INSTALLATION AND OPERATIONS MANUAL

FOR THE

MODEL 1900

MICRO 4-WIRE

TRANSMITTER

Document Number 33-08461

January, 1993

10800 Valley View Street, Cypress, California 90630-5016
Phone (714) 761-1300   FAX (714) 952-2701

Document Number 33-08461

Issued: August 1, 1991

Engineering freeze date: July 1, 1991

Acknowledgments

Dow Corning, is a registered trademark of Dow Corning Inc., Midland, MI.

Loctite, is a registered trademark of Loctite Corp., Newington, CT.

Varec is a registered trademark of Whessoe Varec, Inc.

TankView, is a registered trademark of Whessoe Varec, Inc.

Rosemount, and Smart Family, are registered trademarks of Rosemount Inc.

MODBUS, is a registered trademark of Modicon, Inc.

HART* is a trademark of Rosemount Inc.

All other trademarks are acknowledged.

Disclaimer of Warranties

The contract between the Seller and the Buyer states the entire obligation of the Seller. The contents of this user's manual shall not become part of or modify any prior or existing agreement, commitment or relationship between the Seller and Buyer. There are no express or implied warranties set out in this user's manual. The only warranties that apply are those in the existing contract between the Seller and Buyer.

The Varec Model 1900 Micro 4-Wire Transmitter has not been tested by Whessoe Varec, Inc., under all possible operational conditions, and Whessoe Varec may not have all the data relative to your application. The information in this user's manual is not all inclusive and does not and cannot take into account all unique situations. Consequently, the user should review this product literature in view of his/her application. If you have any further questions, please contact Whessoe Varec for assistance.

Limitations of Seller's Liability

In the event that a court holds that this user's manual created some new warranties, Seller's liability shall be limited to repair or replacement under the standard warranty clause. In no case shall the Seller's liability exceed that stated as Limitations of Remedy in the contract between the Seller and Buyer.

Use of parts that are not manufactured or supplied by Whessoe Varec, Inc., voids any Whessoe Varec warranty and relieves Whessoe Varec of any obligation to service the product under warranty. Whessoe Varec recommends the use of only Whessoe Varec manufactured or supplied parts to maintain or service the Varec Model 1900 Micro 4-Wire Transmitter.

Safety Precautions

READ AND UNDERSTAND THE SAFETY PRECAUTIONS THAT ARE IN THE TEXT PRECEDING THE APPROPRIATE INSTRUCTIONS BEFORE INSTALLING, OPERATING AND PERFORMING MAINTENANCE ON A VAREC MODEL 1900 MICRO 4-WIRE TRANSMITTER. FOLLOW ALL PRECAUTIONS AND WARNINGS NOTED HEREIN WHEN INSTALLING, OPERATING OR PERFORMING MAINTENANCE ON THIS EQUIPMENT.

READ AND UNDERSTAND STATIC AND LIGHTNING ELECTRICAL PROTECTION AND GROUNDING SET FORTH IN API 2003. MAKE CERTAIN THAT THE TANK INSTALLATION, OPERATION, AND MAINTENANCE CONFORMS WITH THE PRACTICE SET FORTH THEREIN.

Safety Precaution Definitions

CAUTION
Damage to equipment may result if this precaution is disregarded.

WARNING

- Direct injury to personnel or damage to equipment which can cause injury to personnel may result if these precautions are not followed.
- Power to the transmitter must be OFF before removing the transmitter cover.
- Before connecting wires to the Model 1900 Micro 4-Wire Transmitter, make certain that the receiver system is not powered.
- Before turning ON the AC power at a receiver, make certain that all Model 1900 Micro 4-Wire Transmitters connected to the receiver system have the covers on and are ready to be powered.
- Do not apply power to the transmitter until all wiring connections have been made and the cover of the transmitter has been replaced.
- Carefully read this instruction manual before installing, operating, and performing maintenance on Varec Model 1900 4-Wire Transmitters.

Table of Contents

List of Illustrations

List of Tables

Section 1 Introduction

USING THIS MANUAL

This manual is designed to assist the user with the installation, operation, maintenance, and troubleshooting of the Varec Model 1900 Micro 4-Wire Transmitter as follows:

Section 1 - Introduction
Contains an overview of this manual and an introduction.

Section 2 - Installation
Contains instructions for unpacking, mounting, wiring, and jumper configuration.

Section 3 - Maintenance and Troubleshooting
Describes maintenance procedures for the Micro 4-Wire Transmitter and the various types of encoders.

Section 4 - Theory of Operation
Describes operation of the Micro 4-Wire Transmitter and the various types of encoders.

Section 5 - Specifications and Reference
Lists specification data including drawings and parts lists.

GETTING ACQUAINTED WITH THE MICRO 4-WIRE TRANSMITTER

The Varec Model 1900 Micro 4-Wire Transmitter is designed to transmit liquid level, temperature, and status data on request from a Varec receiver. The transmitter mounts directly to the Varec 2500 Tank Gauge. Change in liquid level is transferred to an encoder via a rotating radial shaft. The level data, indicated by the radial shaft position, is encoded into a reflected Binary Gray Code (Imperial or Metric) and on demand is transmitted over two conductors to a Varec receiver system.

The transmitter can provide digital temperature data via an on-board temperature converter from a Resistance Temperature Device (RTD). Averaging temperature can be transmitted by using the Varec Model 9909 Averaging Bulb and a Varec "T" feature selection switch.

Operation

The Varec Model 1900 Micro 4-Wire Transmitter is a solid state design using CMOS integrated circuits. The encoder uses either brush or optical code disks to encode the level data. The brush encoder can be reverse as well as forward reading to provide ullage (outage) data in lieu of innage data.

Four conductor wires for power and communications connect Micro 4-Wire Transmitters to the system interface unit or IFU. Each transmitter is assigned a unique ID.

Upon receipt of a 16-bit poll request from the system receiver, the transmitter with a matching ID responds with level, temperature, status, and a parity bit. The message is a 56-bit pulse train in Mark/Space format. The system receiver decodes the Mark/Space message and displays tank data in Imperial or Metric units.

The four conductor wires connecting the transmitter to the system are designated as Mark, Space, B+, and B-. The Mark and Space wires are for signals, while B+ and B- supply power to the transmitter. The four conductor wires are common to all Varec Model 1900 Micro 4-Wire Transmitters in the system.

The Varec Model 1900 Micro 4-Wire Transmitter is enclosed in a cast aluminum explosion-proof housing as shown in Figure 1-1.

Encoder

The encoder disks in the Varec Model 1900 Micro 4-Wire Transmitter are positioned by a shaft coupling to the gauge mechanism. Whenever the gauge is affected by a liquid level change, the encoded information changes accordingly.

When the transmitter is polled by the system, the current liquid level information is transmitted as a digital signal.

Optical Encoder

With an optical encoder, a change in liquid level changes the relative positions of two black metal code disks. Each code disk has a cutout code pattern that allows light to pass through. There is an array of Light Emitting Diodes (LEDs) on one side of the disks and an array of photo-transistors on the other.

Any change in the relative position of the two disks energizes different sets of photo-transistors in the array. This results in a different electrical signal output.

When the transmitter is polled by the system, this information is sent to the system receiver as Mark and Space pulses.

Brush Encoder

With a brush encoder, a change in liquid level changes the relative positions of two code disks. Each code disk consists of a conducting metallic laminate on a non-conducting substrate.

As the disks rotate in their own plane, they change position relative to each other. This change is sensed by brushes contacting the conductive or non-conductive parts of the code pattern on the encoder disks and is output as an electrical signal.

When the transmitter is polled by the system, this information is sent to the system receiver as Mark and Space pulses.

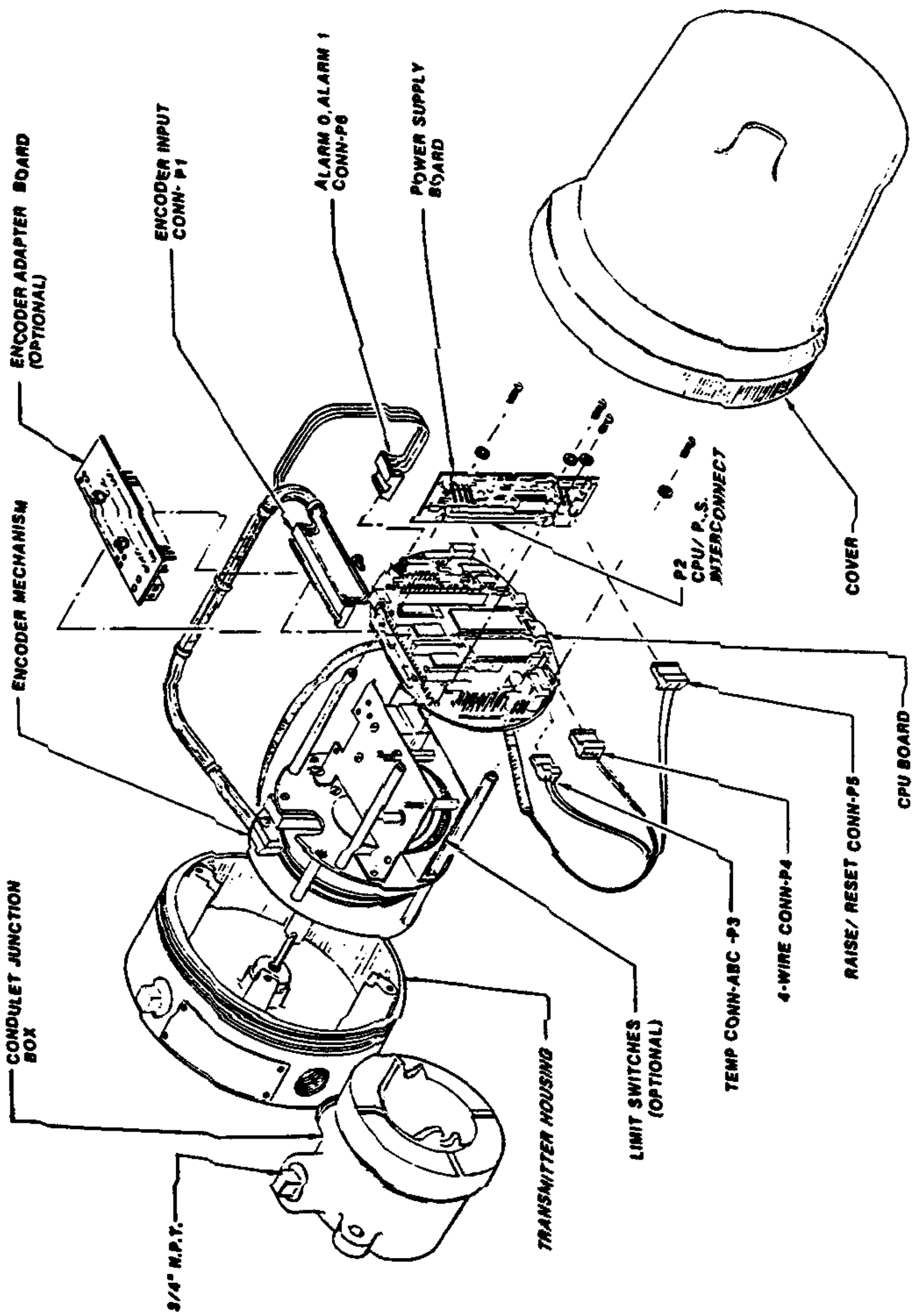


Figure 1-1 1900 Micro 4-Wire Transmitter

This page left blank

Section 2 Installation

OVERVIEW

This section contains instructions for unpacking, mounting, field wiring, jumper configuration, and adjusting the Varec Model 1900 Micro 4-Wire Transmitter. An installation checklist is also included.

WARNING
To avoid electric shock and possible injury, do not perform any service procedures other than those specified in this manual. These installation instructions are for use by qualified service technicians.

UNPACKING

Place the shipping container on a secure bench before unpacking. Open the shipping container, taking care not to damage the contents. Carefully remove the transmitter from the shipping container and set it on the bench top.

Inspect the transmitter for evidence of shipping or handling damage. Report any shipping damage to the carrier. Verify that the contents of the shipping container agrees with the packing list.

Varec Model 1900 Micro 4-Wire Transmitters are shipped fully assembled and ready for installation.

STORAGE PRIOR TO INSTALLATION

If the transmitter is to be stored prior to installation, it should be repacked in its shipping container and stored in a *temperature and humidity controlled environment.*

MOUNTING THE EQUIPMENT

The Varec Model 1900 Micro 4-Wire Transmitter can be installed either on a mounted gaugehead or retrofit with an existing transmitter installation.

CAUTION
Varec does not include coverage against corrosion due to condensation in its warranty. When mounted to a standard Varec Model 2500 Automatic Tank Gauge, the encoder/transmitter assembly must be protected from condensation. The brush encoder/transmitter housing may be filled with Union Carbide HL-45-2CS or equivalent transformer oil to provide this protection. *Do not fill the optical encoder/transmitter housing with oil under any circumstances!* Other methods, such as using desiccants, may be used to provide protection against corrosion due to condensation. In all cases, preventive maintenance must be performed at regular intervals to provide effective protection against corrosion.

Mounting to a Gaugehead

The following procedure is for mounting the transmitter to a Varec Model 2500 Automatic Tank Gauge. The installation of the level gauge must have been completed prior to mounting the transmitter. Refer to Figure 2-1 and proceed as follows:

1. Remove the back cover of the level gauge.

2. Remove the access cap from the back cover of the level gauge.

3. Mount the transmitter in place of the access cap, making certain that the word "Top" cast into the transmitter housing lines up with the top of the level gauge back cover.

4. Install the level gauge back cover with the transmitter in the level gauge. Make certain that the slot in the transmitter drive coupling engages with the pin on the top sheave of the level gauge.

5. Proceed to Field Wiring.

Mounting to an Existing Transmitter Housing

The following procedure is for mounting the transmitter to an existing transmitter housing. Proceed as follows:.

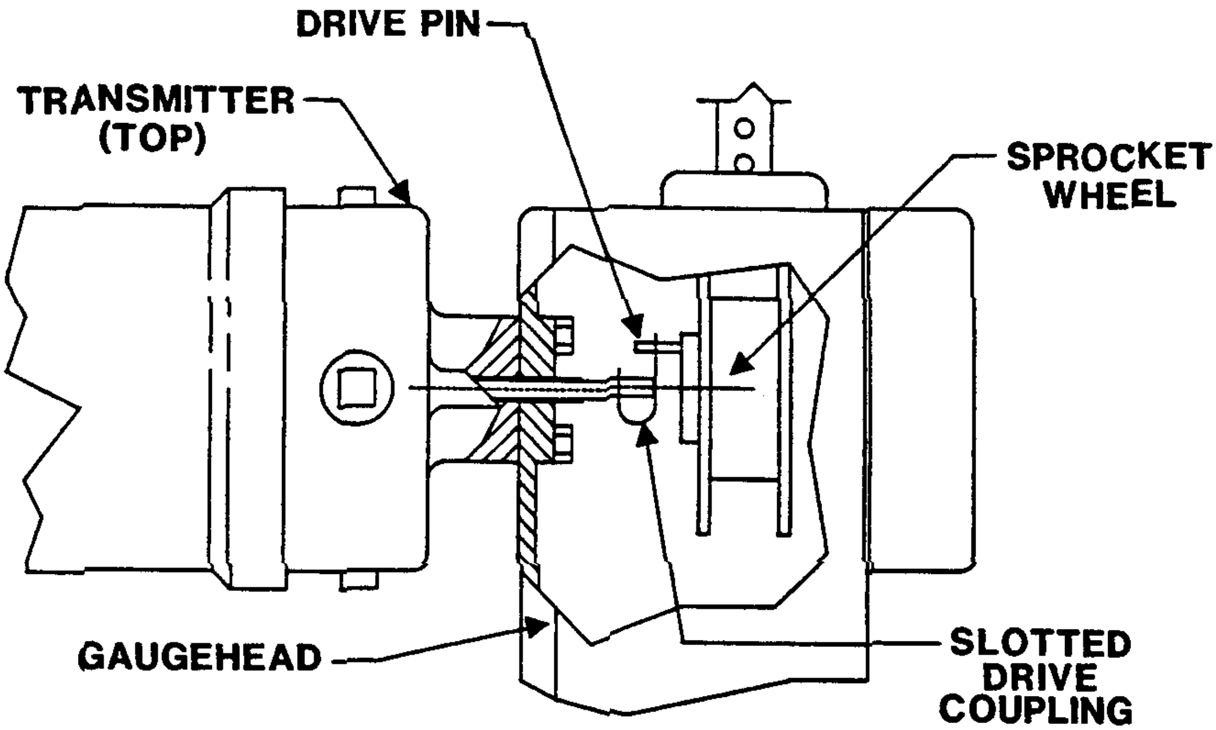


Figure 2-1 Transmitter Mounting

1. Install the entire encoder/transmitter assembly in the existing housing with the screws and hold-down brackets provided.
2. Fasten the encoder base to the transmitter base assembly at four places.
3. With the encoder attached to the base, connect the linkage between the encoder and the base.
4. Tighten the socket-head screws with an Allen wrench.
5. Proceed to Field Wiring.

Mounting to a See-Through Optical Encoder

The following procedure is for mounting the transmitter to a see-through optical encoder. Refer to Figure 2-and proceed as follows:

1. Using four machine screws, attach the CPU transmitter boards to the encoder.
2. Connect P1 on the adapter to J1 on the CPU board.
3. For an English reading standard encoder, connect the encoder plug P1 to J1 on the adapter board.
4. For a Metric reading over-20-meter encoder, connect P1 to J1 on the adapter board.

NOTE
To retrofit an over-20-meter encoder, the encoder must be rewired to 17-bit format, and the microswitch must be wired to TB1 pins 1 and 2.

5. Proceed to Field Wiring.

FIELD WIRING

Connect the transmitter field wiring according to the diagram shown in Figure 2-.3.

Lead Resistance

The maximum line resistance depends on transmitter grouping and the field wiring layout. Field wiring between the control room and the transmitters is critical and has significant impact on the reliability of the entire system.

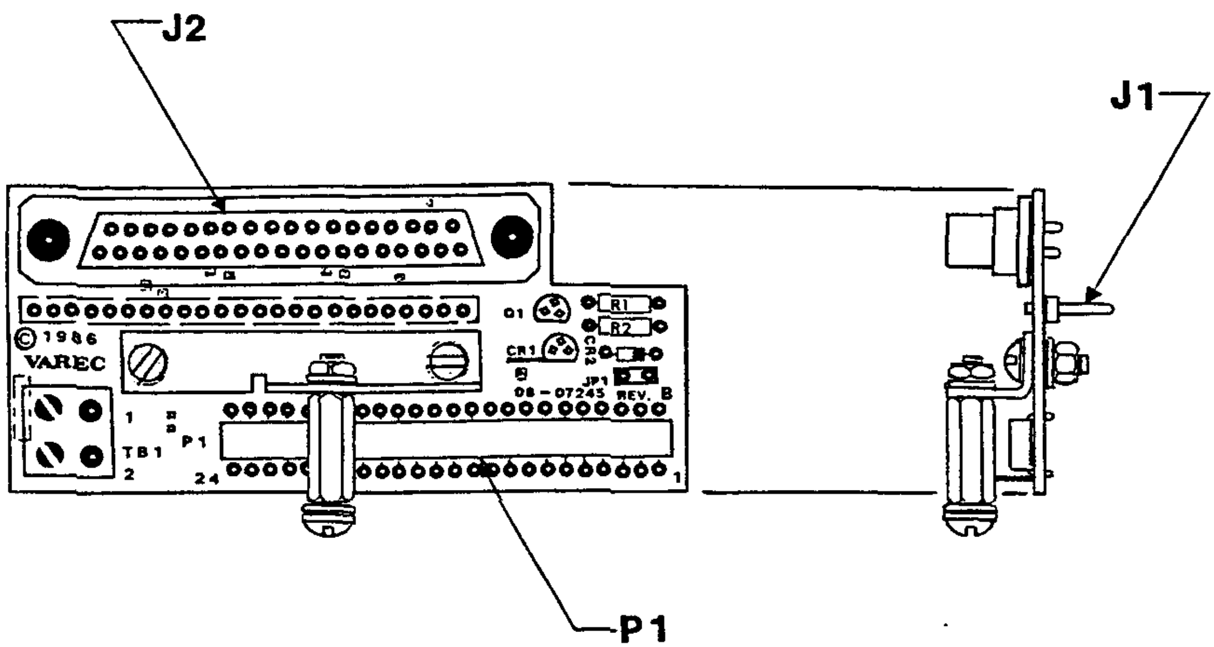


Figure 2-2 Optical Encoder Adapter Board

Grouping transmitters into "areas" of 30 transmitters or less, and independently wiring their common bus back to the receiver, will make bus related failure problems (lightning strikes, wiring faults, or damaged transmitters) easier to isolate and have less impact on the entire system.

Transmitter grouping is readily implemented, as Varec receiving equipment provides an independent wiring connection for groups of 30 transmitters or less.

The maximum voltage drop limits will be met by limiting:

- the number of transmitters in each "area" to 30 or less,
- the maximum wiring distance to 10,000 feet or less,
- and the maximum resistance on each of the four lines (B+, B-, Mark, and Space) to 50 ohms or less.

When existing or proposed wiring cannot meet these limits, the Varec System Engineering department should be consulted for a specific evaluation.

Transmitter Wiring Terminations

When making wiring terminations at the transmitter, the four-pin, three-pin, and two-pin connectors must be first disconnected from the transmitter boards. Reconnect the connectors after the terminations have been completed.

JUMPER CONFIGURATION

Before placing the transmitter in service, the ID jumpers and the function jumpers must be correctly set.

Setting the ID Jumpers

The ID jumpers are located on the CPU board at W1. The jumper is ON when it is installed on the row of pins next to the numbers indicating the position. Refer to Figure 2-4.

Each transmitter is assigned a decimal number ID. This number is converted to Binary Coded Decimal (BCD) notation. That is, each decimal digit is represented by a combination of four binary digits (bits). The four binary digit equivalents of the first nine decimal numbers are as follows:

Decimal	Binary
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

For example, an ID of 136 becomes 0001 0011 0110 in BCD notation. If the BCD notation is rotated 90 degrees counterclockwise, it then represents the settings for ID 136 at jumper W1 as follows:.

BCD	W1	Setting
0	1	Off
1	2	On
1	4	On
0	8	Off
1	10	On
1	20	On
0	40	Off
0	80	Off
1	100	On
0	200	Off
0	400	Off
0	800	Off

Similarly, an ID of 365 becomes 0011 0110 0101 in BCD notation. The jumper settings at jumper W1 should be set as follows:

BCD	W1	Setting
1	1	On
0	2	Off
1	4	On
0	8	Off
0	10	Off
1	20	On
1	40	On
0	80	Off
1	100	On
1	200	On
0	400	Off
0	800	Off

Setting the Function Jumpers

The function jumpers are located on the CPU board at W2. The jumper is ON when it is installed on the row of pins next to the numbers indicating the position. Refer to Figure 2-4.

The appropriate jumper settings for the type of communication used are listed in Tables 2-1 and 2-2.

Table 2-1 Jumper Positions Functions on W2

Jumper	Off	On
0	Always Off	-
1	Always On	-
2	Level Only	Level and Temp
3	Copper RTD	Platinum RTD
4	High Speed	Low Speed
5	(see Table 2-2)	(see Table 2-2)
6	English Encoder	Metric Encoder
7	Normal Operation	Test Mode (A/D converter on continuously

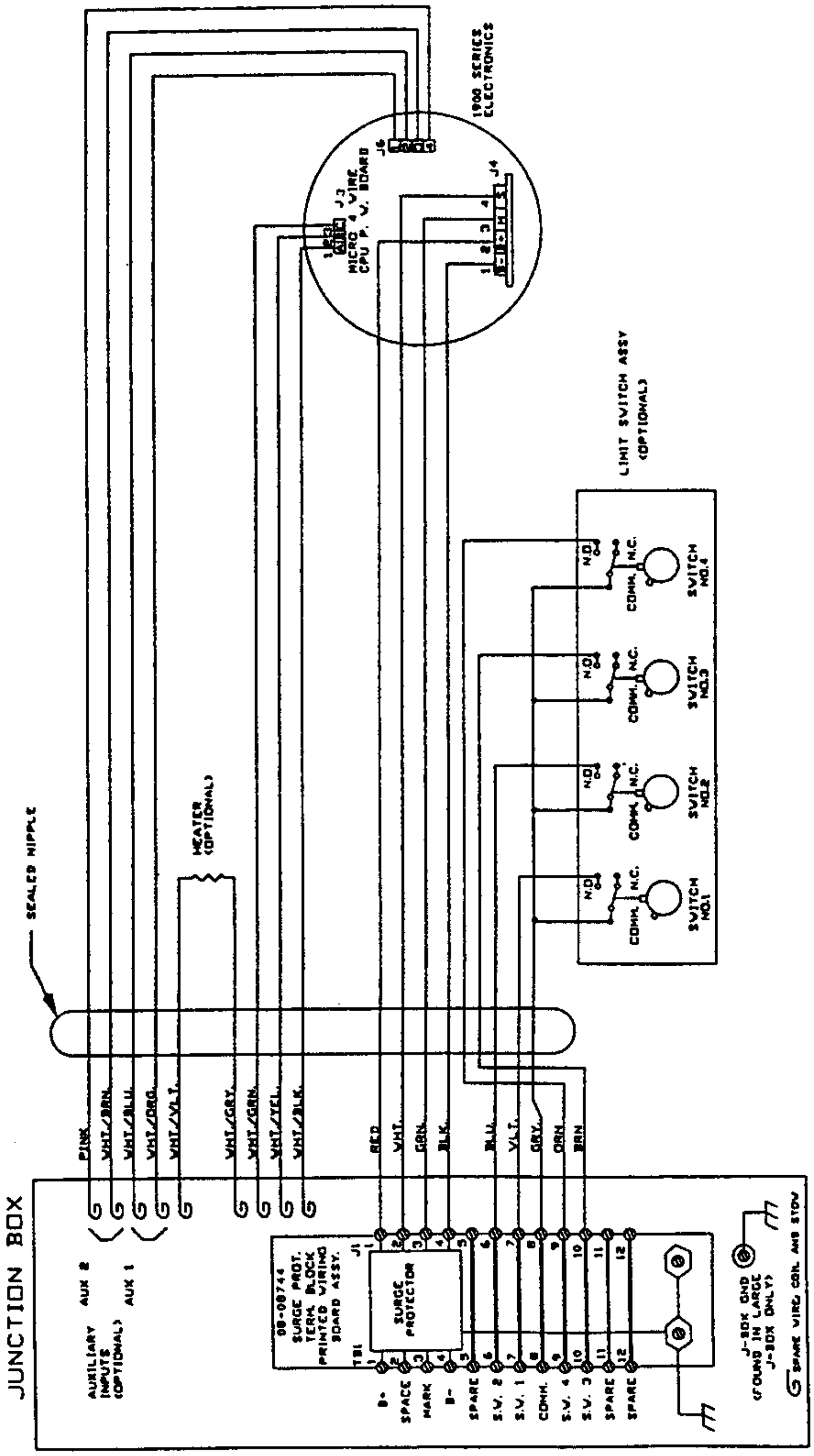


Figure 2-3 Transmitter Field Wiring

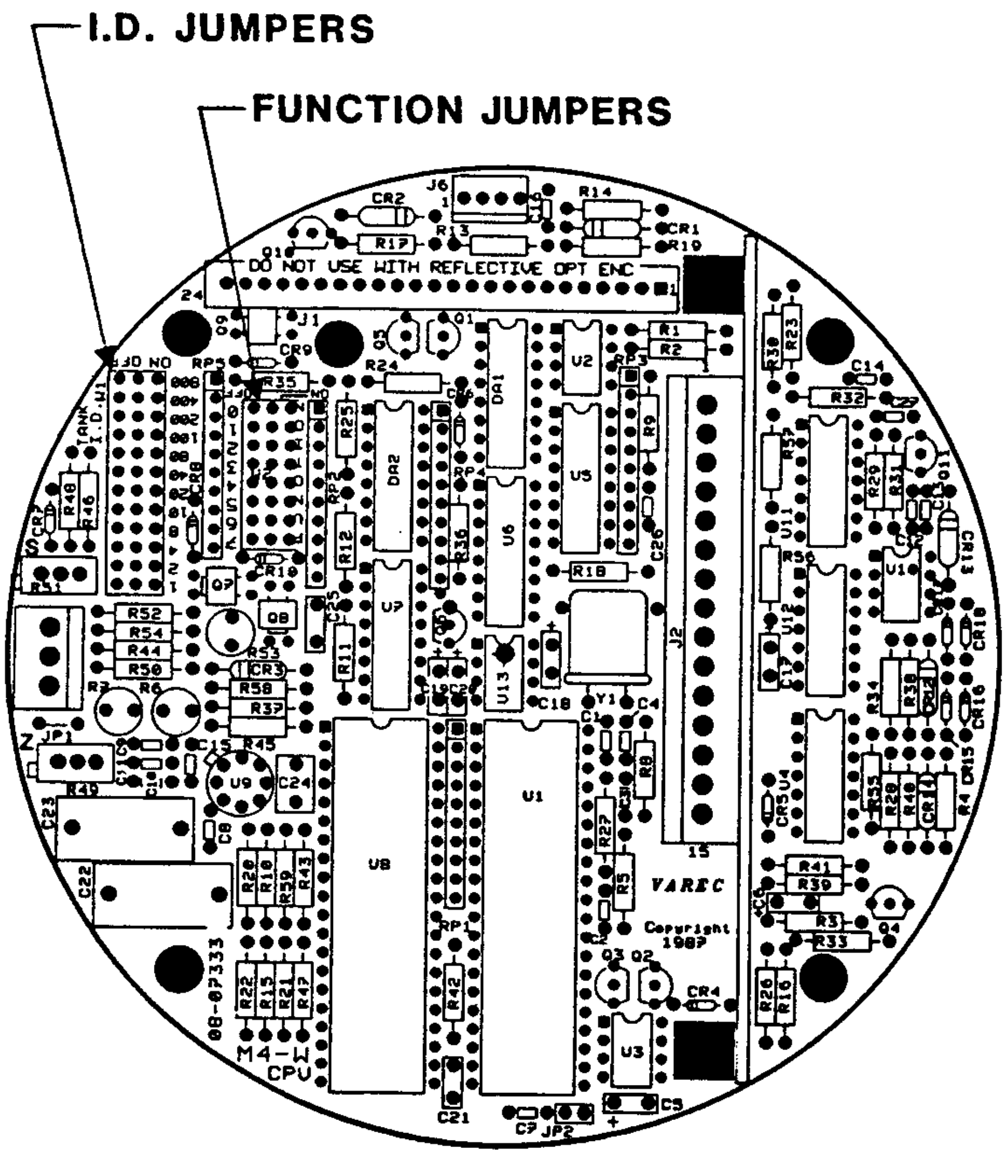


Figure 2-4 Jumper Locations

Table 2-2 Jumper 5 Position Function on W2

Jumper 5	Jumper 6	Function
Off	Off	Temp in °C
On	Off	Temp in °F
Off	On	Gauge system interprets first 18-bits of level message
On	On	Gauge system interprets first 17-bits of level message

To adjust the transmitter after installation or maintenance to the same reading as the gaugehead, proceed as

WARNING
To avoid electric shock and possible injury, power to the transmitter must be OFF before removing the transmitter cover.

1. Remove the cover of the transmitter.
2. Loosen the coupling on the transmitter input shaft. On the Metric model, loosen the set screw on the input gear of the adapter assembly.
3. Gently turn the code disk nearest the coupling until the geared code disk and dial readings match the gaugehead reading.
4. Tighten the coupling on the input shaft. On the Metric model, tighten the set screw on the input gear of the adapter assembly.

WARNING
Do not apply power to the transmitter until all connections have been made and the cover of the transmitter has been replaced.

5. Replace the cover and tighten.

SETTING OPTIONAL LIMIT SWITCHES

All limit switches are wired Normally Open (NO) at the factory. If Normally Closed (NC) contacts are required, it will be necessary to change the wiring at the limit.

To set the optional limit switches, proceed as follows:

WARNING
To avoid electric shock and possible injury, power to the transmitter must be OFF before removing the transmitter cover.

1. Remove the cover of the transmitter
2. Loosen the coupling on the transmitter input shaft. On the Metric model, loosen the set screw on the input gear of the adapter assembly.
3. Turn the code disk nearest the coupling until the geared code disk and dial indicate the required setting for the first limit switch.
4. Loosen the switch cam for the switch being set and turn the cam until the switch actuates.
5. Tighten the switch cam.
6. Gently turn the code disk back and forth to verify the switch operation. Repeat steps 3 and 4 to obtain the exact switching point.
7. Repeat steps 3 through 6 for each of the other limit switches.
8. Gently turn the code disk nearest the coupling until the geared code disk and dial readings match the gaugehead reading.
9. Tighten the coupling on the input shaft. On the Metric model, tighten the set screw on the input gear of the adapter assembly.

WARNING
Do not apply power to the transmitter until all connections have been made and the cover of the transmitter has been replaced.

10. Replace the cover and tighten.

CAUTION

Varec does not include coverage against corrosion due to condensation in its warranty. When mounted to a standard Varec Model 2500 Automatic Tank Gauge, the encoder/transmitter assembly must be protected from condensation. The brush encoder/transmitter housing may be filled with Union Carbide HL-45-2CS or equivalent transformer oil to provide this protection. _Do not fill the optical encoder/transmitter housing with oil under any circumstances!_ Other methods, such as using desiccants, may be used to provide protection against corrosion due to condensation. In all cases, preventive maintenance must be performed at regular intervals to provide effective protection against corrosion.

POWER UP AND INITIAL CHECKOUT

After a thorough check that all connections are correctly made, and that all covers and plugs are installed, turn on power to the unit. Note that tank data is received and displayed correctly. If more than one transmitter is connected to the receiver, it is advisable to bring each transmitter on-line individually.

Section 3 Maintenance and Troubleshooting

MAINTENANCE

Maintenance of the Model 1900 Micro 4-Wire Transmitter consists of routine, regular inspection, whenever the gaugehead is inspected, under normal operating conditions.

The alignment and calibration procedures described in this section provide the information necessary to correct most problems encountered in the field.

WARNING
The maintenance procedures described below are to be performed on the bench. These procedures should not be attempted while the Transmitter is mounted to the gaugehead.

Brush Removal and Replacement Brush Encoder

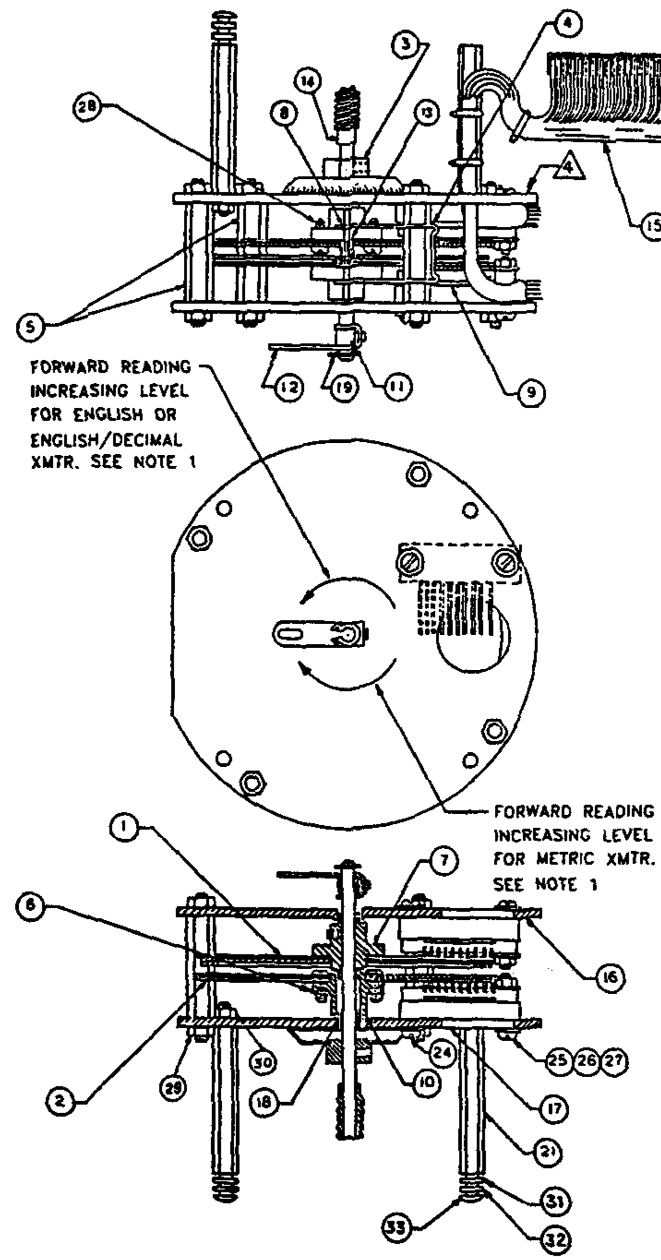
To replace the brush encoder brush, refer to Figure 3-1 and perform the following procedure.

1. Remove the transmitter assembly from the housing by loosening the four clamps which secure the front plate (16) to the bosses on the housing.
2. Disconnect and remove the printed circuit boards from the encoder sub-assembly.
3. If necessary, clean the encoder sub-assembly using isopropyl alcohol.
4. Inspect the Geneva gear (13), the second code disk (2), and the first code disk (1) for worn or broken teeth.
5. Remove the self-tapping screws (24), nuts (27), and screws (25) that hold the brush assembly to the front and back plates.
6. Remove the brush assembly and brush block spacer from the encoder sub-assembly.
7. Place the new brush block with the solid color wires onto the brush block spacer.
8. Hold the assembly in one hand and using a small metal ruler, press the fingers on the brush into the plastic finger guides. Then insert the brush block and spacer into the encoder. This brush mounts on the back plate of the encoder.
9. Remove the metal ruler. The fingers will spring back and make contact with the code disk. The pressure exerted by the fingers will hold the assembly in place while the screws are inserted.
10. Fit the screw, washer, and nut and screw. While tightening, ensure alignment of the finger contact point with the scribed mark on the back plate.
11. Repeat steps 7 through 11 to mount the brush block with striped wires on the front plate of the encoder (16).
12. Refit and reconnect the printed circuit board the encoder assembly and carry out the Brush Alignment Procedure.

Brush Alignment Procedure

To align the brush unit, perform the following steps.

1. Connect the transmitter to the receiver.
2. Rotate the input shaft to align "0" of the second code disk and "0" of the dial with the scribed mark on the back plate.
3. Align the fingers of the solid color wired brush assembly with the scribed line on the back chassis.
4. Align the fingers of the striped color wired brush assembly with the scribed line on the front chassis.
5. If the receiver does not read 00 00 00 (0.000 meters), loosen the screws holding the striped color wired brush assembly on the first code disk and lightly tap into position to obtain a 0 reading. Once a 0 reading is obtained, retighten the screws.
6. Slowly turn the input shaft in a counterclockwise direction and note that the reading increases. Should any number not appear between 0 and 1 ft. (between 0.000 and 0.300 meters) then the fingers are not aligned. Repeat the adjustment in step 5 and then repeat this step.
7. Continue to turn the input shaft. Should any number between 1 ft. to 70 ft. (0.300 and 10.000 meters) not appear, then the solid color wired brush assembly should be adjusted as described in step 5.
8. At the changeover points where the first code advances, the second code disk reading should be noted before and after to ensure that no number is lost at the changeover. If any number is lost, repeat steps 6 or 7.



TABLE

ASSEMBLY	TYPE	ITEM ① 1ST DISC	ITEM ② 2ND DISC	ITEM ③ DIAL	ITEM ⑮ HARNESS ASSY.
C 5762-1 (BME 10265-1)	ENGLISH FORWARD	D 5414-1	D 5415-1	B 12213-1	BME 11147
C 5762-2 (BME 10265-2)	ENGLISH REVERSE	D 5414-1	D 5415-1	B 12213-2	BME 11253
C 5762-3 (BME 10265-3)	METRIC FORWARD	D 5414-2	D 5415-2	B 12213-3	BME 11686
C 5762-4 (BME 10265-4)	METRIC REVERSE	D 5414-2	D 5415-3	B 12213-4	BME 11686
C 5762-5 (BME 10265-5)	DECIMAL FT. FORWARD	D 5414-3	D 5415-1	B 12213-5	BME 11147
C 5762-6 (BME 10265-6)	DECIMAL FT. REVERSE	D 5414-3	D 5415-1	B 12213-6	BME 11253
C 5762-7 (BME 10265-22)	ENGLISH FORWARD 9351P	D 5414-5	D 5415-4	B 12213-1	BME 11147
C 5762-8 (BME 10265-23) △5	FRACTIONAL FORWARD	D 5414-1	D 5415-1	B 12213-1	BME 11147

ITEM	PART NUMBER	DESCRIPTION	QTY.
1	SEE TABLE	1ST CODE DISC	1
2	SEE TABLE	2ND CODE DISC	1
3	SEE TABLE	DIAL	1
4	B 12121	POST AND BRACKET ASSEMBLY	1
5	B 12122	POST	3
6	B 12123 △5	HUB	1
7	B 12124 △5	HUB	1
8	B 12126	SHAFT	1
9	B 12127	SPACER	2
10	B 12128	SHIM WASHER NOTE 2	4
11	B 12129	BUSHING	1
12	B 12137	DRIVE COUPLING	1
13	B 122158-2	GENEVA GEAR	1
14	05-03314	SHAFT AND GEAR ASSEMBLY	1
15	SEE TABLE	HARNESS ASSEMBLY	1
16	D 5274	CHASSIS, FRONT	1
17	D 5275	CHASSIS, BACK	1
18	P2-13	BEARING	4
19	P10-37	3/16 GRIP RING	1
21	B 12253	POST	4
24	P31-1511	PHSMS #8 X 1/2	2
25	P31-1510	BHMS 5-40 X 3/4	2
26	P31-909	STD WASHER #5	2
27	P31-984	HEX NUT 5-40	2
28	P31-809	PHMS 4-40 X 3/8	4
29	P31-943	KEPNUT 8-32	8
30	P31-942	KEPNUT 6-32	4
31	P102-25-005	FIBER WASHER	4
32	P31-1424 △5	#6 WASHER	4
33	P31-704	PHMS 6-32 X 1/4	4

Notes: Unless Otherwise Specified

1. **When Driven by Varec Model 2500 Automatic Tank Gauge**
2. **Item 11, 12, and 19 are not used with Metric encoder.**

Figure 3-1 Brush Encoder Assembly

OPTICAL ENCODER ALIGNMENT AND CALIBRATION

Optical encoders are calibrated at the factory and do not require calibration in the field.

Brush Encoder Calibration

Code Disk Phasing

Phasing means the angular relationship between the code patterns on the two disks (at the point then the second disk is advanced) and the relationship of the code disk sensors.

Encoders are phased at the factory and under normal service should not require phasing in the field.

Should phasing be required, it can be accomplished in the following manner.

1. If the Geneva gear has been disengaged from the code disk, loosen the post bracket assembly.
2. Set the second code disk on 40 feet (10 meters) in reference to the scribe mark on the back plate and the number 40 (10 for metric) on the second code disk.
3. Using the dial, set the first code disk on"1", in reference to the scribe mark.
4. Engage the Geneva gear with the lock disk gear and the second code disk gear. Note: The transmitter must be set to 40 feet and 1 inch (10.01 meters). Secure the post bracket assembly by tightening the two screws. This operation aligns the code patterns between the two code disks.
5. Rotate the input shaft and check for smooth operation. If the unit binds or is hard to turn, loosen the post bracket assembly and reset, allowing a little more play between the first and second code disks. The play can be checked at any point except for the changeover point.
6. Check for excessive play. The second code disk should move no more than one quarter tooth with respect to a fixed reference.
7. Rotate the input shaft slowly between 39 11 15 (39 ft 11 15/16 in) and 40 00 00. (Between 19.999 meters and 20.000 meters for metric transmitters.) Observe the second track from the bottom. Check to see that the code disk as related to the brush moves an equal distance on either side of the conducting and non-conducting pattern.
8. Rotate the input shaft to each side of the changeover point. Check each side to see that the second finger does not move from the conducting to the non-conducting pattern when the second code disk is moved with your finger.
9. Reassemble the transmitter. Connect the transmitter to a receiver and check the changeover point every 10 feet (3 meters) from 0 to 70 feet (0 to 10 meters).

Copper RTD Temperature Calibration

To calibrate the 1900 for a copper resistive temperature device (RTD) perform the following (refer to Table ~~3-1~~)

1. Set the function jumpers on the CPU board as follows:

Jumper 0	NO CHANGE
Jumper 1	ON
Jumper 2	ON
Jumper 3	OFF
Jumper 4	NO CHANGE
Jumper 5	OFF if Jumper 6 is OFF[1] OFF or ON if Jumper 6 is ON
Jumper 6	NO CHANGE
Jumper 7	ON

[1] *Copper RTDs are always calibrated in Centigrade*

2. Disconnect P3 from J3
3. On J3 connect a Decade Resistance Device to A and B, then jumper B to C.
4. Set the Decade Resistance to 119.38 Ohms.
5. Check the receiver for a temperature reading of 75.0 ^{o}C and adjust VR1 as necessary to obtain this temperature reading within ±0.25 ^{o}C.
6. Set the Decade Resistance to 163.97 Ohms.
7. Check the receiver for a temperature reading of 190.0 ^{o}C and adjust VR2 as necessary to obtain this temperature reading within ±0.25 ^{o}C.
8. Set the Decade Resistance to 55.4 Ohms.
9. Check the receiver for a temperature reading of -90 ^{o}C ±0.25 ^{o}C.
10. If the above calibration measurements are successful, calibration is complete. Disconnect the Decade Resistance Device, reconnect P3 to J3, restore the function jumpers to their original locations, fit the cover, and return the unit to service.
11. If the above calibration measurements are not successful or the calibration accuracy of ±0.25 ^{o}C cannot be obtained, the unit should be returned to Varec for repair.

Platinum RTD Temperature Calibration

To calibrate the 1900 for a platinum resistive temperature device (RTD) perform the following (refer to Table 3-1)

1. Set the function jumpers on the CPU board as follows:

Jumper 0	NO CHANGE
Jumper 1	ON
Jumper 2	ON
Jumper 3	ON
Jumper 4	NO CHANGE
Jumper 5	OFF if Jumper 6 is OFF OFF or ON if Jumper 6 is ON
Jumper 6	NO CHANGE
Jumper 7	ON

2. Disconnect P3 from J3.
3 On J3 connect a Decade Resistance Device to A and B, then jumper B to C.
4. Set the Decade Resistance to 119.38 Ohms.
5. Check the receiver for a temperature reading of +50.0 °C and adjust VR1 as necessary to obtain this temperature reading within ±0.25 °C.
6. Set the Decade Resistance to 175.43 Ohms.
7. Check the receiver for a temperature reading of 198.9 °C and adjust VR2 as necessary to obtain this temperature reading within ±0.25 °C.
8. Set the Decade Resistance to 84.21 Ohms.
9. Check the receiver for a temperature reading of -40.0 °C ±0.25 °C.
10. If the above calibration measurements are successful, calibration is complete. Disconnect the Decade Resistance Device, reconnect P3 to J3, restore the function jumpers to their original locations, fit the cover, and return the unit to service.
11. If the above calibration measurements are not successful or the calibration accuracy of ±0.25 °C cannot be obtained, the unit should be returned to Varec for repair.

Table 3-1 Temperature Calibration Data

Temperature Sensor	Precision Resistor (Ohms)	Action	Reading
Copper RTD	119.38 163.97 55.4	Adjust VR1 Adjust VR2 Check for	75.0°C +190.0°C -90.0°C
Platinum DIN RTD	138.5 175.43 84.21	Adjust VR2 Adjust VR2 Check for	+50.0°C +198.9°C -40.0°C

TROUBLESHOOTING

Malfunctions of the transmitter fall into two classes, communications failures and improper measurement failures. A dual trace storage oscilloscope should be used to observe transmitted pulses on the Mark and Space lines. Storage capability is required to permit observation of the code structure. (A transmitter analyzer is also a very useful piece of troubleshooting equipment.) Proper code structure and message length may be verified by referring to the appropriate coding table provided in Section 4, *Operation.*

Communication Failures

Communication failures can be caused by the following conditions:

a. Defective field wiring
b. Incorrect transmitter ID setting
c. Incorrect transmitter function setting
d. Improper voltage at the transmitter
e. Defective component in the transmitter

If the fault is common to more than one transmitter, a check of the field wiring and tank data acquisition system circuits should be performed to determine if the selection signal is being transmitted. If the fault is local to one transmitter, it should be replaced if a check of field wiring and voltage levels does not correct the fault.

Improper Measurement Failures

An erratic measurement may be caused by defective field wiring or by a faulty transmitter. Other reporting points should be interrogated to determine if the fault is localized to one transmitter or common to more than one transmitter.

An incorrect data indication may be caused by slippage of the coupling, improper code disk phasing, malfunction of the optical array, or misalignment of the code contact brushes. Refer to the Section 2, *Installation* for the code disk alignment procedures.

Table 3-2 Spare Parts

Description	Part Number
Metric Optical Encoder w/o Adapter Plate	06-08643
Metric Optical Encoder with Adapter Plate	06-06577D-1
M4W Board Set	06-07335
Fractional Optical Encoder	06-07302
Power Supply Module	08-06001
Encoder Adapter 18-bit	08-07245
CPU Board	08-07333
Encoder Adapter - Optical	08-07576
Fractional Brush Encoder (F)	BME10265Ä1
Fractional Brush Encoder (R)	BME10265-2
Metric Brush Encoder (F)	06-08829-3
Metric Brush Encoder (R)	06-08829-4

Section 4 Theory of Operation

OVERVIEW

This section contain operational descriptions of the Varec Model 1900 Micro 4-Wire Transmitter hardware and Mark/Space communications. Descriptions of both brush and optical encoders is included as well as a complete description of the Mark/Space communications protocol and Model 1900 specific message protocol.

TRANSMITTER HARDWARE

The Varec Model 1900 Transmitter consists of the following major components.

- Housing and Cover
- Encoder
- Electronics
- Limit Switches (optional)

The housing is explosion proof and designed to mount directly to a Varec Model 2500 or equivalent Tank Gauge.

Encoder

The Model 1900 Transmitter can be equipped with one of two types of encoders: optical digital or brush digital. Both types of encoders function similarly in that they are driven by a shaft coupling in the gauge float. Whenever the shaft rotates, the encoders encode information in conformance with a liquid level increase or decrease. The remote liquid level indications are driven by a digital signal.

Encoders are available in two read-out formats, English and metric. The English encoders provide level information in the FT-IN-16th format (12 06 05 represents 12 ft. 6 and 5/16 in.). The metric encoders provide level information in meters with a resolution of 1mm.

Reverse reading encoders are available with disks that rotate in the opposite direction of forward reading encoders. For identification purposes, a red calibration dial is used on forward reading encoders and a blue calibration dial is used on reverse reading encoders.

Optical encoder

The optical encoder consists of the following components.

- Two black metal disks, each with a cut-out forming a code pattern
- Gears to rotate the metal disks
- Arrays consisting of LEDs on one side of the disks and photo-transistors on the other side to sense the code disk position.

The entire optical encoder assembly is protected by a metal cover. The cover keeps ambient light from reaching the optical encoder and prevents interference with photo-transistor reading. The transmitter board is fastened to the outside of the cover. If the encoder assembly has to be replaced, replace the entire assembly. Do not open the cover or attempt other disassembly of the encoder.

The liquid level information is transferred through a shaft drive via a slotted coupling in the float gauge. The shaft rotates two optical code disks sandwiched between the optical arrays. The liquid level information from the gauge float is converted to an electrical signal by means of the relative position of the two optical code disks and the optical arrays.

As the code disks rotate, the solid, black part of the disk blocks the LED source and turns off the corresponding photo-transistor. The cut-out or transparent part of the disk permits the LED light source to illuminate the corresponding photo-transistor and turn it on. The off/on pattern of the photo-transistors is read by the transmitter board and converted into the liquid measurement reading. This information is read by the CPU board that produces the Mark and Space pulses sent to the tank data acquisition system.

Brush Encoder

The brush encoder consists of the following components.

- Two encoder disks
- Gears to rotate the disks
- Brush arrays touching the disks to sense their position

The two brush encoder disks are non-conductive material disks with a conductive metal lamination. The conductive lamination is arranged in a etched-out code pattern on one side of each disk. The positions of the disks are converted into electrical signals through the use of brush arrays. The brush arrays touch the surface of the encoder disks and use the conductive and non-conductive pattern on the surface to identify the disk position.

The liquid level information is transferred through a shaft drive via a slotted coupling in the float gauge. The shaft rotates each of the two code disks and changes the relative positions of the disks to each other. A change in liquid level changes the relative positions of the code disks and the conductive or non-conductive parts of the code pattern contacted by the brushes. This results in a change in the electrical signal read by the CPU board which sends the information as Mark and Space pulses to the central receiver.

CPU Board

The CPU board contains a microprocessor which manages all measurements and communications for the Model 1900 Transmitter. The CPU converts the readings from the optical or brush encoder into the proper format for transfer over the 4-Wire field interface. Various jumpers are provided on the CPU board to indicate to the CPU its operating mode.

Power Supply Board

The power supply board provides the interface circuits between the microprocessor and the 4-Wire field interface as well as the Raise/Reset interface to the Varec Model 6500 Servo Gauge.

The power supply board converts power obtained from the +B/-B connections of the field interface into both +48 volts and +5 volts required for operation of the Model 1900 Transmitter electronics.

COMMUNICATIONS

Communications between the Model 1900 Transmitter and a receiver is provided by a field interface. The field interface consists of 4-Wires identified as B+, B-, Mark and Space.

When the transmitter ID code is received from the receiver, the circuits of the transmitter are activated. The Model 1900 transmits its ID code back to the host followed by level data or level and temperature data (if so configured).

Mark/Space Coding

All communications between the receiver and Model 1900 Transmitter are accomplished over a common pair of Mark/Space pulse code lines. A pulse is sensed as a low (line drops from +48 VDC to approximately 0 VDC) to indicate the presence of either a Mark or Space.

If the Mark line is pulsed low, it is designated a Mark and considered a logic "1". If the Space line is pulsed low, it is designated a Space and considered a logic "0". If both the Mark and Space lines are simultaneously low it is an error or fault condition.

Two basic data rates are supported over the Mark/Space interface; low speed and high speed. The poll and response data bit timing is illustrated in Figure 4-1.

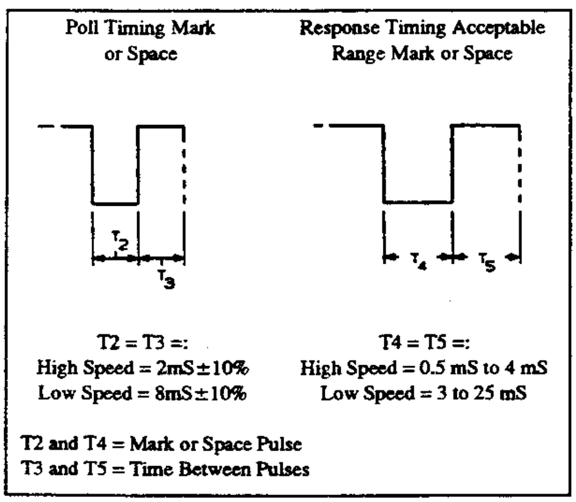
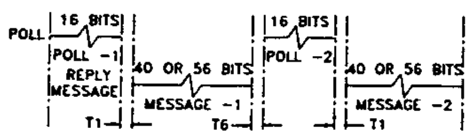


Figure 4-1 Mark/Space Bit Timing

The poll/response timing requirements for a Mark/Space interface are indicated in Figure 4-2.



Poll = 16 Bits of ID
MSG = 40 or 56 Bits of data
T1 = tbd High Speed, tbd Low Speed
T6 = tbd High Speed, tbd Low Speed

Figure 4-2 Poll/Response Timing

Message Structure

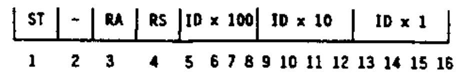
The data transfer between the Model 1900 transmitter and a receiver are accomplished over the common pair of Mark/Space data lines. The message protocol used is an interrogate/response protocol. The receiver places a 16-bit interrogation messages on the data lines containing the ID of the device from which a response is desired. If the ID in the interrogation matches the ID of the transmitter, it responds with a 40 or 56-bit response message

Interrogation (Poll) Message

The interrogation message is a 16-bit message consisting of the following bits (see Figure 4-3).

Bit(s)	Interpretation
1	start bit (Mark)
2	unused
3	Raise Command (for 6500 Servo Gauge)
4	Reset Command (for 6500 Servo Gauge)
5-8	Most significant ID bits (ID x 100)
9-12	Next most significant ID bits (ID x 10)
13-16	Least significant ID bits (ID x 1)

The start bit is always a Mark. Bit 2 is unused. Bit 3 is provided as a command to a Model 6500 Servo Gauge to raise the servo. Bit 4 is provided as a command to a 6500 to reset the servo. Bits 5-16 are the ID number of the transmitter being interrogated.



ST Start bit (Mark)
RA Raise
RS Reset

Figure 4-3 Interrogate Data Structure

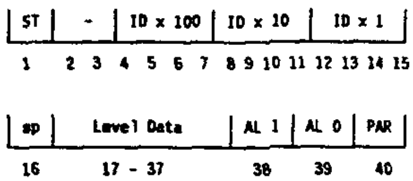
The return message from the Model 1900 transmitter can be either 40 or 56 bits long, depending on whether temperature reporting is configured. The basic format of the 40-bit level message is indicated in Figure 4- 4

The 40-bit response message consists of the following bits

Bit(s)	Interpretation
1	start bit (Mark)
2,3	unused
4-7	Most significant ID bits (ID x 100)
8-11	Next most significant ID bits (ID x 10)
12-15	Least significant ID bits (ID x 1)
16	First data bit (always a Space)
17-37	Level Data
38	Alarm 1 (optional external alarm)
39	Alarm 0 (optional external alarm)
40	Parity

The Start bit is always a Mark. Bits 2 and 3 are unused. Bits 4 through 15 are the ID of the responding transmitter. Bit 16 is always a Space. Bits 17 through 37 contain the actual level data. Bits 38 and 39 reflect the state of the optional external alarm inputs. All unused bits in the message are transmitted as Space pulses.

Bit 40 is the parity bit. The parity bit is a Mark when the number of Mark pulses in the preceding portion of the data message (bits 1 through 39) are even. When the number of Mark pulses is odd, the parity bit will be a Space. Note that in all cases, the entire 40-bit message will contain an odd number of Mark pulses.



ST	Start bit (Mark)
ID	Transmitter ID
AL1	External Alarm Bit 1
AL 0	External Alarm Bit 0
PAR	Parity bit

Figure 4-4 Transmitter Response Message, 40-Bits

The basic format of the 56-bit level message is indicated in Figure 4-5.

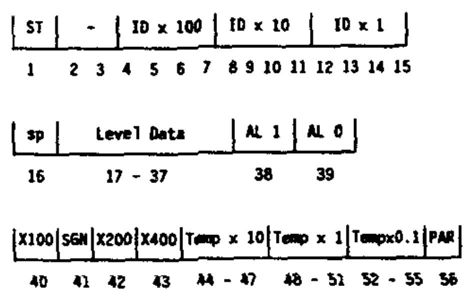
The 56-bit response message consists of the following bits

Bit(s)	Interpretation
1	start bit (Mark)
2,3	unused
4-7	Most significant ID bits (ID x 100)
8-11	Next most significant ID bits (ID x 10)
12-15	Least significant ID bits (ID x 1)
16	First data bit (always a Space)
17-37	Level Data
38	Alarm 1 (optional external alarm)
39	Alarm 0 (optional external alarm)
40	X100 temp bit
41	Sign
42	X200 temp bit
43	X400 temp bit
44-47	Temp x 10
48-51	Temp x 1
52-55	Temp x 0.1
56	Parity

Bits 1 through 39 of the 56-bit response message are identical to the 40-bit level response message. Bit 40 is the X100 digit, bit 41 is the sign bit, bit 42 is the X200 bit and bit 43 is the X400 bit. Bits 44 through 55 contain the 3 temperature digits in BCD format. Bit 56 is the parity bit and acts the same as bit 40 in the 40-bit level response message.

As an example, a temperature of +256.8 degrees would have bits 40 through 55 as follows:

Bits:	40	41	42	43	44-47	48-51	52-55
Data:	0	1	1	0	0101	0110	1000
Temp:	-	+	200	-	5	6	8



ST	Start bit (Mark)
ID	Transmitter ID
AL 1	External Alarm Bit 1
AL 0	External Alarm Bit 0_
X100	Temp Times 100 Multiplier
SGN	Temp Sign (Mark = +, Space = -)
X200	Temp Times 200 Multiplier
X400	Temp Times 400 Multiplier
Temp	Unscaled temperature
PAR	Parity bit

Figure 4-5 Transmitter Response Message, 56-Bits

Encoder Pulse Format

To minimize transmission errors, all pulse code signals consist of Marks (1) and Spaces (0) and have three characteristics:.

For English unit transmissions, the first level pulse is always a Mark (1).

The number of pulses in a message is always constant for a specific type of transmitter and does not vary with the data (always 40 or 56 bits).

Only one level data code element (bit) will change between any two adjacent data increments. For example, only one Mark (1) will change to a Space (0) for a single digit change of data between 29.98 feet (001 1000 0000 0001) and 29.99 feet (001 1000 0000 0001).

The pulse code format for level data used by the transmitter is reflected binary Gray pulse code. Figure 4-6 shows a decimal English code sequence with a range of 00.00 to 79.99 feet in 0.01 foot increments. Code element one, the start pulse that is always a Space, is not shown. Note that in the 0.01 foot increment column, there is only one element change as the level increases from 0.00 to 0.09. Over an 80-foot range, however, this code is required to repeat 8,000 times. Under these conditions, 0.09 and 0.00 become adjacent increments. The code for these increments must still satisfy the rule for *only one code element change between adjacent* increments. This would not be difficult if only the FT x 0.01 column were involved. The FT x 0.1, FT x 1 and FT x 10 columns, however, also come into play.

The above conflict is resolved by using the code itself to determine the code elements. In the FT x 0.01 column in Figure 4-when the level has reached 0.09, the code begins to repeat the preceding in a reflected format. This results in 0.09 being the same as 0.00. The reflected *portion of the code is labeled as ODD and refers* to the next significant digit in this case, the FT x 0.1 column.

Zero (0) is considered to be an even number as are 2, 4, 6, and 8. All other numbers are considered as odd. Note that the requirement that only one code element change between adjacent increments is still satisfied. When the level reaches 0.19, the code is 0001 0000 and has reached a point where 0.09 (odd) is the same code as 0.00 (even). When the level *reaches the next increment, only one code* element changes (#11) from 0 to 1, and the code reads 0011 0000. The 0.1 code is now even, and the 0.01 code now used is also even. This similarity applies to the relationship between FT x 0.1 and FT x 1.0. The even and odd groups for the FT x 0.1 code refer to the odd and even conditions of FT x 1 code, and the even and odd groups for the FT x 1 code refer to the odd and even conditions of FT x 10 code. This coding principle also applies when the level increments are 1 mm in the metric system (see Figure 4-7) A fractional code chart is also provided as Figure 4-8.

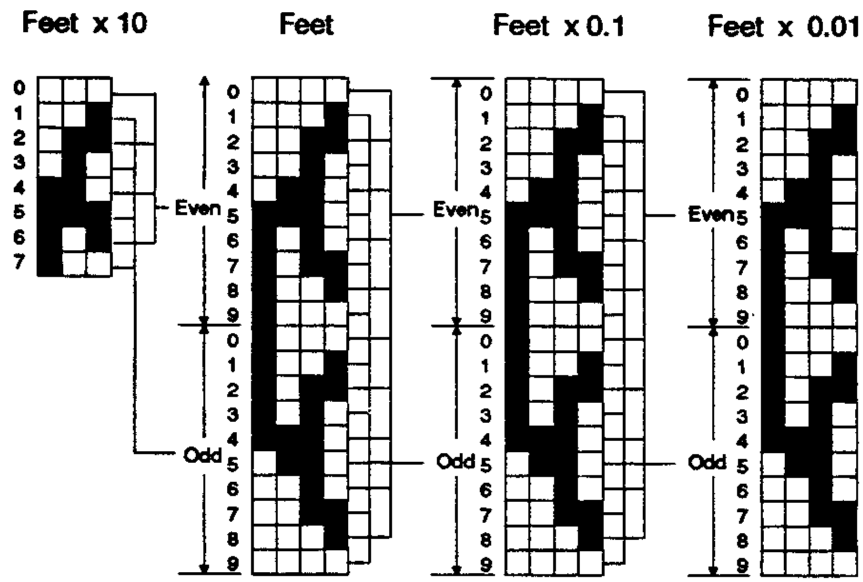
a. When troubleshooting, the following points should be taken into consideration:

b. Only one bit in the code changes between any two successive points of data.

c. Whether the code for a given *digit is odd* or even depends on whether or not the preceding digit is odd or even.

d. Always start with the most significant digit (msd) and go to the least significant digit *(lsd)*.

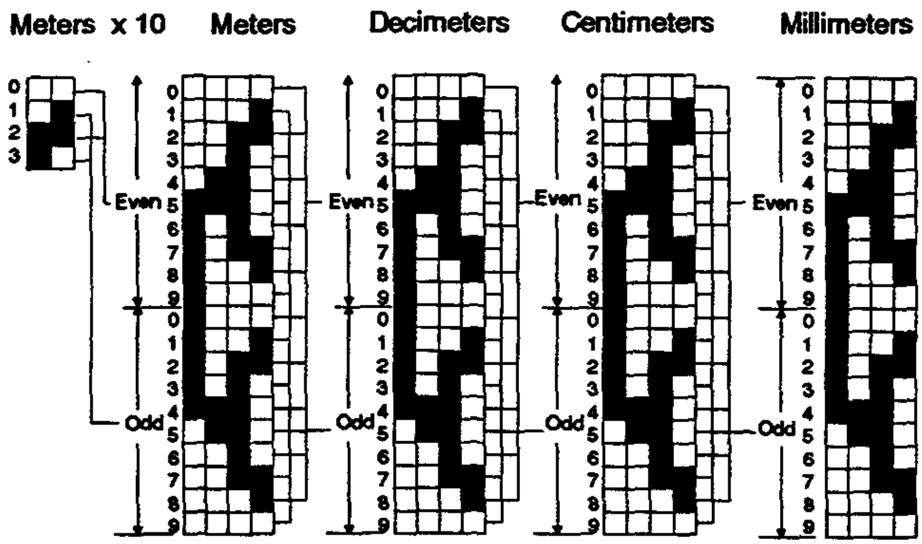
e. The code format is contained on two code disks. The first code disk, which is directly driven by the shaft from the level gauge, contains code tracks 10 through 16. The second disk contains tracks 1 through 9 and synchronized with the first disk via a Geneva gear arrangement. The gearing is such that for one-half a rotation of the first disk, the Geneva gear drives the second disk one increment. Two increments are *equal to one foot of change*.



The use of ODD or EVEN code depends upon the ODD or EVEN condition of the preceding significant digit.

Shaded (black) area represents Mark (1). Unshaded (white) area represents Space (0)

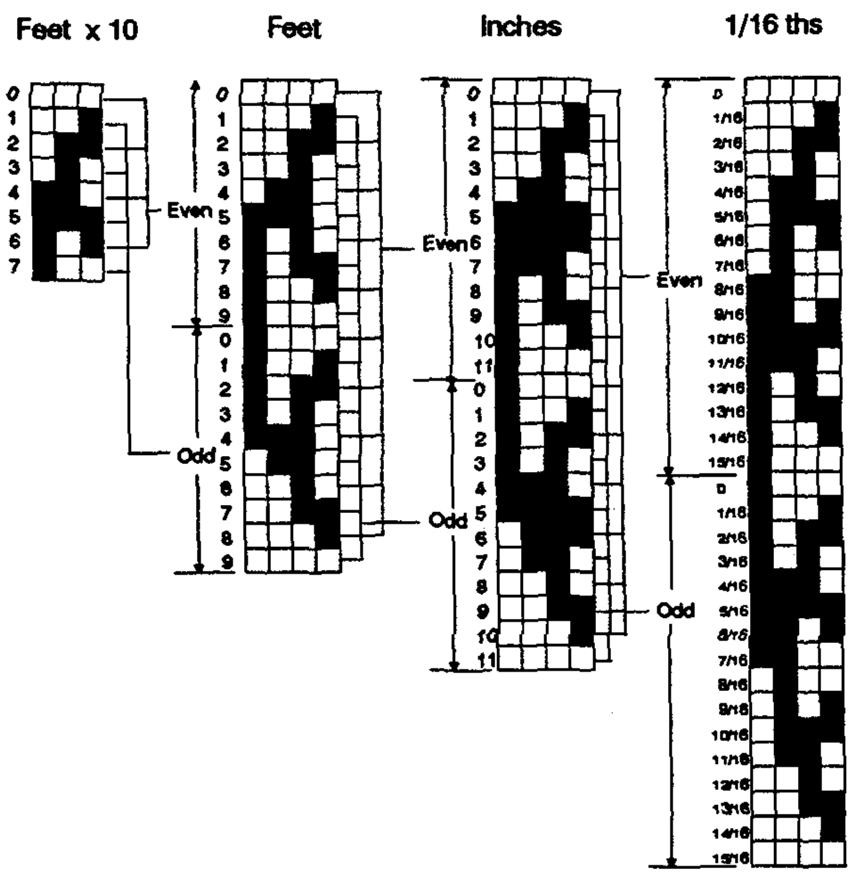
Figure 4-6 Decimal Feet Coding Chart



The use of ODD or EVEN code depends upon the ODD or EVEN condition of the preceding significant digit.

Shaded (black) area represents Mark (1). Unshaded (white) area represents Space (0)

Figure 4-7 Metric Code Chart



The use of ODD or EVEN code depends upon the ODD or EVEN condition of the preceding significant digit.

Shaded (black) area represents Mark (1). Unshaded (white) area represents Space (0)

Figure 4-8 Fractional Feet Coding Chart

Section 5 Specifications and Reference Data

Specifications and Physical Characteristics

The following specifications apply to the Varec 1900 4-Wire Transmitter.

Power Requirements
  48 Volts DC

Current Consumption
  Transmit: 50 mA
  Standby: 1 mA

Voltage Range
  30 Volts DC minimum
  48 Volts DC optimum
  55 Volts DC maximum

Transmission
  From Receiver: 16 bits
  From Transmitter:
    56 bits level & Temperature
    40 bits level only

Pulse Width
  2 ms (high speed)

Data
  ID, Level, Temperature, Status, Parity

Encoder
  Type: Absolute, Brush, or Optical
  Level Data: Reflected Binary Grey Code
  Units/Range:
    Imperial: 79' 11-15/16"
    Metric: 20 Meters
    Metric: 20 Meters

Accuracy
  +/- 1/16" (1.0 mm)

Repeatability
  +/- 1/16" (1.0 mm)

Resolution
  1 mm in 20,000 (metric)
  1/16" in 79' 11 15/16" (fractional)

Temperature Input
  Spot: 3-Wire Copper or Platinum
  Averaging: Copper 10 Element
  Averaging Selection: Varec "T" Feature
  Type/Range:
    100 Ohm Copper: -100 °F to +400 °F
    DIN Platinum: -234 °F to 502 °F
  Accuracy: +/- 0.5 °F (0.25 °C)
  Repeatability: 0.1 °F (0.1 °C)
  Resolution: 0.1 °F (0.1 °C)

Environmental
  Operating Temperature Range
  -13 °F to +185 °F (-25 °C to + 85 °C)
  Operating Humidity Range
  0 to 95% Relative Humidity/Non-Condensing

Enclosure Type
  Explosion Proof: NEC Article 500
    Class I, Div. I, Groups C & D
  Material: Cast Aluminum Base & Cover
  Paint: Epoxy Based

Safety Approvals
  Factory Mutual (FM) File No.
    1K3A6.AE and 1K3A7.AE
  Canadian Standards Association (CSA)
    File No. LR40894-7
  Iniex File No. 85.103.421

Power and Signal Wires
  Number: 4 Conductors
  Type: Shielded
  Size: Per Formula, 18 AWG Typically Used

Limit Switches (Optional)
  Rating:
    20 Amp - 125, 250, 460 VAC
    10 Amp - 125 VAC -
      Tungsten Filament Lamp Load
    1 HP - 115 VAC, 2 HP - 230 VAC
    ½ Amp - 125 VDC, ¼ Amp -250 VDC
  Number: Two or Four - N.O. or N.C.

Table 5-1 Model 1900 Model Options

Model	Description
1900	*Micro 4-Wire Transmitter*

Code	Explosion Proof Approval (Select one)
0	None
1	Factory Mutual (FM)
2	Canadian Standards Assoc. (CSA)
3	CENELEC

Code	Encoder (Select one)
01	Fractional Brush 0-79' 11-15/16" (F)*
02	Fractional Brush 0-79' 11-15/16" (R)*
03	Fractional Optical 0-79' 11-15/16" (F)*
04	Metric Brush 0-20M (F)*
05	Metric Brush 0-20M (R)*
06	Metric Brush > 20M (F)*
07	Metric Brush > 20M (R)*
08	Metric Optical 0-20M (F)*
09	Metric Optical > 20M (F)*

Code	Limit Switches (Select one)
0	None
2	Two (2) SPDT - N.O.
4	Four (4) SPDT - N.O.

Code	Temperature Calibration (Select one)
1	Standard 100Ω Copper
2	DIN Platinum

Code	Options (Select one)
0	None
1	Heater
3	Averaging Temperature Switch ("T" feature)
5	Heater, "T" Feature

Code	Mounting Adapters
-	No Adapter - Varec Mounting
1	Adapter Kit for mounting to GPE/Whessoe 92513, 92514, 92020, and 92030 Gauges
2	Adapter Kit for mounting to GPE/Whessoe 92006, 2006 Gauges
3	Adapter Kit for mounting to Sakura LT-1110 Gauge (Metric only)
4	Adapter Kit for mounting to Tokyo-Keiso FT-1201 Gauge

1900	1	01	0	1	0	1	(Example)

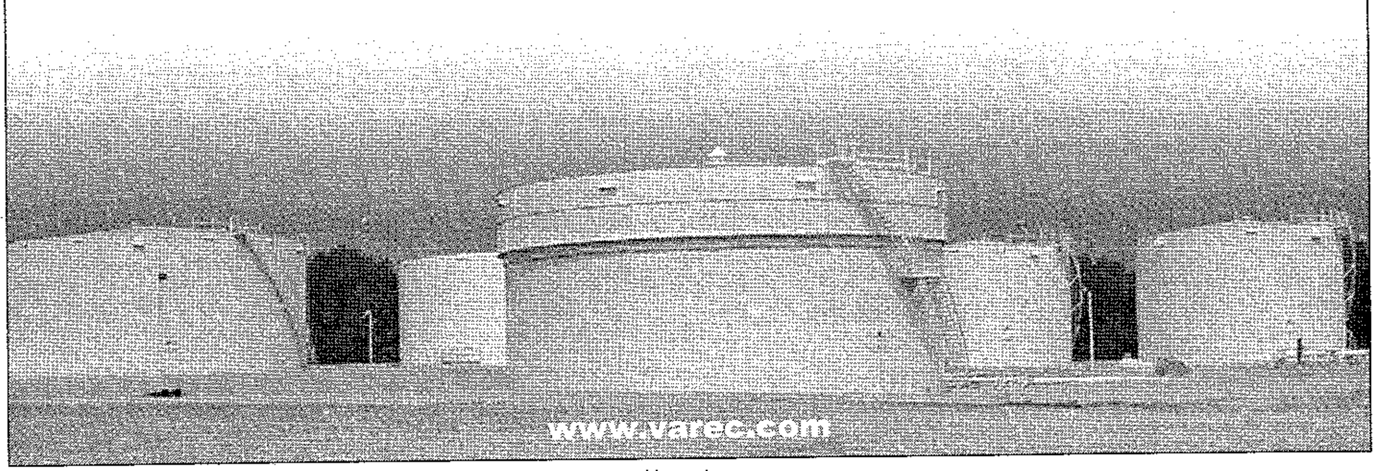
Note: Surge protection is standard. Not every possible combination incorporating options may be available with agency explosion proof approvals.

INDEX

Varec®

Your offical representative

Varec®



Varec, Inc.
5834 Peachtree Corners East, Norcross (Atlanta), GA 30092 USA
Tel: +1 (770) 416-6629 Fax: +1 (770) 662-8939