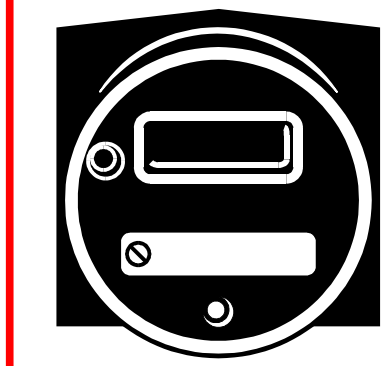
Bailey TBI! PROCESS MONITORING INSTRUMENTS

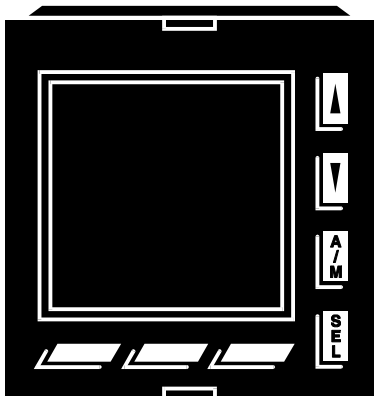
PRODUCT INSTRUCTION

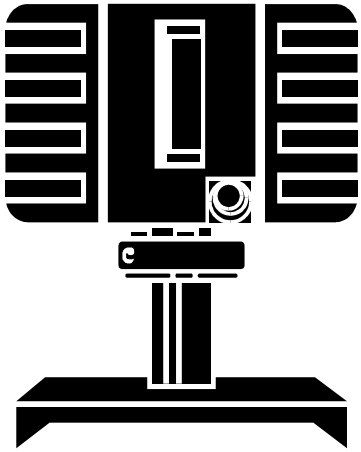
Type TB7

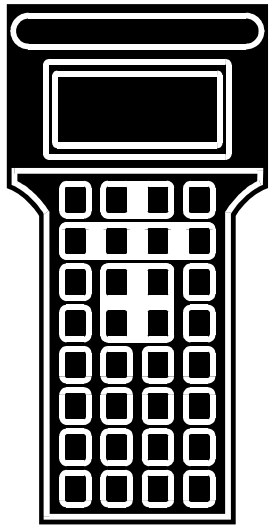
Analytical Controlling Transmitter, pH/ORP

µFACT™ Series









TBI-Bailey Controls

µFACT Series Analytical Controlling Transmitter, pH/ORP
Type TB7

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Preface

This publication is for the use of technical personnel responsible for the installation, operation and maintenance of the TBI-Bailiey Analytical Controlling Transmitter, Type TB701.

List of Effective Pages

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Safety Summary

GENERAL WARNINGS

Hazardous Locations
The equipment described may be used only in those classes of hazardous locations identified on the nameplate.

Substitution of Components
Substitution of components may impair suitability for Class I, Division 2 Hazardous Locations.

Nameplate ratings
Do not at any time exceed the rating listed in the nameplate.

System Maintenance
System maintenance must be performed by qualified personnel and only after securing equipment controlled by the circuit. Altering or rmeoving components from an active circuit may upset the process being controlled.

SPECIFIC WARNINGS

The equipment described may be used only in those classes of hazardous locations identified on the nameplate. (p. 2-3)

Instruments that are powered from AC line voltage constitute a potential for an electrical shock hazard to the user. Make certain the AC line cord or power lines from the operating branch circuit are disconnected from the source before attempting electrical connections. (p. 2-10)

Sensor maintenance must be performed only by qualified personnel and only after securing equipment controlled by the TB7 controller. Cleaning the sensor while connected to an active circuit or disconnecting the sensor from an active circuit may upset the process being controlled. (p. 8-1)

Acids and bases can cause severe burns. Use hand and eye protection when handling. (p. 8-1)

Solution should be stored in a suitable container and labeled as a strong acid and extremely flammable. Use extreme care when handling. (p. 8-2)

Substitution of components may impair suitability for Class I, Division 2 Hazardous Locations. (p. 9-1)

Do not disconnect equipment unless power has been switched off or the area is known to be nonhazardous. (p. 9-1)

Safety Summary (continued)

SPECIFIC WARNINGS (continued)	Disconnecting or reconnecting wiring and, removing or inserting printed circuit boards are not considered normal operation. Operator access to these connections is prevented by a rear cover and faceplate which require a tool to remove them. These operations should only be done if power has been removed from all wiring or if the flammable atmosphere is known not to be present. (p. C-2)

SPECIFIC CAUTIONS	Auto/Solution pH can only be used for processes that are extremely repeatable in both pH values measured and chemical constituents present. (p. 1-1, 3-8) Do not overtighten screws. This will cause the gasket to seat incorrectly and a watertight seal will not be obtained. (p. 2-5) To prevent possible signal degradation, a separate metal conduit run is recommended for the sensor cable. (p. 2-7, 2-12) Do not allow coax or BNC connectors to contact any ground. (p. 2-12) Manual temperature compensation does not require a resistance across the temperature compensation terminals (TB4-2 and TB4-3) unless the shorting straps for the temperature compensation circuit are in place across TB4-1 and 2 and TB4-3 and 4. If the shorting straps are in place, a resistor between 2.0 and 4.0k ohms must be placed across the temperature compensation terminals (TB4-2 and TB4-3). (p. 2-13) During the bench calibration procedure, the TB7 controller executes the user-entered configuration. (p. 5-1) When measuring the pH of a grab or lab sample, make sure that the temperature of the sample is compensated. In some cases, the pH of the solution may change value as the sample cools. Refer to section entitled *Desired Temperature Compensation*. Grab samples should not be left open to the atmosphere. Samples may change or deteriorate as time passes. It is important to measure grab samples as soon as they are taken. (p. 5-11) A ground loop condition can easily and irreversibly destroy a pH reference. (p. 7-1) The linearization must be entered according to the arithmetical progression shown in Table A-3 for each configuration and control type. Errors in entering the linearization will adversely affect control. (p. A-8)

Sommaire de Sécurité

AVERTISSEMENT D'ORDRE GENERAL	**Hazardous Locations** L'equipment descrit par cette notice ne peut etre installed que dans les emplacements specifies sur la plaque signalitique de l'appareil. **Substitution of Components** La substitution de tout composant peut rendre le systeme inapproprie a un emplacement dangereux de classe I et de division 2. **Nameplate Ratings** On no doit en aucune circonstance depasses les valeurs nominales figurant sur le plaque d'identification. **System Maintenance** L'entretien du systeme doit etre effective par des personnes competentes et uniquement a patir du moment ou les elements controles par le cicuit ont ete isoles. Le fait d'enlever ou d'alterer les composants d'une circuit sous tension peut perturber le processus controle.

AVERTISSEMENT D'ORDRE SPECIFIQUE	L'equipment descrit par cette notice ne peut etre installed que dans les emplacements specifies sur la plaque signalitique de l'appareil. (p. 2-3). Les appareils alimentes par le reseau de distribution de courant alternatif comportent des risques de chocs electriques. S'assurer que l'appareil soit completement debranche du circuit de distribution avant de proceder aux diverses connections electriques. (p. 2-10) L'entretien de la sonde ne doit etre effectue que par lepersonnel qualifie, et seutement une fois que l'equipement controle par le controleur de Type TB7 a ete fixe. Le nettoyagede la sonde lorsque celle-ci est branchee a un circuit actif risquerait perturber le processus controle. (p. 8-1) L'acide et les basses peut occasionner des brulers graves. Proteger les mains et les yeux lors de la manutention. (p. 8-1) La solution doit etre entreposee dans un contenant adequat et identifiee comme acide fort et extremement infammable. Manipulez avec beaucoup de precaution. (p. 8-2) La substitution de tout composant peut rendre le systeme inapproprie a un emplacement dangereux de classe I et de division 2. (p. 9-1)

Sommaire de Sécurité (suite)

AVERTISSEMENT D'ORDRE SPECIFIQUE (suite)	Avant de deconnecter l'equipment, couper le courant ou s'assurer que l'emplacement est designe non dangereux. (p. 9-1)
	Le debranchement ou le rebranchement des fils, le retrait ou l'insertion des cartes de circuits imprimes et le basculement de l'interrupteur marche/arret n'entrent pas dans les procedures normales. Un couvercle ne s'ouvrant qu'a l'aide d'un outil empeche a l'operateur d'acceder a ces connexions et a cet interrupteur. Advenant que l'atmosphere soit inflammable, on ne doit effectuer les procedures ci-dessus que si l'alimentation a ete interrompue. (p. C-2)

ATTENTION D'ORDRE SPECIFIQUE	Le mode Auto/Solution pH ne peut etre utilise que pout les processus qui presentent une grande repetabilite quant aux valeurs du pH mesurees et aux composants chimiques presents. (p. 1-1, 3-8)
	Ne pas trop serrer les vis. Sinon, le joint d'etancheite ne serait pas correctement, cale et l'assemblage ne serait pas etanche a l'eau. (p. 2-5)
	Afin d'eviter la defaillance des signaux, il est recommande d'acheminer le cable de la sonde dans un conduit metallique distinct. (p. 2-7, 2-12)
	Na laissez pas le connecteur coaxial ou BNC entrer en contact avec une mise a la terre. (p. 2-12)
	La compensation manuelle de température ne requiert pas une résistance entre les bornes de compensation de température (TB4-2 et TB4-3) à moins que les cavaliers de court circuit soient en position entre TB4-1 et 2 et TB4-3 et 4. Si les cavaliers de court circuit sont en position, une résistance entre 2.0 et 4.0k ohms doit être placée entre les bornes de compensation de température (TB4-2 et TB4-3). (p. 2-13)
	Au cours de l'étalonnage au banc, le contôleur TB701 exécute la configuration introduite par l'utilisateur. (p. 5-1)

ATTENTION D'ORDER SPECIFIQUE (suite)	Lorsqu'on mesure le pH d'un echantillon ponctuel ou d'unechantillon de laboratoire, il faut s'assurer de compenser latemperature de l'enchantillon. Dans certains cas, la valeur dupH de la solution peut changer a mesure que l'enchantillon refroidit. Se reporter a la section intitulee, Desired Temperature Compensation. Il ne faut pas laisser les echantillons ponctuels a l'air libre. Ceux-ci peuvent etre modifies ou alteres si on ne les traite pas rapidement. Il est important de mesurer les echantillons ponctuels des qu'ils sont preleves. (p. 5-11) Si neglige, un courant de boucle dans le circuit de mise a la terre peut facilement detruire la reference de pH irrevocablement. (p. 7-1) La linéarisation doit être introduite en fonction de la progression arithmétique figurant au Tableau A-3 pour chaque configuration et type de commande. Toute erreur d'introduction de la linéarisation aura une incidence sur la commande. (p. A-8)

CONFIGURATION WORKSHEETS

The worksheets have been placed on individual pages so they can be removed from this instruction book and easily reproduced.

Unit Tag:

Desired Configuration

☐ Basic Analyzer/Transmitter ☐ PID Controller ☐ Bidirectional Controller

Desired Controller Parameters (If Applicable)

PID Controller

BAND	_____ (Limits are 1 to 9999%)		
RESET	_____ (Limits are 0 to 99.99 resets/min.)		
DERIV	_____ (Limits are 0 to 99.99 min.)		
INPUT	☐ Linear	☐ Nonlinear[1]	
ACTION	☐ Direct	☐ Reverse	(**NOTE:** Nonlinear input must be reverse.)
CO PWR UP	☐ Lo	☐ Hi	☐ Last
PWR UP ST	☐ Manual	☐ Auto	☐ Last
OUTPUT	☐ Analog	☐ Digital	

Bidirectional Controller

Acid Controller:

HI SETPOINT _____	(Limits are 0 to 14 — Must be higher pH than base controller.)	
BAND	_____ (Limits are 1 to 9999%)	
RESET	_____ (Limits are 0 to 99.99 resets/min.)	
INPUT	☐ Linear	☐ Nonlinear[1]
OUTPUT	☐ Analog	☐ Digital

Base Controller:

LO SETPOINT _____	(Limits are 0 to 14 — Must be lower pH than acid controller.)	
BAND	_____ (Limits are 1 to 9999%)	
RESET	_____ (Limits are 0 to 99.99 resets/min.)	
INPUT	☐ Linear	☐ Nonlinear[1]
OUTPUT	☐ Analog	☐ Digital

Both Controllers:

PWR UP ST	☐ Manual	☐ Auto	☐ Last
CO PWR UP	☐ Lo	☐ Last	☐ Hi (PID only)

Both Controllers:

CROSSOVER Time Delay_____	(Limits are 0 to 99.99 sec.)		
PWR UP ST	☐ Manual	☐ Auto	☐ Last
CO PWR UP	☐ Lo (Acid)	☐ Last	☐ Hi (PID only)

NOTE: 1. When using a nonlinear input, fill out the Function Generator portion of the worksheets.

Desired Analyzer Parameters

Desired Sensor Type ☐ Standard ☐ Antimony ☐ CENTRODE

Desired Temperature Compensation

MANUAL ☐ _____ Process Temperature (Required with Antimony sensor.)
STANDARD AUTOMATIC ☐
AUTOMATIC/SOLUTION ☐ _____ Solution Coefficient (Limits are -1.000 to +1.000 pH/10oC)

Desired Temperature Display Units °C °F

Desired Damping

NONE ☐
pH INPUT ☐ _____ TIME (Limits are 00.00 to 99.99 sec. - Default for bidirectional is 1.0 sec.)
RECORDER OUTPUT ☐ _____ TIME (Limits are 00.00 to 99.99 sec.)

Desired Analog Output Modes

Analog Output 1

MODE ☐ 4-20mA ☐ 0-20mA ☐ 1-5V ☐ 0-5V

SOURCE ☐ Controller ☐ pH ☐ Temp
Lower Limit 0% _____ pH _____ °
Upper Limit 100% _____ pH _____ °

Analog Output 2

MODE ☐ 4-20mA ☐ 0-20mA ☐ 1-5V ☐ 0-5V

SOURCE ☐ Base Bidirectional ☐ pH ☐ Temp
Lower Limit 0% _____ pH _____ °
Upper Limit 100% _____ pH _____ °

Analog Output 3 *(If applicable)*

MODE ☐ 4-20mA ☐ 0-20mA ☐ 1-5V ☐ 0-5V

SOURCE ☐ pH ☐ Temp ☐ Raw pH
Lower Limit _____ pH _____ ° _____ pH
Upper Limit _____ pH _____ ° _____ pH

NOTE: 1. When using a nonlinear output, fill out the Function Generator portion of the worksheets.

Desired Digital Output Modes

Digital Output 1

SOURCE ☐ Controller ☐ pH

MODE

Setpoint (pH source required)
☐ HI SP (High Setpoint) ☐ LO SP(Low Setpoint)
Turn On _____
Turn Off _____
Time Delay _____ (Limits are 00.00 to 99.99 min.)

Cycle Timer (pH source required)
☐ HI CT (High Cycle Timer) ☐ LO CT(Low Cycle Timer)
Turn On _____
Cycle Time _____ (Limits are 0.1 to 99.99 min.)
On Time _____ (Limits are 0.1 to 99.99 min.)

Pulse Duration (Controller source required)
☐ P DURAT
Cycle Time_____(Limits are 0.1 to 1.0 min.)

Pulse Frequency (Controller source required)
☐ P FREQ
Max Pulse/Min_____ (Limits are 0 to 120)

Digital Output 2

SOURCE ☐ Controller ☐ pH ☐ Temp

MODE

Setpoint (pH or Temp source required)
☐ HI SP (High Setpoint) ☐ LO SP (Low Setpoint)
Turn On _____
Turn Off _____
Time Delay _____ (Limits are 00.00 to 99.99 min.)

Cycle Timer (pH or Temp source required)
☐ HI CT (High Cycle Timer) ☐ LO CT (Low Cycle Timer)
Turn On _____
Cycle Time _____ (Limits are 0.1 to 99.99 min.)
On Time _____ (Limits are 0.1 to 99.99 min.)

Pulse Duration (Controller source required)
☐ P DURAT (with Base Bidirectional controller only)
Cycle Time _____ (Limits are 0.1 to 1.0 min.)

Pulse Frequency (Controller source required)
☐ P FREQ (with Base Bidirectional controller only)
Max Pulse/Min _____(Limits are 0 to 120)

Desired Digital Output Modes (continued)

Digital Output 3

SOURCE ☐ pH ☐ Temp ☐ Controller

MODE

Setpoint ☐ HI SP (High Setpoint) ☐ LO SP (Low Setpoint)

Turn On _____

Turn Off _____

Time Delay _____ (Limits are 00.00 to 99.99 min.)

Digital Output 4

SOURCE ☐ pH ☐ Temp ☐ Controller ☐ Washer

MODE

Setpoint ☐ HI SP (High Setpoint) ☐ LO SP (Low Setpoint)

Turn On _____

Turn Off _____

Time Delay _____ (Limits are 00.00 to 99.99 min.)

Washer/Timer

Cycle Time _____ (Limits are 0 to 99.99 hrs.

On Time _____ (Limits are 0 to 9999 sec.

Recovery Time _____ (Limits are 0 to 9999 sec.)

Hold Analog Output _____ (Yes or No)

Desired Alarms

DO1 ACTIVATION	☐ YES	☐ NO
DO2 ACTIVATION	☐ YES	☐ NO
DO3 ACTIVATION	☐ YES	☐ NO
DO4 ACTIVATION	☐ YES	☐ NO

pH HIGH VALUE (CONTROLLER ONLY) _____
pH LOW VALUE (CONTROLLER ONLY) _____

TEMP HI _____
TEMP LO _____

Function Generator

Nonlinear Input

SOURCE ☐ Direct Acting PID Controller ☐ Acid Bidirectional Controller

pH	**Output**
_____	_____%
_____	_____%
_____	_____%
_____	_____%
_____	_____%
_____	_____%

SOURCE ☐ Reverse Acting PID Controller ☐ Base Bidirectional Controller

pH	**Output**
_____	_____%
_____	_____%
_____	_____%
_____	_____%
_____	_____%
_____	_____%

SECTION 1 - INTRODUCTION

OVERVIEW

The TBI-Bailey µFact Series line of instrumentation displays and controls the pH of process fluid streams. The Type TB7 Controller has a number of user-selectable features that optimize measurement of pH. Both the process variable and temperature are measured and displayed. Temperature compensation for pH can be formatted in three ways:

1. None or manual compensation at user-selectable temperature. Within this instruction, this type of compensation will be referred to as MANUAL.

2. Standard Automatic (Nernstien) for process temperature effects on the measurement electrode. This type of compensation will be referred to as STANDARD AUTOMATIC throughout this instruction.

3. User-defined solution compensation which includes both Nernstien and change in pH caused by actual effects of temperature on process pH values. This type of compensation will be referred to as AUTO/SOLUTION.

CAUTION	**Auto/Solution pH can only be used for processes that are extremely repeatable in both pH values measured and chemical constituents present.**
ATTENTION	**Le mode Auto/Solution pH ne peut etre utilise que pout les processus qui presentent une grande repetabilite quant aux valeurs du pH mesurees et aux composants chimiques presents.**

Recorder/data outputs can be selected to represent a number of variables including pH, controller output, temperature and raw pH (no solution temperature compensation). All outputs are separately scalable and are defined by simple prompts on the configuration screen.

Digital outputs can be configured to a number of parameters: i.e., as high or low setpoints for the measured process variable; or as temperature with adjustable hysteresis and time delay functions; as a timer for time relay activation or as percent PID output (exceeded).

Digital outputs can also be used in a cycle timer application operating as a high or low setpoint. As the setpoint is exceeded, the timer begins timing for a fixed duty cycle. As long as the process exceeds the setpoint, the timer will reset

itself at the end of each duty cycle. The relay will activate at the beginning of each cycle for a fixed percentage of the duty cycle. The setpoint, duty cycle, time and percent on time are all tunable.

An integral PID controller can be activated through simple programming prompts. Three types of control output are available: 4 to 20 mA or 0 to 20 mA, pulse frequency adjustable to a maximum of 120 pulses per minute and pulse duration adjustable to a maximum of one minute.

A simple five-segment function generator can be entered for characterization of pH titration curves to enable adaptive control of nonlinear processes.

A bidirectional controller with two control setpoints for control of both acid and base addition is also available with an integral PID controller. The derivative function is not available on the bidirectional controller.

INTENDED USER

Installation Personnel — Should be an electrician or a person familiar with the National Electrical Code (NEC) and local wiring regulations. Should have a strong background in installation of analytical equipment.

Application Technician — Should have a solid background in pH measurement, electronics instrumentation and process control and be familiar with proper grounding and safety procedures for electronic instrumentation.

Operator — Should have knowledge of the process and should read and understand this instruction book before attempting any procedure pertaining to the operation of the Type TB7 Controller.

Maintenance Personnel — Should have a background in electricity and be able to recognize shock hazards. Personnel must also be familiar with electronic process control instrumentation and have a good understanding of troubleshooting procedures.

EQUIPMENT DESCRIPTION

The Type TB7 Controller conforms to DIN sizing standards. The basic assembly contains three printed circuit boards: a flexible main board, a pH board and a front panel assembly (Figure 1-1). The main board connects to the front panel assembly via a 22-pin connector. The pH board plugs into the main board assembly. Two bezel clips secure the front panel assembly in the housing.

The housing is injection molded NORYL™. It contains card guides to ease installation of the circuit board. Multiple

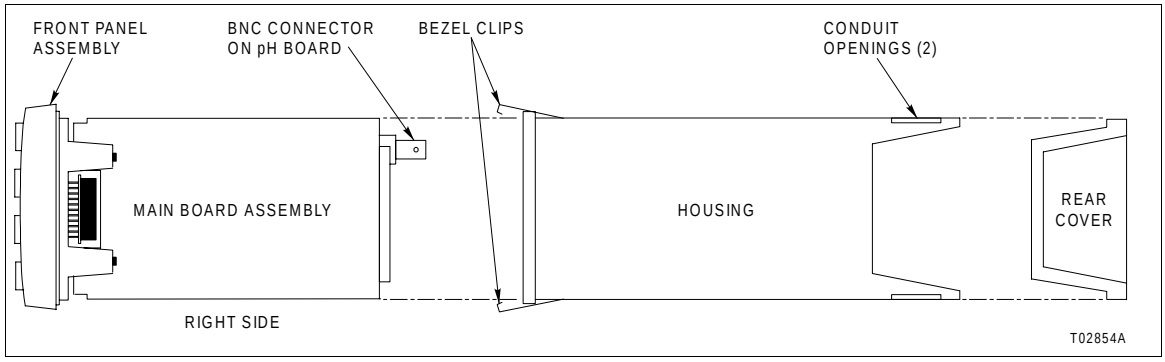


Figure 1-1. Type TB7 Controller Components

knockouts at the rear of the housing provide two ½-inch and two ¾-inch conduit entrance facilities for electrical connections.

The display (faceplate) portion on the front panel assembly contains those operator controls necessary for manual and automatic operation. Operator interface is provided through tactile pushbuttons and the backlit 80 x 80 pixel LCD graphic display. Three pushbuttons at the bottom of the display are multi-function keys (soft keys). The specific function of these keys is defined by the graphics and will vary depending on the screen displayed. The pushbuttons to the right of the graphics include single function keys for scroll UP, scroll DOWN, AUTOMATIC/MANUAL and SELECT (Figure 1-2). These pushbuttons allow the operator to adjust setpoints, control outputs, transfer levels of control, and select display information. The pushbutton functions are described in the operating procedures section.

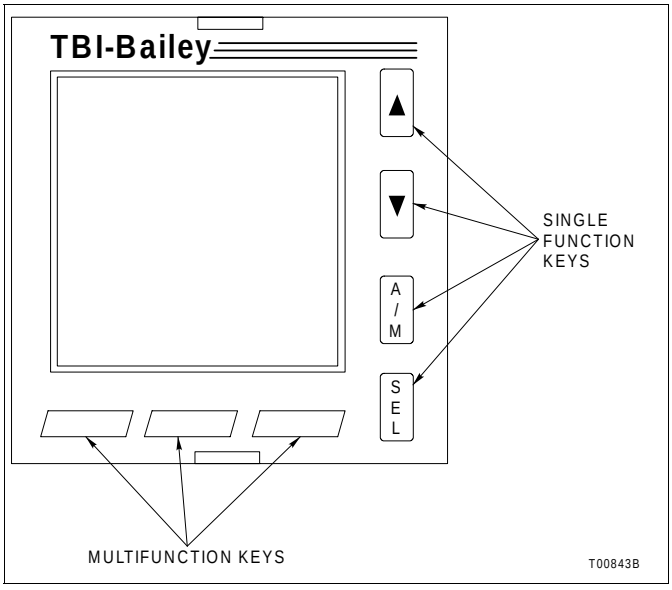


Figure 1-2. Type TB7 Faceplate Display Area

The rear cover has a terminal wiring diagram for reference while installing the unit. The cover should be in place for best environmental performance.

FEATURES

Three Instruments in One

The TB7 controller offers a powerful pH analyzer/transmitter that can be combined with any number of simple to sophisticated pH control techniques. The menu-selectable configurations include: 1.) basic analyzer transmitter, 2.) unidirectional PID controller/analyzer, and 3.) bidirectional controller/analyzer.

Easily Programmable

No other microprocessor-based instrument makes programming as simple as the µFact Series analyzer/controllers. Menu driven displays, minimal keystrokes, and fast graphic response provide maximum information and reduce operator training time. The easily accessible screens are extremely user-friendly and contain simple formats for configuration and calibration procedures.

Multi-Parameter Graphic Display

The primary pH readout is supplemented by temperature, controller mode and alarm status on a backlit 80 x 80 pixel LCD screen.

Direct Sensor Connection

30 meters (100 feet) maximum separation between sensor and transmitter simplifies installation and reduces costs.

Simple Calibration Routines

The TB7 controller provides quick and easy grab sample or two point buffer/millivolt source calibration of the pH input. Slope and offset are automatically calculated and compensated. Temperature is also easily calibrated.

Configurable Digital Outputs

Two standard and two optional digital outputs allow configuration in many combinations of high/low setpoints or alarms, controller, sensor cleaner and timer functions.

Configurable Analog Outputs

Two standard and one optional analog outputs (4 to 20 milliamp/1 to 5 VDC or 0 to 20 milliamp/0 to 5 VDC) are configurable to many combinations of pH, temperature, raw pH or PID controller sources.

Programmable Alarm Functions

High and low pH, temperature and activation of any desired digital output are programmable alarm functions and will appear as an alarm notification on the display and alarm summary submenu.

Programmable Controller Outputs

PID and bidirectional controller outputs can be designated as either analog or digital type. As digital, they are programmable as either a pulse frequency (pulse per minute) or pulse duration (duty cycle) type.

Compact Packaging ¼ DIN size meets industry standard sizing, reduces space requirements and increases installation flexibility.

Security Interlocks Personalized codes are selectable to three levels of security: Master, Tech or None to prevent unauthorized access and tampering.

Nonvolatile Memory In the event of a power failure, the nonvolatile memory stores and retains the configuration data.

Diagnostics A diagnostic routine provides indication of internal electronic and configuration errors, as well as information on sensor efficiency, reference offset and temperature limits.

EQUIPMENT APPLICATION

The TB7 controller is intended for small process monitoring and/or control applications and easily accommodates simple analyzer functions to complex split range PID control algorithms.

Some typical applications include the display and control of pH of process fluid streams, wastewater treatment, and environmental monitoring.

INSTRUCTION CONTENT

Introduction This section provides a product overview, a physical description of the product, possible applications, a description of the instruction manual sections and how to use them. This section also has a glossary of terms and abbreviations, a list of reference documents on related equipment and/or subjects, the product identification (nomenclature), and a comprehensive list of hardware performance specifications including accessories and applicable certification information.

Installation This section contains special handling procedures for boards with MOS devices, inspection instructions for the equipment shipped, special considerations required for mounting the controller in a hazardous location and the physical mounting instructions. Once the controller is mounted, wiring is addressed. Instructions are provided for AC power wiring, analog and digital I/O wiring, and grounding procedures.

Developing a Configuration This section provides the required actions to establish and define the configuration of the TB7 controller. It provides information on configuration data for performing specific tasks, and the procedures for converting the initial data into a configuration.

Operating Procedures This section contains a functional description of the faceplate display and pushbuttons that are used as interface controls. It also describes normal operation. Various operating modes,

i.e., MONITOR, TUNE, CONFIGURE, CALIBRATE, and SECURITY are defined.

Calibration This section provides all the necessary information to bench and process calibrate the controller. It also contains many of the screens that would be viewed during a normal calibration.

Diagnostics This section provides a description of the diagnostics, a list of the error messages and a description of the diagnostic tools available to aid in service of the unit.

Troubleshooting This section provides a listing of faceplate error messages and the corrective action to be taken. A logic flow diagram is also included to help determine and isolate problems encountered.

Maintenance The only periodic maintenance required pertains to the sensor.

Repair/Replacement Procedures This section provides disassembly and assembly procedures for replacement of the main board, main board fuse, front panel assembly and pH board.

Support Services Contains replacement parts drawings, and recommended spare parts.

Appendix A Contains information on programming a linearization function of a PID controller.

Appendix B Contains information on TBI-Bailey setup of pH analysis system/sensor simulation for calibration procedures.

Appendix C Summarizes installation and operating procedures for equipment use in hazardous areas.

Appendix D Contains a reference set of screen flowcharts, listing all variables that could appear depending on the application selected.

Worksheets Provides worksheets for configuration routines.

Quick Reference Contains tables of the option jumper settings as well as an illustration showing the locations of these jumpers on the main board and the expansion board.

HOW TO USE THIS MANUAL

It is important for safety and operating reasons that you read and understand this manual. Do not install or complete any tasks or procedures related to operation until doing so.

The sections of this instruction book are sequentially arranged as they relate to initial start-up; from unpacking to repair and replacement procedures. After initial start-up, refer to the instruction as needed by section.

GLOSSARY OF TERMS AND ABBREVIATIONS

Term	Definition
Automatic Control	A mode in which the operator can adjust the setpoint from the faceplate and the control output is determined by the computation of the algorithm within the unit.
Configuration	The act of setting up equipment to accomplish specific functions or a list of parameters associated with such a setup.
Control Output	The signal that a control system uses to influence the operation of a final control element.
CPU	Central Processing Unit. Section of the controller/analyzer which performs the computations and control functions.
DIN Standards	Deutsches Institut fur Normung e. V., Berlin. DIN is the German member body of the International Organization for Standardization (ISO).
Faceplate	The area of the controller front panel assembly containing the operator accessible indicators and controls.
Fatal Error	An error that causes the controller to no longer control the process.
Front Panel Assembly	A subassembly of the controller consisting of the display (faceplate) assembly, keypad, the bezel assembly and the backplate bezel.
Logic 0 (Low)	Contact OPEN, output OFF.
Logic 1 (High)	Contact CLOSED, output ON.
Loop	That portion of an analog process control loop which resides within the controller. It typically consists of: an analog input measuring the process variable, a manual/auto station generating a setpoint, control algorithm, and an analog output driving a final control element.
Manual Control	A mode in which the operator can directly adjust the control output from the faceplate.
Nonfatal Error	A problem exists but the controller maintains control of the process.
NVRAM	Nonvolatile Random Access Memory. Retains the configuration of the controller/analyzer when power is removed.
pH	Term used for expressing the concentration of acids or bases as determined by the hydrogen ion concentration on a scale whose values run from 0 to 14, with 7 being neutral. Numbers less than 7 represent increasing acidity, numbers greater than 7 represent increasing hydroxyl (OH) concentration.
Process	The collective functions performed in and by the equipment in which the variable or variables are to be controlled.
Process Variable	The parameter of a system to be controlled by a control device. A process variable is sometimes called a controlled variable.
RAM	Random Access Memory. Contents are lost when power is removed.
Raw pH	Nernstien temperature compensated pH without solution compensation.
ROM	Read Only Memory. Contents remain when power is removed.
Setpoint	The desired value for a process variable.
Titration	A process of determining the strength of a solution in a solution in terms of the smallest amount of a reagent (of known concentration) required to bring about a given effect in reaction with a known volume of test solution.

REFERENCE DOCUMENTS

Number	Document
C-E67-21-3	TBI-Bailey pH/ORP Sensor Product Specification
I-E96-500	Site Planning and Preparation
PA67-21-1	TBI-Bailey pH Sensor Installation Guidelines
PA67-60	TBI-Bailey Instrument Configurations
PA67-61	"Hot Tap" Sensors for pH and Conductivity Measurement in the Pulp and Paper Industry
PA67-62	Digital Control Applications, Type TB7
TP87-6	pH Control in Paper Mills - The Wherefore and the Why
TP87-25	pH, Specific Ion and Conductivity Application Breakthroughs in the Pulp and Paper Industry
TP90-1	pH Control in Mechanical Pulping
TP90-2	Calibration and Troubleshooting pH Instrumentation

NOMENCLATURE

POS.	1	2	3	4	5	6	7	8	
	T	**B**	**7**	**0**	☐	☐	☐	☐	ANALYTICAL CONTROLLING TRANSMITTER
					1				**Input:** pH
						0	0		**Options:** None
						0	4		Alarm Expansion Card (2 additional digital outputs and 1 additional analog output
								1	**Power:** 120 VAC
								2	240 VAC

SPECIFICATIONS

Process Display Range	
pH:	0 to 14.00 pH with -2.00 to + 16.00 overrange
Temperature Display Range	-20 to 150°C (-4 to 302°F)
Resolution	
pH:	0.01 pH
Temperature:	1°C or 1°F
pH Display Font Size	13.6 x 10.5 mm (0.54 to 0.41 in.)
Accuracy	
Input:	0.1% of full scale
Output:	0.15% of full scale
Temperature Compensation	
pH:	0 to 140°C (32 to 284°F) manual or standard automatic
Auto/solution compensation per:	$pH \pm \frac{(Temp - 25°C)x}{10}$ where x = change in pH for 10°C (18°F) change.

Input Types	
pH:	1. Standard pH sensor. 2. Antimony pH sensor. 3. CENTRODE® pH sensor.
Temperature:	3k ohm @ 25°C (77°F) positive coefficient Balco coil.
Input Impedance	
pH:	10^{12} ohms
Damping	
Input pH:	0 to 99.99 seconds
Recorder pH:	0 to 99.99 seconds
Analog Outputs	2 standard, 1 optional, all isolated from input. 4 to 20/0 to 20 mA, 1 to 5/0 to 5 VDC.
Load range:	0 to 750 ohms for current; 250 to 1M ohm for voltage.
Ambient temperature effect:	< 0.02%/°C
Maximum span:	14 pH units, 170°C (338°F), CO = 100%
Minimum span:	1 pH unit, 10°C (18°F), CO = 100%
Digital Outputs	2 standard, 2 optional.
Relays:	Form C, SPDT; 2 A @ 250 VAC, 2A @ 30 VDC. **NOTE:** Contacts are derated when used in a Division 2 hazardous location. The maximum voltage and current for typical 24 VDC resistive loads are: Groups A and B: 28 VDC, 150 mA Group C: 28 VDC, 400 mA Group D: 28 VDC, 540 mA
Digital Setpoint	High or low action.
pH:	0 to 14.00 pH
Temperature:	-20 to 150°C (-4 to 302°F)
Controller:	0 to 100%
Hysteresis:	Continuous through range.
Time delay:	Adjustable from 0 to 99.99 min.
Setpoint Cycle Timer	High or low action.
pH:	0 to 14.00 pH
Temperature:	-20 to 150°C (-4 to 302°F)
Cycle time:	0.1 to 99.99 min.
On time:	10 to 90% of cycle time.
Timer (Timed Out)	High or low activation.
Setpoints:	pH, temperature, controller output.
Hysteresis:	Continuous through range.
Timed out timer:	0 to 99.99 min.
Sensor Washer	
Time cycle:	0 to 99.99 hrs.
Clean time:	0 to 9999 sec
Recover delay:	0 to 9999 sec
Hold analog outputs:	Yes or No
PID controller output:	Frozen during clean and recovery time.
Bidirectional controller:	Outputs to 0%.
Digital outputs:	To logic 0 during clean and recovery time.
Power	90 to 135/180 to 260 VAC, 50/60 Hz, 15 VA maximum.
Environmental	
Operating temperature:	0 to 50°C (32 to 122°F).
Storage temperature:	-20 to 65°C (-4 to 149°F).

®CENTRODE is a registered trademark of the Monsanto Corporation.

Relative Humidity	10 to 90% noncondensing.
Weight	1.36 kg (3 lbs) approx.
Size	
Height and width:	96 mm high x 96 mm wide (3.78 in. high x 3.78 in. wide)
Overall length:	237 mm (9.33 in.).
Minimum panel depth:	218 mm (8.6 in.).
Maximum panel cutout:	92 mm x 92 mm (3.62 in. x 3.62 in.).
Agency Approvals	
CSA (Canadian Standards Association):	Certified for CSA Class I, Division 2, Groups A, B, C and D.
FM (Factory Mutual):	Approval pending for Class I, II, III, Division 2, Groups A, B, C, D, E, F and G
Accessories	
Wall mounting kit:	Part No. 4TB9515-0013
Pipe mounting kit:	Part No. 4TB9515-0012
Panel mounting kit:	Part No. 4TB9515-0015
Sensors	TBI-Bailey Combination pH sensor.
In-line threaded:	Part No. TB556
In-line twistlock:	Part No. TB551
Submersible:	Part Nos. TB551 and TB556
Ball valve insertion (hot tap):	Part No. TB557
High pressure hot tap:	Part No. TB564
High pressure In-Line:	Part No. TB567
High purity flow cell:	Part No. TB566
Sterilizable:	Part No. TB561
Sanitary:	Consult the factory.
	NOTE: Request TBI-Bailey literature, C-E67-21-3 for additional information.
Temperature Compensators	Model 590 Flow (3k ohm Balco coil). Model 590 Submersible (3k ohm Balco coil). Integral to pH sensor.
	NOTE: Request TBI-Bailey literature, C-E67-21-3 for additional information.

Specifications subject to change without notice.

CONTROLLER FUNCTIONS

PID Single Output	
Output action:	Direct or reverse. Auto/manual, bumpless transfer. Reset antiwindup.
Linearization:	5-segment function generator (for error signal).
Bidirectional Output Action	1 for acid, 1 for base, auto/manual, bumpless transfer. Reset antiwindup.
Linearization	2 each 5-segment function generators (for error signal).
PID or Bidirectional Output Types	
Analog:	4 to 20/0 to 20 mA, 1 to 5/0 to 5 VDC
Pulse frequency:	By digital output adjustable 0 to 120 pulse/minute maximum.
Pulse Duration	By digital output adjustable 0.1 to 1.0 minute maximum.
PID Parameters	
Proportional band:	0 to 9999%
Integral:	0 to 99.99 reset/min.
Derivative:	0 to 99.99 min.

Specifications subject to change without notice.

SECTION 2 - INSTALLATION

INTRODUCTION

This section contains special handling procedures for boards with MOS devices, inspection instructions for the equipment shipped, special considerations required for mounting the controller in a hazardous location and the physical mounting instructions. Once the controller is mounted, wiring is addressed. Instructions are provided for AC power wiring, analog and digital I/O wiring and grounding procedures.

SPECIAL HANDLING PROCEDURES FOR MOS DEVICES

In addition to the normal precautions for storage and handling of electronic equipment, the TB7 controller has special MOS (Metal Oxide Semiconductor) handling requirements. This equipment contains electronic components that can be damaged from discharges of static electricity. Therefore, do not touch the components on the circuit board if at all possible. Ordinarily, the circuit will not be damaged if the circuit board is handled by the edges.

Metal Oxide Semiconductor (MOS) devices are subject to damage by static electricity. Therefore, special handling techniques should be observed during servicing, troubleshooting, and repair.

1. Assemblies containing MOS devices should be removed from their protective containers only:

    a. When at a designated static-free workstation.

    b. After firm contact with an anti-static mat and/or firmly gripped by a grounded individual.

2. Personnel handling assemblies with MOS devices should be neutralized to a static-free workstation by a grounding wrist strap that is connected to the station or to a good ground point at the field site.

3. Do not allow clothing to make contact with MOS devices. Most clothing generates static electricity.

4. Avoid touching edge connectors and components.

5. Avoid partial connection of MOS devices. MOS devices can be damaged by floating leads, especially the power supply connector. If an assembly must be inserted in a live system, it should be done quickly. Do not cut leads or lift circuit paths when troubleshooting.

6. Ground the test equipment.

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

> **NOTE:** An anti-static kit (ESD Field Service Kit, Bailey Part No. 1948385-1) is available for personnel working on devices containing MOS components. The kit contains a static-dissipative work surface (mat), a ground cord assembly, wrist bands and alligator clip.

UNPACKING AND INSPECTION

Upon receipt of the shipment, the equipment should be examined for possible damage in transit. If damage is found or there is evidence of rough handling, a damage claim should be filed with the responsible transportation company. Also, the nearest TBI-Bailey Sales Office should be notified as soon as possible.

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 ensure satisfactory performance of your unit.

Use the original packing material and container for storage. The storage environment should be protected and free from extremes of temperature and high humidity and fall within the environmental constraints listed in the ***SPECIFICATIONS*** in Section 1 of this manual.

LOCATION CONSIDERATIONS

The TB7 controller is designed for panel mounting, pipe mounting or wall mounting. The installation site should be vibration free and conform to the environmental constraints listed in the ***SPECIFICATIONS*** in Section 1 of this manual. Careful placement of the controller will ensure proper operation as well as overall safety.

> **NOTE:** Temperature is an important consideration. Allow for adequate air flow, especially if the controller is to be installed in an enclosed area.

The TB7 controller can be used with 120, 220 or 240 VAC line service. The proper power source must be made available at the installation site.

Hazardous Locations

The Type TB7 Controller is being submitted to Factory Mutual Research (FM) for approval for use in:

Class I, II, III, Division 2, Groups A, B, C, D, E, F and G.

Canadian Standards Association (CSA) certification has been received for:

Class I, Division 2, Groups A, B, C and D.

Refer to Appendix C for specific guidelines when using the controller in a Division 2 hazardous location.

WARNING	**The equipment described may be used only in those classes of hazardous locations identified on the nameplate.**
AVERTISSEMENT	**L'equipment descrit par cette notice ne peut etre installed que dans les emplacements specifies sur la plaque signalitique de l'appareil.**

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. Prudent practice dictates that steps to caution against the use of portable communications equipment be taken by posting appropriate signs in the plant.

SAFETY RELATED INFORMATION

Analog and Digital Output Default Settings

Upon power up without a configuration, or should a failure condition occur, the analog output will go to a 0 volts/0 milliamps state. The digital outputs will go to a de-energized state. The installation must be designed such that these default states put the process in a safe condition.

Operator Alarms

In noisy environments or when operators may not be close by the controller, it may be necessary to use one of the digital outputs to control a Klaxon™ or other signaling device to notify the operator of alarm conditions.

TM Klaxon is a trademark of the General Motors Corp.

SETUP/PHYSICAL INSTALLATION

Three types of mounting are available. The TB7 controller can be panel mounted, wall mounted or pipe mounted.

NOTE: Weatherproof connectors should be installed in the wiring entry openings. An example of weatherproof connectors would be Hubbel SHC/NHC Series, Daniel Woodhead F2 series, etc.

Panel Mounting

1. Refer to Figure 2-1 for panel cutout dimensions. Cut a hole in the panel.

NOTE: Refer to the size spec in the ***SPECIFICATIONS*** in Section 1 of this manual for minimum panel depth and maximum panel cutout dimensions. These dimensions are critical.

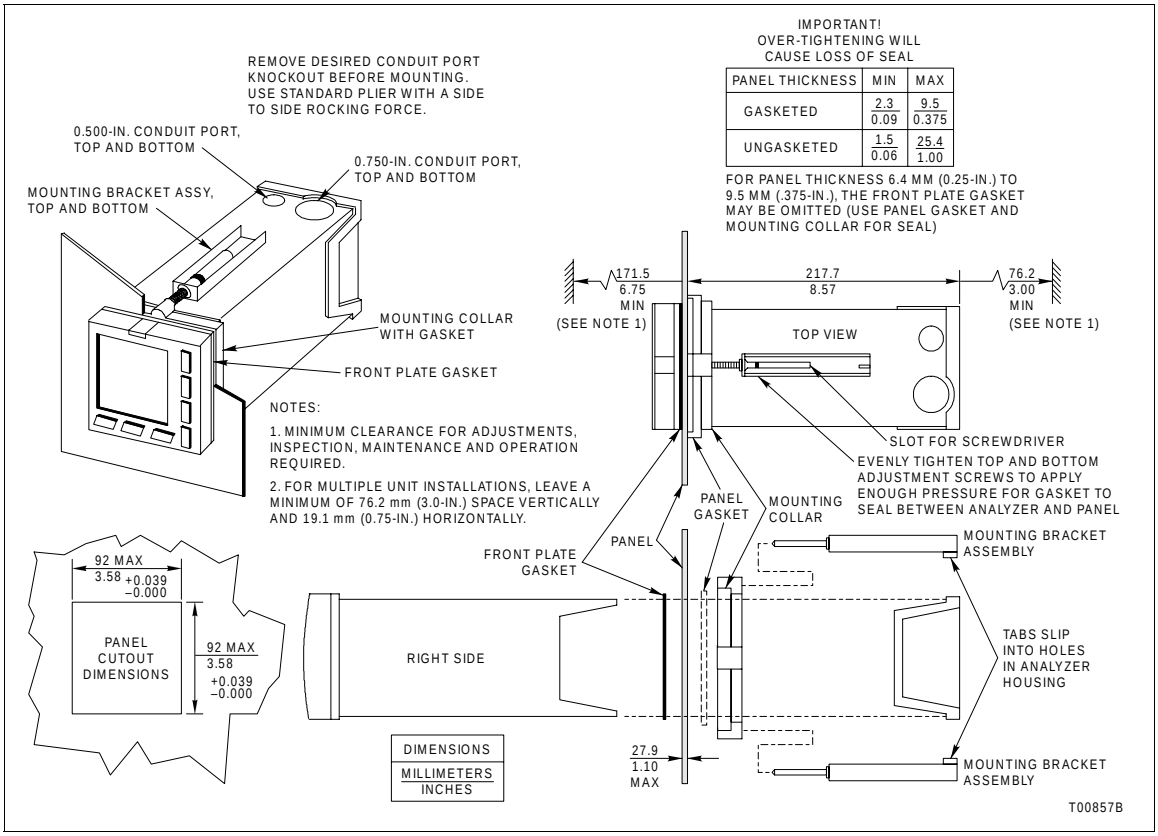


Figure 2-1. Panel Mounting the TB7 Controller

2. Use pliers and remove only the required conduit knockouts from the housing. Refer to ***Removing the Conduit Knockouts*** in this section.

3. Remove the rear cover from the controller.

4. Slide the panel seal gasket over the rear of the housing and position behind the lip on the front of the housing. Insert the housing into the panel hole.

5. Support the weight of the housing and install bottom of mounting bracket into the housing slot and tighten until the bracket screw reaches the panel wall.

> **NOTE:** Carefully center the housing in the panel hole prior to tightening the mounting bracket screws.

6. Install the top mounting bracket into the housing slot and alternately tighten the top and bottom screws until the unit is firmly held to the panel wall.

CAUTION	**Do not overtighten screws. This will cause the gasket to seat incorrectly and a watertight seal will not be obtained.**
ATTENTION	**Ne pas trop serrer les vis. Sinon, le joint d'etancheite ne serait pas correctement, cale et l'assemblage ne serait pas etanche a l'eau.**

7. After wiring, make certain the rear cover is installed on the controller.

Wall Mounting

1. Position the wall mount bracket on the wall and mark the location of the four holes that need to be drilled.

2. Drill the four mounting holes. Install the wall bracket using four customer supplied ⅜-inch mounting bolts. Use the correct bolts for the application.

3. Use pliers and remove only the required conduit knockouts from the housing. Refer to ***Removing the Conduit Knockouts*** in this section.

4. Position the pivot bracket on the left side of the controller housing. Position the clamp bracket assembly on the right side of the housing. Position the clamp and pivot brackets on the controller so that when assembled to the wall bracket there will be ample clearance between the wall and the back of the housing (Figure 2-2).

5. Align the bolt holes in the pivot bracket and the clamp brackets. Install the two ⅜-16 x 0.500 hex bolts through the clamp bracket and into the pivot bracket. Install the two ⅜-16 hex nuts and tighten.

6. Lift the unit into position. Once in position, install the two ¼-20 hex bolts through the pivot assembly and into the wall

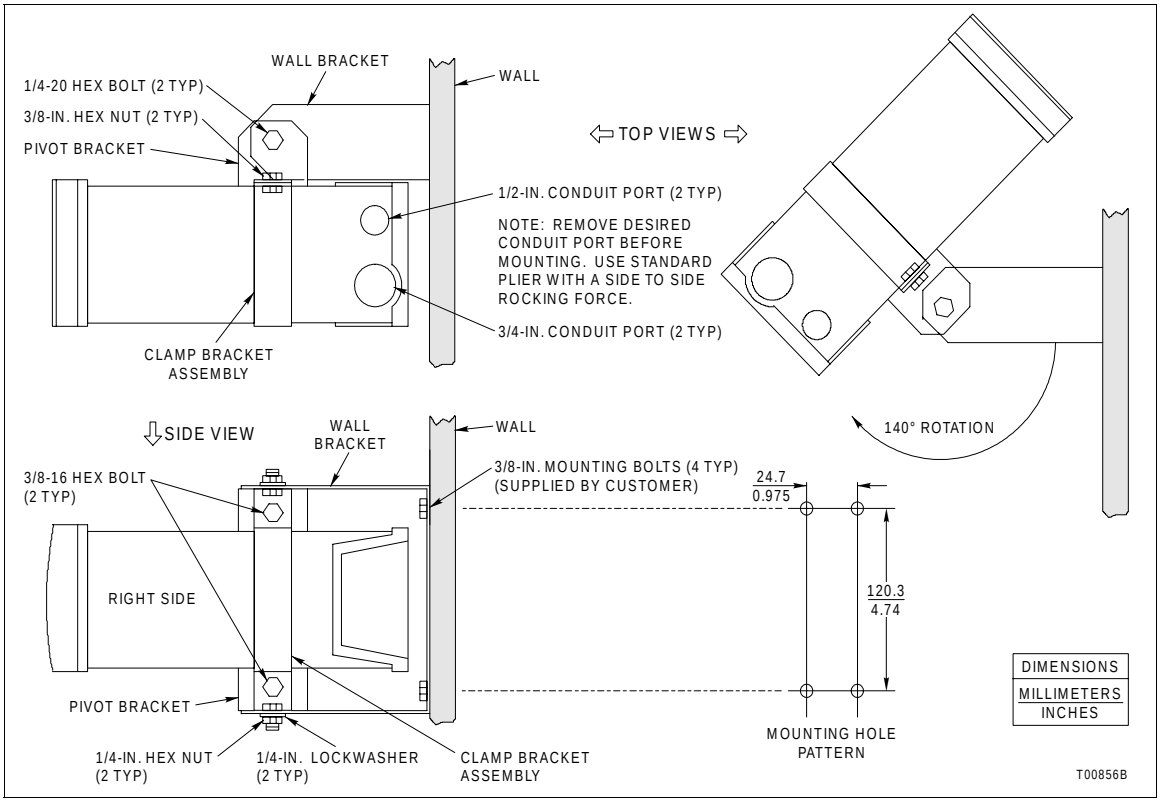


Figure 2-2. Wall Mounting the TB7 Controller

bracket. Position the controller to the correct angle and install the lockwashers and the ¼-20 hex nuts to lock the unit in position.

Pipe Mounting

1. The TB7 controller may be mounted on horizontal or vertical piping. See Figure 2-3.

2. Use pliers and remove only the required conduit knockouts from the housing. Refer to ***Removing the Conduit Knockouts*** in this section.

3. Place the pipe mount bracket in position on the pipe.

4. Install the two 5⁄16-inch by 2-inch U-bolts around the pipe and through the holes in the pipe mount bracket.

5. Install one each flat washer, lockwasher and 5⁄16-18 stainless steel hex nut on each end of the U-bolts. Tighten the hex nuts.

6. Position the U-shaped clamp bracket assembly on the controller. Align the holes in the clamp bracket with the holes in the pipe mount bracket. Install the two ⅜-16 hex bolts from

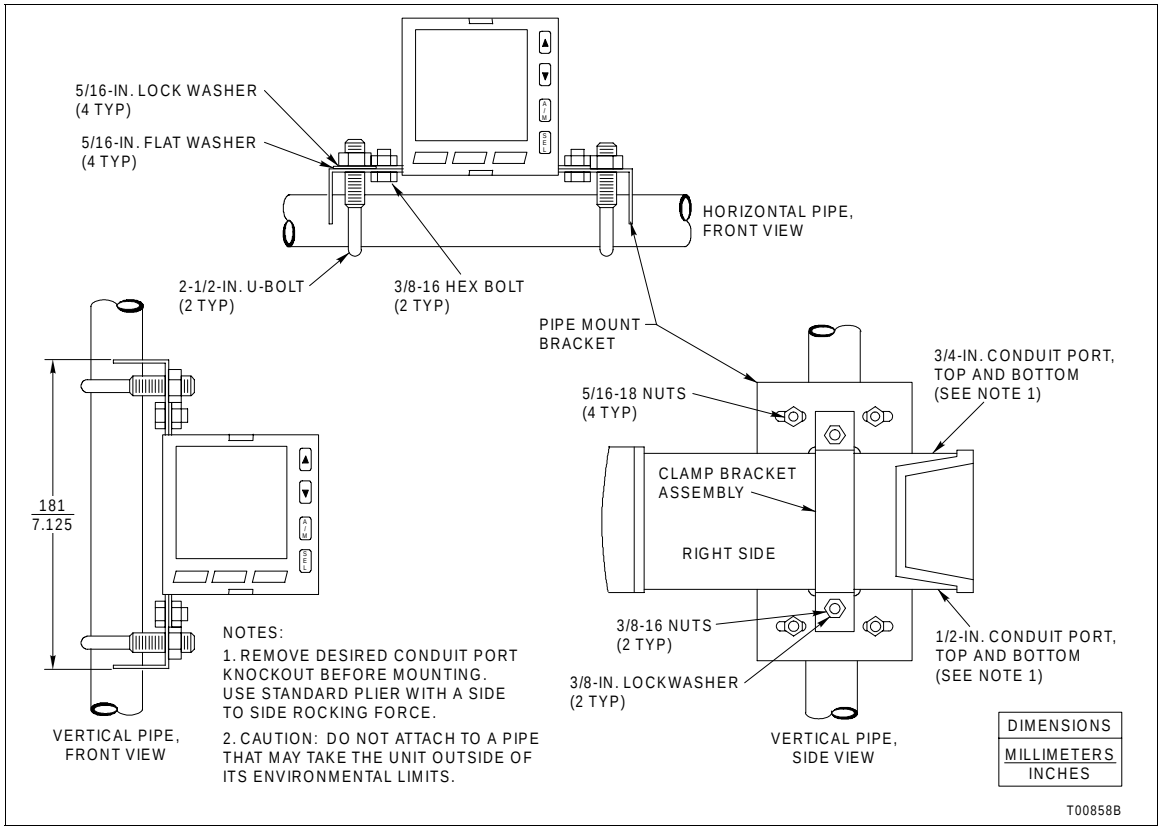


Figure 2-3. Pipe Mounting the TB7 Controller

the back side on the pipe mount bracket. Assemble the two ⅜-16 nuts and tighten.

WIRING CONNECTIONS AND CABLING

Under ideal conditions, the use of conduit and shielded wire may not be required. However, to avoid noise problems, it is recommended that power, signal and output wiring be enclosed in conduit and separated. Just prior to entering the housing, rigid conduit should be terminated and a short length of flexible conduit should be installed to reduce any stress to the housing.

CAUTION	**To prevent possible signal degradation, a separate metal conduit run is recommended for the sensor cable.**
ATTENTION	**Afin d'eviter la defaillance des signaux, il est recommande d'acheminer le cable de la sonde dans un conduit metallique distinct.**

NOTE: Use approved conduit connections.

Removing the Conduit Knockouts

Conduit knockouts (½-inch and ¾-inch) are located at the rear of the controller housing, on the top and the bottom.

1. Open pliers and position them so that the serrated ends are centered on the top and bottom on the conduit knockout to be removed. Close the pliers.

2. Rock pliers back and forth until the knockout becomes loose. Release pliers and the knockout should fall free. If not, gently twist and pull until the knockout is free.

3. If any plastic flashing or rough edges remain on the housing, carefully use the flat blade of a screwdriver or pen knife to remove the remaining material.

Shimming Long Conduit Fittings

When installing the conduit fittings, it is important to check the clearance between the conduit fitting when installed in the ½-inch conduit port and the BNC connector used for pH sensor cable.

If a clearance problem does exist, remove the top portion of the conduit fitting and add washers to the fitting before reinserting the threaded portion of the fitting through the housing again. These washers will shim the conduit fitting up and away from the BNC connector.

Inserting the Wire into the Connector

1. Spring clamp type, lugless connectors are provided at the rear of the housing for making wiring connections. Maximum wire gauge for the connector is 14 AWG. Minimum wire gauge is 26 AWG.

2. Use a small flat blade screwdriver to insert into the connector and push. This will open the jaws of the connector and the stripped wire can be inserted (Figure 2-4).

> **NOTE:** Make certain that the wire insulation is stripped back far enough to assure that the connectors spring clamp jaw contacts the wire and not the wire insulation.

3. Once the wire is in place, remove the tool.

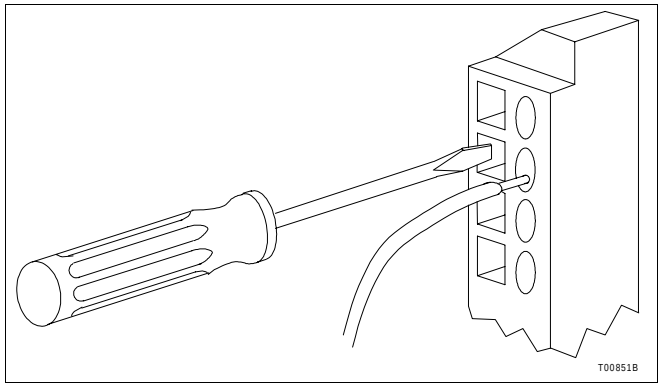


Figure 2-4. Installing/Removing Connector Wiring

Wire Size

The TB7 controller has the capacity for eleven 14-gauge wires. If additional 14-gauge wire is required, some of the other wires must be reduced in size.

For those applications requiring CSA compliance and more than four two-wire inputs plus outputs are used, then some or all of the wires must be reduced in size. The internal volume of the wiring compartment is about 17 cubic inches. The volume required for each conductor is:

26-22 AWG	0.50 cubic inches
20 AWG	0.75 cubic inches
18 AWG	1.00 cubic inches
16 AWG	1.25 cubic inches
14 AWG	1.50 cubic inches

The total number of conductors multiplied by the volume requirement of each conductor should not exceed 17 cubic inches. This includes the power conductors.

A wiring label is provided on the rear cover of the housing. This label contains a nonpermanent adhesive to allow careful removal and replacement wherever it convenient.

NOTE: Once the wiring is completed, and always during operation, the rear cover of the controller must be in place to maintain system safety and accuracy. The cover prevents operator access to live parts and to those which may cause an ignition capable arc. It also acts as an electrical shield to reduce the affects of EMI/RFI, and helps minimize temperature gradients. It is important that the cover be securely mounted during normal use.

AC Power Wiring

The unit is shipped from the factory set for 120 or 240 VAC (nominal), depending on the nomenclature ordered for the controller.

Either a standard 3-prong grounded flexible CSA certified line cord must be supplied by the user for power supply connection or the AC supply must be hard wired.

1. If hard wiring the AC power supply, it is recommended that all power wiring be stranded, copper conductor, no. 14 AWG, and bear a suitable voltage rating for the highest voltage connected to the termination board (either signal or power) and a 75°C (167°F) minimum rating. Wiring must be in accordance with the National Electrical Code.

NOTES:

1. TBI-Bailey Controls recommends installing a power line switch to the controller for safety purposes and for providing power up/power down convenience while servicing the unit.

2. The system should not be powered from a transformer which also powers large motor loads (over 5 horsepower) or any other type of equipment which will generate line voltage surges and sags.

WARNING	**Instruments that are powered from AC line voltage constitute a potential for an electrical shock hazard to the user. Make certain the AC line cord or power lines from the operating branch circuit are disconnected from the source before attempting electrical connections.**
AVERTISSEMENT	**Les appareils alimentes par le reseau de distribution de courant alternatif comportent des risques de chocs electriques. S'assurer que l'appareil soit completement debranche du circuit de distribution avant de proceder aux diverses connections electriques.**

2. Connect the specified line voltage (120/240 VAC, 50 or 60 Hz) to TB1-10(L), the neutral to TB1-11(N/L2), and the ground to terminal TB1-12 ⏚ on the termination board.

Refer to Figure 2-5 for AC power wiring connections.

AC Safety Ground

It is the responsibility of the customer and/or his installation/wiring contractor to ensure that the controller, other associated control or test equipment and all exposed conductive materials are properly grounded in accordance with local, National Electrical Code or Canadian Electrical Code regulations; and are not a hazard, including under fault conditions, to operation and service personnel.

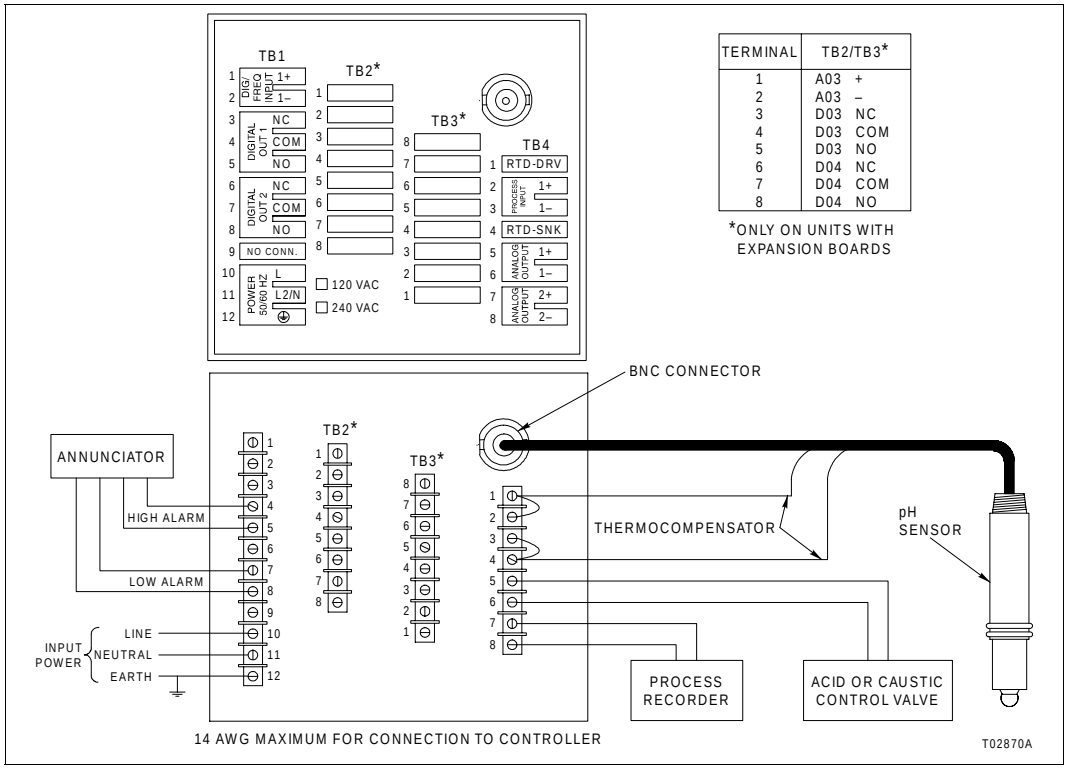


Figure 2-5. AC Power Wiring Connections

The TB7 controller provides for a connection of a grounding conductor (customer supplied) at TB1-12 ⏚ on the rear terminations.

> **NOTE:** Because of the prevailing differences in soil conditions throughout the world and differences in acceptable practices, it is not within the scope of this instruction to describe grounding electrode systems. It is the responsibility of the customer to ensure that a grounding electrode system which is acceptable to the local building and wiring codes exists at the facility where the TB7 controller is to be installed.

The NEC, Article 250, Section H, details requirements for grounding electrode systems acceptable in the United States. The CEC, Section 10, paragraphs 700 through 712, details the requirements for grounding electrode systems acceptable in Canada.

> **NOTE:** The structural metal frame of a building shall not be used as the required equipment grounding conductor for the TB7 controller.

Analog Output Wiring

Wiring used for analog outputs must be carefully chosen, with consideration for environmental and electrical conditions.

Shielded (overall or individually) twisted-pair wires for low level signal conduction are recommended to reduce the effects of electromagnetic and electrostatic noise coupling. An aluminum-mylar type with a drain wire has a very good electrostatic coupling shield efficiency. All shields must be electrically insulated from other shields. Shields are to be grounded at the same earth ground potential as the AC power wiring of the TB7 controller. The field end of the shield should not be connected to a ground.

Conduit is recommended for the field portion of the run. Wherever practical, it is recommended that trays containing analog signals be devoted exclusively to that use. Conduit containing analog signals should cross power lines, etc., at right angles and remain perpendicular for at least ten times the diameter of the crossed element on either side of the crossing joints.

Analog Input Wiring

CAUTION	**To prevent possible signal degradation, a separate metal conduit run is recommended for the sensor cable.**
ATTENTION	**Afin d'eviter la defaillance des signaux, il est recommande d'acheminer le cable de la sonde dans un conduit metallique distinct.**

The pH sensor coaxial cable has a male BNC connector for the pH input. The pH sensor temperature compensation wiring is tie wrapped to the coax wire. Each temperature compensator wire should be connected to the temperature compensation terminals as shown in Figure 2-6. This requires connecting jumper wires to the temperature compensation leads. Use 20-26 AWG wires and refer to the following note.

> **NOTE:** Soldering the jumper wires to the temperature compensation leads is strongly recommended. Errors may occur in temperature measurement and compensation may intermittently occur if poor wire connections exist.

CAUTION	**Do not allow coax or BNC connectors to contact any ground.**
ATTENTION	**Na laissez pas le connecteur coaxial ou BNC entrer en contact avec une mise a la terre.**

Maximum wire gauge for the connectors on the rear of the TB7 housing is 14 AWG; minimum is 26 AWG. Wiring must bear a suitable voltage rating for the highest voltage connected to the termination board (either signal or power) and a 75°C (167°F) minimum rating. Wiring must be in accordance with the National Electrical Code.

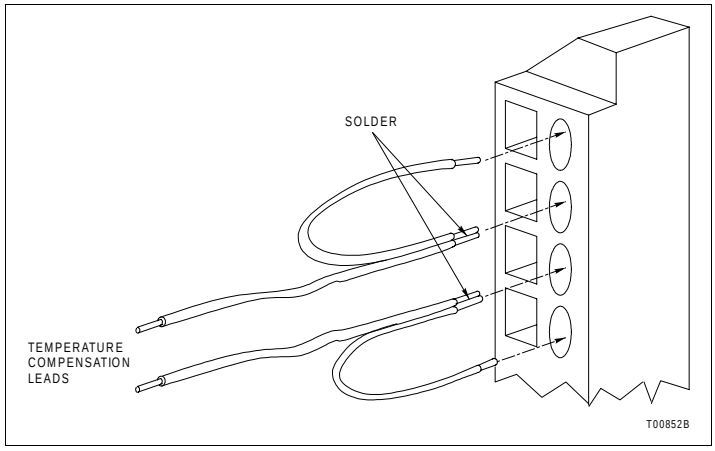


Figure 2-6. Temperature Compensation Wiring

Connect the analog inputs and outputs using the external wiring label (Figure 2-7) as a guideline for terminal block assignments.

CAUTION	**Manual temperature compensation does not require a resistance across the temperature compensation terminals (TB4-2 and TB4-3) unless the shorting straps for the temperature compensation circuit are in place across TB4-1 and 2 and TB4-3 and 4. If the shorting straps are in place, a resistor between 2.0 and 4.0k ohms must be placed across the temperature compensation terminals (TB4-2 and TB4-3).**
ATTENTION	**La compensation manuelle de température ne requiert pas une résistance entre les bornes de compensation de température (TB4-2 et TB4-3) à moins que les cavaliers de court circuit soient en position entre TB4-1 et 2 et TB4-3 et 4. Si les cavaliers de court circuit sont en position, une résistance entre 2.0 et 4.0k ohms doit être placée entre les bornes de compensation de température (TB4-2 et TB4-3).**

Digital Input/Output Wiring

Digital input wires should be twisted pair, stranded wires insulated with low leakage insulation materials. Individually shielded pairs provide greater protection against noise and crosstalk than nonindividually shielded pairs. Shields are to be grounded at the same earth ground potential as the AC power wiring of the TB7 controller. The field end of the shield should not be connected to a ground.

Maximum wire gauge for the connectors on the rear of the Type TB7 housing is 14 AWG; minimum wire size is 26 AWG. Wiring must bear a suitable voltage rating for the highest voltage connected to the termination board (either signal or power)

Alarm Expansion Board		
Terminal	TB2/TB3	
1	AO3	+
2	AO3	-
3	DO3	NC
4	DO3	COM
5	DO2	NO
6	DO4	NC
7	DO4	COM
8	DO4	NO

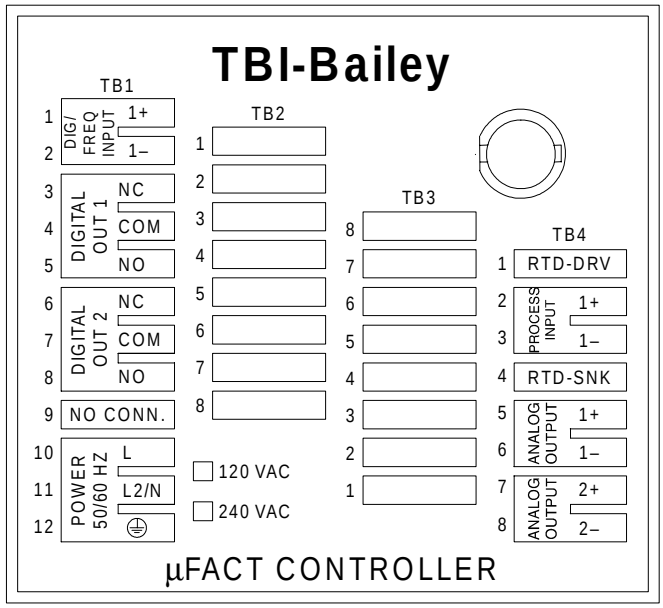


Figure 2-7. External Wiring Label

and a 75°C (167°F) minimum rating. Wiring must be in accordance with the National Electrical Code.

Connect the digital inputs and outputs using the external wiring label (Figure 2-7) on the outside of the rear cover as a guideline for terminal block assignments.

OPTION BOARDS INSTALLATION

If ordered by nomenclature, the option boards are installed in the controller at the factory. If the option boards are ordered by spare parts kit number, the boards are installed by the user. For detailed instructions on installation, refer to the repair/replacement procedures section.

PREOPERATING ADJUSTMENTS

Removing the Circuit Boards

NOTE: The circuit boards contain MOS devices and are subject to damage by static electricity. Refer to section titled ***SPECIAL HANDLING PROCEDURES FOR MOS DEVICES.***

1. Power down the unit. At the top and bottom of the front panel assembly are two bezel clips that hold the front panel assembly to the housing. Push the faceplate portion of the front panel assembly in towards the housing. Release the bezel clips using a flat blade screwdriver.

2. Grasp the front panel assembly by the sides and pull the assembly with the main board out of the housing. Once the assembly unplugs, allow at least 15 seconds to elapse before handling it. Keep in mind that the main board assembly is attached to the faceplate and at no time should these be disassembled from one another.

3. Refer to section entitled ***Selecting Options on the Main Board Assembly*** for procedures to check and/or set the necessary switches prior to placing the unit in service.

Display Contrast Adjustment

The display contrast has been preset at the factory. Due to variances in lighting at the installation site, you might find it necessary to adjust the contrast of the display. Once the unit has been installed, wired and powered up, check the display and adjust if necessary.

1. Remove power from the controller. Remove the front panel/main board assembly from the controller housing. Refer to ***Removing the Circuit Boards*** in this section for details.

2. Locate R101 on the main board (Figure 2-8).

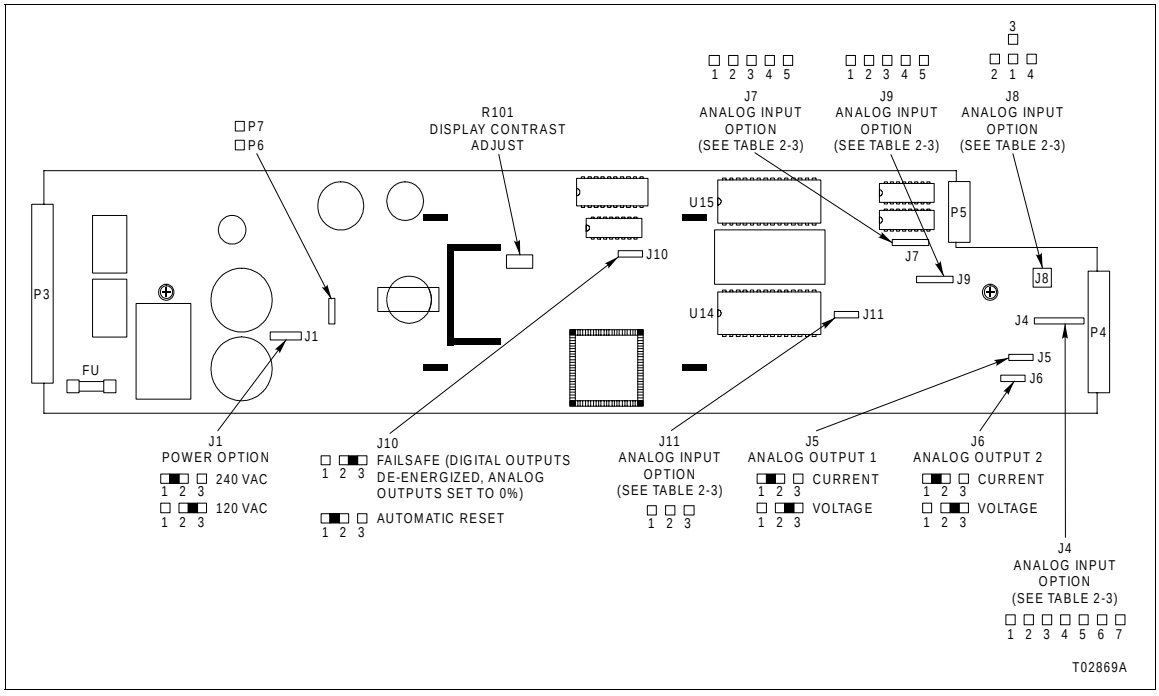


Figure 2-8. Main Board Adjustments and Components

3. If the background was too dark, turn R101 clockwise ⅛ of a turn or less. If the lettering was too light, turn R101 back slightly counterclockwise.

4. Insert the front panel/main board assembly into the housing and apply power.

5. Repeat Steps 1 through 4 until the optimum contrast is achieved.

Factory Jumper Settings

The jumpers on the main board have been preset at the factory. To change the factory jumper positions and customize the controller for your application, refer to ***Removing the Circuit Boards*** in this section for procedures to gain access to the boards and to ***Selecting Options on the Main Board Assembly*** once the boards are removed. The highlighted or screened jumper positions in Tables 2-1 through 2-4 designate the factory settings. A column has been included in each table for the user to record the final jumper positions.

Selecting Options on the Main Board Assembly

The options of the TB7 controller allow variations in the performance to be selected according to the requirements of a particular application. The jumper settings should be made prior to placing the TB7 controller in service. Refer to section titled ***Removing the Circuit Boards*** for the procedures to gain access to the main board assembly and make the proper jumper settings.

Refer to Figure 2-8 for location of these jumpers and to Tables 2-1 through 2-4 for a summary of the options.

POWER OPTION

Refer to Table 2-1 for proper jumper positioning for either 120 or 240 VAC use. This setting is completed at the factory and should be positioned according to the nomenclature of the unit ordered. If a replacement main board is being installed, be certain to set the switch for your application.

Table 2-1. Power Option

Option	Control	Setting	Customer Setting
120 VAC	J1	2-3	
240 VAC		1-2	

NOTE: Factory default settings are determined by the nomenclature ordered.

ANALOG OUTPUT OPTIONS

Analog outputs 1 and 2 can be individually selected to provide either a current or voltage output. Jumper J5 selects either

the current or voltage mode for analog output 1. Jumper J6 selects either the current or voltage mode for analog output 2. The current or voltage range is selectable in the configuration screens. Upon power up and in the event of a failure condition, the analog outputs will default to 0 V or 0 mA, whichever is selected for each individual output. For those TB7 controllers having the expansion board and using analog output 3, the current or voltage range is selectable using Jumper J3. Refer to Figure 2-9 for location of Jumper J3.

Table 2-2. Analog Output Options

Option	Control	Setting	Description	Customer Setting
Analog Output 1	J5	1-2	For current output	
		2-3	For voltage output	
Analog Output 2	J6	1-2	For current output	
		2-3	For voltage output	
Analog Output 3 (expansion board)	J3	1-2	For current output	
		2-3	For voltage output	

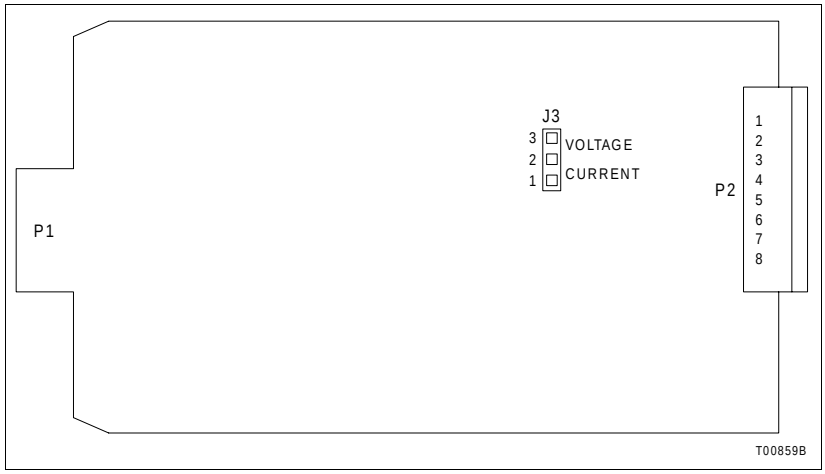


Figure 2-9. Expansion Board - AO3 Current/Voltage Selection

ANALOG INPUT OPTIONS

Analog input 1 is preset. Refer to Table 2-3 for the default jumper settings.

Table 2-3. Analog Input Default Settings

Analog Input 1	J4	J7	J8	J9	J11	Customer Settings
For pH Inputs	2-3	2-3	1-4	1-2	2-3	
	4-5	4-5		3-4		
	6-7					

FAILURE DETECTION OPTION

Refer to Table 2-4. The TB7 controller continually runs a set of self-diagnostics to ensure proper operation. Jumper J10 on the main board is used to select the response of the controller if an on-board failure is detected. Jumper J10, position 2 to 3, holds the unit in a fail-safe condition as the digital outputs are de-energized and the analog outputs are set to 0 V or 0 mA. Jumper J10, position 1 to 2, allows the unit to automatically reset itself in an attempt to resolve the failure and come up running - if diagnostics pass.

Table 2-4. Failure Detection Option

Option	Control	Setting	Customer Setting
Fail-Safe (Low)	J10	2-3	
Auto Reset	J10	1-2	

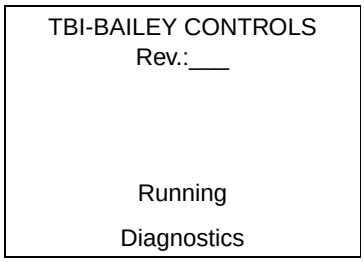
INITIALIZATION

After the TB7 controller has been wired for the application, initialize the controller.

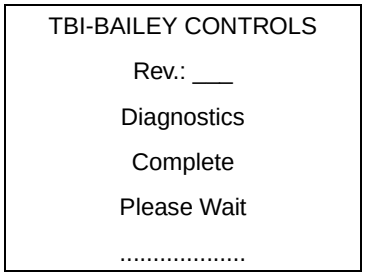
1. Power up the TB7 controller. The initialization procedure will be executed.

2. The initialization procedure takes approximately 60 seconds.

3. During this time period, internal diagnostics are performed. The display will show:



4. After successfully completing the internal diagnostics, the display will show:



5. If a configuration does not exist, the display will go to the MAIN MENU. If a configuration does exist, the display will go to the PROCESS SCREEN.

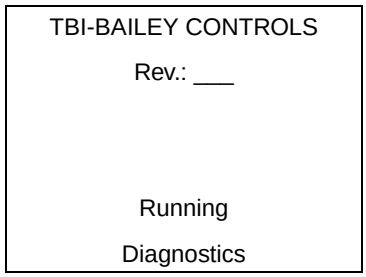
NVRAM INITIALIZATION

The configuration of the TB7 is stored in the NVRAM (Non-volatile Random Access Memory). This type of memory is used because it can be written to electrically, but will retain data in the event of a power failure.

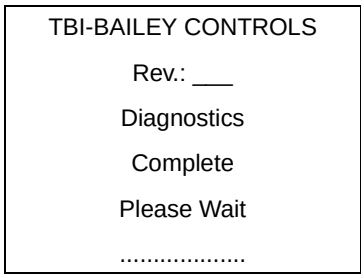
Any previously stored configuration in the NVRAM may be erased.

1. If power to the TB7 controller is on, remove the power.

2. Hold the lower left multi-function soft key on the faceplate and apply power to the controller. This screen then appears:



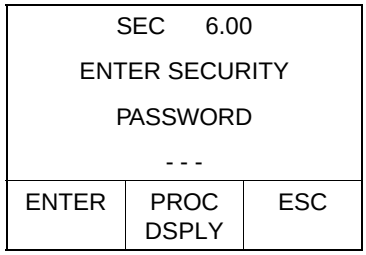
3. If diagnostics pass, this screen appears:



4. Continue to hold the lower left multi-function soft key until the fifth dot appears on the bottom line of the screen.

5. After the configuration is erased, diagnostics will repeat once more.

6. If no previous security password exists, the NVRAM will be erased after the internal diagnostics are completed. The faceplate will display the MAIN MENU. If a previous security password does exist, the faceplate will display the following message.



If the correct password is entered, the NVRAM will be erased and a reinitialization will occur. This takes approximately 20 seconds. After the 20 seconds, the faceplate will display the MAIN MENU. If an incorrect password is entered, the NVRAM will not be erased, and the faceplate will display the MAIN MENU.

SECTION 3 - CONFIGURATION

INTRODUCTION

This section provides the required actions to establish and define the configuration of the TB7 controller. It supplies detailed descriptions of the various selections that appear on the screens during the configuration process. Additional information is provided for the process of entering a configuration and entering the security levels. Refer to the Screen Overview Flowcharts in Appendix D of this instruction. Use these flowcharts as you go through the descriptions in this section. It will help familiarize you with the screens displayed during your selection.

The TB7 controller enables an operator to monitor and control a process either automatically or manually. The faceplate areas of the TB7 controller allow for operator interface to the process; while the main board allows the control configuration to be programmed and stored. Control configuration is accomplished by menu-driven configuration screens. The configuration is saved in NVRAM. The faceplate communicates with the main board and displays information such as process variable, temperature, setpoints and control output.

PRECONFIGURATION DATA REQUIRED

Before a configuration can be entered, define the desired:

- Configuration
- Controller Parameters (if applicable)
- Analyzer Parameters
- Analog Output Modes
- Digital Output Modes
- Alarms
- Security

Refer to the worksheets at the back of this manual and enter the information as you decide on the configuration. These sheets will help during the configuration entry procedure.

Configuration

The first step in configuring the TB7 controller is to select the desired configuration to be executed. There are three standard pH configurations to choose from. These configurations are:

- Basic analyzer transmitter
- PID controller
- Bidirectional controller

Each of these can be customized to meet the requirements of your application.

BASIC ANALYZER TRANSMITTER

The basic analyzer transmitter configuration provides a means to monitor and control the pH of a process fluid. Control of the final element is achieved by using the digital outputs in either a simple ON/OFF or ON/OFF cycle timer mode. (Refer to sections entitled ***Analog Output Modes*** and ***Digital Output Modes***.) The analog outputs in this configuration are dedicated for recorder outputs. The process display shows the pH input, process temperature, user specified setpoints and analog output.

PID CONTROLLER

The PID controller configuration provides the functionality and flexibility of the basic analyzer transmitter configuration plus the capability of single channel PID control with optional linearization of the pH titration curve (refer to ***PROGRAMMING THE PID CONTROLLER AND NONLINEAR INPUT*** in Appendix A). Control of the final elements is achieved by using an analog output and/or by using the digital outputs in a time proportional, frequency proportional, ON/OFF, or ON/OFF cycle timer mode. Recorder outputs are also available in this configuration. The process display shows the process variable, process temperature, PID setpoint, and PID control output.

BIDIRECTIONAL CONTROLLER

The bidirectional controller configuration provides the functionality and flexibility of the basic analyzer transmitter configuration plus the capability of dual output PI control with optional linearization of the pH titration curve for addition of both acid and base (refer to ***PROGRAMMING THE PID CONTROLLER AND NONLINEAR INPUT*** in Appendix A). Control of the final elements is achieved by using analog outputs or by using the digital outputs in a time proportional or frequency proportional mode. Recorder outputs are also available in this configuration. The process display shows the process variable, setpoints, process temperature, and control outputs.

Customize any one of these configurations for the particular application by selecting various options from the configuration screens. These options are discussed in the remainder of this section.

NOTE: The bidirectional controller does not have derivative action.

Controller Parameters

PID CONTROLLER CONFIGURATION

The PID controller uses a control algorithm that requires the operator to enter several tuning variables. These variables are:

- Linear or nonlinear process variable input
- Direct or reverse acting controller
- Power up state of the controller
- Control output power up
- Analog or digital output

Linear or Nonlinear Process Variable Input

Linear control of a nonlinear process is possible by selecting *NONLINEAR*. Linearization data is then entered using a five-segment function generator. (Refer to ***PROGRAMMING THE PID CONTROLLER AND NONLINEAR INPUT*** in Appendix A.)

Direct or Reverse Acting Controller

Select the action of the PID controller. For pH control, acid addition is direct action; base addition is reverse action. When using a function generator to linearize a pH input (nonlinear input), the controller is preset to reverse acting.

BAND The BAND variable represents the proportional band constant (limits are 1 to 9999 percent) of the PID calculation of the output.

RESET The RESET variable represents the integral reset constant (limits are 0 to 99.99 resets/minute) of the PID calculation of the output.

DERIV. The DERIV. variable represents the derivative rate constant (limits are 0 to 99.99 minutes) of the PID calculation of the output.

Power Up State of the Controller (PWR UP ST)

Specify the power up state of the TB7 controller and choose either *AUTO*, *MANUAL* or *LAST*.

If the selection is *AUTO*, upon power up the controller performs the configured algorithm after the initialization and controls the final elements. If the selection is *MANUAL*, upon power up the controller performs the configured algorithm after initialization but does not control the final elements. If the selection is *LAST*, upon power up the controller defaults to

the previous mode before power down. These are controlled by settings from the faceplate.

Control Output Power Up (CO PWR UP)

Specify the power up value of the control output in conjunction with the PWR UP ST of the controller. Choose either *HI*, *LO* or *LAST*. If the selection is *HI*, the control output defaults to 100 percent after the 20 second initialization period. If the selection is *LO*, the control output defaults to 0 percent after the 20 second initialization period. If the selection is *LAST*, the controller defaults to the previous control output value before the loss of power after the 20 second initialization. Bidirectional controller outputs are limited to the choices of LO or *LAST*.

Analog or Digital Output

Select the final elements to be controlled by either an analog or digital output. (Refer to the sections entitled ***Analog Output Modes*** and ***Digital Output Modes***.)

BIDIRECTIONAL CONTROLLER CONFIGURATION

The bidirectional controller uses a control algorithm that, like the PID controller, requires the entering of several tuning variables as previously discussed. These variables are BAND and RESET. The desired setpoints must be entered for both controllers and whether they are analog or digital outputs. Power up state (PWR UP ST) is selectable as *AUTO*, *MANUAL* or *LAST*. Power up value (CO PWR UP) is selectable as *LAST* or *LOW* for both the acid and base controllers.

> **NOTE:** Refer to ***PID CONTROLLER CONFIGURATION*** for detailed descriptions of these variables.

Analyzer Parameters

SENSOR TYPE

Choose whether a standard pH sensor, an antimony pH sensor or the CENTRODE pH 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°C (77°F) 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. Reference offset

calibrations assume a saturated KCl reference potential of -30 millivolts as normal (i.e., displayed as a zero millivolt offset).

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 59 millivolt value. Therefore, a normal efficiency reading will be 86 percent or less. A lack of fresh antimony surface will lower this efficiency. An Ag/AgCl (silver/silver chloride) reference with KCl (potassium chloride) electrolyte is used with antimony sensors. As in the standard pH sensor, this reference produces -30 millivolts which is used as the null point for reference offset calculation. Temperature compensation choice of MANUAL is compatible with the antimony sensor choice only for the purposes of temperature display.

CENTRODE Sensor

CENTRODE sensors have a measurement electrode used with a standard reference (Ag/AgCl) electrode with KCI (potassium chloride) electrolyte. Efficiency calculations assume calibration to 25°C (77°F) with a theoretical slope of 59.15 millivolt per pH unit. All temperature compensation choices are compatible with this choice. Thermo-isopotential is at 2.00 pH. Reference offset calibrations assume a saturated KCl reference potential of -30 millivolt as normal (i.e., displayed as a zero millivolt offset).

TEMPERATURE COMPENSATION

Temperature has two effects on pH measurement. The first 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[1]. The effect of temperature on a pH sensor can mathematically be described as:

$$\frac{0.19841mV(T-25°C)(pH-7)}{(pH)(°C)}$$

It can be seen by this equation that if pH is near 7 or temperature deviates little from 25°C, the effect of temperature is small. Table 3-1 describes this effect.

1. CENTRODE sensors are factored at 2.0 pH isopotential.

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 3-2 and 3-3 describe this effect for stable pH buffers and some solutions.

Table 3-1. Standard pH Electrode Output at Temperature

Temperature	0°C (32°F)	25°C (77°F)	40°C (104°F)	70°C (158°F)	90°C (194°F)
pH	mV	mV	mV	mV	mV
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 3-2. Effects of Temperature of Stable pH Buffers

Temperature °C (°F)	Buffer			
	pH 4.01	pH 6.87	pH 9.18	pH 12.45
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 3-3. Temperature Effects on Specific Solutions

Temperature °C (°F)	Pure H_2O pH	NH_4NO_3 pH	Pulp Liquor pH
18 (64)	7.12	7.47	13.63
25 (77)	7.00	——	13.21
50 (122)	6.64	6.27	11.75
70 (158)	6.41	——	11.38
90 (194)	6.23	5.18	11.04

The TB7 controller allows three types of temperature compensation; manual, standard automatic and auto/solution.

Manual

Manual temperature compensation compensates the pH value for the effects of temperature on the sensor (Nernstien effect) at a specific temperature. An automatic temperature compensator is not required to use this method. Any temperature between -20° and +150°C (-4° and +302°F) can be entered into the TB7 controller and the correct compensation factor will be applied to reference the pH value back to 25°C (77°F).

If an Antimony sensor is selected as the sensor type, the temperature compensation is automatically selected to be manual. If manual temperature compensation is chosen, the user must enter the process temperature (limits are -20 to +150°C, or equivalent degrees F). The 25°C default is typically correct for all processes regardless of actual process temperature when using antimony pH sensors.

Standard Automatic

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 3-4.

Table 3-4. TBI-Bailey Temperature Compensator Resistance Values

Temperature °C (°F)	Resistance kilohms
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 (284)	4.47

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°C.

Auto/Solution

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

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 formula:

$$standard/auto \sim \pm \frac{(ph\ change)(T - 25°C)}{10°C}$$

CAUTION

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

ATTENTION

Le mode Auto/Solution pH ne peut etre utilise que pour les processus qui presentent une grande repetabilite quant aux valeurs du pH mesurees et aux composants chimiques presents.

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 10. 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 (-) for correct solution compensation.

TEMPERATURE DISPLAY UNITS

Select the units of the process temperature, degrees C or degrees F, that will be displayed on the process display screen.

> **NOTE:** The internal computations of the TB7 controller that contain temperature as a variable will always be done in degrees C regardless of which choice is selected to be displayed on the process display screen.

DAMPING

Damping can be helpful in noisy process environments. Select whether damping is to be added to the input pH signal or only to the pH signal that goes to the recorder output. Damping is

added as a capacitive type lag where reaction to any signal change is slowed according to a time constant entered. Five seconds of damping will allow reaction to approximately 63 percent of a step change over the five second period. Choices available for damping are:

None
pH Input
Recorder

Damping the pH input will cause signals to the controller, digital outputs, setpoint alarms and recorder output to be damped. Damping the recorder output affects only the recorder pH output. Both choices can be set separately. Damping both choices will cause ***double damping*** on the recorder output. Damp time is adjustable from 0 to 99.99 seconds.

The bidirectional controller configuration defaults to pH input damping of 1.0 seconds. This is advised for most process applications. Processes having both quick and large erratic changes in process pH may require additional damping for proper control. Basic analyzer and single PID controller configurations default damping to none.

Analog Output Modes

There are a number of modes in which both the analog and digital outputs can operate. The modes that an output may operate in depend upon the configuration chosen.

ANALOG OUTPUTS

All of the analog outputs are selectable to operate in either 0 to 5 volts, 1 to 5 volts, 0 to 20 milliamps, or 4 to 20 milliamps. Refer to ***Selecting Options on the Main Board Assembly*** in the installation section to determine proper jumper settings for voltage or current operation. All of the outputs are separately scalable, and all the outputs are isolated from the input.

RECORDER OUTPUTS

In the basic analyzer transmitter, the analog outputs are dedicated as recorder outputs. In the PID controller and bidirectional controller, the analog outputs may be used as recorder outputs as well by connecting them in series with the control device and recorder. Variables that can be tied to these outputs in this mode include pH, controller output, and temperature. The analog output on the alarm expansion board adds raw pH (no solution compensation) as a source.

CONTROL OUTPUTS

In either the PID controller or the bidirectional controller configuration, the analog outputs, digital outputs or both may be used to control final elements.

Digital Output Modes

The digital outputs can be used for either control or to generate alarms. Select whether or not to display an alarm condition to the faceplate upon activation of a digital output.

HIGH OR LOW SETPOINT

A digital output can be configured as a high setpoint (HI SP) or low setpoint (LO SP) for the measured process variable or temperature. Specify the turn-on (activate) and turn-off (deactivate) point to form an adjustable hysteresis. An adjustable time delay, with a range of 00.00 to 99.99 minutes, can also be used. Refer to Figure 3-1.

NOTE: If Digital Output 2 is sourced to temperature while in the analyzer/transmitter configuration, it will not report the turn-on point to the bar graph display on the process display screen.

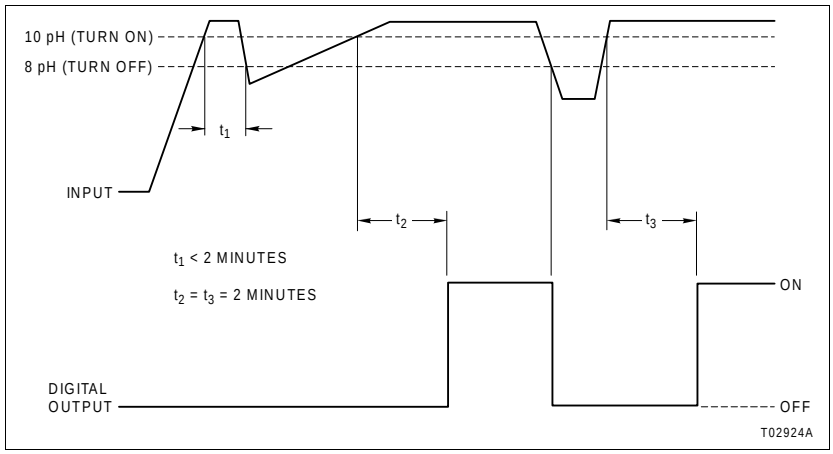


Figure 3-1. High or Low Setpoint Example

The waveforms in Figure 3-1 show how Digital Output 1 will respond to a varying pH input if Digital Output 1 was selected as a high setpoint with pH as the source to control a valve that adds acid to a process flow if the input reaches a level of 10 pH (turn on) and remains above 8 pH (turn off) for at least 2 minutes (time delay).

From left to right, the pH input increases above the turn-on value of 10 pH and then decreases below the turn-off value of 8 pH within the time period of t_1. In this example, t_1 is some period of time less than the user-selected time delay of 2

minutes. The output does not react to this change in pH input. The input then goes above the turn-on value of 10 pH and stays above the turn-off point of 8 pH for some time period greater than t_2. The t_2 value is the user-selectable time delay value of 2 minutes. The output reacts to this input after the time delay period of 2 minutes by adding acid to the process flow. The output stays activated (valve open) until the pH input falls below the turn-off value of 8 pH. The pH input then goes above the turn-on value of 10 pH and stays there. The output reacts to this input after the user-selectable time delay of 2 minutes and will remain activated (valve open) until the pH input falls below the turn-off value of 8 pH.

NOTE: This example used Digital Output 1 as a high setpoint, where the turn-on value is greater than the turn-off value. Digital Output 1 could have been set up to be a low setpoint by making the turn-on value to be less than the turn-off value.

HIGH OR LOW CYCLE TIMER

A digital output can be configured as a high cycle timer (HI CT) or a low cycle timer (LO CT). Specify the turn-on (activation) point, the cycle time, (range 0.1 to 99.99 minutes) and the on-time (range 0.1 to 99.99 minutes).

In this example, digital output 2 has been selected as a low cycle timer with pH as the source to control a valve that adds base to a process flow if the pH input falls below 4 pH (turn-on). The cycle time has been selected to be 10 minutes and the on time to be 6 minutes. The waveforms in Figure 3-2 show how the digital output 2 will respond to a varying pH input.

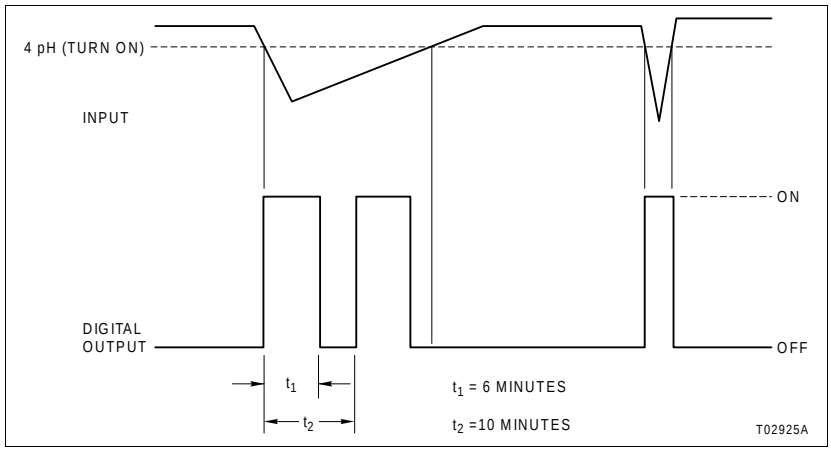


Figure 3-2. High or Low Cycle Timer Example

Refer to Figure 3-2. From left to right, the pH input decreases below the turn-on value of 4 pH and the output begins a 60 percent duty cycle (on time/cycle time), adding base to the process flow. This continues until the pH input goes above the

turn-on value of 4 pH. The pH input then goes low for a period of time less than the user-selected on time. The output begins the 60 percent duty cycle but deactivates as soon as the pH input goes above the turn-on value of 4 pH.

NOTE: This example used digital output 2 as a low cycle timer, a decreasing pH input activates the digital output. Digital output 2 could have been set up to be a high cycle timer which would activate the digital output on an increasing pH input.

PULSE DURATION

The PID controller and bidirectional controller configurations allow for digital outputs to be configured for time proportional control (P DURAT) of the final elements. Specify the cycle time (range 0.1 to 1 minute).

Refer to Figure 3-3. The PID controller has been configured with digital outputs in the PULSE DURATION mode. The cycle time has been selected to be 1 minute. The on time of the digital output will be equal to the PID control output multiplied by the user-selected cycle time. The waveforms in Figure 3-3 show how digital output 1 will respond to a varying PID controller output.

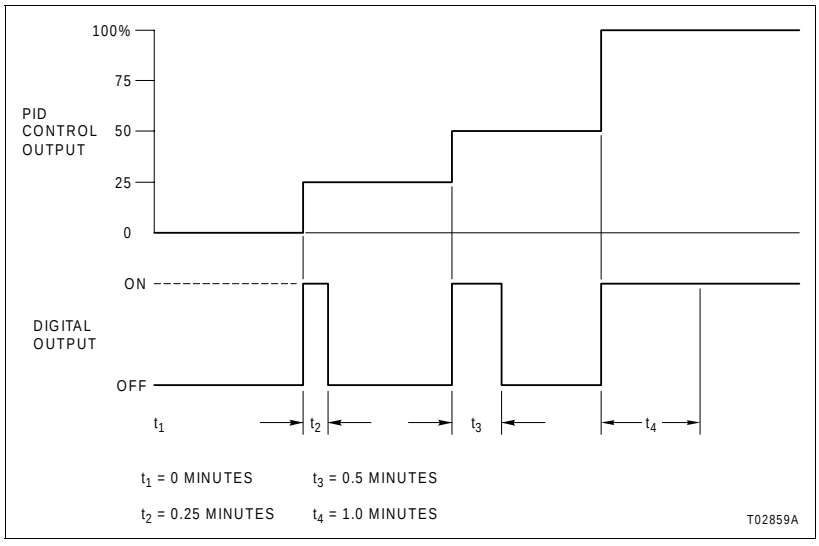


Figure 3-3. Pulse Duration Example

Refer to Figure 3-3. From left to right, the PID control output is at 0 percent, the digital output on time, t_1, is 0 percent x 1 minute = 0 minutes. The PID output then goes to 25 percent and the digital output on time, t_2, is 25 percent x 1 minute = 0.25 minutes. The PID output then goes to 50 percent and the digital output on time, t_3, is 50 percent x 1 minute = 0.5 minutes. The PID output then goes to 100 percent and the digital output on time, t_4, is 100 percent x 1 minute = 1 minute.

PULSE FREQUENCY

The PID controller and bidirectional controller configurations allow for digital outputs to be configured for pulse proportional control (P FREQ) of the final elements. Specify the maximum pulses per minute (range 0 to 120 per minute).

For this example, the bidirectional controller has been configured with digital outputs in the PULSE FREQUENCY mode. The maximum pulses per minute has been selected to be 100. The digital outputs will deliver a pulsed output where the number of pulses will be equal to the PID control output x maximum pulses per minute. Each pulse will have a 50 millisecond duration. The waveforms in Figure 3-4 show how digital output 1 will respond to a varying PID control output.

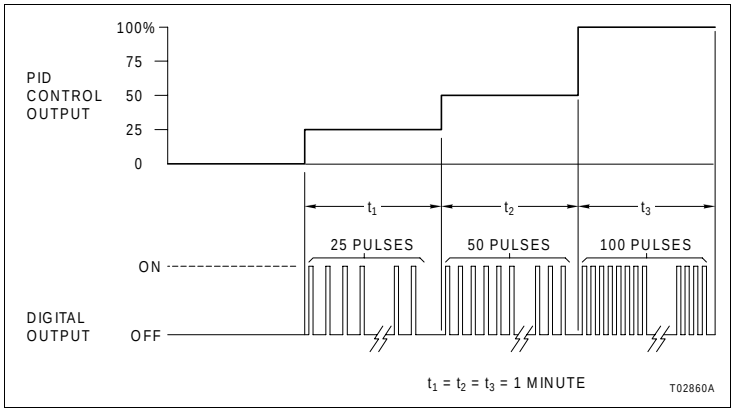


Figure 3-4. Pulse Frequency

Refer to Figure 3-4. From left to right, the PID control output is at 0 percent and the digital output is 0 percent x 100 = 0 pulses/minute. The PID control output then goes to 25 percent and the digital output is 25 percent x 100 = 25 pulses/minute. The PID output then goes to 50 percent and the digital output is50 percent x 100 = 50 pulses/minute. The PID output then goes to 100 percent and the digital output is 100 percent x 100 = 100 pulses/minute.

TIMER

Digital outputs 3 and 4, available with the alarm expansion board, can be configured as timers for timing a digital output activation. A control output above a user-entered percent is also available with the alarm expansion board.

The format for using a digital output as a timer is the same as using it as a high or low setpoint. The difference is that any variable can be used as a source (pH, temperature, controller output). The time delay setting is adjustable from 0.00 to 99.99 minutes. To use digital output 3 or digital output 4 as a

timer, choose high or low setpoint as the mode and the appropriate variable as the source.

In this example, digital output 3 has been selected for use as a timer by mimicing all the settings of digital output 1 except time delays. Thus digital output 3 will be activated if digital output 1 is activated for a period of time greater than the user-specified time delay, 30 minutes. The waveforms in Figure 3-5 show how digital output 3 will respond to varying activation times of digital output 1.

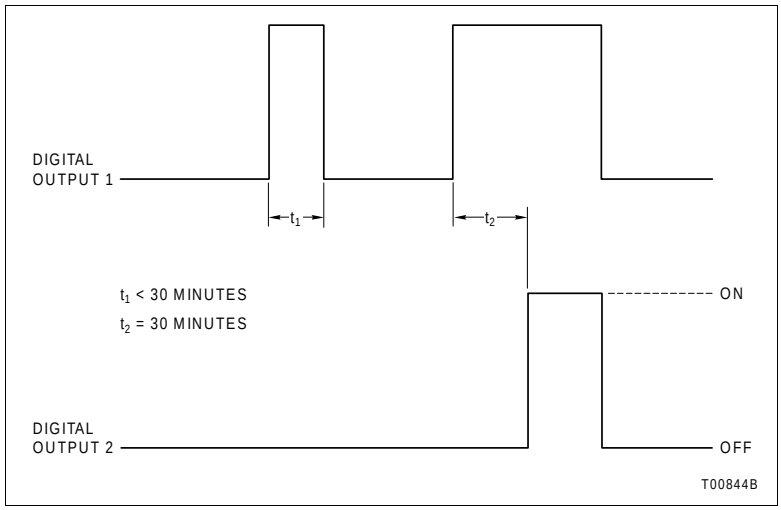


Figure 3-5. Timer Example

Refer to Figure 3-5. From left to right, digital output 1 activates for a period of time, t_1, less than the user-specified time delay, 30 minutes and digital output 3 does not activate. Digital output 1 then activates for a period of time, t_2, greater than the 30 minute time delay. Digital output 3 then activates 30 minutes after digital output 1 becomes active and stays activated until digital output 1 deactivates.

Washer Timer

Digital output 4 can be used to control the activation of an in-process pH sensor cleaner if this mode is chosen.

The washer timer will activate digital output 4 according to a user-entered cycle time and recovery time. At the end of the recovery time, the cycle timer will reset. During the clean and recovery times, a single PID control output (either analog or digital type) will be frozen at the value that existed before cleaning began. All bidirectional control outputs will go to 0 percent output. All other digital outputs will become deactivated (go to logic 0). Analog outputs (other than those sourced to PID or PI controllers) can be programmed as frozen or free to follow process changes initiated by the sensor cleaning solution by means of a HOLD OUTPUT function (Yes/No).

As an example, set the washer timer choices to:

Cycle time:	24 hours
Clean time:	30 seconds
Recovery time:	60 seconds
Hold output:	yes

Every 24 hours, digital output 4 will activate a sensor cleaner. The cleaner will activate for 30 seconds. During this period, a single PID control output will be frozen at the output that existed before cleaning began. (Bidirectional control outputs will go to 0 percent.) All other analog outputs will also be frozen because the HOLD OUTPUT function is activated. All other digital outputs will go to logic 0 (deactivated). These conditions will exist for 60 seconds after the sensor cleaner has stopped operating. This recovery time allows the process to flush any cleaning solution away from the pH sensor. Normal operations will resume at the end of the recovery time. The cycle will repeat 24 hours later.

Alarms

Select which digital outputs upon activation get reported to the process display as an alarm. Process temperature alarm points are preset at -20°C (-4°F) and +150°C (+302°F). Adjust these values for the particular application. If the process temperature exceeds these limits, an alarm will be generated to the process display. For the PID and the bidirectional controllers, the process variable high and low alarm points can be set by the user. When the process variable exceeds these values, an alarm will always be generated on the process display.

Security

The SECURITY environment allows a password to be set consisting of three alphanumerics to two levels: TECHNICIAN and MASTER. The security level of the CONFIGURE, TUNE, and CALIBRATE environments can then be assigned to either of these passwords. The MASTER password can be used to enter any of the environments as it overrides the TECHNICIAN password.

CONFIGURATION SCREENS

The TB7 controller is configured by operator interaction with menu driven displays via the faceplate. The configuration screens seen depend upon the standard configuration chosen and the selections within the screens of the particular configuration. The configuration screens for the standard configurations are shown in detail in Appendix D of this manual.

CONFIGURATION WORKSHEETS

The worksheets at the back of this manual provide information needed to generate the configuration. The worksheets also help organize the data in a usable format prior to entering the configuration via the faceplate.

ENTERING A CONFIGURATION

To enter a configuration, enter the CONFIGURE environment from the MAIN MENU. Then enter the proper security password (if any, refer to ENTERING SECURITY LEVELS) before access to the configuration is allowed. The TB7 controller is configured by operator interaction with menu-driven displays via the faceplate. The configuration screens seen depend upon the standard configuration chosen and the selections within the screens of the particular configuration. The configuration screens for the standard configurations are described in detail in Appendix D of this instruction.

As you are entering the configuration, these points should aid you during the procedure:

1. On the MENU screens, the selection appears in inversed video. To change a selection (move the inversed video), press the **UP** or **DOWN** pushbutton. When you arrive at the correct selection, press the **SEL** pushbutton.

2. To change or add a parameter that is to the right of the inversed video, press the **UP** or **DOWN** pushbutton.

3. Once the parameter has been correctly entered, press the **SEL** pushbutton.

4. The inversed video will then move to the next selection.

5. Once all information on the present screen has been entered, press any one of the soft keys.

6. From the soft key menu, press **NEXT SCRN** to continue the configuration.

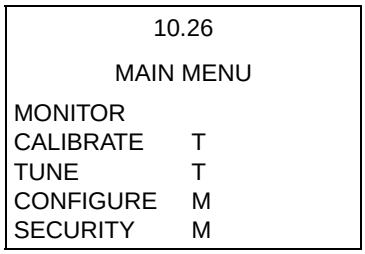
7. Continue with this procedure until all the data has been entered.

8. To save the configuration, the *SAVE AND EXIT* field must be inversed video and then selected. After selection is made, a prompt will appear asking if a new configuration should be saved. If *YES* is selected, the new configuration is saved in the NVRAM. If *NO* is selected by toggling the **UP/DOWN** pushbuttons, the previous configuration remains intact.

ENTERING SECURITY LEVELS

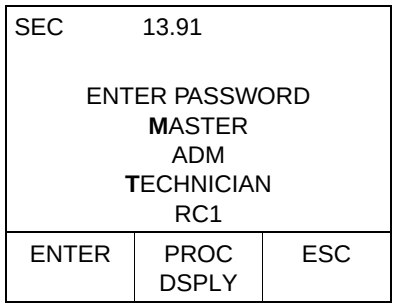
NOTE: Assigning security levels is an option. It is not required for operation of the unit.

1. From the MAIN MENU, select the SECURITY environment. Press the **DOWN** arrow pushbutton until *SECURITY* is in inversed video, press the **SEL** pushbutton.



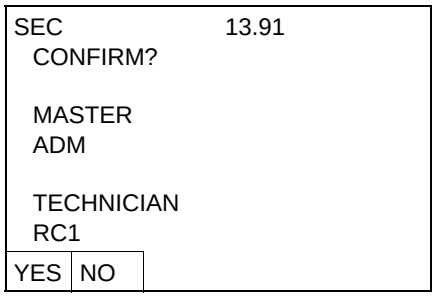
2. If security levels have been assigned previously, the MASTER password is required to enter this environment.

3. If the correct password was entered or no security levels were previously assigned, the password assignment screen will appear.

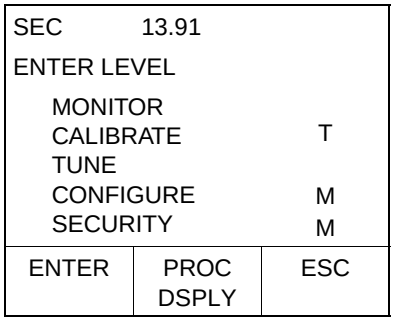


4. Enter the three alphanumeric password for the MASTER and the TECHNICIAN. The **UP/DOWN** pushbuttons are used to scroll through the alphanumeric set. When it is desired to move to the next character, press the **SEL** pushbutton. The user repeats this process until the passwords appear on the screen as desired. The **ENTER** soft key is then pressed to enter the passwords. A confirmation screen then appears. If *YES* is selected, the passwords shall be stored in EEROM and the

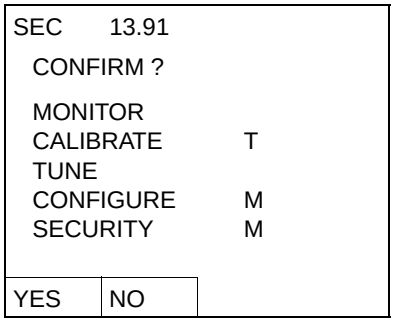
level assignment screen shall appear. If *NO* is selected, the password assignment screen shall reappear..



5. The level assignment screen shows all of the environments as they appear on the MAIN MENU. Use the **SEL** pushbutton to scroll through the environments that can have levels assigned to them (CALIBRATE, TUNE and CONFIGURE). The MONITOR environment has no security level assigned to it.



6. The SECURITY environment cannot be inversed video. As soon as any of the other environments have levels assigned to them, the SECURITY environment becomes automatically assigned to MASTER (M). The **UP/DOWN** pushbuttons are used to scroll through the three levels for the inversed video environment. The three choices are: MASTER (*M*), TECHNICIAN (*T*) and NONE (blank space means no security level installed). When all of the environments have levels selected as desired, the **ENTER** soft key is used to enter the levels. A confirmation screen will then appear. If *YES* is selected, the level assignments must be stored in EEROM and the MAIN MENU appears. If *NO* is selected, the level assignment screen reappears.



INITIALIZING/ERASING THE NVRAM

The configuration of the TB7 controller is stored in the NVRAM (Nonvolatile Random Access Memory). This type of memory is used because it can be written to electrically, but will retain data in the event of a power failure.

NOTE: This procedure ***erases*** any existing configuration data.

The user may erase any previously stored configuration in the NVRAM by performing the sequence listed in NVRAM INITIALIZATION in the installation section.

SECTION 4 - OPERATING PROCEDURES

INTRODUCTION

This section describes the operator interface controls and the various environments that would be encountered during the operation of the controller. It also provides a description of normal operation and the procedure required for tuning (changing the configuration constants) of the controller. Use this section in conjunction with the Screen Overview Flow-charts located in Appendix D of this instruction manual.

OPERATOR INTERFACE CONTROLS

Operator interface is provided through tactile pushbuttons and the backlit 80 x 80 pixel graphic display. Multiple screens guide operators, technicians, and process management personnel through menu-driven configuration and calibration procedures.

Single Function Pushbuttons

The four pushbuttons to the right of the display are single function keys, allowing the operator to change the value or choice on the screen, choose automatic or manual operation, and to select the field displayed on the screen.

UP/DOWN PUSHBUTTONS

The **UP/DOWN** pushbuttons are used to scroll through parameters on menu screens, to change selection choices on screens that have only one menu choice, and to change selected parameter values.

AUTOMATIC/MANUAL PUSHBUTTON

This pushbutton allows the operator the choice of automatic or manual operation. Transfers from automatic to manual and manual to automatic are always bumpless. After switching from manual to automatic, the process variable will be under automatic control in response to the adjustment of the local setpoint in the controller. This pushbutton is only active in the process display screen for the PID and bidirectional controller configurations.

SELECT PUSHBUTTON

This pushbutton allows the operator to select an inversed video parameter in a submenu and on the process display. On

screens where no submenu exists, it will enter the displayed selection.

Multi-Function Soft Keys

Three soft keys at the bottom of the display are multi-function keys. The specific function of these keys is defined by the graphics and will vary depending on the screen displayed. Touching any of these soft keys will first display a soft key menu. Once this soft key menu is displayed, pressing the soft key below the menu item desired will initiate the defined action.

FACEPLATE ENVIRONMENTS

Main Menu

The MAIN MENU is the default screen upon power up when the unit is not configured. It can also be entered into from other screens via the multi-function soft keys. This environment is the gateway to all of the other environments with the exception of the PROCESS SCREEN, which can be entered into from other screens via the multi-function soft keys. The security levels of the different environments are displayed on the main menu and are represented by a *T* (TECHNICIAN) or *M* (MASTER).

Process Screen

The PROCESS SCREEN is the default screen upon power up when a configuration does exist. The PROCESS SCREEN displays information relative to the process: process variable, setpoints, control output, temperature and if alarms exist. This screen can be entered into from the main menu and other screens when a configuration exists. No security level can be placed on this environment. (See Figure 4-1.) The operator can always get to this screen from any other environment by pressing the middle multi-function soft key.

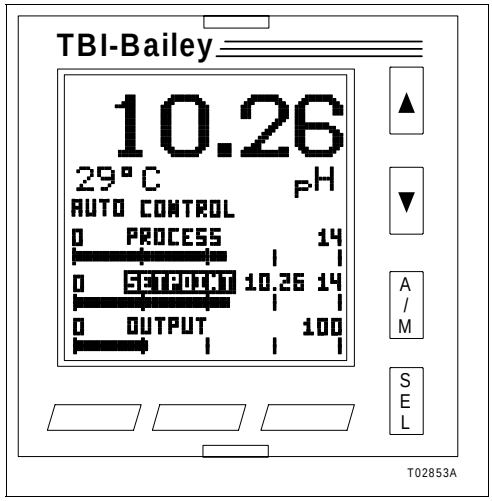


Figure 4-1. Process Screen

Monitor

The MONITOR environment allows the operator to observe the I/O of the TB7 controller in groups, i.e., all analog inputs together, all analog outputs together, etc. This environment is only for monitoring purposes and can only be entered from the MAIN MENU. No security level can be placed on this environment.

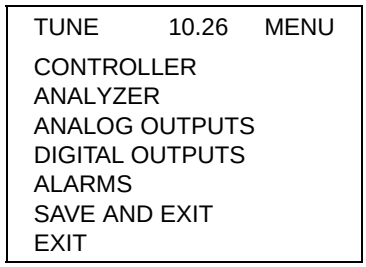
MON 10.26

ANALOG INPUTS
ANALOG OUTPUTS
DIGITAL INPUTS
DIGITAL OUTPUTS

NOTE: If a digital output is configured in the pulse frequency mode, the monitor screen will not show the logic state of the output. This is due to the short duration of the pulses.

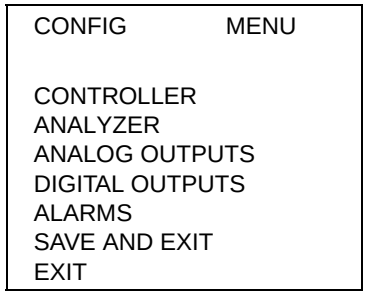
Tune

The TUNE environment (see following screen) allows the operator to examine the configuration and modify some tunable configuration parameters that affect the response of the TB7 controller. The tunable parameters are documented in Appendices C and D of this instruction manual. This environment can only be entered from the MAIN MENU.



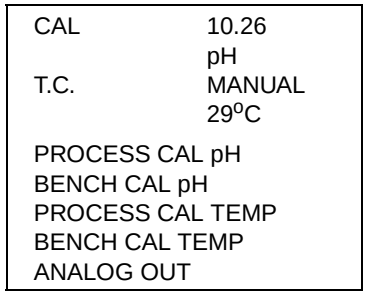
Configure

The CONFIGURE environment allows definition of the operation of the TB7 controller. This is done by selecting one of the standard configurations available and customizing it to fit the specific application. This is accomplished by interaction with menu driven displays. This environment can only be entered from the MAIN MENU.



Calibrate

The CALIBRATE environment allows process and bench calibrations to be performed on the I/O of the TB7 controller. This environment can only be entered from the MAIN MENU.



Security

NOTE: The security feature is optional and is not required for operation of the unit.

The SECURITY environment allows the setting of a password consisting of three alphanumerics to two levels, TECHNICIAN and MASTER. The security level of the following environments: CONFIGURE, TUNE and CALIBRATE can then be assigned to

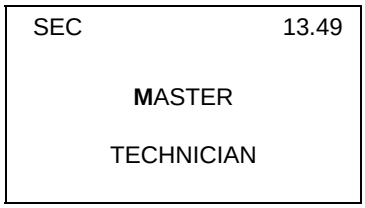
either of these passwords. The MASTER password can be used to enter any of the environments as it overrides the TECHNICIAN password. Security levels provide a way to prevent unauthorized changes to the controller. This environment can only be entered from the MAIN MENU. Once passwords have been entered, the MASTER password is required to enter the security environment.

SECURITY SHORTCUT

Once an environment is entered using a password, upon returning to the PROCESS DISPLAY, the previously entered environment can be returned to via the **PREV SCRN** soft key without using the security password. This would be very useful, for example, when tuning a PID loop.

ESTABLISHING SECURITY

To establish security levels to an environment and eliminate the security shortcut, go from the environment to the MAIN MENU and then to the PROCESS DISPLAY.



NORMAL OPERATING CONSIDERATIONS

Normal operation will occur when communication has been established between all the components within the TB7 controller and everything is operating properly.

Basic Analyzer Transmitter

The setpoints and analog output 1 value will appear on the appropriate bar graphs on the process screen on the front panel display. The pH input value will be displayed in the upper right-hand corner of the display while the process temperature will be displayed in the upper left-hand corner of the display. Setpoints can only be adjusted in the TUNE and CONFIGURE environments.

PID and Bidirectional Controllers

1. The setpoint, process variable and control output will appear on the appropriate bar graphs on the process screen on the front panel display. Figure 4-2 shows a PID controller process screen. Figure 4-3 shows two bidirectional controller

process screens; one in the MANUAL mode with the cursor on OUTPUT, and one in the AUTO mode with the cursor on HI SP.

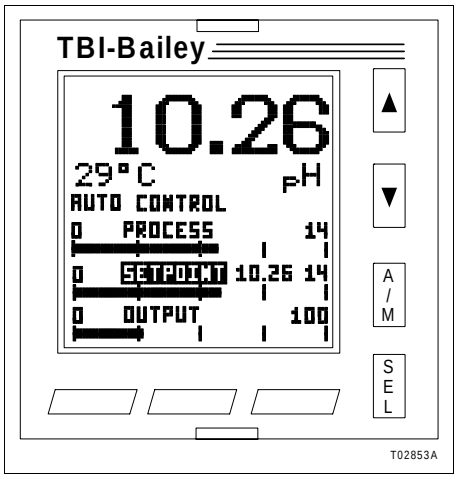


Figure 4-2. PID Controller Process Screen

2. Adjust the setpoint using the **UP/DOWN** pushbuttons when the setpoint is selected using the reverse video function for the PID or bidirectional controller. The control output can be adjusted when the unit is in the MANUAL mode using the **UP/DOWN** pushbuttons when the output is selected using the reverse video function for both the PID and bidirectional controllers.

> **NOTE:** In the bidirectional controller configuration, acid outputs appear as negative percent values (e.g., -27 percent) and base outputs appear as positive values (+ sign does not appear, e.g., 42 percent). For example, if the output value shows -27 percent, the acid output would be 27 percent and the base output would not go above 0 percent. When there is an acid output greater than 0 percent, the base output is less than or equal to 0 percent and vice versa.

ACKNOWLEDGING AND DEFINING ALARMS

1. If an alarm condition occurs, an **ACK ALRM** soft key prompt will appear on the screen (Figure 4-4). Once acknowledged, this prompt will go away. Also at the same time, ALARM will appear on the upper center portion of the screen. This remains as long as there is an alarm condition.

2. To view what the specific alarm is, use the soft keys to bring up the soft key menu. Press **ALARM SUM** to display all current alarms. To return to the PROCESS DISPLAY from this screen, use the soft keys.

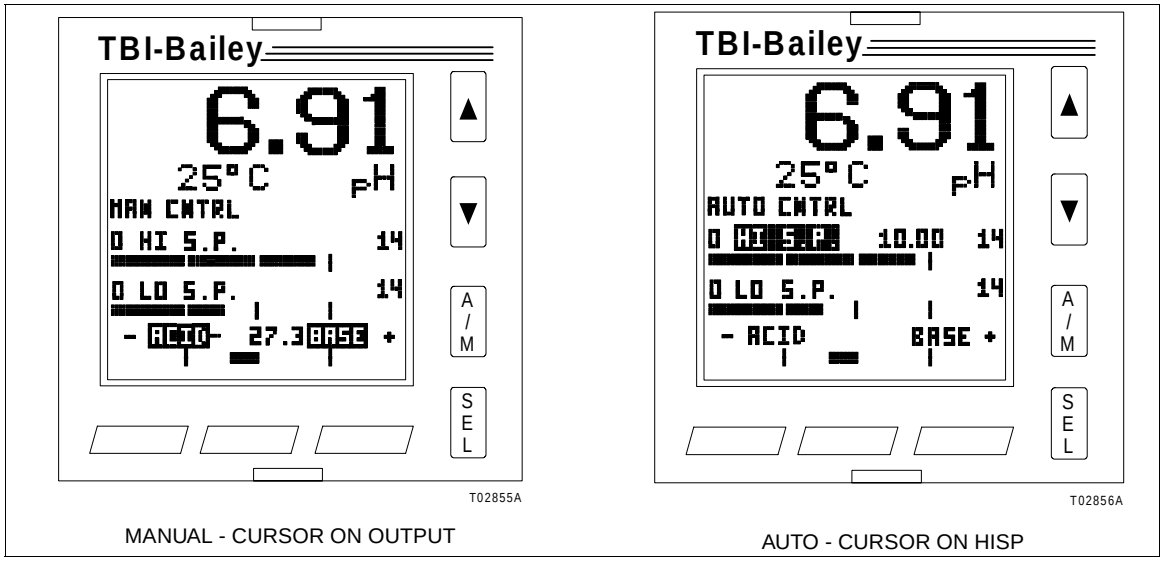


Figure 4-3. Bidirectional Controller Process Screen

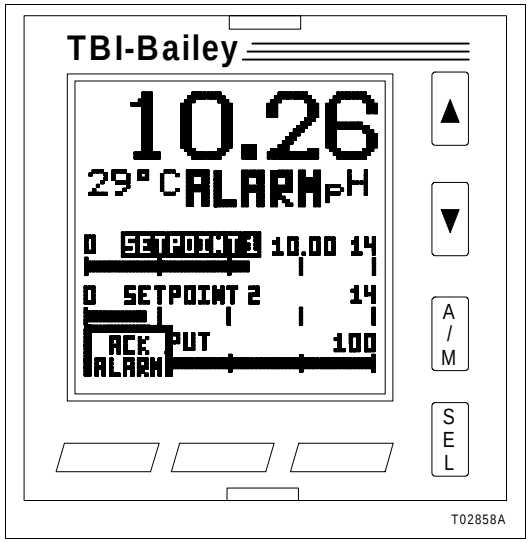


Figure 4-4. Process Screen with Alarm

TUNING

Tuning is the process of changing configuration constants while the TB7 controller is executing the configuration. The TUNE environment is entered into from the MAIN MENU. The correct password must be entered (if any, refer to ***Security***). The display will show the entire configuration as entered. The first tunable parameter on the screen will be inversed video.

The value of the parameter may be changed by using the **UP/DOWN** arrow pushbuttons. To select the next tunable parameter, the **SEL** pushbutton is used. If there are no tunable parameters on a screen or when it is desired to proceed

through the configuration, the soft keys must be used. When the soft key is first pressed, the soft key menu will appear. **NEXT SCRN** will move you in a forward direction and **PREV SCRN** will move you in a backwards direction through the configuration.

The **PROC DSPLY** soft key will take you immediately back to the process display. To enter a tuned value, use the soft keys. Press a soft key after the desired tuning parameters have been entered and the soft key menu will appear. If **ENTER** is pressed, the tuned values will be placed in the configuration. The **PROC DSPLY** soft key will take you immediately back to the process display without changing the value of any of the tunable parameters. The **ESC** soft key will place the tunable parameter values on this particular screen back to their previous values. While in the TUNE environment, the process variable will always be shown in the upper center of the screen. Those parameters that are tunable are noted as such in Appendix D.

SECTION 5 - CALIBRATION

INTRODUCTION

The TB7 controller requires periodic calibration of the pH input. Additionally, the temperature compensator input and analog outputs can be calibrated. The CALIBRATION environment is entered into from the MAIN MENU after the proper password (if any) has been entered. User-friendly displays guide you through the calibration procedures, prompting for the appropriate time to apply calibration signals and/or to enter required information.

The TB7 controller has two modes of calibration; process and bench. Process calibration is a one-point calibration performed while the sensor is installed in the process and the TB7 controller is executing the configuration. Bench calibration is a two-point calibration performed while the TB7 controller is executing the user-entered configuration. The preferred final calibration is the process calibration which is accomplished by adjusting the displayed pH value to the value determined by a grab sample.

> **NOTE:** To escape any operation without saving, press a multi-function soft key and back through the PREV screen, go to the PROCESS SCREEN, or use the **ESC** soft key.

BENCH CALIBRATION

> **NOTE:** Before any bench calibration, check to make certain that the jumpers on the main board are in their correct default position. Refer to Table 2-3. Allow the unit to warm up for approximately 30 minutes so that the internal temperature of the unit will stabilize.

Bench calibration is a two-point calibration. Both the efficiency (slope) and offset of the sensor will be calculated, adjusted and displayed during this procedure.

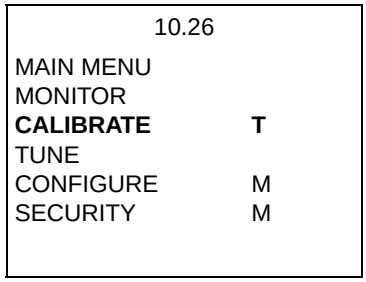
The pH bench calibration is performed at the factory prior to shipment and under normal circumstances need not be done by the customer.

CAUTION	**During the bench calibration procedure, the TB7 controller executes the user-entered configuration.**
AVERTISSEMENT	**Au cours de l'étalonnage au banc, le contôleur TB701 exécute la configuration introduite par l'utilisateur.**

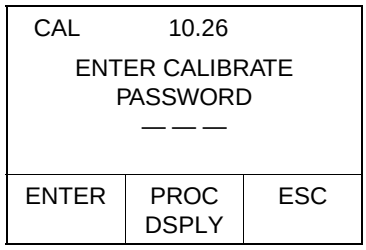
Bench Calibration of the pH Sensor Input

The bench calibration of the pH sensor input can be performed with the sensor and buffers or with a pH simulator or millivolt source. (Refer to Appendix B.) If the sensor and buffers will be used for calibration, the sensor must be cleaned before the calibration. Refer to ***SENSOR MAINTENANCE*** in the maintenance section for detailed sensor cleaning instructions.

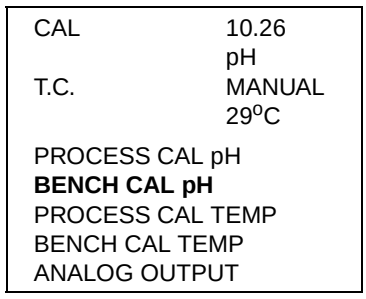
1. From the MAIN MENU select the *CALIBRATE* environment.



The calibration password screen appears if a password has been assigned.



2. If the correct password was entered or no security level was placed on the CALIBRATE environment the CALIBRATION menu appears.



3. Press the **DOWN** pushbutton until *BENCH CAL pH* is in inversed video, then press **SEL** to bench calibrate the pH sensor input. The following screen appears:

CAL 4.04	BENCH pH
LOW pH	4.01 pH
TEMP	29°C
SOFT KEY TO ENTER	

4. Apply the low pH calibration signal.The low pH value displayed on the screen can be changed to match the signal applied. Integral temperature compensators will generally react slowly to buffer temperatures if the sensor had previously been installed in a hot service. At this time, the temperature displayed can be changed to match that of the actual buffer temperature. If not changed, the temperature displayed will be used in the calibration calculation. Pressing a soft key will bring up the soft key menu. After the calibration pH and temperature are correctly chosen, the sensor must be immersed in the calibration solution (or the proper millivolt signal applied). The pH display at the top of the screen will change to the calibration value or a pH value near it. When the reading has stabilized, press **ENTER**. If **ENTER** is pressed, the following screen appears:

CAL	7.03 pH	BENCH
HIGH pH		7.00 pH
TEMP		29°C
EFF		98 PCT
Offset		00.0mV
SOFT KEY TO ENTER		

5. Apply the high pH calibration signal. (Refer to the following NOTE.) The high pH value displayed on the screen can be changed to match the signal applied. Pressing a soft key will bring up the soft key menu. After the calibration pH and temperature are correctly chosen, the sensor must be immersed in the calibration solution (or the proper millivolt signal applied). The pH display at the top of the screen will change to the calibration value or a pH value near it. When the reading has stabilized, press ENTER. If **ENTER** is pressed, the bench calibration procedure will automatically calculate the efficiency of the sensor used during the calibration (efficiency = actual slope divided by the theoretical slope and shown as EFF on the screen). Also during the bench calibration procedure, offset

calculations are made. While the bench calibration calculations are being performed, the following screen appears:

NOTE: If the input pH value does not change from what it was during LOW pH calibration, the calibration will not be performed. The message *NO INPUT CHANGE - USE SOFT KEY TO RETRY* appears. At this time, check to see that the sensor has been moved from the first buffer solution or that the millivolt signal has indeed been changed. If the sensor has been moved and the input pH has been changed, refer to the sensor troubleshooting maintenance section. If a millivolt source was used and is assured to be working properly, contact TBI-Bailey personnel. If the pH reading does change after moving the sensor or checking the millivolt source, the new pH value can be entered by using the soft key.

CAL	4.04 pH	BENCH
HIGH pH		7.00 pH
TEMP		29°C
EFF		98 PCT
OFFSET		00.0 mV
PLEASE WAIT		

6. This calculated efficiency and offset will then be displayed and stored in the NVRAM. The offset value is displayed as millivolts with 6 millivolts equaling a 0.10 pH offset. Calibration with a millivolt source will result in an offset display of 30 millivolts (0.5 pH) as the internal calculations assume a -30 millivolt normal offset with TBI-Bailey sensors. This normal offset is the result of the high KCl (potassium chloride) concentration in TBI-Bailey sensors.

7. If the calibration results are acceptable, press a soft key to proceed. If not acceptable, press the **PREV SCRN** soft key to repeat the calibration.

NOTE: TBI-Bailey advises using the process calibration procedure as the primary field procedure. Bench calibration with known buffers or a pH simulator should always be followed by a process calibration determined by a grab sample of the process.

Bench Calibration of Temperature Compensator Input

The bench calibration of the temperature compensator input is performed with a 3.01 kilohm (±0.1percent) resistor and a short piece of aluminum or copper wire (Figure 5-1).

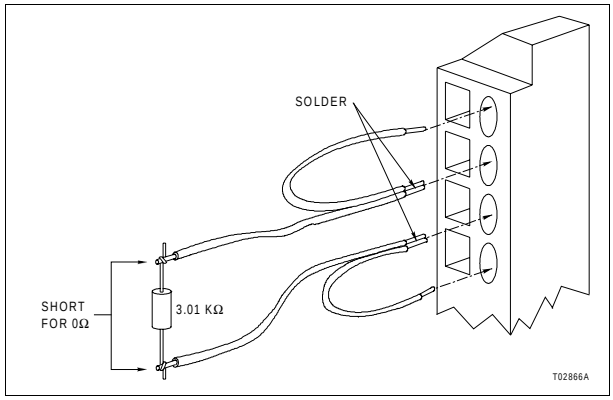


Figure 5-1. Calibrating Temperature Compensator Input

1. From the MAIN MENU, select the *CALIBRATE* environment.

10.26	
MAIN MENU	
MONITOR	
CALIBRATE	**T**
TUNE	
CONFIGURE	M
SECURITY	M

2. The calibration password screen appears if a password has been assigned.

CAL	10.26	
ENTER CALIBRATE PASSWORD — — —		
ENTER	PROC DSPLY	ESC

3. If the correct password was entered or no security level was placed on the CALIBRATE environment, the CALIBRATION menu appears.

CAL	10.26
	pH
T.C	AUTO
	29°C
PROCESS CAL pH	
BENCH CAL pH	
PROCESS CAL TEMP	
BENCH CAL TEMP	
ANALOG OUTPUT	

4. Select *BENCH CAL TEMP* by pressing the **DOWN** arrow pushbutton until the inversed video moves to the selection and then press the **SEL** pushbutton to bench calibrate the temperature compensator input. The following screen appears:

```
CAL                    10.26
BENCH

        PLACE 0 OHMS
        ACROSS A.I.

      SOFT KEY TO ENTER
```

5. With shorting wires in place across TB4-1 and TB4-2 and TB4-3 and TB4-4, place an input resistor or wire across TB4-2 and TB4-3 (see Figure 5-1). Polarity does not matter.

6. Apply the low calibration resistance (wire) to the temperature input. This is 0 ohms (a direct wire short across the temperature input). Once this is completed, pressing a soft key will bring up the soft key menu. If **ENTER** is pressed, the following screen appears:

```
CAL                    10.26
BENCH

        PLACE 0 OHMS
        ACROSS A.I.

        PLEASE WAIT
      ----------
```

7. While the screen shows the *PLEASE WAIT* message, the TB7 controller is taking successive readings of the temperature input in order to obtain the average reading of the low value. Once this is completed, the following screen appears:

```
CAL          10.26       BENCH

        PLACE 3.01K OHMS
        ACROSS A.I.

      SOFT KEY TO ENTER
```

8. Apply the high calibration resistance to the temperature input. This is 3.01 kilohms (±0.1percent). Once this is completed, pressing a soft key will bring up the soft key menu. If **ENTER** is pressed, the following screen appears:

```
CAL          10.26       BENCH

        PLACE 3.01K OHMS
        ACROSS A.I.

        PLEASE WAIT
      ----------
```

9. While the screen shows the *PLEASE WAIT* message, the TB7 controller completes all temperature compensator input calibration calculations. After this is complete, the calibration data is saved in NVRAM and the screen will display the CALIBRATION menu.

Bench Calibration of Analog Outputs

The bench calibration of the analog outputs is performed by connecting a digital voltmeter (accurate to ±0.5 millivolt) across the analog outputs and entering the observed value when prompted by the screens.

NOTE: Check the main board jumpers to make certain they have been correctly set for voltage or current output. If using in current mode, place a 250 ohm (±0.02percent) resistor across the analog output during calibration (Figure 5-2), or read milliamps direct using an ammeter.

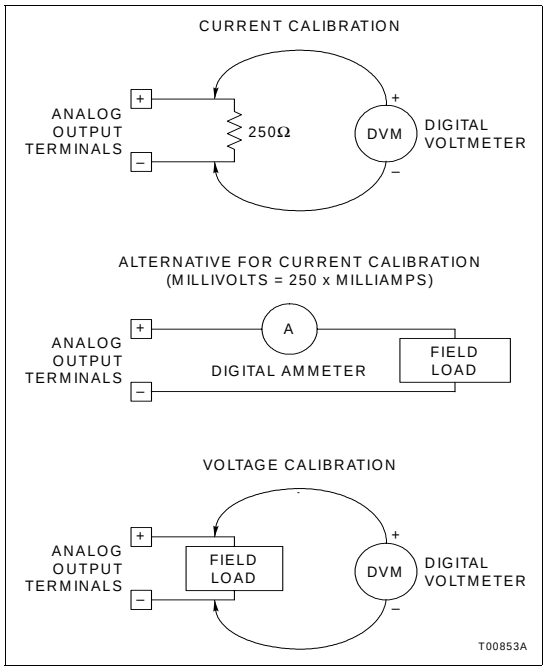


Figure 5-2. Calibration Connections for Current Mode Use

1. From the MAIN MENU, select the *CALIBRATE* environment.

10.26	
MAIN MENU	
MONITOR	
CALIBRATE	**T**
TUNE	T
CONFIGURE	M
SECURITY	M

2. The calibration password screen appears if a password has been assigned.

CAL		10.26
ENTER CALIBRATE PASSWORD — — —		
ENTER	PROC DSPLY	ESC

3. If the correct password was entered or no security level was placed on the CALIBRATE environment, the CALIBRATION menu appears.

CAL	10.26
	pH
T.C.	MANUAL
	29°C
PROCESS CAL pH	
BENCH CAL pH	
PROCESS CAL TEMP	
BENCH CAL TEMP	
ANALOG OUT	

4. Press the **DOWN** arrow pushbutton until the inversed video is at *ANALOG OUT*. Press the **SEL** pushbutton to bench calibrate the analog outputs. The following screen appears:

CAL	10.26	A.O.
	pH	
	A.O.1	
	A.O.2	

5. Select the desired analog output to calibrate by pressing the arrow pushbutton to make your selection and then press the **SEL** pushbutton. The following screen will then appear:

CAL	10.26	A.O.
	pH	
MEASURE THE VOLTAGE ACROSS A.O.1 AND ENTER THE VALUE		
LOW VAL		
1000 mV		
SOFT KEY TO ENTER		

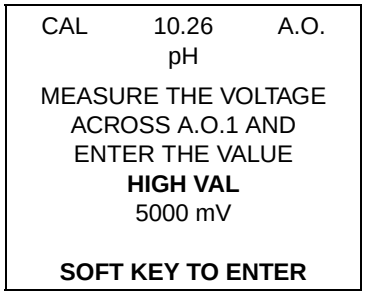
6. At this time, the TB7 controller is putting out a value that it believes is 1000 millivolts. The screen prompts the calibrator to measure the analog output being calibrated and to enter

that value in millivolts if different than the displayed value. If an ammeter was used instead of a 250 ohm resistor and voltmeter, calculate the correct millivolt entry by the equation:

mA x 250 = mV

As an example, if 4.056 mA was measured, the correct entry would be 4.056 x 250 = 1014 mV.

Once this is completed, pressing a soft key will bring up the soft key menu. If **ENTER** is pressed, the following screen appears:



7. At this time, the TB7 controller is putting out a value that it believes is 5000 millivolts. The screen prompts the calibrator to measure the analog output being calibrated and to enter that value in millivolts if different than the displayed value. If an ammeter was used instead of a 250 ohm resistor and voltmeter, calculate the correct millivolt entry by the following equation.

mA x 250 = mV

As an example, if 19.98 mA was measured, the correct entry would be 19.98 x 250 = 4995 mV.

Once this is completed, pressing a soft key will bring up the soft key menu. If **ENTER** is pressed, the TB7 controller will perform the required calibration calculations, save this data in NVRAM and return to the ANALOG OUT calibration menu.

8. At this time, select to calibrate another analog output or exit the analog output calibration menu by pressing a soft key to bring up the soft key menu. If **NEXT SCRN** is pressed, the screen will then go to the CALIBRATE menu.

PROCESS pH CALIBRATION

Process pH calibration is a one point calibration performed while the sensor is installed in the process and the TB7 controller is executing the defined configuration. Process calibration is required periodically when the TB7 controller is in service to maintain sensor accuracy. Calibration frequency is

dependent upon the application and is to be determined by the user.

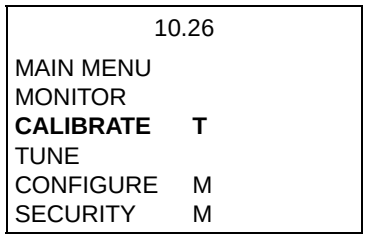
Sensors should be cleaned before a process calibration. Refer to ***SENSOR MAINTENANCE*** in the maintenance section for detailed sensor cleaning instructions.

Process Calibration of the pH Sensor Input

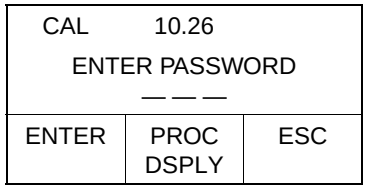
CAUTION	**When measuring the pH of a grab or lab sample, make sure that the temperature of the sample is compensated. In some cases, the pH of the solution may change value as the sample cools. Refer to section entitled *Desired Temperature Compensation*. Grab samples should not be left open to the atmosphere. Samples may change or deteriorate as time passes. It is important to measure grab samples as soon as they are taken.**
ATTENTION	**Lorsqu'on mesure le pH d'un echantillon ponctuel ou d'unechantillon de laboratoire, il faut s'assurer de compenser latemperature de l'enchantillon. Dans certains cas, la valeur dupH de la solution peut changer a mesure que l'enchantillon refroidit. Se reporter a la section intitulee, *Desired Temperature Compensation*. Il ne faut pas laisser les echantillons ponctuels a l'air libre. Ceux-ci peuvent etre modifies ou alteres si on ne les traite pas rapidement. Il est important de mesurer les echantillons ponctuels des qu'ils sont preleves.**

The process calibration of the pH sensor input is accomplished by adjusting the displayed pH value to the value determined by a grab or lab sample.

1. From the MAIN MENU, select the *CALIBRATE* environment.



2. The calibration password screen appears if a password has been assigned.



3. If the correct password was entered or no security level was placed on the CALIBRATE environment, the CALIBRATION menu appears.

CAL	10.26
	pH
T.C.	MANUAL
	29°C
PROCESS CAL pH	
BENCH CAL pH	
PROCESS CAL TEMP	
BENCH CAL TEMP	
ANALOG OUTPUT	

4. Select *PROCESS CAL pH* to process calibrate the pH input. The following screen appears:

CAL	10.26 pH	PROC
pH		10.18 pH
TEMP		29°C
EFF		98.00PCT
OFFSET		00.00mV
SOFT KEY TO ENTER		

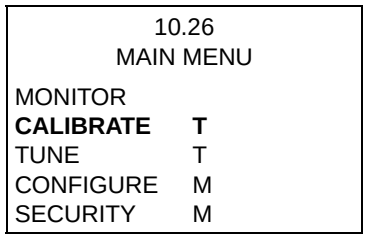
5. The efficiency that was calculated and accepted during the BENCH calibration can be overridden as well as the process temperature. The correct pH value as determined by a grab sample is entered across from pH. Press the **SEL** pushbutton to move the inversed video. Once the desired changes have been made, pressing a soft key will bring up the soft key menu. If **ENTER** is pressed, the TB7 controller will perform the calibration calculations and will display the new offset that was calculated.

6. If the calibration results are acceptable, press a soft key to proceed. If not acceptable, press the **PREV SCRN** soft key to recalibrate.

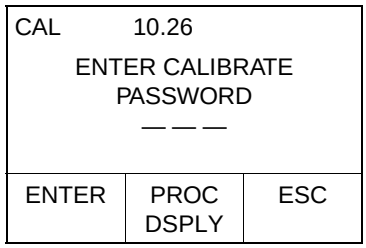
Process Calibration of the Temperature Compensator Input

The process calibration of the temperature compensator input is accomplished by adjusting the displayed process temperature to the value determined by a temperature measuring device.

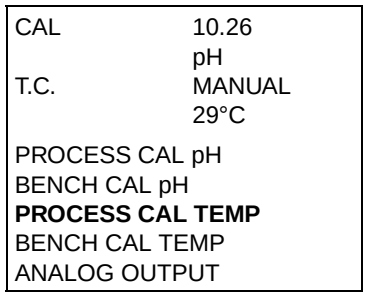
1. From the MAIN MENU select the *CALIBRATE* environment.



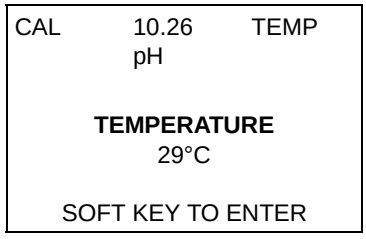
2. The calibration password screen appears if a password has been assigned.



3. If the correct password was entered or no security level was placed on the CALIBRATE environment, the CALIBRATION menu appears.



4. Select *PROCESS CAL TEMP* to process calibrate the temperature compensator input. The following screen appears:



5. The current process temperature will be displayed and can be overridden to indicate the corrected value. Once the desired change has been made, pressing a soft key will bring up the soft key menu. If **ENTER** is pressed, the calibration calculations will be performed, data will be stored in NVRAM, and the screen will display the CALIBRATE menu.

SECTION 6 - DIAGNOSTICS

INTRODUCTION

The TB7 controller continuously runs through a series of self-diagnostics, monitoring such things as NVRAM integrity, configuration integrity, and ROM integrity. If an error is detected, the following occurs:

- Execution of the user-entered configuration ceases.
- All analog outputs go to 0 volts (0 milliamps).
- All digital outputs are de-energized.
- NVRAM is inhibited (cannot be erased or written).
- An error message appears on the screen (Table 6-1).

Table 6-1. Error Messages

Display	Error Description	Recovery
RAM OVERLOAD	The TB7 controller has failed the NVRAM checksum test.	Cycle the TB7 controller power off and on. If the condition does not clear, reinitialize NVRAM. Refer to ***NVRAM INITIALIZATION*** in the installation section.
CHECKSUM FAIL	The TB7 controller has failed the ROM checksum test.	Replace ROM. Contact TBI-Bailey.
CNFG ERROR[1]	The TB7 controller has failed the config checksum test.	Reinitialize NVRAM. Refer to ***NVRAM INITIALIZATION*** in the installation section.
CAL ERROR INPUT OUT OF RANGE CHECK AI JUMPERS	Input out of range or no input connected.	Check jumper positions on main board and check wiring at terminal blocks.

NOTE: 1. If no configuration is entered, the controller powers up to the Main Menu; otherwise it goes to the process display.

DIAGNOSTIC TOOLS

The TB7 controller also has several diagnostic tools to aid in service of the sensor. These are the sensor reference offset, sensor efficiency and sensor temperature. These values are calculated in the calibration environment.

USING THE TB7 CONTROLLER DIAGNOSTICS AS TROUBLESHOOTING AIDS

The TB7 controller contains diagnostic features concerned with pH sensor status and performance. They are: sensor efficiency, sensor offset, sensor temperature low and sensor temperature high.

Efficiency and offset values are updated and displayed during bench or process pH calibration. These values can be viewed by accessing the process calibration pH menu and escaping without entering a new pH calibration value. Sensor

temperature status will be displayed as an alarm if not within the defined values.

Sensor Efficiency

The calculated sensor efficiency is determined by the calibration slope. Sensor efficiency is calculated by the actual slope divided by the theoretical slope. An acceptable range of sensor efficiency is between 70 and 100 percent. If the TB7 controller 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 maintenance section) and repeat the bench calibration procedure (refer to the calibration section). If the second calibration again shows efficiency below 70 percent and the sensor reacts slow, sensor replacement may be 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 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. A typical Antimony sensor will have an efficiency of 84 to 90 percent when new and freshly abraded.

Calculated Sensor Offset

The calculated sensor offset displays in millivolts. Millivolt source calibration results in a +30 millivolt display, because this feature assumes a normal offset of -30 millivolts with new TBI-Bailey pH sensors (new TBI-Bailey sensors will typically display a calculated offset of 0 to ±20 millivolts).

An acceptable range of offset is ±150 millivolts, 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 TB7 controller. Sensor replacement should be considered if the offset ever exceeds the acceptable range stated above.

Sensor Temperature High/Low

An automatic temperature compensator is required before this diagnostic feature can be functional. Full diagnostic capability is effected 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 -20°C (-4°F) or above 150°C (302°F) will be indicated as an alarm on the faceplate. No TBI-Bailey pH sensor is rated for use below -5°C (23°F). Upper temperature limits are 50°C (122°F), 100°C (212°F), or 140°C (284°F) depending on the type of sensor used. Use of the sensor above or below the high/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:

1. Automatic temperature compensator not connected or unsoldered jumper wire connections.

2. Process temperature above or below limits of the pH sensor.

3. Sensor cable connectors wetted (incorrect pH readings result).

4. Sensor cable damaged (incorrect pH readings result).

5. Extension cable (if used) not connected (incorrect pH readings result).

6. pH sensor internally shorted or cracked (incorrect pH readings result).

7. Temperature compensator open or shorted (incorrect pH readings result, but the sensor can still be used in manual temperature compensation mode).

8. pH sensor physically broken (incorrect readings result).

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

If trouble with the sensor is evident, refer to Tables 7-1 and 7-2 in the troubleshooting section.

SECTION 7 - TROUBLESHOOTING

INTRODUCTION

This section provides information on possible error conditions that could occur and the corrective actions to take to remedy the situation. Refer also to the diagnostics section for a listing of error messages.

Figure 7-1 is a troubleshooting flowchart and is supplemented by Table 7-1, a sensor troubleshooting (pH) guide.

GROUND LOOPS

CAUTION	**A ground loop condition can easily and irreversibly destroy a pH reference.**
ATTENTION	**Si neglige, un courant de boucle dans le circuit de mise a la terre peut facilement detruire la reference de pH irrevocablement.**

A ground loop is a path between the process liquid ground and a second ground point elsewhere in the system through which unwanted current flows through the measurement circuitry. The typical symptom would be an offset or erratic measurement in the process line, but correct measurement in an isolated beaker of buffer or process liquid.

Ground loops can be caused by:

1. The TB7 controller BNC connector contacting ground either through metal conduit or the housing.

2. A pH extension cable connector contacting water in a conduit run or in the housing, and that water making contact with a grounded fitting.

3. A sensor cable with nicked insulation contacting metallic conduit. (This could be an intermittent problem.)

4. Loss of isolation between input and output usually resulting from a wiring deficiency.

To verify a ground loop, measure the resistance from the TB7 controller sensor BNC connector shell to earth ground when the sensor is not installed in the process. The reading should quickly climb to infinity as indicated by an ohmmeter in its highest range. A reading near zero ohms indicates a direct ground connection. This test can be performed in two ways.

1. If the sensor is difficult to remove from the process line or vessel, disconnect the BNC connector at the controller.

Perform the resistance test on the shell of the female connector attached to the controller.

2. If the sensor can be easily removed, remove it from the process line or vessel and perform the resistance test on the BNC connector still attached to the controller.

If a ground loop is indicated, disconnect the BNC connector at the controller and check both the female and male ends to determine where the ground loop exists.

Correct the condition and return the controller to service.

CHECKING SENSOR OPERATION

Refer to Figure 7-1 Troubleshooting Flowchart, Table 7-1 Sensor Troubleshooting Guide, and Table 7-2 Troubleshooting the pH Sensor.

Table 7-1. Sensor Troubleshooting Guide, pH

Symptom	Possible Cause	Corrective Action
Noisy measurement.	Electrical AC or RF interference. Lack of adequate shielding. Noisy process.	Run cable in metal conduit or reroute cable. Add damping to input.
Sensor glass bulb broken, cracked or abraded.	Mishandling, normal process 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.	Refer to the maintenance section for cleaning procedures. Consider relocation of the sensor in the process.
Reference junction is dirty, coated or clogged.	Process contamination.	Clean sensor. Refer to the maintenance section for cleaning procedures.
Reference junction is dry.	Poor storage procedures or sensor not in process.	Soak sensor in potassium chloride (KCl) solution. Retest. Relocate sensor in the process.
Chemical degradation.	Process attack.	Obtain process history and contact TBI-Bailey. May be necessary to switch to a 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.

NOTE: Refer to Figure 7-2 for description of sensor components.

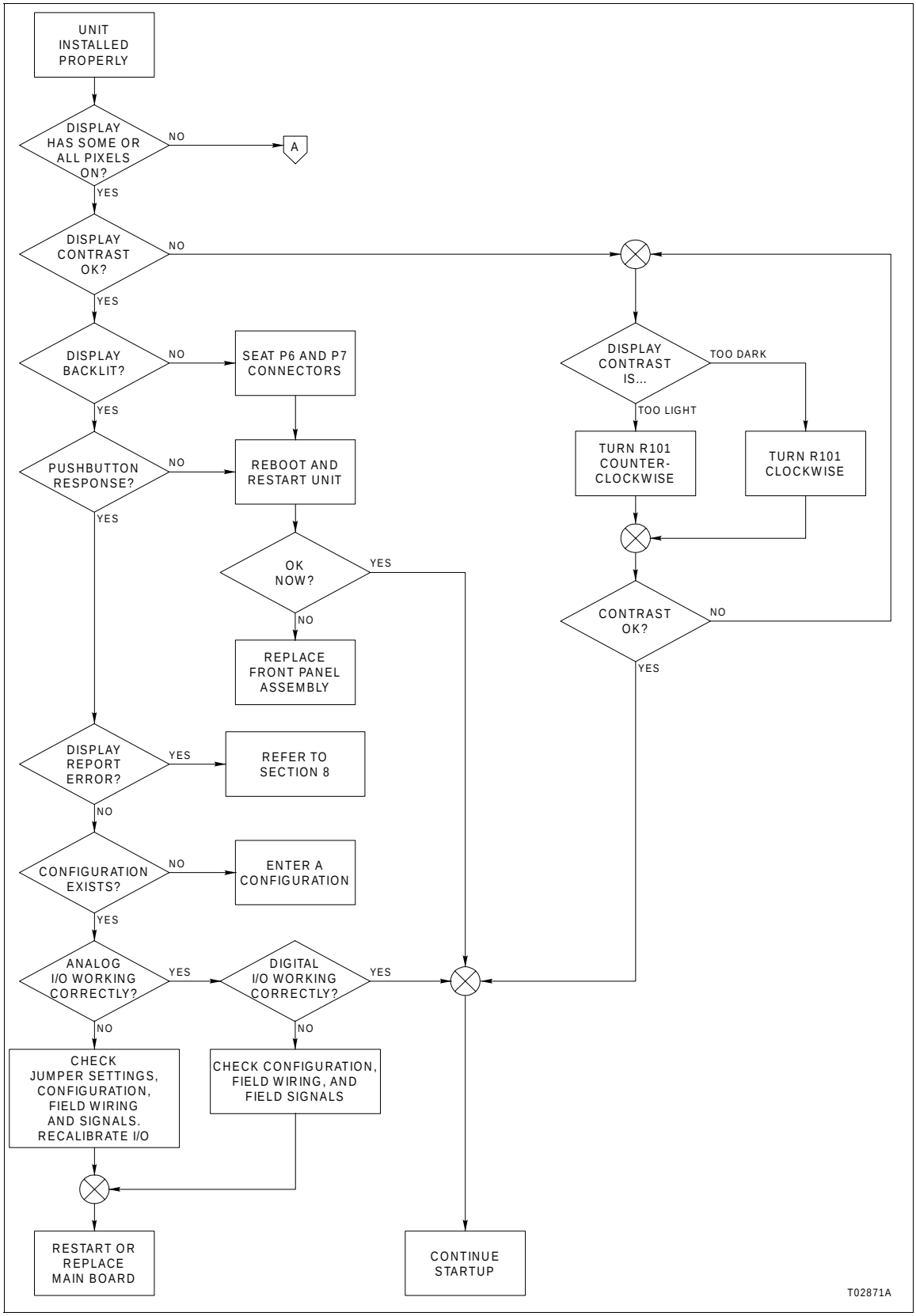


Figure 7-1. Troubleshooting Flowchart (Sheet 1 of 2)

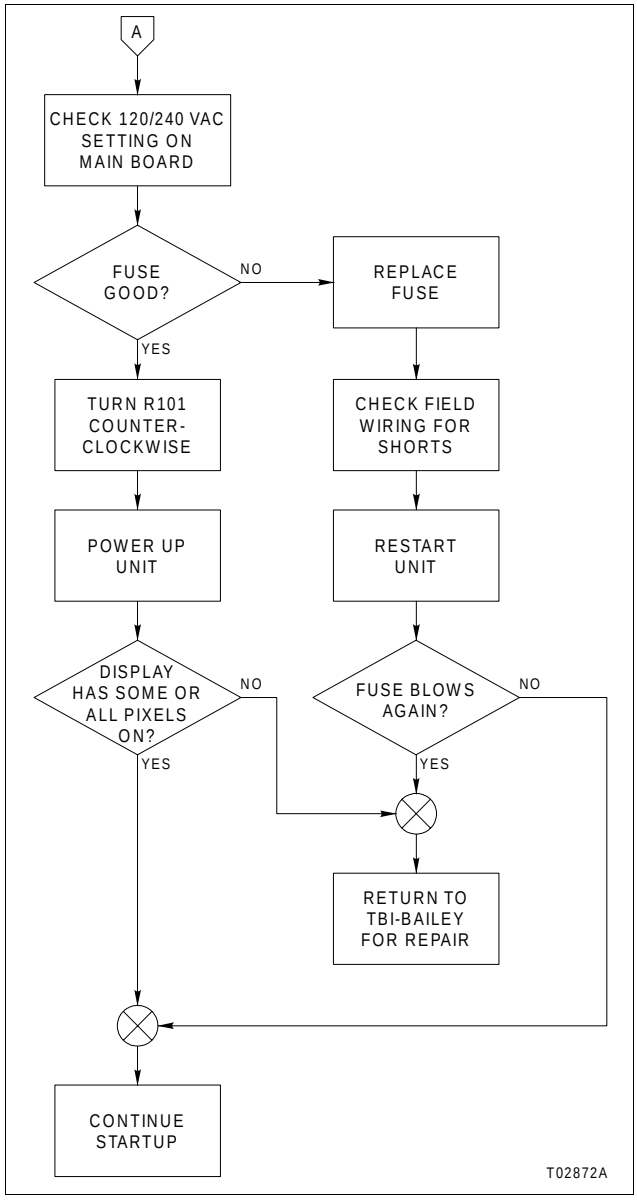


Figure 7-1. Troubleshooting Flowchart (Sheet 2 of 2)

Table 7-2. Troubleshooting the pH Sensor Using Wet Testing in a Buffer Solution

Symptom	Possible Cause	Corrective Action
Slow response or noisy, erratic readings.	Process contamination or attack.	Clean sensor. Refer to the maintenance section for cleaning procedures. Check the cable. If 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.
Huge 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.	Clean sensor. Refer to the maintenance section for cleaning procedures. Replace the sensor if problem still exists.
No response, pH holds at fixed value.[1]	Cracked or depleted glass electrode.	Replace sensor.

NOTES:
1. Wet check the reference junction only with a known good glass electrode.
2. Wet check the glass electrode only with a known good reference junction.

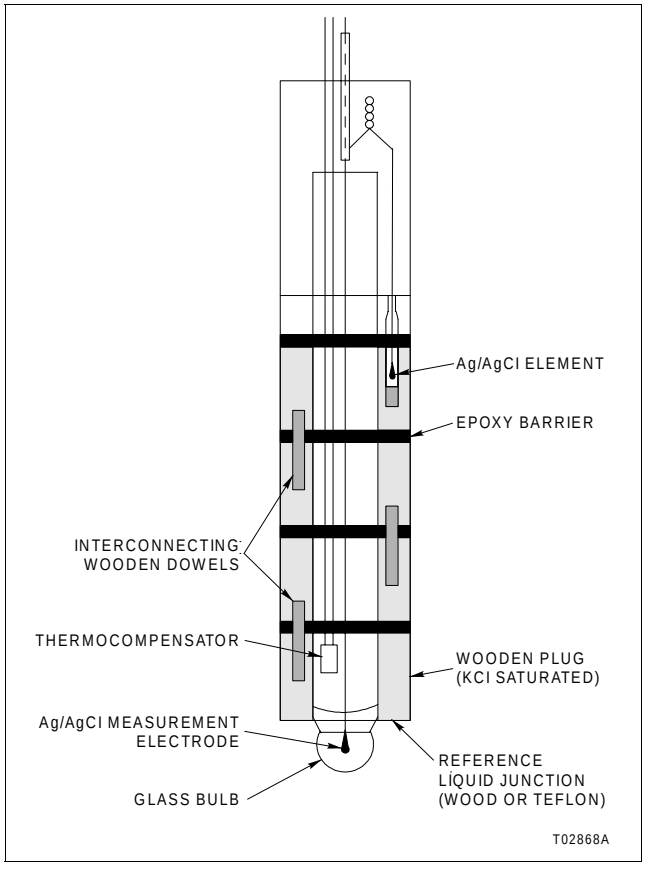


Figure 7-2. Sensor Components

SECTION 8 - MAINTENANCE

INTRODUCTION

WARNING	**Sensor maintenance must be performed only by qualified personnel and only after securing equipment controlled by the TB7 controller. Cleaning the sensor while connected to an active circuit or disconnecting the sensor from an active circuit may upset the process being controlled.**
AVERTISSEMENT	**L'entretien de la sonde ne doit etre effectue que par lepersonnel qualifie, et seutement une fois que l'equipement controle par le controleur de Type TB7 a ete fixe. Le nettoyagede la sonde lorsque celle-ci est branchee a un circuit actif risquerait perturber le processus controle.**

SENSOR MAINTENANCE

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

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. Soak the electrode in the solution for two to ten minutes.

2. Rinse well in tap water. Retest the sensor.

WARNING	**Solution should be stored in a suitable container and labeled as a strong acid and extremely flammable. Use extreme care when handling.**
AVERTISSEMENT	**La solution doit etre entreposee dans un contenant adequat et identifiee comme acide fort et extremement infammable. Manipulez avec beaucoup de precaution.**

Removing Inorganic Scale, Light Soiling, Fibers, etc.

1. Soak the electrode in a solution of one to three Molar hydrochloric acid (HCl) for five to ten minutes.

2. Rinse well in tap water and retest.

Removing Oily Films, Grease and Hydrocarbons

1. Use a long handled cotton swab and wipe the electrode with a fifty/fifty mixture of acetone and isopropyl alcohol.

2. Rinse in tap water.

3. Swish the electrode in a five percent ammonium hydroxide or commercial ammonia-based cleaner for approximately thirty seconds.

NOTE: Avoid using sodium hydroxide solutions. Some electrodes are sensitive to sodium ion poisoning.

4. Rinse well in running tap water.

5. Soak in one to three Molar hydrochloric acid for five minutes.

6. Rinse well in running tap water. Retest the sensor.

Removing Protein Buildup

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

1. Add a few grams of pepsin to a one percent hydrochloric acid solution and soak overnight.

2. Rinse well in running tap water. Retest the sensor.

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.

1. Clean the electrode by soaking in one to three Molar hydrochloric acid (HCl) for five to ten minutes.

2. Rinse well in tap water.

3. Swish the electrode around in a five percent solution of ammonium bifluoride (NH_4HF_2) for forty seconds maximum.

4. Rinse well in tap water.

5. Soak in one to three Molar hydrochloric acid for twenty minutes to ensure that all fluoride has been removed.

6. Rinse well in tap water.

7. Soak in a 25 percent potassium chloride solution for 24 hours to ensure a new gel layer has formed before retesting.

Removing Silica Gels and Other Silica Compounds

1. Soak sensor in heated 65°C (150°F) two to five Molar NaOH solution for ten to thirty minutes.

2. Rinse the sensor in tap water.

3. Soak the sensor in 0.5 to two Molar HCl for five minutes. Rinse in tap water.

4. Retest the sensor.

SECTION 9 - REPAIR/REPLACEMENT PROCEDURES

INTRODUCTION

This section provides disassembly and assembly procedures for replacement of the main board assembly and fuse, the front panel (display) assembly, the pH board and any option boards that may be installed.

WARNING	**Substitution of components may impair suitability for Class I, Division 2 Hazardous Locations.**
AVERTISSEMENT	**La substitution de tout composant peut rendre le systeme inapproprie a un emplacement dangereux de classe I et de division 2.**

WARNING	**Do not disconnect equipment unless power has been switched off or the area is known to be nonhazardous.**
AVERTISSEMENT	**Avant de deconnecter l'equipment, couper le courant ou s'assurer que l'emplacement est designe non dangereux.**

MAIN BOARD OR FRONT PANEL (DISPLAY) ASSEMBLY REMOVAL/REPLACEMENT

1. Remove power from the unit.

2. Push on the front panel assembly and ease the bezel clips off using a flat blade screwdriver.

3. Grasp the front panel assembly and carefully pull the front panel/main board assembly from the housing. See Figure 9-1.

Main Board Removal

1. Disconnect the two display backlight wires from the main board connectors, P6 and P7.

2. Carefully insert a small flat blade screwdriver between the main board and one of the two plastic tabs as shown in Figure 9-1.

3. Slowly pull the screwdriver handle back until the main board disengages from that tab.

4. Repeat Steps 2 and 3 for the remaining tabs.

5. Remove the main board assembly from the front panel assembly, being careful when feeding the display backlight

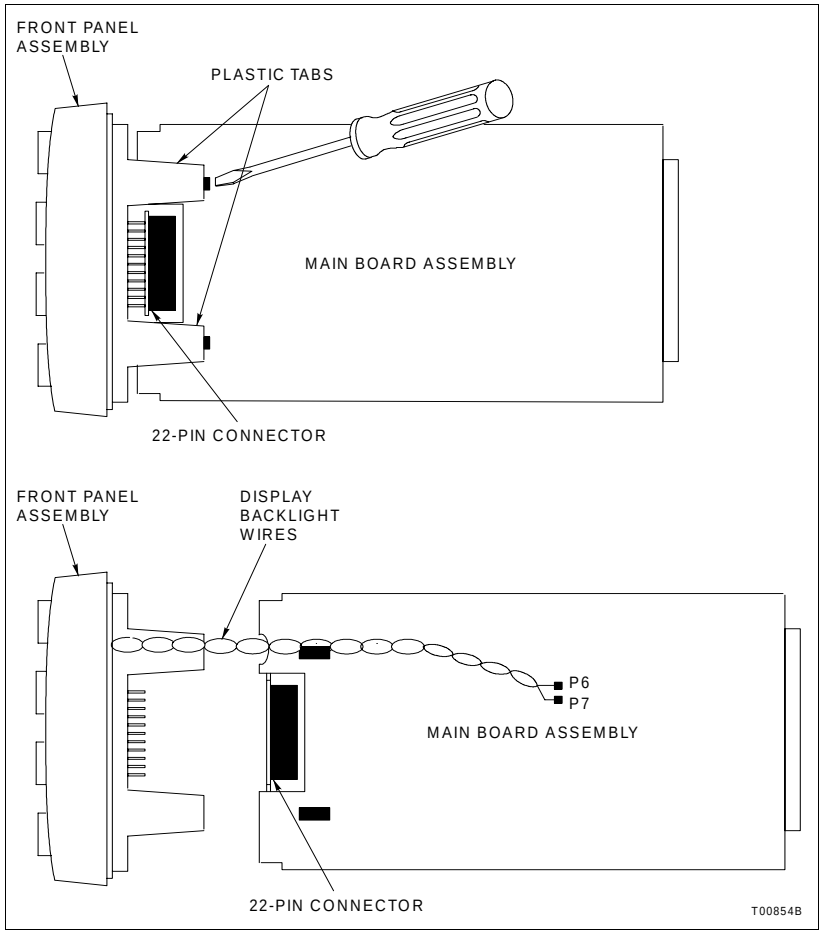


Figure 9-1. Main Board or front panel (Display) Assembly Replacement

wires through the hole in the main board, and also when disengaging the 22-pin display board connector from the main board connection. If replacing just the front panel (display) assembly, proceed to ***Main Board Installation*** for assembly procedures.

> **NOTE:** If the replacement main board is retained in a disposable plastic backplate piece, use the method outlined in Steps 2 through 4 to remove the new board from the disposable backplate.

6. Note the location of any option boards installed on the original main board. Remove the spacer bar screws, spacer bar, and any option boards from the original main board. Install them in the same option board locations on the replacement main board. Install the spacer bar and screws onto the replacement main board assembly (see Figure 9-2).

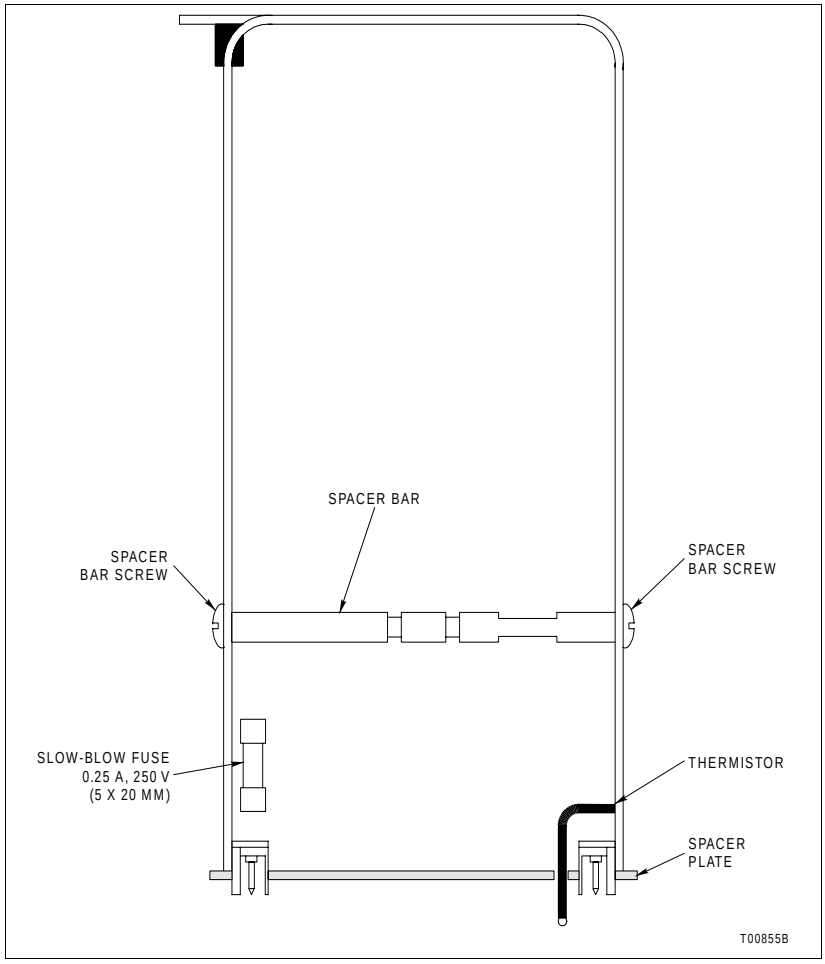


Figure 9-2. Main Board Fuse, Spacer Bar and Spacer Bar Screws

Main Board Installation

1. Carefully feed the two display backlight wires through the small hole in the replacement main board. Bring the new main board assembly close to the front panel assembly, and start the connection between the 22-pin display board header and the corresponding main board connector.

2. Insert the main board fully into the two tabs opposite the display board connector. Carefully insert the main board into the two remaining front panel assembly tabs.

3. Connect the two display backlight wires to connectors P6 and P7 on the main board assembly (polarity does not matter). Push the 22-pin receptacle down onto the display board connector enough to ensure good connection. There should be a 1.5 millimeter ($\frac{1}{16}$-inch) gap between the display backplate and the main board at the connector.

4. Ensure that all replacement main board jumpers are in the correct positions for the intended application per the sections entitled ***Factory Jumper Settings*** and ***Selecting Options on the Main Board Assembly*** in the installation section of this manual.

5. Insert the front panel/main board assembly into the housing. Make certain that the thermistor assembly is guided properly through the hole in the housing. Secure the assembly by engaging the two metal bezel clips.

6. Connect power to the unit.

MAIN BOARD FUSE REPLACEMENT

1. Remove power from the unit.

2. Push on the front panel assembly and ease the bezel clips off using a flat blade screwdriver.

3. Grasp the front panel assembly and carefully pull the front panel/main board assembly from the housing. See Figure 9-1.

4. Carefully remove blown fuse from the main board, and replace it with Bailey Part No. 1948182_32500 ¼amp, 250 volt (5 x 20 millimeter) slow blow fuse. See Figure 9-2.

5. Insert the front panel/main board assembly into the housing, and secure it by engaging the two metal bezel clips.

6. Connect power to the unit.

pH BOARD REPLACEMENT

1. Remove power from the unit.

2. Push on the front panel assembly and ease the metal bezel clips off using a flat blade screwdriver.

3. Grasp the front panel assembly and carefully pull the front panel/main board assembly from the housing (see Figure 9-1). The pH board will remain in the housing.

4. Remove the sensor cable.

5. Remove the nut and lockwasher from BNC connector at the rear housing. Pull the pH board out from the front of the housing.

6. Install the replacement pH board on the main board.

7. Insert the front panel/main board assembly into the housing, and secure it by engaging the two metal bezel clips.

8. Install the lockwasher and nut to the pH board BNC connector at the rear of the housing.

9. Connect the sensor cable.

10. Connect power to the unit.

OPTION BOARD REPLACEMENT

1. Remove power from the unit.

2. Push on the front panel and ease the two metal bezel clips off using a flat blade screwdriver.

3. Grasp the front panel assembly and carefully pull the front panel/main board assembly from the housing (Figure 9-1).

4. Remove the spacer bar screws to allow the spacer bar to be removed (Figure 9-2).

5. Note the location and orientation of the option boards before removing. Remove the option boards to be replaced.

6. Set replacement option board jumpers as desired.

7. Make certain the replacement option board is correctly oriented. Seat the replacement option board in the expansion slot that was previously used. The option board should always be located between connectors P1 and P2 on the main board. Refer to Figure 10-1, Section B-B, in the support services section of this instruction.

8. Install the spacer bar and spacer bar screws.

9. Insert the front panel/main board assembly into the housing, and secure it by engaging the two metal bezel clips.

10. In pencil or permanent marker, write the appropriate terminal signals on the wiring label for the option board.

> **NOTE:** Option board terminal block TB2 signals 1 to 8 run top to bottom; however, terminal block, TB3 signals 1 to 8 run bottom to top.

11. Connect power to the unit.

SECTION 10 - SUPPORT SERVICES

INTRODUCTION

Figure 10-1 is a parts drawing of the TB7 controller. When ordering replacement parts, specify nomenclature type, part name and part number or spare parts kit part number.

TBI-Bailey Controls Company is ready to assist in the use and repair of its products at any time. Requests for sales and/or application service should be made to the nearest sales or service office.

Factory support in the use and repair of the TB7 controller can be obtained by contacting:

TBI-Bailey Controls Co.
2175 Lockheed Way
Carson City, NV 89706
(702) 883-4366

REPLACEMENT PARTS

When making repairs at your facility, order spare parts kits from a TBI-Bailey sales office. Provide this information:

1. Spare parts kit description, part number, and quantity.

2. Model and serial numbers (if applicable).

3. TBI-Bailey instruction manual number, page number, and reference figure that identifies the spare parts kit.

When you order standard parts from TBI-Bailey Controls, use the part numbers and descriptions from the ***RECOMMENDED SPARE PARTS*** List. You must order parts without commercial descriptions from the nearest TBI-Bailey Controls sales office.

RECOMMENDED SPARE PARTS

Part No. 1948182-32500 - Fuse, ¼amp, slow blow, 5 x 20 millimeter located on the main board assembly (Item 9, Figure 10-1).

Part No. 4TB9515-0022 - TB7 controller housing with bezel clips (does not include rear cover or front panel assembly).

PARTS LIST FOR FIGURE 10-1

Item	Description
1	FRONT PANEL ASSEMBLY
2	8-POS TERMINAL BLK CONN
	TERMINAL BLK SCREWS, 4 REQD (NOT SHOWN)
4	REAR COVER
5	REAR COVER GASKET
6	REAR COVER SCREWS, 2 REQD
7	pH BOARD ASSEMBLY
8	HOUSING WITH BEZEL CLIPS
9	MAIN BOARD ASSEMBLY
10	—
11	12-POS TERMINAL BLK CONN
12	SPACER ROD
13	PART NO. LABEL
14	ALARM BOARD ASSEMBLY (TB7 4 ONLY)
15	SPACER SCREWS, 2 REQD
16	WIRING LABEL
17	ELECTRICAL LABEL
18	O-RING, 4 REQD
19	PANEL MOUNT BRACKET ASSY, 2 REQD (NOT SHOWN)
20	ROM[1]
21	ROM[1]

NOTE: 1. Not shown. Located on item 9, Main Board Assembly.

SPARE PARTS KITS

Part No. 4TB9515-0024 - Main Board Assembly

Item	Description	Qty
9	MAIN BOARD ASSEMBLY	1
12	SPACER ROD	1
15	SPACER SCREWS	2
	BACKPLATE[1]	1
21	ROM 1 (U15)	1
20	ROM 2 (U14)	1

NOTE: 1. Component is part of item 1, Front Panel Assembly.

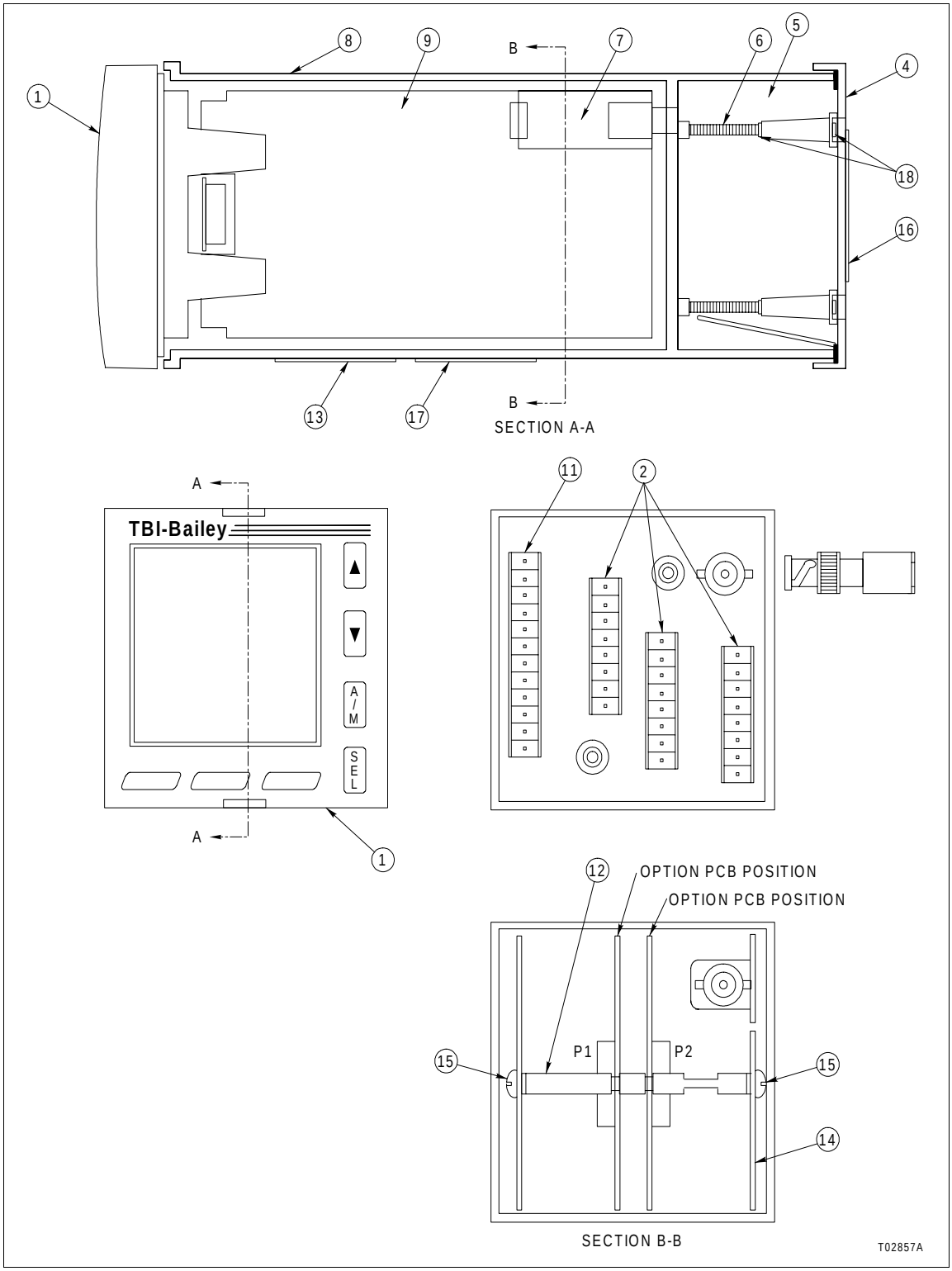


Figure 10-1. Type TB7 Controller Assembly and Parts Drawing

SPARE PARTS KITS (continued)

Part No. 4TB9515-0025 -Front Panel (Display) Assembly

Item	Description	Qty
1	FRONT PANEL ASSY	1
	GASKET, FRONT PLATE[1]	1

NOTE: 1. Component is part of item 1, Front Panel Assembly.

Part No. 4TB9515-0028 - Termination Hardware

Item	Description	Qty
11	TERM. BLOCK, 12 POS.	1
2	TERM. BLOCK, 8 POS.	2 MAX
	MOUNTING SCREWS (NOT SHOWN)	6 MAX

Part No. 4TB9515-0026 - Rear Cover

Item	Description	Qty
4	REAR COVER	1
5	GASKET, REAR COVER	1
16	LABEL, WIRING	1
6	REAR COVER SCREWS	2
18	O-RING	4

Part No. 4TB9515-0027 - pH Board Assembly

Item	Description	Qty
7	pH BOARD ASSY	1
	NUT[1]	1
	WASHER[1]	1

NOTE: 1. Component is part of item 7, pH Board Assembly.

Part No. 4TB9515-0023 - Alarm Expansion Board

Item	Description	Qty
14	ALARM BOARD ASSY	1
2	TERM. BLOCK, 8 POS.	1
	MOUNTING SCREWS (NOT SHOWN)	2
12	SPACER ROD	1
15	SPACER SCREWS	2

APPENDIX A - PROGRAMMING THE PID CONTROLLER AND NONLINEAR INPUT

THE PID CONTROLLER SETTINGS

The TB7 controller offers two types of PID controllers; a single loop (PID controller) that can be used for either acid or base addition, but not both at the same time. The second type is a dual output controller (bidirectional controller) that is used for controlling both an acid and a base addition.

Programming both types of controllers is similar. The main difference is that in the PID controller configuration only one setpoint, proportional band and reset value are entered. In the bidirectional controller configuration two setpoints, proportional band and reset values are entered. A description of the configurable specifications for each controller follows.

Proportional BAND (Both)

The proportional band is a percentage of the instrument span, within which the control output changes in proportion to the difference between the process pH and the setpoint. For the TB7 controller, the instrument span is 14 pH units. As the proportional BAND is increased, the less the output changes for a given process pH change. Refer to Table A-1 for examples of proportional band when using a linear to pH input.

Table A-1. Proportional Band Examples

Proportional Band (%)	pH Deviation From Setpoint (pH)	Control Output Change (%)
7.14	1	100
10	1	71.4
100	1	7.14
1000	1	0.714

RESET (Both)

RESET refers to a change in the control output level over a period of time in addition to the effect due to the proportional BAND action. RESET is entered as ***repeats per minute*** and will add to the control output some portion of the output value as determined from process pH deviation from the setpoint pH. A RESET rate of 0.5 repeats per minute will cause the control output to change by half the amount caused by the deviation in pH multiplied by 7.14 percent in one minute. Table A-2 lists examples.

Protective reset anti-windup programming stops the RESET action when the controller output reaches either +105 percent or -5 percent. If the process pH returns to the setpoint level, the proportional BAND portion of the control output disappears, but the RESET portion will remain until there is another pH deviation change (refer to control ACTION and error signal).

Table A-2. RESET Examples (Linear pH Input)

Proportional Band (%)	Deviation From Setpoint (pH)	Control Reset (RPM)	Time (min.)	Output (%)
50	1	0.5	0 1 2 3	14.28 17.85 21.42 24.99
100	1	1.0	0 1 2 3	7.14 14.28 21.42 28.56
100	3	0.1	0 1 2 3	21.42 22.14 22.85 23.56

NOTE: The bidirectional controller requires some RESET to operate properly. A minimum of 0.10 resets per minute is advised.

DERIVATIVE (PID Single Loop Only)

Derivative refers to an action that adds output to the controller based on how fast the process pH is changing. There is no DERIVATIVE action even if the process pH is two pH units (or more) from the setpoint unless the process pH is changing. DERIVATIVE action is entered as x.xx minutes. It immediately changes the output as much as the Proportional BAND would in a given number of minutes based on the rate of change of the process pH. The higher the DERIVATIVE value, the greater the change will be. DERIVATIVE action bleeds off the control output when the process pH and the resulting proportional output change stabilize.

> **NOTE:** The derivate function is not normally advised for pH control. The default value of 0.0 minutes will disable this function. If a value other than 0.0 is to be entered, it should be very low, otherwise instability could result. The bidirectional controller does not have derivation action available. If used, derivative values above 1.0 will most likely cause unstable controller action.

Controller ACTION (PID Single Loop Only)

Controller action can be DIRECT or REVERSE. DIRECT action is used to lower the process pH (addition of ACID). REVERSE action is used to increase the process pH (addition of base).

The controller ACTION sets the internal math that will determine the error signal used in calculating the Proportional Output and Reset output values.

DIRECT Action = Process pH - Setpoint pH = error
REVERSE Action = Setpoint pH - Process pH = error

When using a nonlinear input to the PID controller, the controller ACTION is locked to REVERSE. The shape of the curve entered will determine the proper error signal. The bidirectional controller has the controller action preset.

SETPOINT (PID Single Loop)

SETPOINT is the desired pH to which the process will be controlled. It is entered from the process display screen by using the **SEL** key to reverse video *SETPOINT* and adjusting the value displayed up or down by the **UP/DOWN** keys.

SETPOINTS (Bidirectional Controller)

SETPOINT are the desired pH levels to which the process will be controlled. The HI SETPOINT is associated with the acid controller. The LO SETPOINT is associated with the base controller. For best operation, a difference of a minimum of 0.5 pH units is advised between the high and low setpoints. Internal lockouts prevent a pH value higher than the HI SETPOINT from being entered as the LOW SETPOINT (and vice versa).

The HI and LO SETPOINTS can be entered from the process display screen by using the **SEL** key to reverse video the appropriate *SETPOINT* and adjusting the displayed value up or down by the **UP/DOWN** keys. They can also be changed in the TUNE or CONFIGURE mode by accessing the proper submenu.

NOTE: An internal buffer zone between the acid and base controller, plus any difference between the high and low setpoints, can cause an offset to the proportional portion of the control output. This offset will be quickly eliminated by the action of the reset portion of the controller. During start-up or check-out, this offset may become noticeable if the controller is operated in proportional only mode (Reset = 0.00 repeats per minute). This should be accepted as normal as long as the offset is no more than 10 percent of full scale.

Additionally, if a 100 percent output is exceeded (output saturated), the controller may not respond in a proportional manner when it comes out of saturation. This is noticeable only if the controller is operated without reset, i.e. proportional only mode.

PROGRAMMING THE CONTROLLER FOR NONLINEAR INPUTS

Often a standard PID controller will not effect good pH control, especially for waste neutralization applications. This is because in pH control, the process gain is rarely constant. Typical process gains can vary from very small to very large values through a relatively narrow range of pH. Compounding this control problem is the fact that, in most all cases, this change in process gain is also nonlinear.

Process gain for pH can be calculated from a plot of pH to volume of chemical addition, i.e., a titration curve (Figure A-1).

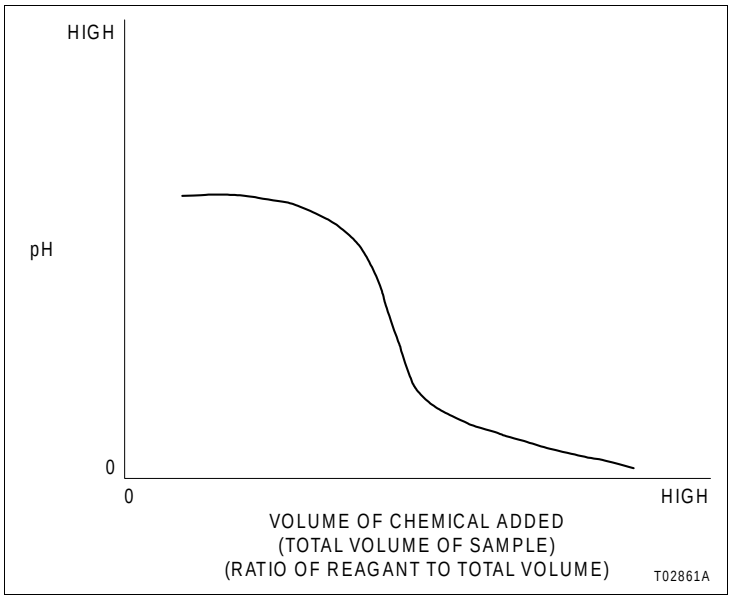


Figure A-1. Typical Titration Curve

Process gain is nothing more than the slope of a line. As can be seen by Figure A-1, a typical pH titration curve has many different slopes, that is process gains. In fact, the slope of pH to reagent demand is different at any two pH values.

The TB7 controller allows users to compensate for the nonlinearities of pH process gain by entering a five-segment linear relationship of pH to reagent demand. Any titration curve can be fitted simply and easily through the following procedure.

1. Derive a titration curve of the process by using either Method A or Method B.

Method A Take a representative sample of the process to be controlled to the lab and titrate it with the chemical to be used as the reagent for process control. It is imperative that the chemical used in the lab be exactly the same as that used in the process. This reagent can be diluted as long as the dilution factor is known and saved for future calculations.

Method B Manually add the desired chemical to the process while measuring input and output pH, process flow (if any), and chemical addition flow (or valve/pump position). Input pH is measured to make sure that no changes in influent pH take place during the test. If influent flow is stable, mark the x axis with the reagent flow or 0 to 100 percent valve opening. If process flow is not stable, mark the x axis with the ratio of process flow to chemical addition or reagent valve opening. The y axis is always the pH after chemical addition. If influent pH changes, enter data derived after the change on a separate curve.

2. Plot the titration curve on graph paper as shown in Figure A-2.

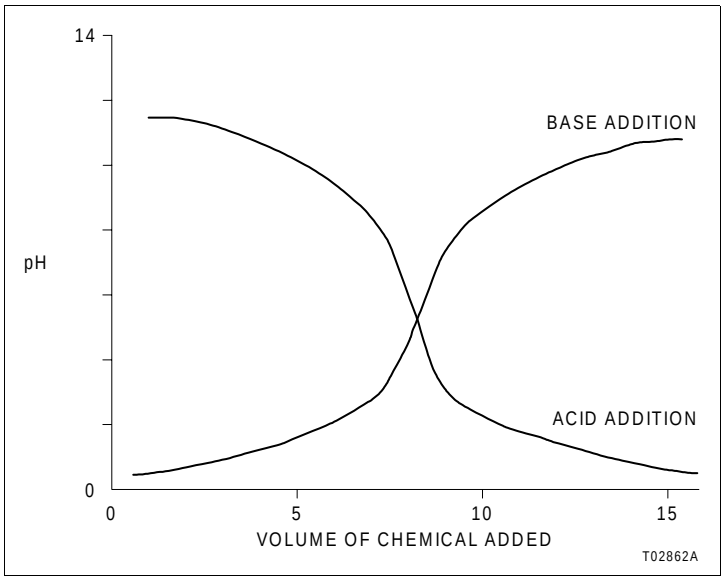


Figure A-2. Plotting the Titration Curve

y axis Always put the high pH value at the top of the graph on the y axis.

x axis Always have zero volume at the left of the x axis. Units of measurement can be in any units as long as these units are consistent for all curves and calculations.

> **NOTE:** Most processes will not have a constant titration curve. It is best to run numerous titrations and determine a composite or average curve for entry into the TB7 controller. In some cases where severe upsets can occur, it is desirable to average sections of the curve. Please read this complete Appendix before attempting to average any specific section of the curve.

3. Determine the highest and lowest pH values expected to be encountered in the field or those positions indicated by 0 and 100 percent valve actuation. These values must consider pH

values caused by process excursions and reagent over-addition. Mark these points on the curve.

4. Divide the x axis marked by the low and high pH values (or 0 to 100 percent valve actuation) of the graph into ten equal sections as shown by the dotted lines in Figure A-3. Label these segments as 0 to 100 percent.

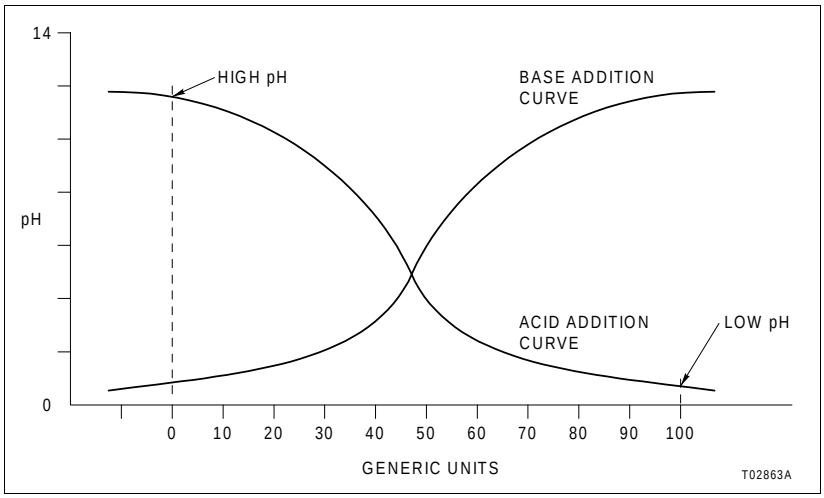


Figure A-3. Segmenting the Titration Curve into 10 Equal Sections

5. If these points (refer to Step 3) exist on steep slopes, you may choose to add two pH units to the high and low pH values and mark these on the curve (Figure A-3). Extending the curve in this manner (i.e., to a less steep gain) may cause a lengthened recovery time for large upsets, but lessens the chance of overshoot.

6. Using the highest and lowest pH values marked in Step 4 or 5 as the start and end points, convert the remainder of the titration curve into a maximum of five straight line segments. Use care in determining what segments of the curve to linearize, as steep slopes and deflection points must be well represented (see Figure A-4). It is desirable to have the area around the controller setpoint well bracketed by straight lines, with areas outside of the normal control region less represented.

7. After linearizing the curve, calculate the values of the x and y points for each intersection (see Figure A-4). Tabulate the intersects as shown in Table A-3. Start with low pH values at the top of the chart.

8. Enter the intersect points starting with the x_1, then y_1, followed by x_2, y_2, etc. Note that the pH values are entered as x_1 through x_6, even though they appear on the y axis of the graph. Also note that x_2 must be a greater number than x_1, etc.

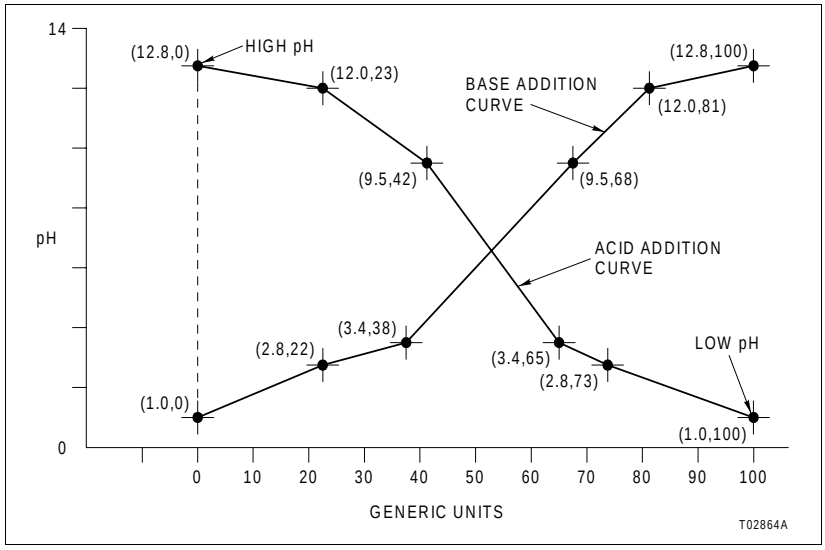


Figure A-4. Converting the Curve to Straight Line Segments

Table A-3. Intersect Points for Linearization

pH Input	Generic Unit Output			
X Values (pH)	Y Values Add Acid PID (%)	Add Base PID (%)	Y Values[1] Acid Bidirectional	Y Values Base Bidirectional (%)
x1 = 1.0	y1 = 100	y1 = 0	y1 = 0	y1 = 0
x2 = 2.8	y2 = 73	y2 = 22	y2 = 27	y2 = 22
x3 = 3.4	y3 = 65	y3 = 38	y3 = 35	y3 = 38
x4 = 9.5	y4 = 42	y4 = 68	y4 = 58	y4 = 68
x5 = 12.0	y5 = 23	y5 = 81	y5 = 77	y5 = 81
x6 = 12.8	y6 = 0	y6 = 100	y6 = 100	y6 = 100

CAUTION

The linearization must be entered according to the arithmetical progression shown in Table A-3 for each configuration and control type. Errors in entering the linearization will adversely affect control.

ATTENTION

La linéarisation doit être introduite en fonction de la progression arithmétique figurant au Tableau A-3 pour chaque configuration et type de commande. Toute erreur d'introduction de la linéarisation aura une incidence sur la commande.

The method of entering y values changes depending on the type of configuration and control action desired. Table A-3 shows the proper arithmetical progression for each type. These must be followed as shown for proper nonlinear control.

NOTE: Acid bidirectional *y* values are determined by subtracting the generic unit on the plotted curve from 100.

It is not necessary to use the full pH scale (0 through +14) when entering *x* values. Conversely, *y* values should use the full percent scale (0 to 100 percent). Internally, the controller will limit output to the *y* value shown for pH values x_1 and x_6. As an example, the controller will deal with values above 12.8. In Table A-3, add acid PID by assigning a generic unit of 0 percent, and values below 1.0 pH with generic unit 100 percent. This means no additional control calculations will be made outside of those pH values.

9. The titration curve has now been entered into the controller. Its action will be on the error signal used as a multiplier to the PID algorithm (non-interacting controller):

$$ke\left(\frac{100Kp}{1}\right) + ke(KI) + derivative = \text{control output in percent}$$

where:

e	=	error signal
k	=	scaler for pH band (100/14 for linear type, 1/1 for nonlinear type)
Kp	=	proportional gain
KI	=	integral reset
$\frac{100}{1}$	=	proportional band scaler
pv	=	process variable (pH)
derivative	=	$\left(\frac{60KDs + 1}{\frac{(60Kd)s}{10} + 1}\right)$
error	=	setpoint - process variable (reverse acting or nonlinear controller)
		- or -
	=	setpoint *y* - process *y* (where *y* is the generic unit used in linearization)
		- or -
	=	process variable - setpoint (direct acting controller)

NOTE: The derivative function is not advised for pH control. The default value of 0.0 minutes will disable this function. Bidirectional controller does not have derivative action available.

It can be seen by this algorithm that the proportional band must be entered before complete controller linearization can be accomplished. Entering these values can be done in two

ways: by calculation or by educated guess work. As an example, assume it is known that for the process shown by the previous acid addition titration curve, an incoming pH of 10 requires a 30 percent valve opening to neutralize the process to 7 pH.

a. Find the *y* values for 10 and 7 pH on Figure A-3 or Figure A-4.

pH (x)	Generic Unit (y)
10	32
7	50

Setpoint *y* (50) - Process +y (32) = 18 error units

b. Divide the required 30 percent output by this error signal.

30 percent divided by 18 = 1.67
The controller gain = 1.67

c. Invert the controller gain and multiply by 100 to arrive at the estimated proportional band.

$$\frac{100}{1.67} = 60 \text{ proportional band}$$

d. Enter 60 as the proportional band

There are a number of ways to determine the percent controller output needed to effect a specific change in pH. The easiest is to manipulate the valve (or pump) manually and measure the input and output pH. In another method, the titration curve can be used to calculate the amount of chemical required to change the pH of a known volume of process liquid according to the following.

$$Q_{reagent} = \frac{(Q_{process})(V_{reagent})(C_{sample})}{(V_{sample})(C_{process})}$$

where:

$Q_{reagent}$ = required reagent flow

$Q_{process}$ = expected flow rate of process

V_{sample} = volume of sample used in the titration

$V_{reagent}$ = volume of reagent used during titration

C_{sample} = Molar strength of reagent used in the titration

$C_{process}$ = Molar strength of reagent used in the process

10. Determining the Integral (Reset) Settings. As can be seen from the equation in Step 9, the integral function is also multiplied by the error signal (which has now been linearized to the titration curve). This means that the effect of the integration will be less at steep parts of the curve than at the flatter slopes. As a result, the integral function is also linearized, thus allowing conventional running techniques to be used for reset settings.

Example: The integral rate is directly related to the hold up time of the process. Assume that neutralization occurs in a 1000 gallon tank and that the influent flow rate is 100 gallons per minute. The hold-up time is given as volume/flowrate which is 10 minutes in this example. The integral rate should be set to:

$$I = \frac{1 reset}{0.8(\text{hold up time in minutes})}$$

$$I = \frac{1}{0.8(10)} = 0.125 \text{ resets per minute}$$

Because the controllers are a non-interacting type, reset values will typically be higher than values used with interacting (conventional) controllers.

NOTE: When using a nonlinear input to the PID controller, the controller ACTION is locked to REVERSE. The shape of the curve entered will determine the proper error signal. The bidirectional controller has the controller action preset.

APPENDIX B - TBI-BAILEY SETUP OF pH ANALYSIS SYSTEM/ SENSOR SIMULATION

GENERAL INFORMATION

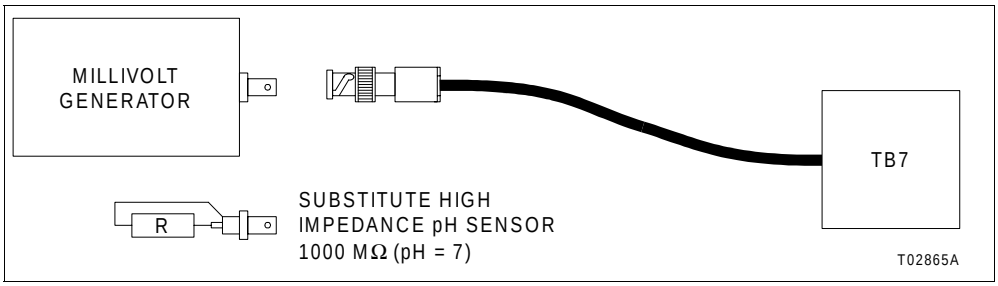


Figure B-1. Setup of pH Analysis System/Sensor Simulation

Table B-1. Theoretical pH Sensor Output - 100% Efficiency (Standard pH Sensor)

Temperature pH	0°C (32°F) mV	25°C (77°F) mV	40°C (104°F) mV	50°C (122°F) mV	70°C (158°F) mV	90°C (194°F) mV	100°C (212°F) mV
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	+432.3	+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
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	-68.09	-72.05	-74.03
9	-108.4	-118.3	-124.2	-128.2	-136.2	-144.1	-148.1
10	-162.6	-177.5	-186.4	-192.4	-204.3	-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	-434.9	-448.8	-476.6	-504.4	-518.2

NOTE: Should the millivolt generator not terminate in a BNC connector, connect the positive (+) lead to the inner conductor and the negative (-) lead to the shell of the BNC connector of the TB7 Controller for a positive input. For a negative input, reverse the leads.

Table B-2. Typical pH Sensor Output - 98% Efficiency (Standard pH Sensor)

Temperature T/C Resistor pH	0°C 2.68k mV	25°C 3.00k mV	40°C 3.19k mV	50°C 3.32k mV	70°C 3.58k mV	90°C 3.83k mV	100°C 3.96k mV
0	+371.7	+405.7	+426.2	+439.8	+467.1	+494.3	+507.8
1	+318.6	+347.8	+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	+2824	+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

APPENDIX C - APPLICATIONS IN FLAMMABLE ATMOSPHERES

OVERVIEW

NOTE: As of the printing date of this instruction manual, submittals have been made for the stated categories to the agencies listed.

Factory Mutual Research (FM) approval is pending for:

Class I, II, III, Division 2, Groups A-G.

Canadian Standards Association (CSA) certification has been received for:

Class I, Division 2, Groups A-D.

NOTE: Hazardous locations approvals are for ambient conditions of 86 to 108 kPa (12.47 to 15.66 psi), 21% oxygen maximum, and -25°C to 40°C (-13°F to 104°F).

CLASS I, DIVISION 2 HAZARDOUS LOCATIONS

Hazardous Locations

The TB7 controller is designed for use in a Class I, Division 2 Hazardous Locations as defined in the National Electrical Code and the Canadian Electrical Code. These locations are made hazardous by the potential presence of a flammable gas or vapor in air mixture.

A Division 2 classification assumes that the flammable substance is normally adequately contained or is normally adequately diluted by ventilation. Flammable or explosive concentrations would exist rarely and for short periods of time. Guidelines for area classification are found in ANSI/NFPA 497A, *Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 1986.

Weatherproof connectors must be installed in the wiring entry openings of the controller housing if the controller is operating in a hazardous location such as would be found in environments containing dust.

Nonincendive Equipment Rating

A nonincendive rating for the controller means that the unit has been evaluated to FM Class Number 3611 and CSA C22.2 No. 213 and has been found that under normal operation will not create a spark capable of igniting a specified test gas.

The T3A temperature code means that the Type TB7 Controller Transmitter cannot be used with gases that have an autoignition temperature (AIT) less than 180°C (356°F). Autoignition temperatures for many common gases and vapors can be found in ANSI/NFPA 497M, *Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations*.

WARNING

Disconnecting or reconnecting wiring and, removing or inserting printed circuit boards are not considered normal operation. Operator access to these connections is prevented by a rear cover and faceplate which require a tool to remove them. These operations should only be done if power has been removed from all wiring or if the flammable atmosphere is known not to be present.

AVERTISSEMENT

Le debranchement ou le rebranchement des fils, le retrait ou l'insertion des cartes de circuits imprimes et le basculement de l'interrupteur marche/arret n'entrent pas dans les procedures normales. Un couvercle ne s'ouvrant qu'a l'aide d'un outil empeche a l'operateur d'acceder a ces connexions et a cet interrupteur. Advenant que l'atmosphere soit inflammable, on ne doit effectuer les procedures ci-dessus que si l'alimentation a ete interrompue.

Disconnecting the signal wiring connected to field equipment may be permitted if the circuit is a Nonincendive Circuit (NEC). Guidelines are provided for making this determination under the section titled Nonincendive Circuit (NEC). Such circuits may use any wiring method and may be installed and tested while powered. Care must be taken to ensure that only one circuit is worked on at a time and that separate circuits are not shorted. Shorting of separate circuits is not part of the evaluation and could result in ignition capable arcs.

Wiring Requirements

Power and signal wiring to and from the controller is normally assumed to be at ignition capable levels. Therefore, this wiring must be suitable for use in Class I, Division 2, hazardous locations. The National Electrical Code requires the use of rigid metal conduit or non-metallic cable (Types MV, PLTC, SNM, TC) or metallic cable (Types MI, MC). The Canadian Electrical Code requires metal conduit or non-metallic cable certified as ***HL.***

PLTC cable is rated 300 volts and can be obtained in wire sizes 22 AWG to 16 AWG at various temperature ratings. This would be the recommended wiring for both power and signal circuits in the United States.

Digital Output Load

The load must be limited such that an ignition capable arc is not created when the relay makes or breaks the circuit. The open circuit voltage, short circuit current, circuit capacitance and circuit inductance must be limited to values below the ignition curves found in the documents listed at the end of this appendix. As a reference, the following table is provided for a 24 VDC supply.

Group	V_{max}	I_{max}	Cmax	L_{max}
A or B	28 VDC	150 mA	0.4µFd	3.5 mH[1]
C	28 VDC	400 mA	1.2 µFd	2.0 mH[1]
D	28 VDC	540 mA	3.2 µFd	2.0 mH[1]

Nonincendive Circuits (NEC)

The Type TB7 Controller has analog/digital inputs and outputs. The wiring between the field equipment and the controllers may be considered as part of Nonincendive Circuits (NEC) if the power supply is properly voltage and current limited and field equipment does not increase the energy in the circuits to unacceptable levels. This requires that the field equipment not exceed specified inductance and capacitance values. The digital output field equipment must already meet this requirement because of the arcing contacts in the relay. A Nonincendive Circuit (NEC) is considered as non-ignition capable even if the wires are shorted, opened, or grounded. Therefore, any wiring type is allowed per the exception in NEC article 501-4(b) and CEC article 18-066(2).

ANALOG OUTPUTS

The controller normally outputs only 4 to 20 milliamps. If the wiring were to be opened, the open circuit voltage would be 27.6 volts. A current regulator limits fault current to 92 milliamps. The load (field equipment and cable) must not exceed the following values:

Class I	Capacitance	Inductance
A or B	0.4 µFd	8 mH
C	1.2 µFd	30 mH
D	3.2 µFd	60 mH

ISOLATED DIGITAL INPUTS

Digital inputs which have a power source other than from the controller must be evaluated for energy limiting. Ignition curves for various gases can be found in documents listed at the end of this appendix.

DIGITAL OUTPUTS

The controller provides a relay contact closure. The load and the power source for the load are external and must be evaluated for energy limiting. Although the load must limit the current to nonincendive levels so that the relay is not an ignition source, the power supply itself must be energy limited if the external circuit is to be considered nonincendive. The TB7 controller does not add capacitance or inductance to the circuit.

Applicable Standards

The following standards are available for designing and installing nonincendive circuits and equipment:

Instrument Society of America

ANSI/ISA RP12.6-1988, *Installation of Intrinsically Safe systems for Hazardous (Classified) Locations.*

ANSI/ISA S12.12-1984, *Electrical Equipment for use in Class I,Division 2 Hazardous (Classified) Locations.*

Canadian Standards Association

CSA C22.2 No. 213-M1987, *Nonincendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations.*

Underwriters Laboratories

UL 1604 (1982), *Electrical Equipment for Use in Hazardous Locations.*

APPENDIX D - TB7 CONTROLLER SCREEN OVERVIEW FLOWCHARTS

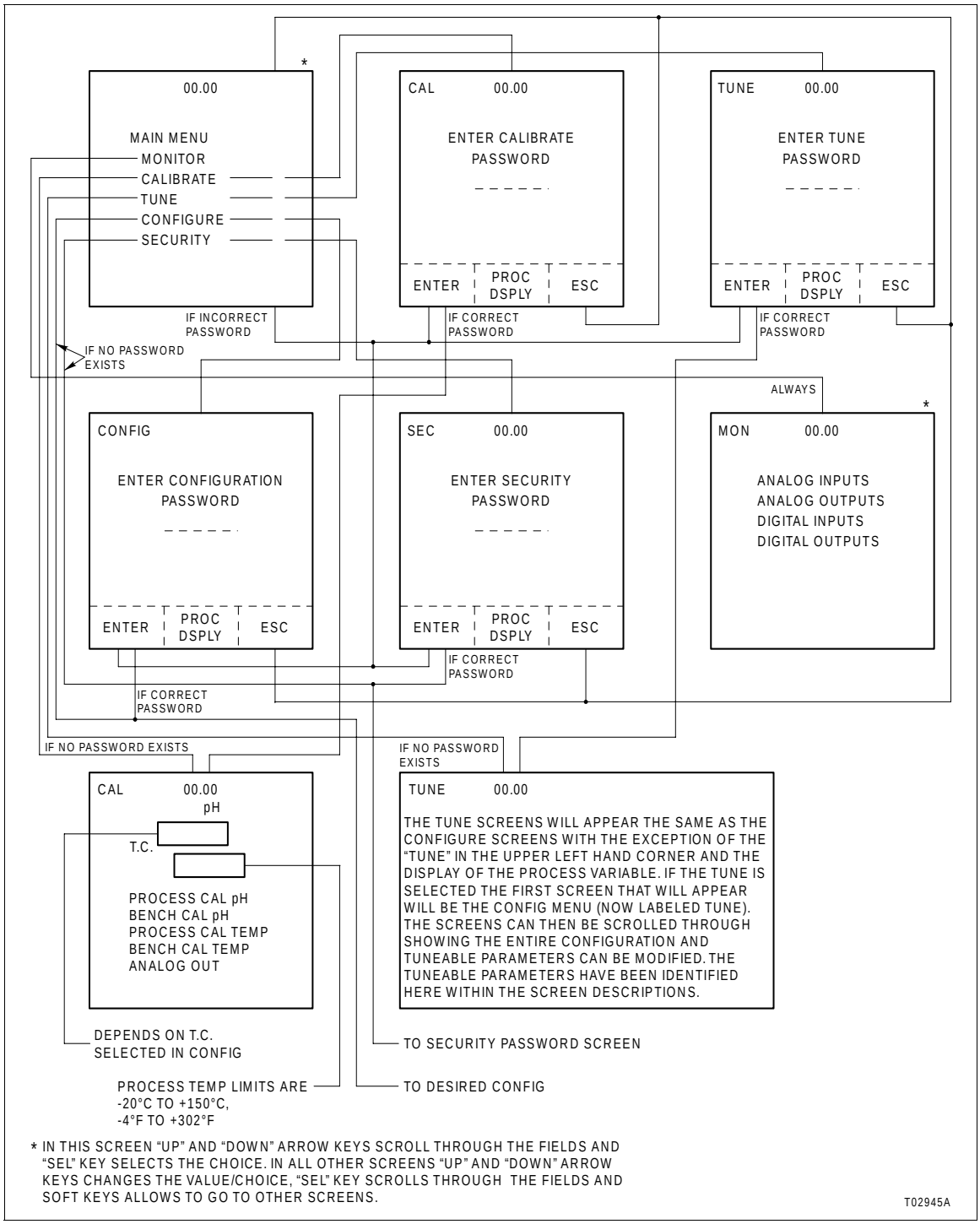


Figure D-1. Menu Overview

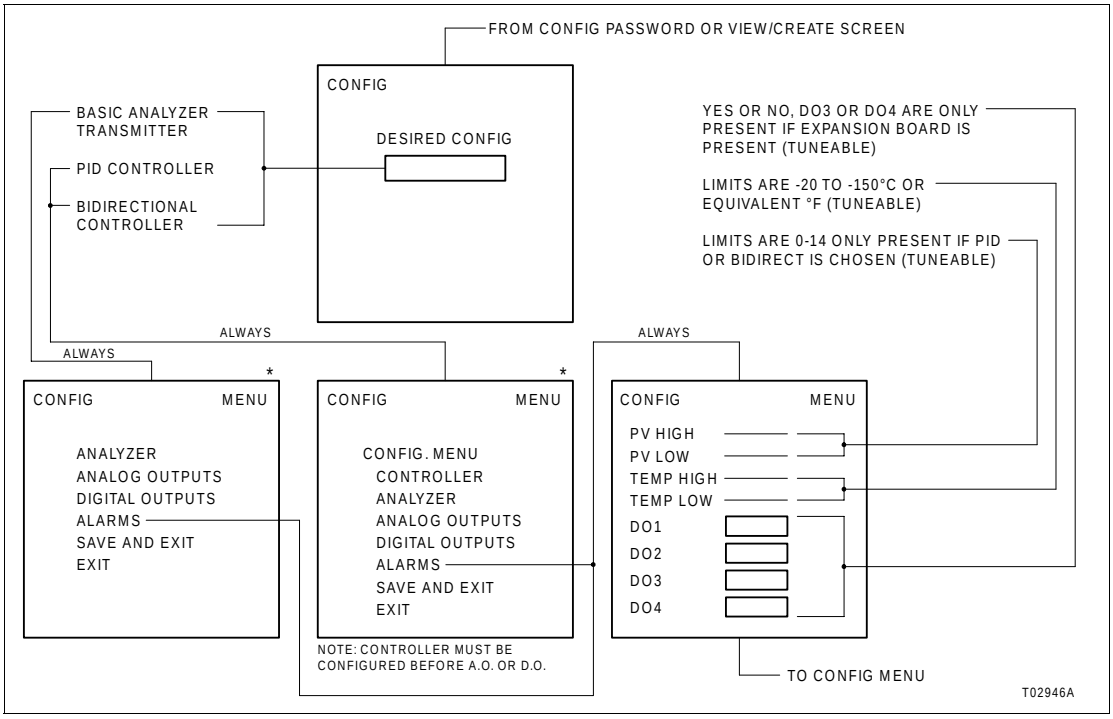


Figure D-2. Configuration Menus (Page 1 of 6)

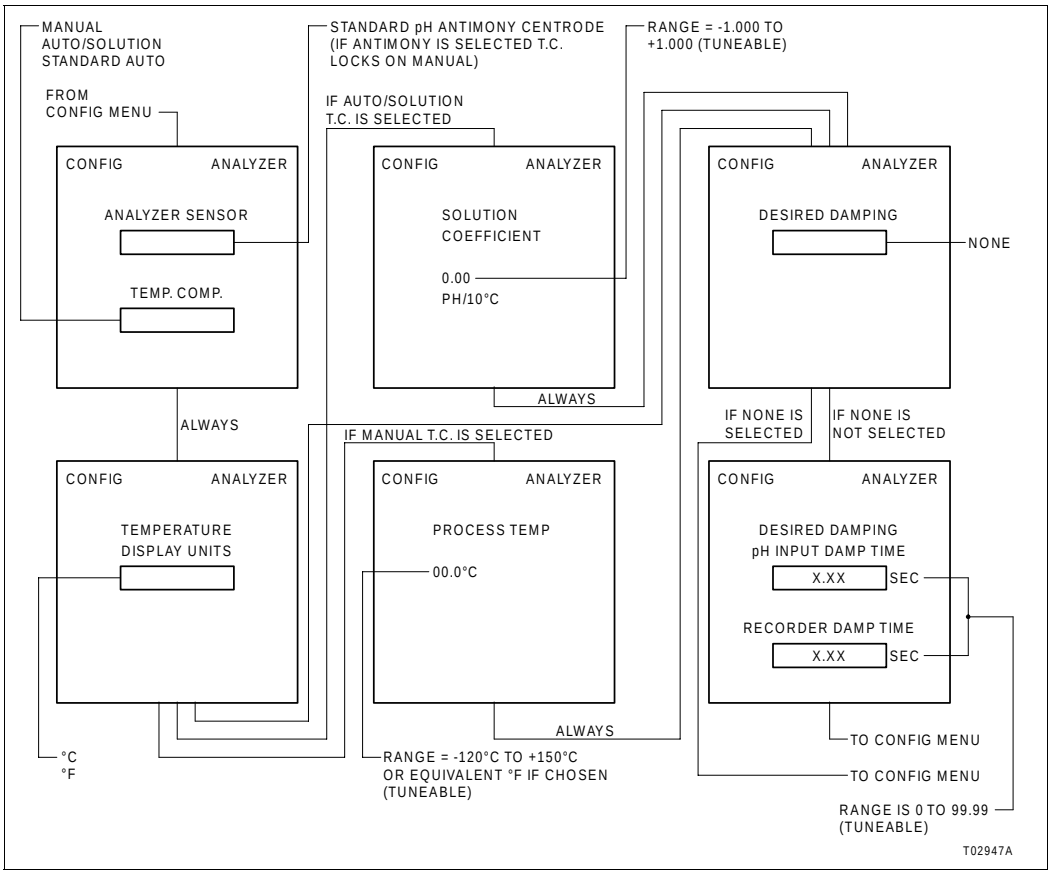


Figure D-2. Configuration Menus (Page 2 of 6)

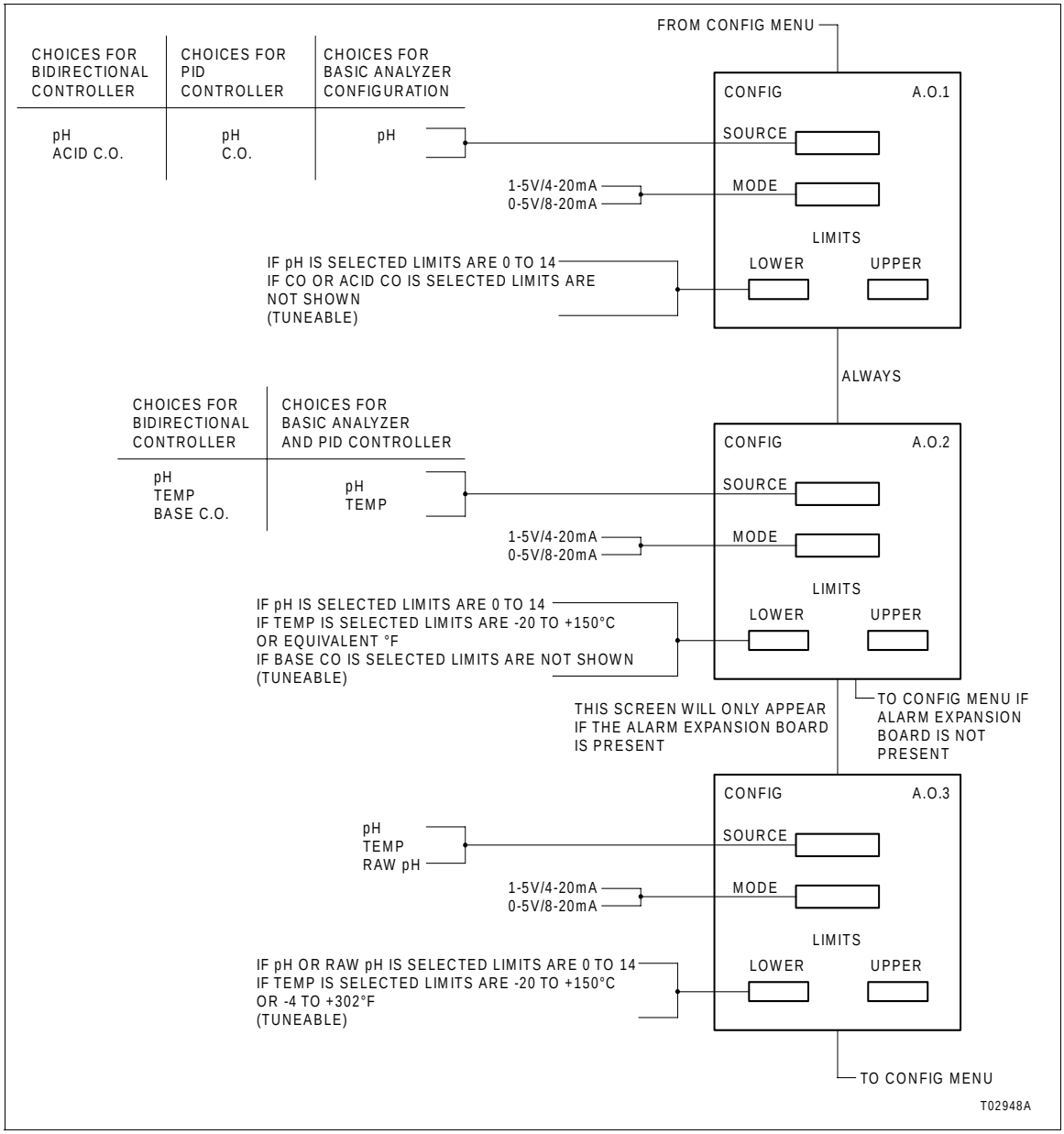


Figure D-2. Configuration Menus (Page 3 of 6)

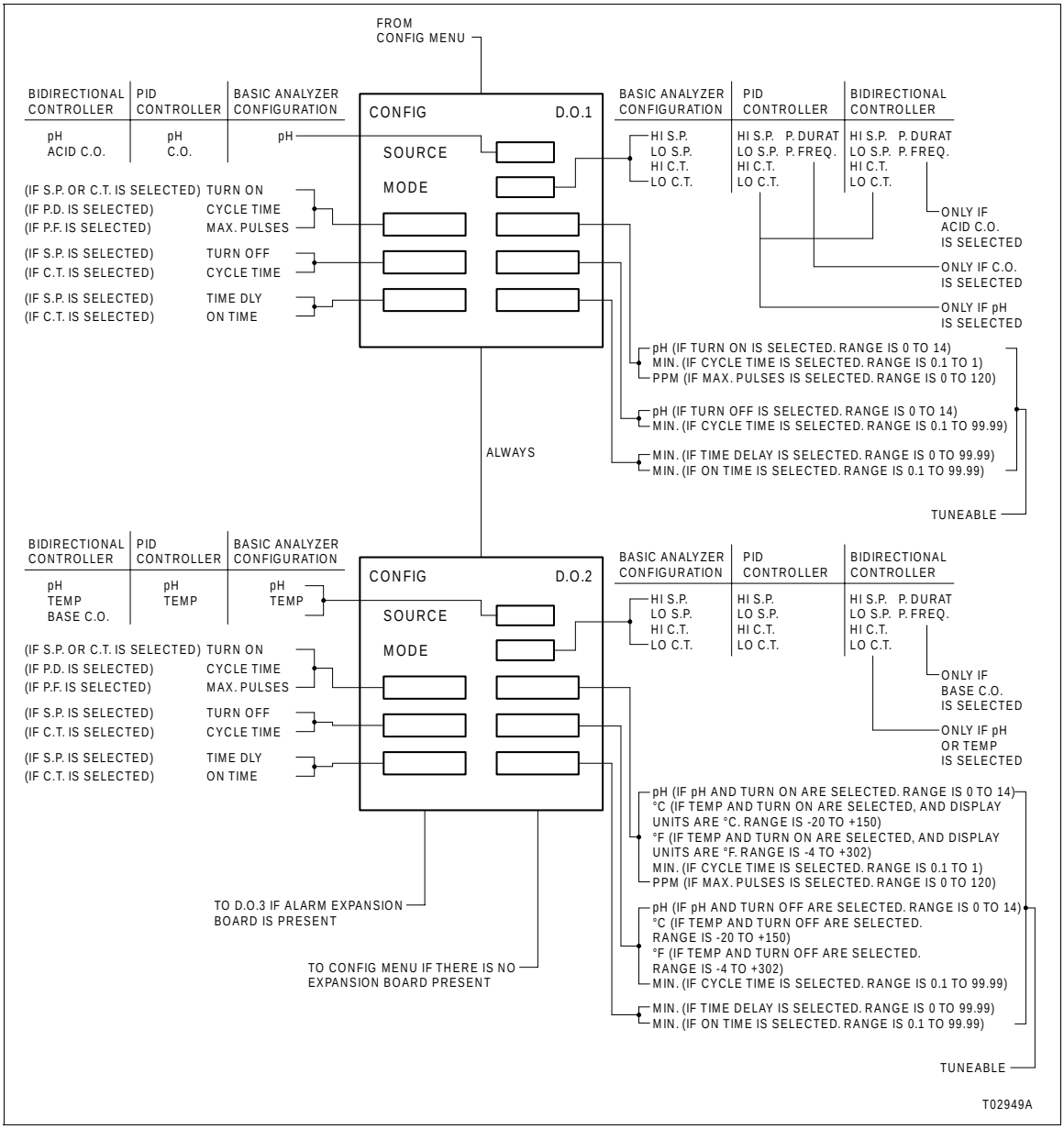


Figure D-2. Configuration Menus (Page 4 of 6)

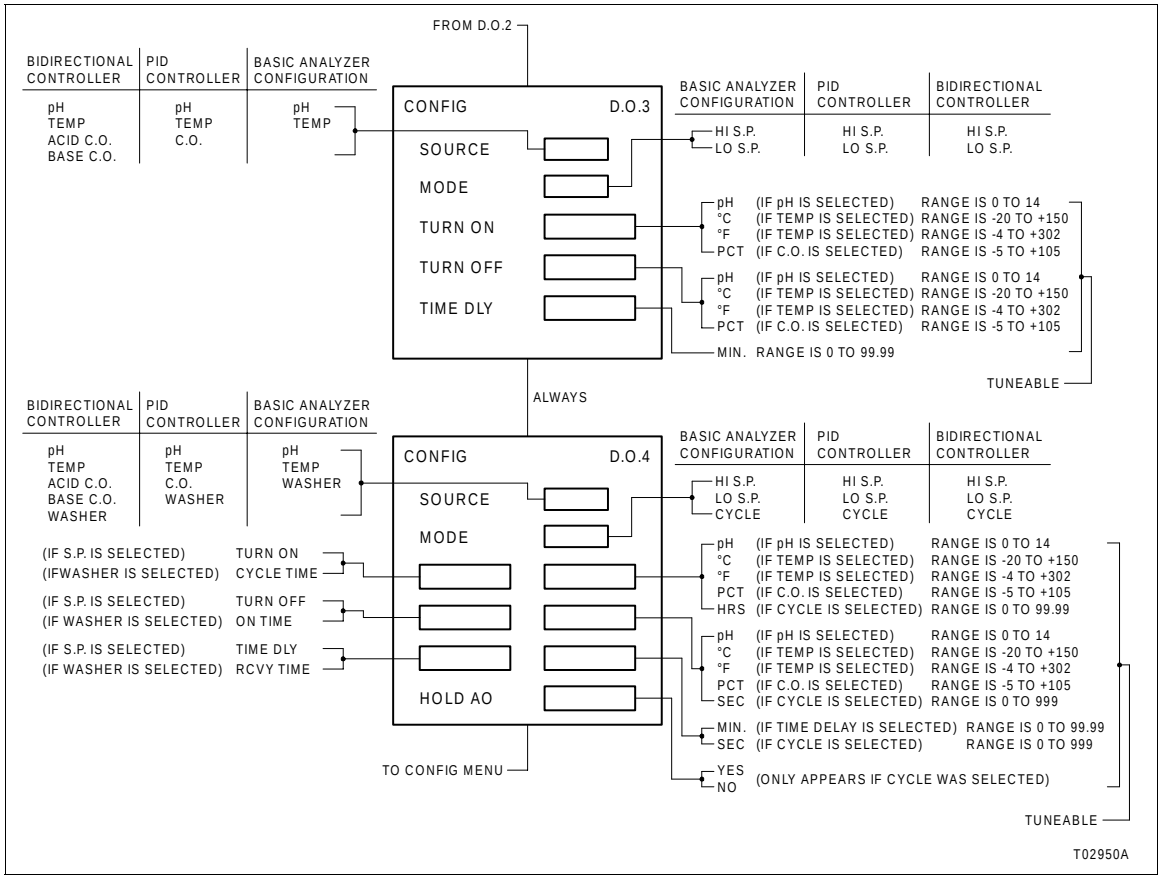


Figure D-2. Configuration Menus (Page 5 of 6)

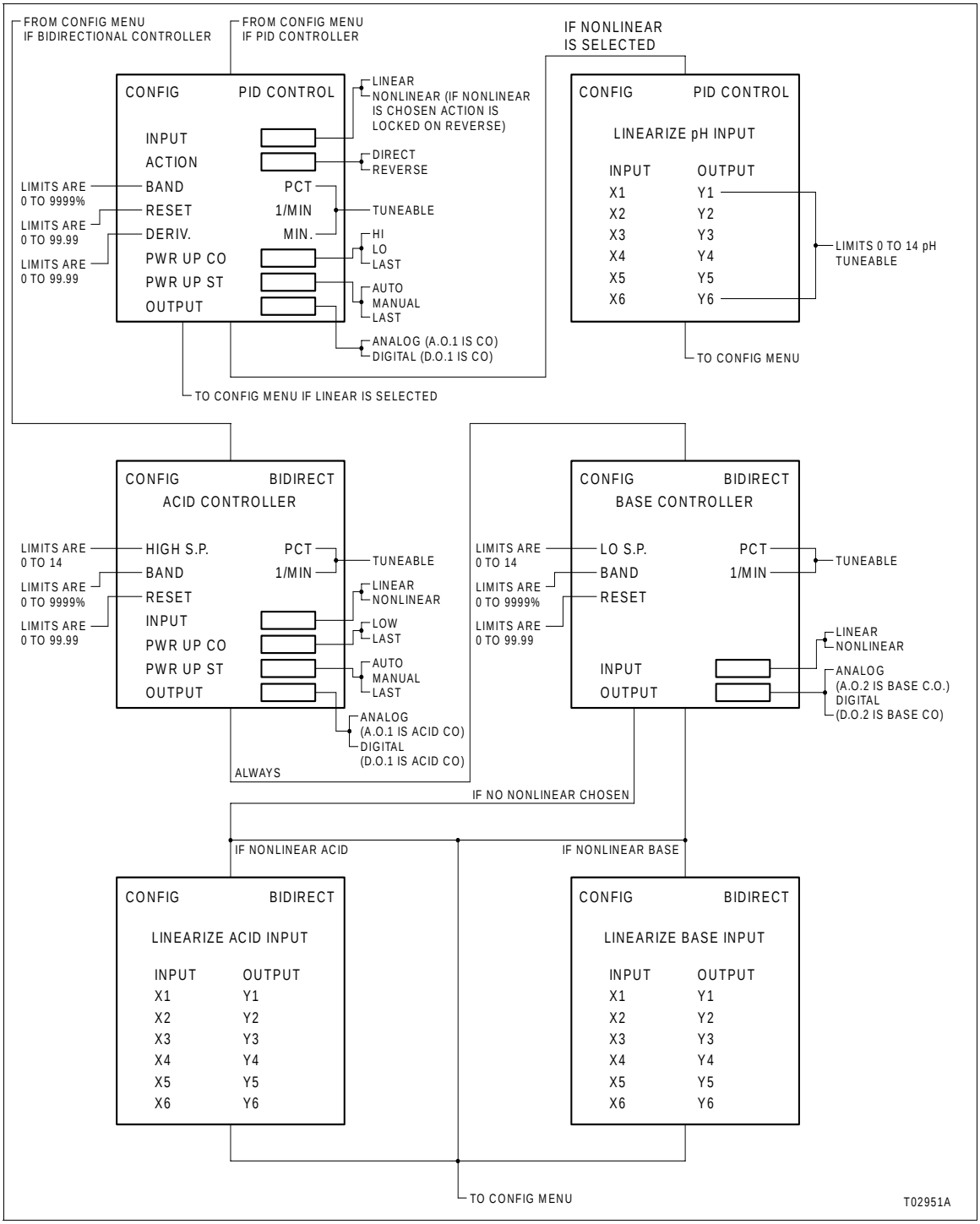


Figure D-2. Configurations Menus (Page 6 of 6)

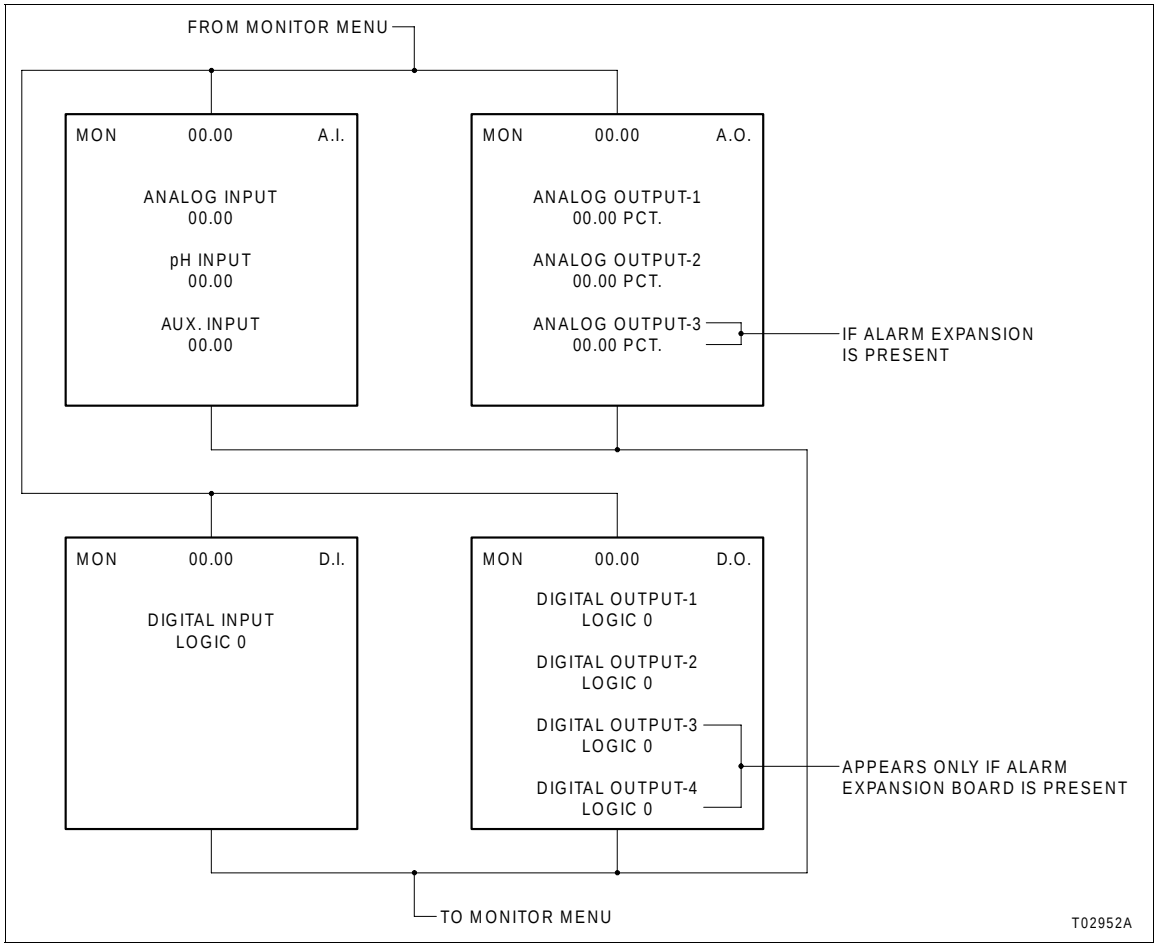


Figure D-3. Monitor Menus

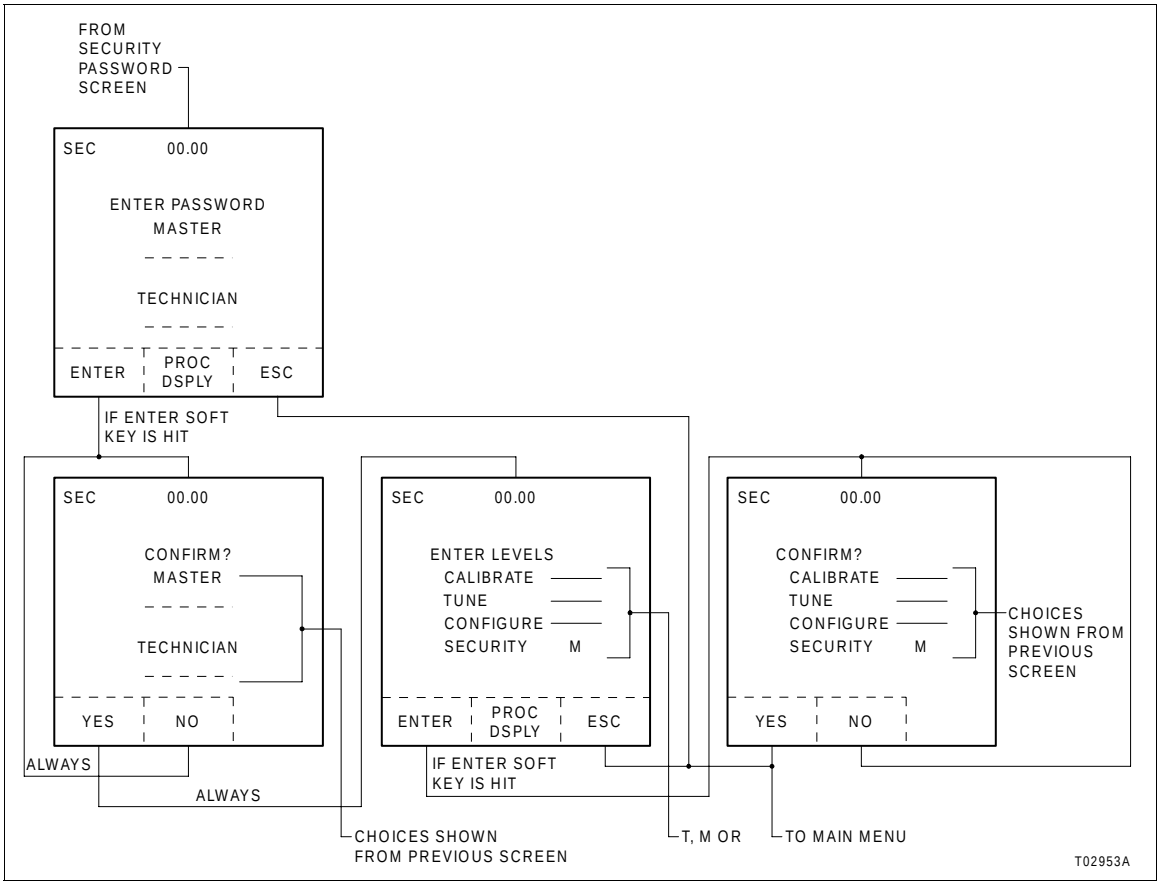


Figure D-4. Security Menus

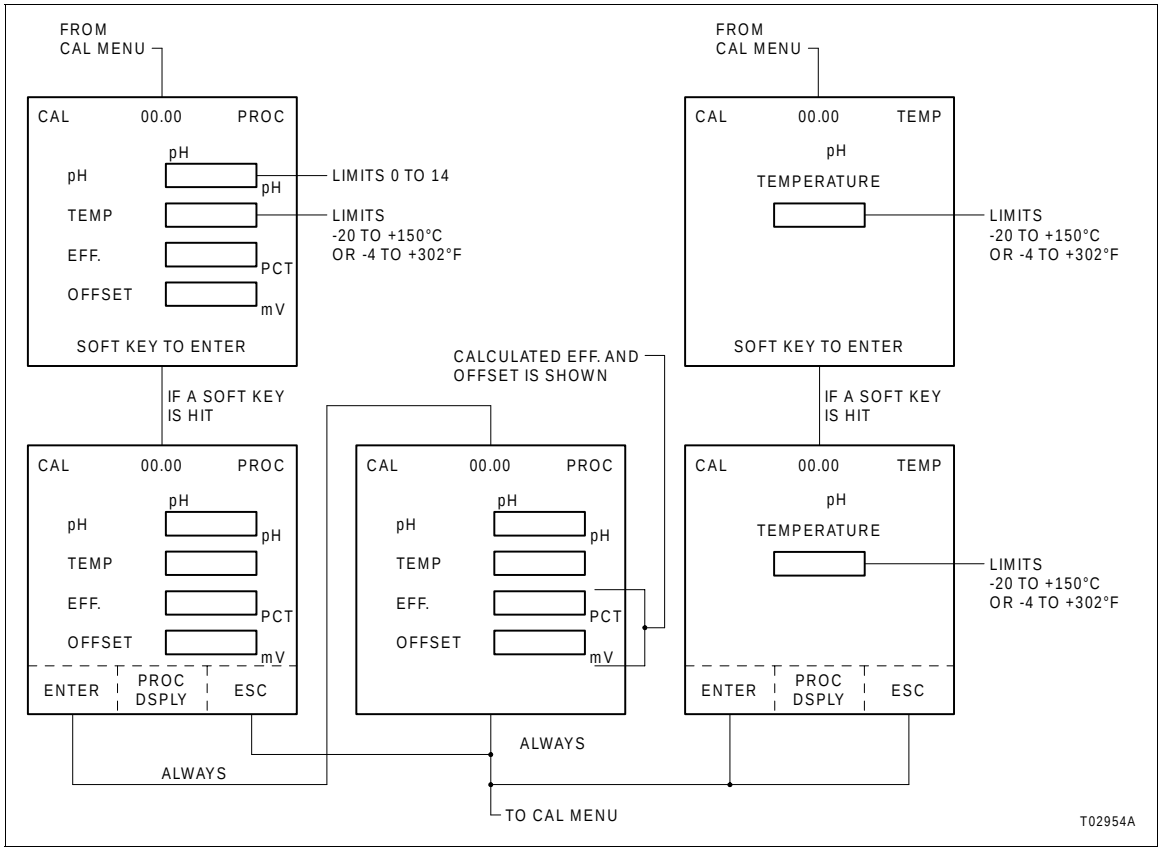


Figure D-5. Calibration Menus (Page 1 of 4)

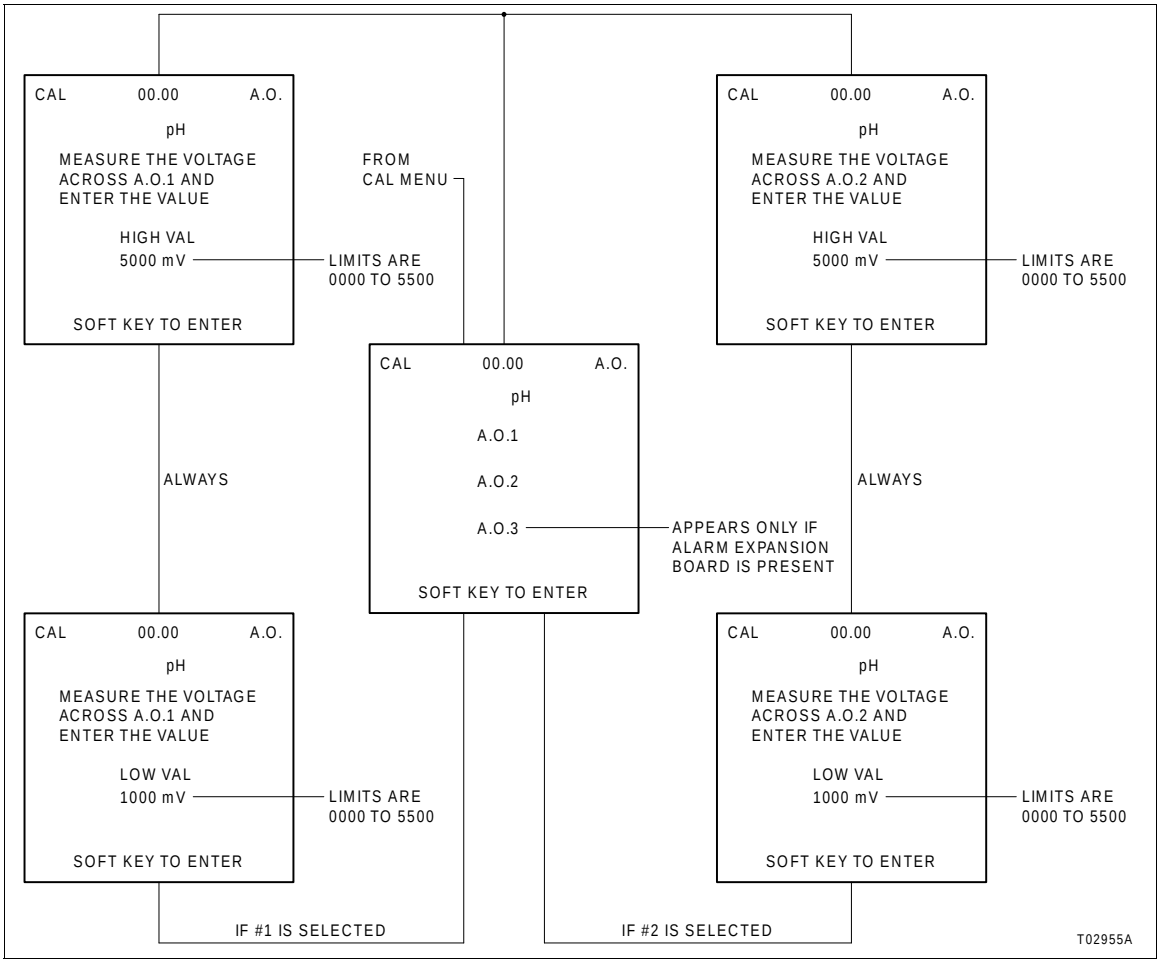


Figure D-5. Calibration Menus (Page 2 of 4)

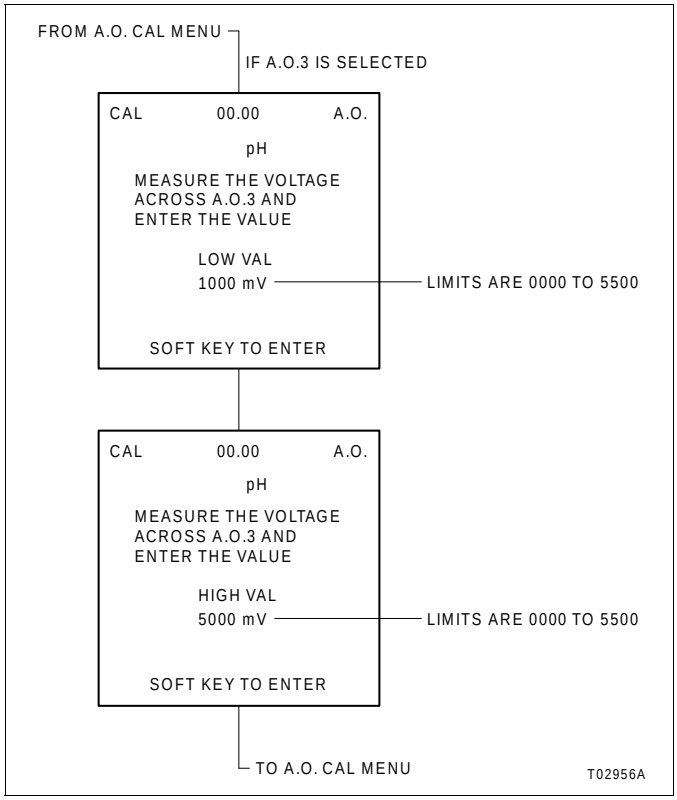


Figure D-5. Calibration Menus (Page 3 of 4)

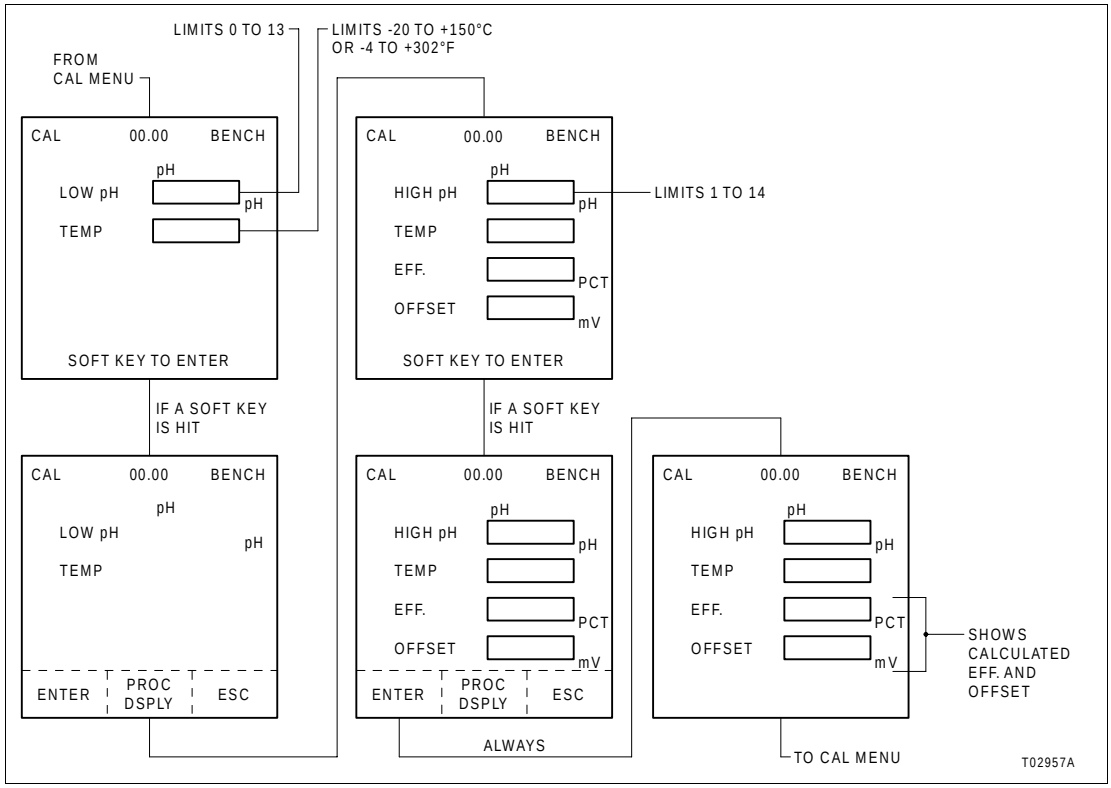


Figure D-5. Calibration Menus (Page 4 of 4)

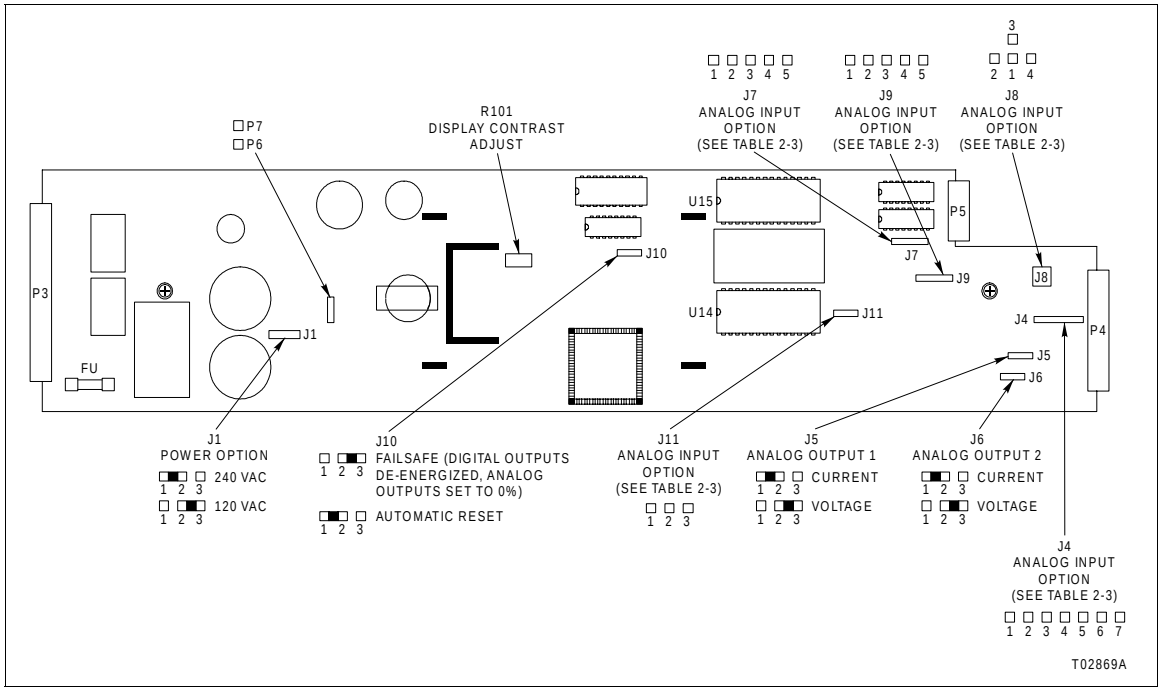
TB7 QUICK REFERENCE

POWER OPTION

Option	Control	Setting	Customer Setting
120 VAC 240 VAC	J1	2-3 1-2	

ANALOG INPUT DEFAULT SETTINGSFAILURE DETECTION OPTION

Analog Input 1	J4	J7	J8	J9	J11	Customer Setting
For Conductivity or pH/ORP Inputs	2-3 4-5 6-7	2-3 4-5	1-4	1-2 3-4	2-3	

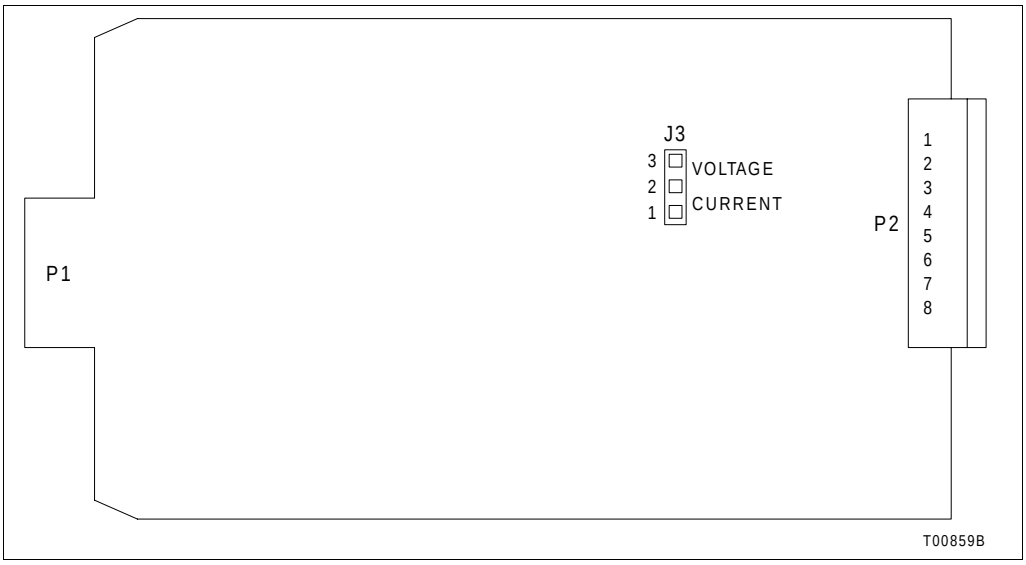


FAILURE DETECTION OPTION

Option	Control	Setting	Customer Setting
Auto Reset Failsafe (low)	J10	1-2 2-3	

ANALOG OUTPUT OPTIONS

Option	Control	Setting	Description	Customer Setting
Analog Output 1	J5	1-2 2-3	For current output For voltage output	
Analog Output 2	J6	1-2 2-3	For current output For voltage output	
Analog Output 3 (expansion board)	J3	1-2	For current output For voltage output	



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