M E S A
L A B S

OPERATION MANUAL

MODEL 86 PID

Pipeline Interface Detector

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Part Number: 600151-002 Rev. A

Warranty

All products manufactured by the seller are warranted against defects in materials and workmanship for a period of one (1) year from the date of shipment to the original purchaser. Any Mesa Laboratories, Inc. product which proves to be defective during the warranty period will be repaired or replaced free of charge, provided that the product is returned freight prepaid to Mesa Laboratories, Inc. factory from which original shipment was made. The customer will also pay return freight costs following the repair or replacement of the product.

This warranty will become void if the product is used for other purposes or in environments other than those for which it was designed, or if its circuits or mechanisms are tampered with except as normally required for installation purposes. Products of other manufacturers which are supplied by Mesa Laboratories, Inc. will be covered by the original equipment manufacturer's warranty.

Materials of construction are warranted to be compositions stated by Mesa Laboratories, Inc. and warranted as to their integrity. Conditions in the medium to be analyzed are beyond the control of Mesa Laboratories, Inc. and, hence, resistance to corrosion/erosion is specifically not warranted.

No other warranty is expressed or implied.

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SECTION I GENERAL INFORMATION

1.1 INTRODUCTION

This manual contains installation, operation and maintenance information for the Model 86 PID (Pipeline Interface Detector) manufactured by Mesa Laboratories, Inc. The Model 86 PID is the latest in a line of instruments that utilize the measurement of the speed of sound through a liquid in the determination of chemical and/or physical properties of a liquid.

Through these measurements, the Model 86 PID indicates the arrival of interfaces in hydrocarbon pipelines. Interface detection is virtually instantaneous, and applicable to a wide range of hydrocarbons, from LPG's to heavy crude oils. The measurement precision of the Model 86 PID also enables detection of difficult interfaces between products with nearly identical densities (such as two types of unleaded gasoline). In terms of density, the sensitivity of the Model 86 PID is on the order of 0.000015 SGU (repeatable to 0.0001 SGU).

The output of the units is usually the compensated sound velocity, compensated for pressure and temperature variations, and expressed in meters/second. These units provide the greatest resolution for interface detection. The 86 PID may also be set to output in °API (compensated to °60F) or SGU. The output of density units is derived by correlation to sound velocity and will have excellent repeatability, but the accuracy may be affected by formulation and additive content. A graph of the relationship between sound velocity and density is presented on page 14.

1.2 TRANSDUCERS

The Model 86 PID consists of a transmitter that accepts inputs, performs calculations and provides outputs; and a set of sensing elements that provide the necessary inputs to the transmitter. These sensing elements include sound velocity, temperature and pressure transducers. They are immersed in the pipeline liquid.

1.2.1 SOUND VELOCITY TRANSDUCER

The sound velocity transducer consists of a piezoelectric ceramic element sealed within a metal housing for protection from the pipeline environment. Since most hydrocarbons encountered in pipeline applications are not particularly corrosive, the transducer is usually provided in 316 stainless steel, the standard material of construction.

1.2.2 TEMPERATURE TRANSDUCER

A platinum-element resistance temperature detector (RTD) is included as a standard process sensor, since the precise measurement of sound velocity is temperature-dependent. The RTD sensing element is sealed within a metal sheath, usually constructed of the same material as the sound velocity transducer. Other materials are available for special requirements.

1.2.3 PRESSURE TRANSDUCER

Changes in pipeline pressure in many cases may be extreme; since sound velocity may vary with respect to pressure, some form of compensation for the pressure effect is required. Thus, each Model 86 PID is equipped with a pressure transducer.

The pressure transducer consists of semiconductor strain gauges sealed within a steel diaphragm and body. They are connected to form a Wheatstone bridge that provides an output signal proportional to pressure when an excitation voltage is applied.

1.2.4 INTERCONNECTING CABLE

Mesa Laboratories, Inc. Nusonics Division provides cable for connecting transducers to the transmitter. The standard length for all cabling is 25 feet. Up to 100 feet may be provided in some instances. Generally, such extended cable lengths are ill-advised when the unit is to be located in an electrically noisy environment, or when there is the potential for AC line noise or RF interference.

1.3 TRANSMITTER

The transmitter includes the Model 86 PID printed-circuit boards (PCBs), wiring terminals, diagnostic displays, LCD display and keypad, chassis and enclosure. Units equipped with the optional NEMA 7 enclosures may include a remote keypad in order to satisfy explosion-proof requirements.

1.3.1 PRINTED CIRCUIT BOARDS

The transmitter contains four removable PCB's in the card cage to the left (facing) of the keypad and display panel. Each PCB may be identified by the color-coding of the topmost ejector mechanism. The position of these ejectors is shown in Figure 1-1. From left to right (facing) the PCBs and color coding are:

PCB#	COLOR CODE	DESCRIPTION
1	Green	Power Supply
2	Red	Sound Velocity
3	Yellow	I/O (input/output) or Analog board
4	White	Unused
5	Blue	Microprocessor

The appropriate cage location may be identified by matching ejector color with the upper card guide.

NOTE: HANDLE MODEL 86 PID PCB'S BY EJECTOR MECHANISMS ONLY!

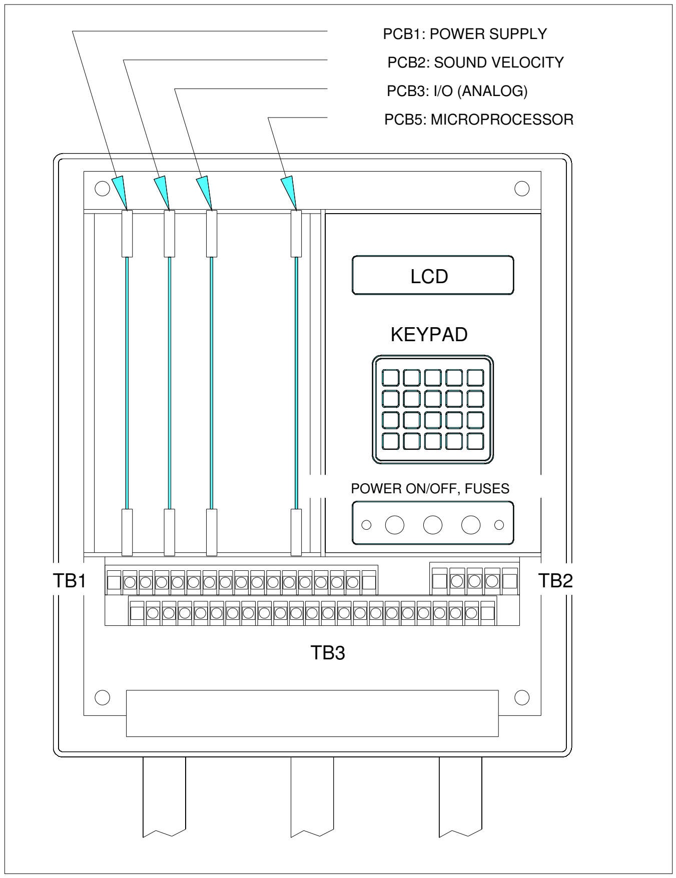


Figure 1-1

1.3.2 TERMINAL BLOCKS

The wiring or terminal blocks are shown in Figure 1-1. The input / output designation for each of the terminal block positions is listed in the Field Wiring Diagram at the back of this manual. The general function of each terminal block is:

TB1 Analog outputs, set point and alarm relay connections.
TB2 Main power.
TB3 Inputs from sensors and RS-232 communications.

1.3.3 KEYPAD AND LCD (DISPLAY PANEL)

The keypad and display are located on the blue panel on the right facing side of the Model 86 PID. All setup, calibration and operational parameters may be established via keypad. These settings are observed on the LCD display (2 line x 16 character) located directly above the keypad.

At the bottom of the display panel are (from left) a "heater on" LED and 3 amp fuse for optional heater; power switch, 1/2 amp fuse and "power on" indicating LED.

SECTION II INSTALLATION

2.1 INTRODUCTION

This section provides instructions for the installation of the Model 86 PID. This manual should be reviewed completely before proceeding with installation, as certain requirements concerning start-up may influence the location of the interface detector.

2.2 UNPACKING

Each Model 86 PID is given a thorough functional inspection prior to shipment. However, on receipt, the unit should be carefully examined for any damages which might have occurred in the course of shipment. If any damage to the unit is sustained in shipment, file a claim against the shipper immediately.

CAUTION! THE TRANSMITTER CONTAINS CMOS DEVICES WHICH MAY BE DAMAGED BY ELECTROSTATIC CHARGE.

Storage: If the unit is to be stored for any period of time prior to installation, it should be stored in a dry indoor location. Retain all original packing materials and containers until the instrument is installed and operating.

2.3 INSTALLATION PLANNING

The transmitter should not be located in direct sunshine. This can cause the temperature inside the enclosure to increase to a point where component failure may occur. When mounted outdoors, the Model 86 PID transmitter should be protected with a sunshield and also should be adequately ventilated.

Twenty-five (25) feet of transducer cable are provided with each unit. Thus, the transmitter normally must be mounted within 25 feet of the proposed pipeline installation point for the transducers. In some instances, up to 100 feet of transducer cable may be provided, but increasing cable length increases the possibility of external interference.

Besides the physical limitation imposed by cable length restricting the distance between transducers and transmitter, there are other considerations to the location of the unit:

1. The transmitter should not be located in an area where rotating electrical equipment or high-current carrying AC lines which may cause interference.

2. Entrained air or gas bubbles will impede the performance of the unit. The transducers must be located in an area where entrained gas is minimal.

3. Transducers in the retractor or flanged assemblies should be offset from 0° to 45° either side of the horizontal pipe axis (see Figure 2-1). This will prevent bubbles from adhering to the transducer face, particularly in low flow velocity applications.

4. The transducers should be placed 10 pipe diameters or more away from flow obstructions such as partially opened valves.

5. The transducers must be completely immersed in liquid.

6. The RTD should always be mounted downstream of the sound velocity transducer. Each piece of mounting hardware is tagged or otherwise marked so that it can be properly oriented with respect to flow direction. When transducers are provided unmounted, they should be located as close together as possible.

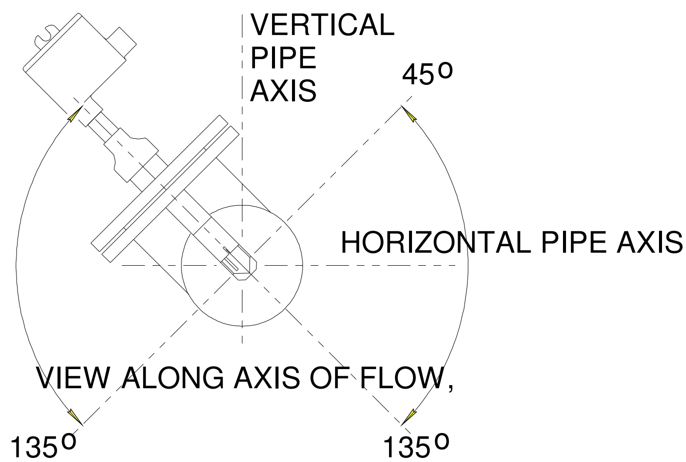


Figure 2-1: Transducer or Retractor Orientation

2.4 PROBE RETRACTOR

Most interface detectors are supplied with the optional probe retractor assembly. This design is intended primarily for pipelines in which mechanical cleaning or "pigging" may occur. The retractor facilitates removal of the probe assembly from the pipeline so that the assembly is not damaged when cleaning occurs.

Retractors are built to meet the specific requirements of each installation with respect to flange rating, pipeline pressure, riser height, full bore valve dimensions, pipe diameter, etc. The retractor is typically set to place the probe assembly 1 3/4" inside the pipeline.

The dimensions of the retractor are shown in the retractor drawing located at the end of this manual. The user should insure that the necessary space for mounting the retractor is available at the installation site. A standard retractor measures about 104 inches from face of flange to connection head when fully retracted. A minimum of 110 inches clearance is recommended.

A bleeder nipple is provided on the lower portion of the retractor pressure housing. This nipple should be fitted with a valve prior to retractor installation. This allows the user to depressurize the pressure housing when the probes are completely retracted through the full-bore valve, once that valve has been closed.

A grease fitting at the rotating handle allows for periodic lubrication of the handle assembly.

When facing the handle from the connection-head side of the retractor (as opposed to the flange side of the retractor), counterclockwise rotation of the handle results in retraction (removal) of the probe assembly from the pipeline. Clockwise rotation extends the probes into the line. The probes can be extended only as far as allowed by the lead screw seal nut. The position of the seal nut is determined at the factory, based on customer-specified extension length.

Some retractor users have found the Model 86 PID will perform well even if the sensor is retracted. Operating in this manner may slow the response time of the Model 86 PID, but does have the advantage that a pig cannot damage the sensor.

2.5 POWER AND SIGNAL WIRING

All wiring is shown schematically on the Field Wiring Diagram located at the back of this manual. Make transducer connections to TB3 prior to making AC power connections.

NOTE: DO NOT SPLICE TRANSDUCER CABLES TO INCREASE OR DECREASE CABLE LENGTH. IF CHANGED, THE INSTRUMENT MAY REQUIRE RECALIBRATION.

Sound velocity transducers, transmitters and cable length are matched. There are specific calibration constants for the instrument included at the back of this manual. Before wiring the transducers, insure that the transmitter and transducer are properly matched by reviewing the Configuration Information sheet in Appendix D, page 44.

If the current outputs (4-20 mA proportional to sound velocity span) are to be used, then they should be wired to TB1 at this time. Resistance of the peripheral equipment must be within the 600 ohm range specified. Improper loading may result in invalid output indication.

Power wiring: Insure that the transmitter power switch is in the "OFF" position.

CAUTION! AC POWER OF 115 OR 230 VOLTS IS USED IN THE OPERATION OF THIS INSTRUMENT. SERIOUS INJURY OR DEATH MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. EXERCISE CARE TO AVOID CONTACT WITH HIGH VOLTAGE CONNECTIONS WHILE INSTALLING AC POWER AND OPERATING EQUIPMENT.

Remove the protective cover from TB2 and proceed with AC wiring in accordance with the Field Wiring Diagram located at the end of this manual. A tag affixed to the chassis mounting plate identifies unit model, serial number and AC power requirement.

CAUTION! INSURE THAT AC POWER SUPPLIED TO THE UNIT MATCHES THE IDENTIFICATION TAG INPUT POWER REQUIREMENT!

After AC power wiring has been connected, replace the protective cover over TB2. Close the transmitter cover until ready to place the unit into service.

2.5.1 CONDUIT

Use of conduit for all cables is highly recommended. If conduit is employed, then signal and power wiring should be run through separate conduit.

If explosion-proofing of conduit runs is required, installation should be performed in full accordance with the specified requirements of the National Electrical Code Articles 501 and 502.

WARNING! THE USER MUST INSURE THAT ALL CODES AND MEASURES NECESSARY TO ISOLATE HAZARDOUS FROM NON-HAZARDOUS LOCATIONS ARE ADHERED TO.

SECTION III OPERATION

3.1 INTRODUCTION

This section describes the various menus used in setup, calibration and operation of the Model 86 PID and the procedures for obtaining startup data. Most of these items may also be accessed remotely, via RS-232 communications link (see Appendix B, Remote Communication, page 35).

3.2 MENUS

The user may access any of six menus from the keypad. These menus may be activated at any time during operation. Access to two of the menus may be denied depending on the "code access" status of the unit, which denies menu entry to unauthorized personnel, unless the correct access code is entered. This feature may be activated or deactivated at the discretion of the user responsible for initial startup.

Either of two menus may be selected from each of the three menu keys. Those menus appearing in blue (HELP, SETUP, DSPLY) are accessed by pressing the appropriate menu key. The red menus (CAL, PARAM, ALARM) are shifted menus; that is, they may be accessed by first pressing the 2ND FUNC key, then the appropriate menu key.

3.3 MOVEMENT AND DATA ENTRY

Each menu is entered at a particular location (menu step). The "down arrow" advances any menu by one step. Conversely, the "up arrow" returns the display to the previous menu step. Pressing the "up arrow" at the first step of any menu takes the user to the last step in the menu sequence. It should also be noted that where a menu step requires data entry, new values are accepted simply by changing the existing value, then pressing the up or down arrows to move to a different menu step.

Entry steps appear in three forms:

1. YES-NO where input of "1" results in a NO choice and "2" results in a YES choice. The present value or selection is displayed.

2. Selection of units, where pressing " · " reveals other choices for a particular menu step (ex.: °C or °F for TEMPERATURE). Pressing the up or down arrow keys enters the displayed selection. Usually, this mode of entry applies to menu steps where the range of choices is internally defined (i.e., a list of choices rather than the entry of numerical data).

3. Numerical data entry. These menu steps include calibration constants, scaling and startup factors. Unlike other entry steps, these menu steps typically display the existing value, and keying in a new value replaces the existing value with the new value. It should be noted that the previous entry may be reinstated by pressing CLEAR if the new value has not been committed by pressing the up or down arrow keys.

3.4 HELP MENU

The HELP menu is invoked by pressing the HELP key. This menu offers a basic description of the operations performed by each menu, and instructions for advancing menu steps and starting and stopping the monitor.

3.5 SETUP MENU

The SETUP menu is accessed by pressing the SETUP key. It contains no specific calibration values; it can be accessed at any time by either keypad or RS-232 and is not subject to code access. Most of the steps in the SETUP menu configure the Model 86 PID for units of measurement, and output scaling. In the following sections, each step is discussed in the sequence in which it appears upon entering the menu. Note that the measurement units have been factory preset for standard hydrocarbon interface detection. Please contact the factory for further assistance if it is desired to use different measurement units.

3.5.1 Output Units

Output units are defined at the opening step of the SETUP menu. To view the unit selections on the lower line of the LCD, press the period key as instructed. When the desired unit appears, press the down key to commit the new unit to memory and move on to the next step. Since the Model 86 PID is capable of detecting interfaces of liquids other than refined hydrocarbons, and can in fact measure the concentration of chemicals in solution, there are many choices other than the standards used by the petroleum industry. The unit choices are indicated below:

OUTPUT UNITS:
"." ➔

°**API**	(PID usage)
SGU	(PID usage)
m/sec	(PID usage)
wt. %	(analyzer usage)
gm/ltr	(analyzer usage)
vol%	(analyzer usage)
U-D	(analyzer usage)
°**Brix**	(analyzer usage)
°**Baume**	(analyzer usage)

Comments Concerning Output Units

Output units are simply labels that are attached to the end of numbers. The actual value displayed does not change when new output units are selected. The value displayed is determined by the constants loaded in the PARAM Menu. For standard hydrocarbon interface detection, the factory preset values are already properly associated with the units, and will be properly updated if a different active recipe is selected in the PARAM Menu. Recipe #1 is compensated meters/second; # 2 is °API and # 3 is SGU (details about recipes are in Section 3.10, page 28).

3.5.2 Measurement Units: Temperature

This step permits the user to select temperature units. Unit options are viewed by pressing the period key. To commit a temperature-measurement unit to memory and advance to the next step, press the down key.

TEMP. UNITS:
"." ➔°C
°F (typ. 86 PID)
°K

Changing Temperature Units

Temperature units must match the units used for the T0 constant. Unlike the output units, temperature units are more than just labels that follow an input or calculated value. The value is passed to the output calculation polynomial (see Section 3.6.1) and having the wrong units would result in erroneous temperature compensation. For standard PID applications the proper selection is °F and should not be changed without consulting with the factory.

3.5.3 Measurement Units: Pressure

This step permits the user to select pressure units. The pressure value is continuously input to the Model 86 PID's output-calculation polynomial. Like temperature units, pressure units are more than labels following an input pressure value. The standard for PID applications is PSIG, and should not be changed without consulting with the factory.

PRESSURE UNITS:
"." ➔ psig (typ. 86 PID)
kPa
kg/sqcm
Bar

3.5.4 Output Scaling: Selecting a range

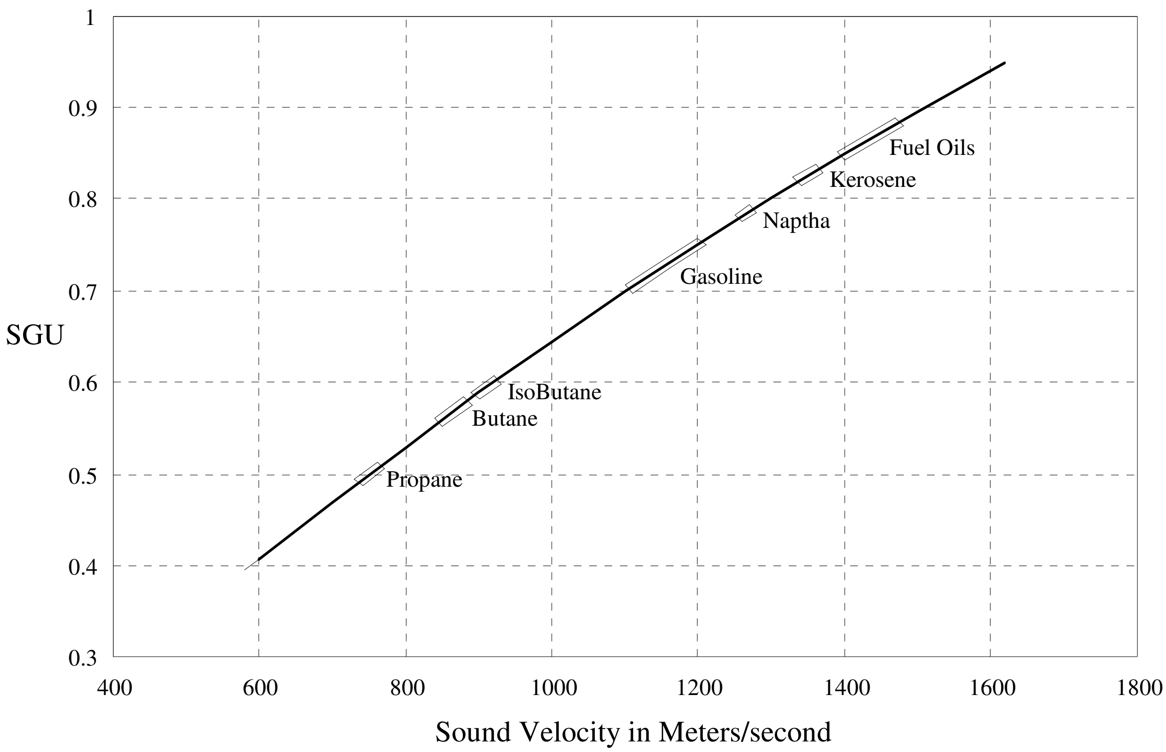
Selection of sound velocity low (4 mA) and high (20 mA) can be established by recording the sound velocity of each product from the DSPLY step SOUND VELOCITY, or determined from the subsequent graph. When sound velocities have been determined for all products, then the range may be established. Say for example the pipeline will contain the following:

Product 1:	SV = 1229 m/s	(regular gasoline brand X)
Product 2:	SV = 1238 m/s	(regular gasoline brand Y)

Product 3: SV = 1186 m/s (premium gasoline)
Product 4: SV = 1424 m/s (Fuel Oil)

For this range of products the appropriate settings for Output #1 would be 4 mA = 1150 m/s and 20 mA = 1450 m/s. This wide range will make it somewhat difficult to observe the close gasoline to gasoline interfaces, therefore it would be appropriate to set Output #2 to Measured Variable, and scale it to 4 mA = 1150, and 20 mA = 1250 m/s.

Figure 3-1, below, offers approximate sound velocity ranges for some classes of hydrocarbons.



3.5.5 Output Scaling: Output 1

Output 1, the 4-20 mA output at terminal block 1, positions 1 and 2, delivers the scaled output in units which are recipe dependent. The first two steps of the SETUP menu allow the user to scale the 4-20 mA output to the desired minimum and maximum values.

Enter the desired low concentration value at 4 mA. Suppose a user wishes to rescale the output for 50 °API to 65 °API; at the first step (4 mA) enters "50", then press down to store the new value ("50") and advance to the next step.

OUTPUT 1: 4 mA
= 50.00 °API

Enter the desired high concentration value at 20 mA. Using the numeric keys, enter "65", then press down to advance to the next step.

OUTPUT 1: 20 mA
= 65.00 °API

The output-scaling steps reflect the units selected in the SETUP menu's earlier steps. Factory-default units appear in the examples given in this manual; depending on user selected recipe; the values and units that appear on the analyzer LCD may be different than those shown in these examples.

Output 1 Scaling: How it Affects UNDER RANGE and OVER RANGE Alarms

The UNDER RANGE alarm setpoint (see ALARM menu, Section 3.9, page 25) can be set no lower than the output 1 value selected for 4 mA, and the OVER RANGE alarm setpoint can be set no higher than the output value selected for 20 mA. The UNDER RANGE and OVER RANGE alarms respond only to output 1. Output 2 can be scaled for the same range of concentration as output 1, but its value will not activate the alarms.

3.5.6 Output Scaling: Output 2

Output 2 is the 4-20 mA output at terminal block 1, positions 3 and 4. If output 2 is set for "measured variable", the Model 86 PID automatically sets its output units identical to output 1, though output 2 may be scaled for a different range. Output of temperature in lieu of "measured variable" is a user option. The opening menu step for output 2 allows the user to select either measured variable (MEAS) or temperature (TEMP) by pressing the "." key:

OUTPUT 2: MEAS
PRESS "." TO CHG

Selecting "Measured Variable"

When MEAS (measured variable) is selected, the Model 86 PID accepts the measurement units associated with the active recipe selected in the PARAM menu, then allows the user to enter low- and high-output values corresponding to 4 mA and 20 mA: Note that the units will be the same as selected for output 1.

OUTPUT 2: 4 mA
= 25.00 °API

OUTPUT 2: 20 mA
= 65.00 °API

Note that the output values shown as an example for output 1 and 2 are typical. Output 1 is scaled to provide good resolution for tight gasoline to gasoline interfaces. Output 2 is scaled over a broader range to include gasolines, diesels and fuel oils.

Selecting Temperature

When TEMP (temperature) is selected, the Model 86 PID output temperature and allows the user to enter low- and high-output values corresponding to 4 mA and 20 mA:

OUTPUT 2: 4 mA
= 5.00 °F

OUTPUT 2: 20 mA
= 185.00 °F

A standard Model 86 PID is calibrated to operate over a 5° to 185°F (-15° to 85°C) temperature range.

3.5.7 Averaging Time

Rapid changes in the pipeline, bubbles in the liquid, or electrical noise can cause small fluctuations in both the displayed and measured variable output. Such fluctuations can be smoothed by employing input averaging. The Model 86 PID includes an algorithm that smoothes the continuous input of sound velocity. The factory-default setting for averaging time is 10.0 seconds. Averaging time may not exceed 30 seconds. Entry of a negative averaging time will cause an error message to appear.

AVERAGING TIME =
1.0 secs.

3.6 DISPLAY MENU

The display menu is entered by pressing the DSPLY key. Continuously updated measured values are displayed in this mode. The values may be monitored via front-panel alpha/numeric liquid crystal display (LCD) during unit operation, and must be recorded during the data-gathering phase of startup. The individual menu displays are as follows:

3.6.1	**OUTPUT 1 = 1233.22 m/s**	**OUTPUT 2 = 54.57 °F**
	OUTPUT 1 = XX.X % OF SPAN	**OUTPUT 2 = X.XX % OF SPAN**

The present value of outputs 1 and 2 as measured and as percent of span are displayed in successive steps.

3.6.2 TEMPERATURE

TEMPERATURE =
60.00 °F

This is a display of process temperature as measured by the resistance temperature director (RTD). Units (°C or °F) are selected in the SETUP menu. The output temperature is dependent upon temperature scaling established in the CAL menu.

3.6.3 SOUND VELOCITY

SOUND VELOCITY =
1350.00 m/s

The present value of sound velocity is displayed in this menu setup. This value is always displayed in meters/second. It is the measured (i.e. uncompensated) value of sound velocity. If recipe #1 has been selected for compensated m/sec output, this value and the output value will have the same units and the distinction must be made when recording data.

3.6.4 ATTENUATION

ATTENUATION =
15.00 %

Attenuation is a relative measure of the amount of signal loss through a liquid. An "ATTENUATION HIGH" alarm activates when the attenuation exceeds 95%.

The attenuation value reflects the amount of gain applied to amplify the receive signal to a threshold level. 100% attenuation should occur only when the transducer cables are disconnected, or the signal from transmitter to transducer is physically interrupted.

3.6.5 PRESSURE

PRESSURE =
600.0 psig

Operating pressure as measured by the pressure transducer is indicated in this display.

3.7 The CALIBRATE (CAL) Menu

The CAL menu is accessed by pressing the 2ND FUNC key, then the CAL key. All Model 86 PIDs are subjected to a factory sound velocity calibration, or "standardization calibration", which insures that each analyzer delivers the same sound velocity under the same concentration and temperature conditions. The standardization calibration should not be confused with the specific application calibration described by the coefficients in the PARAMETERS menu. The CAL menu contains these sound velocity calibration constants, displays the present values of inputs to the Model 86 PID, and includes a series of menu steps that set the communication characteristics of the RS-232 data link.

Both "host lockout" and "code access" features can be activated to deny access to the CAL menu. If host lockout is activated, the calibration and configuration data in the CAL menu can be read via RS-232, but cannot be overwritten. If code access is enabled, the correct access code must be entered before the CAL menu can be accessed by keypad.

3.7.1 CAL Menu Opening Steps

The CAL menu may open with either of two steps, depending upon the status of code access (active or inactive). If code access is active (enabled), the first step of the CAL menu prompts the user to enter a four-digit access code:

ENTER ACCESS
CODE: _____

Mesa Laboratories, Inc. ships all Model 86 PIDs with a "0000" initial access code. If an invalid access code is entered, the following message appears:

INCORRECT
ACCESS CODE.

Pressing the CLEAR key returns the analyzer to the screen shown prior to attempting access to the cal menu.

When the access code is changed from its factory default (0000), the new access code should be recorded. The Configuration Information Sheet in Appendix D includes a section that allows the user to record changes to the access code.

When code access is enabled and the correct access code is entered in the first step, the second step of the CAL menu allows the user to change the access code:

CHANGE ACCESS
CODE TO: 0000

To retain the active access code and move to the next step, press down.

When code access is disabled, the first step of the CAL menu gives the user the option of enabling the feature:

CODE ACCESS?
1=NO, 2=YES: NO

To retain the default setting (code access disabled), press the down key. To enable code access, press "2" as instructed. The status indication at the far right of the second display line changes to "YES" indicating that code access is enabled. The user may proceed into the CAL menu. However, if the CAL menu is exited then reentered, the user must enter the access code as described in the previous section in order to gain entry into the menu. Code access also governs entry into the PARAM menu.

3.7.3 A, B, "Alpha", N and Z Constants

Each of these constants is an important element in the equation used by the Model 86 PID to calculate sound velocity. Sound velocity, in turn, is used to calculate concentration. Before describing these constants, it may be useful to understand how they relate to the measurement of sound velocity.

The Sound Velocity Equation

The Model 86 PID produces an output from three basic inputs, sound velocity, pressure and temperature. Sound velocity, typically expressed in meters per second (m/s), is the distance per unit of time that a sound wave travels through a substance. Sound velocity (c) is calculated by the Model 86 PID through the following equation:

$$C = \frac{A\,(1 + \alpha T)}{(N / F) - (B + ZF) \cdot 10^{-6}}$$

where:

C = sound velocity, meters/sec
A = "A" constant, acoustic path length, meters
α = "alpha", coefficient of thermal expansion in m/m°C
T = temperature, °C
N = N-factor, 3 or 7, sets range
F = frequency, Hertz
B = "B" constant, electronic time delay in microseconds
Z = "Z" constant, frequency dependent delay in usecs/hertz.

Sound waves are transmitted across a fixed distance, called the "acoustic path" of the sound velocity transducer. The Model 86 PID measures the amount of time, or "transit time", that it takes the sound waves to traverse this distance through the process liquid. This time measurement (in the form of a frequency) is so precise that extremely small changes due to the thermal expansion of the transducer are observable. These are compensated for by "Alpha" (α), the coefficient of thermal expansion per unit of temperature.

Standardization Calibration Constants

Mesa Laboratories, Inc. performs a standardization calibration on every Model 86 PID. During this calibration, a series of frequency and temperature data pairs are recorded over a broad temperature range in deionized water and HPLC grade Methanol. The data are regressed to yield the constants "A", "B" and "Z" for a particular sound velocity transducer/cable/transmitter set.

The "A" constant is the acoustic path length, or the distance that an acoustic signal travels through the process liquid. The "B" and "Z" constants are used to calculate the delay time, contributed by cabling between the transducer and transmitter, the time that it takes the acoustic signal to pass through the transducer's acoustic window and other electronic performance delays.

The values of A, B, Z and "alpha" appear in the Configuration Information Sheet in Appendix D. These constants are valid only for the transducer and transmitter pair identified by serial number, at the indicated connecting cable length.

Entering A,B, "Alpha" and "N" and "Z" Constants In the CAL Menu

As noted, all Model 86 PIDs are shipped factory-calibrated. It should not be necessary to enter new values unless the user is calibrating a new transducer/transmitter. The following five steps allow the user to change the values of A, B, "alpha", N and Z:

The A constant must be expressed in meters. The A constant may be entered in decimal notation or in scientific notation. If entered in decimal notation, the Model 86 PID automatically converts the value to scientific notation.

"A" CONSTANT
= 8.00000E-02

B constant values vary significantly with transducer construction configuration and cable length. Note that the B constant is expressed in decimal notation, not scientific notation.

"B" CONSTANT
= 3.000000

"Alpha", the coefficient of thermal expansion for the sound velocity transducer material, is given in m/m/°C units. In some cases, "alpha" is a composite value, including both the coefficient of thermal expansion and other factors to compensate the sound velocity measurement (e.g. changes in the speed of sound through the acoustic window due to temperature). If a composite is used, the value of "alpha" will differ from the documented coefficient of thermal expansion for the material from which the sound velocity transducer is constructed.

SOUND VELOCITY
Alpha =1.130E-05

"Auto" is the standard factory setting for N; some spool designs may be factory-preset at N=3. In the "auto" mode, the Model 86 PID automatically adjusts N as required to maintain an in-range VCO frequency.

SV EQ. "N": AUTO
PRESS "." TO CHG

The Z constant must be expressed in microseconds per hertz. Z constant values are typically very small, on the order of E-05, and may be either positive or negative.

"Z" CONSTANT
= 4.00E-05

3.7.4 Pressure Control Settings

The CAL menu includes two steps that configure the instrument to deal with radical pressure fluctuations (commonly known as pressure hammer). Since the sound velocity and the pressure transducers have slightly different response times, very rapid fluctuations in pressure might not be properly compensated. This can then lead to a false interface detection. It is uncommon that a pipeline be operated in a manner where there is rapid pressure fluctuation at a time when an interface is expected, therefore this problem might not be of concern. If the 86 PID is used in a control loop, it may be desirable to minimize this effect.

The method used to control this problem is as follows: The 86 PID measures the rate of change of pressure (in units of PSIG/minute). If the rate exceeds a user selectable threshold, the outputs are frozen until the pressure disturbance subsides.

In order to measure the rate of change (also called pressure slew) and identify disturbances, it is necessary to delay the output. The factory default is a delay of 15 seconds. The pressure slew rate is then calculated as (PSIG 15 seconds ago minus PSIG now) / (15 seconds).

The delay time may be changed. If the user does not desire to use this feature it may be set to 1 (the minimum value).

DELAY TIME =
15.0 SECS

The next step allows setting the threshold or limit at which an alarm will be activated and the outputs frozen. The factory default is 200 psig/min. If it is not desired to use this feature, the limit should be set to a very high number (such as 1E+30).

PRESS SLEW LIMIT
= 200.0 PSI / MIN

3.7.5 Attenuation and Temperature Inputs

The CAL menu includes several steps that show the input values of certain measured variables to the microprocessor. These values are expressed as percent of full scale, and normally should be viewed in the DISPLAY menu. These steps are intended for diagnostic use by Mesa Laboratories, Inc. technicians.

Attenuation Input

Attenuation is a relative measure of signal loss used for diagnostic purposes.

ATTENUATION
INPUT = 10.00 %

Temperature Input

The temperature input is displayed as % of scale for diagnostic purposes.

TEMPERATURE
INPUT = 23.00 %

3.7.6 Pressure Variable Input and Scaling Steps

The three steps that follow pertain to optional pressure compensation:

Pressure Input

Like the attenuation and temperature input steps previously described, the pressure input step displays the value of pressure input to the microprocessor as percent of full scale for diagnostic purposes:

PRESSURE
INPUT = 0.00 %

Pressure-Scaling Steps

Although the Model 86 PID has no 4-20 mA pressure output, different range pressure transducers can be provided. The Model 86 PID's software requires that the transducer in use be identified:

PRESSURE MINIMUM
=   0.0 psig

PRESSURE MAXIMUM
= 2000.0 psig

3.7.7 Auxiliary Input

Auxiliary input is a rarely used feature. It allows the user to input data from another instrument into the Model 86 PID's output-calculating polynomial. Auxiliary input is usually 0-10 V dc, but may be set-up for 4-20 mA input. Consult with the factory regarding the use of the auxiliary input.

AUXILIARY
INPUT = 0.00 %

3.7.8 Frequency

VCO frequency is displayed at this step; it is sometimes used for diagnostic purposes. Rapid fluctuation may indicate the presence of entrained gas or solids. Frequency is observed and recorded at this step when performing standardization calibration.

FREQUENCY =
51600. Hz

3.7.9 Analog Output Check

Two "hidden" steps allow the operator to calibrate external loads connected to 4-20 mA outputs 1 and 2. By forcing the outputs to known values. These menu steps appear only when the Model 86 PID is in the STOP mode. The analyzer is placed in the STOP mode by pressing the START/STOP key.

Output 1 and 2 Check Procedure

To force output 1, set a calibrated digital multimeter to a range encompassing 4-20 mA, then attach the test leads to TB1-1 (common) and TB1-2(+). Observe the multimeter output. At 0.00% indicated output (4.000 mA), the multimeter should indicate a difference no greater than ±0.002 mA (i.e., 3.998 mA to 4.002 mA). Press the period key "." to increase the analog output by 10.00%. Since a 4-20 mA output has a 16 mA span, each increase of 10% corresponds to 1.60 mA. At 10.00%, the multimeter should indicate 5.600 mA, ±0.002 mA. At 100.00%, the multimeter should indicate 20.000 mA, ±0.002 mA.

To calibrate display devices like loop-powered meters or chart recorders, connect the display device, instead of a multimeter, to the desired output terminals.

This is the format of the analog output calibration steps:

OUTPUT 1= 0.00%
"." TO CHANGE.
(0.00% to 100.00% in 10.00% increments, i.e. 4 to 20 mA in 1.6 mA increments)

Press the down arrow to advance from output 1 to output 2:

OUTPUT 2= 0.00%
"." TO CHANGE.
(0.00% to 100.00% in 10.00% increments)

To return to the START mode, press the START/STOP key, and then press DISPLAY to view the output of the 86 PID.

3.8 CAL (CALIBRATE) MENU COMMUNICATIONS STEPS

The CAL menu includes steps used to establish remote communications via RS-232. This section details the menu steps and options available at each step. The choices selected by the user depend largely upon the characteristics of the remote device. For additional information, refer to Appendix B, Remote Communications, page 35.

3.8.1 HOST LOCKOUT FEATURE

NO HOST LOCKOUT	**HOST LOCKOUT ON**
PRESS "·" TO CHG	**PRESS "·" TO CHG**

The host lockout feature status is toggled by pressing the "·" key. When the host lockout is off (i.e., NO HOST LOCKOUT) data in the 86 PID can be viewed and changed remotely. When the HOST LOCKOUT ON status exists, these values may be viewed only, and cannot be remotely changed.

Note: RS-232 bypasses the ACCESS CODE feature which normally denies to unqualified users access to CAL and PARAM menus. To insure that CAL and PARAM values are not changed remotely, the HOST LOCKOUT ON status is factory-preset.

3.8.2 COMMUNICATIONS CHARACTERISTICS

Sections 3.8.3 through 3.8.6 concern communication characteristic settings. The factory-preset values of these settings are commonly used communications values.

3.8.3 BAUD RATE SELECTION

BAUD RATE: 1200
PRESS "·" TO CHG

This menu step allows the user to select a data transmission rate. 1200 baud is the factory preset rate. Available baud rates are: 50, 75, 100, 110, 150, 200, 300, 600, 1200, 2400, 4800, 9600 and 19200 baud.

3.8.4 CHARACTER LENGTH

CHAR LENGTH: 8
PRESS "·" TO CHG

This menu step establishes the number of data bits per character. The most common setting is 8. Available values include: 5, 6, 7, 8.

3.8.5 STOP BITS

STOP BITS: 2
PRESS "·" TO CHG

3.8.6 PARITY

PARITY DISABLED **PRESS "·" TO CHG**	**PARITY ENABLED** **PRESS "·" TO CHG**

This menu step determines the status of the optional parity check. Parity is factory preset as disabled (no parity). When the parity check is enabled, the following menu step appears:

PARITY: ODD **PRESS "·" TO CHG**	**PARITY: EVEN** **PRESS "·" TO CHG**

When parity checking is selected, the choice of odd or even parity is left to the user. This menu will not appear when the factory configured CAL menu is scrolled through, since parity has been factory preset as disabled.

3.9 ALARM MENU

The alarm menu includes both steps pertaining to the status of certain alarms and definition of under range and over range alarm limits. Some steps report the status of an alarm condition as "YES" or "NO", meaning that the condition that would generate an alarm either does or does not exist. The main difference between status reports and alarm reports is that alarm reports interrupt operation in the DISPLAY mode, include the word "ALARM" and can be cleared (and normal DISPLAY function restored) by pressing the CLEAR key.

3.9.1 ATTENUATION HIGH STATUS

ATTENUATION HIGH
ALARM: YES / NO

This step reports the status of the attenuation. An attenuation high alarm condition exists when attenuation equals or exceeds 95%. As previously noted, attenuation is a relative measure of signal loss.

3.9.2 OUT-OF-LOCK-STATUS

OUT-OF-LOCK
ALARM: YES / NO

This step reports the status of "out-of-lock". An out-of-lock condition occurs when the VCO divide-by 3 or 7 signal is not synchronized with the arrival time of a received signal, or when there is no receive signal.

Usually, an out-of-lock alarm is associated with high attenuation. This is not always the case, however. Excessive electrically-induced "noise" may also cause this condition.

The out-of-lock and attenuation status reports/alarms are useful as troubleshooting tools, and the out-of-lock alarm in particular can also be utilized as an indicator of some process upset conditions (such as entrained gas/flashing or high concentrations of particulate).

3.9.3 UNDER RANGE STATUS

UNDER RANGE
ALARM: YES / NO

Displays whether or not there is currently an under range alarm. There are separate displays for range 1 and range 2.

3.9.4 OVER RANGE STATUS

OVER RANGE
ALARM: YES / NO

Displays whether or not there is currently an over range alarm. There are separate displays for range 1 and range 2.

3.9.5 ALARMS ACTIVATION / DEACTIVATION

ALARMS ACTIVE?
1 = NO 2 = YES: YES/NO

Alarms may be activated or deactivated in this step. In some instances, it may be advantageous to deactivate alarms, since under alarm conditions the alarm report will momentarily interrupt displays in any of the other menus. When the alarm relays are not being used, the user may wish to retain the factory setting, ALARMS ACTIVE: NO (alarms deactivated). It is also recommended that the alarms be deactivated during unit setup.

When alarms are active, an alarm status "YES" will result in the interruption of operation. Normal access to menus may be restored by pressing the CLEAR key.
Note: Regardless of its previous setting, when power to the unit is interrupted, this step is restored to a default setting of ALARMS ACTIVE: NO.

3.9.6 FAIL SAFE MODE SELECTOR

FAILURE OUTPUT =
ZERO; "·" TO CHG 100%

The Model 86 PID includes a feature which drives concentration outputs to zero or to 100% (4.0 mA or 20.0 mA, respectively for current output) when out-of-lock or attenuation high alarm conditions exist. This feature is a useful means of detecting a process abnormality when the alarm relays are not being utilized.

3.9.7 UNDER RANGE / OVER RANGE ALARM LIMITS

UNDER RANGE 1 **= 0.0% OF SPAN**	**UNDER RANGE 2** **= 0.0% OF SPAN**
OVER RANGE 1 **= 100% OF SPAN**	**OVER RANGE 2** **= 100% OF SPAN**

The under range and over range alarm limits for both ranges are established by these four consecutive steps. These alarms are activated by the value of the output in relation to the minimum and maximum output scaling values established by these four consecutive steps. These alarms are activated by the value of the output in relation to the minimum and maximum output scaling values established in the SETUP menu. Example:

SETUP MENU	OUTPUT 1 MINIMUM (4 mA) = 1000 m/s
	OUTPUT 1 MAXIMUM (20 mA) = 1200 m/s
	OUTPUT 2 MINIMUM (4 mA) = 900 m/s
	OUTPUT 2 MAXIMUM (20 mA) = 1400 m/s

ALARM MENU UNDER RANGE 1 = 10 % OF SPAN
OVER RANGE 1 = 90 % OF SPAN

UNDER RANGE 2 = 20 % OF SPAN
OVER RANGE 2 = 80 % OF SPAN

The span is defined as the difference between output maximum and minimum. In this instance, the spans correspond to 200 and 500 m/s, respectively. The under and over range settings then establish 1020 and 1180 m/s as output 1 alarm limits, and 1000 and 1300 m/s as output 2 alarm limits. When the actual sound velocity in either range falls outside of the established range, then depending on the reading, an over range or under range report is issued. This report may be observed via LCD or remotely, via RS-232.
IMPORTANT: The high/low setpoint relay operates only in conjunction with the alarm limits established for OUTPUT 1. Thus, if the alarm relay is to be utilized, output 1 should be scaled for the appropriate interface.

3.10 The PARAMETERS Menu

The PARAMETERS (PARAM) menu is accessed by pressing the 2ND FUNC key, then PARAM key. The opening step of the PARAM menu may prompt the user to enter an access code, if the access code feature has been enabled in the CAL menu. If the access code feature has been enabled, the sequence of opening steps is identical to the those described at the beginning of Section 3.7, CAL menu (page 17).

What Are PARAMETERS?

Model 86 PID "parameters" are the coefficients of a polynomial from which output is calculated. A recipe consists of numbers that describe a single, specific relationship between sound velocity and engineering units. The Model 86 PID can store up to sixteen different recipes. The recipes can describe different concentration ranges of the same application, or entirely different applications.

Factory default recipes are preprogrammed into the 86 PID. Recipe #1 is for compensated meters/second output; #2 is °API output and #3 is SGU (specific gravity units) output.

3.10.1 The Model 86 PID Polynomial

A polynomial is a mathematical equation containing two or more terms. The Model 86 PID polynomial contains fourteen terms which deliver accurate pressure and temperature compensation. Unit conversion is also performed by the polynomial, even when the relationship between sound velocity, temperature and pressure and the desired measured variable is nonlinear.

3.10.2 Recipe Number

The opening step of the PARAM menu displays the active recipe and allows the user the option of selecting a new recipe:

RECALL RECIPE
NO. (1-16): 1

When Mesa Laboratories, Inc. develops single-application data based on customer specifications, the application data are always stored in recipe 1. The Start-Up Information Sheet in Appendix D (page 46) contains all recipe data stored in your Model 86 PID. Recipes are stored in nonvolatile RAM; in the event of primary (AC) power loss, no application or setup data will be lost. A recipe contains:

The reference temperature T0, described below.
The reference sound velocity Cmax, described below.
The constants K0 - K13, described in the following text.

Recipes also contain the minimum and maximum scaling values for outputs 1 and 2, as well as the units of measure. These items are selected in the SETUP menu. If an analyzer has been provided with multiple recipes that have different output scaling values or concentration units, the activation of a new recipe will cause the existing scaling values/concentration units to be superseded by those contained in the new recipe. Methods for adjusting the recipe are discussed in Appendix A, Process Fine Tuning, page 33.

3.10.3 Reference Temperature T_0

T_0 is the median, or middle, temperature of the start-up data set.

REF. TEMP. To °F
= 60.00

The application coefficients of a recipe have been generated using one particular temperature. Changing Ref Temp will require changing all the following parameters.

3.10.4 Reference Sound Velocity Cmax

The reference sound velocity Cmax is a constant which is derived from the relationship between the concentration and the velocity. Over broad ranges this relationship is many times parabolic in nature. Cmax is the value of the apex of this parabola. It must have a value greater than any expected measured sound velocity, and is the upper limit of sound velocity for the purpose of correlation to desired units.

One term of the Model 86 PID polynomial involves the square root of (Cmax - C). If the measured sound velocity "C" were greater than Cmax, a square root of a negative number error would result.

REF. SV Cmax
= 1700.00

3.10.5 Application Coefficients

As stated before, the Model 86 PID polynomial includes fourteen terms. Associated with each term is a coefficient resulting from the regression of test data acquired from lab or process testing. Regression coefficients may be obtained by sending data consisting of desired variable, sound velocity, temperature and pressure to Mesa Laboratories, Inc. Those wishing to perform their own regressions should contact the factory for assistance.

A sequence of fourteen menu steps identify the coefficient on the first line of the LCD and the value of the coefficient on the second line of the LCD:

CONC. EQ. "K0" =
8.550000E+02

Note that the K0 term is an offset constant. Should it be necessary to standardize or offset the output of the Model 86 PID versus some other instrument or lab assay, it may be done by changing the value of K0. Increasing the current value by 1 would increase the output value by exactly 1, decreasing its current value by 0.5 would decrease the output by exactly 0.5

Press the down key to advance to the next menu step.

Comments Concerning Coefficients: Scientific Notation and Zero Coefficients

As you press the down key to advance through the fourteen coefficients, you will see that they are each expressed in scientific notation. Each coefficient has six decimal places. Users can enter coefficients in decimal notation; they will be automatically converted to scientific notation.

These menu steps are like any other steps requiring data input; if you make a mistake while entering a new value, press the CLEAR key to restore the original value. If you exit the step, whatever has been entered is committed to Model 86 PID RAM.

SECTION IV
MAINTENANCE

4.1 INTRODUCTION

This section includes service-related information and preventive maintenance recommendations.

The Model 86 PID transmitter does not include moving parts, thus routine maintenance is unnecessary. It does contain sensitive components in both the transmitter and the transducers, thus, the unit as a whole should be handled with care.

If the Model 86 PID was provided with a probe retractor occasional lubrication is recommended (See Section 4.4, Item 4).

If a problem should occur with the Model 86 PID, please contact the factory.

4.2 REPORTING PROBLEMS

Mesa Laboratories, Inc. Nusonics Division should be contacted by telephone or FAX prior to returning a unit for repair or replacement under warranty or otherwise.

The following information will be required:

- Nusonics project number and unit serial number from the special information sheet at the back of this manual.

- Date of failure and a full description of symptoms of failure. This information should be provided to the Mesa Laboratories, Inc. Nusonics Division Field Service Department, which will recommend the appropriate course of action.

SHIPPING ADDRESS:

Mesa Laboratories, Inc.
12100 W. 6th Avenue
Lakewood CO 80228

Tel: (800) 628-8393
(303) 987-8000
Fax: (303) 987-8989

E-mail: nusonicsservice@mesalabs.com

4.3 SHIPPING INSTRUCTIONS

The unit should be packed in its original container (if available) when returning the unit to the factory. If the original container is not available, or if only parts of the unit are to be returned, pack the items with 3 or more inches of shock-absorbing material on all sides. Include Nusonics project number, unit serial number and description of problem or failure with the unit or part.

It is sometimes acceptable to return only the electronic printed circuit boards and the transducers. This can minimize transportation costs. These details should be discussed with the NuSonics service department prior to the return of the equipment.

Ship the carton or package prepaid to the shipping address listed above, via the most suitable method.

4.4 PREVENTIVE MAINTENANCE

Since the interface detector transmitter and sensors have no moving parts, lubrication is unnecessary. During storage and use of the unit, a few measures should be taken to insure trouble-free operation:

1. Keep the area inside the transmitter enclosure free of moisture, dust or dirt, and corrosive gas. Keep the enclosure tightly closed unless access to the keypad, wiring blocks or PCBs is required. All access holes should be plugged.

2. The unit's electronic components are designed to operate to ambient temperatures of 50°C (122°F). Direct sunlight may cause an excessive buildup of heat inside the enclosure and subsequent component failure. If necessary, install a sunshield to prevent exposure to temperature in excess of the rated maximum.

3. If the transmitter has been subjected to unusual conditions (dust, moisture, etc.), dusting and drying the interior using forced dry air under medium pressure is recommended.

4. If the Model 86 PID was supplied with a probe retractor the retractor should be lubricated occasionally. Anti-sieze grease should be applied to the threads to protect them from corrosion and facilitate operation. This should be done as needed each time the retractor is used, or once a year. A zerk fitting is located on the handle to lubricate internal items of the retractor and standard chassis grease should be applied to this fitting once a year.

APPENDIX A
PROCESS FINE TUNING

A-1 When is Process Fine Tuning Appropriate:

The purpose of Process Fine Tuning is to improve the absolute accuracy of the Model 86 PID. The Model 86 PID measures the speed of sound through the liquid in the pipeline. Some users prefer to correlate this sound velocity to units of density with which they are more familiar. Variations in formulation of the product in the pipeline can cause the density correlation to differ from the factory standard. While these variations do not affect the sensitivity or ability of the 86 PID to identify an interface, the Model 86 PID can be adjusted to provide better density accuracy.

The most important determination to be made is output repeatability. Collecting data including the output, sound velocity, temperature and pressure, and comparing the output to independently measured or assayed samples allows for the determination of repeatable performance. If the output is repeatable and the magnitude of error relatively small then Process Fine Tuning may be appropriate. The final two factors are whether an accurate independent assay of the process can be made, and whether samples can be drawn from the process which are identical to what is being measured by the Model 86 PID. The assay accuracy must be more precise than the accuracy desired from the Model 86 PID.

A-2 Procedure:

Gather 4 to 6 data points consisting of the 86SCM reading and an assay or reference value. Collect two data points at similar temperatures and sound velocities but at different times in order to evaluate the repeatability of the instrument. If desired, data can be forwarded or faxed to the Mesa Laboratories, Inc. Nusonics Division Lab for analysis.

Repeatability = ABS ((Out 1 - Out 2) - (Assay 1 - Assay 2))

ABS is the absolute value, and Out is the Model 86 PID output. For example, two samples taken at different times are assayed at 61.6 °API and 53.4 °API. The Model 86 PID reported 59.4 °API and 51.4 °API respectively. Therefore, repeatability = 0.2 °API. It is recommended that the process of evaluating repeatability be performed several times.

Find the Average Offset. Offset equals assay value minus output value. Using the available data, calculate the average.

Determine if the offset value is relatively constant or if it changes with respect to sound velocity or temperature. The offset may be considered constant if any changes due to temperature or sound velocity are smaller than the desired accuracy.

If the offset is a constant, correct the recipe:

The recipe is a mathematical formula (polynomial) which converts the values of sound velocity and temperature into the desired output. The polynomial has the general form:

$$Output = K0 + f(K1\text{-}K13)$$

If the value of K0, accessible in the Recipe Editor Menu, is increased by 1.00, the displayed output will increase by exactly 1.00.

1. Record the current value of K0.
2. Subtract the average offset from K0.
3. Enter this new value as K0 in the Model 86 PID.
4. Record the new value of K0.

If the offset is not constant over the process concentration and temperature ranges, the required mathematical manipulations become much more difficult. It is recommended data be forwarded to Mesa Laboratories, Inc. For the algebra and computer proficient user, the expanded form of the polynomial to be corrected is:

$$Output = K0 + K1*(Cmax-C) + K4*(T-T_0) + f(K2,K3,K5\text{-}K13, Cmax, T_0)$$

K0, K1, K4, Cmax and T0 are Recipe Coefficients. C is the measured sound Velocity, T is the measured temperature.

Without altering the values of Cmax or T_0, calculate the best fit error expression that fits the following:

$$Error = k0 + k1*(Cmax-C) + k4(T-T_0)$$

This calculation is best done via computer software with multiple linear regression capabilities. Since the desired output is the current output less the error, subtract the error equation from the current equation, combine terms and calculate the new coefficients. Be sure to keep a record of all changes made.

Appendix B: Model 86 PID RS-232 Communications Syntax

The user can communicate with the Model 86 PID from a remote terminal or from a computer via RS-232. This appendix describes communications syntax. Setup os serial communications parameters (Baud rate, Parity, Data and Stop Bits) is described previously on page 24. The factory default is: Baud rate 1200, No Parity, 8 Data Bits, 2 Stop Bits.

Model 86 PID communication syntax is in standard ASCII characters, and takes two forms:

"Read" Syntax:

/ccR<cr>

/ represents the forward-slash key
cc is a two-digit item code for the item or variable that the user wants to access (listed below).
R is the upper-case character R
<cr> is a carriage return, or line feed, or both (ASCII codes 13 and 10, respectively)

The Model 86 PID returns data in the format *ddd...<string>

The * symbol precedes the value returned and ddd... represents the value. Values that have associated units are followed by a string of characters identifying those units. Units of temperature (°C or °F) are one such example, where the unit selected immediately follows the returned value of temperature.

"Send" (Write-to) Syntax:

This sends a string to the designated location, replacing the previous contents.

/ccS <cr>
*ddd....<cr>

/ represents the forward-slash key
cc is a two-digit item code for the item or variable that the user wants to access (listed below).
S is the upper-case character S

<cr> is a carriage return or line feed
* is the asterisk character
ddd... represents the new value which the user wishes to enter

The following operating values may be read:

Code	Description
00	Status string #1 (described below)
01	Status string #2 (described below)

02 Frequency
05 Sound velocity
06 Temperature
08 Pressure
09 Attenuation
10 Measured Variable
17 Auxiliary input (0-100%)

Codes 18-60 apply to menu items which have user-input values. They can be both read and written to, unless the user-lockout feature is "ON", in which case the values are read-only.

18 T0 (Median temperature)
19 Cmax (maximum process sound velocity)
20 Smoothing constant
21 Active recipe number (1-16)
22 Output 1: 4 mA (concentration minimum)
23 Output 2: 4 mA (concentration minimum)
24 Output 1: 20 mA (concentration maximum)
25 Output 2: 20 mA (concentration maximum)
26 Under range alarm limit
28 Over range alarm limit
30 PARAM menu "K0"
31 PARAM menu "K1"
32 PARAM menu "K2"
33 PARAM menu "K3"
34 PARAM menu "K4"
35 PARAM menu "K5"
36 PARAM menu "K6"
37 PARAM menu "K9"
38 PARAM menu "K10"
39 PARAM menu "K12"
40 PARAM menu "K8"
41 PARAM menu "K7"
42 PARAM menu "K11"
43 PARAM menu "K13"
44 Temperature Eq. term KT0
46 Temperature Eq. term KT1
48 Pressure input minimum
49 Pressure input maximum
50 Sound velocity equation "A"
52 Sound velocity equation "B"
54 Sound velocity equation "Alpha"
56 Sound velocity equation "N"

58 Sound velocity equation "Z"
60 Temperature Eq. term KT2

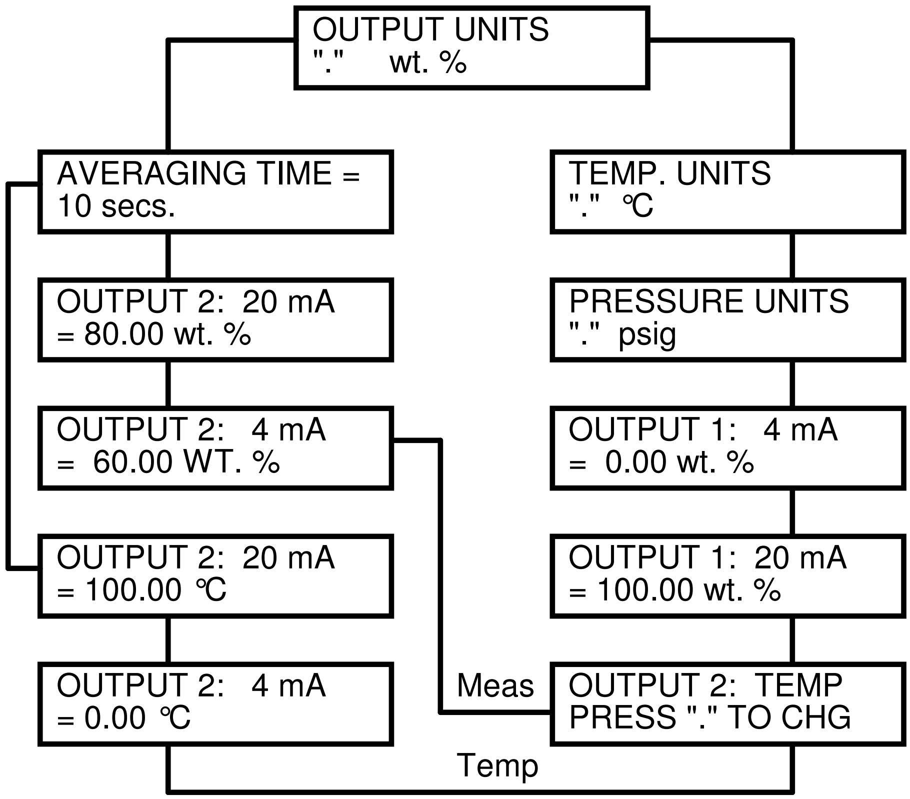
Caution: The reader will note that not all codes are defined. Some codes are reseved for the internal functions of the 86 PID. Writting to these locations may cause operational errors.

The Model 86 PID RS-232 functions support full access to the instrument. It is possible to read or write to the unused recipes, obtain diagnostic information or error codes, etc. These functions are generally used only for diagnostic purposes by factory personnel. Please contact the factory if further information in desired on this subject.

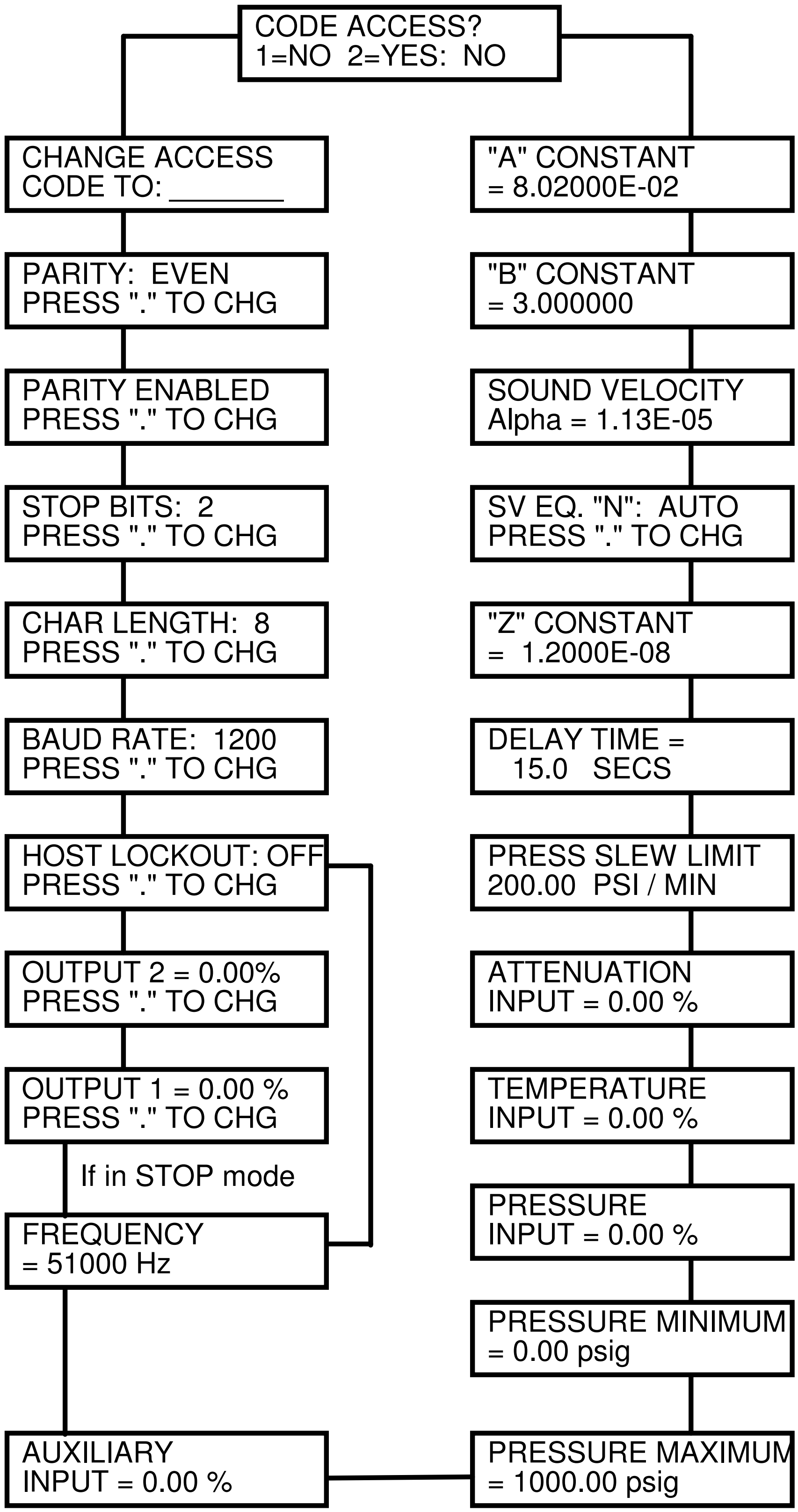
Appendix C: Model 86 PID Menu Flowchart

Use the down arrow to move clockwise through the menus.

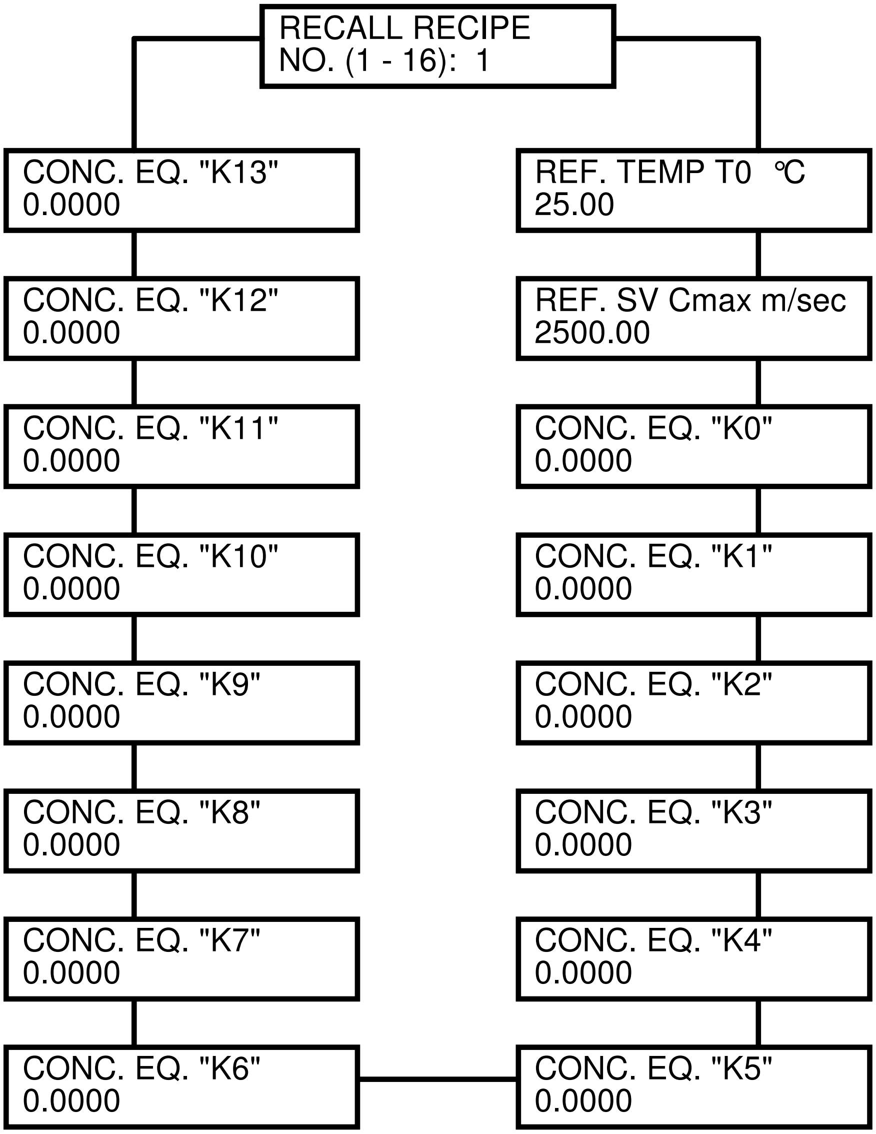
SETUP Menu



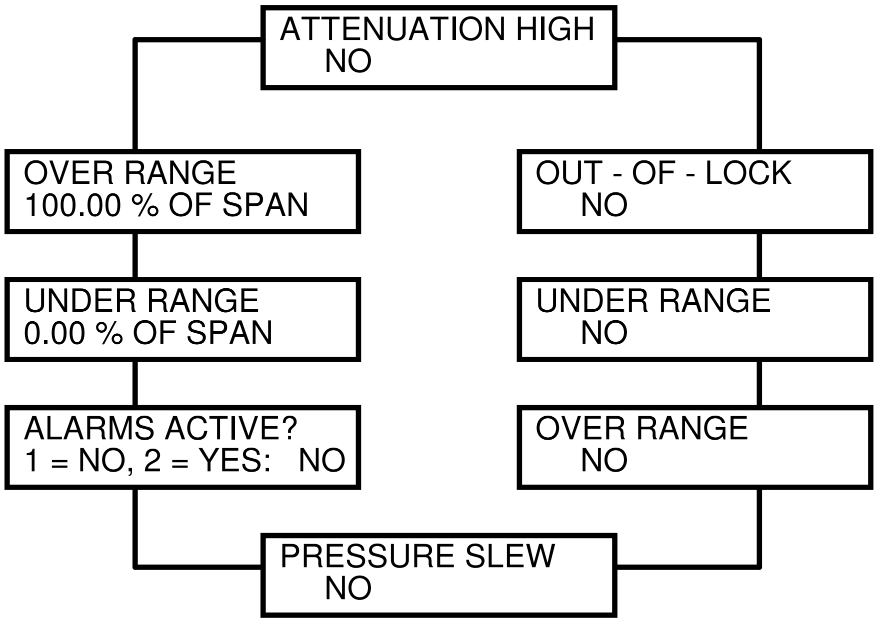
CAL Menu:


CODE ACCESS?
1=NO 2=YES: NO
CHANGE ACCESS
CODE TO: ________
PARITY: EVEN
PRESS "." TO CHG
PARITY ENABLED
PRESS "." TO CHG
STOP BITS: 2
PRESS "." TO CHG
CHAR LENGTH: 8
PRESS "." TO CHG
BAUD RATE: 1200
PRESS "." TO CHG
HOST LOCKOUT: OFF
PRESS "." TO CHG
OUTPUT 2 = 0.00%
PRESS "." TO CHG
OUTPUT 1 = 0.00 %
PRESS "." TO CHG
If in STOP mode
FREQUENCY
= 51000 Hz
AUXILIARY
INPUT = 0.00 %
"A" CONSTANT
= 8.02000E-02
"B" CONSTANT
= 3.000000
SOUND VELOCITY
Alpha = 1.13E-05
SV EQ. "N": AUTO
PRESS "." TO CHG
"Z" CONSTANT
= 1.2000E-08
DELAY TIME =
15.0 SECS
PRESS SLEW LIMIT
200.00 PSI / MIN
ATTENUATION
INPUT = 0.00 %
TEMPERATURE
INPUT = 0.00 %
PRESSURE
INPUT = 0.00 %
PRESSURE MINIMUM
= 0.00 psig
PRESSURE MAXIMUM
= 1000.00 psig

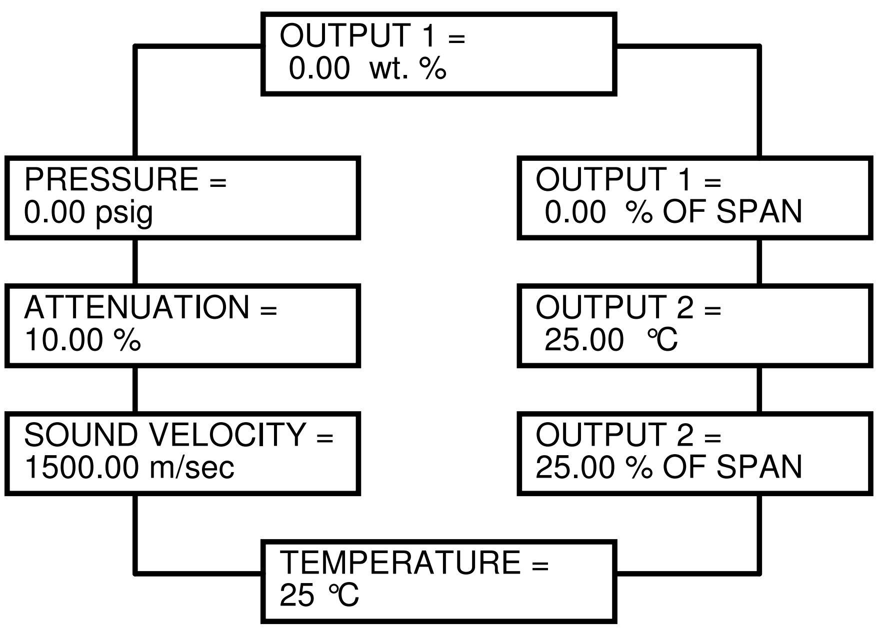
PARAM Menu:


RECALL RECIPE
NO. (1 - 16): 1
REF. TEMP T0 ℃
25.00
REF. SV Cmax m/sec
2500.00
CONC. EQ. "K0"
0.0000
CONC. EQ. "K1"
0.0000
CONC. EQ. "K2"
0.0000
CONC. EQ. "K3"
0.0000
CONC. EQ. "K4"
0.0000
CONC. EQ. "K5"
0.0000
CONC. EQ. "K6"
0.0000
CONC. EQ. "K7"
0.0000
CONC. EQ. "K8"
0.0000
CONC. EQ. "K9"
0.0000
CONC. EQ. "K10"
0.0000
CONC. EQ. "K11"
0.0000
CONC. EQ. "K12"
0.0000
CONC. EQ. "K13"
0.0000

ALARM Menu:



DSPLY (Display) Menu:



Appendix D

Specifications
Configuration Information Sheet
Start-Up Information Sheet

Specifications: Model 86 PID

Power Requirements:

115V ac (±10%)
230V ac (±10%)
Frequency: 50 to 60 Hz

Transmitter Power Consumption:

Standard:	35 watts
With heater:	200 watts @ 115V ac or 250 watts @ 230 V ac

Output Signals:

Concentration:	4-20 mA (Isolated) into 600 ohms max.	
Temperature:	4-20 mA (Isolated) into 600 ohms max.	
Data Link:	RS-232 (RS-485 optional)	
Fault Indication:	Form-C relay	1.5A @ 115V ac or 1.0A @ 230V ac
High Alarm:	Form-C relay	1.5A @ 115V ac or 1.0A @ 230V ac
Low Alarm:	Form-C relay	1.5A @ 115V ac or 1.0A @ 230V ac

Temperature Range:

-15°C to 85°C standard
Other 100°C spans optional (ex.: 30°-130°C, 0°-100°C, etc.)

Sound Velocity Range:

500-2500 m/s

Enclosure Dimensions and Total Weight:

NEMA 4X:	15.3" (H) x 13.3" (W) x 8.3" (D) @ 20 lbs. (9.1 kg.)
NEMA 7:	21.9" (H) x 15.9" (W) x 10.8" (D) @ 114 lbs. (51.7 kg.)

Operating Temperature Range:

Transmitter:	0° to + 50°C (32° to 122°F) standard
	- 40° to + 50°C (- 40° to 122°F) with optional heater
Transducers:	- 40° to +150°C (- 40° to 302°F) standard
	-200° to +400°C (-328° to 752°F) optional

Display:

Liquid Crystal (LCD), 2-line x 16 character

Wetted Materials:

Standard: 316 stainless steel standard, others optional

Accuracy:

As percent of the measured variable, accuracy depends on the characteristics of the measured substance. The repeatability is better than ±0.0001 SGU. For the measured variables the accuracies are:

Sound velocity:	±0.10 m/s
Temperature:	±0.10 °C
Pressure	± 1 % Full Scale

Configuration Information

Date: ____________________

Model 86 PID Serial No.: ________________
Factory Proj. No.: ____________________
Customer Name: ________________________________
Customer Order No.: ________________________________

Transmitter Options:

Enclosure type:

NEMA 4X	[ ]
NEMA 7 w/o window	[ ]
NEMA 7 w/window	[ ]
NEMA 7 w/window, & external controls	[ ]
Air purge	[ ]
Heater/thermostat	[ ]

Temperature Range: __________________________ °C
Pressure Range: __________________________ psig (optional)
Cable Length: __________________________ feet

Mounting Configuration:

Flange Mount [ ]

Flange size: ____________________
Flange rating (ANSI): ____________________
Material: ____________________

Retractor [ ]

Material: ____________________

Other [ ]

Description:____

____

____

Access Code Log:

Use this log to document changes to the Model 86 PIDs 4-digit access code.

0 0 0 0 Factory Default

New Access Code	Date	Changed By
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	
	/ /	

Start-Up Information

Date: ____________________________________
Model 86 PID Serial No.: ____________________
Factory Proj. No.: ________________________
Customer Name: ____
Customer Order No.: ____

Transducer(s) Serial Number:____________

"A" Constant: ____________ meter
"B" Constant: ____________ microseconds
"Alpha": ____________ m/°C
"Z": ____________ usecs/hz

Application Data (per Customer Specifications):

RECIPE #1:	Sound Velocity, compensated to 60 °F and 0 PSIG
Units:	m/sec
Range:	All refined hydrocarbon liquids
Temperature Units:	° F
Temperature Range:	________________________ (Same for Recipes 1-3)
Pressure Units:	PSIG
Pressure Range:	________________________ (Same for Recipes 1-3)

Ref Temp T0	70
Ref SV Cmax	1800
K0	8668.97
K1	-7.798963E+00
K2	1.225020E+03
K3	-3.885545E+03
K4	7.910090E+00
K5	-4.834484E-03
K6	1.361156E-02
K7	-5.575229E-01
K8	-1.798845E-06
K9	-1.475008E-04
K10	0.00
K11	0.00
K12	1.81162E-06
K13	-7.310091E-05

RECIPE #2:	°API, compensated to 60 °F and 0 PSIG
Units:	°API
Range:	All refined hydrocarbon liquids (20 to 80 °API typ.)
Temperature Units:	°F
Pressure Units:	PSIG

Ref. Temp T0	80
Ref. SV Cmax	1700
K0	-3.453097E+03
K1	4.923756E+00
K2	-7.333906E+02
K3	2.197227E+03
K4	-4.098734E+00
K5	-2.112771E-03
K6	-1.161025E-02
K7	4.267398E-01
K8	9.702210E-06
K9	-1.404669E-02
K10	0.000000E+00
K11	0.000000E+00
K12	0.000000E+00
K13	4.272577E-05

RECIPE #3:	SGU, compensated to 60 °F and 0 PSIG
Units:	SGU
Range:	All refined hydrocarbon liquids (0.6 to 1.1 SGU typ.)
Temperature Units:	°F
Pressure Units:	PSIG

Ref. Temp T0	80
Ref. SV Cmax	1700
K0	1.537825E+01
K1	-1.953783E-02
K2	2.969064E+00
K3	-8.972739E+00
K4	1.933473E-02
K5	1.116312E-05
K6	5.007261E-05
K7	-1.917560E-03
K8	-4.201772E-08
K9	4.731415E-05
K10	0.000000E+00
K11	0.000000E+00
K12	0.000000E+00
K13	-1.547669E-07

Custom Application : ____
Units: ___________________
Range: ___________________

T0	__________	° ______
Cmax	__________	m/sec
K0	___.________________	E______
K1	___.________________	E______
K2	___.________________	E______
K3	___.________________	E______
K4	___.________________	E______
K5	___.________________	E______
K6	___.________________	E______
K7	___.________________	E______
K8	___.________________	E______
K9	___.________________	E______
K10	___.________________	E______
K11	___.________________	E______
K12	___.________________	E______
K13	___.________________	E______

Comments:____

Spare Parts Provided: ____