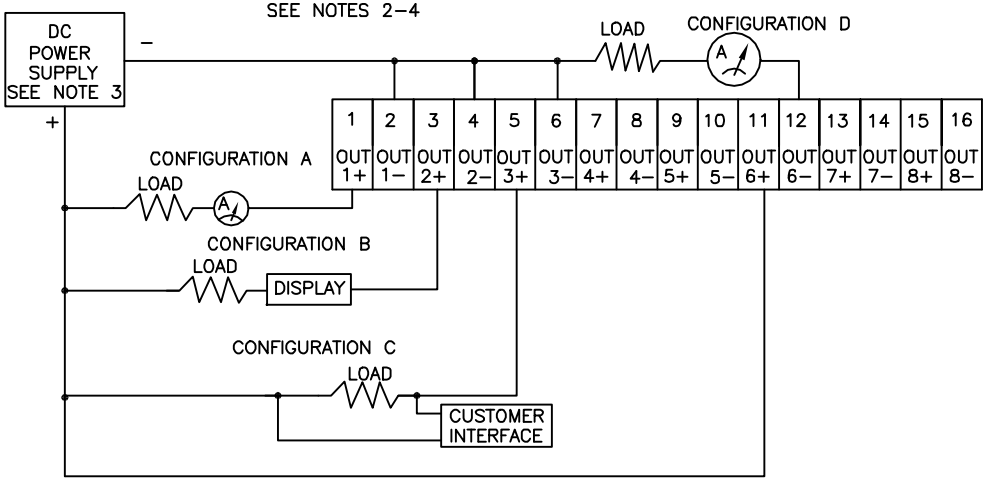
DWG NO. 650567 REV A

RELAY OUTPUTS
SEE NOTE 5

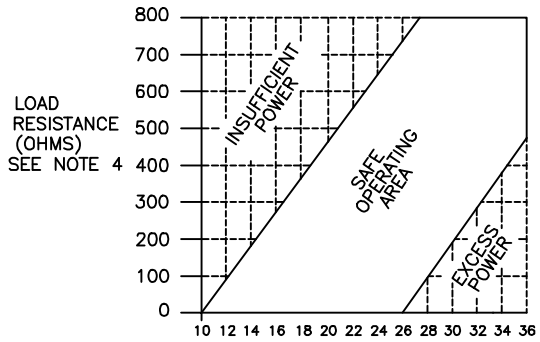
AC POWER CONNECTIONS
SEE NOTE 1



ANALOG OUTPUTS
ISOLATED 4–20 mA
SEE NOTES 2–4



4–20 OUTPUTS
LOOP RESISTANCE VS SUPPLY VOLTAGE

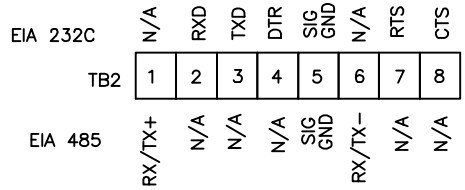


GRAPH 1.

R_L max. = (Vsupply – 10.5Vdc) ÷ (0.022A)

Vsupply max. = 24Vdc + ($R_{Lmax.}$ x 0.022 A)

COMMUNICATIONS
SEE NOTES 6 AND 7



NOTES:

1. CONNECTION OF AC POWER LINES MUST CONFORM TO APPLICABLE SECTIONS OF THE NATIONAL ELECTRICAL CODE OR OTHER LOCAL CODES AS REQUIRED.
2. ALL OUTPUTS (OUT 1–OUT 8) CAN BE WIRED AS PER CONFIGURATIONS A,B,C OR D. ANY COMBINATION OF CONFIGURATION A'S AND OR B'S AND OR C'S AND OR D'S CAN BE WIRED IN ONE LEVEL PLUS MONITOR.
3. POWER SUPPLY VOLTAGE AND LOAD RESISTANCE SHALL BE SELECTED TO BE WITHIN SAFE OPERATING AREA AS INDICATED IN GRAPH 1. TYPICAL VALUES ARE 24 VDC WITH 250 OHM LOAD RESISTANCE.
4. LOAD RESISTANCE IS THE TOTAL LOOP RESISTANCE OF ALL DEVICES CONNECTED IN THE LOOP.
5. NO = NORMALLY OPEN CONTACT. CONTACT RATING = 3 AMPS @ 30 VDC OR 250 VAC MAXIMUM, CONTINUOUS DUTY.
6. FOR RS232 APPLICATIONS: CONNECT RXD, TXD, SIG GND, RTS AND CTS TO CUSTOMER COMMUNICATION EQUIPMENT, JUMPER RTS TO CTS IF NOT CONNECTED TO CUSTOMER EQUIPMENT. DTR IS ALWAYS ACTIVE (SPACE CONDITION).
7. FOR RS485 APPLICATIONS: CONNECT RX/TX+ AND RX/TX– TO CUSTOMER EQUIPMENT. CONNECT SIG GND TO CABLE SHIELD AT ONE END OF CABLE ONLY OR ADD A 100 OHM, 1 WATT RESISTOR IN SERIES WITH SIG GND CONNECTION TO LIMIT GROUND CURRENTS. JUMPER RTS TO CTS. SOME APPLICATIONS MAY REQUIRE 120 OHM, 1/2 WATT TERMINATION RESISTORS ACROSS RX/TX+ AND RX/TX– AT THE FURTHEST END POINTS OF CABLE TO MINIMIZE CABLE REFLECTIONS AND RINGING.

REV.	DATE	BY	DCR NO.	DESCRIPTION
A	1–95	RB	2891	RELEASE TO PRODUCTION
P1	9–88			REVISED PER DCR 1405

UNLESS OTHERWISE SPECIFIED:
.XX = ± .01
.XXX = ± .005
ANGULAR = ± 1°
REMOVE BURRS AND SHARP EDGES .015 MAX
DIM. LIMITS HELD AFTER PLATING OR CONVERSION COATING
DRILL DEPTHS ARE TO FULL DIAMETER
TAP DEPTHS ARE MINIMUM FULL THREADS

MATERIAL: --------
FINISH: --------
DO NOT SCALE DRAWING

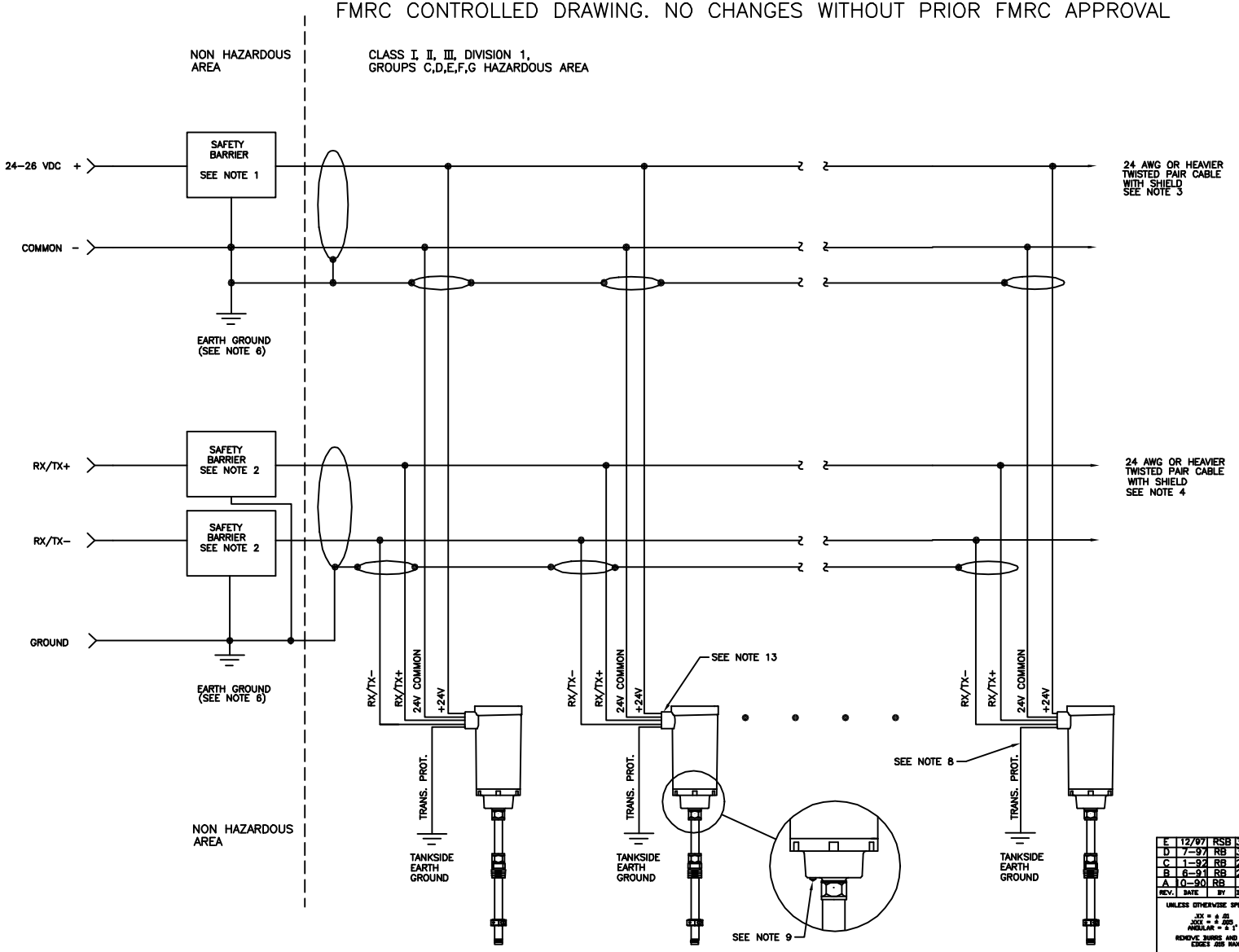
DRAWN	R.BARR	DATE 4/12/93
CHK		DATE
ENGR		DATE
QC		DATE
MFG		DATE
SCALE	1:1	
SHEET	1 OF 1	

MTS SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE: TERMINAL BLOCK IDENTIFICATION LEVEL PLUS DDA MONITOR

DWG NO. 650561 REV A

FMRC CONTROLLED DRAWING. NO CHANGES WITHOUT PRIOR FMRC APPROVAL



NOTES:

1. SEE PAGE 2 OF THIS DRAWNG FOR FMRC APPROVED LIST OF SAFETY BARRIERS FOR THE DDA POWER SUPPLY CIRCUIT.
2. SEE PAGE 2 OF THIS DRAWING FOR FMRC APPROVED LIST OF SAFETY BARRIERS FOR THE DDA COMMUNICATIONS CIRCUIT.
3. POWER SUPPLY CABLE MUST BE 24 AWG OR HEAVIER, SHIELDED TWISTED PAIR CABLE. CABLE CAPACITANCE MUST BE LESS THAN 50 pF PER FOOT. CABLE TYPE AND LENGTH MUST BE SELECTED TO MEET MAXIMUM ALLOWABLE CAPACITANCE AND INDUCTANCE VALUES FOR SELECTED SAFETY BARRIER. SEE NOTE 5. CABLE SHIELD IS CONNECTED TO SYSTEM GROUND AT SAFETY BARRIER END ONLY. SEE INSTALLATION MANUAL FOR ADDITIONAL CABLE INFORMATION.
4. COMMUNICATIONS CABLE MUST BE 24 AWG OR HEAVIER, SHIELDED TWISTED PAIR CABLE. CABLE CAPACITANCE MUST BE LESS THAN 24 PF PER FOOT. CABLE TYPE AND LENGTH MUST BE SELECTED TO MEET MAXIMUM ALLOWABLE CAPACITANCE AND INDUCTANCE VALUES FOR SELECTED SAFETY BARRIERS. SEE NOTE 5. CABLE SHIELD IS CONNECTED TO SYSTEM GROUND AT SAFETY BARRIER END ONLY. SEE INSTALLATION MANUAL FOR ADDITIONAL CABLE INFORMATION.
5. THE INPUT CAPACITANCE OF EACH DDA GAUGE MUST BE INCLUDED IN THE TOTAL CAPACITANCE CONNECTED TO EACH SAFETY BARRIER. FOR THE 24 VOLT POWER SUPPLY CONNECTION C INPUT = 1600 PICOFARADS (PER GAUGE). FOR THE RX/TX COMMUNICATION CONNECTION, C INPUT = 4000 PICOFARADS (PER GAUGE).
   FOR ALL INSTALLATIONS: Ca(barrier) >= C cable + C gauges.
   THE INPUT INDUCTANCE OF EACH DDA GAUGE = 0.
   FOR ALL INSTALLATIONS: La(barrier) >= L cable.
6. THE WIRE CONNECTION BETWEEN EARTH GROUND AND THE SAFETY BARRIER GROUND TERMINAL MUST BE LESS THAN 1 OHM.
7. MAXIMUM APPROVED NUMBER OF DDA GAUGES FOR INTRINSICALLY SAFE WIRING NETWORKS IS 32. SEE OPERATION AND INSTALLATION MANUAL FOR SYSTEM CONFIGURATIONS AND RESTRICTIONS.
8. CONNECTION TO EARTH GROUND FOR TRANSIENT PROTECTION CIRCUITRY.
9. GROUND SCREW PROVIDED TO CONNECT GAUGE HOUSING TO EARTH GROUND.
10. ELECTRONIC EQUIPMENT CONNECTED TO ASSOCIATED APPARATUS MUST NOT USE OR GENERATE MORE THAN 250 VOLTS RMS.
11. CABLE SETS THAT ARE RUN TOGETHER MUST HAVE SUFFICIENT INSULATION TO WITHSTAND 250 VOLTS RMS BETWEEN SETS.
12. ALL WIRING MUST MEET THE REQUIREMENTS OF THE NEC AND LOCAL CODES.
13. DUST TIGHT SEAL AT CONDUIT ENTRY REQUIRED IN CLASS II OR CLASS III LOCATIONS.
14. INTRINSIC SAFETY BARRIERS USED FOR DDA POWER AND DDA COMMUNICATIONS CIRCUITS MUST BE OF THE SAME MANUFACTURER.

NO REVISIONS SHALL BE MADE WITHOUT NOTIFICATION TO APPROVAL AGENCY(S)

REV.	DATE	BY	DCR NO.	DESCRIPTION
E	12/97	RSB	3551	ON SHEET 1 ADD NOTE 14, ON SHEET 2 REMOVE ITEMS C & F
D	7-97	RB	3434	ADDED NEW SAFETY BARRIERS TO NOTES 1 AND 2
C	1-92	RB	2180	REVISED NOTES AND DRAWING
B	6-91	RB	2099	REVISED NOTES AND DRAWING
A	10-90	RB		RELEASE TO PRODUCTION

UNLESS OTHERWISE SPECIFIED: XX = ± .01, XXX = ± .005, ANGULAR = ± 1°. REMOVE BURRS AND SHARP EDGES .005 MAX. DIM LIMITS HELD AFTER PLATING OR CONVERSION COATING. DRILL DEPTHS ARE TO FULL DIAMETER. TAP DEPTHS ARE MINIMUM FULL THREADS.

MATERIAL: --------
FINISH: --------
DO NOT SCALE DRAWING

DRAWN	R.BARR	DATE 1-3-90
CHK		DATE
ENGR	KAD	DATE 1-3-90
QC		DATE
MFG		DATE

SCALE: ---
SHEET 1 OF 2

MTS SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE: WIRING DIAGRAM INTRINSICALLY SAFE DDA LIQUID LEVEL

DWG NO. 650511 REV E

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FMRC APPROVED SAFETY BARRIERS FOR DDA POWER SUPPLY CIRCUIT INCLUDE:

A. STAHL TYPE 8901/31-280/165/80 Cext (max)=0.30uF Lext (max)=5.1mH

B. MTL TYPE 728+ Cext (max)=0.13uF Lext (max)=4.2mH

D. STAHL TYPE 9001/01-280-165-10 Cext (max)=0.43uF Lext (max)=5.4mH

E. CROUSE HINDS TYPE SB19140M2410 Cext (max)=0.43uF Lext (max)=6.96mH

F. CROUSE HINDS TYPE SB49140M2410 Cext (max)=0.43uF Lext (max)=6.96mH (DUAL CHANNEL TYPE)

G. STAHL TYPE 9002/11-280-186-00 Cext (max)=0.39uF Lext (max)=16.4mH (DUAL CHANNEL TYPE)

FMRC APPROVED SAFETY BARRIERS FOR DDA COMMUNICATIONS CIRCUIT INCLUDE:

A. STAHL TYPE 8901/31-086/150/70 Cext (max)=10.8uF Lext (max)=4.2mH

B. MTL TYPE 710+ Cext (max)=3.0uF Lext (max)=0.95mH

D. STAHL TYPE 9001/01-086-150-10 Cext (max)=17.6uF Lext (max)=6.7mH

E. CROUSE HINDS TYPE SB19140M0710 Cext (max)=3.0uF Lext (max)=0.95mH

G. STAHL TYPE 9002/22-093-300-00 Cext (max)=11.4uF Lext (max)=6.5mH (DUAL CHANNEL TYPE)

DRAWN R.BARR	DATE 8-7-97
DOCUMENT OWNER K.PETERSON	
PRODUCT LINE DDA	
SCALE 1:1	DRAWING SIZE B
SHEET 2 OF 2	

MTS SYSTEMS CORPORATION
SENSORS DIVISION
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

TITLE
FMRC WIRING DIAGRAM
INTRINSICALLY SAFE
DDA LIQUID LEVEL

DWG NO. 650511 REV E

6 The Control Panel

The Level Plus control panel is shown in Figure 3.

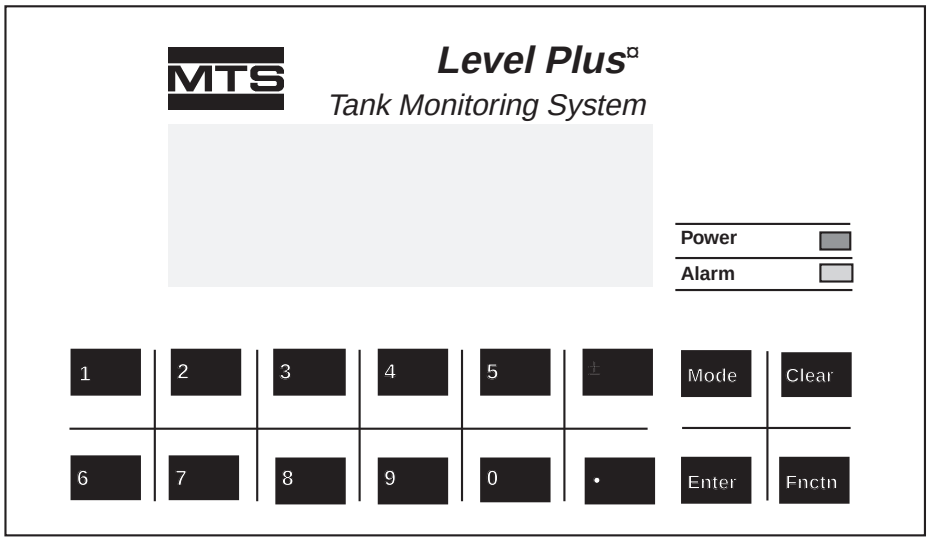
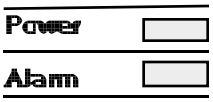
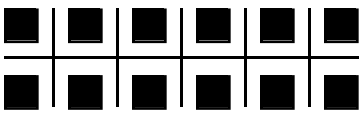


Figure 3. Level Plus Control Panel

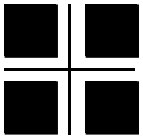
The control panel includes LED's for power and alarm indication, a LCD screen displaying 4 lines of 20 characters each, 12 numeric keys, and 4 control keys.



The green Power LED and red Alarm LED are located at the right side of the control panel. The Power LED is lit when the monitor is connected to power and Switch S1 is in the ON (up) position. The red Alarm LED flashes to indicated an alarm condition.



In program mode, the number keys (0 to 9, ±, and •) are used to enter numeric values for programmable parameters. In measurement mode, the number keys are used to access tank gauge measurement data and to change the basic display modes provided by the software.



The four control keys are primarily used to enter parameters and move to different programming displays:

- **Mode:** Used to indicate that you wish to change the parameter displayed on the screen. For scrolling type menus, Mode will scroll forward through the available selections. The ± key can be used to scroll backwards through the available selections. In measurement mode, the Mode key is used to access Program mode.

- **Enter:** Used to confirm the parameter on the screen or advance to the next parameter. In measurement mode, the Enter key is used to initiate a printer report.

- **Fnctn:** Used to return to a previous parameter.
  NOTE: In measurement mode, the Fnctn key is used as a "shift" key providing dual functions for each numeric key (0 to 9).

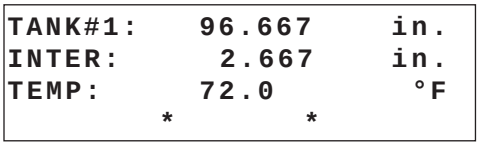
- **Clear:** Used to clear incorrect numeric entries or to exit from the programming mode screens. In measurement mode, the Clear key is used to acknowledge system alarms and to clear the audible alarm beeper.

The LCD screen displays current measurements of level, temperature, and volume. During programming, the screen displays parameters and prompts the user for information.

7 Keypad Control Functions

During measurement mode the keypad allows the user to control the different display modes supported by the Level Plus Monitor software. In addition, the user can use the keypad to override the default scan order and access individual tank gauge measurement data directly. This section describes the key functions that are currently supported.

In measurement mode, the Level Plus software defaults to a sequential scan order based on the tank gauges currently programmed in the system. Direct access to tank data is accomplished by depressing the numeric key corresponding to the tank number. For example, tank #6 data can be called to the LCD screen by depressing the numeric “6” key. The data will be displayed for three seconds and then the DISPLAY processor will automatically go back to scan mode. If the data requires viewing for longer periods, the DISPLAY scan hold function can be activated. This is done by first depressing a tank # and then depressing the numeric “9” key within three seconds. DISPLAY scan hold is indicated by two moving asterisks on the fourth line of the LCD display. See example screen below.



Moving asterisks (on screen) indicate DISPLAY scan hold is active

Level Plus Screen - DISPLAY SCAN HOLD ACTIVE

During DISPLAY scan hold, other tanks can be called to the screen by depressing their respective numeric key. The DISPLAY scan hold function is deactivated by depressing the “9” key again, causing the display processor to default back to sequential scan mode.

The hardware SCAN processor can also be controlled by the keypad, allowing the hardware SCAN to be fixed on a selected tank gauge. This forces continuous updates for the currently selected gauge.

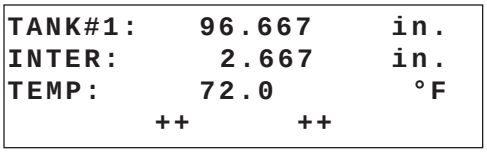
CAUTION

When the hardware SCAN hold function is active, processing of all other gauge data (other than the selected gauge) is suspended. The system will display a warning message when the hardware SCAN hold function is activated.

The hardware SCAN hold function is activated by first depressing a tank # and then depressing the “+/-” key within three seconds. A warning message is then displayed indicating that the automatic hardware SCAN processor has been disabled. See example screen below.

Level Plus Screen - HARDWARE SCAN HOLD WARNING MESSAGE

After three seconds, the warning message will disappear and the selected tank data will be displayed and updated continuously. The hardware SCAN hold is indicated by flashing "++" characters on the fourth line of the LCD display. See example screen below.

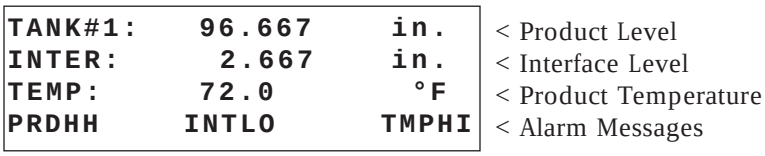


*Flashing "**++**" characters indicate HARDWARE scan hold is active.*

Level Plus Screen - HARDWARE SCAN HOLD ACTIVE

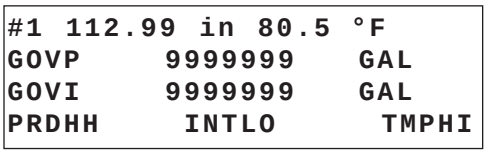
During hardware SCAN hold other tank gauges can be selected by depressing their respective numeric key (i.e. "4" for gauge #4). The hardware SCAN hold function is deactivated by depressing the "+/-" key again, causing the hardware SCAN processor to default back to sequential scan mode.

Changing the display mode is done using the FNCTN (shift) key. Seven display modes are currently supported. If the volumetric option is disabled, only the basic level/temperature display and the individual RTD temperature display modes are supported. A level display example is shown below.



Default Level Display Mode (Mode #5)

Volume display mode #1 is shown below. This screen includes gross volume data (product and interface), along with level, temperature, and alarm information. Mode #1 can be displayed by depressing the FNCTN key and then depressing the numeric "1" key (within 3 seconds).



Mode #1 Volume Display

NOTE

On all volume screens, only product level is displayed and the data is displayed in decimal inches or centimeters with two decimal places. The interface level can only be seen on the LEVEL display mode screens (FNCTN key and "5").

Net product volume and net product mass information (mode #2) can be displayed by depressing the FNCTN key and then depressing the numeric “2” key (within 3 seconds). See example.

```
#1 112.99 in 80.5 °F
NSVP     9999999    GAL
MASS     9999999    LBS
PRDHH           TMPHI
```

Mode #2 Volume Display

Tank capacity (volume) information is accessed by volume display mode #3. Working capacity, safe fill, and maximum safe fill information can be displayed by depressing the FNCTN key and then the numeric “3” key. See example.

```
#1   WC   10000      GAL
SF        11000      GAL
MSF       12000      GAL
PRDHH    INTLO      TMPHI
```

Mode #3 Volume Display

Gross total volume and net product volume information (Mode #4) can be displayed by depressing the FNCTN key and the numeric “4” key. See example.

```
#1 112.99 in 80.5 °F
GOVT     9999999    GAL
NSVP     9999999    GAL
PRDHH     INTLO      TMPHI
```

Mode #4 Volume Display

If the Level Plus is programmed for volume mode, basic level/temperature information can be displayed using mode #5.

```
TANK#1:    96.667     in.
INTER:      2.667     in.
TEMP:      72.0        °F
PRDHH     INTLO      TMPHI
```

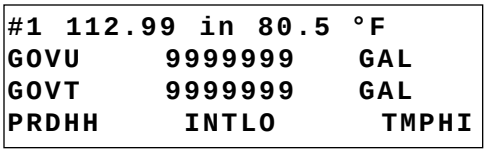
Mode #5 Level Display

Individual RTD data can be displayed by depressing the FNCTN key and the numeric “6” key. See example. This screen includes product level, average temperature, individual RTD temperatures and alarm information. The RTD data is displayed on lines two and three with RTD #1, 2 and 3 on line two and RTD #4 and 5 on line three. If an RTD is not programmed (or disabled) the display will show *NA (not active).

```
#1 112.99 in 80.5 °F
80.4    :80.3    :80.7
80.6    :*NA
PRDHH     INTLO      TMPHI
```

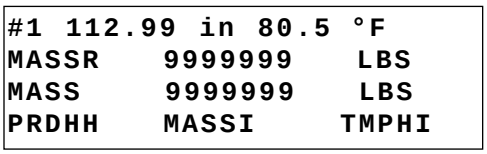
Mode #6 RTD Display Mode

Gross ullage volume and gross total volume information (Mode #7) can be displayed by depressing the FNCTN key and the numeric “7” key. See example.



Mode #7 Volume Display

Mass stabilization data is displayed only after the mass stabilization function is enabled. Once enabled for a particular tank, other display modes are not accessible for that tank. To enable the mass stabilization function, press the MODE key and then enter the proper “enable” security access code. After the code has been entered correctly, the user must respond (within 5 seconds) with the tank number that the user desires to activate. Disabling of mass stabilization mode is performed in the same manner, but the “disable” security code is used. Again the user must respond with the proper tank number that the user wishes to disable. The mass stabilization data screens include product level, temperature, alarm and product mass stabilization information. See example below. The mass reference (MASSR) is the value of the product mass at the time the function was activated and the MASS is the current value of the temperature corrected product mass for the given tank number.



Mass Stabilization Display

Mass low (MASLO), mass high (MASHI) or mass error (MASER) alarms can only be canceled by deactivating the mass stabilization function for that tank number. The MASER alarm indicates that invalid data was obtained for that tank during the measurement period and that the mass leak measurement is invalid and must be performed again. Additional information on mass stabilization mode can be found in the programming section of this manual.

Other measurement mode key functions include the MODE key and the decimal “.” key. The MODE key is used to access programming mode and the decimal key displays the current real time clock data. The clock data is displayed for three seconds and then the display processor defaults to scan mode.

The ENTER key is used to initiate a printer report if the monitor is programmed for RS232 printer mode. See the programming section of the manual for additional information about printer modes.

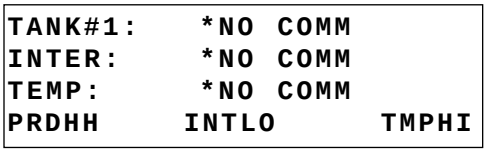
The CLEAR key is used to acknowledge (clear) the system alarm audible beeper. The CLEAR key does not clear the visual alarm messages or the red alarm indicator light or change the state of any relay outputs.

8 System Error Message Descriptions

The Level Plus software displays several error messages that typically reflect system problems. The possible system error messages are described below.

Error messages are grouped into two categories: error messages associated with data communications with the DDA tank gauges and error messages associated with system operations.

An example of a communication error message is shown below.



Communication error message example

The *NO COMM communication error message indicates that no address/command communication echo (no response) was received from the DDA tank gauge associated with tank #1.

Possible causes for the *NO COMM communication error message include:

A. Incorrect field wiring or faulty connections.
B. DDA gauge communication address switch improperly programmed
C. Inadequate power supply voltage available to DDA tank gauge.
D. Power override switch in DDA tank gauge set to 'ON' (should always be OFF).
E. Malfunctioning DDA tank gauge.

Other communication error messages and their possible causes are listed below.

*COMM ERR - improper address/command communication echo received from DDA tank gauge.
*DATA ERR - unexpected data format received from DDA tank gauge.
*NO DATA - no data received from DDA tank gauge after address/command communication echo received.

Possible causes for these communication error messages include:

A. Two DDA tank gauges programmed with the same communication address.
B. Excessive noise on the RX/TX communication wires.
C. Malfunctioning DDA tank gauge.

*CSUM ERR - data checksum error

Possible causes for the *CSUM ERR communication error message include:

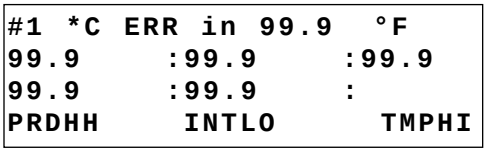
A. Checksum function on DDA tank gauge not enabled.
B. Excessive noise on the RX/TX communication wires.

*UART ERR - System UART malfunction.

Possible cause for the *UART ERR communication error message include:

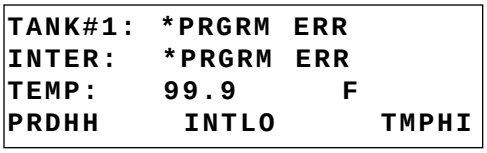
A. Electronic component failure on the Level Plus Monitor communication board.

NOTE
*Due to LCD display space limitations, communication error messages are shown on volume and individual RTD display mode screens as *C ERR. See example below.*



Communication error message on individual RTD display example.

An example of a system error message is shown below.



System error message example.

The *PRGRM ERR system error message indicates that Level Plus monitor is incorrectly programmed. Possible cause for the *PRGRM ERR system error message include:

A. The Level Plus monitor 'number of floats' parameter is set equal to 2 floats and the DDA tank gauge internal 'number of floats' parameter is programmed for 1 float.

Other system error messages and their possible causes are listed below.

*FLOAT ERR - DDA tank gauge not receiving expected return signals from floats.

Possible causes for the *FLOAT ERR system error message include:

A. DDA tank gauge internal memory set for 2 floats and only 1 float installed on gauge.
B. DDA tank gauge float(s) allowed to enter inactive zone at tip of gauge.
C. Malfunctioning DDA tank gauge.

*GAUGE ERR - Hardware malfunction detected from DDA gauge level measurement circuitry.

Possible cause for the *GAUGE ERR system error message include:

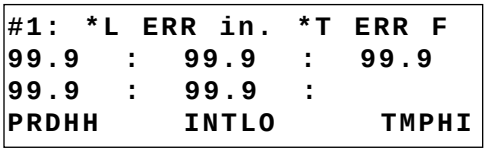
A. Malfunctioning DDA tank gauge electronics.

*AVG ERR - Average submerged temperature could not be calculated.

Possible causes for the *AVG ERR system error message include:

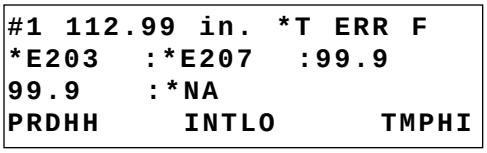
A. DDA tank gauge product float below lowest positioned RTD.
B. DDA tank gauge detected error from individual RTD reading.
C. Hardware malfunction detected from DDA gauge temperature measurement circuitry.

NOTE
*Due to LCD display space limitations, system error messages are shown on volume and individual RTD display mode screens as *L ERR and *T ERR. See example below.*



System error messages on individual RTD display example.

Some additional system error messages associated only with the individual RTD display mode are described below. These are coded error messages that are reported directly from the DDA tank gauge electronics and usually indicate a problem with the DDA tank gauge temperature measurement circuitry or the individual RTD elements. These error codes are displayed in the individual RTD data fields on the LCD display. See example below.



Coded RTD error messages on individual RTD display example.

Coded RTD error message definitions.

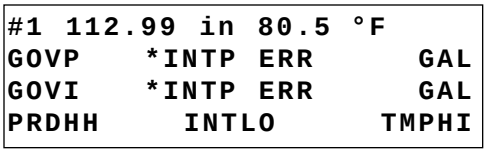
* E203 - DDA tank gauge temperature under-range
* E204 - DDA tank gauge temperature over-range
* E205 - DDA tank gauge internal electronics failure
* E206 - DDA tank gauge internal electronics failure
* E207 - DDA tank gauge shorted RTD element
* E208 - DDA tank gauge open RTD element
* E211 - DDA tank gauge internal electronics failure
* E212 - DDA tank gauge RTD processing disabled
* NA - RTD not active

NOTE
**NA is displayed in respective fields for DDA tank gauges with less than five RTDs.*

*PRINTER OFF LINE - Printer mode status error message.

The *PRINTER OFF LINE error message indicates that the printer is off line and not ready. The Level Plus communication software observes the CTS input line for printer not ready conditions. If a print has been scheduled and the CTS line is low for more than 5 seconds, the above message is displayed for 3 seconds and the current print buffer is purged. The Level Plus will try to print again at the next scheduled print interval. This error message will only appear if the Level Plus is programmed for printer mode. If the monitor is programmed for host communications and the CTS line is inactive, *CTS COMM ERROR message is displayed.

The volume software also provides the user with informational system error messages. These messages generally indicate that the software requires additional information or data to perform the desired volume calculations. The example screen below indicates that the software was unable to determine the gross observed volume for tank #2 because an interpolation error was encountered. The software displays *INTP ERR in the respective data fields.



Volume system error message example

Possible causes for the *INTP ERR message include:

A. Current level value is less than first level entry in the strapping table or greater than the last entry in the strapping table (i.e out of range).
B. Negative level value passed to the interpolation function.
C. Erroneous entry encountered in strapping table.
D. Level value exceeds allowable range of associated tank volume equation
E. Calculated interface volume value exceeds calculated total volume value.
F. Erroneous entry encountered in VCF correction table.
G. Current temperature value is less than first temperature entry in the VCF correction table or greater than the last entry in the VCF correction table (i.e out of range).

Other volume related system error messages and their possible cause are listed below.

*LEVL ERR - Volume data could not be calculated because of missing level information or level error messages active.

Possible causes for the *LEVL ERR message include:

A. See level related system error messages in previous section.

*TEMP ERR - Net volume data could not be calculated because of missing temperature information or temperature error messages active.

Possible causes for the *TEMP ERR message include:

A. See temperature related system error messages in previous section.
B. Temperature function not enabled for selected tank gauge.

*CALC ERR - Math calculation error encountered (i.e. underflow or overflow result).

Possible causes for the *CALC ERR message include:

A. Resultant value exceeds allowable range (i.e. volume value greater than 999,999,999)
B. Negative volume calculated.
C. Division by zero.

*VCF ERR - VCF parameter (API or TEC) exceeded allowable range for selected volume tables (6A, 6B, 6C, 6CMOD).

Possible causes for the *VCF ERR message include:

A. Programming errors when entering API or TEC programming parameters. Normally user entries are checked against allowable limits during program mode. It is still possible to enter illegal API or TEC values by first selecting an API table with wider limits (6A) and entering for example an API of 100. Then reselecting a new API table with narrower limits (6B). Unless the API programming screen is reentered, the API value of 100 would not be rechecked and changed to the current limit for table 6B. This will cause a *VCF ERR message to be displayed during measurement mode because the API value of 100 exceeds the allowable range for table 6B. See General Software Information section of this manual for additional information about allowable limits for API tables.

*INIT - Mass stabilization function is initializing.

Possible causes for the *INIT message include:

A. The mass stabilization function has been enabled for the selected tank and the MASSR (mass reference) has not been updated. This message will clear after the selected tank has been updated by the scan processor.

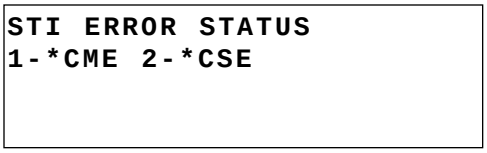
*NO REF - Mass stabilization mass reference could not be initialized.

Possible causes for the *NO REF message include:

A. Net mass data not available at time mass stabilization function was enabled due to other active volume error messages. See related volume error messages in previous section.

*OFF - Mass Stabilization function is disabled.

Error messages for the Side Tank Indicator (STI) interface appear on a separate STI error status screen. The STI error status screen is only displayed if the STI interface is enabled and error messages are active or by depressing the “0” key during measurement mode. An example of the STI error status screen is shown below.



Side Tank Indicator error message example

The example shown indicates Side Tank Indicator #1 currently has a communication error (*CME) and Side Tank Indicator #2 currently has a checksum error (*CSE). The error messages are abbreviated due to limited LCD display space. The abbreviated error messages for the STI interface are defined below.

*CME - Communication Error. The CME error indicates that a general communication error has occurred.

Possible causes for the *CME error message include:

A. Incorrect field wiring or faulty connections.
B. STI communication address switch improperly programmed
C. Inadequate power supply voltage available to STI module.
D. Power override switch in STI module set to 'ON' (should always be OFF).
E. Two STI modules programmed with the same communication address.
F. Excessive noise on the RX/TX communication wires.
G. Malfunctioning STI module.

*CFE - Command Format Error. The CFE error indicates that Level Plus monitor received a command format NAK from the STI module.

Possible causes for the *CFE error message include:

A. Two STI modules programmed with the same communication address.
B. Excessive noise on the RX/TX communication wires.
C. Malfunctioning STI module.

*CSE - Checksum Error. The CSE error indicates that Level Plus monitor received a checksum calculation NAK from the STI module.

Possible causes for the *CSE error message include:

A. Excessive noise on the RX/TX communication wires.
B. Malfunctioning STI module.

*UAE - UART Error. The UAE error indicates that Level Plus monitor communication UART circuitry is not responding.

Possible causes for the *UAE error message include:

A. Electronic component failure on the Level Plus Monitor communication board.

9 Pre-Start Up Check List

The following items need to be performed before attempting to start up a Level Plus DDA Monitor system.

1. Install the Level Plus Monitor enclosure. See the Monitor Installation and Electrical Terminations section of this manual for installation information.

2. Install the DDA tank gauges in the tanks to be monitored. DDA tank gauge installation information is provided in section 5 of this manual. Additional tank gauge specific installation information can be found in the MTS DDA Tank Gauge Operation and Installation manual provided with the tank gauges (MTS #550164). Install Side Tank Indicators, if desired. Refer to Side Tank Indicator Installation and Operation manual (MTS P/N 550436).

3. Complete all field wiring requirements as defined in section 5 of this manual and section 6 of the Tank Gauge Manual (MTS #550164). If Side Tank Indicators are installed, refer to the Field Wiring Installation section of the STI manual (MTS P/N 550436). Ensure that all installation drawing notes and requirements have been completed.

4. If the Level Plus system is installed in a hazardous area, double check to insure that all hazardous area requirements have been completed.

5. Program each DDA tank gauge communication address switch (located inside the tank gauge housing) with the proper communication address and checksum mode. The DDA 'tank gauge checksum' switch and the 'communication time-out timer' switch must be ON (enabled) and the DDA tank gauge power override switch must be OFF (disabled). The Level Plus monitor system only supports a fixed tank gauge addressing scheme. The system will always poll the DDA tank gauge addressed at C0 hex (192 decimal) for Tank #1 (channel #1), C1 hex (193 decimal) for Tank #2, C2 hex for Tank #3 and so on. This fixed addressing scheme must be considered before attempting to program the Level Plus monitor. Additional information about setting the DDA tank gauge address switch can be found in the programming section of this manual and in the MTS DDA Tank Gauge Operation and Installation manual provided with the tank gauges (MTS #550164).

6. Program each STI module communication address switch (located inside the module housing) with the proper communication address and checksum mode. The STI module checksum switch must be ON (enabled) and the STI module power override switch must be OFF (disabled). The Level Plus monitor system only supports a fixed STI addressing scheme. The system will always poll the STI addressed at 80 hex (128 decimal) for Tank #1 (channel #1), 81 hex (129 decimal) for Tank #2, 82 hex for Tank #3 and so on. This fixed addressing scheme must be considered before attempting to program the Level Plus monitor. Additional information about setting the STI module address switch can be found in the programming section of this manual and in the MTS STI Operation and Installation manual provided with the STI modules.

7. Proceed to the programming section of this manual to perform any applicable programming requirements for the intended application. The Level Plus monitor defaults to scanning only level for one DDA tank gauge at address C0 hex. If additional tank gauges are connected to the system, the user must program the monitor to scan the additional gauges and enable other functions as desired (i.e. temperature, alarms, volume calculations, external communications, etc.).

10 Starting Up

Turn on power to the monitor. The main power switch is located behind the front cover below the keypad/display assembly. The green power LED lights and the screen displays an initialization message.

```
     MTS LEVEL PLUS
  TANK MONITOR SYSTEM
mo-day-yr  hr-min-sec
    INITIALIZING
```

After initializing all tank data, the system begins displaying the current measurements for level and temperature. The initialization procedure takes approximately 5 to 10 seconds per tank gauge. A typical level display is shown below.

```
TANK #1:  17.164  in.
INTER:     7.649  in.
TEMP.:     76.2    °F
PRDHH
```

The control panel (keypad) can be used to control the different types of information displayed. See section 7 of this manual for additional information on keypad control functions. To leave the measurement display mode and begin programming, press the MODE key.

Enter program mode by pressing the MODE key. After a short delay, the system asks for a 6-digit access code. If you have a 6-digit code enter it now. If you have never changed the factory default code or eliminated the access code simply press ENTER.

```
SECURITY ACCESS CODE
ENTER 6 DIGIT NUMBER

------
```

If the code is entered incorrectly, the system times out after 5 seconds.

```
ACCESS DENIED
```

After the security code has been entered properly, the system will display a WARNING message indicating that all processes in the Level Plus monitor will be stopped. See below. If the user continues into program mode by pressing the "ENTER" key, all scanning of tank gauge data will stop and all output controls will go to user defined default status. If any other key is pressed or after a 5 second time out period has elapsed, the Level Plus monitor will go back to measurement mode.

```
WARNING!!!      ALL
PROCESSES WILL BE
STOPPED.
'Enter" TO CONTINUE
```

Copyright

Upon entry into program mode, MTS copyright information and software version numbers are displayed. Press the ENTER key to continue.

```
MTS SYSTEMS CORP.
VERSION: X.XX
COPYRIGHT 1993, 94, 95
'Enter' TO CONTINUE
```

Product Information

The product information screen shows the Level Plus monitor model and serial numbers. Press the ENTER key to continue.

```
MTS SYSTEMS CORP.
MOD# xxxxxx
SER# xxxxx-xx-xxx
'Enter' TO CONTINUE
```

Help Screens

Two help screens are displayed. These screens describe the use of the four FNCTN keys used during programming. If you do not wish to enter any parameters press the CLEAR key; otherwise, press the ENTER key to continue.

```
PARAMETER ENTERING
PROCEDURES
PRESS 'Clear' TO EXIT
OR 'Enter' TO CONTINUE
```

```
PRESS 'Enter' FOR NEXT
PARAMETER OR 'Fnctn'
FOR PREVIOUS ONE
OR 'Mode' TO CHANGE
```

A programming flow chart has been included to give the programmer a global view of how the software expects data to be entered. The programming environment is divided into 6 major sections which include the following: SYSTEM parameters, TANK (gauge) parameters, SIDE TANK INDICATOR parameters, ANALOG parameters, VOLUMETRIC parameters and system TEST functions.

SYSTEM parameters are typically global parameters such as the following: display update time, display units, and communication parameters (parameters that affect the system operation or the system hardware). TANK parameters are associated with the DDA tank gauge and tank characteristics. These parameters include gauge tag (alphanumeric label), level data resolution, temperature function enable, level offset, number of floats, and tank alarm functions. The SIDE TANK INDICATOR parameters are associated with the set-up and data display mode selection of the MTS DDA field indicators. The ANALOG parameters are associated with the assignment and scaling of the analog (4-20mA) outputs. The VOLUMETRIC parameters deal only with the optional volumetric correction software. It is important for the programmer to understand that the Level Plus programming software qualifies many submenu screens based on previous screen settings. For example, if the tank gauge temperature function is not enabled, subsequent screens like temperature high alarm (TMPHI) would not be displayed. This feature speeds programming and helps prevent erroneous parameter assignments. With this in mind, the programmer should plan out the programming sequence. Typically, start with the SYSTEM parameters and then proceed to the TANK parameters. Program the tank parameters for all of the tank gauges in the system , proceed to the ANALOG parameters, and then end the programming session with the VOLUMETRIC parameters. This sequence is not mandatory, but will likely save considerable time in not having to jump around into the different parameter groups, enabling various functions to allow access to certain programming screens.

All Level Plus Monitor systems are shipped from the factory with pre-programmed (default) parameter values. In the default state, all analog and volumetric parameters are disabled (off) and many of the tank gauge parameters are also disabled. Review the programming flow chart to become more familiar in how to proceed through the programming environment. (Figure 4)

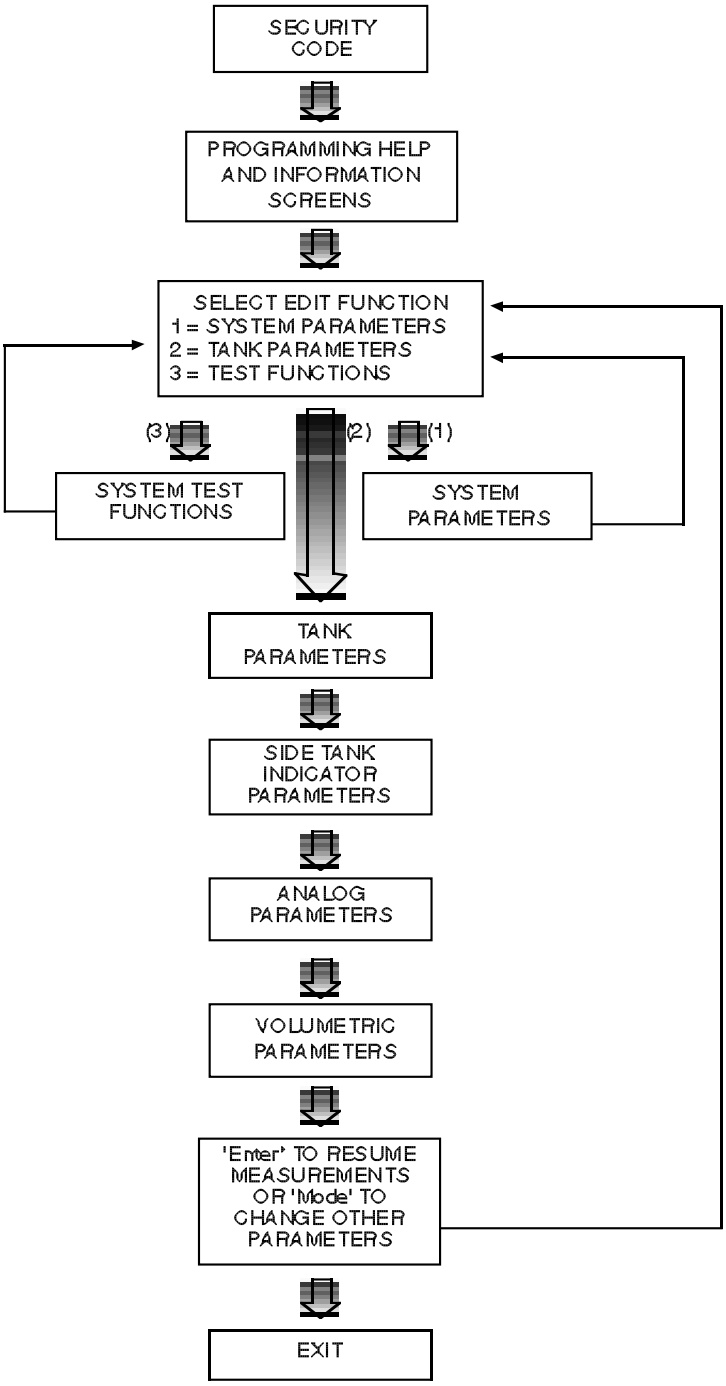


Figure 4. Programming Flow Chart

Select Edit Function

After proceeding through the help screens, the edit selection menu will be displayed.

```
SELECT EDIT FUNCTION
1=SYSTEM PARAMETERS
2=TANK PARAMETERS
3=TEST FUNCTIONS
```

Pressing the "1" key will select SYSTEM parameters, "2" or the ENTER key will select TANK parameters and "3" will select TEST functions. To edit SIDE TANK INDICATOR parameters, ANALOG

parameters or VOLUMETRIC parameters, press "2" (or ENTER) and proceed past the TANK parameter edit screens (see programming flow chart). Proceed to the applicable section in this manual based on the selected item from the edit selection menu.

System parameters - proceed to section 12
Tank parameters - proceed to section 13
Side Tank Indicator parameters - proceed to section 14
Analog parameters - proceed to section 15
Volumetric parameters - proceed to section 16
Test functions - proceed to section 17

Display Viewing Angle

Press the MODE key to change the LCD display viewing angle (contrast).

```
DISPLAY CONTRAST = 5

'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to enter a new display contrast value (1-8) and press the enter key.

```
DISPLAY CONTRAST = -
'1' = MINIMUM (LIGHT)
'8' = MAXIMUM (DARK)
'Enter' NEW VALUE
```

NOTE

The LCD is a top view type. The best viewing angle will be observed when the display is positioned at or below eye level.

Security Access Codes

You are given the opportunity to change your access codes. Security access codes are used to limit access to program mode and Level Plus mass stabilization mode. There are three different codes available. Security code #1 is used to limit access to program mode. Security code #2 is used to enable mass stabilization mode and code #3 is used to disable mass stabilization mode. Each code must be unique for the security access system to work properly. If you wish to change any of your codes press the MODE key; otherwise, press the ENTER key and proceed to LEVEL DISPLAY UNITS.

```
SECURITY CODE #1

'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Type in your new security code (up to 6 characters) and press the ENTER key. If you wish to eliminate the code just press the ENTER key. This will allow anyone to access the monitor by pressing the ENTER key.

```
SECURITY CODE #1
     ------
'Enter' NEW VALUE
(up to 6 characters)
```

Your new code will be displayed, press the ENTER key to confirm or the MODE key to change.

```
SECURITY CODE #1
CHANGED TO:
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Repeat the above procedure for each security code.

Level Display Units

The current level display units selection is shown. Press the MODE key (or the ± key, see note below) to change the selected units. The available selections are:

- Decimal Inches
- Decimal Feet
- Fractional Inches
- Decimal Millimeters
- Decimal Meters

NOTE

For scrolling menu programming screens, the MODE can be used to scroll forward through the available selections and the ± key can be used to scroll backwards through the available selections.

```
LEVEL DISPLAY UNITS:
     DECIMAL INCHES
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Temperature Display Units

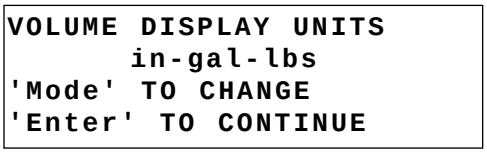
The current temperature display units selection is shown. Press the MODE key to change from Fahrenheit to Celsius (Centigrade). Press the ENTER key to continue.

```
TEMPERATURE UNITS:
       FAHRENHEIT
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Volume Display Units

The current volume display units selection is shown. Press the MODE key or +/- key to change the selected units. The available selections are shown below.

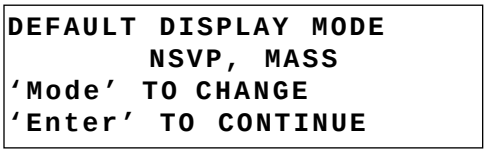
In-gal-lbs	(Inches-gallons-pounds)
In-bbl-lbs	(Inches-barrels-pounds)
In-gal-kgs	(Inches-gallons-kilograms)
In-ltr-kgs	(Inches-liters-kilograms)
In-ltr-lbs	(Inches-liters-pounds)
mm-ltr-kgs	(Millimeters-liters-kilograms)



Default Display Mode

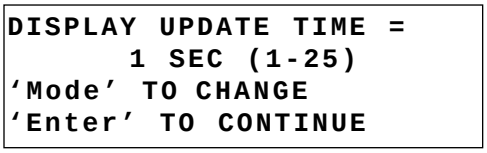
The default display mode allows the user to program which of the 7 display modes will be active after the Level Plus has been initialized following a power off condition (or a programming session). Press the MODE or ± key to select one of the available choices.

- **GOVP, GOVI** (gross observed volume product, gross observed volume interface)
- **NSVP, MASS** (net standard volume product, net standard mass product)
- **WC, SF, MSF** (tank working capacity, safe fill, max safe fill)
- **GOVT, NSVP** (gross observed volume total, net standard volume product)
- **LEVEL-TEMP** (product level, interface level, average temperature)
- **LEVEL-RT** (product level, average temperature, individual RTD temperatures)
- **GOVU, GOVT** (gross observed volume ullage, gross observed volume total)



Display Update Time

The display update time for level measurements is shown, press the MODE key to change the display update time. The allowed update times are shown in parenthesis (i.e. 1-25 seconds). Otherwise, press the ENTER key to continue.



Use the number keys to enter a new time (1 to 25 seconds) and press the ENTER key.

```
DISPLAY UPDATE TIME =
      --- SEC (1-25)

'Enter' NEW VALUE
```

NOTE
The display update time setting does not affect the tank gauge scan rate or output updates.

System Clock

The system clock time base selection is displayed. The system clock uses the power line frequency as a time base. The clock time base selection must match the power line frequency as supplied to the monitor. Press the mode key to change the clock time base selection. Available selections are 50 or 60 hertz.

```
  CLOCK LINE FREQUENCY
        60 HERTZ
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE
After changing the clock time base, the power must be temporarily removed from the Level Plus monitor to activate the new selection. This can be done by cycling the on/off switch located behind the front cover (at the end of the programming session).

The current system clock time is displayed. To change the time setting press the MODE key and enter the desired month, day, year, hour (24 hour clock), minutes, and seconds.

```
THE CURRENT TIME IS:
6-15-95    10:29:42
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Communications

The host communication port baud rate is shown. Press the MODE or ± key to change the baud rate selection (300, 1200, 2400, 4800, 9600, 19200).

```
SELECT COM BAUD RATE
          9600
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The communication mode for remote data access is shown. Press the MODE or ± key to change the selected communication mode. The available choices are shown below. See section 19 of this manual for additional communication protocol information.

```
SELECT COM PORT MODE
HOST PORT ADDR = A
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Standard Level Plus ASCII Communication Protocol modes

HOST PORT ADDR = A
thru
HOST PORT ADDR = R

MTS DDA Emulation Modes

MTS DDA (C0 - C7)
MTS DDA (C8 - CF)
MTS DDA (D0 - D7)
MTS DDA (D8 - DF)
MTS DDA (E0 - E7)
MTS DDA (E8 - EF)
MTS DDA (F0 - F7)
MTS DDA (F8 - FF)

EIA232 Printer modes

PRINT ON TIME
PRINT ON ALARM
PRINT ON TIME & ALARM

NOTE

For EIA 232 printer modes, the Level Plus monitor requires an 80 column printer with a minimum buffer size of 1K (thousand) bytes.

Modbus Communication Protocol Modes

If you have a Level Plus Monitor with Modbus ASCII or Modbus RTU communications protocol, the following Modbus screens are shown.

```
MODBUS SLAVE ADDR=
   1      (1-247)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Press the MODE key to change the Modbus slave communication address. The following screen is displayed:

```
MODBUS SLAVE ADDR=
  _ _ _   (1-247)

'Enter' NEW VALUE
```

Use the number keys to enter the new address and press the 'Enter' key to continue.

Printer Mode Setup

If one of the available printer modes is selected, the printer mode setup screen is displayed. Press the MODE key to change the current printer setup values or press ENTER to continue.

NOTE

If you are using a Level Plus Monitor with Modbus ASCII or Modbus RTU communications protocol, this screen is not available.

```
PRINTER MODE SETUP

'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The printer report format includes seven data print fields (columns). The left most print field always contains the TANK ID and the right most print field always contains the ALARM and TIME STAMP data. The remaining five print fields (referenced as 1 through 5) can be customized by the user.

```
PRINT FIELD #1
         PRODUCT
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Press the MODE or +/- key to select one of the available choices for each print field.

PRODUCT
INTERFACE
TEMPERATURE
GOVP
GOVI
NSVP
MASS
GOVT
GOVU
BLANK

Printer reports can be scheduled in two ways. The user can select PRINT EVERY HOUR or print by customized PROGRAMMED TIMES. Press the MODE key to select the desired print scheduler mode.

```
PRINT INTERVAL
     ONCE EVERY HOUR
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE
Print reports can also be scheduled by pressing the "0" key during measurement mode.

If PROGRAMMED TIMES is selected, the user can input up to 12 different print times.

```
PRINT INTERVAL #1
          14:30
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Press the MODE key to change the selected PRINT INTERVAL or ENTER to continue to the next PRINT INTERVAL.

```
PRINT INTERVAL #1
          --:--
(HOURS:MINUTES)
'Enter' NEW VALUE
```

Print times must be entered in 24 hour clock format. Enter hours first, followed by minutes. Enter 99:99 to disable the selected print interval.

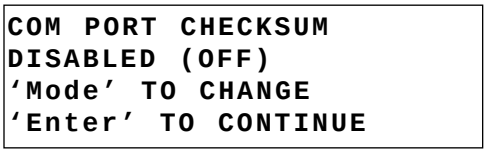
Notes about printer reports:

* Print field headers are printed only after monitor initialization.
* All system error messages are truncated to 8 characters.
* Fractional data is displayed as xx-xx-xx (feet-inches-fractions).
* Due to limited space, no negative sign can be displayed for negative fractional data.
* Print on alarm reports are denoted by any asterisk in column 80.
* Alarm messages are truncated to 3 characters (i.e. PRDHH is shown as PHH, INTLO is shown as ILO, etc.)

Example: Printer Report:

TANK ID	PRODUCT	INTR	TEMP	GOVP	NSVP	ALARMS	TIME
TANK#1:	119.55	2.35	70.4	73478	73456	PHI ILO THI	14:23
TANK#2	267.43	1.25	68.3	23678	23780	PHI THI	
TK529	465.32	5.68	56.6	773478	772636	ILO TLO	
TANK#1:	119.55	2.35	70.4	73478	73456	PHI ILO THI	16:23
TANK#2:	267.43	1.25	68.3	23678	23780	PHI THI	
TK529	465.32	5.68	56.6	773478	772636	ILO TLO	
TANK#1:	119.55	2.35	70.4	73478	73456	PHI ILO	16:45*

The Level Plus communication system allows the user to enable or disable the communication checksum function. If the checksum function is enabled, the system will calculate and append a two-byte checksum value to the end of each message transmitted. Press the MODE key to enable/disable the checksum function or ENTER to continue.



NOTE
If you are using a Level Plus Monitor with Modbus ASCII or Modbus RTU communications protocol, this screen is not available.

NOTE
The checksum function only applies to standard Level Plus protocol modes. When checksum mode is enabled, data is transmitted as 8 bits with no parity to allow transmission of the binary checksum data. The receiving communication equipment must be set to match this format or data communication errors will occur. Additional information on the checksum function can be found in the COMMUNICATION PROTOCOL section of this manual.

Relay Polarity

The relay output polarity can be software programmed for normally open (NO) or normally closed (NC) operation. The relay contacts are internally wired as normally open when the relay coils are de-energized, allowing the user to program the system for "fail-safe" relay control. (i.e. relay outputs are open when alarms are active).

```
RELAY OUTPUTS OPEN
WHEN ALARM IS ACTIVE
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Press the MODE key to change the relay polarity or press the ENTER key to continue.

Audible Beeper Control

The audible sonalert beeper can be enabled to signal keypad key depressions (audible feedback) and/or system alarms. Press the MODE key to enable or disable the keypad audible beep. The new beep control selection will not take effect until program mode is exited.

```
KEYPAD AUDIBLE BEEP
ENABLED (ON)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The system alarm audible beep can be disabled, enabled for all alarms or enabled for alarms assigned to relay #0 only. Press the MODE key to select the desired alarm audible beep mode.

```
ALARM AUDIBLE BEEP
DISABLED (OFF)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

If the alarm audible beep is enabled, the alarm audible beep rate can be set for FAST, MEDIUM or SLOW beep rates. Press the MODE key to select the desired beep rate.

```
ALARM AUDIBLE BEEP
RATE = FAST
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

This completes the SYSTEM parameter programming section. Press ENTER to return to the SELECT EDIT FUNCTION menu.

Enter the desired tank numbers to be polled during measurement mode. Type the respective tank number once to turn on the multiplex assignment (i.e. enable tank gauge to be polled). Type the respective tank number again to turn off the multiplex assignment. Press the ENTER key to continue.

```
TYPE TANK# TO TOGGLE
MULTIPLEX ASSIGNMENT
   1 - - - - - - -
'Enter' TO CONTINUE
```

NOTE

The user must program (set) the communication address switch inside the DDA tank gauge to match the desired tank channel in the Level Plus monitor. The Level Plus monitor will always poll the DDA tank gauge at communication address C0 hex (192 decimal) for Tank # 1, C1 hex (193 decimal) for Tank #2, C2 hex for Tank #3, etc. See the MTS DDA tank gauge operation manual (MTS #550164) for additional information on setting the DDA gauge communication address switch.

Some examples of DDA tank gauge switch settings are shows as follows.

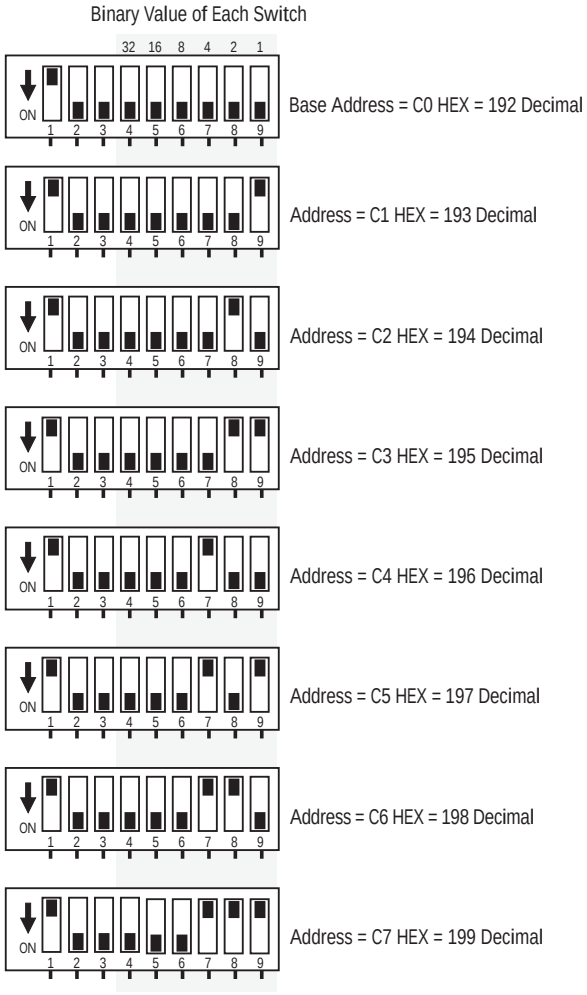


Figure 8.4 Example DDA Tank Gauge Address Switch Settings

Enter the tank number you wish to edit and press the ENTER key.

```
SELECT TANK NUMBER
TO EDIT:       (1-8)

'Enter' TO CONTINUE
```

Alphanumeric Tank Label

The alphanumeric tank label can be up to 7 characters long and comprised of any of the alphanumeric characters in the list shown in the next section. The default tank label is TANK#1: as shown below in the example screen (where x is the given tank #). Press the MODE key to change the current tank label.

```
CURRENT LABEL FOR
TANK#1 = TANK#1:
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The tank label edit screen is shown below:

Edit Cursor >

```
TANK#1:    1,2 = +1,-1
^          6,7 = +5,-5
           9,0 = <   >
'Enter' TO CONTINUE
```

< Edit Key Definitions

Editing is performed as follows:

- Use the "9" and "0" keys to move the edit cursor left or right, respectively.
- Use the "1" and "2" keys to scroll through the available alphanumeric characters (see list below). The "1" key moves forward through the list one character at a time where as the "2" key moves backwards through the list one character at a time.
- Use the "6" and "7" keys to advance or back up through the character list 5 characters at a time.
- Press the 'Enter' key when the edit session is complete
- Alphanumeric Character List: A-Z, 0-9, : , # , < , >, blank, @

NOTE

The complete 7 character alphanumeric tank label can only be displayed in display mode #5. This is due to screen size limitations when displaying volume or individual RTD temperature information. The volume and individual RTD display modes can only display the 5th, 6th, and 7th characters of the 7 character tank level. Tank labels should be created that show uniqueness for the 3 characters (i.e. TANK589, TANK621, etc.)

Level Resolution

The tank gauge level resolution is shown in the units you have previously selected during system parameter editing. To change the selected resolution press the MODE key or the ± key. Press the ENTER key to continue. The available selections are:

- Decimal Inches: 0.1, 0.01, 0.001
- Decimal Feet: 0.01, 0.001, 0.0001
- Fractional Inches: 1/16, 1/32, 1/64
- Millimeters: 1.0, 0.1, 0.025
- Meters: 0.001, 0.0001, 0.000025

```
TANK#1 RESOLUTION:
        0.001 in
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE:
The selected level resolution will directly affect the tank gauge (sensor) scan rate. The higher the resolution selected, the slower the overall system scan rate will be. See appendix C of this manual for additional information on calculating system scan rates.

Level Averages

The LEVEL AVERAGES parameter controls the number of tank gauge level reads performed and averaged before the result is displayed on the LCD. This function is useful for averaging out level variances caused by tank agitation or wave action inside of tanks. Press the MODE key to change the number of averages to be performed for the selected tank. The default value is one and up to 20 averages can be selected.

```
TANK#1 LEVEL AVGS=
      1 AVG (1-20)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE:
The system scan rate is directly affected by the level averaging function. The overall system scan rate is based on the total of all individual gauge polls. Each gauge can have a different averaging value. See appendix C of this manual for additional information on calculating system scan rates.

Number of Floats

The number of floats for tank gauge #1 is shown. To change this number press the MODE key. The choices are one or two floats. The number of floats programmed must be equal to or less than the number of floats programmed in the DDA tank gauge or *PROGRAM ERR message will be displayed during measurement mode.

```
TANK#1 NUMBER OF
       FLOATS: TWO
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Level Offset (Product and Interface)

The LEVEL OFFSET function allows the user to add or subtract a fixed value from the level measurement(s) received from the DDA tank gauge. This allows the displayed tank gauge level reading to be calibrated to the users hand gauged tank reading (or other level reference). The offset value may be entered directly from the keypad or the user may enter the hand gauged value and the system will read the selected tank gauge and calculate the necessary calibration offset. The level offset for the product float level is shown (default value is 0.000).

```
PROD. LEVEL OFFSET
     0.000       in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Press the MODE key to change the LEVEL OFFSET value or press ENTER to continue. After pressing the MODE key, the user is prompted to select the calibration method.

```
SELECT CALIBRATION
METHOD:
1 - ENTER LEVEL OFFSET
2 - ENTER TANK LEVEL
```

Selecting method one allows the user to directly enter the level offset value.

NOTE:
Negative offsets may be entered by pressing the +/- key after number entry.

```
ENTER PROD. LEVEL
OFFSET FOR TANK #1:

        ----- in.
```

Selecting method two allows the user to enter the hand gauged tank level and the system will calculate the required offset level. The calibrate method can only be used if the DDA tank gauge is connected to the system and the float(s) are floating on the liquid surface.

```
ENTER CURRENT PROD.
LEVEL FOR TANK #1:

        ----- in.
```

Repeat the above procedure for the interface float for two float DDA tank gauges. The NUMBER OF FLOATS parameter must be set for two floats to enable the LEVEL OFFSET screens for the interface float.

Temperature Display

The temperature display function can be enabled or disabled. Press the MODE or +/- key to enable and select the desired temperature resolution. Press the ENTER key to continue.

```
TANK#1 TEMPERATURE
MED RES (0.2 F)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The available selections for the temperature enable screen include:

- OFF (DISABLED)
- LOW RES (1 F)
- MED RES (0.2 F)
- HI RES (0.02 F)
- FAST TEMP (1 F)

NOTE

The enabling and selected resolution of the temperature function will directly affect the tank gauge (sensor) scan rate. See Appendix C of this manual for additional information about calculating system scan rates.

NOTE

FAST TEMP selection uses a special non filtered DDA tank gauge temperature command to reduce the time delays associated with temperature updates. Since the tank gauge temperature output for this mode is not filtered the possibility of temperature jumps could exist in noisy environments. The Level Plus monitor software limits any temperature changes to a maximum of 5 degrees (F) between updates. FAST TEMP mode will only work with DDA tank gauge software versions 1.04 and later.

Alarms and Relays

The enable status for TANK #1 PRODUCT HiHi software alarm is shown. Press the MODE key to ENABLE or DISABLE the selected alarm. The available programmable software alarms are:

- Product HiHi
- Product High
- Product Low
- Product LoLo
- Interface High (if 2 floats are specified)
- Interface Low (if 2 floats are specified)
- Temperature High (if temperature function enabled)
- Temperature Low (if temperature function enabled)
- Gauge Error (used to signal inoperative tank gauges)
- STI Error (used to signal inoperative STI modules)

```
TK#1 PROD HiHi ALARM
ENABLED (ON)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to optionally assign software alarms to specific relays and press the ENTER key. Multiple alarm assignments to any or all relays is permissible. The eight available relays are referenced as RELAY #0 to RELAY #7.

```
TK#1 PROD HiHi ALARM
RELAY ASSIGNMENT:
 - 1 - - - - - -
TYPE RELY# TO TOGGLE
```

The limit value for TANK #1 PRODUCT HiHi alarm is shown. Press the MODE key to change the value or the ENTER key to continue.

```
TK#1 PROD HiHi LIMIT
     0.000 in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to type a new alarm limit value and press the ENTER key.

```
TK#1 PROD HiHi LIMIT
       ------ in.

'Enter' NEW VALUE
```

Each alarm limit can be assigned an independent hysteresis value. The programmable hysteresis function is useful for relay control applications that require a programmed hysteresis (or dead-band) around the set point. Press the MODE key to enable/disable the programmable hysteresis function.

```
TK#1 PROD HiHi HYST.
     DISABLED (OFF)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The value for TANK #1 PRODUCT HiHi hysteresis is shown. Press the MODE key to change or the ENTER key to continue.

```
TK#1 PROD HiHi HYST.
     0.000 in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE

Very small or zero (0.000) hysteresis values may cause the relay outputs to become unstable when the float position is exactly equal to the alarm set point. If the hysteresis function is disabled, the software uses "default" hysteresis values to keep this condition from occurring. The default values are shown below.

Preselected Display Resolution	Default Hysteresis Value
0.001 in	0.0 in.
0.010 in	0.020 in.
0.100 in	0.200 in.
0.0001 ft	0.010 in.
0.001 ft	0.024 in.
0.01 ft	0.240 in.
1/64 in	0.031 in.
1/32 in.	0.062 in.
1/16 in.	0.125 in.

Use the number keys to type a new hysteresis value and press the ENTER key.

```
TK#1 PROD HiHi HYST.
       ------ in.

'Enter' NEW VALUE
```

NOTE

No limits are imposed on the hysteresis value. The user must be aware that it is possible to assign hysteresis values that overlap with other alarms assigned in the system. In this situation it is possible to have a LEVEL HiHi alarm active simultaneously with a LEVEL LoLo alarm (or any other combination of alarms). Due to the limited display area on the LCD screen, both alarm indicators cannot be shown at the same time. If this occurs, only the highest priority alarm (LEVEL HiHi in this case) will be shown on the LCD screen when multiple alarms are active.

Repeat the above sequence for each of the remaining programmable alarms.

14 Side Tank Indicator Parameters

MTS DDA Side Tank Indicator modules can be connected to the system to provide display of tank data at remote locations. The devices are multidropped on the 4-wire MTS DDA network and can be located physically anywhere along the main cable run. See the Side Tank Indicator Operation and Installation manual for additional information about this MTS product.

Enter the desired STI module numbers to be polled during measurement mode. Type the respective STI module number once to turn on the multiplex assignment. Type the respective module number again to turn off the multiplex assignment (i.e. enable the STI module to be polled). Press the ENTER key to continue.

```
TYPE STI# TO TOGGLE
MULTIPLEX ASSIGNMENT
   1 - - - - - - -
'Enter' TO CONTINUE
```

NOTE

The user must program (set) the communication address switch inside the STI module to match the desired tank channel in the Level Plus monitor. The Level Plus monitor will always poll the STI module at communication address 80 hex (128 decimal) for Tank #1, 81 hex (129 decimal) for TANK #2, 82 hex for Tank #3, etc. See the STI Operation and Installation manual for additional information on setting the STI communication address switch.

Enter the STI number you wish to edit and press the ENTER key.

```
SELECT STI# NUMBER
TO EDIT:  (1-8)

'Enter' TO CONTINUE
```

STI Display Format

The only STI parameter to program is the DISPLAY FORMAT. This parameter determines what type of information to display on the remote STI module. The available selections are:

LEVEL-TEMP
GOVP (each volume selection includes temperature display)
GOVI
NSVP
MASS
GOVT
GOVU

```
STI #1 DISPLAY FORMAT
LEVEL - TEMP
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to select the analog output number to edit and press the ENTER key. The eight available analog output channels are referenced as analog output #1 to analog output #8.

```
SELECT ANALOG OUTPUT
TO EDIT:    (1-8)

'Enter' TO CONTINUE
```

The analog output #1 assignment is shown. To change this assignment press the MODE key.

```
ANALOG OUTPUT #1
ASSIGNED TO TANK #1
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Enter the tank number that analog output #1 will be assigned to, or enter "0" to disable the analog output.

```
ASSIGN OUTPUT #1
TO TANK # --
ENTER TANK NUMBER OR
'0' TO DISABLE OUTPUT
```

The default output value for analog output #1 is shown. This control parameter defines the state of the analog output channel when system errors occur. System errors include uninitialized data (after power-up), invalid volume data and tank gauge errors. Press the MODE key to change the default output value. The available choices are 4 ma, 20 ma and LAST VAL.

```
ANALOG OUTPUT #1
ON SYS ERR = 4 ma
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The analog output #1 is assigned to TANK #1, PRODUCT. Press the MODE key to change the analog control parameter. Available parameters are:

- Interface level
- Product level
- Temperature
- GOVP
- GOVI
- GOVT
- NSVP
- MASS
- GOVU

```
OUTPUT #1, TANK #1
ASSIGNED TO PRODUCT
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The control parameter value corresponding to the 4mA output limit is displayed. Press the MODE key to change this value.

```
OUTPUT #1, TANK #1
4 MA= 10.000 in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to type a new 4mA value and press the ENTER key.

```
OUTPUT #1, TANK #1
4 MA=--------  in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The control parameter value corresponding to the 20mA output limit is displayed. Press the MODE key to change this value.

```
OUTPUT #1, TANK #1
20 MA= 100.000 in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to type a new 20mA value and press the ENTER key. Repeat the above sequence for each analog output (1-8).

```
OUTPUT #1, TANK #1
20 MA=-------  in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE:
Negative offsets may be entered by pressing the +/- key after number entry.

NOTE
The volume display units are controlled by the 'volume display units' SYSTEM parameter (see section 12). Independent of this SYSTEM parameter setting, all volume programming parameters must be entered in English tank gauging units (inches, gallons and pounds or inches, barrels, and pounds).

Select the volumetric tank number to edit and press the ENTER key.

```
SELECT VOLUMETRIC
TANK # TO EDIT:
     (1-8)
'Enter' TO CONTINUE
```

Select the desired temperature correction method by using the MODE or +/- key to scroll through the selections and then press the ENTER key. Available selections are:

- DISABLED (off)
- 6A - Heavy Oils
- 6B - Light Oils
- 6C - Chemicals
- 6C MOD - Wider coefficients than 6C and a moveable reference temperature.
- CUST TAB

```
TANK #1 VOLUMETRIC
CORRECTION: 6C MOD
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE
If "CUSTOM TABLE" volumetric correction mode is selected, proceed to "CUSTOM TABLE ENTRY" section of manual.

API Gravity

NOTE
To enter API gravity values, temperature correction method 6A or 6B must have been selected above. If 6A or 6B was not selected proceed to "THERMAL EXPANSION COEFFICIENT" section of manual..

Enter the API gravity (normalized density) value for the product being measured by tank gauge #1. Allowable values are:

- 6A - 0.0° to 100.0° API
- 6B - 0.0° to 85.0° API

```
TANK #1 API GRAVITY
     0.0        °API
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

To change the API gravity value, use the number keys to type a new value and press the ENTER key.

```
TANK #1 API GRAVITY
     -----      °API

'Enter' NEW VALUE
```

Thermal Expansion Coefficient (TEC)

Temperature correction method 6C uses the thermal expansion coefficient of the product being measured to determine the volume correction factor. Allowable values are 270.0 to 930.0. TEC units are in 10E-6/°F.

```
TANK #1 TEC
     270.0    *10E-6/°F
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

To change the TEC, use the number keys to type a new value and press the ENTER key.

```
TANK #1 TEC
     -----    *10E-6/°F

'Enter' NEW VALUE
```

Reference Temperature (Only if 6C MOD is selected)

Select the desired base temperature for the volume calculations. The allowable values are 32°F to 150°F.

```
TANK #1 REF. TEMP.
     60.0      °F
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

If you wish to change the reference temperature, enter the new value and press the ENTER key.

```
TANK #1 REF. TEMP.
     -----     °F

'Enter' NEW VALUE
```

Custom Table Entry (Only if CUST TAB is selected)

The custom table function allows the user to create a custom data table that defines the temperature expansion characteristics of the product being measured. This function can be used when the expansion characteristics of the product do not follow API tables 6A, 6B or 6C.

NOTE

Refer to Appendix A for additional information about creating custom volume expansion tables.

```
TANK #1 CUSTOM VCF
     TABLE
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Press the mode key to begin editing the custom VCF table, or press ENTER to continue to TANK DENSITY. The number of entries for tank #1 VCF table is shown. If you wish to change this number press the mode key.

```
TANK #1 VCF TABLE
SIZE 10
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to change the number of entries for tank #1 VCF table and press the ENTER key. Table sizes can range from 2 to 50 entries.

```
TANK #1 VCF TABLE
SIZE: --- (2-50)

'Enter' NEW VALUE
```

VCF Data

Tank #1, VCF #0 value is shown. Press the MODE key to change this value.

```
TANK #1   VCF # 0
0.00           °F
1.00000      VCF
'Mode' TO CHANGE
```

Use the number keys to type the new temperature and VCF values for tank #1 and press the ENTER key.

```
TANK #1   VCF # 0
     -------        °F
     -------       VCF
'Enter' NEW VALUE
```

NOTE

All temperatures and VCF values are restricted to positive values as follows:

- *Valid Temperature Range = 0 to 300°F*
- *Valid VCF Range = 0.80000 to 1.20000.*
- *All data must be entered by order of increasing temperatures. i.e. VCF #0 must have the lowest temperature for a given table and VCF #n must have the highest temperature for a given table.*

Repeat the above sequence for each VCF data value until the table is complete.

Direct access to any VCF table value can be done by pressing the CLEAR key. Pressing the CLEAR key twice will access the beginning of the table. Pressing the CLEAR key again will end the programming session.

```
NEXT VCF
NUMBER TO EDIT: --

'Enter' NEW VALUE
```

The Level Plus software includes a VCF TABLE copy function. This function can be used to duplicate VCF tables for other tank numbers. This function can only be accessed from the VCF TABLE size screen. See example below.

```
TANK #X   VCF TABLE
SIZE 10
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

When the 'VCF TABLE SIZE' screen is displayed, press the '+/-' key to activate the table copy function. The Level Plus system will prompt for the table number to copy 'from'. Enter the tank/table number that you want to copy FROM.

```
SELECT VCF TABLE #
TO COPY FROM:
     (1-8)
'Enter' TO CONTINUE
```

The Level Plus system will then prompt for the table number to copy 'to'. Enter the tank/table number that you want to copy TO.

```
SELECT VCF TABLE #
TO COPY TO:
     (1-8)
'Enter' TO CONTINUE
```

The Level Plus system will now prompt the user to verify the tank/table numbers previously entered.

```
COPY VCF TABLE #X
TO VCF TABLE #Y
'Clear' TO ABORT
'Enter' TO CONTINUE
```

If these table numbers are incorrect, press the 'Clear' key to abort (cancel) the copy function and reenter the correct values.

CAUTION

Once the copy process has started there is no way to cancel it. Once a table has been copied over by another table, there is no way to recover the old table.

After the 'copy from' and the 'copy to' table numbers have been verified to be correct, press the 'Enter' key to start the copy process. The 'COPY IN PROGRESS' message will be displayed.

```
COPY IN PROGRESS
```

After approximately 5 seconds, the 'TABLE COPY COMPLETED' message will be displayed.

```
TABLE COPY COMPLETED
```

After 3 seconds, the Level Plus system will return back to the 'VCF TABLE SIZE' screen. The user can then continue programming other parameters or copy another VCF table.

Tank Density

Temperature correction method 6C and 'custom table' requires the user to enter the density (lb/cu ft, at the given reference temperature) of the product being measured for net mass calculations.

NOTE

Mass calculations are optional and can be displayed during measurement mode by pressing the FUNCTION key and then the number 2 key.

```
TANK #X   DENSITY
     64.0000   lb/cu ft
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

To change the product density, use the number keys to type a new value and press the ENTER key.

```
TANK #1 DENSITY
     -----      lb/cu ft

'Enter' NEW VALUE
```

Mass Stabilization

The mass stabilization function can be used as a leak detect function or as an inventory "watch dog" when the tank is in a static condition. Once programmed, the mass stabilization function can only be enabled or disabled through security access codes when the Level Plus is in measurement mode.

NOTE

See Section 12 of this manual for additional information pertaining to mass stabilization security codes. See Section 7 of this manual for additional information pertaining to the operation of the mass stabilization function.

Press the MODE key to enable/disable the mass stabilization function.

```
TK#1 MASS STAB ALARM
DISABLED (OFF)
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE

The Level Plus volumetric software does not calculate temperature corrected INTERFACE volume or INTERFACE mass data. Since the mass stabilization calculations only include the product mass data (and not interface mass data) the function will not detect mass changes properly when two floats are enabled. i.e. the interface mass would have to be removed before a change in the product mass could be detected. This may be resolved by programming the monitor for one float during leak detection operations. This method is deemed acceptable for tanks with small interface volumes in that the induced error is negligible. For single float applications no error is present.

Use the number keys to assign the mass stabilization alarm to specific relays and press the ENTER key. Multiple alarm assignments to any or all relays is permissible. The eight available relays are referenced as RELAY #0 to RELAY #7.

```
TK#1 MASS STAB ALARM
RELAY ASSIGNMENT
 - 1 - - - - - -
TYPE RELY# TO TOGGLE
```

The value for the TANK #1, DELTA MASS LIMIT alarm is shown. Press the MODE key to change or the ENTER key to continue.

```
TANK #1   DELTA MASS
LIMIT = 0      lbs.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to type a new DELTA MASS LIMIT value and press the ENTER key.

```
TANK #1   DELTA MASS
LIMIT = ------ lbs.

'Enter' NEW VALUE
```

Tank Capacity Parameters (Optional)

Enter the working capacity for tank #1. The working capacity parameter is used to calculate Gross Observed Volume Ullage (GOVU), GOVU = WORKING CAPACITY - GOVT. Working capacity, safe fill capacity, and maximum safe fill capacity information may be displayed during measurement mode by pressing the FUNCTION key and then the number 3 key. If you wish to change this value press the MODE key.

```
TANK #1   WORK CAPAC.
     100000    gal
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to change the working capacity value and press the ENTER key.

```
TANK #1 WORK CAPAC.
     --------  gal

'Enter' NEW VALUE
```

Safe Fill

The safe fill capacity for tank #1 is shown. If you wish to change this value press the MODE key.

```
TANK #1 SAFE FILL
     100090    gal
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to change the safe fill value and press the ENTER key.

```
TANK #1 SAFE FILL
     --------  gal

'Enter' NEW VALUE
```

Max Safe Fill

The maximum safe fill capacity for tank #1 is shown. If you wish to change this value press the MODE key.

```
TANK #1 MAX SAF FILL
     100095    gal
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to change the maximum safe fill value and press the ENTER key.

```
TANK #1 MAX SAF FILL
     --------  gal

'Enter' NEW VALUE
```

The volumetric calculation system requires the user to input tank height versus tank volume information. The Level Plus monitor currently supports GAUGE TABLES (strapping tables) or equations for SPHERE type vessels. Select the desired type of STRAP MODE by pressing the MODE key.

```
TANK #1 STRAP MODE
     STRAP TABLE
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

NOTE
If STRAP TABLE mode is selected, proceed to STRAP TABLE section of manual.

The current SPHERE radius length is shown Press the MODE key to change the current value or press ENTER to continue.

```
TANK #1 SPHERE RAD.
     700   in.
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

The SPHERE offset parameter is used to add or subtract a fixed volume from the equation calculated sphere volume. This parameter is typically used to account for volume errors created by non-uniform sphere geometries (i.e. flat bottoms or internal structures). Press the MODE key to change the current offset value or press ENTER to continue. Press the +/- key to change the ADD/SUB (subtract) indicator.

```
TANK #1 SPHERE OFF.
ADD       0          gal
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

If SPHERE STRAP MODE was previously selected, the SPHERE OFFSET parameter is the last volumetric parameter to program. Pressing ENTER will return the user to the STRAP MODE menu. The user may use the FNCTN (function) key to back up through the volume parameter screens or press the CLEAR key to proceed to the system exit menu.

Strap Table (Only if STRAP TABLE MODE selected)

The strap table is used to define the tank volume versus tank height information to the volumetric calculation system.

The number of entries for tank #1 strap table is shown. If you wish to change this number press the MODE key.

```
TANK #1 STRAP TABLE
SIZE: 3
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

Use the number keys to change the number of entries for tank #1 gauge table and press the ENTER key. Table sizes can range from 2 to 100 entries.

```
TANK #1 STRAP TABLE
SIZE: ---      (2-100)

'Enter' NEW VALUE
```

Strap Location

Tank #1, strap #0 value is shown. Press the MODE key to change this value.

```
TANK #1   STRAP # 0
     0.000      in.
     100        gal
'Mode' TO CHANGE
```

Use the number keys to type the new strap value for tank #1 and press the ENTER key. (No negative values are allowed.)

```
TANK #1   STRAP # 0
     --------   in.
     --------   gal
'Enter' NEW VALUE
```

Repeat the above sequence for each strap location until the table is complete.

NOTE

The maximum strap to strap deltas are 100.000 inches and 10,000,000 gallons. All strap values must increase with each strap location.

Direct access to any strap location can be done by pressing the CLEAR key. Pressing the CLEAR key twice will access the beginning of the strap table. Pressing the CLEAR key again will end the programming session.

```
NEXT STRAP
NUMBER TO EDIT: --

'Enter' NEW VALUE
```

The Level Plus software includes a STRAP TABLE copy function. This function can be used to duplicate strap tables for other tank numbers. This function can only be accessed from the STRAP TABLE size screen. See example below.

```
TANK #X STRAP TABLE
SIZE: 10
'Mode' TO CHANGE
'Enter' TO CONTINUE
```

When the 'STRAP TABLE SIZE' screen is displayed, press the '+/-' key to activate the table copy function. The Level Plus system will prompt for the table number to copy 'from'. Enter the tank/table number that you want to copy FROM.

```
SELECT STRAP TABLE #
TO COPY FROM:
          (1-8)
'Enter' TO CONTINUE
```

The Level Plus system will then prompt for the table number to copy 'to'. Enter the tank/table number that you want to copy TO.

```
SELECT STRAP TABLE #
TO COPY TO:
          (1-8)
'Enter' TO CONFIRM
```

The Level Plus system will now prompt the user to verify the tank/table numbers previously entered.

```
COPY STRAP TABLE #X
TO STRAP TABLE #Y
'Clear' TO ABORT
'Enter' TO CONFIRM
```

If these table numbers are incorrect, press the 'Clear' key to abort (cancel) the copy function and reenter the correct values.

CAUTION

Once the copy process has started there is no way to cancel it. Once a table has been copied over by another table, there is no way to recover the old table.

After the 'copy from' and the 'copy to' table numbers have been verified to be correct, press the 'Enter' key to start the copy process. The 'COPY IN PROGRESS' message will be displayed.

```
COPY IN PROGRESS
```

After approximately 5 seconds, the 'TABLE COPY COMPLETED' message will be displayed.

After 3 seconds, the Level Plus system will return back to the ‘STRAP TABLE SIZE’ screen. The user can then continue programming other parameters or copy another STRAP table.

If GAUGE TABLE STRAP MODE was previously selected, the strap table entries are the last volumetric parameters to program. Pressing ENTER will proceed to the end of the strap table. Once the end of the table is reached, the user must use the FNCTN (function) key to back up through the volume parameter screens or press the CLEAR key (three times) to proceed to the system exit menu.

17 System Test Functions

System test functions can be used to test selected hardware functions of the Level Plus monitor.

Available test functions include:

KEYPAD/LED/BEEP TEST
LCD DISPLAY TEST
RELAY OUTPUT TEST
DDA COM PORT TEST
HOST COM PORT TEST
ANALOG OUTPUT TEST

The first test function is used to test the keypad, the red alarm LED, the audible beeper and the associated control circuitry.

```
KEYPAD/LED/BEEP TEST

'Mode' TO TEST
'Enter' TO CONTINUE
```

Press the MODE key to enter the selected test function or press ENTER to continue to the next test function.

```
KEYPAD/LED/BEEP TEST

PRESS ANY KEY
'Enter' TO CONTINUE
```

Press any key on the keypad to display the registered key value on the LCD. After each key is pressed the red LED will light and the sonalert beeper will beep. Press each key to verify complete keypad operation. Press the ENTER key last because this key also ends the keypad/led/beeper test.

The LCD DISPLAY TEST is used to test the basic operation of the LCD front panel display and associated LCD control circuitry. Press the MODE key to enter the selected test function or press ENTER to continue to the next test function.

```
LCD DISPLAY TEST

'Mode' TO TEST
'Enter' TO CONTINUE
```

After the MODE key is pressed, all character fields on the LCD will be turned off. Verify that each character and all character pixels are off. Press any key and all character fields on the LCD will be lit. Verify that each character field and all character pixels are lit. Press any key again to end the LCD test.

The RELAY OUTPUT TEST is used to test the operation of the relays and the associated relay control circuitry.

CAUTION

This relay test will toggle the relay outputs. The user must insure that any devices connected to the relay outputs will not be affected by the test and that any personnel could not be harmed due to any connected devices coming on or off at unexpected times.

```
RELAY OUTPUT TEST

'Mode' TO TEST
'Enter' TO CONTINUE
```

Press the MODE key to enter the selected test function or press ENTER to continue to the next test function. A warning message will be displayed.

```
CAUTION! RELAY TEST
WILL TOGGLE OUTPUTS
'Mode' TO TEST
'Enter' TO CONTINUE
```

If it has been determined that the relay test can be safely performed, press the MODE key again or press ENTER to skip the relay test.

```
RELAY OUTPUT TEST
TYPE RELY# TO TOGGLE
   - 1 - - - - - -
'Enter' TO CONTINUE
```

Press the respective relay number (0 - 7) to toggle the relay output. Press the ENTER key to continue to the next test function.

The DDA COM PORT TEST is used to test the communication port and associated circuitry that communicates with the DDA tank gauges and STI modules.

```
DDA COM PORT TEST

'Mode' TO TEST
'Enter' TO CONTINUE
```

Press the MODE key to enter the selected test function or press ENTER to continue to the next test function.

```
DDA COM PORT TEST
1=TX CHAR 2=RX CHAR
3=SEND DDA COMMANDS
'Enter' TO CONTINUE
```

To transmit characters out of the Level Plus monitor DDA communication port, press the "1" key. To receive characters into the communication port and display them on the LCD, press the "2" key. To transmit DDA commands and display the data received from a DDA tank gauge, press the "3" key.

If the "1" key is pressed the TX CHARACTERS screen is displayed.

```
DCPT TX CHARACTERS


'Enter' TO CONTINUE
```

Press any key to transmit that respective character out of the DDA communication port. If the "1" key is pressed, the ASCII character 31 hex (49 decimal) will be transmitted. The MODE, CLEAR and FNCTN keys will transmit ASCII characters M, C and F respectively. The +/- key will transmit the 11 character message "MTS DDA LPM". Press the ENTER key to continue to the next test function.

NOTE

External communication equipment (EIA485 compatible) will be required to receive and verify the characters transmitted out of the DDA communication port.. The MTS HT-100 terminal product may be used for this purpose. The baud rate/word length parameters for the DDA communication port are defined as follows:

4800 baud, 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit.

If the "2" key is pressed the RX CHARACTERS screen is displayed.

```
DCPT RX CHARACTERS


'Enter' TO CONTINUE
```

This test will display all characters received into the DDA communication port onto lines two and three of the LCD screen. If more than 40 characters are received, the characters will wrap around to the first character position on line two. Only LCD compatible ASCII characters can be displayed. Non compatible characters are displayed as solid character blocks. Press the ENTER key to continue to the next test function.

NOTE

External communication equipment (EIA485 compatible) will be required to input characters into the DDA communication port to verify the receive functionality. The MTS HT-100 terminal product may be used for this purpose. The baud rate/word length parameters for the DDA communication port are defined as shown below.

4800 baud, 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit.

If the "3" key is pressed the SEND DDA COMMANDS screen is displayed.

```
DCPT SEND DDA CMNDS
'Mode' TO SELECT:01
(0-7) TO SEND COMMAND
'Enter' TO CONTINUE
```

The SEND DDA COMMANDS test will send selected DDA commands and display the data received from the DDA tank gauge onto lines two and three of the LCD display. Press the MODE key or +/- key to change the selected DDA command to transmit. The DDA commands are displayed in hexadecimal units. After the desired command is selected, press the respective number key (0-7) to send the command to the respective DDA tank gauge. Pressing "0" will send the command to DDA tank gauge addressed at C0 hex, pressing "1" will send the command to address C1 hex and so on. A WAITING FOR RESPONSE message will be displayed until the data is received. Some DDA commands may take up to 15 seconds to respond. If no DDA gauge is connected or communication errors are encountered, the respective DDA communication error messages will be displayed. See section 8 of this manual for further explanation of possible DDA error messages. Press the ENTER key to continue to the next test function.

The HOST COM PORT TEST is used to test the host communication port and associated circuitry used to communicate with external customer communication equipment.

```
HOST COM PORT TEST

'Mode' TO TEST
'Enter' TO CONTINUE
```

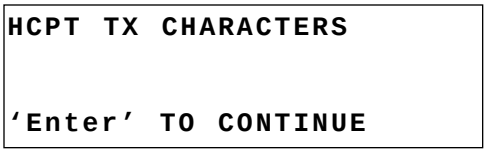
Press the MODE key to enter the selected test function or press ENTER to continue to the next test function.

```
HOST COM PORT TEST
1=TX CHAR 2=RX CHAR

'Enter' TO CONTINUE
```

To transmit characters out of the Level Plus monitor host communication port, press the "1" key. To receive characters into the host communication port and display them on the LCD, press the "2" key.

If the "1" key is pressed the TX CHARACTERS screen is displayed.



Press any key to transmit that respective character out of the host communication port. If the "1" key is pressed, the ASCII character 31 hex (49 decimal) will be transmitted. The MODE, CLEAR and FNCTN keys will transmit ASCII characters M, C and F respectively. The +/- key will transmit the 11 character message "MTS DDA LPM". Press the ENTER key to continue to the next test function.

NOTE

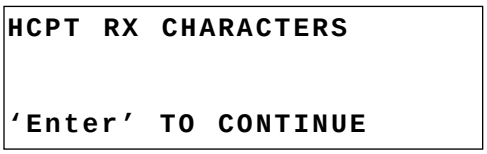
External communication equipment (EIA485 or EIA232 compatible depending on Level Plus monitor host port configuration) will be required to receive and verify the characters transmitted out of the host communication port.. The baud rate/word length parameters for the host communication port are defined as shown below.

If the Level Plus monitor checksum function is enabled: 1 start bit, 8 data bits (no parity) and 1 stop bit.

If the Level Plus monitor checksum function is disabled: 1 start bit, 7 data bits, 1 even parity bit and 1 stop bit.

In both modes the baud rate is controlled by the Level Plus monitor programmable baud rate parameter.

If the "2" key is pressed the RX CHARACTERS screen is displayed.



This test will display all characters received into the host communication port onto lines two and three of the LCD screen. If more than 40 characters are received, the characters will wrap around to the first character position on line two. Only LCD compatible ASCII characters can be displayed. Non compatible characters are displayed as solid character blocks. Press the ENTER key to continue to the next test function.

NOTE

External communication equipment (EIA485 or EIA232 compatible depending on Level Plus monitor host port configuration) will be required to input characters into the host communication port to verify the receive functionality. The baud rate/word length parameters for the host communication port are defined in the previous section.

The ANALOG OUTPUT TEST function is used to test and software trim the 4-20 milliamp analog outputs and the associated analog output control circuitry.

```
ANALOG OUTPUT TEST

'Mode' TO TEST
'Enter' TO CONTINUE
```

Press the MODE key to enter the selected test function or press ENTER to continue to the next test function. Enter the desired analog output (channel) number to test.

```
SELECT ANALOG OUTPUT
TO TEST:    (1-8)

'Enter' TO CONTINUE
```

The selected analog output number is shown in the right top portion of the LCD (CH#1 in the example below). The user may press the "1" or the "2" key to set the analog outputs to 4 and 20 milliamps respectively. The "3" and the "4" keys are used to adjust the 20 milliamp trim value. The current trim value is shown in brackets on line 2 of the LCD, (+2 in the example below). The trim value can be adjusted from +9 to -9 which will provide a total adjustment range of approximately 0.2 milliamps. Pressing the "5" key will cause the analog output to ramp from 4 to 20 milliamps at an approximate rate of 12 hertz.

```
1=4ma 2=20ma  CH#1
3=ADJ+ 4=ADJ-  [+2]
5=RAMP OUTPUT
'Enter' TO CONTINUE
```

The analog output test is the last available test function. Press the ENTER key to continue to the SELECT EDIT FUNCTION menu.

The LPM MEMORY TRANSFER function is used to upload or download the contents of the Level Plus Monitor's non-volatile EEPROM memory in 2-kilobyte pages for archive purposes or to copy memory from one monitor to another. The user must have MTS DDASETUP software running on an IBM compatible PC to perform the memory transfer. Contact MTS Technical Support for additional information on the use of this function.

The memory transfer screen is displayed.

```
LPM MEMORY TRANSFER

'Mode' TO START
'Enter' TO CONTINUE
```

Press the 'Mode' key to start the transfer operation. The following screen is displayed.

```
LPM MEMORY TRANSFER
SELECT EEPROM PAGE #
     (0-3)
'Clear' TO EXIT
```

Use the number keys (0-3) to select the 2-kilobyte EEPROM memory page to transfer. Note that the memory transfer procedure must be repeated for all EEPROM memory pages (0-3).

The following screen is displayed.

```
LPM MEMORY TRANSFER
1 = LPM->HOST
2 = HOST->LPM
'Clear' TO EXIT
```

Use the number keys to select the transfer direction. If 'LPM->HOST" is selected, the following screen is displayed, where PAGE X refers to the memory page (0-3) chosen above.

```
LPM MEMORY TRANSFER
LPM->HOST (PAGE X)
WAITING FOR HOST
'Clear' TO EXIT
```

If ‘HOST->LPM” is selected, the following screen is displayed, where PAGE X refers to the memory page (0-3) chosen above.

```
LPM MEMORY TRANSFER
HOST->LPM (PAGE X)
WAITING FOR HOST
‘Clear’ TO EXIT
```

After the host has initiated the transfer, the following screen is displayed.

```
LPM MEMORY TRANSFER
HOST->LPM (PAGE X)
TRANSFER IN PROGRESS
‘Clear’ TO EXIT
```

The transfer operation can be aborted at any time by pressing the ‘Clear’ key. The following screen is displayed.

```
LPM MEMORY TRANSFER
HOST->LPM (PAGE X)
TRANSFER ABORTED
‘Clear’ TO EXIT
```

If the transfer operation is successful, the following screen is displayed.

```
LPM MEMORY TRANSFER
HOST->LPM (PAGE X)
TRANSFER COMPLETE
‘Clear’ TO EXIT
```

18 Ending The Programming Session

This completes the cycle of parameter entries for the Level Plus monitor. If you are using more than one tank, be sure to repeat all necessary parameter assignments for each additional tank.

If you wish to enter more parameters press the MODE key. If you have finished entering parameters press the ENTER key. The system will then initialize and begin displaying measurements.

NOTE
The initialization sequence takes approximately 5 to 10 seconds per tank gauge.

```
'Enter' TO RESUME
MEASUREMENTS
OR 'Mode' TO CHANGE
OTHER PARAMETERS
```

If the MODE key is pressed, the user can select the type of parameters to edit.

```
SELECT EDIT FUNCTION
  1=SYSTEM PARAMETERS
  2=TANK PARAMETERS
  3=TEST FUNCTIONS
```

19 Level Plus Host Communication Protocol

This section describes the communication protocol required to access LEVEL PLUS Tank Monitoring System data from a remote EIA 232 or EIA 485 communication device.

Hardware Considerations

RS485 SYSTEM — This system allows one host terminal (or computer) to communicate with up to 19 LEVEL PlUS monitors over a two wire balanced differential network. Signals RX, TX, and shield ground are supported. Communication is restricted to half duplex operation only and the host device must provide local character echo, as the LEVEL PLUS system does not.

RS232 SYSTEM — This system allows one host terminal (or computer) to communicate with only one LEVEL PlUS monitors over a standard EIA 232 network. Signals RX, TX, RTS, CTS and signal ground are supported. Communication is restricted to half duplex operation only and the host device must provide local character echo, as the LEVEL PLUS system does not. The EIA 232 system can also be connected to an 80 column printer for data logging purposes. Printer buffer size must be 1000 bytes or larger. Printer interfaces should use CTS signal input to indicate printer buffer full conditions. The Level Plus will not transmit when CTS is low. If the CTS line is low for more than 5 seconds, the scheduled transmission will be aborted.

The asynchronous data format is 10 bits defined as follows:

1. Programmable checksum function disabled -1 start bit, 7 data bits, 1 parity but (even) and 1 stop bit. (ASCII).
2. Programmable checksum function enabled -1 start bit, 8 data bits (even parity) and 1 stop bit (MODBUS RTU).

NOTES:
See *Appendix B* for serial printer interfacing information.

Command Structure

The following command structure is used to issue commands to the Level Plus monitor.

<SOH><addr><tank#><register#><EOT>

Where:

1. <SOH> is an ASCII start of header code (01 Hex).
2. <addr> is the communication address decoded by each Level Plus monitor. Valid addresses are upper case ASCII A through S (41 through 53 Hex). Each Level Plus monitor address is user programmable through the Level Plus programming system.
3. <tank#> is the tank number to interrogate. Valid tank numbers are ASCII 0 through 8 (30 through 38 Hex). Tank number "0" will output all eight tanks.
4. <register#> is the two digit ASCII pointer to the type of data to output. Valid ASCII register numbers are defined below.

    00 = Remote keypad mode request
    01 = Product level
    02 = Interface level
    03 = Average temperature
    04 = GOVP (gross observed volume product)
    05 = GOVI (gross observed volume interface)
    06 = GOVT (gross observed volume total)
    07 = GOVU (gross observed volume ullage)
    08 = NSVP (net standard volume product)
    09 = MASS (net standard mass)
    10 = MASSR (net standard mass reference)
    11 = Product level, interface level and average temperature
    12 = Individual RTD temperatures
    13 = System alarms
    14 = Read tank gauge data (product level, interface level, average temperature, individual RTD temperatures, GOVT and NSVP)
    20 = Enable mass stabilization mode
    21 = Disable mass stabilization mode
    30 = Read VCF mode
    31 = Read API gravity
    32 = Read system volume units
    60 = Write VCF mode
    61 = Write API gravity

5. <EOT> is an ASCII end of transmission code (04 Hex).

NOTE

ASCII carriage return <CR> (OD Hex) may be substituted for <EOT>.

Data Output Formats

The data output formats for each data type (register number) are detailed below.

Register 00 - Remote Keyboard Mode.

The remote keyboard mode allows an external terminal device to communicate with the Level Plus monitor and emulate the front panel keypad during programming operations only. This allows users to modify programming data from remote locations or in areas where access to the front panel keypad is not possible. During emulation mode, all display information is sent to both the Level Plus LCD display and the externally connected terminal device. All programming menus are self prompting and the user only needs to respond with the requested information in each programming menu. Valid terminal keys for use with the keypad emulation mode are listed below.

Numeric keys	0,1,2,3,4,5,6,7,8,9
Alphanumeric keys	M (Mode)
	C (Clear)
	F (Function)
Special keys	'.' (decimal key) and <CR> (Carriage return or Enter)

The data record output from the monitor during each screen update includes all the data and necessary screen control characters to properly display on the terminal device screen. An example output record is shown below.

<LF><CR>ddddddddddddddddddddd<CR>ddddddddddddddddddddd<CR>ddddddddddddddd
dddddd<CR>ddddddddddddddddddddd<LF><CR>aKBD><CR>

Where:

<LF> = ASCII line feed character (0A Hex)
<CR> = ASCII carriage return character (0D Hex)
a = Level Plus communication address (upper case ASCII A through S)
KBD> = Remote keyboard screen prompt

Registers 01 through 10 general format.

<STX>atrr:ddddddddddd<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = Tank number
rr = Register number
: = ASCII colon field delimiter (3A Hex)
d = Data (fixed at 1 data field of 10 characters)
<ETX> = ASCII end of text character (03 Hex)
cc = Optional 2 byte checksum (if enabled)

NOTE

For all data output formats:

1. *Each data record always begins with <STX> (01 Hex) as the first character transmitted.*
2. *The second character is always the address character of the responding monitor (Upper case ASCII A through S, or 41 through 53 Hex).*
3. *The third character is always the tank number interrogated (ASCII 0 through 8, or 30 through 38 Hex). Tank number "0" will output all eight tanks.*
4. *The fourth and fifth characters are always the register number interrogated (ASCII 00 through 99).*
5. *The sixth character is always an ASCII colon character (3A Hex).*
6. *Each data field is always a fixed length as defined for each data type.*
7. *Multiple data field output formats use ASCII colon characters to delimit individual data fields.*
8. *Multiple tank outputs use ASCII # pound signs (23 Hex) to separate each individual tank field.*
9. *Data is always left justified in the data fields.*
10. *Data is always padded with ASCII blanks (20 Hex) when the data is shorter than the defined data field length.*
11. *If the requested tank gauge number is not active (i.e., not multiplexed) the data field will only contain ASCII blanks (20 Hex).*
12. *Each data record always ends with an <ETX> (03 Hex) character.*
13. *The two byte checksum (if enabled) is calculated over the complete data record including the <STX> and <ETX> characters and appended to the end of the transmitted data record.*

Register 01 (product level) output example from monitor at communication address A, Tank 1. Examples shown with checksum function disabled.

<STX>A101:129.586~~~<ETX>

NOTE

~ represents ASCII blank character (20 Hex)

Register 08 (NSVP) output example from monitor at communication address B, Tank 2.

<STX>B208:45890231~~<ETX>

Register 11 general format (Product level, interface level and average temperature).

<STX>atrr:ddddddddddd:ddddddddddd:ddddddddddd<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = Tank number
rr = Register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 3 data fields, 10 characters for each data field)
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 11 output example from monitor at communication address C, Tank 3.

<STX>C311:129.586~~~:11.555~~~~:83.1~~~~~~~<ETX>

Register 12 general format (Individual RTD temperatures).

<STX>atrr:dddddd:dddddd:dddddd:dddddd:dddddd<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 5 data fields, 6 characters for each data field)
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 12 output example from monitor at communication address D, Tank 4.

<STX>D412:78.2~~:79.6~~:80.4~~:81.2~~:82.5~~<ETX>

Register 13 general format (System alarms).

<STX>atrr:ddddddddddddddddd<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 1 data field of 16 characters)
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

The individual data characters represent the status of the individual system alarms. An ASCII "0" indicates that the alarm is inactive and an ASCII "1" indicates that the alarm is active. The alarm definitions are listed below.

d1 = PRDHH (product level high high)
d2 = PRDHI (product level high)
d3 = PRDLO (product level low)
d4 = PRDLL (product level low low)
d5 = INTHI (interface level high)
d6 = INTLO (interface low level)
d7 = TMPHI (temperature high)
d8 = TMPLO (temperature low)
d9 = GAUGE level error
d10 = STI error
d11 = mass stab error
d12 = RTD average error
d13 = GAUGE temperature error
d14 = MASHI (mass stabilization high)
d15 = MASLO (mass stabilization low)
d16 = not defined (always ASCII "0")

NOTE
d1 is the first character after colon delimiter character.

Register 13 output example from Level Plus monitor at communication address E, Tank 5, LVLLO and INTHI alarms active, all others inactive.

<STX>E513:0010100000000000<ETX>

Register 14 general format (Read tank gauge data)

<STX>attr:dddddd:dddddd:dddddd:dddddd:dddddd:dddddd:dddddd:dddddd:dddddddd:dddddddd<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 8 fields of 6 characters and 2 fields of 8 characters)
field 1 = product level
field 2 = interface level
field 3 = average temperature
field 4 = RTD 1 temperature
field 5 = RTD 2 temperature
field 6 = RTD 3 temperature
field 7 = RTD 4 temperature
field 8 = RTD 5 temperature
field 9 = GOVT
field 10 = NSVP
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 20 and 21 general format (Mass stabilization enable and disable).

<STX>atrr:d<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 1 data field of 1 character)
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

The value of the 1 data character indicates if the mass stabilization command action was completed. An ASCII "0" indicates that the requested action was not completed and an ASCII "1" indicates that the requested action was completed.

Register 30 general format (Read VCF mode)

<STX>attr:d<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 1 field of 1 character)
d = 0 = volumetric function disabled
d = 1 = table 6A
d = 2 = table 6B
d = 3 = table 6C
d = 4 = table 6C MOD
d = 5 = CUST TAB
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 31 general format (Read API gravity)

<STX>attr:ddd.d<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
ddd.d = data (where ddd.d is a variable length field with 1 to 3 characters to the left of the decimal point and 1 character to the right of the decimal point)
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 32 general format (Read system volume units)

<STX>attr:d<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 1 field of 1 character)
d = 0 = Inches-gallons-pounds
d = 1 = Inches-barrels-pounds
d = 2 = Inches-gallons-kilograms
d = 3 = Inches-liters-kilograms
d = 4 = Inches-liters-pounds
d = 5 = Millimeters-liters-kilograms
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 60 general format (Write VCF mode)

Host issued command:
<SOH>attr:d<EOT>

<SOH> = ASCII start of header character (01 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = VCF mode to write
d = 0 = volumetric function disabled
d = 1 = table 6A
d = 2 = table 6B
d = 3 = table 6C
d = 4 = table 6C MOD
d = 5 = CUST TAB
<EOT> = ASCII end of transmission character (04 Hex)

LPM response:
<STX>attr:d<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 1 field of 1 character)
d = 0 = memory write not completed successfully
d = 1 = memory write completed successfully
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Register 61 general format (Write API gravity)

Host issued command:
<SOH>attr:ddd.d<EOT>

<SOH> = ASCII start of header character (01 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
ddd.d = API gravity to write (where ddd.d is a variable length field with 1 to 3 characters to the left of the decimal point and 1 character to the right of the decimal point)
<EOT> = ASCII end of transmission character (04 Hex)

NOTE

*The user must insure that the proper range of API gravity is specified for the particular API table that is selected or the Level Plus Monitor will indicate the *VCF ERR error message for NSVP and MASS outputs.*

LPM response:
<STX>attr:d<ETX>cc

<STX> = ASCII start of text character (02 Hex)
a = Level Plus communication address
t = tank number
rr = register number
: = ASCII colon field delimiter (3A Hex)
d = data (fixed at 1 field of 1 character)
d = 0 = memory write not completed successfully
d = 1 = memory write completed successfully
<ETX> = ASCII end of text character (03 Hex)
cc = optional 2 byte checksum (if enabled)

Error Messages

For all data related output commands, error messages may be present instead of actual data. All error messages are preceded by an ASCII asterisk character (*) for easy parsing. As with data, all error messages are left justified so only the first character needs to be checked to determine if an error message is present. The error message text and format is exactly like those documented in section 8 of this manual.

For all level register outputs (01, 02 and 11) the following error messages are possible. The description for these and other error messages can be found in section 8 of this manual.

*NO COMM
*COMM ERR
*NO DATA
*DATA ERR
*CSUM ERR
*UART ERR
*PRGRM ERR
*FLOAT ERR
*GAUGE ERR

For all average temperature register outputs (03 and 11) the following error messages are possible.

*NO COMM
*COMM ERR
*NO DATA
*DATA ERR
*CSUM ERR
*UART ERR
*AVG ERR

For the individual RTD temperature register output (12) the following coded (*Exxx) error messages are possible in each data field.

*E203 - DDA gauge temperature under-range
*E204 - DDA gauge temperature over-range
*E205 - DDA gauge internal electronics failure
*E206 - DDA gauge internal electronics failure
*E207 - DDA gauge shorted RTD element
*E208 - DDA gauge open RTD element
*E211 - DDA gauge internal electronics failure
*E212 - DDA gauge RTD processing disabled.
*NA - RTD not active

For all volume register outputs (04 through 10) the following error messages are possible.

*LEVL ERR
*INTP ERR
*TEMP ERR
*CALC ERR
*VCF ERR

NOTES AND RESTRICTIONS

1. All communications are half duplex only. Only the host device or the Level Plus monitor can transmit characters at any one time.

2. In keyboard emulation mode the Level Plus monitor can only accept characters from the external terminal device at a rate of 10 characters per second.

3. The Level Plus monitor will not respond to external data requests during power up initialization mode or to tank numbers that are not active (i.e. not enabled).

4. The data output does not include units of measure information. The units of the data is always controlled by the current Level Plus monitor program settings.

5. Level data output formats do not support fractional data. If monitor is programmed for fractional level display, communication data outputs will be in decimal inches.

20 DDA LPM Modbus Implementation

The MTS DDA LPM Modbus implementation conforms to the “Modicon Modbus Protocol Reference Guide, PI-MBUS-300 Rev. G” available from Modicon, Inc. The information provided below assumes familiarity with the Modbus protocol as outlined in this reference guide. All information provided applies to both Modbus RTU and Modbus ASCII protocol versions.

Modbus Function Codes

The following Modbus function codes are supported:

Function 03 - Read Holding Registers
Function 04 - Read Input Registers
Function 08 - Diagnostics (Subfunction 00, Return Query Data)
Function 08 - Diagnostics (Subfunction 01, Restart Communications Option)
Function 08 - Diagnostics (Subfunction 04, Force Listen Only Mode)
Function 17 - Report Slave ID

Function 03 - Read Holding Registers
The LPM responds to this message by returning the contents of the requested data register(s) (see Appendix F, LPM Modbus Register Maps). The following implementation-specific considerations apply:

• If an unsupported or reserved register is requested, a maximum negative value (8000H or 80000000H for paired-registers) is returned (see Appendix F, LPM Modbus Register Maps for unsupported/reserved registers).

• If a register contains an LPM error (displayed on the LPM’s LCD screen as a '*' character followed by an error message), a maximum negative value is returned.

• If a register is blank, indicating that the desired function is not enabled (e.g., volume calculations), a value of 0000H is returned.

• If the alarm data register is requested, and either a 'GAUGE level' error or 'GAUGE temperature' error exists, both the SCERR (Sensor Communication Error, bit D12) and the SOERR (Sensor Operation Error, bit D13) bits will be set. Unsupported or reserved bits will always be set to 0. See Appendix F, LPM Modbus Register Maps, for alarm bit definitions.

Function 04 - Read Input Registers
This function is handled exactly the same as Function 03. Note that all registers are read-only in this implementation.

Function 08 - Diagnostics (Subfunction 00, Return Query Data)
The LPM responds to this request with the following data:

Slave address:	echoed
Function:	08H
Subfunction high:	00H
Subfunction low:	00H
Query data (16-bit):	echoed
Error check:	16-bit CRC/8-bit LRC

Function 08 - Diagnostics (Subfunction 01, Restart Communications Option)
If the LPM is in listen-only mode, the LPM responds to this message by switching out of listen-only mode (note that no response is sent to the request). If the LPM is not in listen-only mode, it responds as follows:

Slave address:	echoed
Function:	08H
Subfunction high:	00H
Subfunction low:	01H
Query data (16-bit):	echoed (0000H or FF00H)
Error check:	16-bit CRC/8-bit LRC

Note that since no Communications Event Log is supported, the 'Query data' field is irrelevant (normally FF00H would clear the log).

Function 08 - Diagnostics (Subfunction 04, Force Listen Only Mode)
The LPM responds to this request by switching to listen-only mode. Messages are still received and parsed, but no responses are transmitted. To switch out of listen-only mode, issue a 'Restart Communications Option' request (function 08, subfunction 01) or cycle power.

Function 17 - Report Slave ID
The LPM responds to this request with the following data:

Slave address:	echoed
Function:	11H
Byte count:	05H
Slave ID:	FFH
Run indicator status:	FFH (ON)
Additional data:	'LPM'
Error check:	16-bit CRC/8-bit LRC

Modbus Exceptions
The following standard Modbus exceptions are implemented:

Error code 01 (Illegal Function)
Reported when:
• A function other than 03, 04, 08, or 17 is requested.
• Function 08 is requested, and a subfunction other than 00, 01, or 04 is requested.

Error code 02 (Illegal Data Address)
Reported when:
• Function 03 or 04 is requested and the starting register number is greater than 915 (register greater than 30916 or 40916).

Error code 03 (Illegal Data Value)
Reported when:
• Function 03 or 04 is requested and the number of data points is greater than 40 (RTU) or 20 (ASCII), or the number of data points added to the start address results in a register greater than 30916 or 40916.

Procedure for Calculating Volume Correction Factors (VCF)

1. Obtain a copy of the temperature versus density data for the desired product (API tables or other source).

2. Determine the reference temperature (usually 60 degrees F for petroleum products).

3. Calculate the VCF values for the product at the desired operating temperatures using the following equation:

   VCF = Density at given temp / Density at reference temp

4. Create a table of VCF values versus temperature covering the normal operating temperatures of the desired product.

> **NOTE**
> *The VCF table entries are limited to temperature values between 0 and 300 degrees Fahrenheit and VCF values between 0.80000 and 1.20000.*

5. Program the VCF versus temperature data into the Level Plus monitor. Enter the values into the table by increasing temperatures. For this example, the VCF table would start with 40°F and VCF = 1.03099, and end with 80°F and VCF = 0.96718

Example:

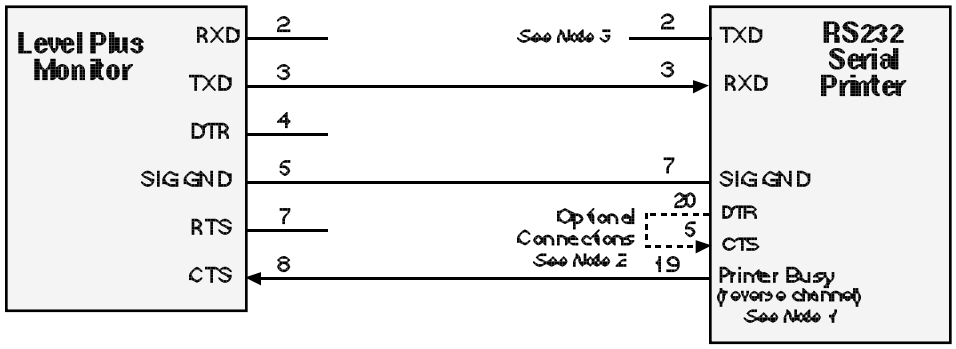
TEMP (degrees F)	Density (lb / cu ft)	VCF
40	32.7340	1.03099
50	32.2491	1.01572
60	31.7500	1.00000
70	31.2351	0.98378
80	30.7080	0.96718

Appendix B

Typical RS232 Printer Connections

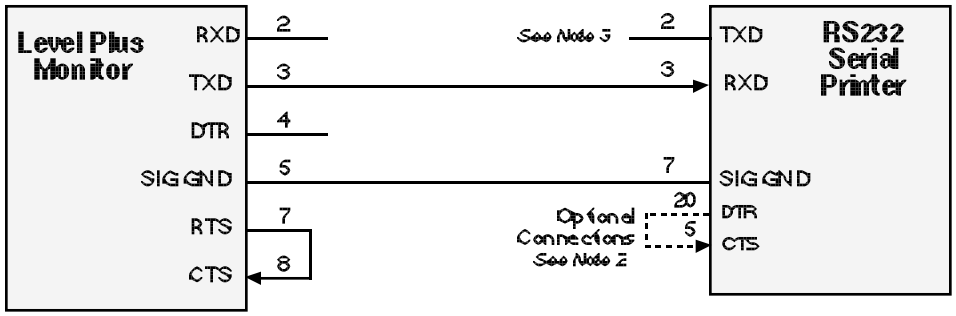
NOTE
The Level Plus requires an 80 column printer with a minimum buffer size of 1K (thousand) bytes.

CONFIGURATION #1: Printer ***with*** a "Busy Flag" Output



NOTES:
1. Printer Busy = LOW ('0'), Printer Ready = HIGH ('1')
2. "Optional" connections are required by some printer.
3. Pin numbers may vary for different printer types.

CONFIGURATION #2: Printer ***without*** a "Busy Flag" Output



Appendix C

Procedure to Calculate System Scan (Polling) Rates

This procedure allows the user to calculate the expected system scan rate for a given application. The system scan rate is controlled by several user programmable parameters. The programmable parameters that affect system scan rates are described below.

Tank Multiplex Assignment

The Level Plus monitor polls each DDA tank gauge in a sequential order based on the tank numbers that are enabled on the tank multiplex assignment programming menu. Level data is sequentially polled from each active tank gauge in the scan loop. The level scan loop is repeated five times and then temperature data (if enabled) is polled from the first tank gauge in the multiplex assignment. The level polling loop is repeated again (five times) and then temperature (if enabled) is polled from the second active tank gauge in the multiplex assignment. This polling sequence is continued until temperature data has been polled from all active tank gauges in the multiplex assignment. The polling process then repeats continuously in the defined order.

Temperature Display (Tank parameter)

The temperature display programmable parameter determines which tank gauges should be polled for temperature data. Only the tank gauges that have the temperature display function enabled are polled for temperature data. If the temperature function is disabled then the overall system polling rate will be faster. The temperature function can be enabled or disabled on a gauge by gauge basis. In addition the temperature display programmable parameter determines which temperature command is sent to the DDA tank gauge. The higher the temperature resolution setting (low, medium or high) the longer it will take for the DDA tank gauge to acquire and transmit the temperature data. Consequently, the overall system polling rates will be slower. The typical per gauge time delays are based on equations from the DDA tank gauge operation and installation manual.

Low resolution (1 degree Fahrenheit) = 1.0 seconds + 0.9 seconds per RTD

Medium resolution (0.2 degrees Fahrenheit) = 1.7 seconds + 1.6 seconds per RTD

High resolution (0.02 degrees Fahrenheit) = 2.9 seconds + 2.7 seconds per RTD

Fast temp (1 degree Fahrenheit) = 0.5 seconds + 0.5 seconds per RTD

Level Resolution (Tank parameter)

The level resolution programmable parameter determines which level command is sent to the DDA tank gauge. The higher the level resolution setting (0.1, 0.01 or 0.001 inches) the longer it will take for the DDA tank gauge to acquire and transmit the level data. Consequently, the overall system polling rates will be slower. The typical per gauge time delays are based on equations from the DDA gauge operation and installation manual. Note that the level data time delays for Dx model DDA tank gauges are less than for LD models. Delay times for single float DDA tank gauges are listed below in seconds.

	'Dx' tank gauge models	**'LD' tank gauge models**
Low resolution (0.1 inches) =	0.30	0.45
Medium resolution (0.01 inches) =	0.46	0.73
High resolution (0.001 inches) =	1.32	2.20

The actual time delays for level data may be slightly less than the values listed above since the level time delay is also a function of tank gauge length. The shorter the gauge length, the slightly less the time delay will be. The above listed values are based on the worst case time delays assuming maximum gauge lengths per model type (Dx and LD).

Level Averages (Tank parameter)

The level averages programmable parameter determines how many times to poll (and then average) level data from the specified tank gauge. The specified number of level averages (polls) is completed before advancing to the next gauge in the multiplex assignment. The level average factor directly affects the overall polling rate by the specific gauge time delay times the level average factor (gauge poll rate = level time delay x level averages).

Number of Floats (Tank parameter)

The number of floats programmable parameter determines which level command (one or two float level command) is sent to the DDA tank gauge. Two float commands take approximately 50% longer than single float commands for the DDA tank gauge to acquire and transmit the level data. Consequently, the overall system polling rates will be slower. The typical per gauge time delays are based on equations from the DDA gauge operation and installation manual. Note that the level data time delays for Dx model DDA tank gauges are less than for LD models. Delay times for two float DDA tank gauges are listed below in seconds. See previous section on level resolution for delay times of single float DDA tank gauges.

	'Dx' tank gauge models	**'LD' tank gauge models**
Low resolution (0.1 inches) =	0.40	0.58
Medium resolution (0.01 inches) =	0.65	1.02
High resolution (0.001 inches) =	1.94	3.26

The actual time delays for level data may be slightly less than the values listed above since the level time delay is also a function of tank gauge length. The shorter the gauge length, the slightly less the time delay will be. The above listed values are based on the worst case time delays assuming maximum gauge lengths per model type (Dx and LD).

Based on the user programmable parameters the overall polling rate can be approximated by the following equations.

Overall system delay time to scan all tank gauges for level and temperature.

1. (T1L)x(A1)x(NT)x(5) + (T1T) + (T2L)x(A2)x(NT)x(5) + (T2T) + ... + (TnL)x(An)x(NT)x(5) + (TnT)

Where:

T1L = Tank gauge #1 level delay time (based on selected level resolution and # of floats)
T2L = Tank gauge #2 level delay time (based on selected level resolution and # of floats)
TnL = Tank gauge #n level delay time (based on selected level resolution and # of floats)

A1 = Number of level averages for tank gauge #1
A2 = Number of level averages for tank gauge #2
An = Number of level averages for tank gauge #n

NT = Number of tank gauges with temperature function enabled

T1T = Tank gauge #1 temperature delay time (based on selected temperature resolution)
T2T = Tank gauge #2 temperature delay time (based on selected temperature resolution)
TnT = Tank gauge #n temperature delay time (based on selected temperature resolution)

NOTE
Temperature delay time = 0 if temperature polling is disabled for selected tank gauge.

Worst case delay time to acquire level data from all tank gauges in system (assumes one temperature poll from gauge with longest temperature delay time).

2.(T1L)x(A1) + (T2L)x(A2) + (TnL)x(An) + (TwT)

Where:

T1L = Tank gauge #1 level delay time (based on selected level resolution)
T2L = Tank gauge #2 level delay time (based on selected level resolution)
TnL = Tank gauge #n level delay time (based on selected level resolution)
A1 = Number of level averages for tank gauge #1
A2 = Number of level averages for tank gauge #2
An = Number of level averages for tank gauge #n

TwT = Temperature delay time of tank gauge with most RTDs
(i.e., longest time delay (based on selected temperature resolution)

NOTE
TwT = 0 seconds if all temperature polling is disabled.

Example Calculations.

What is the expected overall system delay time for a 4 tank gauge system with the following programmable parameter settings:

Tank Gauge #1
- model D8
- 1 float
- Level averages = 1
- Level resolution = 0.001 inches
- Temperature enabled/LOW resolution (gauge w/5 RTDs)

Tank Gauge #2
- model D9
- 2 floats
- Level averages = 1
- Level resolution = 0.01 inches
- Temperature disabled

Tank Gauge #3
- model LD
- 1 float
- Level averages = 3
- Level resolution = 0.01 inches
- Temperature disabled

Tank Gauge #4
- model LD
- 2 floats
- Level averages = 1
- Level resolution = 0.1 inches
- Temperature enabled/LOW resolution (gauge has 2 RTDs)

The overall system delay time equation becomes,

(T1L)x(A1)x(NT)x(5) + (T1T) + (T2L)x(A2)x(NT)x(5) + (T2T) + (T3L)x(A3)x(NT)x(5) + (T3T) + (T4L)x(A4)x(NT)x(5) + (T4T)

Substituting each variable with the respective values the equation becomes,

(1.32)x(1)x(2)x(5) + (5.5) + (0.65)x(1)x(2)x(5) + (0) +
(0.73)x(3)x(2)x(5) + (0) + (0.58)x(1)x(2)x(5) + (1.9)

Overall system delay time to update level and temperature on all 4 gauges = 54.8 seconds.

What is the expected worst case delay time to acquire level data from the above described 4 tank gauge system (assumes one temperature poll from gauge with longest temperature delay time).

The worst case delay time equation for level data from all gauges in the system becomes,

$$(T1L)x(A1) + (T2L)x(A2) + (T3L)x(A3) + (T4L)x(A4) + (TwT)$$

Substituting each variable with the respective values the equation becomes,

$$(1.32)x(1) + (0.65)x(1) + (0.73)x(3) + (0.58)x(1) + (5.5)$$

Worst case delay time to update level on all 4 gauges = 10.2 seconds.

Appendix D

EPROM Replacement Procedure

NEMA 1 Model

1. Disconnect AC power from the Level Plus monitor at the main fuse panel.

2. Remove the EPROM access cover located on the rear of the NEMA 1 enclosure (1 screw).

3. The EPROM's are the two labeled integrated circuits installed in the latching sockets. Remove one eprom at a time by releasing the latching mechanism on the socket. The latching mechanism is released by carefully pushing the latching levers away from the body of the EPROM into the horizontal position. The levers will lift the eprom from the socket.

4. Install the new EPROM into the socket. Note that each EPROM is numbered (-1 or -0) and must be installed in the respective socket and oriented properly. The small indentation on the end of each EPROM must be oriented as shown in illustration D-1.

5. Visually inspect the newly installed EPROM's to insure all 28 pins are properly seated in the sockets and that the orientation is correct. Compare to illustration D-1 shown below.

6. Reinstall the EPROM access cover.

7. Reconnect AC power and check for proper monitor operation.

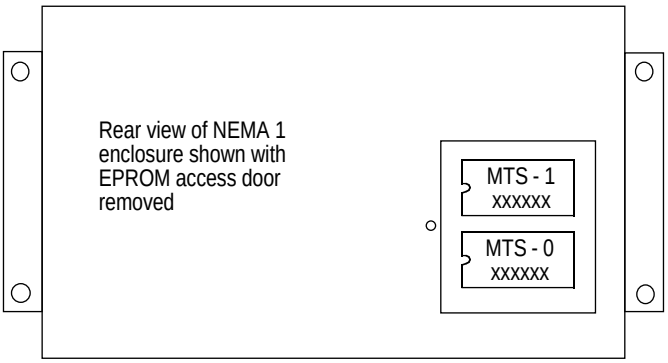


Figure D-1. NEMA 1 EPROM orientation

NEMA 4X Model

1. Disconnect AC power from the Level Plus monitor at the main fuse panel.

2. The main electronics assembly must be removed from the NEMA 4X enclosure to gain access to the EPROM devices. Follow steps 3 through 9 to remove the main electronic assembly.

3. Disconnect the AC power terminations at terminal block TB1.

4. Disconnect any customer terminations to the relay contacts (TB3) and to the communication interface (TB2). Terminal blocks TB2 and TB3 are of the pluggable type.

5. Disconnect any customer terminations to the 4-20 milliamp terminal block. The 4-20 milliamp terminal block is of the pluggable type.

6. Disconnect the tank gauge field wiring from intrinsic safety barriers.

7. Remove the four mounting screws that secure the mounting plate to the rear of the NEMA 4X enclosure. See illustration D-2.

8. Lift the electronic assembly and mounting plate out of the enclosure and place on a clean working surface or bench.

9. Separate the electronic assembly from the mounting plate by removing the 4 mounting screws (and lock washers) from the rear of the mounting plate. Be careful not to damage the rubber heater secured to the rear of the mounting plate. It is not necessary to remove the ground cable from the mounting plate.

10. The EPROMs are the two labeled integrated circuits installed in the latching sockets on the rear of the electronics assembly. Remove one EPROM at a time by releasing the latching mechanism on the socket. The latching mechanism is released by carefully pushing the latching levers away from the body of the EPROM into the horizontal position. The levers will lift the EPROM from the socket.

11. Install the new EPROMs into the sockets. Note that each EPROM is numbered (-1 or -0) and must be installed in the respective socket and oriented properly. The small indentation on the end of each EPROM must be oriented as shown in illustration D-4.

12. Visually inspect the newly installed EPROMs to insure all 28 pins are properly seated in the sockets and that the orientation is correct. Compare to illustration D-4.

13. Reinstall the electronic assembly and mounting plate into the NEMA 4X enclosure. The installation is performed in the reverse order of the removal. Retighten all removed screws. Ensure that all cables and customer wiring are properly installed.

14. Reconnect AC power and check for proper monitor operation.

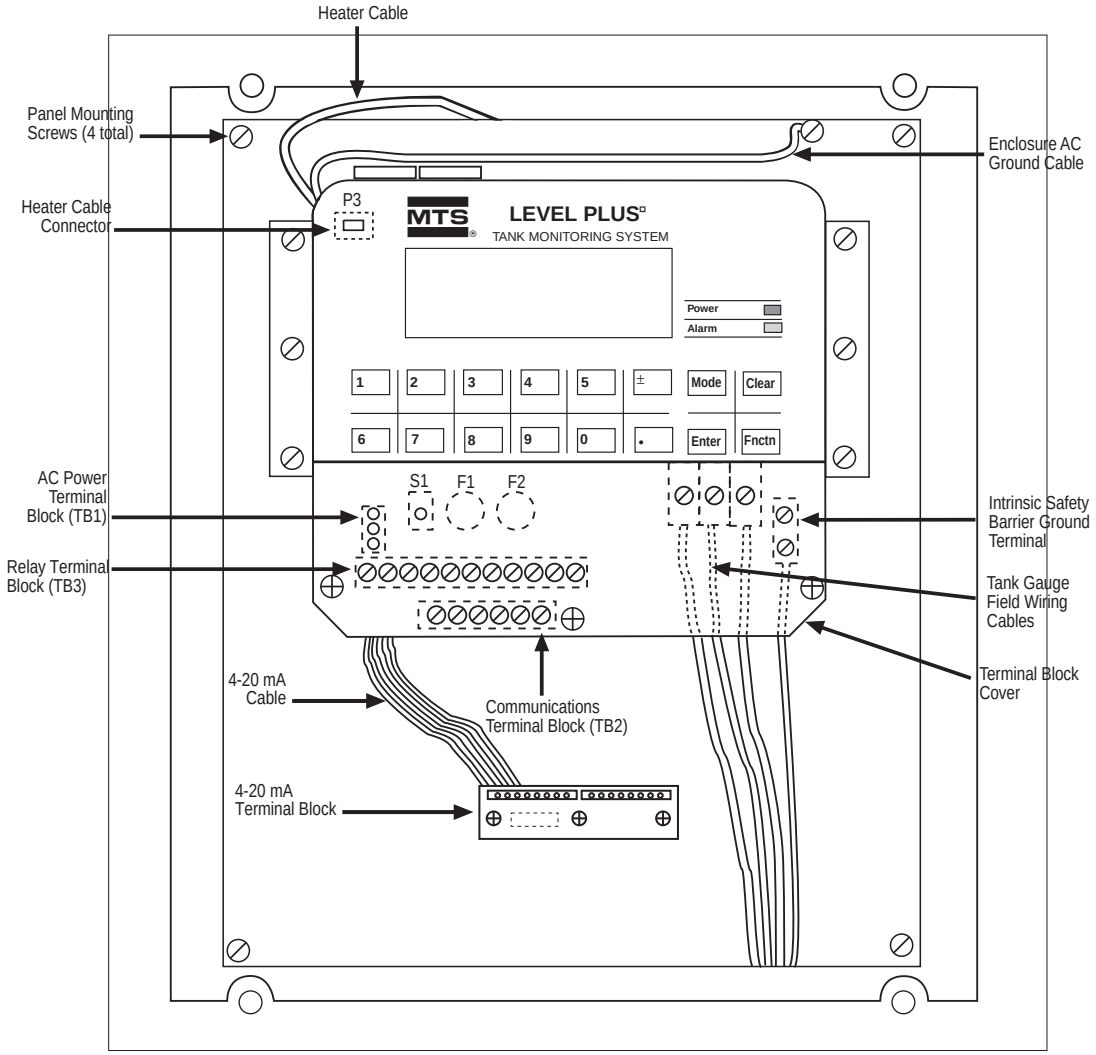


Figure D-2 NEMA 4X Mounting Screws and Cable Locations

NEMA 7 Model:

1. Disconnect AC power from the Level Plus monitor at the main fuse panel.

2. The main electronics assembly must be removed from the NEMA 7 enclosure to gain access to the EPROM devices. Follow steps 3 through 8 to remove the main electronic assembly.

3. Disconnect the AC power terminations at terminal block TB1.

4. Disconnect any customer terminations to the relay contacts (TB3) and to the communication interface (TB2). Terminal blocks TB2 and TB3 are of the pluggable type.

5. Disconnect the tank gauge field wiring from intrinsic safety barriers.

6. Remove the six mounting screws (and lock washers) that secure the electronic assembly to the aluminum brackets in the NEMA 7 enclosure. See illustration D-3. Do not remove the four screws that hold the aluminum brackets to the back of the NEMA 7 enclosure.

7. Begin to lift the electronic assembly out of the enclosure. To fully remove the electronic assembly it will be necessary to disconnect the heater cable, 4-20 milliamp cable, the AC ground cable and the intrinsic safety barrier ground cable. The heater cable can be unplugged from the connector (P3) located at the top left corner behind the keypad panel. The 4-20 milliamp cable can be disconnected from the connector located on the lower left corner of the 4-20 milliamp PCB. The AC ground cable can be removed from the ground stud inside the NEMA 7 enclosure. The intrinsic safety barrier ground can be removed from the ground lug located under the terminal block cover. See illustration D-3 for connector locations.

8. After all cables have been disconnected, carefully remove the electronic assembly completely from the NEMA 7 enclosure. Be extremely careful not to damage the keypad ribbon cables exiting from the top left corner of the keypad. Place the removed electronic assembly on a clean working surface or bench.

9. The EPROMs are the two labeled integrated circuits installed in the latching sockets on the rear of the electronics assembly. Remove one EPROM at a time by releasing the latching mechanism on the socket. The latching mechanism is released by carefully pushing the latching levers away from the body of the EPROM into the horizontal position. The levers will lift the EPROM from the socket.

10. Install the new EPROMs into the sockets. Note that each EPROM is numbered (-1 or -0) and must be installed in the respective socket and oriented properly. The small indentation on the end of each EPROM must be oriented as shown in illustration D-4.

11. Visually inspect the newly installed EPROMs to insure all 28 pins are properly seated in the sockets and that the orientation is correct. Compare to illustration D-4.

12. Reinstall the electronic assembly into the NEMA 7 enclosure. The installation is performed in the reverse order of the removal. Insure that all cables and customer wiring are properly reinstalled.

13. Reinstall the six screws to secure the electronic assembly to the aluminum brackets. It may be necessary to loosen the four screws securing the brackets to the back of the NEMA 7 enclosure to realign the brackets. Retighten all screws.

14. Reconnect AC power and check for proper monitor operation.

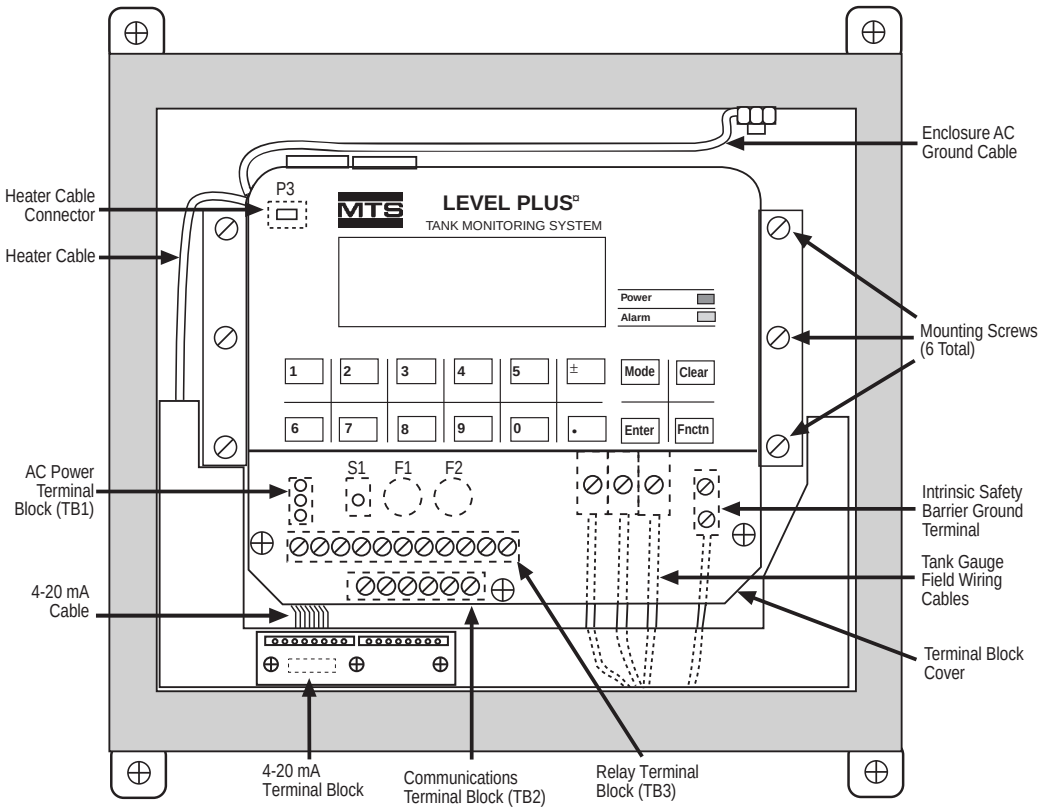


Figure D-3. NEMA 7 Mounting Screws & Cables Locations

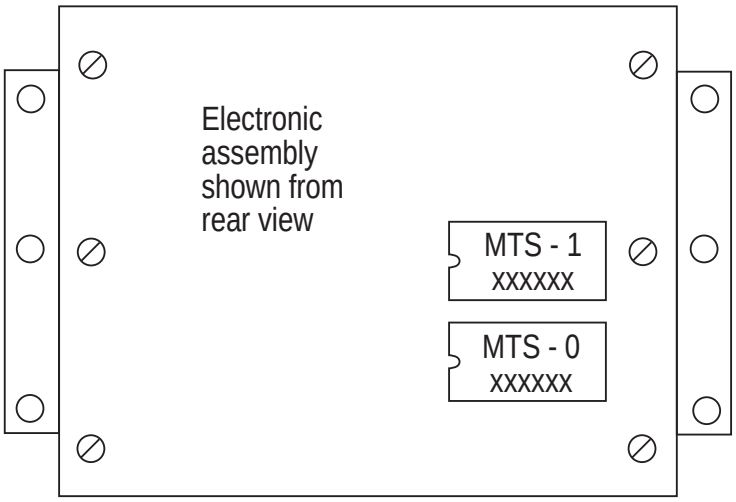
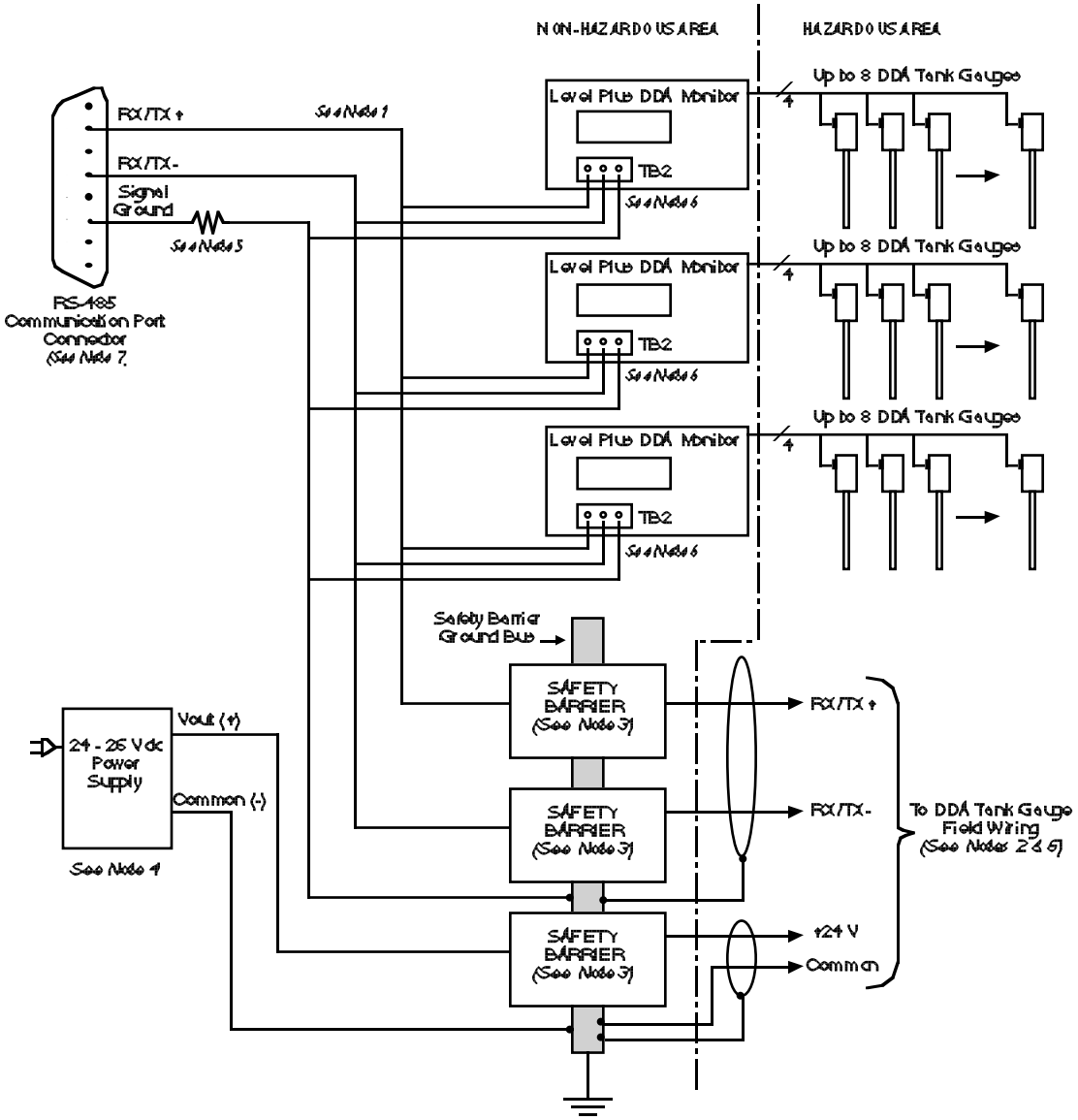


Figure D-4. NEMA 7 EEPROM Orientation

Connecting Level Plus DDA Monitor to Level Plus System80™ (LPS80) Software



NOTES:

1. Maximum allowable number of EIA-485 devices per communication port is 30
   - Level Plus DDA Monitor = 1 device
   - Level Plus DDA Tank Gauge = 1 device
2. Maximum allowable number of DDA tank gauges per safety barrier set is 20
3. Refer to MTS DDA Tank Gauge Manual (P/N 550164) Section 6 for approved safety barrier types and field wiring information.
4. Refer to MTS DDA Tank Gauge Manual (P/N 550164) Section 7 for DDA tank gauge power requirements.
5. Resistor in ground connection is optional to limit possible ground currents due to different ground voltage potentials. Resistor should have 1 watt minimum power rating.
6. To insure proper safety, intrinsically safe applications must meet all requirements of MTS tank gauge installation drawing #650511.
7. Refer to manufacturer's documentation for connector pin-out information.
8. Refer to MTS Level Plus DDA Tank Gauge Monitor Operation and Installation Manual (Section 5) for communication wire termination to communication terminal block TB2. Monitor host communication port must be configured for EIA-485 mode, 4800 baud and DDA tank gauge 'emulation' output protocol (See Section 12).

Appendix F LPM Modbus Register Maps

Map 1: Registers arranged by tank number

Modbus Register	*Data Address*	*Data Description*
30001	0000	Tank 1, Level 1 High Word (x 1000) see notes 2, 3, 4
30002	0001	Tank 1, Level 1 Low Word (x 1000)
30003	0002	Tank 1, Level 2 High Word (x 1000) see note 5
30004	0003	Tank 1, Level 2 Low Word (x 1000)
30005	0004	Tank 1, Average Temperature (x 100) see note 6
30006	0005	Tank 1, RTD 1 (x 100) see note 1
30007	0006	Tank 1, RTD 2 (x 100)
30008	0007	Tank 1, RTD 3 (x 100)
30009	0008	Tank 1, RTD 4 (x 100)
30010	0009	Tank 1, RTD 5 (x 100)
30011	0010	Tank 1, Alarm Status, see note 8
30012	0011	Reserved, see note 9
30013	0012	Tank 1, GOVP High Word, see note 10
30014	0013	Tank 1, GOVP Low Word
30015	0014	Tank 1, GOVI High Word, see note 11
30016	0015	Tank 1, GOVI Low Word
30017	0016	Tank 1, GOVT High Word, see note 12
30018	0017	Tank 1, GOVT Low Word
30019	0018	Tank 1, GOVU High Word
30020	0019	Tank 1, GOVU Low Word
30021	0020	Tank 1, NSVP High Word
30022	0021	Tank 1, NSVP Low Word
30023	0022	Tank 1, Mass High Word
30024	0023	Tank 1, Mass Low Word
30025	0024	Reserved
30026	0025	Reserved
30051	0050	Tank 2, Level 1 High Word (x 1000)
30052	0051	Tank 2, Level 1 Low Word (x 1000)
30053	0052	Tank 2, Level 2 High Word (x 1000)
30054	0053	Tank 2, Level 2 Low Word (x 1000)
30055	0054	Tank 2, Average Temperature (x 100)
30056	0055	Tank 2, RTD 1 (x 100)
30057	0056	Tank 2, RTD 2 (x 100)
30058	0057	Tank 2, RTD 3 (x 100)
30059	0058	Tank 2, RTD 4 (x 100)
30060	0059	Tank 2, RTD 5 (x 100)
30061	0060	Tank 2, Alarm Status
30062	0061	Reserved
30063	0062	Tank 2, GOVP High Word

Modbus Register	*Data Address*	*Data Description*
30064	0063	Tank 2, GOVP Low Word
30065	0064	Tank 2, GOVI High Word
30066	0065	Tank 2, GOVI Low Word
30067	0066	Tank 2, GOVT High Word
30068	0067	Tank 2, GOVT Low Word
30069	0068	Tank 2, GOVU High Word
30070	0069	Tank 2, GOVU Low Word
30071	0070	Tank 2, NSVP High Word
30072	0071	Tank 2, NSVP Low Word
30073	0072	Tank 2, Mass High Word
30074	0073	Tank 2, Mass Low Word
30075	0074	Reserved
30076	0075	Reserved
30101	0100	Tank 3, Level 1 High Word (x 1000)
30102	0101	Tank 3, Level 1 Low Word (x 1000)
30103	0102	Tank 3, Level 2 High Word (x 1000)
30104	0103	Tank 3, Level 2 Low Word (x 1000)
30105	0104	Tank 3, Average Temperature (x 100)
30106	0105	Tank 3, RTD 1 (x 100)
30107	0106	Tank 3, RTD 2 (x 100)
30108	0107	Tank 3, RTD 3 (x 100)
30109	0108	Tank 3, RTD 4 (x 100)
30110	0109	Tank 3, RTD 5 (x 100)
30111	0110	Tank 3, Alarm Status
30112	0111	Reserved
30113	0112	Tank 3, GOVP High Word
30114	0113	Tank 3, GOVP Low Word
30115	0114	Tank 3, GOVI High Word
30116	0115	Tank 3, GOVI Low Word
30117	0116	Tank 3, GOVT High Word
30118	0117	Tank 3, GOVT Low Word
30119	0118	Tank 3, GOVU High Word
30120	0119	Tank 3, GOVU Low Word
30121	0120	Tank 3, NSVP High Word
30122	0121	Tank 3, NSVP Low Word
30123	0122	Tank 3, Mass High Word
30124	0123	Tank 3, Mass Low Word
30125	0124	Reserved
30126	0125	Reserved
30151	0150	Tank 4, Level 1 High Word (x 1000)
30152	0151	Tank 4, Level 1 Low Word (x 1000)
30153	0152	Tank 4, Level 2 High Word (x 1000)
30154	0153	Tank 4, Level 2 Low Word (x 1000)

Modbus Register	*Data Address*	*Data Description*
30155	0154	Tank 4, Average Temperature (x 100)
30156	0155	Tank 4, RTD 1 (x 100)
30157	0156	Tank 4, RTD 2 (x 100)
30158	0157	Tank 4, RTD 3 (x 100)
30159	0158	Tank 4, RTD 4 (x 100)
30160	0159	Tank 4, RTD 5 (x 100)
30161	0160	Tank 4, Alarm Status
30162	0161	Reserved
30163	0162	Tank 4, GOVP High Word
30164	0163	Tank 4, GOVP Low Word
30165	0164	Tank 4, GOVI High Word
30166	0165	Tank 4, GOVI Low Word
30167	0166	Tank 4, GOVT High Word
30168	0167	Tank 4, GOVT Low Word
30169	0168	Tank 4, GOVU High Word
30170	0169	Tank 4, GOVU Low Word
30171	0170	Tank 4, NSVP High Word
30172	0171	Tank 4, NSVP Low Word
30173	0172	Tank 4, Mass High Word
30174	0173	Tank 4, Mass Low Word
30175	0174	Reserved
30176	0175	Reserved
30201	0200	Tank 5, Level 1 High Word (x 1000)
30202	0201	Tank 5, Level 1 Low Word (x 1000)
30203	0202	Tank 5, Level 2 High Word (x 1000)
30204	0203	Tank 5, Level 2 Low Word (x 1000)
30205	0204	Tank 5, Average Temperature (x 100)
30206	0205	Tank 5, RTD 1 (x 100)
30207	0206	Tank 5, RTD 2 (x 100)
30208	0207	Tank 5, RTD 3 (x 100)
30209	0208	Tank 5, RTD 4 (x 100)
30210	0209	Tank 5, RTD 5 (x 100)
30211	0210	Tank 5, Alarm Status
30212	0211	Reserved
30213	0212	Tank 5, GOVP High Word
30214	0213	Tank 5, GOVP Low Word
30215	0214	Tank 5, GOVI High Word
30216	0215	Tank 5, GOVI Low Word
30217	0216	Tank 5, GOVT High Word
30218	0217	Tank 5, GOVT Low Word
30219	0218	Tank 5, GOVU High Word
30220	0219	Tank 5, GOVU Low Word
30221	0220	Tank 5, NSVP High Word

Modbus Register	*Data Address*	*Data Description*
30222	0221	Tank 5, NSVP Low Word
30223	0222	Tank 5, Mass High Word
30224	0223	Tank 5, Mass Low Word
30225	0224	Reserved
30226	0225	Reserved
30251	0250	Tank 6, Level 1 High Word (x 1000)
30252	0251	Tank 6, Level 1 Low Word (x 1000)
30253	0252	Tank 6, Level 2 High Word (x 1000)
30254	0253	Tank 6, Level 2 Low Word (x 1000)
30255	0254	Tank 6, Average Temperature (x 100)
30256	0255	Tank 6, RTD 1 (x 100)
30257	0256	Tank 6, RTD 2 (x 100)
30258	0257	Tank 6, RTD 3 (x 100)
30259	0258	Tank 6, RTD 4 (x 100)
30260	0259	Tank 6, RTD 5 (x 100)
30261	0260	Tank 6, Alarm Status
30262	0261	Reserved
30263	0262	Tank 6, GOVP High Word
30264	0263	Tank 6, GOVP Low Word
30265	0264	Tank 6, GOVI High Word
30266	0265	Tank 6, GOVI Low Word
30267	0266	Tank 6, GOVT High Word
30268	0267	Tank 6, GOVT Low Word
30269	0268	Tank 6, GOVU High Word
30270	0269	Tank 6, GOVU Low Word
30271	0270	Tank 6, NSVP High Word
30272	0271	Tank 6, NSVP Low Word
30273	0272	Tank 6, Mass High Word
30274	0273	Tank 6, Mass Low Word
30275	0274	Reserved
30276	0275	Reserved
30301	0300	Tank 7, Level 1 High Word (x 1000)
30302	0301	Tank 7, Level 1 Low Word (x 1000)
30303	0302	Tank 7, Level 2 High Word (x 1000)
30304	0303	Tank 7, Level 2 Low Word (x 1000)
30305	0304	Tank 7, Average Temperature (x 100)
30306	0305	Tank 7, RTD 1 (x 100)
30307	0306	Tank 7, RTD 2 (x 100)
30308	0307	Tank 7, RTD 3 (x 100)
30309	0308	Tank 7, RTD 4 (x 100)
30310	0309	Tank 7, RTD 5 (x 100)
30311	0310	Tank 7, Alarm Status
30312	0311	Reserved

Modbus Register	*Data Address*	*Data Description*
30313	0312	Tank 7, GOVP High Word
30314	0313	Tank 7, GOVP Low Word
30315	0314	Tank 7, GOVI High Word
30316	0315	Tank 7, GOVI Low Word
30317	0316	Tank 7, GOVT High Word
30318	0317	Tank 7, GOVT Low Word
30319	0318	Tank 7, GOVU High Word
30320	0319	Tank 7, GOVU Low Word
30321	0320	Tank 7, NSVP High Word
30322	0321	Tank 7, NSVP Low Word
30323	0322	Tank 7, Mass High Word
30324	0323	Tank 7, Mass Low Word
30325	0324	Reserved
30326	0325	Reserved
30351	0350	Tank 8, Level 1 High Word (x 1000)
30352	0351	Tank 8, Level 1 Low Word (x 1000)
30353	0352	Tank 8, Level 2 High Word (x 1000)
30354	0353	Tank 8, Level 2 Low Word (x 1000)
30355	0354	Tank 8, Average Temperature (x 100)
30356	0355	Tank 8, RTD 1 (x 100)
30357	0356	Tank 8, RTD 2 (x 100)
30358	0357	Tank 8, RTD 3 (x 100)
30359	0358	Tank 8, RTD 4 (x 100)
30360	0359	Tank 8, RTD 5 (x 100)
30361	0360	Tank 8, Alarm Status
30362	0361	Reserved
30363	0362	Tank 8, GOVP High Word
30364	0363	Tank 8, GOVP Low Word
30365	0364	Tank 8, GOVI High Word
30366	0365	Tank 8, GOVI Low Word
30367	0366	Tank 8, GOVT High Word
30368	0367	Tank 8, GOVT Low Word
30369	0368	Tank 8, GOVU High Word
30370	0369	Tank 8, GOVU Low Word
30371	0370	Tank 8, NSVP High Word
30372	0371	Tank 8, NSVP Low Word
30373	0372	Tank 8, Mass High Word
30374	0373	Tank 8, Mass Low Word
30375	0374	Reserved
30376	0375	Reserved

Map 2: Registers arranged by data type

Modbus Register	*Data Address*	*Data Description*
30401	0400	Tank 1, Level 1 High Word (x 1000)
30402	0401	Tank 1, Level 1 Low Word (x 1000)
30403	0402	Tank 2, Level 1 High Word (x 1000)
30404	0403	Tank 2, Level 1 Low Word (x 1000)
30405	0404	Tank 3, Level 1 High Word (x 1000)
30406	0405	Tank 3, Level 1 Low Word (x 1000)
30407	0406	Tank 4, Level 1 High Word (x 1000)
30408	0407	Tank 4, Level 1 Low Word (x 1000)
30409	0408	Tank 5, Level 1 High Word (x 1000)
30410	0409	Tank 5, Level 1 Low Word (x 1000)
30411	0410	Tank 6, Level 1 High Word (x 1000)
30412	0411	Tank 6, Level 1 Low Word (x 1000)
30413	0412	Tank 7, Level 1 High Word (x 1000)
30414	0413	Tank 7, Level 1 Low Word (x 1000)
30415	0414	Tank 8, Level 1 High Word (x 1000)
30416	0415	Tank 8, Level 1 Low Word (x 1000)
30451	0450	Tank 1, Level 2 High Word (x 1000)
30452	0451	Tank 1, Level 2 Low Word (x 1000)
30453	0452	Tank 2, Level 2 High Word (x 1000)
30454	0453	Tank 2, Level 2 Low Word (x 1000)
30455	0454	Tank 3, Level 2 High Word (x 1000)
30456	0455	Tank 3, Level 2 Low Word (x 1000)
30457	0456	Tank 4, Level 2 High Word (x 1000)
30458	0457	Tank 4, Level 2 Low Word (x 1000)
30459	0458	Tank 5, Level 2 High Word (x 1000)
30460	0459	Tank 5, Level 2 Low Word (x 1000)
30461	0460	Tank 6, Level 2 High Word (x 1000)
30462	0461	Tank 6, Level 2 Low Word (x 1000)
30463	0462	Tank 7, Level 2 High Word (x 1000)
30464	0463	Tank 7, Level 2 Low Word (x 1000)
30465	0464	Tank 8, Level 2 High Word (x 1000)
30466	0465	Tank 8, Level 2 Low Word (x 1000)
30501	0500	Tank 1, Average Temperature (x 100)
30502	0501	Tank 2, Average Temperature (x 100)
30503	0502	Tank 3, Average Temperature (x 100)
30504	0503	Tank 4, Average Temperature (x 100)
30505	0504	Tank 5, Average Temperature (x 100)
30506	0505	Tank 6, Average Temperature (x 100)
30507	0506	Tank 7, Average Temperature (x 100)
30508	0507	Tank 8, Average Temperature (x 100)
30551	0550	Tank 1, RTD 1 (x 100)

Modbus Register	*Data Address*	*Data Description*
30552	0551	Tank 1, RTD 2 (x 100)
30553	0552	Tank 1, RTD 3 (x 100)
30554	0553	Tank 1, RTD 4 (x 100)
30555	0554	Tank 1, RTD 5 (x 100)
30556	0555	Tank 2, RTD 1 (x 100)
30557	0556	Tank 2, RTD 2 (x 100)
30558	0557	Tank 2, RTD 3 (x 100)
30559	0558	Tank 2, RTD 4 (x 100)
30560	0559	Tank 2, RTD 5 (x 100)
30561	0560	Tank 3, RTD 1 (x 100)
30562	0561	Tank 3, RTD 2 (x 100)
30563	0562	Tank 3, RTD 3 (x 100)
30564	0563	Tank 3, RTD 4 (x 100)
30565	0564	Tank 3, RTD 5 (x 100)
30566	0565	Tank 4, RTD 1 (x 100)
30567	0566	Tank 4, RTD 2 (x 100)
30568	0567	Tank 4, RTD 3 (x 100)
30569	0568	Tank 4, RTD 4 (x 100)
30570	0569	Tank 4, RTD 5 (x 100)
30571	0570	Tank 5, RTD 1 (x 100)
30572	0571	Tank 5, RTD 2 (x 100)
30573	0572	Tank 5, RTD 3 (x 100)
30574	0573	Tank 5, RTD 4 (x 100)
30575	0574	Tank 5, RTD 5 (x 100)
30576	0575	Tank 6, RTD 1 (x 100)
30577	0576	Tank 6, RTD 2 (x 100)
30578	0577	Tank 6, RTD 3 (x 100)
30578	0578	Tank 6, RTD 4 (x 100)
30580	0578	Tank 6, RTD 5 (x 100)
30581	0580	Tank 7, RTD 1 (x 100)
30582	0581	Tank 7, RTD 2 (x 100)
30583	0582	Tank 7, RTD 3 (x 100)
30584	0583	Tank 7, RTD 4 (x 100)
30585	0584	Tank 7, RTD 5 (x 100)
30586	0585	Tank 8, RTD 1 (x 100)
30587	0586	Tank 8, RTD 2 (x 100)
30588	0587	Tank 8, RTD 3 (x 100)
30589	0588	Tank 8, RTD 4 (x 100)
30590	0589	Tank 8, RTD 5 (x 100)
30601	0600	Tank 1, Alarm Status
30602	0601	Tank 2, Alarm Status
30603	0602	Tank 3, Alarm Status
30604	0603	Tank 4, Alarm Status

Modbus Register	*Data Address*	*Data Description*
30605	0604	Tank 5, Alarm Status
30606	0605	Tank 6, Alarm Status
30607	0606	Tank 7, Alarm Status
30608	0607	Tank 8, Alarm Status
30651	0650	Tank 1, GOVP High Word
30652	0651	Tank 1, GOVP Low Word
30653	0652	Tank 2, GOVP High Word
30654	0653	Tank 2, GOVP Low Word
30655	0654	Tank 3, GOVP High Word
30656	0655	Tank 3, GOVP Low Word
30657	0656	Tank 4, GOVP High Word
30658	0657	Tank 4, GOVP Low Word
30659	0658	Tank 5, GOVP High Word
30660	0659	Tank 5, GOVP Low Word
30661	0660	Tank 6, GOVP High Word
30662	0661	Tank 6, GOVP Low Word
30663	0662	Tank 7, GOVP High Word
30664	0663	Tank 7, GOVP Low Word
30665	0664	Tank 8, GOVP High Word
30666	0665	Tank 8, GOVP Low Word
30701	0700	Tank 1, GOVI High Word
30702	0701	Tank 1, GOVI Low Word
30703	0702	Tank 2, GOVI High Word
30704	0703	Tank 2, GOVI Low Word
30705	0704	Tank 3, GOVI High Word
30706	0705	Tank 3, GOVI Low Word
30707	0706	Tank 4, GOVI High Word
30708	0707	Tank 4, GOVI Low Word
30709	0708	Tank 5, GOVI High Word
30710	0709	Tank 5, GOVI Low Word
30711	0710	Tank 6, GOVI High Word
30712	0711	Tank 6, GOVI Low Word
30713	0712	Tank 7, GOVI High Word
30714	0713	Tank 7, GOVI Low Word
30715	0714	Tank 8, GOVI High Word
30716	0715	Tank 8, GOVI Low Word
30751	0750	Tank 1, GOVT High Word
30752	0751	Tank 1, GOVT Low Word
30753	0752	Tank 2, GOVT High Word
30754	0753	Tank 2, GOVT Low Word
30755	0754	Tank 3, GOVT High Word
30756	0755	Tank 3, GOVT Low Word
30757	0756	Tank 4, GOVT High Word

Modbus Register	*Data Address*	*Data Description*
30758	0757	Tank 4, GOVT Low Word
30759	0758	Tank 5, GOVT High Word
30760	0759	Tank 5, GOVT Low Word
30761	0760	Tank 6, GOVT High Word
30762	0761	Tank 6, GOVT Low Word
30763	0762	Tank 7, GOVT High Word
30764	0763	Tank 7, GOVT Low Word
30765	0764	Tank 8, GOVT High Word
30766	0765	Tank 8, GOVT Low Word
30801	0800	Tank 1, GOVU High Word
30802	0801	Tank 1, GOVU Low Word
30803	0802	Tank 2, GOVU High Word
30804	0803	Tank 2, GOVU Low Word
30805	0804	Tank 3, GOVU High Word
30806	0805	Tank 3, GOVU Low Word
30807	0806	Tank 4, GOVU High Word
30808	0807	Tank 4, GOVU Low Word
30809	0808	Tank 5, GOVU High Word
30810	0809	Tank 5, GOVU Low Word
30811	0810	Tank 6, GOVU High Word
30812	0811	Tank 6, GOVU Low Word
30813	0812	Tank 7, GOVU High Word
30814	0813	Tank 7, GOVU Low Word
30815	0814	Tank 8, GOVU High Word
30816	0815	Tank 8, GOVU Low Word
30851	0850	Tank 1, NSVP High Word
30852	0851	Tank 1, NSVP Low Word
30853	0852	Tank 2, NSVP High Word
30854	0853	Tank 2, NSVP Low Word
30855	0854	Tank 3, NSVP High Word
30856	0855	Tank 3, NSVP Low Word
30857	0856	Tank 4, NSVP High Word
30858	0857	Tank 4, NSVP Low Word
30859	0858	Tank 5, NSVP High Word
30860	0859	Tank 5, NSVP Low Word
30861	0860	Tank 6, NSVP High Word
30862	0861	Tank 6, NSVP Low Word
30863	0862	Tank 7, NSVP High Word
30864	0863	Tank 7, NSVP Low Word
30865	0864	Tank 8, NSVP High Word
30866	0865	Tank 8, NSVP Low Word
30901	0900	Tank 1, Mass High Word
30902	0901	Tank 1, Mass Low Word

Modbus Register	*Data Address*	*Data Description*
30903	0902	Tank 2, Mass High Word
30904	0903	Tank 2, Mass Low Word
30905	0904	Tank 3, Mass High Word
30906	0905	Tank 3, Mass Low Word
30907	0906	Tank 4, Mass High Word
30908	0907	Tank 4, Mass Low Word
30909	0908	Tank 5, Mass High Word
30910	0909	Tank 5, Mass Low Word
30911	0910	Tank 6, Mass High Word
30912	0911	Tank 6, Mass Low Word
30913	0912	Tank 7, Mass High Word
30914	0913	Tank 7, Mass Low Word
30915	0914	Tank 8, Mass High Word
30916	0915	Tank 8, Mass Low Word

1. All registers can be accessed using either Modbus Function 03 (Read Holding Registers) or Modbus Function 04 (Read Input Registers). However, all registers are read-only in this implementation.

For example:
Registers 30001 and 30002 (using Function 03) can also be read as registers 40001 and 40002 (using Function 04).

2. Level 1 = product level.

3. Pairs of registers identified as 'High Word' and 'Low Word' must be read together and concatenated by the master to form a 32-bit 'long word' quantity.

For example:
Register 30001 (16-bit high word) = 0002H
Register 30002 (16-bit low word) = 3F8CH
Long word (32-bit) = 00023F8CH (decimal 147340)

Or:
Register 30001 (high word) = 2
Register 30002 (low word) = 16268
Multiply register 30001 x 65536 : 2 x 65536 = 131072
Add result to register 30002 : 131072 + 16268 = 147340

4. All registers identified as '(x 100)' or '(x 1000)' have been scaled (multiplied) by a factor of 100 or 1000 before transmission to preserve the fractional portion of the data value. The master must divide these values by the scale factor as necessary.

For example:
Register 30001 (16-bit high word) = 0002H
Register 30002 (16-bit low word) = 3F8CH
Long word (32-bit) = 00023F8CH (decimal 147340)
Divide by 1000, actual value = 147.340

5. Level 2 = interface level.

6. Average submerged temperature (as polled from DDA tank gauge).

7. Individual RTD (Resistive Temperature Device) temperature [as polled by DDA tank gauge(s)]

8. Alarm status bit definitions:

Bit	*Alarm Type*	*Description*
D1	LVLHH	LEVEL HIGH-HIGH
D2	LVLHI	LEVEL HIGH
D3	LVLLO	LEVEL LOW
D4	LVLLL	LEVEL LOW-LOW
D5	INTHI	INTERFACE HIGH
D6	TMPHI	TEMPERATURE HIGH
D7	TMPLO	TEMPERATURE LOW
D8	MASHI	MASS HIGH
D9	MASLO	MASS LOW
D10	MASERR	MASS ERROR
D11	Reserved	
D12	SCERR	SENSOR COMM. ERROR
D13	SOERR	SENSOR OPERATION ERROR
D14	INTLO	INTERFACE LOW
D15	Reserved	
D16	Reserved	

For each corresponding alarm bit:
0 = ALARM OFF
1 = ALARM ON

Reserved bits will always be set to 0 (OFF).

9. Undefined or reserved registers within the register map will return a maximum negative value (8000H, or 80000000H for register pairs). Attempting to read registers outside the register map (30917 or higher) will cause a Modbus Exception Error Code 02 (Illegal Data Value) to be returned.

10. GOVP = Gross Observed Volume Product.

11. GOVI = Gross Observed Volume Interface.

12. GOVT = Gross Observed Volume Total.

13. GOVU = Gross Observed Volume Ullage.

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