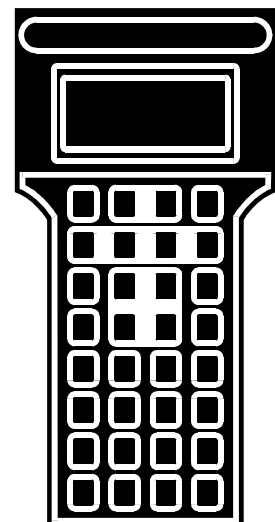
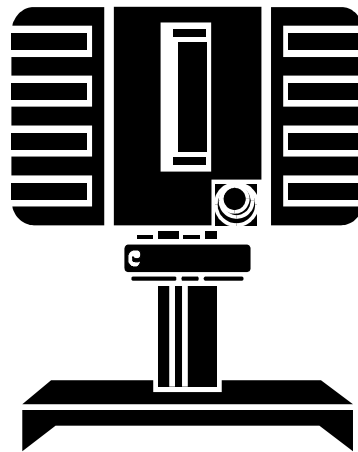
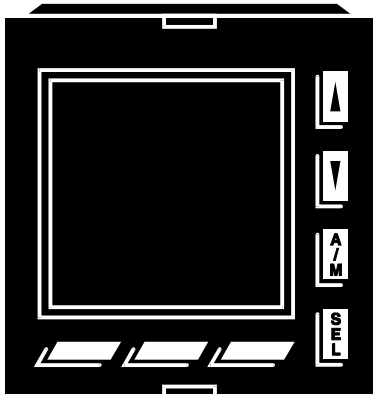
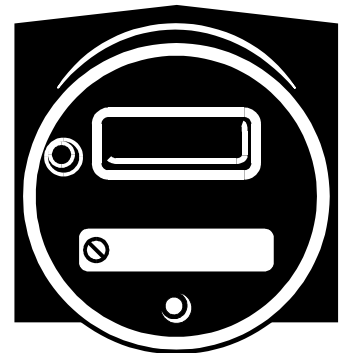
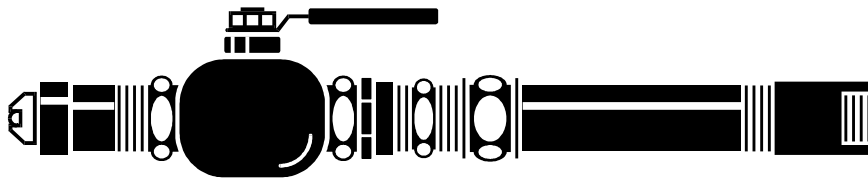


Smart pH/ORP/pION Transmitter



Smart pH/ORP/pION Transmitter

Type TBN580/TBN581

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- A pH Analysis and Sensor Simulation Setup

Preface

This publication is for the use of technical personnel responsible for installation, operation and maintenance on the Series TBN580 pH and TBN581 ORP/pION Smart Transmitters.

List of Effective Pages

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Safety Summary

GENERAL WARNINGS

Equipment Environment

All components, whether in transportation, operation or storage, must be in a noncorrosive environment.

Electrical Shock Hazard During Maintenance

Disconnect power or take precautions to insure that contact with energized parts is avoided when servicing.

SPECIFIC WARNINGS

Use this equipment only in those classes of hazardous locations listed on the nameplate. Uses in other hazardous locations can lead to unsafe conditions that can injure personnel and damage equipment. (p. 3-2)

The outputs of smart devices change to a fixed value during initialization and detected failure conditions. These values must be selected by the user to ensure safe operation. (p. 5-9)

Secure the process before performing this procedure. Performing this procedure while the equipment is in the process can upset that process. Some process upsets can injure personnel and damage equipment. (p. 7-1)

System maintenance must be performed only by qualified personnel and only after securing the equipment controlled by the circuit. Altering or removing components from an active circuit may upset the controlled process leading to personnel injury and equipment damage. (p. 7-2)

Acids and bases can cause severe burns. Use hand and eye protection when handling. (p. 7-2)

Store the solution in a suitable container. Label it as containing an extremely flammable strong acid. Use extreme care when handling. Failure to follow this warning can injure personnel and damage equipment. (p. 7-2)

Do not substitute components that compromise the certifications listed on the nameplate. Invalidating the certifications can lead to unsafe conditions that can injure personnel and damage equipment. (p. 8-1)

Do not disconnect equipment unless power has been switched off at the source or the area is known to be nonhazardous. Disconnecting equipment in a hazardous location with source power on can produce an ignition capable arc that can injure personnel and damage equipment. (p. 8-1)

Safety Summary (continued)

SPECIFIC CAUTIONS

Remove DC power before performing these procedures. Failure to do so can damage the equipment. (p. 3-8)

When installing the electronics assembly, be careful not to pinch any wires between the electronics assembly and the housing. Damage to wire insulation and the resulting inadvertent electrical connection will cause damage to the unit and the process. (p. 8-4)

Sommaire de Sécurité

AVERTISSEMENTS D'ORDRE GÉNÉRAL

Environnement de l'équipement

Ne pas soumettre les composants à une atmosphère corrosive lors du transport, de l'entreposage ou l'utilisation.

Possibilité de chocs électriques durant l'entretien

Débrancher l'alimentation ou prendre les précautions pour éviter tout contact avec des composants sous tension durant l'entretien.

AVERTISSEMENTS D'ORDRE SPÉCIFIQUE

L'équipement décrit ici ne doit être utilisé que dans les catégories d'emplacement dangereux identifiées sur la plaque signalétique. Son emploi dans tout autre catégorie d'emplacement dangereux pourrait présenter des risques, et provoquer des dommages matériels et des blessures. (p. 3-2)

Les signaux de sortie des transmetteurs intelligents prennent une valeur fixe au moment de l'initialisation, ainsi que lors de la détection d'une défectuosité. L'utilisateur doit affecter une valeur qui assurera un fonctionnement sécuritaire. (p. 5-9)

Mettez le processus dans un état d'arrêt stable avant d'effectuer cette procédure. Si vous effectuez cette procédure tandis que l'équipement intervient dans le processus, ceci risque de perturber le processus, ce qui pourrait provoquer des blessures et des dommages matériels. (p. 7-1)

Sommaire de Sécurité)))))))

AVERTISSEMENTS D'ORDRE SPÉCIFIQUE

L'entretien du système ne doit être effectuée que par le personnel qualifié et seulement une fois que l'équipement contrôlé par le circuit est fixé en place. La modification ou le retrait des composants d'un circuit actif pourraient perturber le processus contrôlé et mener à des blessures au personnel et à l'endommagement de l'équipement. (p. 7-2)

L'acidé et les basses peut occasionner des brulers graves. Protégér les mains et les yeux lors de la manutention. (p. 7-2)

Entreposez la solution dans un contenant approprié. Apposez-y une étiquette indiquant qu'il contient de l'acide fort extrêmement inflammable. Manipulez avec grand soin. Toute négligence à cet égard risque de provoquer des blessures et des dommages matériels. (p. 7-2)

Ne substituez pas des composantes qui pourraient annuler la conformité aux classes figurant sur la plaque signalétique relativement aux endroits dangereux. Ceci peut entraîner des conditions dangereuses qui risquent de provoquer des blessures et des dommages matériels. (p. 8-1)

Ne débranchez l'équipement que si l'alimentation a été interrompue ou si l'environnement est non dangereux. Le débranchement de l'équipement sous tension peut produire une étincelle, ce qui peut mener à une explosion et à des blessures au personnel. (p. 8-1)

ATTENTIONS D'ORDRE SPÉCIFIQUE

Interrompez l'alimentation c.c. avant d'effectuer ces procédures. Toute négligence à cet égard risque de provoquer des dommages matériels. (p. 3-8)

Lorsque vous installez la section électronique, veillez à ce qu'aucun fil ne soit coincé entre la section électronique et le boîtier. Si l'isolant du fil est endommagé, la connexion électrique qui en résulte entraînerait des dommages à l'unité ainsi que la perturbation du processus. (p. 8-4)

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SECTION 1 - INTRODUCTION

OVERVIEW

The Series TBN58□ transmitter is a two-wire, four to 20 milli-amp compatible pH/ORP/pION transmitter with state-of-the-art technology. It can be placed in a digital field bus mode for direct communications to the INFI 90[®] Strategic Process Management System. Digital electronics using the latest microcomputer technology allow calibration and troubleshooting from a local or remote location. The transmitter constantly performs a series of self-diagnostics, checking areas such as configuration integrity and input circuitry. It also computes sensor efficiency and reference offset. When configured for pH sensor inputs, internal diagnostics check the temperature compensator input to notify of high or low process temperature.

The transmitter communicates with the Type STT02 Smart Transmitter Terminal. This handheld terminal performs output monitoring, configuration, reranging, diagnostics checks, sensor status, and calibration checks from a local or remote location.

The Series TBN580 transmitter accepts pH sensor inputs. The Series TBN581 accepts ORP (oxidation reduction potential) sensor, pION (specific ion) sensor or Kegold sensor inputs. It converts them to a current signal (four to 20 milliamps) or a digital communication signal. When configured for pH measurements, several software techniques allow for temperature compensation of these inputs.

An optional liquid crystal display (LCD) provides for local transmitter input or output indication. It rotates 360 degrees in steps of 90 degrees. This provides four different viewing angles for optimum placement.

INTENDED USER

The information in this instruction is a guide for technical personnel responsible for the installation and operation of the TBI-Bailey Series TBN580 (pH) and TBN581 (ORP/pION) transmitters.

TRANSMITTER DESCRIPTION (PHYSICAL)

The transmitter consists of an electronics housing, a pH converter assembly and a mounting stem (Figure 1-1). Several sensors are available for pH, ORP, or pION measurement, with or without the capability of temperature compensation.

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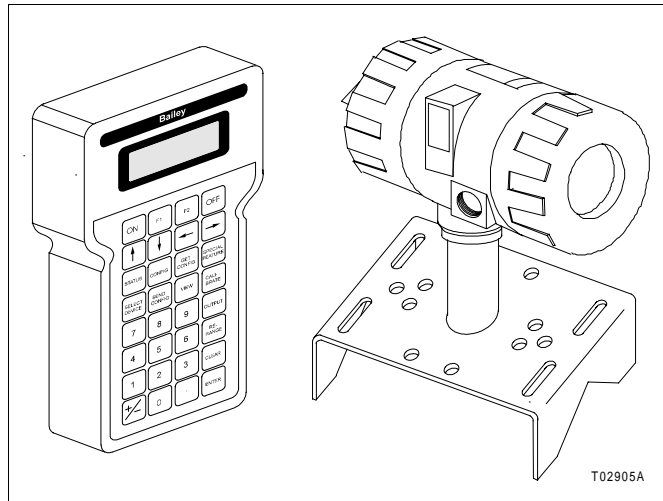


Figure 1-1. Smart Transmitter Terminal and Smart Transmitter

INSTRUCTION CONTENT

Introduction	Provides a description of this instruction, its sections and their uses, along with a brief description of the transmitter. Also included in this section are instructions on how to use this document, a glossary of terms and abbreviations, product identification (nomenclature) and performance specifications.
Description and Operation	Describes the operation of principal components of the transmitter. Also covered in this section are communication techniques and the diagnostic commands.
Installation	Details the tasks related to the installation of the transmitter. Procedures provide guidelines for unpacking, location considerations, physical installation and wiring instructions.
Calibration	Explains the calibration methods of the unit. It also has calibration check procedures and explains temperature compensation.
Operating Procedures	Addresses transmitter start-up procedures and configuration using the Type STT02 handheld smart transmitter terminal, and the procedures that make the unit operational.
Troubleshooting	Provides information on solving operating problems. Included are tables that list corrective action that relate to error messages appearing on the Type STT02 terminal display. Also included is a troubleshooting flowchart.
Maintenance	Includes maintenance information as it pertains to the sensor assembly.

- Repair and Replacement Procedures** Details procedures involved in replacing transmitter components. It also includes ordering information for replacement parts and spare parts lists.
- Appendix A** Provides information on the setup of a pH analysis system or sensor simulation.

HOW TO USE THIS INSTRUCTION

It is important for safety and operating reasons that this product instruction be read and understood completely before installing or completing any tasks or procedures associated with operation.

The sections of this instruction are sequentially arranged as they relate to initial start-up: from unpacking to repair and replacement procedures. After initial start-up, the instruction may then be referred to as needed by section.

GLOSSARY OF TERMS AND ABBREVIATIONS

Table 1-1 lists the terms and abbreviations used in this instruction.

Table 1-1. Glossary of Terms and Abbreviations

Term	Definition
Analog	Continuously variable as opposed to discretely variable.
Bench Calibration	A calibration procedure with a sensor or millivolt source performed with the instrument off-line and the sensor out of service.
Control Output	The signal that influences the operation of a final control element.
Damping	Damp time described as a lag.
EEPROM	Electrically erasable programmable read only memory. A type of nonvolatile memory that is programmed and erased electrically.
EPROM	Erasable programmable read only memory. This memory holds the operating program for the microcomputer.
FSK	Frequency shift keying. The transmission of digital signals done by shifting a continuously running carrier in frequency between two closely spaced frequencies according to the ones and zeroes being transmitted. This can be thought of as digital FM (frequency modulation).
Ground Loop	A path between the process liquid ground and a second ground point elsewhere in the system. This path allows unwanted current flow through the measurement circuitry.
LCD	Liquid crystal display. An optional 12-character alphanumeric display that allows local readout of the transmitter.
Nonvolatile Memory	Memory that retains programmed information, such as configuration and calibration parameters, even when power is removed.
ORP	Oxidation reduction potential. Also known as redox. The potential created during a chemical reaction in which one or more electrons are transferred from one atom or molecule to another.

Table 1-1. Glossary of Terms and Abbreviations (continued)

Term	Definition
pH	The negative logarithm of the effective hydrogen ion concentration or hydrogen ion activity in gram equivalents per liter. A unit used in expressing both acidity and alkalinity on a scale whose values run from 0 to 14, with 7 representing neutrality. Numbers less than 7 represent increasing acidity, while numbers greater than 7 represent increasing alkalinity.
pION	Specific ion measurement.
RTD	Resistance temperature detector. A sensing device that changes resistance within a temperature range.
Set Point	Target set for process variable or standard representing desired value of the process variable.
SSD	Static sensitive device.
Temperature Compensation	Correcting measurements for the effects of temperature on a sensor or solution.

REFERENCE DOCUMENTS

Table 1-2. Reference Documents

Document Number	Title
C-E67-21-3	TBI-Bailey pH/ORP Sensor Product Specification
I-E21-28-1	Smart Transmitter Terminal, Type STT02
I-E96-302	IMFBS01 Field Bus Module
PA67-21-1	TBI-Bailey pH Sensor Installation Guidelines
P-E21-001	Installing a 4 to 20 mA Transmitter in a Hazardous Location

NOMENCLATURE

Table 1-3. Series TBN58□ Nomenclature

Position	1	2	3	4	5	6	7	8	
Series	T	B	N	5	8	□	□	□	Smart Transmitter
									Type
					0				pH
					1				ORP/pION
									Display
						0			Without LCD display
						1			With LCD display
									Identification tag
							0		No tagging
							1		Stainless steel tag
							2		Mylar® tag

® Mylar is a registered trademark of E. I. DuPont de Nemours and Co.

SPECIFICATIONS

Table 1-4. Specifications

Property	Characteristic/Value
Inputs:	
pH	Glass, antimony
ORP	Platinum
pION	Sodium, chloride, etc.
Special	Kegold cyanide sensor for gold mining
Temperature	3.01 kΩ (at 25°C) Balco RTD for pH temperature compensation
Input range:	
pH	-2.00 to +16.00 pH
ORP	-1,200 to +1,200 mV
pION	-1,200 to +1,200 mV
Special	-1,200 to +1,200 mV
Analog output span:	
pH	1 to 16 pH configurable across full pH range
ORP	50 to 1,000 mV configurable across full ORP range
pION	50 to 150 mV configurable across full pION range
Output:	
Analog mode	Isolated 4 to 20 mA
Digital mode	Percent span
Accuracy:	
pH	±0.1% or ±0.1 pH, whichever is greater
ORP and pION	Inputs <100 mV: ±0.2% of span Inputs ≥100 mV: ±0.1% of span
Temperature compensation types	Manual Automatic Nernstian Automatic Nernstian with solution compensation per: $Nernst\ pH\ \frac{(Temp - 25^{\circ}C)}{10} \times$ where: X = change in pH for 10°C (18°F) change Automatic Nernstian with pure water solution for both acid and base conditions. Proprietary TBI-Bailey algorithms.
Repeatability	±0.05% of input span
Zero shift	±0.05% if input span over allowed ambient temperature range
Total error	±1.0% of input span over allowed ambient temperature range
Supply voltage	13 to 42 VDC
Power supply effect	±0.005% of span per volt
Maximum power supply ripple	500 mV peak-to-peak at any frequency to allow for communications
Response time	300 msec maximum (electronics only)
Damping	Continuously adjustable from 0.00 to 32.00 secs

Table 1-4. Specifications (continued)

Property	Characteristic/Value
Function generator	User-defined, 6-segment
Normal mode interference effect	1.0% of input span (60 to 120 Hz at peak amplitudes input span)
Turn-on time	2 secs typical, 4 secs maximum
Mounting position effect	None
Load resistance range	See Figure 1-2
Input isolation	Input to output high pot: 700 VDC, 500 VAC
Temperature limits:	
Operation	-25° to +60°C (-13° to +140°F)
Operation limits	-40° to +60°C (-40° to +140°F). The transmitter will continue to operate, but may not meet specifications.
Storage	-51° to +80°C (-60° to +176°F)
Temperature limits for optional LCD units:	
Operating and visibility limits	0° to 50°C (32° to 122°F). Exceeding these limits will cause the LCD to go blank. The transmitter will remain functional. When the limits return to the acceptable range, the display will be restored.
Storage	-20° to +70°C (-4° to +158°F)
Enclosure classification	NEMA 4X; watertight, indoor and outdoor
Installation category	III, per IEC 1010-1
Agency certifications: ¹	
CSA (Canadian Standards Association)	Nonincendive (nonsparking) Class I, Division 2, Groups A, B, C, D. Class II, Division 2, Groups E, F and G. Class III, Division 2, T3. Intrinsically safe (when used with appropriate barriers per application guide P-E21-001) Classes I, II, III; Division 1; applicable Groups A, B, C, D, E, F and G; T3. Dust-ignition proof Class I, Division 2, Groups E, F and G. Class III, Division 1.
FM (Factory Mutual)	Explosion proof Class I, Division 1, Groups B, C and D. Nonincendive (nonsparking) Class I, Division 2, Groups A, B, C, D. Class II, Division 2, Groups F and G. Class III, Division 2, T6. Intrinsically safe (when used with appropriate barriers per application guide P-E21-001) Classes I, II, III; Division 1; applicable Groups A, B, C, D, E, F and G; TC3.
SAA (Standards Association of Australia)	Nonincendive (nonsparking) Ex n, Zone 2, Group IIC, T6. Intrinsically safe (when used with appropriate barriers per application guide P-E21-001) Ex ia, Zone 0, Group IIC, T3.

NOTE:

1. Hazardous location approvals for use in flammable atmospheres are for ambient conditions of -25° to 40°C (-13° to 104°F), 86 to 108 kPa (12.5 to 15.7 psi) with a maximum oxygen concentration of 21%. If the normal temperature range of the product is not within these temperature limits, the temperature rating of the product takes precedence.

Table 1-5. Accessories

Item	Description	Nomenclature/ Part No.
LCD meter	Integral circuit board provides 12-digit alphanumeric liquid crystal display of transmitter output signal as percent of span or in engineering units. Display is accurate to 0.01% of span and suitable for calibration of the device. The meter can be rotated in 90° increments inside the cover to yield the best viewing orientation.	Refer to the nomenclature for selection.
IMFBS01 Field Bus Module	Allows interface of smart instruments to the INFI 90 system. Routes 15 channels of direct digital communications back to the field instruments.	IMFBS01
Transient suppressor	Mounts internally to suppress lightning induced transients. Tested to suppress 10 successive 8 by 20 μsec pulses with a peak value of 20 kA (reference IEEE C62-41).	258563_1
Antistatic field service kit	Kit for personnel working on equipment containing static sensitive devices (SSD). Includes static dissipative work mat, ground cord assembly, alligator clip and wrist band.	1948385_1

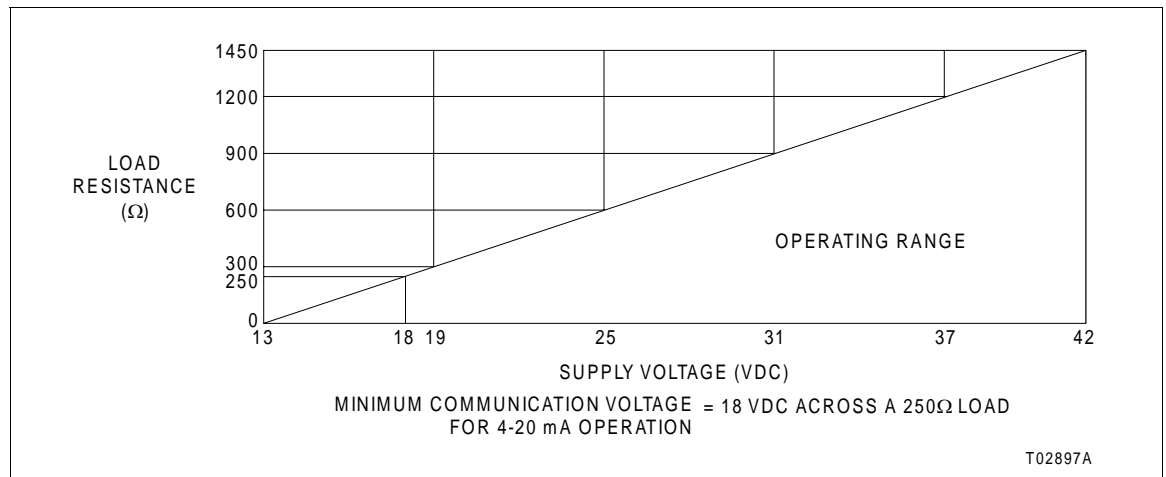


Figure 1-2. Load Limits for 4 to 20 mA Operation

SECTION 2 - DESCRIPTION AND OPERATION

INTRODUCTION

The transmitter is a high performance pH, oxidation-reduction potential (ORP), or specific ion (pION) analyzer transmitter. The transmitter accepts the low level outputs from pH, ORP, or pION combination electrodes, provides the capability of temperature compensation when the appropriate temperature compensation sensor is supplied, and outputs a four to 20 milliamp signal or a digital signal. The capability of internal linearization is also provided to allow concentration to be output instead of the logarithmic p function. The digital electronics package using the latest microcomputer technology allows troubleshooting and calibration from either a local or remote location. The transmitter continuously runs through a series of self-diagnostics, monitoring such areas as configuration integrity and input circuitry. Irregularities are indicated for maintenance purposes.

Sensors may be replaced without removing the transmitter from the line for calibration. A process calibration procedure can be used to accommodate for the new sensor efficiency and offset variations.

There are no hardware changes required to configure the transmitter as an ORP or pION unit. Software is provided to allow complete flexibility without even a jumper change.

FUNCTIONAL OPERATION

The transmitter provides a four to 20 millamp output signal in response to the output of any electrochemical sensor having a DC voltage output in the range of -1,000 to +1,000 millivolts. This includes sensors requiring electrometer type detectors such as pH sensors, ORP sensors and pION electrodes. The transmitter can also be used as a millivolt to milliamp converter with the source impedance of the millivolt input as high as 1,000 megohms.

See Figure 2-1 for a simplified block diagram of the transmitter electronics.

LCD DISPLAY

The optional LCD display is alphanumeric with 12 characters. The microcomputer updates the display every second. The type of data to be displayed can be selected using the Type STT02 Configuration and Tuning Terminal.

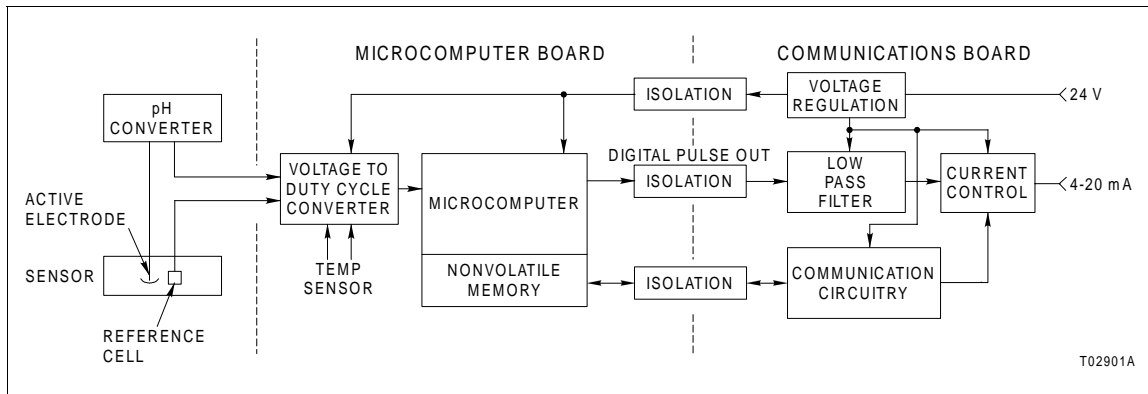


Figure 2-1. Electronics Block Diagram

The display rotates 360 degrees, in increments of 90 degrees, for four possible viewing angles. Refer to **LCD DISPLAY ROTATION** in Section 3.

COMMUNICATIONS

Two types of communication are available: point-to-point mode or field bus mode.

Point-to-Point Mode

Connecting the Type STT02 terminal anywhere along the signal wires establishes communications between the transmitter and a remote terminal. No adapters, jacks or plugs are necessary. An AC voltage imposed on the signal wires allows communications between the transmitter and the terminal. Since the communication signal, a high frequency AC signal, has a zero DC average, it has no effect on the output of the transmitter. Two different frequency levels transmit a logic zero or a logic one. This enables the transmitter to be located up to 1.6 kilometers (one mile) from the handheld terminal and provides excellent noise immunity for remote communications.

NOTE: A minimum of 250 ohms loop resistance is necessary to support communication capabilities (Figure 2-2).

Field Bus Mode

The transmitter is programmed, via the Type STT02 terminal, into the digital field bus mode by selecting a bus address for the transmitter. The microcomputer sets the output of the transmitter to approximately four milliamps for low power consumption. The transmitter provides a digital process variable signal and reports its output (in percent) up to ten times per second for control purposes. The field bus mode makes monitoring of up to 15 transmitters on a single pair of wires from the control system possible (Figure 2-3). A fully populated field

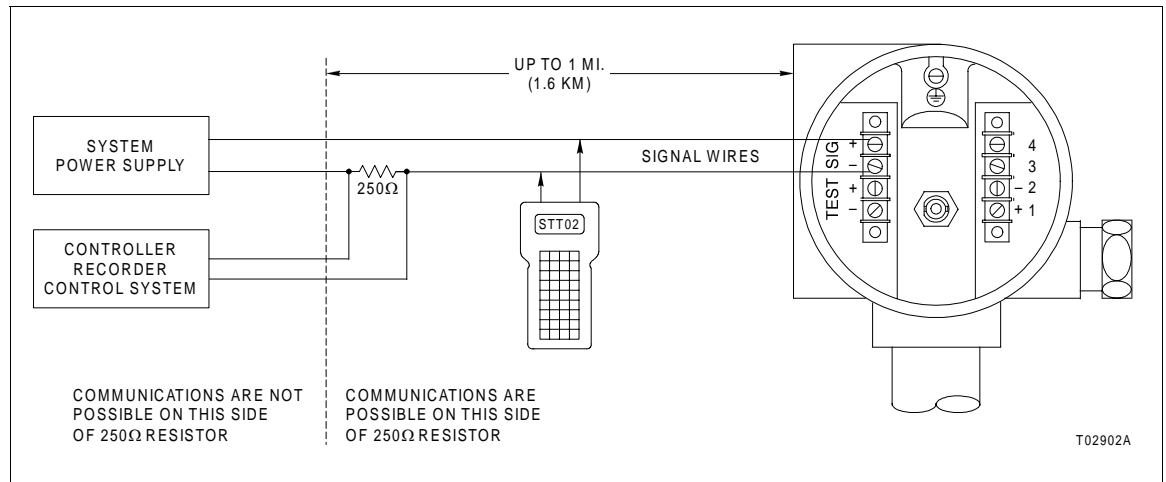


Figure 2-2. Point-to-Point Communications

bus slows the response for each transmitter to three output updates per second for each transmitter. Using the IMFBS01 Field Bus Module allows changes to transmitter parameters. The Type STT02 terminal can talk to the transmitter while the process runs, but cannot change any transmitter parameters until the unit has been brought off-line from the IMFBS01 Field Bus Module.

NOTES:

1. Refer to the IMFBS01 instruction for detailed information on wiring practices, the length and type of wire to use, and the maximum distance between transmitters on the bus.
2. The IMFBS01 module can handle up to 15 transmitters. The Type STT02E terminal can program a maximum of eight transmitters on a system. Refer to the Type STT02E instruction for more information. Refer to Table 1-2 for the current document number.

INTERNAL POWER SUPPLY

The power supply, a low power switching type, operates with a minimum of 13 VDC across the signal wiring of the transmitter. The power supply and the transmitter have protection against power reversals.

TRANSMITTER SOFTWARE FUNCTIONS

The transmitter understands and responds to communication, output, and calibration commands received from the Type STT02 terminal.

Communication commands permit monitoring the input (in pH units or millivolts), the output (in percent or secondary engineering units), the configuration, and the status of the

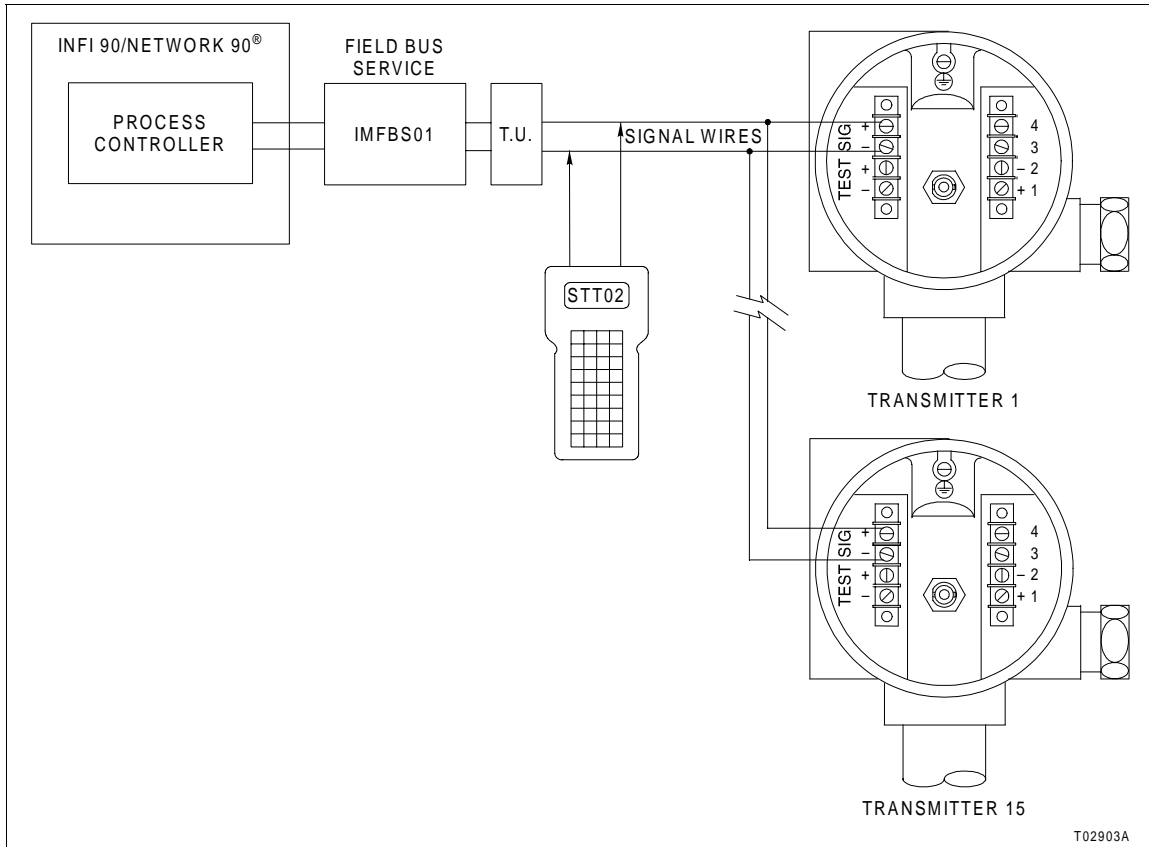


Figure 2-3. Field Bus Communications

transmitter. The user can also change ranges, input engineering units, ID tags and addresses in the transmitter configuration, and monitor the sensor characteristics.

The output commands allow defining the output as linear with respect to the input, or as a function generator that follows a six-segment curve programmed by the user. The output, when set to normal or reverse acting and/or fixed to a specific value, aids in troubleshooting. Other commands allow setting a user-selectable output value upon transmitter failure and power up. A damping adjustment command also exists.

The calibration commands to which the transmitter responds allow bench calibration and reranging the transmitter current output. Process calibration for sensor and temperature also exists.

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TEMPERATURE COMPENSATION

Monitoring the resistance of a 3.01-kilohm Balco RTD provides temperature compensation on pH sensor inputs. This temperature can be monitored using the Type STT02 terminal. Compensation of the output of the pH sensor, due to the effect of temperature on the electrode response, complies with the Nernst equation. Additionally, effects of temperature on process solution can be added to this Nernstian compensation according to the following equation:

$$\text{Nernst pH} \frac{(\text{Temp} - 25^{\circ}\text{C})}{10} X$$

where:

X = Change in pH for 10°C (18°F).

Example: Pure water: $x = +0.18$ pH per 10°C
 Pure water with 1 ppm ammonia: $x = +0.31$ pH per 10°C

An option also exists in the case of ultrapure water. This option compensates for the effect of temperature on the pH of that water.

Manual temperature compensation is also possible.

The effect of temperature on ORP sensors is negligible. The effect of temperature on pION sensors is unknown, except in specific applications. When configured for ORP or pION measurements (Series TBN581 transmitter), the use of a temperature compensator provides no benefit and is not offered.

Selection of temperature compensation options occurs during the configuration procedure.

DIAGNOSTICS

The Type STT02 terminal provides continuous self-diagnostic results. Areas monitored include configuration integrity, reference voltage, sensor temperature and input circuitry failure. The modular amplifier design allows the diagnostics to identify the malfunctioning electronic section. The diagnostics also indicate if a calibration error is made.

SECTION 3 - INSTALLATION

INTRODUCTION

This section will assist in all levels of the installation process. It provides simple procedures for placing the transmitter into service.

SPECIAL HANDLING

Besides the normal precautions for storage and handling of electronic equipment, the transmitter has special static sensitive device (SSD) handling requirements. This equipment contains semiconductors subject to damage by discharge of static electricity. Therefore, do not touch the components on the circuit board.

To minimize the chances of damage by static electricity, follow these techniques during service, troubleshooting and repair.

1. Remove assemblies containing semiconductors from their protective containers only:
 - a. When at a designated static free work station.
 - b. After firm contact with an antistatic mat and/or firmly gripped by a grounded individual.
2. Personnel handling assemblies with semiconductors must be neutralized to a static free work station by a grounding wrist strap connected to the station or to a good ground point at the field site.
3. Do not allow clothing to make contact with semiconductors. Most clothing generates static electricity.
4. Do not touch edge connectors, circuit traces and components.
5. Avoid partial connection of semiconductors. Semiconductors can be damaged by floating leads, especially the power supply connector. If inserting an assembly into a live system, do so quickly. Do not cut leads or lift circuit paths when troubleshooting.
6. Ground the test equipment.

7. Avoid static charges during maintenance. Make sure the circuit board is thoroughly clean around its leads but do not rub or clean with an insulating cloth.

NOTE: An antistatic field service kit (refer to Table 1-5) is available for personnel working on devices containing static sensitive components. The kit contains a static dissipative work surface (mat), a ground cord assembly, wrist bands and alligator clip.

UNPACKING AND INSPECTION

Examine the equipment upon receipt for possible damage in transit. File any damage claims with the transportation company responsible. Notify the nearest TBI-Bailey sales office.

Carefully inspect the packing material before discarding it to make certain that all mounting equipment and any special instructions or paperwork have been removed. Careful handling and installation will insure satisfactory performance of the equipment.

Use the original packing material and container for storage. Select a storage environment free of corrosive vapors, extremes of temperature and humidity. Storage temperature must not exceed -20 degrees to 70 degrees Centigrade (-4 degrees to 158 degrees Fahrenheit) with optional LCD display; -51 degrees to 80 degrees Centigrade (-60 degrees to 176 degrees Fahrenheit) without optional LCD display.

LOCATION CONSIDERATION

When mounting the unit, leave ample clearance for removal of the end covers. Signal wiring should not run in conduit or open trays where power wiring or heavy electrical equipment could contact or interfere with the signal wiring. Twisted, shielded pairs should be used for the best results.

HAZARDOUS LOCATIONS

WARNING	Use this equipment only in those classes of hazardous locations listed on the nameplate. Uses in other hazardous locations can lead to unsafe conditions that can injure personnel and damage equipment.
AVERTISSEMENT	L'équipement décrit ici ne doit être utilisé que dans les catégories d'emplacement dangereux identifiées sur la plaque signalétique. Son emploi dans tout autre catégorie d'emplacement dangereux pourrait présenter des risques, et provoquer des dommages matériels et des blessures.

Refer to Table 1-4 for a list of certifications and approvals applicable to the transmitter.

Refer to the *Installing a 4 to 20 mA Transmitter in a Hazardous Location* application guide for additional information when using equipment in a hazardous area (Table 1-2). This document is available from both TBI-Bailey Controls or Bailey Controls Company.

RADIO FREQUENCY INTERFERENCE

Most electronic equipment is influenced by radio frequency interference (RFI). Caution should be exercised with regard to the use of portable communications equipment in the area. Post appropriate signs in the plant.

MOUNTING

The design of the transmitter allows for wall mounting using the bracket assembly provided, or it may be mounted to a two-inch pipe (Figure 3-1) using the universal mounting kit. Select an installation site that is free from vibration and that conforms to the temperature constraints listed in Table 1-4.

WIRING CONNECTIONS AND CABLING

The signal wiring and sensor connections for the transmitter are located on the back of the electronics housing when the cover is removed.

Signal Wiring

Select point-to-point mode or field bus mode and connect the signal wiring as described in the appropriate procedure.

POINT-TO-POINT MODE (ANALOG)

In the point-to-point mode of operation, complete the electrical connections in the typical two-wire, four to 20 milliamp fashion. The signal terminals, located in the back of the electronics housing (Figure 3-2), accept wire sizes to 14 AWG. The housing is marked **SIG** for the signal connection and also shows the polarity.

Signal wiring should not be run in conduit or open trays where power wiring or heavy electrical equipment could contact or interfere with the signal wiring. Twisted, shielded pairs should be used for best results. Reverse polarity protection, built into the transmitter, protects it against accidental reversal of the field wiring connections.

NOTE: Power must be free of any AC potential. AC on the power wiring can interfere with transmitter communications.

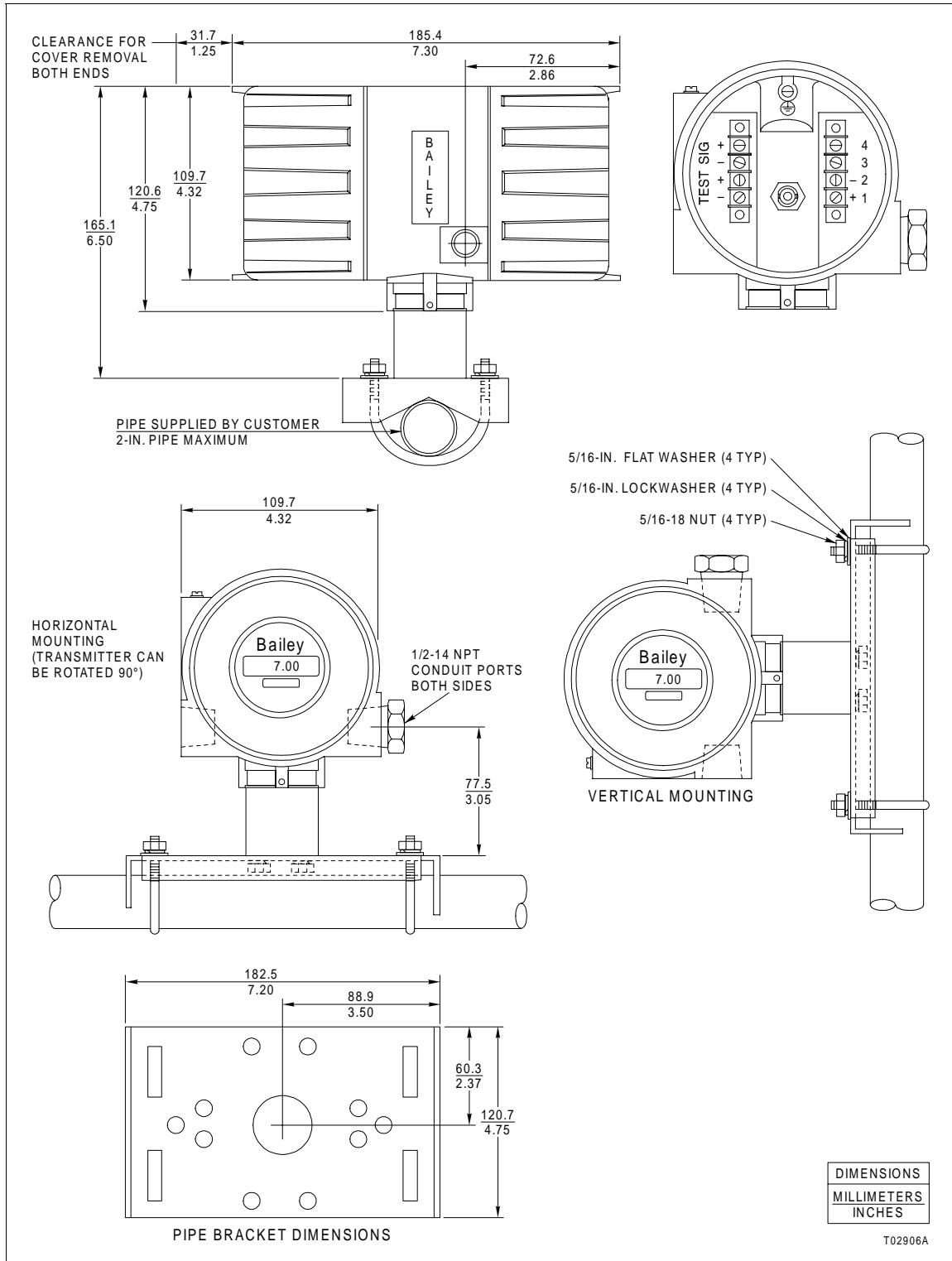


Figure 3-1. Typical Mounting of a Series TBN580 or TBN581 Transmitter

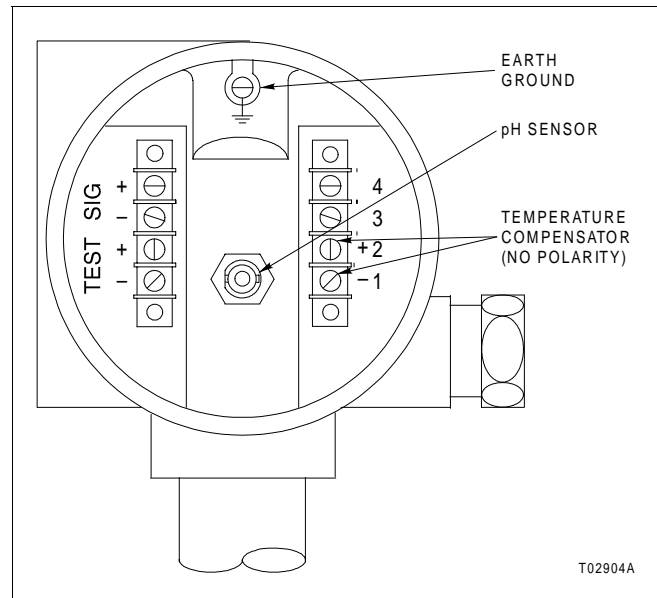


Figure 3-2. Wiring Connections

All power passes over the signal leads via a standard 24 VDC system power supply. The maximum supply voltage is 42 VDC. Minimum power supply voltage is determined by the loop resistance as follows:

$$\text{Min. supply} = 13 \text{ V} + 0.020 \text{ A } \xi \text{ load resistance (in } \Omega \text{)}$$

$$\text{Min. supply for communications} = 18 \text{ V with } 250\text{-}\Omega \text{ resistor}$$

Load resistance must include any meters external to the transmitter, the wiring, and the system input (Figure 1-2). Power supply regulation is not critical as long as supply voltage remains above the minimum value required to drive the external load resistance.

NOTE: The transmitter must be connected to a good earth ground at the earth ground terminal.

To monitor loop current without disturbing the existing wiring, two terminals are marked **TEST** and are also marked for polarity (Figure 3-2). A jumper is placed across the test terminals during normal operation and removed during testing.

NOTE: When removing this jumper, a minimum of 13.7 volts is required at the terminals of the transmitter.

FIELD BUS MODE (DIGITAL)

In this mode, up to 15 transmitters can share a common set of signal wires. There is no four to 20 milliamp output from the transmitter. Each transmitter draws less than four milliamps. The process variable of each transmitter is a digitally poled

variable. The IMFBS01 Field Bus Module sequentially asks each transmitter on the bus for its output. Each transmitter on the bus has its own unique address, programmed during calibration (refer to [Section 5](#)). Using these addresses, the module knows with which transmitter it is communicating.

Each transmitter on the bus connects by wiring the signal leads from the control system to the positive and negative **SIG** terminals of the transmitter (Figure [3-2](#)). Maximum wire size is 14 AWG. Signal wiring should not be run in conduit or open trays where power wiring or heavy electrical equipment could contact or interfere with the signal wiring. Twisted, shielded pairs should be used for best results. Reverse polarity protection, built into the transmitter, protects it against accidental reversal of the field wiring connections.

NOTE: Power must be free of any AC potential. AC on the power wiring can interfere with transmitter communications.

Connect the transmitters on the bus in parallel.

Minimum field bus power supply voltage is determined by the xloop resistance as follows:

$$\text{Min. supply} = 13 \text{ V} + [(0.004 \text{ A} \times \text{no. of transmitters}) \times \text{load resistance (in } \Omega)]$$

Load resistance must include the resistance of the wire and the system input. Do not place any meters or measuring devices into the field bus loop, because the transmitters do not output an analog process variable.

Refer to the IMFBS01 instruction for detailed information on wiring practices and maximum distance between transmitters on the bus.

The Type STT02 terminal can be connected anywhere there is access to the signal leads. Since the terminal also has its own bus address, it can be connected to the field bus even while the control system is on-line. Only one terminal can be connected to the field bus at any one time. While the field bus is active (on-line), the terminal can monitor any transmitter on the bus. To change a calibration or configuration parameter using the handheld terminal, the transmitter must be brought off-line. Changes to the transmitter parameters are normally done using the IMFBS01 Field Bus Module.

Sensor Wiring

The sensor wiring is located adjacent to the signal wiring. It contains a terminal strip for the leads from the temperature compensation sensor (if used), and a mating connector for the BNC connector from the sensor.

Connect the leads from the temperature compensation sensor (if used) as shown in Figure 3-2. The pH, ORP, or pION sensor leads must be connected through the BNC connector. Approved extension cables may be used.

NOTE: Do not connect the sensor lead wires to a terminal strip. Use the BNC connector only. If any means other than the BNC connector is used, the high impedance circuitry will be degraded and the indicated analysis will not be correct.

For additional protection, sensor wiring can be run in conduit or other protection from the environment. Do not allow the wires or BNC connector to become wet. The cables should not lay on the ground or over any other equipment. Make sure they are not abraded, pinched or bent at installation. The BNC connector must be insulated from ground or metal conduit. Make certain the black rubber cap provided is positioned over the BNC connector. If the cap is lost, use black electrical tape.

Grounding

Signal wiring may be either ungrounded (floating) or grounded at any one point in the signal loop. If more than one transmitter is connected to a single power supply, grounding should be at the supply. The case must be grounded. A ground terminal is provided.

OTHER EQUIPMENT INTERFACE

The Type STT02 terminal can be connected anywhere there is access to the signal leads. Since the terminal also has its own bus address, it can be connected to the field bus even while the control system is on-line. Only one terminal can be connected to the field bus at any one time. While the field bus is active (on-line), the Type STT02 terminal can monitor any Series TBN580 or TBN581 transmitter on the bus. To change a calibration or configuration parameter using the handheld terminal, the transmitter must be brought off-line. Changes to transmitter parameters normally occur using the IMFBS01 Field Bus Module.

Refer to the IMFBS01 instruction for detailed information on wiring practices and maximum distance between transmitters on the bus.

LCD DISPLAY ROTATION

CAUTION

Remove DC power before performing these procedures. Failure to do so can damage the equipment.

ATTENTION

Interrompez l'alimentation c.c. avant d'effectuer ces procédures. Toute négligence à cet égard risque de provoquer des dommages matériels.

If better viewing of the LCD is desirable, the LCD (if supplied) rotates 360 degrees, in 90-degree increments. The transmitter comes with the LCD in an upright position (Figure 3-3, view A). The procedures that follow assume the rotation to be from this position.

1. Turn off power to the unit.

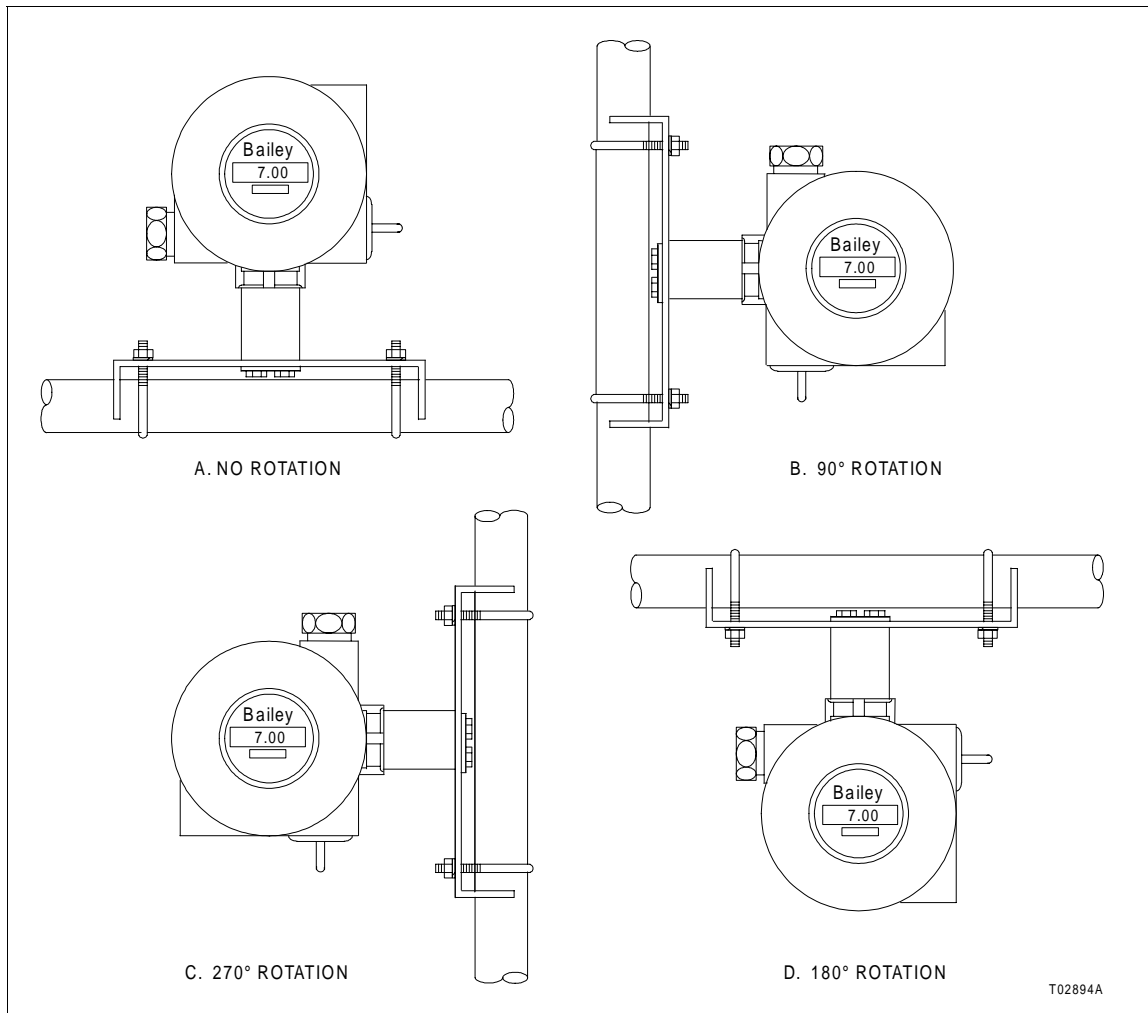


Figure 3-3. LCD Rotation

2. Remove the end cover from the electronics side of the transmitter housing.
3. Remove the two screws holding the LCD support plate to the microcomputer board (Figure 3-4).

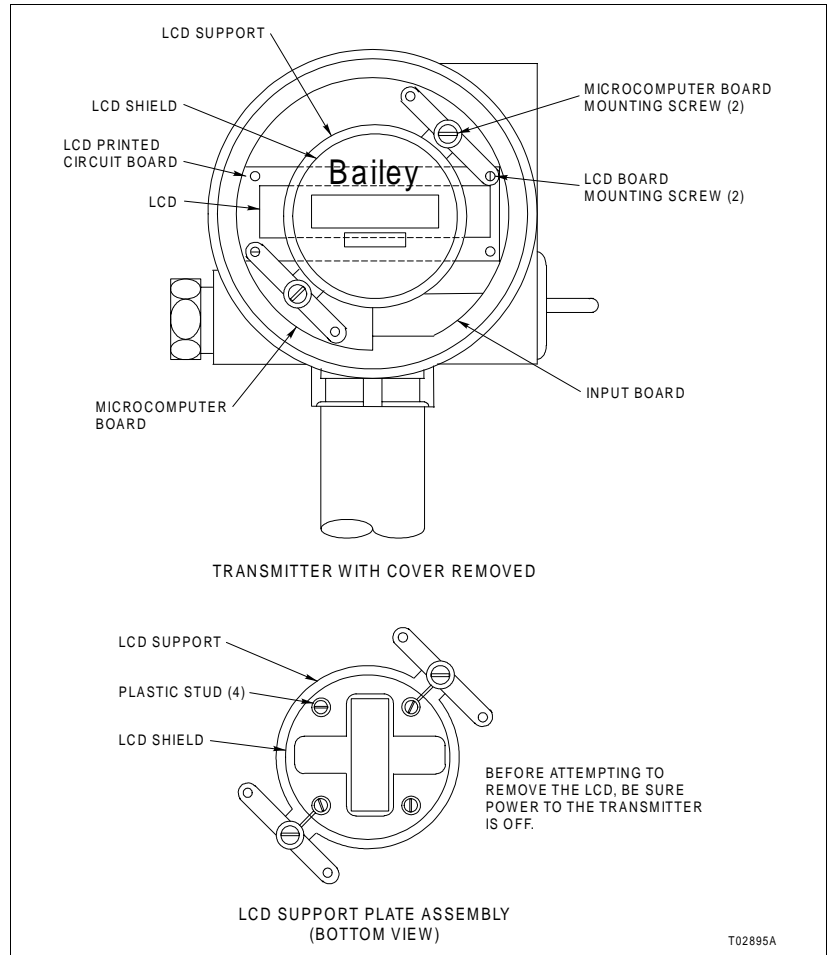


Figure 3-4. Removing the Optional LCD Assembly

4. Pull the LCD support plate free from the microcomputer board.
5. Remove the two screws holding the support plate assembly to the LCD assembly.
6. Separate the LCD shield from the support plate by gently pressing the plastic studs on the bottom of the assembly.
7. Rotate the top half of the shield clockwise and press together.
8. Locate the appropriate connector for the desired orientation (i.e., P1, P2, P3 or P4). Plug the LCD/support assembly into the appropriate connector.

9. Put the support plate assembly back on the LCD assembly. Be sure the **TBI-Bailey** is at the top of the display in relation to the **UP** silkscreened on the LCD board.
10. Replace and tighten the screws to secure the support plate to the LCD assembly.
11. Replace and tighten the two screws to secure the LCD/support plate assembly to the microcomputer board.
12. Screw the cover onto the transmitter housing.
13. Restore power to the unit.

SECTION 4 - CALIBRATION

INTRODUCTION

Fully configured and calibrated transmitters may be ordered from the factory. Fully calibrated transmitters only require standardizing (using the process calibration procedure) after installation of the sensor in the field. Transmitters not factory calibrated or improperly bench calibrated must undergo proper bench calibration procedures prior to process calibration or transmitter use. The process calibration procedure will not provide a correct calibration if an improper bench calibration has been performed.

The transmitter requires repeat calibration if servicing necessitates changing the zero and span points, or changing the amplifier assembly or pH converter assembly.

The calibration procedures are divided into two sections: one for pH measurement and one for ORP/pION measurement. Included in each of these sections are bench and process calibration procedures using the Type STT02 Smart Transmitter Terminal. Any transmitter not calibrated at the factory requires bench calibration. Process calibration is the preferred method of calibrating a pH sensor in the field. To use the process calibration procedure, the transmitter must have been correctly bench calibrated at some prior time.

SERIES TBN580 pH CALIBRATION

Equipment Required for Bench Calibration

The following equipment is required for bench calibration of the transmitter:

- Power supply: 24 VDC, ± 1 VDC output.
- Resistor: 250-ohm, $\frac{1}{2}$ -watt minimum, ± 0.1 percent.
- Digital voltmeter (DVM): 4- $\frac{1}{2}$ digit display minimum.
- pH/ORP simulator or sensor and desired reference solutions, or a millivolt source.
- Type STT02 Smart Transmitter Terminal.
- Temperature meter for measuring solution temperature: ± 0.5 degrees Centigrade accuracy.
- Resistor: 3.01-kilohm, $\frac{1}{4}$ -watt minimum, ± 1 percent (if temperature compensation sensor is not used).

pH Calibration Procedures (Series TBN580)

The following calibration procedures apply only to transmitters configured for pH sensor inputs (Series TBN580). These procedures also include information on automatic or manual temperature compensation techniques.

pH BENCH CALIBRATION PROCEDURE (SERIES TBN580)

NOTE: All Series TBN580 and TBN581 transmitters are bench calibrated at the factory. This procedure is not necessary if a two-point buffer calibration is not deemed necessary. If this procedure is not done, a process calibration procedure with the sensor must be performed.

The bench calibration may be performed with pH buffer solutions in order to test the transmitter with its sensor. The best results will be obtained with the transmitter if a pH sensor simulation instrument or DC millivolt generator is used for the bench calibration prior to placing the transmitter in service. The following procedure is written for the use of buffers or a pH sensor simulator. The millivolt values generated by a pH sensor simulator are given in [Appendix A](#). Process pH calibration is recommended as a final calibration procedure before putting the transmitter and its sensor into service.

1. Connect the transmitter in a calibration setup. If the optional temperature compensation sensor is not used, attach a 3.01-kilohm, ¼-watt resistor across the terminals designated for the optional temperature compensation sensor. If using the temperature compensation sensor, remove the resistor and connect the sensor lead wires to those terminals.
2. Turn on the transmitter power and wait 15 minutes for equipment stabilization before continuing.

NOTE: Without the temperature compensation sensor, automatic temperature compensation techniques cannot be performed.

3. The Type STT02 terminal must be turned on and connected to the transmitter within the 4 to 20 mA loop.
4. Press **CALIBRATE** on the Type STT02 terminal. Step down to the *BENCH CAL pH* selection and press **ENTER**.
5. The input source is requested. Three choices appear: *SAME SENSOR*, *NEW SENSOR* and *mV SOURCE*. Enter the correct choice.
6. The display shows the type of temperature compensation chosen during configuration. When bench calibrating, the *AUTO SOLUTION* and *AUTO PURE H₂O* selections will not be used. *AUTO NERNSTIAN* is the default compensation for the above two types. Once the chosen temperature compensation

appears on the screen, press **ENTER** (this screen does not permit changes). Configuration is required if the type shown is incorrect.

7. The display shows the temperature at which the compensation algorithms are performed. The value displayed comes from either the auto temperature compensation input, or it defaults to 25°C (77°F). Integral automatic temperature compensators are generally slow to react to buffer temperatures if previous use or storage of the sensor was done at temperatures other than ambient.

If the displayed temperature is incorrect, enter the correct value. When the temperature displayed is correct, press **ENTER**.

NOTE: Buffer temperatures must be measured carefully and accurately; otherwise, bench calibration will be incorrect and invalid.

8. Enter the low and high pH calibration values. For buffer calibration with a sensor, enter the actual buffer pH value at calibration temperature. Refer to Table 5-2 for correct values.

NOTE: Buffer pH values appearing on the container label represent buffer pH at a specific temperature, typically 25°C (77°F). The actual pH of the buffer may differ considerably at higher or lower temperatures. Refer to Table 5-2 for proper pH values.

9. For millivolt source calibration, enter the pH represented by the applied millivolts. Refer to Tables A-1 and A-2 for proper pH values.

10. The default values for buffer calibration are 4.01 and 7.00 pH. The default values for mV source calibration are 0.00 and 14.00 pH. When the correct values are displayed, press **ENTER**.

11. Apply the low pH calibration input. The desired low calibration point (or the uppermost display) appears and will not vary. The uncalibrated input value, as determined by the transmitter, also is displayed. This value will be fluctuating, and will generally not agree with the desired input. When the value stabilizes, press **ENTER**.

12. Apply the high pH calibration input. The desired high calibration point (or the uppermost display) appears and will not vary. The uncalibrated input value, as determined by the transmitter, also is displayed. This value will be fluctuating, and will generally not agree with the desired input. When the value stabilizes, press **ENTER**.

13. The calculated efficiency determined by the new calibration slope appears on the display. Press **ENTER** to access the next

screen. Refer to **Sensor Efficiency** in Section 6 for additional information.

14. The calculated sensor offset displays in pH units. Press **ENTER** to access the next screen. Refer to **Calculated Sensor Offset** in Section 6 for additional information.

15. The cumulative sensor offset displays in pH units. This represents the change in offset for any particular sensor over its entire service life. This value resets to 0.00 pH if an input source of *NEW SENSOR* is chosen. Millivolt source calibrations will not affect this calibration. After reviewing this screen, press **ENTER**. Refer to **Cumulative Sensor Offset** in Section 6 for additional information.

pH PROCESS CALIBRATION PROCEDURE (SERIES TBN580)

The process calibration procedure is the preferred method of calibrating a pH sensor in the field. In order to use this procedure, the transmitter must have undergone bench calibration at some previous time. The following is a step-by-step procedure for performing the process pH calibration procedure.

NOTE: As shipped from TBI-Bailey, all Series TBN580 transmitters have been bench calibrated at the factory. Because of this, it is acceptable to begin sensor calibrations with a process calibration procedure as described here.

1. The transmitter must be powered. The Type STT02 terminal must be turned on and connected to the transmitter or connected to the 4 to 20 mA loop.
2. Press **CALIBRATE** on the handheld terminal. Three choices are provided. Step down to the *PROCESS pH CAL* selection and press **ENTER**.
3. Indicate whether or not a new sensor has been installed for this calibration. Answering *yes* resets the sensor cumulative offset to 0.00 pH. After specifying *yes* or *no*, press **ENTER**.
4. The type of temperature compensation configured for the transmitter is displayed. If the choice displayed is incorrect, the transmitter requires configuration. If the choice displayed is correct, press **ENTER**.
5. The process temperature, as determined by the automatic temperature compensator, is displayed. If the temperature displayed is incorrect, change it at this time. A change in temperature modifies the calibration of the temperature input as well. When the process temperature is properly displayed, press **ENTER**.
6. The current pH of the process is displayed. Key in the desired pH of the process as determined by a sample pH mea-

surement. If a delay occurs in determining the sample pH value, note the transmitter display when a sample is drawn. Measure the sample independently and determine the difference between the sample and the transmitter display. Key in a value that makes up for that difference. When the correct value is displayed, press **ENTER**.

NOTE: When measuring the pH of the sample with a lab meter, make sure that the temperature of the sample is compensated. In some cases, the pH of the sample may change value as the sample cools. Refer to **Desired Temperature Compensation Type** in Section 5. Samples should not be left open to the atmosphere. Samples may deteriorate as time passes.

7. The sensor efficiency displays as determined by the previous calibration: either bench or process. This efficiency can be changed to reflect sensor current status. Incorrect bench calibrations can be edited at this time.

A new pH sensor is at least 98% efficient. This is a reasonable default value to use when actual sensor efficiency is unknown, but the sensor exhibits normal response to changes. When the value displayed is correct, press **ENTER**. Refer to **Sensor Efficiency** in Section 6 for additional information.

8. The calculated sensor offset displays in pH units. After reviewing this screen, press **ENTER**. Refer to **Calculated Sensor Offset** in Section 6 for additional information.

9. The cumulative sensor offset displays in pH units. This is the change in offset for any particular sensor over its entire service life. This value resets to 0.00 pH if an input source of **NEW SENSOR** is chosen. Millivolt source calibration will not affect this calculation. After reviewing this screen, press **ENTER**. Refer to **Cumulative Sensor Offset** in Section 6 for additional information.

ph BENCH CALIBRATION TEMPERATURE (SERIES TBN580)

Bench calibration temperature is a shortcut to calibrating the pH sensor's temperature compensator to process temperature or for changing the temperature at which manual temperature compensation is performed.

1. The transmitter must be powered. The Type STT02 terminal must be turned on and connected to the transmitter or connected to the 4 to 20 mA loop.
2. Press **CALIBRATE** on the handheld terminal. Three choices are provided. Step down to the **BENCH CAL TEMP** selection and press **ENTER**.
3. If using an automatic temperature compensator, enter the correct process temperature. If **MANUAL TEMPERATURE COM-**

PENSATION has been chosen, enter a value that represents the average temperature of the process or the temperature at which pH accuracy is most important.

4. After entering the proper data, press **ENTER**.

SERIES TBN581 ORP/pION CALIBRATION

These procedures apply only to transmitters configured for ORP or pION sensor inputs (Series TBN581).

The ORP/pION transmitter reads the millivolt signal produced by ORP (oxidation reduction potential) and pION (specific ion) sensors directly.

The effect of temperature on ORP sensors is negligible. The effect of temperature on pION sensors is unknown, except for specific applications. For these reasons, the use of an automatic temperature compensator provides no benefit and is not offered. However, temperature change alters solution potentials (ORP) and ionic specie concentrations (ORP and pION). Even when solution or process chemistry remains almost constant, any slight changes may change the effect of temperature on an ORP or pION measurement. Therefore, the effects of temperature on the solution cannot be predicted. When comparing field and laboratory data, if temperature changes occurred in the field, duplicate these changes in the lab. During wet calibration, keeping the temperature constant from calibration to calibration becomes crucial.

ORP measurement is typically applied when holding an excess of a chemical specie in a solution or monitoring the progress of a reaction. Any change in chemistry affects these readings, including changes in pH. Therefore many ORP measurements require pH control or comparison to match process conditions.

The lack of commercially prepared buffers hampers calibration of ORP sensors. Usually ORP analyzer calibrations use a millivolt source. Sensors are then connected and installed without further calibration. Comparing the repeatability of the sensor to known, static process conditions and adjusting the transmitter reading to agree provides a simple method for subsequent calibrations. Refer to **ORP/pION Process Calibration Procedure (Series TBN581)**.

For wet bench calibrations, standard ORP solutions can be prepared by mixing $\frac{1}{8}$ -teaspoon of quinhydrone in pH 4.01 and 7.00 buffers. The oxidation reduction potential produced remains repeatable for each brand or batch of buffers used, but an offset from one batch/brand to another could exist (Table 4-1).

Table 4-1. ORP Solution Millivolt Values

Buffer Solution	Temperature °C (°F)	mV
4.01 pH + quinhydrone	0 (32)	268
	25 (77)	263
	35 (95)	258
7.00 pH + quinhydrone	0 (32)	92
	25 (77)	86
	35 (95)	79

ORP/plON Bench Calibration Procedure (Series TBN581)

Refer to **Equipment Required for Bench Calibration** for a list of the necessary hardware.

1. Connect the transmitter in a calibration setup.
2. Turn on the transmitter power and wait 15 minutes for the equipment to stabilize before continuing.
3. The Type STT02 terminal must be turned on and connected to the transmitter.
4. Press **CALIBRATE** on the handheld terminal.
5. Use **↑** and **↓** to step down to the *BENCH CAL* selection and press **ENTER**.
6. The input source is requested. Three choices appear: *SAME SENSOR*, *NEW SENSOR* and *mV SOURCE*. Enter the correct choice.
7. The next screen asks for the low and high mV calibration values. These are the values used to calibrate the transmitter. Enter the mV values that the mV source will supply or the ones indicative of the solutions used for calibration. The low reading will be the most negative value if calibrating in negative voltage areas. Press **ENTER** after recording each value.
8. Apply the low mV calibration input. The desired low calibration point (or the uppermost display) appears and does not vary. This represents the actual value entered in Step 7. The lower display represents the uncalibrated mV input from the DC millivolt generator or sensor. This value fluctuates and generally does not agree with the desired input. When the value stabilizes, press **ENTER**.
9. Apply the high mV calibration input. The desired high calibration point (or the uppermost display) appears and does not vary. This represents the actual value entered in Step 7. The lower display represents the uncalibrated mV input from the DC millivolt generator or sensor. This value fluctuates and gen-

erally does not agree with the desired input. When the value stabilizes, press **ENTER**.

10. The efficiency displays as calculated during this procedure. Press **ENTER** to access the next screen.

11. The calculated sensor offset displays. Press **ENTER** to access the next screen. Refer to **Calculated Sensor Offset** in Section 6 for additional information.

12. The cumulative sensor offset displays. This represents the change in offset for any particular sensor over its entire service life. This value resets to 0.00 mV if an input source of **NEW SENSOR** was chosen in Step 6. After reviewing this screen, press **ENTER**. Refer to **Cumulative Sensor Offset** in Section 6 for additional information.

ORP/pION Process Calibration Procedure (Series TBN581)

The process calibration procedure is the preferred method of calibrating an ORP or pION sensor in the field. In order to use this procedure, the transmitter must have undergone bench calibration at some previous time. Refer to **ORP/pION Bench Calibration Procedure (Series TBN581)**.

1. Turn off the power to the transmitter and wait 15 minutes for equipment stabilization before continuing.
2. Turn on the Type STT02 terminal and connect it to the transmitter 4 to 20 mA current loop.
3. Press **CALIBRATE** on the handheld terminal.
4. Three choices appear. Press **↓** or **↑** to select **PROCESS CAL**. Press **ENTER**.
5. Indicate whether or not a new sensor has been installed for this calibration. Answering *yes* resets the sensor cumulative offset to 0.00 mV. After specifying *yes* or *no*, press **ENTER**.
6. The current mV value of the process displays, and the desired mV value is requested. To enter this value, the output potential of the sensor assembly must be known. Refer to **SERIES TBN581 ORP/pION CALIBRATION** for more information.
7. Enter the value determined in Step 6 and press **ENTER**.
8. The sensor efficiency displays as determined by the previous calibration: either bench or process. If desired, change this efficiency to reflect current sensor status. Edit incorrect bench calibrations at this time.

9. Enter the value in percent (usually 98% to 100%). Refer to **Sensor Efficiency** in Section 6 for additional information.
10. The calculated sensor offset displays in mV. After reviewing this screen, press **ENTER**. Refer to **Calculated Sensor Offset** in Section 6 for additional information.
11. The cumulative sensor offset displays in mV. This is the change in offset for any particular sensor over its entire service life. This value resets to 0.00 mV if *NEW SENSOR* was chosen in Step 6. After reviewing this screen, press **ENTER**. Refer to **Cumulative Sensor Offset** in Section 6 for additional information.

D-A Adjustment (Fine Tuning the Analog Output)

Compensation for slight inaccuracies in the four to 20 milliamp current loop (or in receiving devices such as recorders) is accomplished by accessing the calibration menu while the Type STT02 handheld terminal is connected to the target transmitter.

1. Select *D-A ADJUSTMENT* and press **ENTER**. The instruction *ADJUST TO 4 mA THEN HIT ENTER* appears on the terminal display. Using **↑** and **↓** on the terminal, adjust for exactly 4.00 mA as determined by an ammeter placed in series with the transmitter current loop. If using a receiving unit (e.g., recorder), adjust for a 0% indication. Press **ENTER** when correct.
2. The instruction *ADJUST TO 20 mA THEN HIT ENTER* appears on the terminal display. Adjust the current as displayed by the ammeter to 20.00 mA or to the 100% indication of the receiving unit by using **↑** and **↓** on the Type STT02 terminal. Press **ENTER** when correct.

SECTION 5 - OPERATING PROCEDURES

INTRODUCTION

The Series TBN580 and TBN581 transmitters can be monitored and controlled using the Bailey Type STT02 Smart Transmitter Terminal. The terminal can be connected anywhere there is access to the signal wires.

INITIALIZATION/START-UP PROCEDURES

Transmitter configuration using the Type STT02 terminal includes defining an ID tag number, transmitter address (digital mode), engineering units, damping constant, lower and upper range values and output parameters.

Use **CONFIG** and follow the step-by-step procedures in the Type STT02 Smart Transmitter Terminal product instruction.

CONFIGURATION

Configuration consists of selecting an ID tag, choosing a communication mode, the type of sensor input, temperature compensation selection and other operating parameters.

ID Tag

The ID tag is a 14-character alphanumeric tag which can be programmed into the transmitter.

Communication Mode

Communication is established between the transmitter and the remote terminal by wiring the transmitter for point-to-point or field bus mode.

POINT-TO-POINT MODE

In the point-to-point mode, the transmitter puts itself into the analog mode, providing a four to 20 milliamp output signal in proportion to the input. No transmitter address is required. When in an analog mode (point-to-point), do not connect the transmitter to a field bus; this arrangement will not support analog output devices.

FIELD BUS MODE

The transmitter address is used for field bus operation. Each transmitter on the field bus must have a separate address. The

address range is one through 15, and when programmed, the transmitter places itself into the digital mode and no four to 20 milliamp output signal appears. The output **locks** below four milliamps.

Sensor Input

Choose whether a standard pH sensor, an antimony pH sensor, or an ORP/pION sensor will be used.

STANDARD pH SENSOR

Select *STANDARD pH SENSOR* for any pH sensor having a glass electrode as the measuring element and a Ag/AgCl (silver/silver chloride) reference with KCl (potassium chloride) electrolyte. Efficiency calculations assume calibration to 25 degrees Centigrade (77 degrees Fahrenheit) with a theoretical slope of 59.15 millivolts per pH unit. All temperature compensation choices are compatible with this choice. Thermo-isopotential is at 7.00 pH.

ANTIMONY pH SENSOR

An antimony pH sensor uses a plug of antimony metal as the measuring device rather than the glass electrode used in standard sensors. Antimony sensors are used only in highly erosive applications as they require abrasion across the electrode face to work efficiently. A freshly abraded antimony sensor will produce a nominal slope of 51 millivolts per pH unit.

Isopotential point is 1.0 pH. Efficiency is factored at the 51 millivolt value. A lack of fresh antimony surface will lower this efficiency. A Ag/AgCl (silver/silver chloride) reference with KCl (potassium chloride) electrolyte is used with antimony sensors. Temperature compensation choices are locked on manual with the antimony sensor choice. Internally, all pH temperature compensation values are locked at 25 degrees Centigrade (77 degrees Fahrenheit) for antimony sensors.

ORP AND pION SENSORS

The effect of temperature on ORP sensors is negligible. The effect of temperature on pION sensors is unknown, except for specific applications. For these reasons, the use of an automatic temperature compensator provides no benefit and is not offered. However, temperature changes alter solution potentials (ORP) and ionic specie concentrations (ORP and pION). Even when solution or process chemistry remains almost constant, any slight changes may change the effect of temperature on an ORP or pION measurement. Therefore, the effects of temperature on the solution cannot be predicted. When comparing field and laboratory data, if temperature changes occurred in

the field, duplicate these changes in the lab. During wet calibration, keeping the temperature constant from calibration to calibration becomes crucial.

ORP measurement is typically applied when holding an excess of a chemical specie in a solution or monitoring the progress of a reaction. Any change in chemistry affects these readings, including changes in pH. Therefore, many ORP measurements require pH control or comparison to match process conditions.

Temperature Compensation Input

NOTE: All sections related to temperature compensation apply only to transmitters that are being configured for pH sensor inputs (Series TBN580).

Two choices exist for the temperature compensation input. The first choice is a 3.01-kilohm Balco coil. TBI-Bailey pH sensors having an automatic temperature compensator, or separate automatic temperature compensator Model TB590, contain this type of temperature compensation input.

The second choice, for pH measurements made without temperature compensation, is *NONE* (manual). In this mode, it is necessary to place a 3.01-kilohm resistor across the temperature compensation terminals. An input choice of *NONE* (manual) sets the transmitter in manual temperature compensation mode.

Desired Temperature Compensation Type

Temperature has two effects on pH measurement. The first effect (the Nernstian effect) is that increasing temperature increases the voltage produced by a pH sensor at all pH values other than the thermo-isopotential point of the sensor (the point where the sensor output is not affected by temperature). For standard pH sensors, this is at 7.0 pH (actual thermo-isopotential). The effect of temperature on a pH sensor can mathematically be described by the Nernst equation as:

$$0.19841 \text{ mV} \xi (T - 25^\circ\text{C}) \xi (\text{pH} - 7)$$

It can be seen by this equation that if pH is near 7.0 or temperature deviates little from 25 degrees Centigrade (77 degrees Fahrenheit), the effect of temperature is small. Table 5-1 describes this effect.

The second effect of temperature is on actual solution pH. This effect cannot be given a general mathematical description. It is different for every solution and the pH value of every solution. Tables 5-2 and 5-3 describe this effect for **stable** pH buffers and some solutions.

The transmitter allows four types of temperature compensation: manual, auto-Nernstian, auto solution, and auto pure H₂O (water).

Table 5-1. Standard pH Electrode Output at Temperature (in Millivolts)

pH	Temperature °C (°F)				
	0 (32)	25 (77)	40 (104)	70 (158)	90 (194)
0	+379.3	+414.0	+434.9	+476.6	+504.4
3	+216.8	+236.6	+248.5	+272.4	+288.2
5	+108.4	+118.3	+124.2	+136.2	+144.1
7	0	0	0	0	0
8	-54.19	-59.15	-62.13	-68.09	-72.05
10	-162.6	-177.5	-186.4	-204.3	-216.2
12	-270.1	-295.8	-310.7	-340.5	-360.3
14	-379.3	-414.0	-434.9	-476.6	-504.4

Table 5-2. Effects of Temperature on Stable pH Buffers

Temperature °C (°F)	pH 4.01 Buffer	pH 6.87 Buffer	pH 9.18 Buffer	pH 12.45 Buffer
0 (32)	4.00	6.98	9.46	13.42
25 (77)	4.01	6.87	9.18	12.45
50 (122)	4.06	6.83	9.01	11.71
70 (158)	4.13	6.85	8.92	11.22
100 (212)	4.25	6.90	8.81	10.65

Table 5-3. Temperature Effects on Specific Solutions

Temperature °C (°F)	Pure H ₂ O (pH)	NH ₄ NO ₃ (pH)
18 (64)	7.12	7.47
25 (77)	7.00	—
50 (122)	6.64	6.27
70 (158)	6.41	—
90 (194)	6.23	5.18

MANUAL

Temperature compensation compensates the pH value for the effects of temperature on the sensor (Nernstian effect) at a specific temperature. An automatic temperature compensator is not required to use this method. Any temperature between -20 degrees and +150 degrees Centigrade (-4 degrees and +302 degrees Fahrenheit) can be entered into the transmitter and the correct compensation factor will be applied to reference the pH value back to 25 degrees Centigrade (77 degrees Fahrenheit).

If an antimony sensor is selected as the sensor type, the temperature compensation is automatically selected to be manual. If selecting manual temperature compensation, enter the process temperature (limits are -20 degrees to +150 degrees Centigrade, or equivalent degrees Fahrenheit). The default value of 25 degrees Centigrade (77 degrees Fahrenheit) is recommended for all applications.

AUTO NERNSTIAN

Standard automatic temperature compensation requires an input from a temperature sensing device. Typically, this is a TBI-Bailey automatic temperature compensator which can be either integral to the sensor or a separate device. Refer to Table 5-4.

Standard automatic temperature compensation will correct the pH reading for the effects of temperature on the pH sensor for any temperature within the range of measurement. Correction will be to 25 degrees Centigrade (77 degrees Fahrenheit).

*Table 5-4. TBI-Bailey
Temperature Compensator
Resistance Values*

Temperature °C (°F)	Resistance (kΩ)
0 (32)	2.68
25 (77)	3.00
40 (104)	3.19
50 (122)	3.32
70 (158)	3.58
90 (194)	3.83
100 (212)	3.96
120 (248)	4.22
140 (294)	4.47

AUTO SOLUTION

If automatic solution compensation is selected, the solution coefficient must be entered (pH/10 degrees Centigrade, limits are -1.000 to +1.000 pH).

Auto solution temperature compensation also requires an input from a temperature sensing device, i.e., a TBI-Bailey automatic temperature compensator. This method compensates for the effect of temperature on the pH sensor the same as the standard automatic method. Additionally, it allows a

user-entered coefficient to match the effect of temperature on solution pH according to the following formula:

$$\text{Nernst pH} \frac{(\text{Temp} - 25^{\circ}\text{C})}{10} X$$

where:

X = Change in pH for 10°C (18°F) change.

NOTE: Auto/solution pH can only be used for processes that are extremely repeatable in both pH values measured and chemical constituents present.

To use auto solution compensation, a representative sample of the process must be taken and pH measured with a pH sensor **and** a standard automatic temperature compensator at two distinct temperatures. The change in pH between the two measurements must be divided by the change in temperature and multiplied by ten. If pH dropped as temperature was increased, the coefficient used for solution compensation must be positive (+). Conversely, if pH increased as temperature increased, the coefficient must be negative (-).

$$\text{Nernst pH} \frac{(\text{Temp} - 25^{\circ}\text{C})}{10} X$$

where:

X = Change in pH for 10°C (18°F) change.

Example: Pure water: $x = +0.18$ pH per 10°C (18°F)
Pure water with 1 ppm ammonia: $x = +0.31$ pH per 10°C (18°F)

AUTO PURE H₂O

A temperature compensation routine specific to pure water applications is chosen by selecting *AUTO PURE H₂O*. This routine includes Nernstian compensation for the pH electrode and nonlinear solution compensation for pure water. This nonlinear compensation distinguishes separate sets of algorithms for neutral, acidic and basic pure water solutions.

Desired Temperature Display Units

Select the units of the process temperature, in degrees Centigrade or Fahrenheit, that will be displayed on the Type STT02 terminal screen during calibration or monitor modes.

NOTE: The internal computations of the transmitter that contain temperature as a variable will always be done in degrees Centigrade regardless of the selection chosen to be displayed on the process display screen.

Output Parameters

The various output commands allow definition of transmitter output type and action under normal operating conditions. These commands also permit definition of the output value during start-up and/or a diagnosed failure of the transmitter, sensor, or wiring.

OUTPUT TYPE

The transmitter output should be specified as linear with respect to the input, or as a function generator. If function generator output is selected, the five input and output points as a percent of output must also be specified.

OUTPUT ACTION

A transmitter in the ***normal acting*** mode has an output that increases with increasing input. The output of a transmitter acting in the ***reverse acting*** mode decreases with increasing input.

Damping Adjustment

Damping is adjustable and provides time constant values from 0.00 to 32.00 seconds selected electronically by the Type STT02 Smart Transmitter Terminal. Damping adjustments have no effect on the calibration or accuracy of the transmitter, but can smooth out a fluctuating input signal.

Primary Lower and Upper Range Values

The transmitter range (analog equals four to 20 milliamps, digital equals percent of input span) may be set through configuration to any value within the input span. Values entered determine the analog output span of pH or millivolt values; i.e., four pH equals four milliamps, ten pH equals 20 milliamps.

Primary Engineering Units

The primary engineering units come preprogrammed for the transmitter: pH equals pH, ORP equals millivolts and pION equals millivolts.

Secondary Lower and Upper Range Values

The transmitter secondary lower and upper range values can be set to any range within ± 9999 . The Type STT02 terminal or the optional LCD display monitor these ranges. The ranges are a function of the output of the device; therefore, if a nonlinear output such as function generator is selected, the LCD or

terminal display in nonlinear units. These units represent the nonlinear function generator.

Secondary Engineering Units

With the Type STT02 Smart Transmitter Terminal, secondary engineering units can be programmed. These units use a free-form format of six characters. Any six characters can be programmed into the transmitter such as milliamps (mA) or millivolts (mV). These units are used in conjunction with the secondary lower and upper range values.

Store Configuration

If using the Type STT02 terminal, the present configuration can be stored in the memory of the terminal. The message *STORE THIS CONFIGURATION* appears on the terminal display. Only a *YES* response will store the configuration in memory.

Send Configuration

If the Type STT02 terminal is not connected to the transmitter at this time, do so. Press **SEND CONFIG** and select the appropriate tag number.

The configuration procedure is complete. To review the configuration, refer to **Get Configuration**.

Get Configuration

To review a configuration once the transmitter has been configured, press **GET CONFIG** on the Type STT02 terminal.

CONFIGURATION LOCKOUT

The transmitter has a lockout feature that, once engaged, allows all transmitter functions to be monitored. This feature, however, prevents the transmitter configuration or calibration from being altered. To use the lockout feature, change jumper J1 on the microcomputer board from pins two and three to pins one and two (Figure 5-1). To gain access to this board, refer to **ELECTRONICS ASSEMBLY REMOVAL/REPLACEMENT** in Section 8.

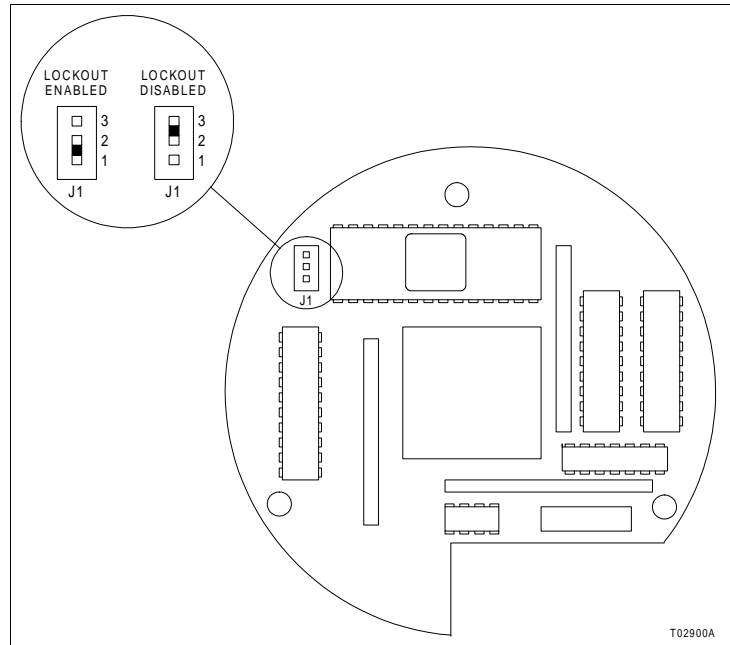


Figure 5-1. Configuration Lockout Feature Jumper Location on Microcomputer Board

INITIALIZATION

WARNING

The outputs of smart devices change to a fixed value during initialization and detected failure conditions. These values must be selected by the user to ensure safe operation.

AVERTISSEMENT

Les signaux de sortie des transmetteurs intelligents prennent une valeur fixe au moment de l'initialisation, ainsi que lors de la détection d'une défectuosité. L'utilisateur doit affecter une valeur qui assurera un fonctionnement sécuritaire.

On power up, a two-second initialization period occurs during which the transmitter output becomes either 100 percent or zero percent as defined during configuration. Initialization low sets the output to zero percent (four milliamps) while initialization high sets the output to 100 percent (20 milliamps). The default initialization value is zero percent (four milliamps). After initialization, the output ramps up from four milliamps (zero percent) or down from 20 milliamps (100 percent) to the correct value.

FAILURE CONDITIONS

If during its continual diagnostics the microcomputer detects a problem fatal to the transmitter or system, the transmitter output will be set to a predetermined level. This level must be selected during configuration. The default level is set low at zero percent (four milliamps).

NOTE: For a transmitter in the *normal acting* mode, zero percent corresponds to four milliamps and 100 percent to 20 milliamps. For a transmitter in the *reverse acting* mode, zero percent coincides with 20 milliamps and 100 percent with four milliamps.

SPECIAL FEATURES

Additional programming features are available when using the Type STT02 terminal.

Local LCD Setup

The local LCD can be programmed to display output in percent or secondary engineering units, or input in primary engineering units. Refer to the Type STT02 Smart Transmitter Terminal product instruction. Press **SPECIAL FEATURE** on the Type STT02 terminal to program this feature. If the variable to be displayed is outside the range of ± 9999 , the LCD flashes lines across the display.

Fix Output/Cancel Fix Output

For system troubleshooting purposes, the transmitter output can be set to a constant, specified as a percent of span input. Select *FIX OUTPUT* from the special features menu on the Type STT02 terminal. Refer to the Type STT02 terminal product instruction.

MONITORING AND STATUS CHECK COMMANDS

Various transmitter status and monitor functions are available using the Type STT02 terminal.

Monitor Input

To monitor the transmitter input, press **OUTPUT** on the Type STT02 terminal and select *REPORT INPUT* from the output menu. Refer to Type STT02 terminal product instruction. The input displays in primary engineering units and updates every second.

Monitor Output

To monitor the transmitter output, press **OUTPUT** on the Type STT02 terminal and select *REPORT OUTPUT* from the output menu. Refer to Type STT02 terminal product instruction. The output displays as a percent of span and updates every second.

Monitor Sensor Parameters

Three more uses for **SPECIAL FEATURE** exist other than those previously mentioned. When connected to the Series TBN580 and TBN581 Smart Transmitters, **SPECIAL FEATURE** can also interrogate the calculated sensor efficiency, the calculated sensor offset and the cumulative sensor offset.

Monitor Sensor Temperature

To display the sensor temperature, press **OUTPUT** on the Type STT02 terminal and select *MONITOR TEMPERATURE*.

Monitor Secondary Engineering Units

To monitor the secondary engineering variable using the Type STT02 terminal, press **SPECIAL FEATURE** on the terminal and select *MONITOR SECONDARY UNITS*. The value reflects the output of the transmitter expressed as a percentage of the secondary lower and upper range values, and displays in secondary engineering units.

Transmitter Status Check

The status of the transmitter, determined from results of the continuous self-diagnostics, can be checked with the Type STT02 terminal. Refer to [Section 6](#) for the applicable corrective action.

Reranging the Analog Output

Press **RE-RANGE** on the Type STT02 handheld terminal and the current (four to 20 milliamp) output can be quickly reranged to represent a different portion of the input span. This procedure bypasses the need to completely redo the configuration of the transmitter. Damping can also be adjusted during the rerange procedure.

SECTION 6 - TROUBLESHOOTING

INTRODUCTION

The Series TBN580 and TBN581 transmitters continuously run through a series of self-diagnostics, monitoring such areas as configuration integrity and input circuitry. Refer to the Type STT02 Smart Transmitter Terminal instruction.

GROUND LOOPS

NOTE: A ground loop condition can easily and irreversibly destroy a pH reference.

A ground loop is a path between the process liquid ground and a second ground point elsewhere in the system. This path allows unwanted current to flow through the measurement circuitry. The typical symptom is an offset or erratic measurement in the process line, while getting a correct measurement in an isolated beaker of buffer or process liquid.

Ground loops can be caused by:

- The sensor assembly BNC connector contacting ground either through metal conduit or the housing.
- A sensor extension cable connector contacting water in a conduit run or the housing, and that water making contact with a grounded fitting.
- A sensor or extension cable with nicked insulation contacting metallic conduit. (This could be an intermittent problem.)
- An internal fault on a printed circuit board shorting input to output, while either side of the output current loop is grounded.

To verify a ground loop, measure the resistance from the sensor BNC connector shell to earth ground (transmitter ground terminal). An ohmmeter should indicate infinity on its highest range. A reading near zero ohms denotes a direct ground connection. There are two ways to perform this test:

- If the sensor is difficult to remove from the process line or vessel, disconnect the BNC connector at the transmitter. Perform the resistance test on the shell of the female connector attached to the transmitter. If no ground loop is indicated, then removal of the sensor from the process line or vessel becomes necessary. Upon removal of the sensor, do the resistance test on the shell of the male connector attached to the sensor cable.

- If the sensor can be removed easily, remove it from the process line or vessel. Perform the resistance test on the BNC connector at the transmitter and check both the female and male ends to determine where the ground loop exists.

SENSOR TROUBLESHOOTING

The transmitter contains diagnostic features concerned with sensor status and performance: sensor efficiency, sensor offset, sensor cumulative offset, sensor temperature low, and sensor temperature high.

Efficiency and offset values are updated and displayed during bench or process calibration. These values, as well as sensor temperature status, can be accessed by pressing **SPECIAL FEATURE** on the Type STT02 handheld terminal when connected to the associated transmitter of the sensor.

Sensor Efficiency

The calculated sensor efficiency is determined by the bench calibration slope, or by independently testing and entering during the process calibration. Sensor efficiency is calculated by the actual slope divided by the theoretical slope. An acceptable range of sensor efficiency is between 70 percent and 100 percent. If the transmitter calibration calculations show the efficiency below the acceptable range, actual solution temperature, as well as solution pH at that temperature, must be verified. Incorrect entry of these parameters is the most common cause of low efficiency calculations.

Other causes are fouled or exhausted pH sensors. Clean the sensor thoroughly. Refer to **Sensor Cleaning** in Section 7 for cleaning procedures. When cleaning is complete, repeat the bench calibration procedure in **Section 4**. If the second calibration again shows efficiency below 70 percent and the sensor reacts slowly, sensor replacement is advisable.

Low efficiency display with a sensor that reacts quickly to buffer changes indicates the sensor is in good condition, but that incompatibilities between process and buffer chemistries preclude accurate buffer calibration. Process calibration with a manually entered 95 percent to 98 percent efficiency is strongly recommended.

Sensor efficiencies above 100 percent are theoretically and practically impossible. Only improper calibration causes a sensor efficiency above 100 percent. Typical calibration errors include entering too low a temperature or an incorrect pH value. As the pH of the buffer solution changes with temperature, the buffer temperature must be entered accurately. The change in buffer pH must also be considered when entering the pH calibration value.

Repeated attempts that result in sensor efficiencies above 100 percent indicate that final calibration must be done using the process calibration procedure.

NOTE: Antimony pH sensors may be quite serviceable with efficiencies as low as 50 percent.

Calculated Sensor Offset

The calculated sensor offset displays in pH units. Typical TBI-Bailey sensors have an offset of +0.5, ± 0.2 pH when received. The high salt concentration in the TBI-Bailey solid state reference (potential) causes this offset.

An acceptable range of offset is ± 2.5 pH, depending upon the application and age of the sensor. Generally, the sensor offset (reference potential) gradually increases as a sensor ages. If the increase is gradual, this is not cause for concern. Stability of the reference offset is the greater concern. The effect of sensor reference offset is eliminated during the bench or process calibration of the transmitter. Sensor replacement should be considered if the offset ever exceeds the acceptable range of ± 2.5 pH.

Cumulative Sensor Offset

The cumulative sensor offset displays in pH units. This represents the change in offset for any particular sensor over its entire service life. This value resets to 0.00 pH if an input source of *NEW SENSOR* is chosen. Millivolt source calibrations will not affect this calibration.

Sensor Temperature High or Low

Press **MONITOR** to access *SENSOR TEMP*. Press **STATUS** to access *SENSOR TEMP STATUS*.

NOTE: This section applies only to transmitters configured for pH sensor inputs (Series TBN580).

An automatic temperature compensator is required before this diagnostic feature can be functional. Full diagnostic capability is affected only if the automatic temperature compensator is integral to the pH sensor. Use of Type TB590 separate temperature compensator results in diagnostic capability that does not include potential sensor deficiencies.

Indication of sensor temperatures below -25 degrees Centigrade (-13 degrees Fahrenheit) or above 150 degrees Centigrade (302 degrees Fahrenheit) is cause for concern. No TBI-Bailey pH sensor is rated for use below -5 degrees Centigrade (23 degrees Fahrenheit). Upper temperature limits are 50 degrees, 100 degrees or 140 degrees Centigrade (122 degrees,

212 degrees or 284 degrees Fahrenheit) depending on the type of sensor used. Use of the sensor above or below the high or low diagnostic limits generally causes sensor damage, resulting in inaccurate pH measurements.

Additionally, other measurement deficiencies may be indicated. These deficiencies, in order of occurrence probability, are as follows:

1. Automatic temperature compensator is not connected.
2. Process temperature is above or below the limits of the pH sensor.
3. Sensor cable connectors are wetted (incorrect pH readings result).
4. Sensor cable is damaged (incorrect pH readings result).
5. Extension cable (if used) is not connected (incorrect pH readings result).
6. pH sensor is internally shorted or cracked (incorrect pH readings result).
7. Temperature compensator is open or shorted (incorrect pH readings result, but the sensor can still be used in manual temperature compensation mode).
8. pH sensor is physically broken (incorrect pH readings result).

NOTE: Shorted, cracked, or broken pH sensor assemblies will not always cause the temperature compensator high or low temperature diagnostics to activate.

If trouble with the sensor is evident, refer to Tables 6-1 and 6-2. See Figure 6-1 for an illustration of sensor components.

Table 6-1. Sensor Troubleshooting Guide, pH and ORP

Symptom	Probable Cause	Corrective Action
Noise measurement.	Electrical AC or RF interference. Lack of adequate shielding.	Run cable in metal conduit or reroute cable.
Sensor glass bulb is discolored.	Mishandling, normal wear, exceeding temperature rating, unexpected heavy solids in process.	Replace sensor. Recheck process conditions and make sure the sensor is correct for the application.
Fill solution in glass bulb is discolored.	Mishandling, normal process wear, exceeded temperature rating, cracked electrode.	Replace sensor.
Sensor glass bulb is dirty, coated or black.	Process contamination.	Clean sensor (refer to Section 7). Consider relocation of the sensor in the process.

Table 6-1. Sensor Troubleshooting Guide, pH and ORP (continued)

Symptom	Probable Cause	Corrective Action
Reference junction is dirty, coated or clogged.	Process contamination.	Clean sensor (refer to Section 7).
Reference junction is dry.	Poor storage or sensor not in process.	Soak sensor in potassium chloride (KCl) solution. Retest. Relocate sensor in process.
Chemical degradation.	Process attack.	Obtain process history and contact TBI-Bailey. May be necessary to switch to Teflon® junction if wood has been previously used.
Sensor body cracked, warped or leaking.	Process attack.	Contact TBI-Bailey with process description for possible alternative body material.

Table 6-2. Troubleshooting the pH Sensor Using Wet Testing in a Buffer Solution

Symptom	Possible Cause	Corrective Action
Slow response or noisy, erratic readings.	Process contamination.	Clean sensor (refer to Section 7). Check the cable. If a problem still exists, replace the sensor.
Reading holds at 7.0, ±1.0 pH.	Shorted cable connection, cracked glass.	Test cable. Replace cable and/or sensor if necessary.
Reading sticks at 14 pH or drifts off scale.	Open circuit, cracked glass.	Check connections. If glass is cracked, replace sensor.
Large pH offset. ¹	Reference junction defective or ground loop exists.	Clean reference junction. Expose new wood or Teflon. Boil in a solution of potassium chloride (KCl). Check for a ground loop and correct if necessary. Replace sensor if problem still exists.
Sluggish response or noisy signal. ²	Coated or chemically depleted glass electrode. ²	Clean sensor (refer to Section 7). Replace the sensor if problem still exists.
No response. pH holds at fixed value. ²	Cracked or depleted glass electrode.	Replace sensor.

NOTES:

1. Wet check reference junction only with known good glass electrode.
2. Wet check glass electrode only with known good reference junction.

TRANSMITTER DIAGNOSTICS

If the transmitter cannot implement any command, the Type STT02 terminal identifies the problem. Press **STATUS** on the handheld terminal to display an error message. The error messages and the corrective action to take when the transmitter diagnostics detect a problem appear in [Table 6-3](#). See [Figure 6-2](#) for additional help in troubleshooting the transmitter. If the transmitter is not communicating with the Type STT02 terminal, complete or check the following items:

1. Cycle power (off/on) on both the transmitter and on the Type STT02 terminal. If a problem still exists, go to Step 2.
2. Check for AC on power lines. Presence of AC may be intermittent. AC will corrupt communications. The power supply must be filtered if AC is present.

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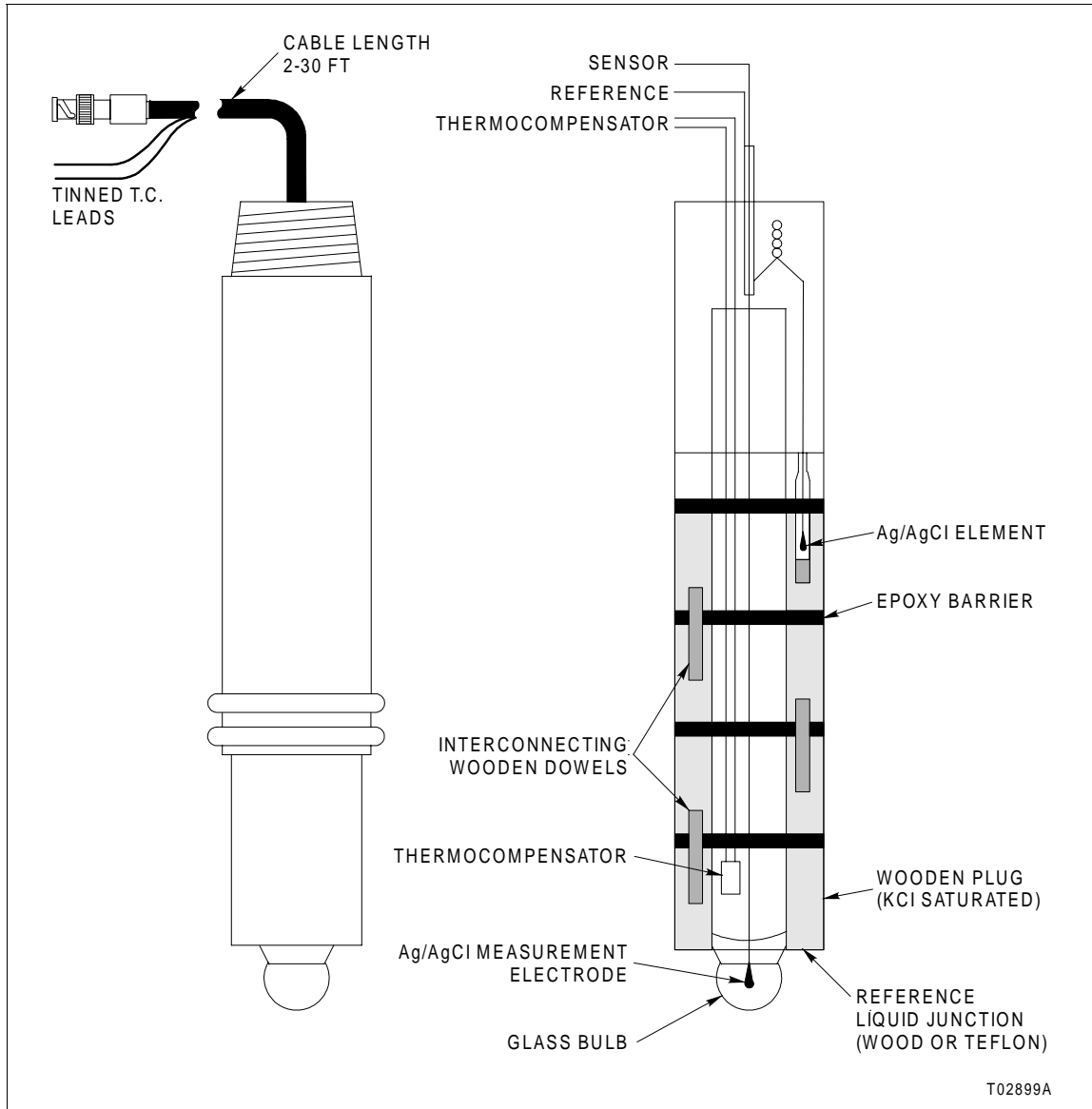


Figure 6-1. Sensor Components

Table 6-3. Error Messages

Error Message	Probable Cause	Corrective Action
Checksum error.	The data the transmitter received did not pass a checksum test (data corrupted).	Extreme line noise could cause this code to randomly appear. Since the transmitter and STT02 do check data for integrity, this is not a problem. If error code appears frequently, replace amplifier assembly. Refer to ELECTRONICS ASSEMBLY REMOVAL/REPLACEMENT in Section 8.
Cannot execute due to hardware problems.	Detected error in hardware. Input possibly over allowable range.	Press STATUS on the STT02 and use this table for appropriate corrective action.

Table 6-3. Error Messages (continued)

Error Message	Probable Cause	Corrective Action
Lockout engaged command not allowed.	The hardware lockout jumper on the microcomputer board is set in the lockout mode. No parameters can be changed when this jumper is set in the lockout mode.	Refer to CONFIGURATION LOCKOUT in Section 5 and Figure 5-1.
On-line with FBM command not allowed.	The STT02 is normally not used when the transmitter is in the field bus mode. The terminal cannot change parameters while the field bus is active.	Normal communications are through the field bus module. The field bus module can change parameters. Transmitter must be taken off-line. There is a 2-min. time-out period until the STT02 will be allowed to change parameters. After the 2-min. time-out, the transmitter will allow the terminal access.
Failed RAM check.	Microcomputer defective.	Replace electronics assembly. Refer to Section 8 .
Failed EEPROM check.	The microcomputer has a detected a memory problem.	Configure and calibrate the transmitter. The microcomputer will attempt to fix the problem. If it cannot, it will send out a MICROCOMPUTER BAD error message.
Microcomputer bad.	The microcomputer cannot retain configuration and calibration data. Microcomputer board is defective.	Replace the electronics assembly. Refer to Section 8 .
A-D failure.	Input board or microcomputer board is defective.	
Input failure.	Input board failure.	Check input board connections. Refer to ELECTRONICS ASSEMBLY REMOVAL/REPLACEMENT in Section 8. Replace electronics assembly. Refer to Section 8 .
Over range or under range.	Input out of range.	Make sure the proper input is applied to the transmitter. Calibrate the transmitter. If error is still present, go to next paragraph. Input board not connected properly. Check the connections. Replace the electronics assembly. Refer to Section 8 .
Input signal applied incorrectly.	Input signal is not correct.	Correct the input signal and calibrate.
Output in fix output or adjust mode.	STT02 turned off when the output was fixed to a value or while the 4 to 20 mA output was being adjusted.	Power down the transmitter and then power up the transmitter.
Temp over/under	Refer to Sensor Temperature High or Low .	Refer to Sensor Temperature High or Low .

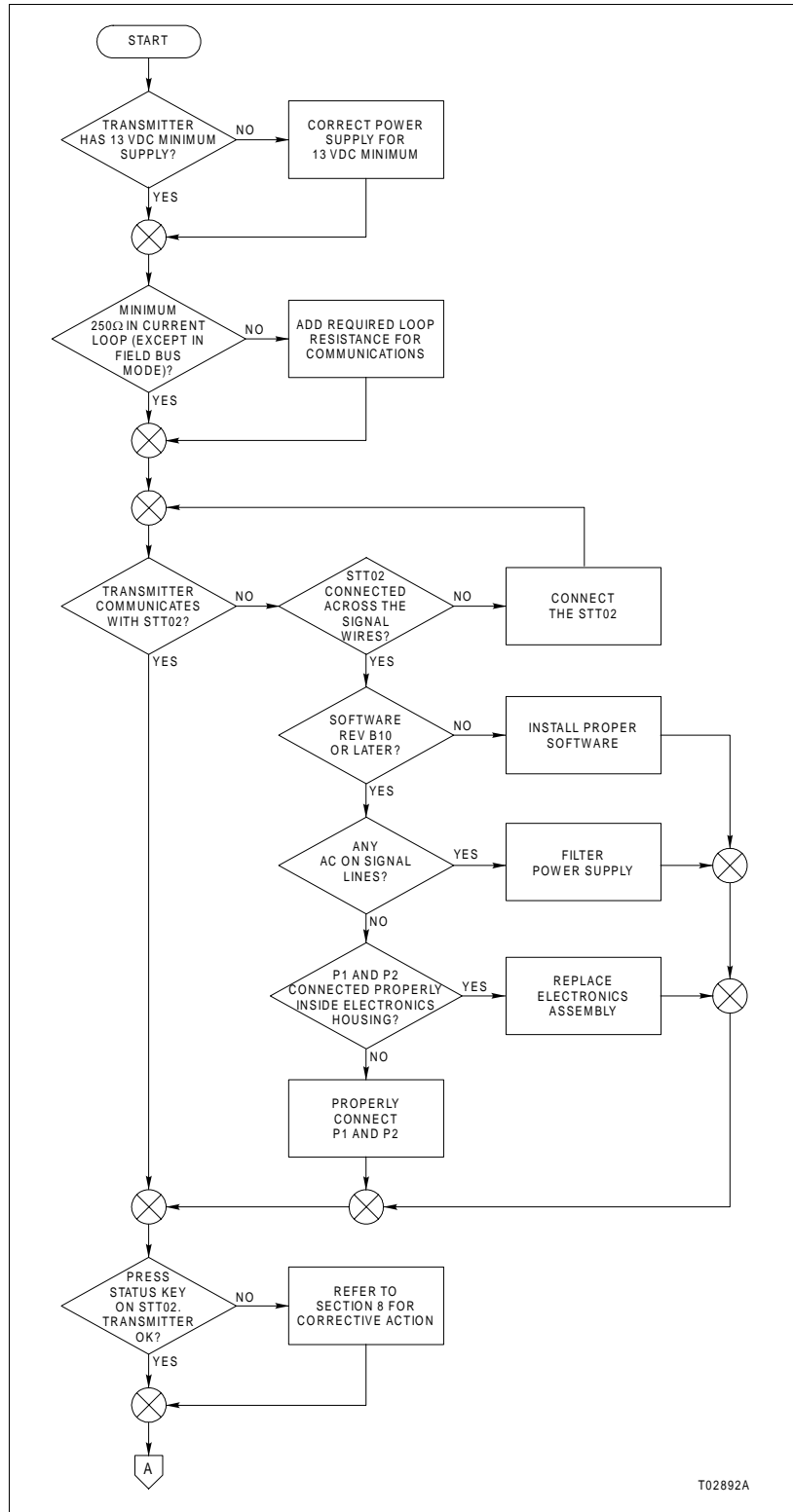


Figure 6-2. Transmitter Troubleshooting Flowchart (1 of 2)

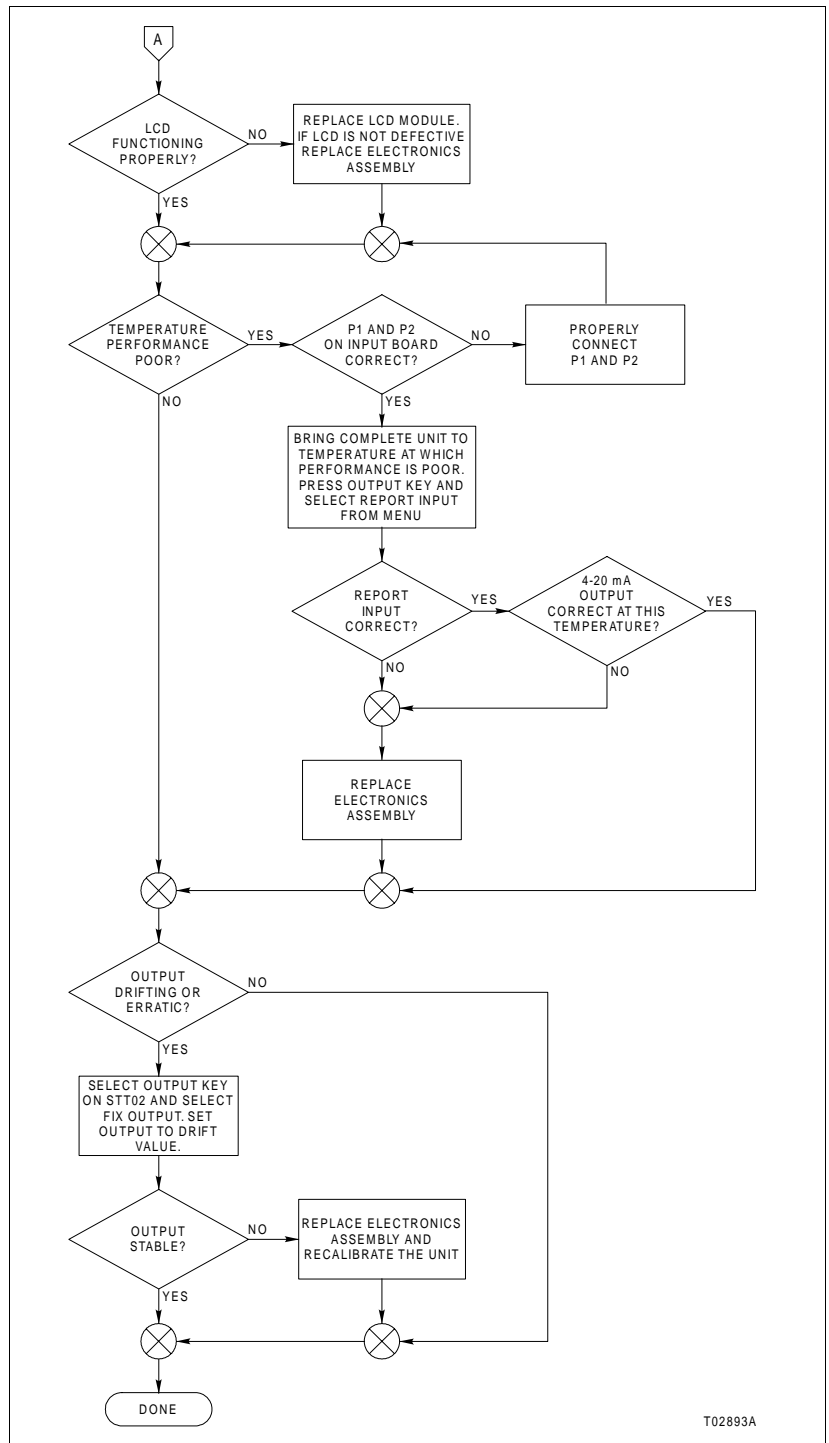


Figure 6-2. Transmitter Troubleshooting Flowchart (2 of 2)

SECTION 7 - MAINTENANCE

INTRODUCTION

WARNING

Secure the process before performing this procedure. Performing this procedure while the equipment is in the process can upset that process. Some process upsets can injure personnel and damage equipment.

AVERTISSEMENT

Mettez le processus dans un état d'arrêt stable avant d'effectuer cette procédure. Si vous effectuez cette procédure tandis que l'équipement intervient dans le processus, ceci risque de perturber le processus, ce qui pourrait provoquer des blessures et des dommages matériels.

Maintenance personnel should be qualified electrical technicians or engineers that know the proper use of test equipment. They should also be familiar with the transmitter, have experience working with process control systems, and know what precautions to take when working on live systems.

The reliability of any stand-alone product or control system is affected by the maintenance of the equipment. TBI-Bailey Controls strongly recommends that all equipment users practice a preventive maintenance program that will keep the equipment operating at an optimum level.

PREVENTIVE MAINTENANCE SCHEDULE

Table 7-1 is the preventive maintenance schedule for the Series TBN580 and TBN581 transmitters. The table lists the preventive maintenance tasks in groups according to their specified maintenance interval. Some tasks in Table 7-1 are self explanatory. Instructions or tasks that require further explanation are covered under **PREVENTIVE MAINTENANCE PROCEDURES**.

Table 7-1. Preventive Maintenance Schedule

Task	Frequency
Clean optional LCD faceplate. Operating conditions may require more frequent cleaning. See procedure.	3 months
Check and tighten all wiring connections, including power and ground connections.	6 months
Check and tighten all conduit connections.	
Clean sensor. Operating conditions may require more frequent cleaning. See procedure.	As needed. Minimum: monthly

PREVENTIVE MAINTENANCE PROCEDURES

This section covers tasks from Table 7-1 that require specific instructions or further explanation: cleaning the optional LCD display area and sensor cleaning.

Optional LCD Display Cleaning

Equipment required:

- Window cleaning solution.
 - Soft, lint-free cloth.
1. Use a soft, lint-free cloth and gentle window cleaning solution to clean the optional LCD display.
 2. Spray the solution on the cloth and apply to the window. Do not directly spray the display area.

Sensor Cleaning

WARNING	System maintenance must be performed only by qualified personnel and only after securing the equipment controlled by the circuit. Altering or removing components from an active circuit may upset the controlled process leading to personnel injury and equipment damage.
AVERTISSEMENT	L'entretien du système ne doit être effectuée que par le personnel qualifié et seulement une fois que l'équipement contrôlé par le circuit est fixé en place. La modification ou le retrait des composants d'un circuit actif pourraient perturber le processus contrôlé et mener à des blessures au personnel et à l'endommagement de l'équipement.

WARNING	Acids and bases can cause severe burns. Use hand and eye protection when handling.
AVERTISSEMENT	L'acide et les bases peut occasionner des brûlures graves. Protéger les mains et les yeux lors de la manutention.

WARNING	Store the solution in a suitable container. Label it as containing an extremely flammable strong acid. Use extreme care when handling. Failure to follow this warning can injure personnel and damage equipment.
AVERTISSEMENT	Entreposez la solution dans un contenant approprié. Apposez-y une étiquette indiquant qu'il contient de l'acide fort extrêmement inflammable. Manipulez avec grand soin. Toute négligence à cet égard risque de provoquer des blessures et des dommages matériels.

A coated or dirty bulb or clogged reference junction may cause a very slow response, as the sensor impedance will be greatly increased. Often the electrode can be rejuvenated by cleaning. The following procedures allow the selection of a cleaning procedure applicable to the contaminant to be removed.

GENERAL PURPOSE CLEANER

A universal electrode cleaner which has proven very effective can be made with the following ingredients.

- One part 4N sulfuric acid.
- One part ten percent hydrochloric acid.
- Two parts methanol or isopropyl alcohol.

This solution has been effective in removing everything from Bunker-C fuel oil to lime scale.

1. Remove the sensor from the process.
2. Soak the electrode in the solution for 2 to 10 minutes.
3. Rinse well in tap water.

REMOVING INORGANIC SCALE, LIGHT SOILING AND FIBERS

Ingredients required:

- One to three Molar hydrochloric acid (HCl).
1. Remove the sensor from the process.
 2. Soak the electrode in 1 to 3 Molar hydrochloric acid (HCl) for 5 to 10 minutes.
 3. Rinse well in tap water.

REMOVING OIL FILMS, GREASE AND HYDROCARBONS

Ingredients required:

- Cotton swabs.
 - One to three Molar hydrochloric acid (HCl).
 - 50/50 mixture of acetone and isopropyl alcohol.
 - Five percent ammonium hydroxide (or commercial ammonia-based cleaner).
1. Remove the sensor from the process.

2. Use a long-handled cotton swab and wipe the electrode with a 50/50 mixture of acetone and isopropyl alcohol.
3. Rinse in tap water.
4. Swish the electrode in a 5% ammonium hydroxide or commercial ammonia-based cleaner for approximate 30 seconds.

NOTE: Avoid using sodium hydroxide solutions. Some electrodes are sensitive to sodium ion poisoning.
5. Rinse well in running tap water.
6. Soak in 1 to 3 Molar hydrochloric acid for 5 minutes.
7. Rinse well in running tap water.

REMOVING PROTEIN BUILDUP

Milk, blood, malt extracts, and some vegetable extracts may cause protein buildup which can be easily removed.

Ingredients required:

- Pepsin.
 - One percent hydrochloric acid.
1. Remove the sensor from the process.
 2. Add a few grams of pepsin to a 1% hydrochloric acid solution and soak overnight.
 3. Rinse well in running tap water.

REMOVING DIFFICULT CONTAMINANTS

NOTE: The following procedure will tend to significantly reduce the usable life and reliability of the sensor. It partially removes the aged gel layer on the electrode, making the bulb thinner and more fragile. The impedance will be lower and the response time faster. This procedure should only be used as a **stop-gap** measure until a replacement sensor can be installed.

Ingredients required:

- One to three Molar hydrochloric acid (HCl).
 - Five percent ammonium bifluoride (NH₄HF₂).
 - 25 percent potassium chloride solution.
1. Remove the sensor from the process.
 2. Clean the electrode by soaking in 1 to 3 Molar hydrochloric acid (HCl) for 5 to 10 minutes.

3. Rinse well in tap water.
4. Swish the electrode around in a 5% solution of ammonium bifluoride for 40 seconds maximum.
5. Rinse well in tap water.
6. Soak in 1 to 3 Molar hydrochloric acid for 20 minutes to insure that all fluoride has been removed.
7. Rinse well in tap water.
8. Soak in a 25% potassium chloride solution for 24 hours to insure a new gel layer has formed before retesting.

REMOVING SILICA GELS AND OTHER SILICA COMPOUNDS

Ingredients required:

- NaOH solution.
1. Remove the sensor from the process.
 2. Soak the sensor in heated 65°C (149°F) 2 to 5 Molar NaOH solution for 10 to 30 minutes.
 3. Rinse the sensor in tap water.
 4. Soak the sensor in 0.5 to 2 Molar HCl for 5 minutes.
 5. Rinse in tap water.

SECTION 8 - REPAIR/REPLACEMENT PROCEDURES

INTRODUCTION

WARNING

Do not substitute components that compromise the certifications listed on the nameplate. Invalidating the certifications can lead to unsafe conditions that can injure personnel and damage equipment.

AVERTISSEMENT

Ne substituez pas des composantes qui pourraient annuler la conformité aux classes figurant sur la plaque signalétique relativement aux endroits dangereux. Ceci peut entraîner des conditions dangereuses qui risquent de provoquer des blessures et des dommages matériels.

WARNING

Do not disconnect equipment unless power has been switched off at the source or the area is known to be nonhazardous. Disconnecting equipment in a hazardous location with source power on can produce an ignition capable arc that can injure personnel and damage equipment.

AVERTISSEMENT

Ne débranchez l'équipement que si l'alimentation a été interrompue ou si l'environnement est non dangereux. Le débranchement de l'équipement sous tension peut produire une étincelle, ce qui peut mener à une explosion et à des blessures au personnel.

This section provides removal and installation procedures for the optional LCD assembly, the EEPROM and the electronics assembly.

OPTIONAL LCD REPLACEMENT

1. Turn off power to the unit. Allow at least 1 minute for the transmitter to discharge.
2. Remove the cover from the electronics end of the transmitter housing.
3. Remove the two screws securing the LCD/support plate assembly to the microcomputer board.
4. Pull the LCD/support plate assembly free from the microcomputer board. Note in which connector (P1, P2, P3 or P4) the LCD is located.
5. Remove the two screws holding the support plate assembly to the LCD assembly.

6. Reverse Steps 2 through 5 to install the new LCD and complete the procedure.
7. Restore power to the unit.

EEPROM REPLACEMENT

Occasionally, the operating software of the transmitter may be updated. This requires replacement of the EEPROM.

1. Turn off power to the unit. Allow at least 1 minute for the transmitter to discharge.
2. Perform Steps 2 through 4 under **OPTIONAL LCD REPLACEMENT**.
3. Remove the EEPROM from its socket, designated by XU2 silk screened on the microcomputer printed circuit board.
4. Insert the new EEPROM in the socket. Make sure the EEPROM is oriented properly and that all pins are firmly inserted in the socket.
5. Reverse Steps 2 and 3 to complete the procedure.
6. Restore power to the unit.

ELECTRONICS ASSEMBLY REMOVAL/REPLACEMENT

1. Turn off power to the unit. Allow at least 1 minute for the transmitter to discharge.
2. Remove the end covers from the transmitter housing.
3. Remove the two screws holding the LCD/support plate assembly to the microcomputer board.
4. Pull the LCD/support plate assembly free from the microcomputer board. Note in which connector (P1, P2, P3 or P4) the LCD is located.
5. Remove the hex nut securing the BNC connector to the housing.

NOTE: Do not lose the insulating spacers that isolate the BNC ground from the housing. There is a spacer on each side of the connector.

6. Remove the wires from connectors P1 (brown) and P2 (brown) on the input board assembly (Figure 8-1).

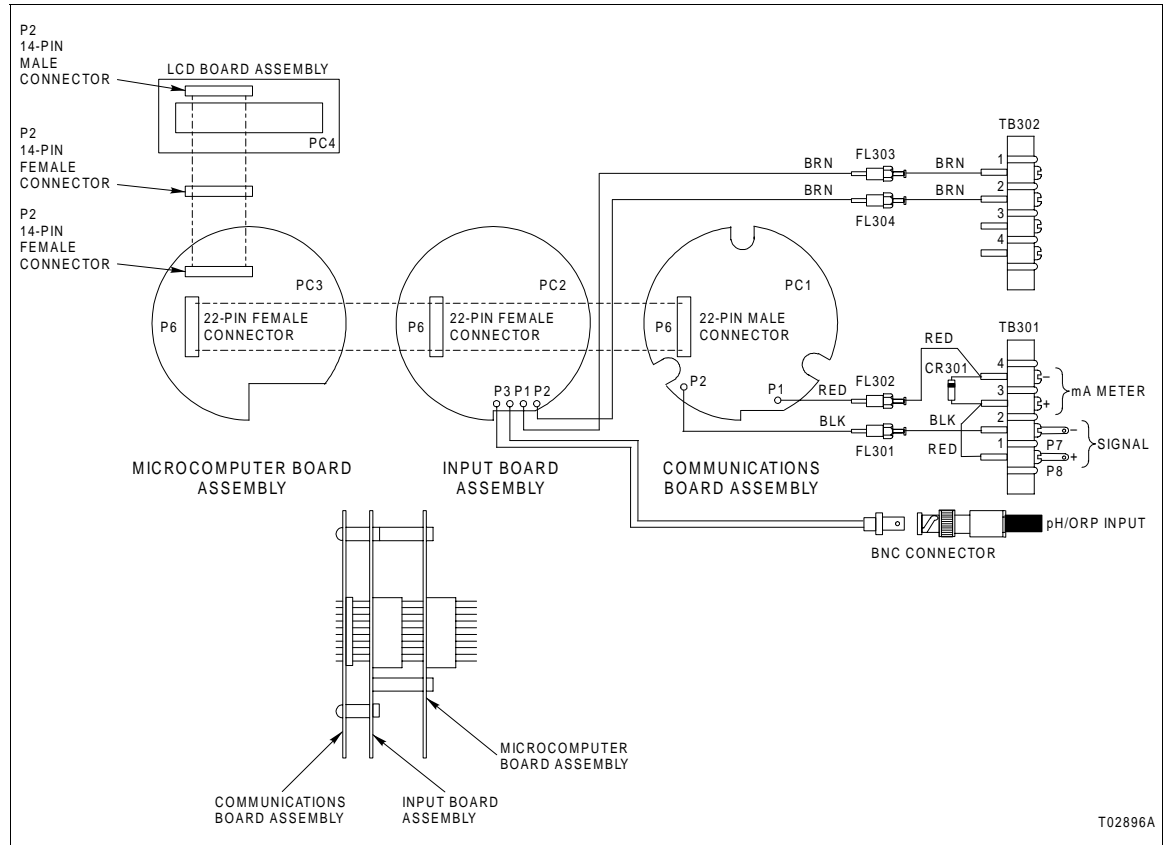


Figure 8-1. Electronics Assembly Replacement

7. Remove the wires from P1 (red) and P2 (black) on the communications board assembly (Figure 8-1). Proper polarity must be observed when installing the new electronics assembly.
8. Remove the entire electronics assembly, including the BNC connector, from the housing.
9. Connect the two brown wires to P1 and P2 on the input board on the new electronics assembly (Figure 8-1).
10. Connect the black wire to P2 and the red wire to P1 on the communications board of the new electronics assembly.
11. Install the insulating washers around the new BNC connector and insert into the opening in the housing. Be sure the washers seat properly in the opening.
12. Place the insulating washer on the other side of the connector and tighten the hex nut. Do not tighten so far as to split the insulating washer.
13. Install the new electronics assembly into the housing.

CAUTION

When installing the electronics assembly, be careful not to pinch any wires between the electronics assembly and the housing. Damage to wire insulation and the resulting inadvertent electrical connection will cause damage to the unit and the process.

ATTENTION

Lorsque vous installez la section électronique, veillez à ce qu'aucun fil ne soit coincé entre la section électronique et le boîtier. Si l'isolant du fil est endommagé, la connexion électrique qui en résulte entraînerait des dommages à l'unité ainsi que la perturbation du processus.

14. Tighten the three screws securing the electronics assembly to the transmitter housing.
15. Install the LCD/support plate assembly in the desired orientation.
16. Tighten the two screws securing the LCD/support plate assembly to the microcomputer board.
17. Install the covers on the transmitter housing.
18. Restore power to the unit.

NOTE: After replacing the electronics assembly, the unit must go through a bench calibration procedure. Refer to *pH Calibration Procedures (Series TBN580)* in Section 4.

REPLACEMENT PARTS

When making repairs at your facility, order replacement parts from a TBI-Bailey sales office. Provide the following information:

1. Part description, part number, and quantity.
2. Model and serial numbers (if applicable).
3. TBI-Bailey instruction number.

When ordering standard parts from TBI-Bailey Controls, use the part numbers and descriptions from the **RECOMMENDED SPARE PARTS LIST**.

RECOMMENDED SPARE PARTS LIST

Table 8-1. Recommended Spare Parts

Part No.	Description
4TB9515_0030	O-ring kit
4TB9515_0031	LCD assembly kit
4TB9515_0032	3-tier electronics assembly
4TB9515_0033	Window kit

Table 8-1 is a list of recommended spare parts to have at your facility.

RETURN MATERIALS PROCEDURES

If any equipment should need to be returned for repair or evaluation, please contact TBI-Bailey at (702) 883-4366, or your local TBI-Bailey representative for a return material authorization (RMA) number. At the time the RMA number is given, repair costs will be provided and a customer purchase order number will be required. The RMA and purchase order numbers must be clearly marked on all paperwork and on the outside of the carton. ***Equipment returned to TBI-Bailey with incorrect or incomplete information may result in significant delays.***

APPENDIX A - pH ANALYSIS AND SENSOR SIMULATION SETUP

SENSOR SIMULATION SETUP

See Figure A-1 for connecting the analyzer to a millivolt generator. If the millivolt generator does not terminate in a BNC connector, connect the positive (+) lead to the inner conductor and the negative lead (-) to the shell of the transmitter BNC for a positive input. For a negative input, reverse the leads.

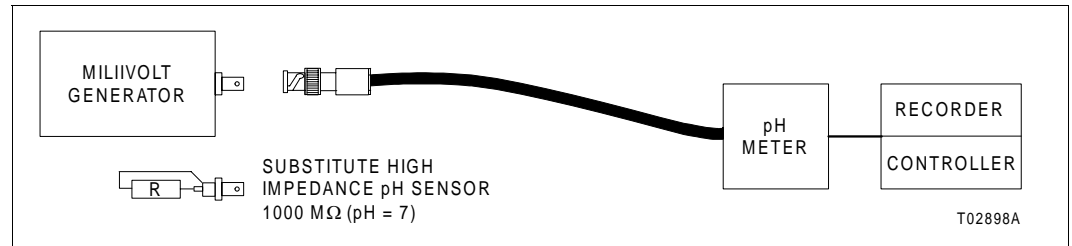


Figure A-1. Setup of pH Analysis System/Sensor Simulation

The values listed under 25 degrees Centigrade (77 degrees Fahrenheit) in Tables A-1 and A-2 should be used to simulate a pH signal when calibrating the current transmitter output. To verify proper setting of the display electronics, use the 25 degrees Centigrade column also.

After the display has been calibrated for correct zero to 14 pH indication, the transmitter outputs can be easily adjusted. Simulate the desired pH values for baseline and full scale output value.

These procedures are to be used only for electronic calibration. The system will still require standardization of the pH sensor. Outputs calibrated by using these instructions will not be adversely affected by sensor standardization.

Table A-1. Theoretical pH Sensor Output at 100% Efficiency (in Millivolts)

pH	Temperature °C (°F)						
	0 (32)	25 (77)	40 (104)	50 (122)	70 (158)	90 (194)	100 (212)
0	+379.3	+414.0	+434.9	+448.8	+476.6	+504.4	+518.2
1	+325.1	+354.9	+372.8	+384.7	+408.5	+423.3	+444.2
2	+270.1	+295.8	+310.7	+320.6	+340.5	+360.3	+470.2
3	+216.8	+236.6	+248.5	+256.5	+272.4	+288.2	+296.1
4	+162.6	+177.5	+186.4	+192.4	+204.3	+216.2	+222.1
5	+108.4	+118.3	+124.2	+128.2	+136.2	+144.1	+148.1

Table A-1. Theoretical pH Sensor Output at 100% Efficiency (in Millivolts) (continued)

pH	Temperature °C (°F)						
	0 (32)	25 (77)	40 (104)	50 (122)	70 (158)	90 (194)	100 (212)
6	+54.19	+59.15	+62.13	+64.12	+68.09	+72.05	+74.03
7	0	0	0	0	0	0	0
8	-54.19	-59.15	-62.13	-64.12	-69.09	-72.05	-74.03
9	-108.4	-118.3	-124.2	-128.2	-136.2	-144.4	-148.1
10	-162.16	-177.5	-188.4	-192.4	-204.2	-216.2	-222.1
11	-216.8	-236.6	-248.5	-256.5	-272.4	-288.2	-296.1
12	-270.1	-295.8	-310.7	-320.6	-340.5	-360.3	-370.2
13	-325.1	-354.9	-372.8	-384.7	-408.5	-432.3	-444.2
14	-379.3	-414.0	-434.9	-448.8	-476.6	-504.4	-518.2

Table A-2. Typical pH Sensor Output at 98% Efficiency (in Millivolts)

pH	Temperature °C (°F) T/C Resistor (kΩ)						
	0 (32) 2.68	25 (77) 3.00	40 (104) 3.19	50 (122) 3.32	70 (158) 3.58	90(194) 3.83	100 (212) 3.96
0	+371.7	+405.7	+426.2	+439.8	+467.1	+494.3	+507.8
1	+318.6	+347.7	+365.3	+377.0	+400.3	+423.7	+435.3
2	+264.7	+289.9	+304.5	+314.2	+333.7	+353.1	+362.8
3	+212.5	+231.9	+243.5	+251.4	+267.0	+282.4	+290.2
4	+159.3	+174.0	+182.7	+188.6	+200.2	+211.9	+217.7
5	+106.2	+115.9	+121.7	+125.6	+133.5	+141.2	+145.1
6	+53.11	+57.98	+60.89	+62.84	+66.73	+70.61	+72.55
7	0	0	0	0	0	0	0
8	-53.11	-57.98	-60.89	-62.84	-66.73	-70.61	-72.55
9	-106.2	-155.9	-121.7	-125.6	-133.5	-141.2	-145.1
10	-159.3	-174.0	-182.7	-188.6	-200.2	-211.9	-217.7
11	-212.5	-231.9	-243.5	-251.4	-267.0	-282.4	-290.2
12	-264.7	-289.9	-304.5	-314.2	-333.7	-353.1	-362.8
13	-318.6	-347.8	-365.3	-377.0	-400.3	-423.7	-453.3
14	-371.7	-405.7	-426.2	-439.8	-467.1	-494.3	-507.8