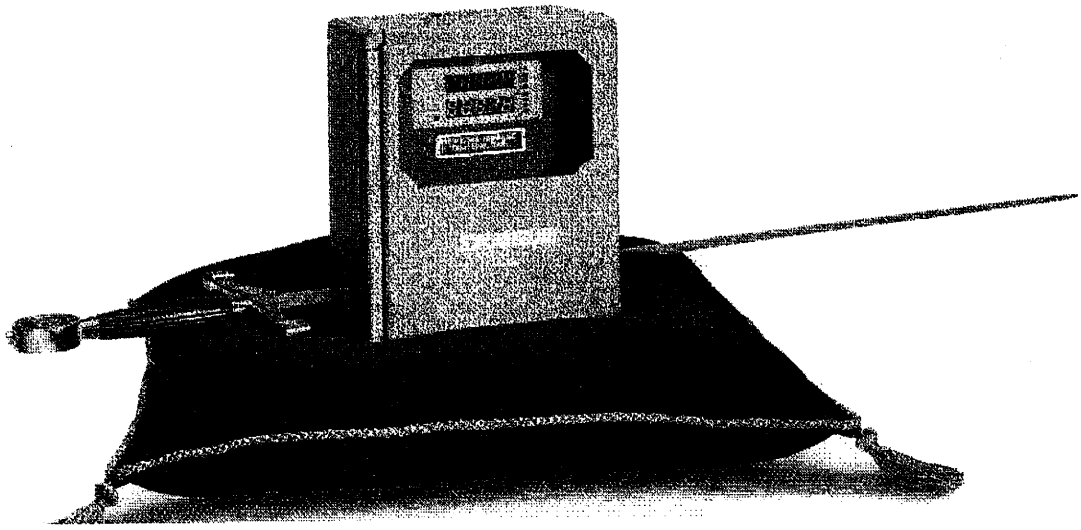
INSTRUCTION MANUAL

Excalibur 7000
Level Controller



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SECTION I – DESCRIPTION

1.1 GENERAL

The **Excalibur 7000** Level Controller is a microprocessor based, advanced technology, level measurement system with various control options available. The microprocessor technology when coupled with the patented Pulse Frequency Modulation (PFM) measurement transmission scheme allows for an extremely user friendly system that is easy to setup, calibrate and operate.

The basic unit consists of a wall mounted controller and a probe mounted transmitter that can be separated in distance by up to a mile, but interconnected with common two wire cabling. The basic controller is housed in a NEMA 4/4X non-metallic enclosure. The transmitter is housed in a rain-tight enclosure. Various enclosure options are available to match the system to the application's requirements

The controller is equipped with various displays and controls to facilitate the operation of the instrument:

- **Process Variable Display** -- a five digit, red, LED display. Typically used to display the measurement.

- **Setpoint Display** -- similar to the process variable display, except green. Typically used to display the control setpoint when PID control is active or the analog output when the PID is in manual. Can be used to display other variables when the PID control option is not present.

- **Alpha-numeric Display** -- a two line by 20 character vacuum fluorescent display (VFD) that is user configurable as to the measured data displayed during normal operations.

  When in the SETUP or CALIBRATION modes this display is used to prompt the user while reviewing and/or making entries.

- **Status LED's** -- a set of eight discrete LED's that indicate the current controller status.

- **Alarm LED's** -- a set of eight discrete LED's that indicate the current status of the user selectable alarms.

- **Keypad** -- a 20 key array consisting of a 12 key numeric section and two sections of four function keys each.

1.2 OPTIONS

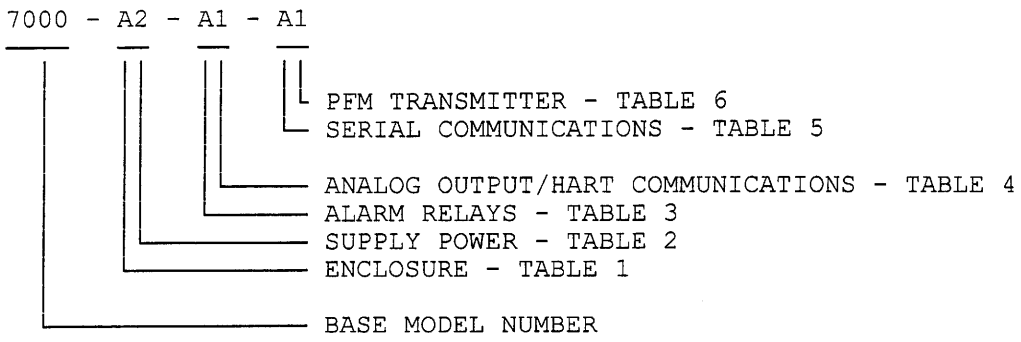
There are several options available for the **Excalibur 7000**. There are optional enclosures, power supply voltages, alarm relays, analog outputs and serial communications features as well as a firmware PID control package. These options are detailed in the following section, MODEL IDENTIFICATION.

It should be noted that in some cases one option is not available without another. In the case of the PID control firmware one of the analog output options must be installed for the option to function properly. In order to have the HART communications protocol you must also have the analog output option.

In certain other cases options are mutually exclusive. That is to say that they can not be installed at the same time. In the case of the alarm relays either the dual or quad option may be installed, but not both. If HART communications are selected then the serial communications options (RS-232/422/485) can not be installed.

1.3 MODEL IDENTIFICATION

Models should be identified in accordance with the designations and descriptions shown in the following tables. dashes are used in the model number only in the spaces indicated below.



Base Model Number

MODEL NUMBER	DESCRIPTION
7000	EXCALIBUR 7000, MICROPROCESSOR BASED LEVEL CONTROL SYSTEM. CONSISTING OF A WALL MOUNTED CONTROLLER AND A FIELD MOUNTED PFM TRANSMITTER.

Table 1 -- Controller Enclosure

DESIGNATION	DESCRIPTION
A	NEMA-4/4X, NON-METALLIC
B	NEMA-4/4X, STAINLESS STEEL (LATER)
C	EXPLOSION-PROOF W/O WINDOW (LATER)
D	EXPLOSION-PROOF W/WINDOW (LATER)

Table 2 -- Supply Power

DESIGNATION	DESCRIPTION
1	18 - 30 VDC (LATER)
2	120/240 VAC $\pm$10%, 50/60 HZ

Table 3 -- Alarm Relays

DESIGNATION	DESCRIPTION
A	NONE
B	TWO (2) SPDT, 10 AMP, RELAYS (See Note 1)
C	FOUR (4) SPDT, 10 AMP, RELAYS (See Note 1)

Note 1 -- Only one relay option can be installed in a given instrument.

Table 4 – Analog Output

DESIGNATION	DESCRIPTION
1	NONE
2	ISOLATED 4-20 mADC
3	ISOLATED 4-20 mADC W/PID CONTROL
4	ISOLATED 4-20 mADC W/HART PROTOCOL COMMUNICATIONS (See Note 2)
5	ISOLATED 4-20 mADC W/HART AND PID CONTROL (See Note 2)

Note 2 – Not available with Designation B or C in Table 5 below.

Table 5 -- Serial Communications

DESIGNATION	DESCRIPTION
A	NONE
B	MODBUS PROTOCOL W/RS-485 USER TERMINAL STRIP (SEE NOTES 3 & 4)
C	MODBUS PROTOCOL W/RS-232 USER TERMINAL STRIP (SEE NOTE 3 & 4)

Note 3 – Not available with Designations 4 & 5 in Table 4 above.
Note 4 -- Designations B & C are identical except for the user terminal strip supplied.

Table 6 -- PFM Transmitter

DESIGNATION	DESCRIPTION
1	STANDARD, PROBE MOUNTED, NEMA 4
2	STANDARD, PROBE MOUNTED, NEMA 4X
3	STANDARD, REMOTE MOUNTED, NEMA 4 (See Note 5)
4	STANDARD, REMOTE MOUNTED, NEMA 4X (See Note 5)
5	NONE, CONTROLLER ONLY – NO TRANSMITTER
6	ANTI-COATING, PROBE MOUNTED, NEMA 4
7	ANTI-COATING, PROBE MOUNTED, NEMA 4X
8	ANTI-COATING, REMOTE MOUNTED, NEMA 4 (See Note 5)
9	ANTI-COATING, REMOTE MOUNTED, NEMA 4X (See Note 5)

Note 5 -- Maximum distance between transmitter and probe is 15 feet.

SECTION II -- SPECIFICATIONS

2.1 ELECTRICAL/ELECTRONIC

Supply Voltage ..... 120/240 VAC ±10%, 50/60 Hz switch selectable, standard

Supply Power: ..... 20 VA (Max.)

Measurement Range(s):

Standard PFM Transmitter ..... 0 to 6,000 pF

Anti-Coating PFM Transmitter 0 to 6,000 pf in 5 Ranges
(0 - 200, 0 - 500, 0 -1000, 0 - 2000 & 0 - 6000 pF)

Resolution ..... ±0.002% of Span

Accuracy ..... ±0.5% Typical

Repeatability: ..... ±0.1 pf

Linearity ..... ±0.5%

Ambient Temperature Effect ..... ±0.005 pF/Deg. F, ±0.01 pF/Deg. C

Alarm Setpoint ..... 0 to 100.00 %, 0.01% Resolution

Alarm Differential ..... 0 to 100.00 %, 0.01% Resolution

Alarm Time Delays ..... 0 to 60.000 seconds, 0.001 sec resolution

Relay Output -- Optional

Type ..... Electro-Mechanical, SPDT

Contact Ratings ..... 5 Amps @ 120 VAC, Inductive
10 Amps @ 250 VAC, General Purpose
8 Amps @ 30 VDC, Non-Inductive
1/3 HP @ 120 VAC

Analog Output -- Optional ..... 4-20 mADC into a 650 ohm load (Max.)

Maximum Distance Between Transmitter and Controller:
Refer to the requirements shown in the Instruction Manual supplied with the PFM Transmitter

Interconnecting Cable Between Transmitter and Controller:
Refer to the requirements shown in the Instruction Manual supplied with the PFM Transmitter

2.2 ENVIRONMENTAL

Temperature (Operating or Storage): ..... -40 to +140 Deg. F (-40 to +60 Deg. C)

Relative Humidity ..... 0 to 95%, Non-Condensing

Vibration ..... ±2 G, 10 to 200 Hz

Shock ..... 75 G's for 11 msec. without permanent damage

2.3 ENCLOSURE

PFM Transmitter

Material ..... Cast Aluminum
Finish ..... Polyurethane Enamel, Blue, standard
Epoxy Enamel, Gray, optional

Ratings
Rain-tight ..... NEMA-4 / UL 4 / CSA ENCL 4, standard
NEMA-4X / UL 4X / CSA ENCL 4, optional
Intrinsically Safe ..... Barrier Required,
Refer to the Instruction Manual furnished with the PFM transmitter

Controller

Material ..... Fiberglass (Blue)
Finish ..... None

Ratings
Raintight ..... NEMA 4 / UL 4 / CSA ENCL 4
Corrosion Resistant ..... NEMA 4X / UL 4X / CSA ENCL 4

Weights

Transmitter ..... 2.5 lb.s (1.14 kg)
Controller ..... 8.7 lb.s (3.95 kg)

2.4 AGENCY CERTIFICATIONS

Controller Enclosure
UL Listed ..... NEMA 4 / 4X, UL 4
C-UL ..... CSA ENCL 4

PFM Transmitter
Refer to the instruction manual supplied with the PFM Transmitter.

SECTION III – INSTALLATION

3.1 GENERAL

Examine the instrument for possible shipping damage. Choose a mounting location in accordance with good instrument practice, avoiding extremes of temperature, humidity and vibration (see **SECTION II -- SPECIFICATIONS**).

IMPORTANT

If for any reason it is determined that parts should be returned to the factory, please notify the nearest ROBERTSHAW TENNESSEE sales representative prior to shipment. Each unit must be properly packaged to prevent damage in transit. ROBERTSHAW assumes no responsibility for equipment damaged in transit due to improper packaging.

3.2 PROBE MOUNTING

ROBERTSHAW probes are purchased separately in a variety of sizes and types for specific applications involving liquids or granular materials. Insulated rod type probes are used for liquid solutions or liquid interface detection where only one of the two liquids is electrically conductive. Bare rod type probes can be used in non-conductive materials only.

CAUTION

When installing an insulated probe, care should be taken to prevent accidental puncture of the probe insulation.

Non-flanged probes should be installed so that the face of the packing gland is flush (or nearly so) with the vessel wall. Flanged type probes should be installed with the proper mating flange.

When installing the probe in a nozzle, recess or open end well, a sheathed probe should be used, the sheath length should equal the nozzle, recess or well length. The sheath on the sensing probe has the effect of deadening that section of the probe so condensate or product build-up will not affect the instrument or the measurement.

3.2.1 Horizontal Mounting

Horizontally mounted probes are not commonly used in continuous measuring applications, but if required certain precautions must be taken. The probe should have a slight downward angle from the gland to facilitate draining of the material from the probe. This becomes especially important when viscous materials are being measured.

3.2.2 Vertical Mounting

Vertically mounted probes may be installed from either the top or bottom of the vessel, but top mounting is the preferred orientation. In addition to the sheath considerations discussed above the length of the probe must be sufficient to extend for the full length of the measurement range, but be shorter than the vessel height.

3.3 INSTRUMENT MOUNTING

The Excalibur 7000 consists of two (2) components. The controller is a wall mounted device and the PFM transmitter can be either a probe mounted, or remote mounted, device. The configuration of a particular instrument can be determined from its model number (see **Paragraph 1.3 – MODEL IDENTIFICATION**).

3.3.1 Control Unit

The **Excalibur 7000** control unit is designed to be mounted remote from the PFM transmitter. It may be mounted in any orientation, but for ease of use, vertical mounting is recommended. See the following figures and the PFM Transmitter instruction manual for mounting dimensions. The unit should always be mounted in the factory supplied enclosure.

3.3.2 PFM Transmitter

The PFM transmitter is usually mounted directly to the probe. The following steps should be followed:

A. Remove the cover from the transmitter assembly. Remove the plastic bag containg the 'Probe Pin Kit' and finally remove the electronics assembly with its mounting bracket.

B. Remove the 'banana' pin from the 'Probe Pin Kit' and install it in the center rod of the probe. Do not over tighten.

C. Apply a conductive anti-seize compound, such as NEVER-SEEZ to the ½ NPT threads on the probe. Then install the transmitter enclosure base by screwing it onto the threads of the probe assembly. Align the hubs as required.

D. Re-install the electronics assembly into the enclosure. Verify that the banana pin on the

probe makes good electrical contact with the mating jack on the electronics assembly.

E. Re-install the cover assembly to protect the electronics from the weather until the electrical connections are to be made.

For remote a mounted PFM transmitter refer to the instruction manual supplied with the transmitter.

3.4 ELECTRICAL CONNECTIONS

All electrical connections should be made in accordance with the following figures. See **SECTION II -- SPECIFICATIONS** for relay contact ratings. The unit must be grounded for proper operation. Also, all wiring must conform to any applicable codes.

For intrinsically safe PFM installation also refer to the instruction manual supplied with the transmitter.

NOTICE
Tighten field wiring terminal screws to five (5) pound-inches (0.56 NM).

3.4.1 PFM Transmitter

The PFM transmitter is normally mounted directly on the sensing probe assembly and connected to the Excalibur 7000 controller unit using two wires (color coded, twisted pairs are recommended) in grounded metallic conduit, with no power lines present. Belden #8205, or equal, cable is recommended in this case. Otherwise shielded , twisted pair, cable must be used for this connection. In this case Belden #8762, or equal, cable is recommended.

When shielded cable is used it is important that the shield be terminated at one end only. It is recommended that the connection be made to the green ground screw in the PFM transmitter housing.

WARNING
SEAL FITTINGS MUST BE INSTALLED ON ALL EXPLOSION-PROOF INSTALLATIONS

For the optional remote mounted PFM transmitter refer to the instruction manual supplied with the transmitter.

NOTE
Polyethylene dielectric coaxial cable is not recommended for remote mounted PFM applications, due to its poorer temperature stability.

Field wiring for the PFM transmitter is to be 14 AWG, maximum, and rated for 80 Deg. C, minimum.

3.4.2 Supply Power

Connect the supply power to the appropriate terminals as shown in **FIGURE 3.3**. For AC units, before applying power to the instrument position the supply voltage selector switch, SW601, for the proper supply voltage.

The power supply wiring to the instrument is to be 12 AWG, maximum and rated for 80 Deg. C, minimum.

3.4.3 Dual/Quad Relay Options

ARC suppression networks are provided, when the alarm relay options are installed. They are intended for installation across inductive loads such as relay coils, motors, solenoid valves, etc... It is important that these networks be used to prevent problems caused by interference generated by arcing contacts.

The field wiring for the relay options is to be 12 AWG, maximum, and rated for 80 Deg. C, minimum.

3.4.4 Analog Output (4-20 mADC) Option

When one of the analog output options is installed the connections are made using two wires (color coded, twisted, shielded, pair cable is recommended). Belden #8762, or equal, is recommended.

When shielded cable is used it is important that the shield be terminated at one end only. It is recommended that the connection be made at the receiver end.

The field wiring for the analog output option is to be 12 AWG, maximum, and rated for 80 Deg. C, minimum.

3.4.5 Serial Communications Options

3.4.5.1 HART Protocol

The HART protocol serial communications option uses the analog output option wiring. Refer to **Paragraph 3.4.4** above for the wiring requirements.

3.4.5.2 MODBUS Protocol

The MODBUS protocol serial communications option requires the addition of the RS-232/485 serial communications hardware option card. Refer to the manual supplement for this option for wiring details.

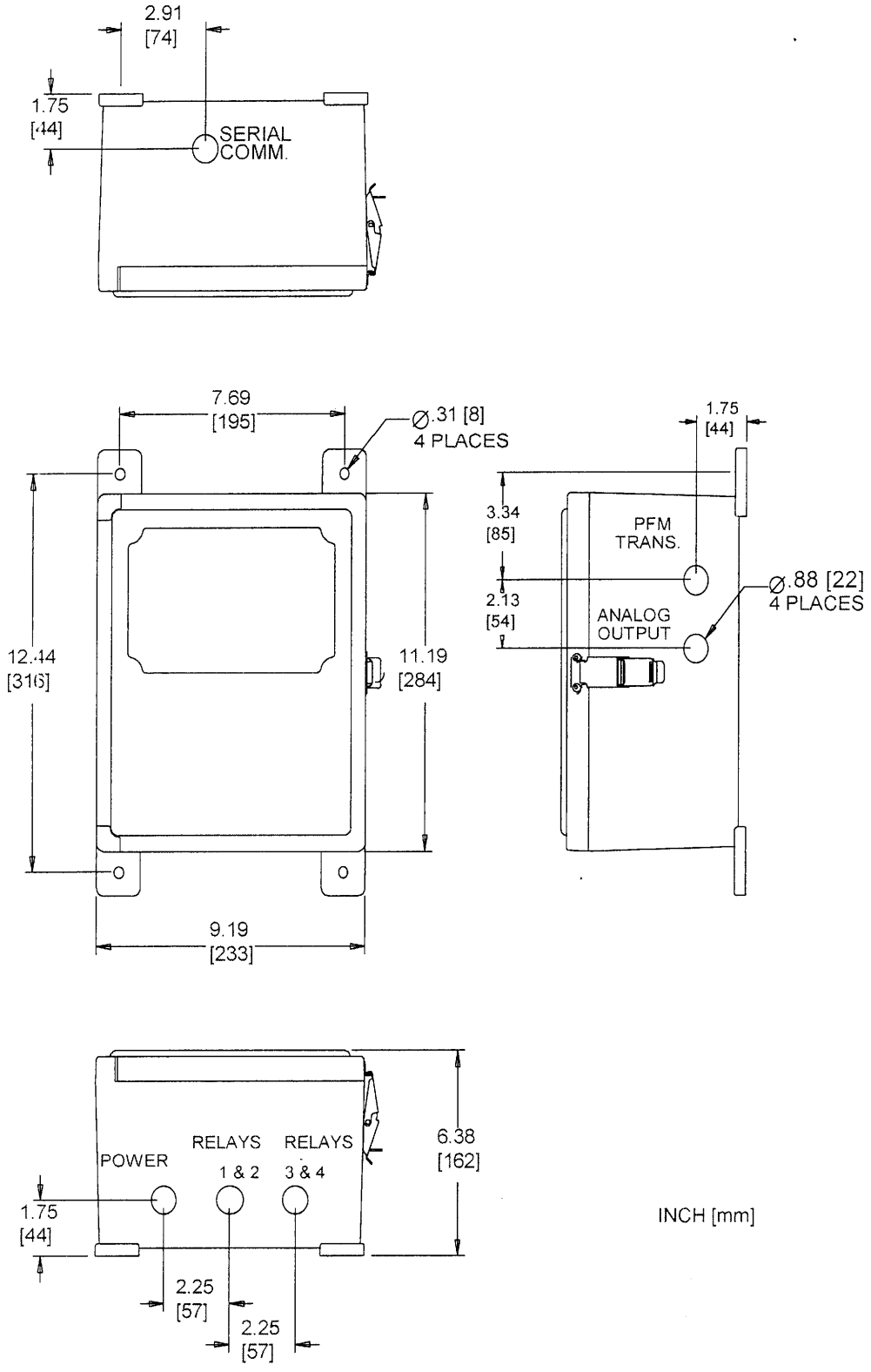


FIGURE 3.1 – Control Unit Dimensions

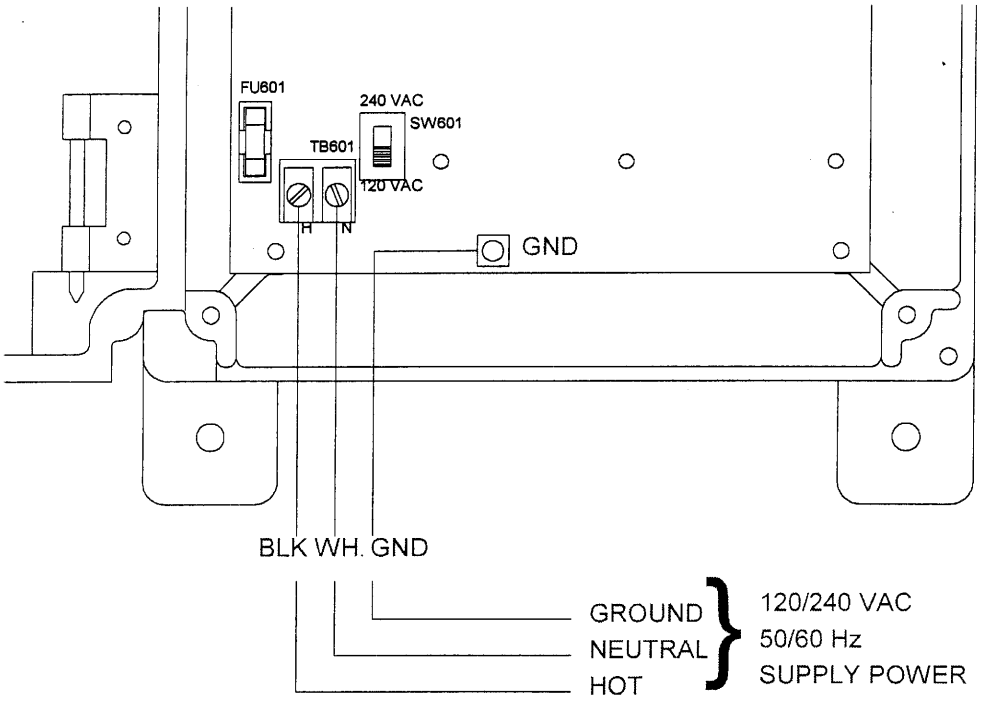
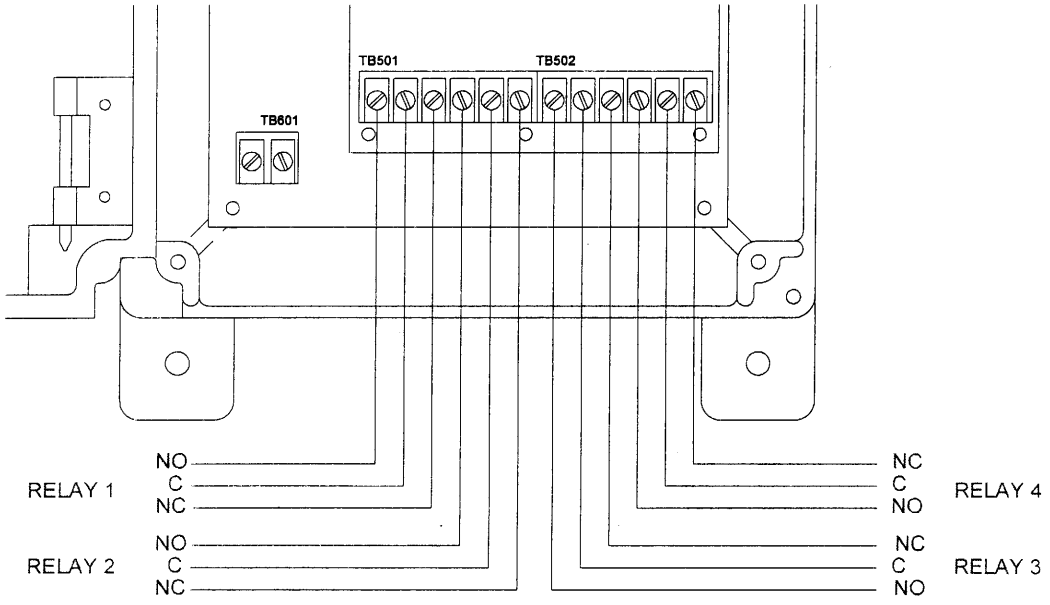


FIGURE 3.2 – Supply Power Connections



RELAY CONTACT DESIGNATIONS NO AND NC ARE AS SHOWN WHEN AN ALARM CONDITION EXISTS OR WHEN THE SUPPLY POWER IS DISCONNECTED WHEN POWER IS APPLIED AND NO ALARM CONDITION EXISTS THE CONTACT STATE IS REVERSED.

FIGURE 3.3 – Dual/Quad Relay Connections

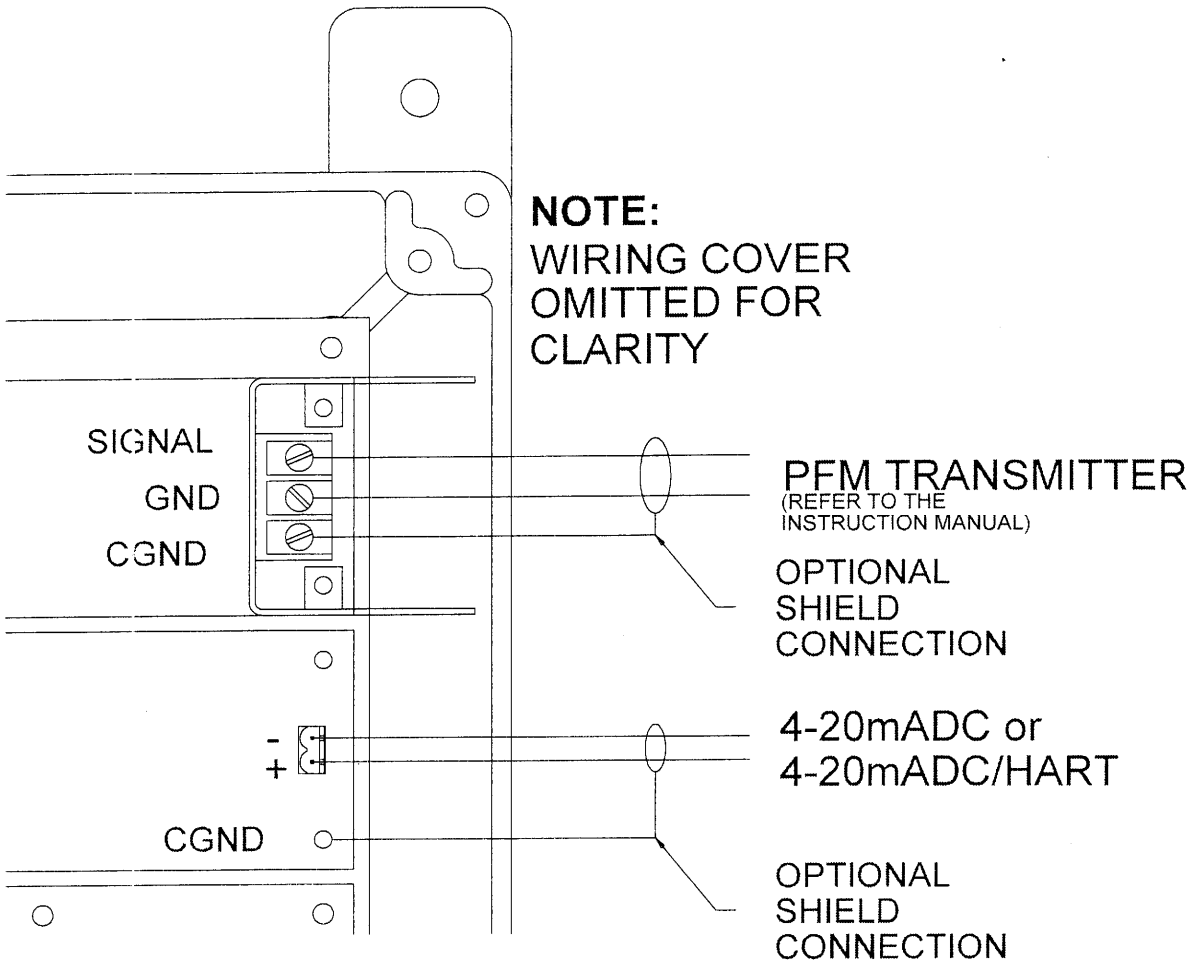


FIGURE 3.4 – PFM Transmitter & 4-20 mADC Analog Output Connections

SECTION IV – SETUP & CALIBRATION

4.1. GENERAL

This section describes the initial setup and calibration procedures to be followed when placing the instrument into service. These procedures are based on using the integral keypad and display panel located on the front of the instrument. These procedures can also be accomplished over either of the optional serial communications interfaces and the details for using these options are contained in the associated manual supplement. A detailed description of the instrument's menu structure can be found **in Appendix B – MENU STRUCTURE** of this manual.

The first step in placing the instrument in service should be to fill out a "Setup and Calibration Worksheet". A copy of this worksheet can be found **in Appendix A – SETUP & CALIBRATION WORKSHEET** of this manual. It should be noted that not all items in the worksheet apply to all instrument configurations. But the applicable items can be determined from the options installed and the application. Obviously the selections related to only one of the secondary variables, volume or flow, can be used and not all applications will support a secondary variable. Another example is the PID Control option which will only be effective if one of the analog output options is present. Also, relay selections for alarms are only meaningful when a relay option card is installed, but alarms are always useful because they have local indication and the alarm status is available over the serial communications link.

It should be noted that the instrument has provisions for loading a default database. This feature can be accomplished in two different ways. The first way is automatically at power-up, if a corrupted database is detected. The default values can also be loaded on demand by using menu selections available in the Diagnostics menu. There are also certain default variables that are made when an associated item is changed.

The procedures described in this section, with the exception of the Input Calibration can be accomplished before the instrument is actual installed on the process to be monitored and/or controlled.

4.2. LOCAL KEYPAD OPERATIONS

Before beginning to make actual changes in the instrument's database you should first be familiar with the operation of the keypad/display that is located on the front of the instrument. Access to this panel is obtained by opening the hinged cover on the front of the instrument.

When power is applied to the instrument the front panel will be operating in the normal mode. Neither of the menus will be active and the values being displayed will be determined by the current display setup information. The instrument can always be returned to this mode by pressing the **[CLEAR]** key until all menus are exited. The only exceptions to this are certain diagnostic functions that require a specific termination sequence.

4.2.1 Key Functions

There are six (6) dedicated keys that are used to navigate through the menus. The functions of these keys are as follows.

4.2.1.1 [SETUP] Key

This key is used to access the setup menu structure and is only active when the unit is in the normal operating mode, with no menus active.

4.2.1.2 [CALIBRATE] Key

This key is used to access the calibration menu structure and is only active when the unit is in the normal operating mode, with no menus active.

4.2.1.3 [ENTER] Key

This key is used to accept the current numerical entry or menu selection. It is only active when one of the menu structures has been entered. When making selections from a list the currently displayed selection becomes the selected value when the **[ENTER]** key is pressed. If a numeric entry is required the value currently entered using the numeric keys is accepted, subject to error checking. This key is only active while in a menu structure.

4.2.1.4 [CLEAR] Key

This key is used to either clear the numeric entry that is in progress or to move up one level in the menu structure. Each press of this key moves up one level in the menu structure until the normal operating mode is reached. This key is only active while in a menu structure.

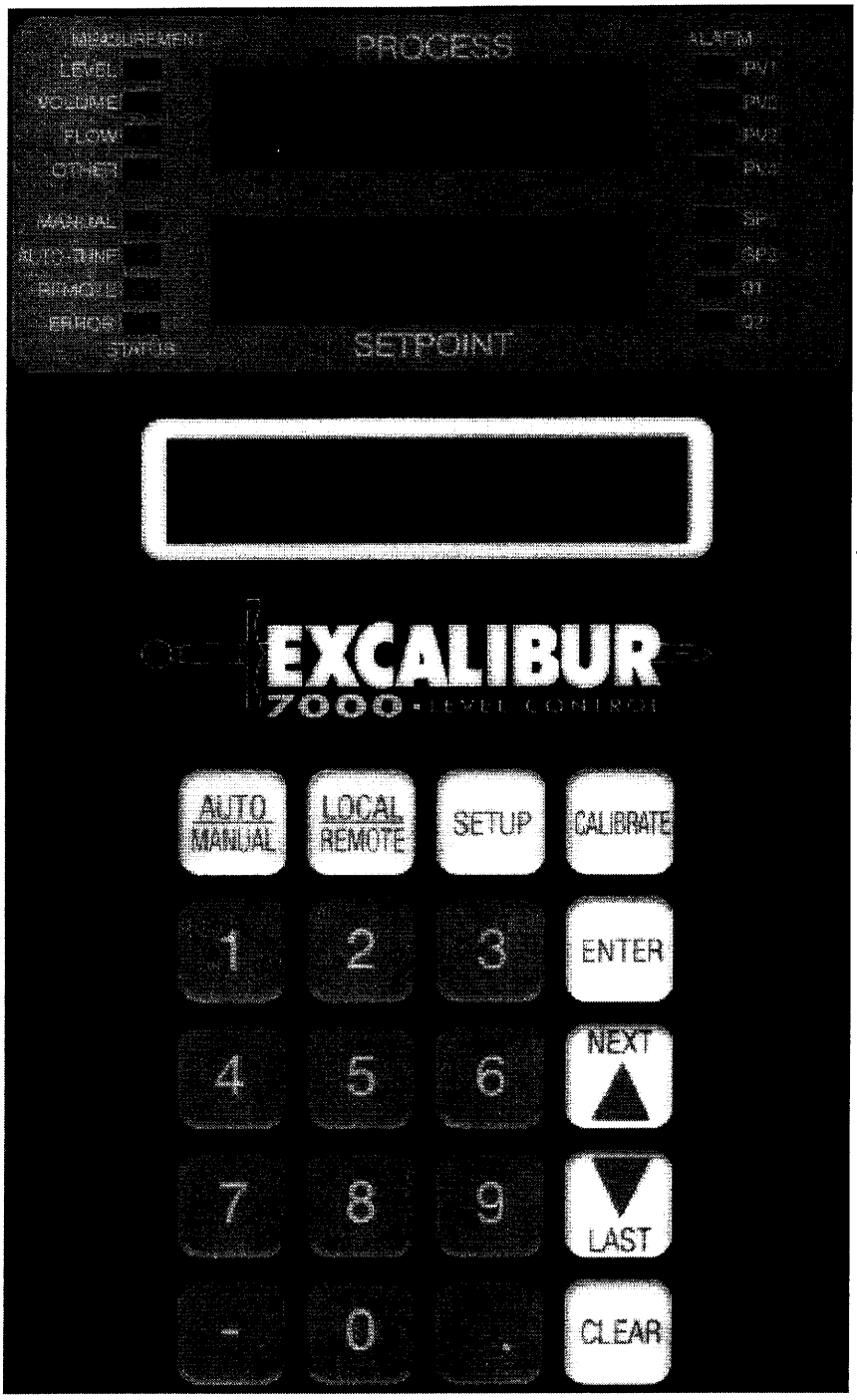


FIGURE 4.1 -- Front Panel Display/Keypad

4.2.1.5 [NEXT] Key

This key is used to page forward through a menu structure or selection list. This key is only active while in a menu structure.

4.2.1.6 [LAST] Key

This key is used to page backwards through a menu structure or selection list. This key is only active while in a menu structure.

4.2.1.7 Numeric Keypad

This 12 key numeric pad is used to make entries into the instrument's database when a menu item requiring a numeric entry is accessed. When the PID Control option is enabled and the instrument is operating in the normal mode pressing a numeric key will access the either the control setpoint or output depending on whether the control is in 'Automatic' or 'Manual' mode.

4.2.1.8 [AUTO/MANUAL] Key

This key is used in conjunction with the PID Control option. It is used to toggle between 'Automatic' and 'Manual' operation. This key is only active when the PID Control is enabled. Refer to the paragraphs on the PID Control option for more information on the use of this key.

4.2.1.9 [LOCAL/REMOTE] Key

This key is used in conjunction with the PID Control option. It is used to regain local control of the PID Control from the serial communications link. This key is only active when the PID Control is enabled and the serial communications option is active. Refer to the paragraphs on the PID Control option for more information on the use of this key.

4.2.2 Making Entries In The Database

There are two methods of making entries into the instruments database. The first is to make a selection from a list and the other is to enter a numeric value. The following paragraphs describe each of these methods.

4.2.2.1 Making A Selection From A List

When making a selection from a list the **[NEXT]** and **[LAST]** keys are used to scroll through the list until the desired selection is displayed on the bottom line of the vacuum florescent display, VFD. If the current selection is the selection being displayed there will be an indicator displayed in the right most character position of the bottom line and the selection process can be aborted by pressing the **[CLEAR]** key. If the desired selection is the not the current selection then the **[ENTER]** key is pressed to make it the current selection. Pressing the **[CLEAR]** or **[ENTER]** keys will cause the display to revert to the previous menu.

4.2.2.2 Making A Numerical Entry

When a menu item requires a numeric entry the current value is displayed on the left hand side of the bottom line of the VFD and the right hand side is blanked to receive the new value. The new value being entered is displayed as it is entered and a limited editor is provided to allow for the correction of typing mistakes.

If the current value displayed is the desired value then the entry process can be aborted by pressing the **[CLEAR]** key. Otherwise the new value is entered via the keypad. If a mistake is made the cursor can be backed up one character position at a time by pressing the **[LAST]** key or the whole entry can be erased by pressing the **[CLEAR]** key. When the desired value has been typed in the value is accepted by pressing the **[ENTER]** key.

All entries are checked for validity by comparing the entered value to the acceptable limits for the item being changed. If the value is not acceptable the display will revert to the beginning of the entry process otherwise the display will revert to the previous menu.

4.3. SETUP MENU

The "Setup Menu" contains items that define the basic operation of the Excalibur 7000. These items and the procedures for setting them are described in the following paragraphs.

4.3.1 Access Level

In order to change items in the instrument's database the proper access level must be set. The various access levels provide security when the instrument is in normal operation and prevent unauthorized access to the setup and calibration entries. In normal operation the "Access Level" could be set to either "Limited" or "Operator", but for the procedures described in this section the access level should be set to "Full".

The changing of access levels is password protected. All instruments are shipped from the factory with the password set to "12345". The procedure for changing the password is detailed in **SECTION VI – TROUBLE SHOOTING & DIAGNOSTICS**. The procedure for changing the access level is described in the following paragraphs and assumes that the password is still at its default value. If the password has

been changed simply substitute the current value for the default value.

4.3.1.1 Changing The Access Level

To begin the process of changing the access level be sure the instrument is in the normal operating mode. That is to say that no menus are active. This mode can be obtained by pressing the **[CLEAR]** key until any active menus are exited. The process then begins by pressing the **[SETUP]** key and the instrument will then respond by displaying *"Setup Menu / Access Level"* on the VFD.

Next press the **[ENTER]** key followed by pressing the **[NEXT]** key until the instrument responds by displaying *"Access Level / Full"* on the VFD. If the current selection indicator is displayed then the **[CLEAR]** key can be pressed. Otherwise, press the **[ENTER]** key and the instrument will respond by displaying *'Password? / ********* -> " on the VFD. At this point enter the password by pressing **[1]**, **[2]**, **[3]**, **[4]**, **[5]** and **[ENTER]** keys. If the correct password was entered the instrument will respond by returning to the previous menu. An incorrect entry will cause the instrument to momentarily display *"--Warning -- / Write Access Denied"* and the return to allow the correct value to be entered.

Once the proper access level has been set you can proceed to the next step by pressing the **[CLEAR]** and **[NEXT]** keys or return to normal operation by pressing the **[CLEAR]** key twice.

4.3.2 Measurement Mode

The first configuration item that should be set is the measurement mode. The Excalibur always measures level, but has the ability to interpolate one secondary variable. This secondary variable can be either volume or open channel flow. The secondary variable can be displayed, alarmed and/or controlled. The interpolation of this variable is based upon either the specified geometry of the vessel, flow element or by a user specified strapping table.

4.3.2.1 Changing The Measurement Mode

The menu selection to select the measurement mode can be entered as described above or from the normal operating mode by pressing the **[SETUP]**, **[NEXT]** and **[ENTER]** keys. Once the menu is successfully entered the instrument will *display "Measurement Mode / Level Only"* on the VFD. The **[NEXT]** and/or **[LAST]** keys can be used to scroll to the desired selection.

When the desired selection is on the display the **[ENTER]** key can be used to make it the current selection, or if it is the current selection the **[CLEAR]** key can be used to return to the previous menu.

Note: When the measurement mode is changed the displayed variables will are reset to their default values as shown below:

Table 4.1 – Display Defaults

Display	Operating Mode	
	Transmitter	Controller
PV Display	Measurement	Measurement
SP Display	None or Level	Setpoint
VFD Top Line	(Not Affected)	(Not Affected)

Once the proper measurement mode has been set you can proceed to the next step by pressing the **[NEXT]** key or return to normal operation by pressing the **[CLEAR]** key.

4.3.3 PID Control Option Mode

The next configuration item that should be set is the PID control option mode. The Excalibur PID control option requires one of the analog output options to be present in order to function correctly. You can turn on the PID control, but without an analog output there will be no control signal. This selection determines the basic function of the instrument. With PID control turned 'Off' the instrument functions as an indicator/transmitter and with it turned 'On' the instrument functions as a single loop controller. The actual setup and tuning of the PID control is covered in **SECTION V – OPERATION** of this manual.

4.3.3.1 Turning 'On' or 'Off' The PID Control

The menu selection to determine the state of the PID control option can be entered as described above or from the normal operating mode by pressing the **[SETUP]** key and then pressing the **[NEXT]** key until *"Setup Menu / PID Mode"* is displayed on the VFD. Once this item is successfully displayed the selection menu is accessed by pressing the **[ENTER]** key. The message *"PID Mode / Off"* will be displayed on the VFD. The **[NEXT]** or **[LAST]** keys can be used to scroll to the desired selection. When the desired selection is on the display the **[ENTER]** key can be used to

make it the current selection, or if it is the current selection the **[CLEAR]** key can be used to return to the previous menu.

Note: When the PID control option is turned on or off the items displayed on the front of the instrument are changed to the default values shown below:

Table 4.2 – Display Defaults

Display	PID Controller Mode	
	Off	On
PV Display	Measurement	Measurement
SP Display	None or Level	Setpoint
VFD Top Line	None	PID Output

Once the desired PID mode has been set you can proceed to the next step by pressing the **[CLEAR]** and **[NEXT]** keys or return to normal operation by pressing the **[CLEAR]** key twice.

4.3.4 Displays

The next configuration items that should be set are the displayed variables. As detailed above the action of turning on or off the PID control option plus selecting the measurement mode causes default selections to be made for the front panel displays. If the desired display variables are different than these defaults, or the current selections, then these changes should be made at this time.

4.3.4.1 Process (PV) Display

This is intended to be the main measured variable. When the instrument is operating as an indicator/transmitter or controller this would logically be the level measurement unless a secondary variable is being interpolated in which case the secondary variable would be displayed. The value displayed will be in the engineering units, EU's, selected for that variable.

The menu selection to select the PV display variable can be entered as described above or from the normal operating mode by pressing the **[SETUP]** key followed by pressing the **[NEXT]** key until *"Setup Menu / PV Display Variable"* is displayed on the VFD. Press the **[ENTER]** key and the instrument will display *"PV Display Variable / Level"* on the VFD. The **[NEXT]** or **[LAST]** keys can be used to scroll to the desired selection.

When the desired selection is on the display the **[ENTER]** key can be used to make it the current selection, or if it is the current selection the **[CLEAR]** key can be used to return to the previous menu.

Once the proper display variable has been set you can proceed to the next step by pressing the **[NEXT]** key or return to normal operation by pressing the **[CLEAR]** key.

4.3.4.2 Setpoint (SP) Display

This is intended to be the setpoint value when the instrument is functioning in the controller mode. When the instrument is functioning in the indicator/transmitter mode and a secondary measurement has been selected this display could be used to display the level measurement. If the PID setpoint is selected the value displayed will be in the EU's selected for the controlled variable otherwise the EU's will be those selected for the variable displayed.

The menu selection to select the SP display variable can be entered as described above or from the normal operating mode by pressing the **[SETUP]** key followed by pressing the **[NEXT]** key until *"Setup Menu / SP Display Variable"* is displayed on the VFD. Press the **[ENTER]** key and the instrument will display *"SP Display Variable / Level"* on the VFD. The **[NEXT]** or **[LAST]** keys can be used to scroll to the desired selection.

When the desired selection is on the display the **[ENTER]** key can be used to make it the current selection, or if it is the current selection the **[CLEAR]** key can be used to return to the previous menu.

Once the proper display variable has been set you can proceed to the next step by pressing the **[NEXT]** key or return to normal operation by pressing the **[CLEAR]** key.

4.3.4.3 VFD Top Line Variable

This display is intended to be the PID control output value when the instrument is functioning in the controller mode. When the instrument is functioning in the indicator/transmitter mode the use of this display has no logical assignment. If the output is selected the units are percent of span.

The menu selection to select the VFD top line display variable can be entered as described above or from the normal operating mode by pressing the **[SETUP]** key followed by pressing the **[NEXT]** key until *"Setup Menu / VFD Line 1 Variable"* is displayed on the VFD. Press the **[ENTER]** key

and the instrument will display *"VFD Line 1 Variable / Output (%) "* on the VFD. The **[NEXT]** and/or **[LAST]** keys can be used to scroll to the desired selection.

When the desired selection is on the display the **[ENTER]** key can be used to make it the current selection, or if it is the current selection the **[CLEAR]** key can be used to return to the previous menu.

Once the proper display variable has been set you can proceed to the next step by pressing the **[NEXT]** key or return to normal operation by pressing the **[CLEAR]** key.

4.3.4.4 VFD Bottom Line Variable

This display has no logical assignment.

The menu selection to select the VFD bottom line display variable can be entered as described above or from the normal operating mode by pressing the **[SETUP]** key followed by pressing the **[NEXT]** key until *"Setup Menu / VFD Line 2 Variable"* is displayed on the VFD. Press the **[ENTER]** key and the instrument will display *"VFD Line 2 Variable / Output (%) "* on the VFD. The **[NEXT]** and/or **[LAST]** keys can be used to scroll to the desired selection.

When the desired selection is on the display the **[ENTER]** key can be used to make it the current selection, or if it is the current selection the **[CLEAR]** key can be used to return to the previous menu.

Once the proper display variable has been set you can proceed to the next step by pressing the **[CLEAR]** key to return to the normal operating mode.

4.4. CALIBRATION MENU

The sub-menus located in this menu structure provide for defining the operation of the process measurement(s)and alarms. The actual calibration process for the level measurement is also located in this menu.

4.4.1 Measurement Setup

The Excalibur 7000 has three (3) possible measurement modes that are selectable under the Setup Menu (See **Paragraph 4.3.2.1** above). The selected mode will determine which menu is presented when the calibration mode is entered. To begin the process of setting up the process variable be sure the instrument is in the normal operating mode, that is to say that no menus are active. This mode can be obtained by pressing the **[CLEAR]** key until any active menus are exited. The process then begins by pressing the **[CALIBRATE]** key.

4.4.1.1 Level Measurement Only

If the measurement mode selected is "Level Only" the instrument will respond by displaying *"Calibrate Menu / Level"* on the VFD.

4.4.1.1.1 Level Engineering Units Selection

Next press the **[ENTER]** key and the instrument will respond by displaying *"Calibrate Level / Units"* on the VFD. Pressing the **[ENTER]** key again will transfer to the level engineering units selection list and the instrument will respond by displaying *'Select Level Units / inches"* on the VFD.

The **[NEXT]** and **[LAST]** keys can now be used to scroll among the possible level engineering units until the desired units of measure are displayed on the bottom line of the VFD. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu.

4.4.1.1.2 Maximum Measured Level Entry

The menu selection to specify the maximum measurable level, upper sensor limit (USL), can be entered from the previous step by pressing the **[NEXT]** key. This menu selection can also be reached from the normal operation mode by pressing the **[CALIBRATE]**, **[ENTER]** and **[NEXT]** keys in sequence. In either case the instrument will respond by displaying *"Calibrate Level / Maximum Level"* on the VFD.

Pressing the [ENTER] key will cause the instrument to respond by displaying *'Maximum Level / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

The value entered into this menu item is determined by the application and would normally be either the top of the vessel or the top of the active section of the sensing probe. Refer to Figure 4.2 below. It should be noted that the measurement range for a given installation is always from the lower sensor limit (LSL), which is fixed at 0.00 to the Maximum Level. Input conversion outside of this range will generate an error condition.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.1.3 Lower Range Value

The menu selection to enter the lower range value (LRV) associated with the level measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Lower Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Lower Range Value / xxx.xx ->* ____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the level measurement value at which the optional analog output will be 4.00 mADC. The analog output is scaled linearly between this entry and the following entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

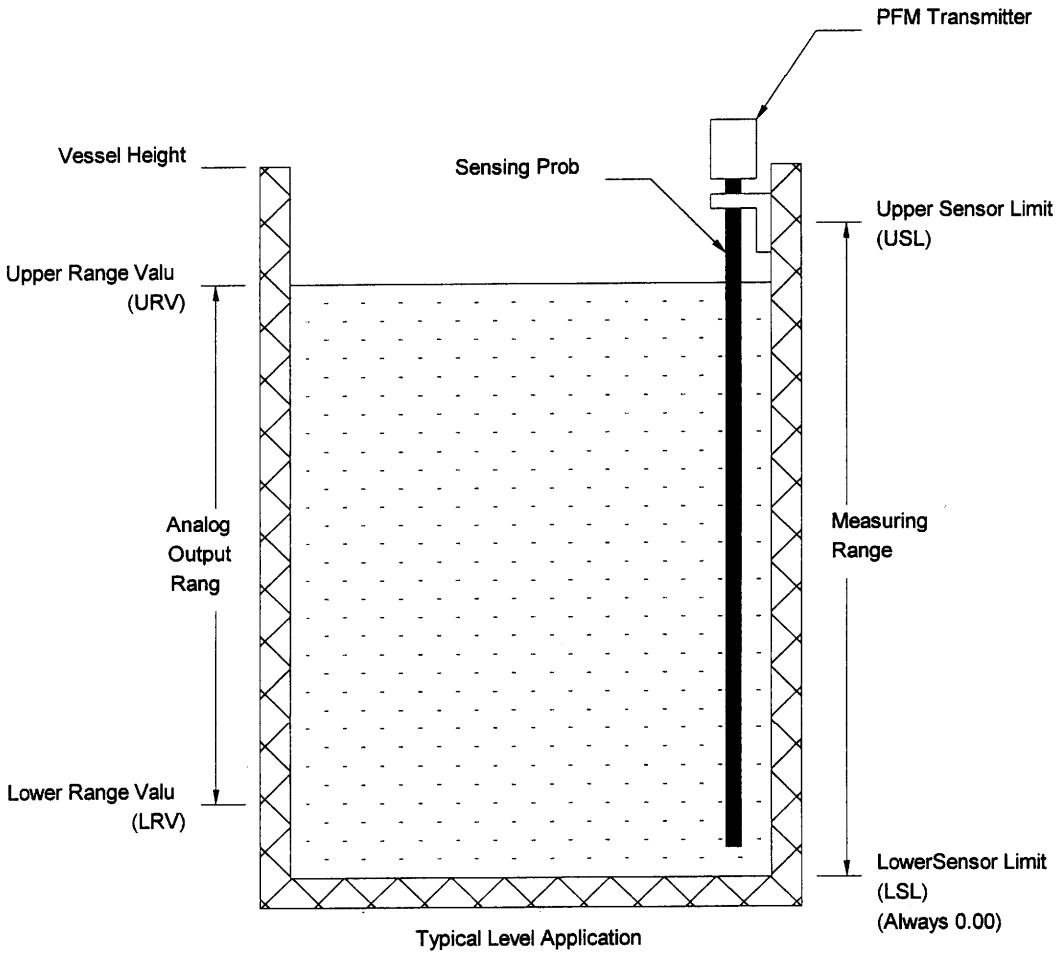


FIGURE 4.2 – Typical Level Measuring Application

4.4.1.1.4 Upper Range Value

The menu selection to enter the upper range value (URV) associated with the level measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT, [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Upper Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Upper Range Value / xxx.xx ->* _____"

on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the level measurement value at which the optional analog output will be 20.00 mADC. The analog output is scaled linearly between this entry and the preceding entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.1.5 Damping Time

The menu selection to enter the level measurement filter time constant can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT, [NEXT, [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Damping Time"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Damping Time / xxx.x ->* _____*"* on the VFD. The "xxx.x" will be the current setting, seconds and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

The value entered is the time constant, in seconds, for the first order filter that is applied to the level measurement. This entry has an acceptable range of 0.0 to 100.0 seconds. The time constant entered represents the amount of time that will elapse between a step change occurring and the displayed value reaching approximately 63% of it full value.

Once the desired value has been entered the instrument will respond by returning to the previous menu. Since there are no other items in this menu the **[NEXT]** and **[LAST]** keys can be used to return to previous items or the **[CLEAR]** key can be used to exit the level calibration menu.

Proceed to **Paragraph 4.4.2** below to continue with the alarm calibration procedures.

4.4.1.2 Level and Volume Measurement

If the measurement mode selected is "Level & Volume" pressing the **[CALIBRATE]** key in **Paragraph 4.4.1** above will cause the instrument to respond by displaying *"Calibrate Menu / Level"* on the VFD.

4.4.1.2.1 Level Measurement Calibration

Even though when in the level and volume measurement mode the volume is the primary variable for display and control purposes the primary measurement remains the level. Depending upon the vessel geometry this might be either the tank height or radius. The calibration of the level measurement generally follows that outlined under the level only measurement mode above.

4.4.1.2.1.1 Level Engineering Units Selection

Next press the **[ENTER]** key and the instrument will respond by displaying *"Calibrate Level / Units"* on the VFD. Pressing the **[ENTER]** key again will transfer to the level engineering units selection list and the instrument will respond by displaying *'Select Level Units / inches"* on the VFD.

The **[NEXT]** and **[LAST]** keys can now be used to scroll among the possible level engineering units until the desired units of measure are displayed on the bottom line of the VFD. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu.

4.4.1.2.1.2 Maximum Measured Level Entry

The menu selection to specify the maximum measurable level, upper sensor limit (USL), can be entered from the previous step by pressing the **[NEXT]** key. This menu selection can also be reached from the normal operation mode by pressing the **[CALIBRATE]**, **[ENTER]** and **[NEXT]** keys in sequence. In either case the instrument will respond by displaying *"Calibrate Level / Maximum Level"* on the VFD.

Pressing the [ENTER] key will cause the instrument to respond by displaying *'Maximum Level / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

The value entered into this menu item is determined by the application and would normally be either the top of the vessel or the top of the active section of the sensing probe. It should be noted that the measurement range for a given installation is always from the lower sensor limit (LSL), which is fixed at 0.00 to the Maximum Level. Input conversion outside of this range will generate an error condition.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.2.1.3 Lower Range Value

The menu selection to enter the lower range value (LRV) associated with the level measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Lower Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Lower Range Value / xxx.xx ->* ____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in paragraph 4.2.2.2 above.

This value is the level measurement value at which the optional analog output will be 4.00 mADC. The analog output is scaled linearly between this entry and the following entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

NOTE
When in the "Level & Volume" mode the optional analog output normally transmits volume related information, but the optional HART Serial Communications Protocol permits remapping this to the level measurement. If you do not plan on remapping the analog output, or if the option is not present, this entry can be left at its default value.

4.4.1.2.1.4 Upper Range Value

The menu selection to enter the upper range value (URV) associated with the level measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT, [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Upper Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Upper Range Value / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the level measurement value at which the optional analog output will be 20.00 mADC. The analog output is scaled linearly between this entry and the preceding entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

NOTE
When in the "Level & Volume" mode the optional analog output normally transmits volume related information, but the optional HART Serial Communications Protocol permits remapping this to the level measurement. If you do not plan on remapping the analog output, or if the option is not present, this entry can be left at its default value.

4.4.1.2.1.5 Damping Time

The menu selection to enter the level measurement filter time constant can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT, [NEXT, [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Damping Time"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Damping Time / xxx.x ->* _____" on the VFD. The "xxx.x" will be the current setting, seconds and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

The value entered is the time constant, in seconds, for the first order filter that is applied to the level measurement. This entry has an acceptable range of 0.0 to 100.0 seconds. The time constant entered represents the amount of time that will elapse between a step change occurring and the displayed value reaching approximately 63% of it full value.

Once the desired value has been entered the instrument will respond by returning to the previous menu. Since there are no other items in this menu the **[NEXT]** and **[LAST]** keys can be used to return to previous items or the **[CLEAR]** key can be used to exit the level calibration menu.

NOTE
Since the volume measurement is interpolated from the level measurement the damping time constant entered here will also effectively apply to the volume measurement.

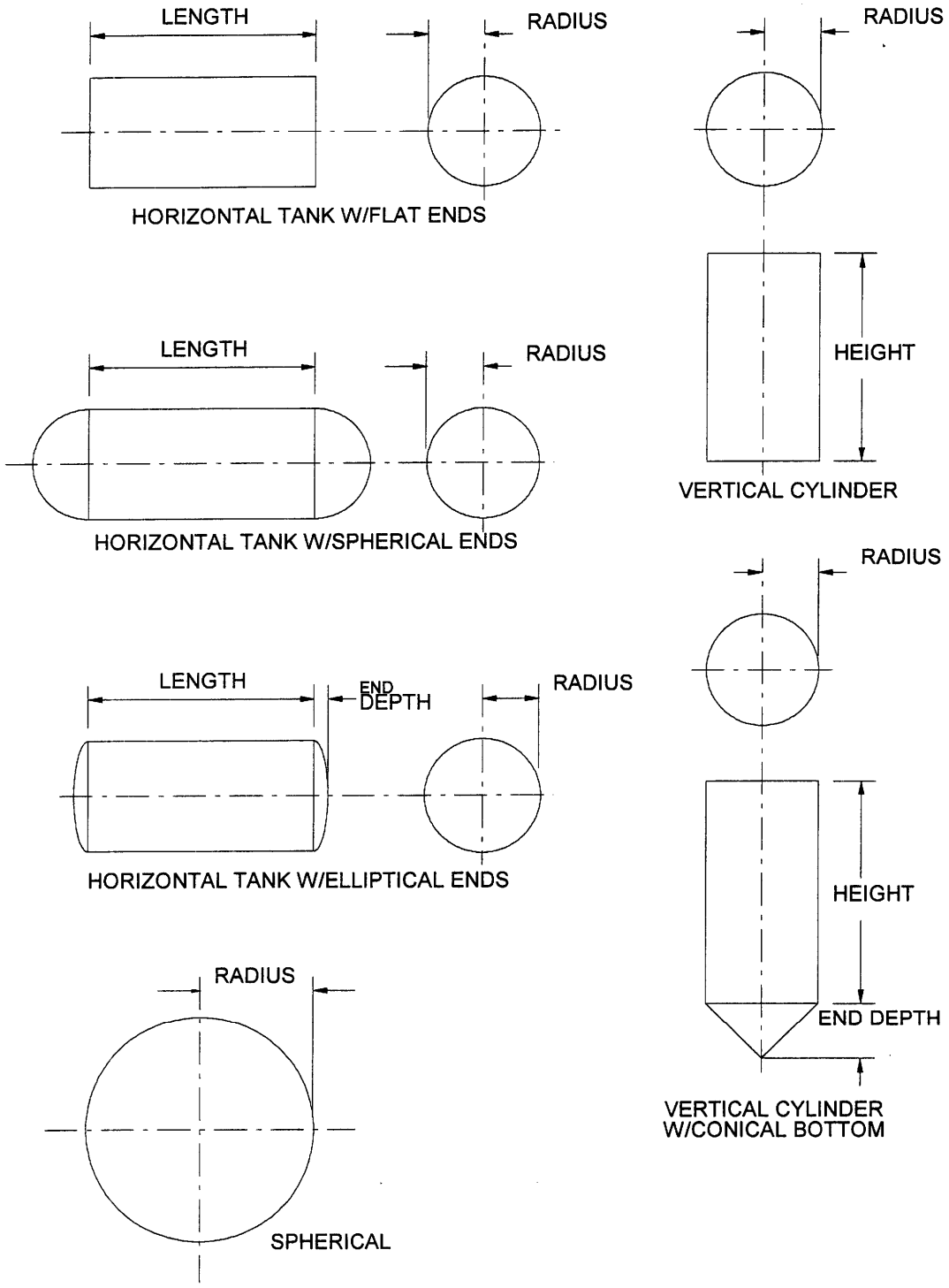


FIGURE 4.3 – Vessel Configurations

4.4.1.2.2 Volume Measurement Calibration

When in the level and volume measurement mode the volume is interpolated from the level measurement using the following selections and entries.

4.4.1.2.2.1 Volume Engineering Units Selection

This sub-menu can be entered from the previous menu by pressing the **[CLEAR]**, **[NEXT]** and **[ENTER]** keys in sequence. It can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[NEXT]** and**[ENTER]** keys in sequence. The instrument will respond by displaying *'Calibrate Volume / Units"* on the VFD.

The **[NEXT]** and **[LAST]** keys can now be used to scroll among the possible volume engineering units until the desired units of measure are displayed on the bottom line of the VFD. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu.

4.4.1.2.2.2 Lower Range value

This sub-menu can be entered from the previous menu by pressing the **[CLEAR]**, **[NEXT]** and **[ENTER]** keys in sequence. It can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[NEXT]**, **[ENTER]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Volume / Lower Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Lower Range Value / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the volume measurement value at which the optional analog output will be 4.00 mADC. The analog output is scaled linearly between this entry and the following entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.2.2.3 Upper Range value

This sub-menu can be entered from the previous menu by pressing the **[CLEAR]**, **[NEXT]** and **[ENTER]** keys in sequence. It can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[NEXT]**, **[NEXT]**, **[ENTER]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Volume / Upper Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Upper Range Value / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the volume measurement value at which the optional analog output will be 20.00 mADC. The analog output is scaled linearly between this entry and the following entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.2.2.4 Vessel Type

The sub-menu to select the vessel geometry can be entered from the previous menu by pressing the **[NEXT]** key or from the normal operating mode by pressing the **[CALIBRATE]**, **[NEXT]**, **[ENTER]**, **[NEXT]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"Calibrate Menu / Vessel Type"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to go to the list of supported vessel geometry's. The **[NEXT]** and **[LAST]** keys can now be used to scroll among the possible vessel types. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will then transfer to a sub-menu to allow the entry of the vessel dimensions. These sub-menus are detailed in the paragraphs below.

4.4.1.2.2.4.1 Vertical Cylinder

This sub-menu is used when the vertical cylinder vessel type is selected from the previous menu. When the VFD displays *"Select Vessel Type / Vert Cylinder"* press the **[ENTER]** key.

4.4.1.2.2.4.1.1 Tank Height

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Tank Height / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.1.2 Tank Radius

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Tank Radius / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.2.2.4.2 Vertical Cylinder With Conical Bottom

This sub-menu is used when the vertical cylinder vessel type is selected from the previous menu. When the VFD displays *"Select Vessel Type / Vert w/Cone Bottom"* press the **[ENTER]** key and the instrument will respond by displaying *"Tank Dimensions / Tank Height"* on the VFD.

4.4.1.2.2.4.2.1 Tank Height

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Tank Height / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described **in Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.2.2 Tank Radius

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Tank Radius / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.2.3 Cone Height

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Cone Height / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.2.2.4.3 Horizontal Cylinder With Flat Ends

This sub-menu is used when the vertical cylinder vessel type is selected from the previous menu. When the VFD displays *"Select Vessel Type / Horz Cylinder"* press the **[ENTER]**.

4.4.1.2.2.4.3.1 Tank Length

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Tank Length / xxx.xx ->*_____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.3.2 Tank Radius

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Tank Radius / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.2.2.4.4 Horizontal Cylinder With Elliptical End Caps

This sub-menu is used when the vertical cylinder vessel type is selected from the previous menu. When the VFD displays *"Select Vessel Type / Horz w/Ellip Ends"* press the **[ENTER]** key.

4.4.1.2.2.4.4.1 Tank Length

The instrument will respond by displaying *"Tank Length / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.4.2 Tank Radius

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Tank Radius / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.4.3 End Cap Depth

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *End Depth / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.2.2.4.5 Horizontal Cylinder With Spherical End Caps

This sub-menu is used when the horizontal cylinder with spherical end caps is the vessel type selected in the previous menu. When the VFD displays *"Select Vessel Type / Horz w/Sphere Ends"* press the **[ENTER]** key.

4.4.1.2.2.4.5.1 Tank Length

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Tank Length / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.5.2 Tank Radius

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Tank Radius / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

4.4.1.2.2.4.5.3 End Cap Depth

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *End Depth / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.2.2.4.6 Spherical Vessel

This sub-menu is used when the horizontal cylinder with spherical end caps is the vessel type selected in the previous menu. When the VFD displays *"Select Vessel Type / Sphere"* press the **[ENTER]** key.

4.4.1.2.2.4.6.1 Tank Radius

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Tank Radius / xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate

the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.2.2.4.7 User Defined Strapping Table

This sub-menu is used when the user defined vessel type is selected from the previous menu. When the VFD displays *"Select Vessel Type / User Defined"* press the **[ENTER]** key and the instrument will respond by displaying *"Strapping Table / Tank Capacity"* on the VFD.

4.4.1.2.2.4.7.1 Tank Capacity

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Tank Capacity / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the selected engineering units, and the space to the right of "->" is reserved for the entry of a new value. This value represents the volume at 100% of the measured level, the level upper sensor limit (USL), and is used along with the strapping table entries to interpolate the volume form the measured level. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.1.2.2.4.7.2 Strapping Table Values

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Edit Strapping Table / Entry #1, 5% Level"* on the VFD. This is the starting point for entering the user defined volume strapping table. The table consists of twenty (20) entries, in 5% steps of measured level, with each entry representing the equivalent percentage volume. The **[NEXT]** and **[LAST]** keys can be used to scroll through the table until the desired entry is located.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Entry #n, yy% Level / xxx.xx ->* _____*"*on the VFD. The "n" will be the table entry number, the "yy" will be the associated percentage measured level and "xxx.xx" will be the current entry in percent of tank capacity. A new value is entered as described in **Paragraph 4.2.2.2** above.

Once all of the entries are at the desired values pressing the **[CLEAR]** key four (4) times will return the menu structure to the calibrate menu main level.

Proceed to **Paragraph 4.4.2** below to continue with the alarm calibration procedures.

4.4.1.3 Level and Flow Measurement

If the measurement mode selected is "Level & Flow" pressing the **[CALIBRATE]** key in **Paragraph 4.4.1** above will cause the instrument to respond by displaying *"Calibrate Menu / Level"* on the VFD.

4.4.1.3.1 Level Measurement Calibration

Even though when in the level and flow measurement mode the flow is the primary variable for display and control purposes the primary measurement remains the level. The calibration of the level measurement generally follows that outlined under the level only measurement mode above.

4.4.1.3.1.1 Level Engineering Units Selection

Next press the **[ENTER]** key and the instrument will respond by displaying *"Calibrate Level / Units"* on the VFD. Pressing the **[ENTER]** key again will transfer to the level engineering units selection list and the instrument will respond by displaying *'Select Level Units / inches"* on the VFD.

The **[NEXT]** and **[LAST]** keys can now be used to scroll among the possible level engineering units until the desired units of measure are displayed on the bottom line of the VFD. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu.

4.4.1.3.1.2 Maximum Measured Level Entry

The menu selection to specify the maximum measurable level, upper sensor limit (USL), can be entered from the previous step by pressing the **[NEXT]** key. This menu selection can also be reached from the normal operation mode by pressing the **[CALIBRATE]**, **[ENTER]** and **[NEXT]** keys in sequence. In either case the instrument will respond by displaying *"Calibrate Level / Maximum Level"* on the VFD.

Pressing the [ENTER] key will cause the instrument to respond by displaying *'Maximum Level / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

The value entered into this menu item is determined by the application and would normally be the top of the vessel. It should be noted that the measurement range for a given

installation is always from the lower sensor limit (LSL), which is fixed at 0.00 to the Maximum Level. Input conversion outside of this range will generate an error condition.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.3.1.3 Lower Range Value

The menu selection to enter the lower range value (LRV) associated with the level measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Lower Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Lower Range Value / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the level measurement value at which the optional analog output will be 4.00 mADC. The analog output is scaled linearly between this entry and the following entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

NOTE
When in the "Level & Flow" mode the optional analog output normally transmits volume related information, but the HART Serial Communications Protocol permits remapping this to the level measurement. If you do not plan on remapping the analog output, or the option is not present, this entry can be left at its default value.

4.4.1.3.1.4 Upper Range Value

The menu selection to enter the upper range value (URV) associated with the level measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT, [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Upper Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Upper Range Value / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the level measurement value at which the optional analog output will be 20.00 mADC. The analog output is scaled linearly between this entry and the preceding entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

NOTE
When in the "Level & Flow" mode the optional analog output normally transmits volume related information, but the HART Serial Communications Protocol permits remapping this to the level measurement. If you do not plan on remapping the analog output, or the option is not present, this entry can be left at its default value.

4.4.1.3.1.5 Damping Time

The menu selection to enter the level measurement filter time constant can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT, [NEXT, [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Level / Damping Time"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Damping Time / xxx.x ->* _____*"* on the VFD. The "xxx.x" will be the current setting, seconds and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in paragraph 4.2.2.2 above.

The value entered is the time constant, in seconds, for the first order filter that is applied to the level measurement. This entry has an acceptable range of 0.0 to 100.0 seconds. The time constant entered represents the amount of time that will elapse between a step change occurring and the displayed value reaching approximately 63% of it full value.

NOTE
Since the flow measurement is interpolated from the level measurement the damping time constant entered here will also effectively apply to the flow measurement.

Once the desired value has been entered the instrument will respond by returning to the previous menu. Since there are no other items in this menu the **[NEXT]** and **[LAST]** keys can be used to return to previous items or the **[CLEAR]** key can be used to exit the level calibration menu.

4.4.1.3.2 Flow Measurement Calibration

When in the level and flow measurement mode the flow is interpolated from the level using the following selections and entries.

4.4.1.3.2.1 Flow Engineering Units Selection

Next press the **[ENTER]** key and the instrument will respond by displaying *"Calibrate Flow / Units"* on the VFD. Pressing the **[ENTER]** key again will transfer to the flow engineering units selection list and the instrument will respond by displaying *'Select Flow Units /cubic feet/second"* on the VFD.

The **[NEXT]** and **[LAST]** keys can now be used to scroll among the possible flow engineering units until the desired units of measure are displayed on the bottom line of the VFD. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu.

4.4.1.3.2.2 Lower Range Value

The menu selection to enter the lower range value (LRV) associated with the flow measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Flow / Lower Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Lower Range Value / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the flow measurement value at which the optional analog output will be 4.00 mADC. The analog output is scaled linearly between this entry and the following entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

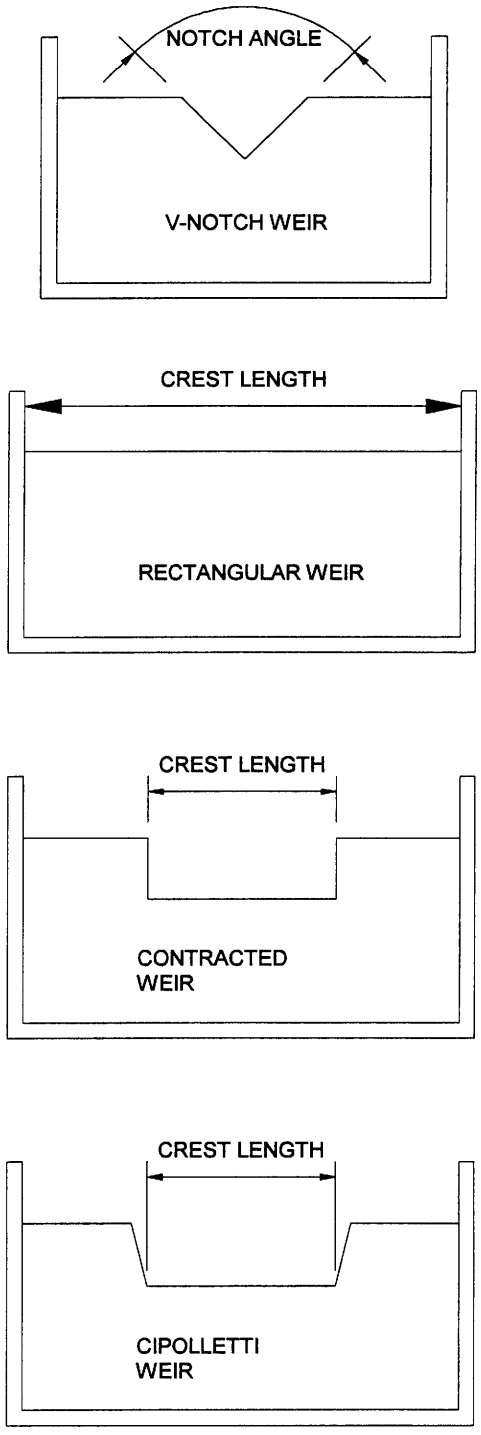


FIGURE 4.4 – Flow Element Geometry's

4.4.1.3.2.3 Upper Range Value

The menu selection to enter the lower range value (URV) associated with the flow measurement can be entered from the previous menu by pressing the **[NEXT]** key. This menu selection can also be entered from the normal operating mode by pressing the **[CALIBRATE]**, **[ENTER]**, **[NEXT]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'Calibrate Flow / Upper Range Value"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *'Upper Range Value / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above.

This value is the flow measurement value at which the optional analog output will be 20.00 mADC. The analog output is scaled linearly between this entry and the preceding entry. This entry must be located between the lower and upper sensor limits and differ from the next entry by the minimum allowable output span.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.3.2.4 Flow Element Selection

The menu to select the type of open channel flow element used can be entered from the previous menu by pressing the **[NEXT]** key. It can also be accessed from the normal operating mode by pressing the **[CALIBRATE]**. **[NEXT]**, **[ENTER]**, **[NEXT]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"Calibrate Flow / Element Type"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to go to the first item in a list of supported open channel flow elements. The **[NEXT]** and **[LAST]** keys can be used to scroll through the list. The current selection will be indicated by the indicator located at the right most character position of the display line showing the units label. With the desired label displayed press the **[ENTER]** key to make it the current selection. The instrument will then transfer to the appropriate sub-menu to define the properties of the selected element. These sub-menus are detailed below.

4.4.1.3.2.4.1 V-Notch Weir

This sub-menu is used when the flow element selected is a v-notch weir and is entered from the previous menu. When the VFD displays *"Select Flow Element / V-Notch Weir"* press the **[ENTER]** key and the instrument will respond by transferring to the selection list of supported notch angles.

4.4.1.3.2.4.1.1 V-Notch Angle Selection

This sub-menu is used to select the included angle of the v-notch weir being used. Upon entry the VFD will display *'V-Notch Angle / 22.5 Degrees"*. The **[NEXT]** and **[LAST]** keys can be used to scroll through the list. The current selection will be indicated by the indicator located at the right most character position of the display line showing the angle. With the desired angle displayed press the **[ENTER]** key to make it the current selection.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.3.2.4.2 Parshall Flume

This sub-menu is used when the flow element selected is a Parshall flume and is entered from the previous menu. When the VFD displays *"Select Flow Element / Parshall Flume"* press the **[ENTER]** key and the instrument will respond by transferring to the selection list of supported throat widths.

4.4.1.3.2.4.2.1 Throat Width Selection

This sub-menu is used to select the Parshall flume throat width being used. Upon entry the VFD will display *'Parshall Flume / 1 inch Throat"*. The **[NEXT]** and **[LAST]** keys can be used to scroll through the list. The current selection will be indicated by the indicator located at the right most character position of the display line showing the angle. With the desired throat width displayed press the **[ENTER]** key to make it the current selection.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

4.4.1.3.2.4.3 Rectangular Weir

This sub-menu is used when the flow element selected is a rectangular weir and is entered from the previous menu. When the VFD displays *"Select Flow Element / Rectangular Weir"* press the **[ENTER]** key and the instrument will respond by transferring to sub-menu for entering the weir crest length.

4.4.1.3.2.4.3.1 Weir Crest Length

Pressing the **[ENTER]** key above will cause the instrument to respond by displaying *"Weir Crest Length / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.3.2.4.4 Contracted Weir

This sub-menu is used when the flow element selected is a rectangular weir with end contractions and is entered from the previous menu. When the VFD displays *"Select Flow Element / Contracted Weir"* press the **[ENTER]** key and the instrument will respond by transferring to sub-menu for entering the weir crest length.

4.4.1.3.2.4.4.1 Weir Crest Length

Pressing the **[ENTER]** key above will cause the instrument to respond by displaying *"Weir Crest Length / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.3.2.4.5 Cipolletti Weir

This sub-menu is used when the flow element selected is a Cipolletti weir with end contractions and is entered from the previous menu. When the VFD displays *"Select Flow Element / Cipolletti Weir"* press the **[ENTER]** key and the instrument will respond by transferring to sub-menu for entering the weir crest length.

4.4.1.3.2.4.5.1 Weir Crest Length

Pressing the **[ENTER]** key above will cause the instrument to respond by displaying *"Weir Crest Length / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the engineering units selected above and the blank space to the right of "->" is reserved for the entry of the new value. A new value is entered as described in **Paragraph 4.2.2.2** above. The new value entered will then be used to calculate the maximum measured volume and the instrument will respond by returning to the previous menu.

Pressing the **[CLEAR]** key twice will return to the vessel type selection menu.

4.4.1.3.2.4.6 User Defined Table

This sub-menu is used when the user defined vessel type is selected from the previous menu. When the VFD displays *"Select Flow Element / User Defined"* press the **[ENTER]** key and the instrument will respond by displaying *"Strapping Table / Maximum Flow Rate"* on the VFD.

4.4.1.3.2.4.6.1 Tank Capacity

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Maximum Flow Rate / xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in the selected engineering units, and the space to the right of "->" is reserved for the entry of a new value. This value represents the flow at 100% of the measured level, the level upper sensor limit (USL), and is used along with the strapping table entries to interpolate the volume form the measured level. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.1.3.2.4.6.2 Strapping Table Values

Pressing the **[NEXT]** and **[ENTER]** keys will cause the instrument to respond by displaying *"Edit Strapping Table / Entry #1, 5% Level"* on the VFD. This is the starting point for entering the user defined volume strapping table. The table consists of twenty (20) entries, in 5% steps of measured level, with each entry representing the equivalent percentage flow. The **[NEXT]** and **[LAST]** keys can be used to scroll through the table until the desired entry is located.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Entry #n, yy% Level / xxx.xx ->* _____*"* on the VFD. The "n" will be the table entry number, the "yy" will be the associated percentage measured level and "xxx.xx" will be the current entry in percent of maximum flow. A new value is entered as described in **Paragraph 4.2.2.2** above.

Once all of the entries are at the desired values pressing the **[CLEAR]** key four (4) times will return the menu structure to the calibrate menu main level.

4.4.2 Alarms

The sub-menus located in this menu structure provide for defining the operation of the alarm system. There are four alarms related to the measured variable(s), two alarms related to the optional PID control setpoint and two alarms related to the optional analog output. These alarms are present in every unit and each has a dedicated indicator on the front panel of the instrument. Since all the alarms in any group are identical the following paragraphs will only address calibrating one alarm of each type.

The alarm menu can be entered from the previous menu by pressing the **[NEXT]** key or from the normal operating mode by pressing the **[CALIBRATE]** key followed by pressing the **[NEXT]** key until the instrument displays *"Calibrate Menu / Alarms"* on the VFD.

4.4.2.1 Process Variable (PV) Alarms

These four alarms are associated with the measured variables (level, volume and flow) and are applicable to all configurations of the Model 7000 Excalibur. They are accessed from the previous menu by pressing the **[ENTER]** key to which the instrument will respond by displaying *'Calibrate Alarms / Process Alarm #1"* on the VFD. The **[NEXT]** and **[LAST]** keys can be used to select the desired alarm.

4.4.2.1.1 Alarm Status

The menu to determine whether or not the alarm is active is accessed by pressing the **[ENTER]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Status"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"Disable"* (inactive) and *"Enable"* (active). The current selection will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired status displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.1.2 Alarm Measurement Source

The menu to determine which measurement will be checked for an alarm condition is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Measurement"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between the possible measurements. The selections presented will be determine by the measurement mode. The current selection will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired measurement displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.1.3 Alarm Fail-Safe Mode

The menu to determine the alarm type is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Failsafe Mode"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"LLFS"* (low alarm) and *"HLFS"* (high alarm). The current mode will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired alarm mode displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.1.4 Differential Mode

The menu to determine the differential action is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Alarm Type"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"Fixed Differential"* and *"Adjustable Differential"*. In the fixed differential mode the alarm resets when the measurement moves a predetermine amount from the setpoint and in the adjustable differential mode the other alarm setpoint determines where the alarm will reset. The current mode will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired differential mode displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.1.5 Low Alarm Setpoint

The entry to determine the low alarm setpoint is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Low Setpoint"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PVn Low Setpoint / xxx.xx ->* _____*"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.xx" will be the current setting, in the selected measurement engineering units, and the

space to the right of "->" is reserved for the entry of a new value. This value is only used when the alarm failsafe mode is LLFS or the differential mode is adjustable. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.1.6 High Alarm Setpoint

The entry to determine the low alarm setpoint is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / High Setpoint"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PVn High Setpoint / xxx.xx ->* _____" on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.xx" will be the current setting, in the selected measurement engineering units, and the space to the right of "->" is reserved for the entry of a new value. This value is only used when the alarm failsafe mode is HLFS or the differential mode is adjustable. A new value is entered as described **in Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.1.7 Time Delay On Return To Normal

The entry to determine the time delay on going from the alarm to the normal condition is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Off Delay"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PVn Time Delay Off / xxx.x ->* _____" on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.x" will be the current setting, in seconds, and the space to the right of "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.1.8 Time Delay On Alarm

The entry to determine the time delay on going from the alarm to the normal condition is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / On Delay"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PVn Time Delay On / xxx.x ->* _____" on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.x" will be the current setting, in seconds, and the space to the right of "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.1.9 Alarm Relay Selection

The menu to determine the output relay to be operated by this alarm is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Output Relay"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between the five possible selections (none, 1, 2, 3 or 4). The current selection will be indicated by the indicator located at the right most character position of the display line showing the relay number. With the desired relay displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

Pressing the **[CLEAR]** key will return to the process variable alarm selection menu.

4.4.2.2 PID Control Setpoint (SP) Alarms

These two alarms are associated with the setpoint value for the optional PID control. They have no meaning if the PID control option is not being used and are not displayed in the menu if the PID control is not active. The **[NEXT]** and **[LAST]** keys can be used to select the desired alarm. When a setpoint alarm is selected the instrument will respond by displaying *Calibrate Alarms / Setpoint Alarm #n"* on the VFD. . The "n" represents the alarm number being calibrated (1 or 2).

4.4.2.2.1 Alarm Status

The menu to determine whether or not the alarm is active is accessed by pressing the **[ENTER]** key. The instrument will respond by displaying *'Calibrate SPn Alarm / Status"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"Disable"* (inactive) and *"Enable"* (active). The current selection will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired status displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.2.2 Alarm Fail-Safe Mode

The menu to determine the alarm type is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate SPn Alarm / Failsafe Mode"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"LLFS"* (low alarm) and *"HLFS"* (high alarm). The current mode will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired alarm mode displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.2.3 Differential Mode

The menu to determine the differential action is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate SPn Alarm / Alarm Type"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"Fixed Differential"* and *"Adjustable Differential"*. In the fixed differential mode the alarm resets when the measurement moves a predetermine amount from the setpoint and in the adjustable differential mode the other alarm setpoint determines where the alarm will reset. The current mode will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired differential mode displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.2.4 Low Alarm Setpoint

The entry to determine the low alarm setpoint is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / Low Setpoint"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"SPn Low Setpoint / xxx.xx ->* _____*"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.xx" will be the current setting, in the controlled variable engineering units, and the space to the right of "->" is reserved for the entry of a new value. This value is only used when the alarm failsafe mode is LLFS or the differential mode is adjustable. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.2.5 High Alarm Setpoint

The entry to determine the low alarm setpoint is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate PVn Alarm / High Setpoint"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"SPn High Setpoint / xxx.xx ->* _____*"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.xx" will be the current setting, in the controlled variable engineering units, and the space to the right of "->" is reserved for the entry of a new value. This value is only used when the alarm failsafe mode is HLFS or the differential mode is adjustable. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.2.6 Alarm Relay Selection

The menu to determine the output relay to be operated by this alarm is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate SPn Alarm / Output Relay"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between the five possible selections (none, 1, 2, 3 or 4). The current selection will be indicated by the indicator located at the right most character position of the display line showing the relay number. With the desired relay displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

Pressing the **[CLEAR]** key will return to the process variable alarm selection menu.

4.4.2.3 Analog Output (O) Alarms

These two alarms are associated with the optional analog output, 4-20 mADC, and can be used either with or without the PID control option. They actually can be set without an analog output option board being present. The **[NEXT]** and **[LAST]** keys can be used to select the desired alarm. When a setpoint alarm is selected the instrument will respond by displaying *Calibrate Alarms / Output Alarm #n"* on the VFD. . The "n" represents the alarm number being calibrated (1 or 2).

4.4.2.3.1 Alarm Status

The menu to determine whether or not the alarm is active is accessed by pressing the **[ENTER]** key. The instrument will

respond by displaying *'Calibrate On Alarm / Status"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"Disable"* (inactive) and *"Enable"* (active). The current selection will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired status displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.3.2 Alarm Fail-Safe Mode

The menu to determine the alarm type is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate On Alarm / Failsafe Mode"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"LLFS"* (low alarm) and *"HLFS"* (high alarm). The current mode will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired alarm mode displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.3.3 Differential Mode

The menu to determine the differential action is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate On Alarm / Alarm Type"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between *"Fixed Differential"* and *"Adjustable Differential"*. In the fixed differential mode the alarm resets when the measurement moves a predetermine amount from the setpoint and in the adjustable differential mode the other alarm setpoint determines where the alarm will reset. The current mode will be indicated by the indicator located at the right most character position of the display line showing the status. With the desired differential mode displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

4.4.2.3.4 Low Alarm Setpoint

The entry to determine the low alarm setpoint is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate On Alarm / Low Setpoint"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"On Low Setpoint / xxx.xx ->* _____*"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.xx" will be the current setting, in percent of scale, and the space to the right of "->" is reserved for the entry of a new value. This value is only used when the alarm failsafe mode is LLFS or the differential mode is adjustable. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.3.5 High Alarm Setpoint

The entry to determine the low alarm setpoint is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate On Alarm / High Setpoint"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"On High Setpoint / xxx.xx ->* _____*"* on the VFD. The "n" represents the alarm number being calibrated (1, 2, 3 or 4). The "xxx.xx" will be the current setting, in percent of scale, and the space to the right of "->" is reserved for the entry of a new value. This value is only used when the alarm failsafe mode is HLFS or the differential mode is adjustable. A new value is entered as described in **Paragraph 4.2.2.2** above. When the new value is entered the instrument responds by returning to the previous menu.

4.4.2.3.6 Alarm Relay Selection

The menu to determine the output relay to be operated by this alarm is accessed by pressing the **[NEXT]** key. The instrument will respond by displaying *'Calibrate On Alarm / Output Relay"* on the VFD. The "n" represents the alarm number being calibrated (1 or 2).

The **[NEXT]** and/or **[LAST]** keys can now be used to select between the five possible selections (none, 1, 2, 3 or 4). The current selection will be indicated by the indicator located at the right most character position of the display line showing the relay number. With the desired relay displayed press the **[ENTER]** key to make it the current selection. The instrument will respond by returning to the previous menu level.

Pressing the **[CLEAR]** key will return to the process variable alarm selection menu.

4.4.3 Level Measurement Calibration, To The Process

This is the only step in this procedure that could not normally be accomplished without the instrument being installed on the process. It is possible to do this step using a

capacitance substitution device and calculated values, but this will usually result in reduced accuracy.

While there are three possible calibration procedures, it should be noted that until both a low level point and high level point have been calibrated, the level can not be measured accurately. Therefore, it is recommended that the initial calibration be done using the two point method as described in **Paragraph 4.4.3.1**. When this is not practical, either a low point or high point calibration as specified in **Paragraphs 4.4.3.2** and **4.4.3.3** may be performed with the other point being done at a later time. Rear in mind that the primary purpose of the low point and high point calibrations specified in **Paragraphs 4.4.3.2** and **4.4.3.3** are to increase the span at which the instrument was previously calibrated so as to improve accuracy. The greater the distance between the two points the greater the accuracy.

The input calibration sub-menu can be entered from the previous step by pressing the **[NEXT]** key, or from the normal operating mode by pressing the **[CALIBRATE]**and **[LAST]** keys in sequence. In either case the instrument will respond by displaying *"Calibrate Menu / Input"* on the VFD. Pressing the **[ENTER]** key will transfer to the input calibration menu and the instrument will respond by displaying *"Calibrate Input / Two Point"* on the VFD.

4.4.3.1 Two Point Calibration

Pressing the **[ENTER]** key will transfer to this procedure and cause the instrument to display *"Lo Level Input Cal / xxx.xx -> _____"* on the VFD. The "xxx.xx" represents the last low calibration point and the space to the right of the "->" is reserved for the entry of the new low calibration point. Establish a new low calibration level and then enter the value, in the selected level engineering units, as described in **Paragraph 4.2.2.2** above.

The instrument will respond by displaying *"Hi Level Input Cal / xxx.xx -> _____"* on the VFD. The "xxx.xx" represents the last high calibration point and the space to the right of the "->" is reserved for the entry of the new high calibration point. Establish a new high calibration level and then enter the value, in the selected level engineering units, as described in **Paragraph 4.2.2.2** above. This level must be higher than the low level established above by the minimum input calibration span.

The instrument will then calibrate the constants used to convert the PFM input signal to a level measurement and store the values for future use. The instrument will return to the previous menu and pressing the **[ENTER]** key twice will return the instrument to normal operation.

4.4.3.2 Low Point Calibration

This calibration procedure is entered from the main input calibration menu in paragraph 4.4.3 above by pressing the **[NEXT]** key and the instrument responds by displaying *"Calibrate Input / Low Point"* on the VFD. This procedure is intended to be used when it is desirable to re-calibrate the instrument with a greater calibration span. Since a large difference between the low and high calibration levels will result in better accuracy the procedure could be used when the level is lower than that used in the previous calibration.

Pressing the **[ENTER]** key will transfer to this procedure and cause the instrument to display *"Lo Level Input Cal / xxx.xx -> _____"* on the VFD. The "xxx.xx" represents the last low calibration point and the space to the right of the "->" is reserved for the entry of the new low calibration point. Establish a new low calibration level and then enter the value, in the selected level engineering units, as described in **Paragraph 4.2.2.2** above. This level must be lower than the high level established above by the minimum input calibration span.

The instrument will then calibrate the constants used to convert the PFM input signal to a level measurement and store the values for future use. The instrument will return to the previous menu and pressing the **[ENTER]** key twice will return the instrument to normal operation.

4.4.3.3 High Point Calibration

This calibration procedure is entered from the main input calibration menu in paragraph 4.4.3 above by pressing the **[NEXT]** key twice and the instrument responds by displaying *"Calibrate Input /High Point"* on the VFD. This procedure is intended to be used when it is desirable to re-calibrate the instrument with a greater calibration span. Since a large difference between the low and high calibration levels will result in better accuracy the procedure could be used when the level is higher than that used in the previous calibration.

Pressing the **[ENTER]** key will transfer to this procedure and cause the instrument to display *"Hi Level Input Cal / xxx.xx -> _____"* on the VFD. The "xxx.xx" represents the last high calibration point and the space to the right of the "->" is reserved for the entry of the new high calibration point. Establish a new high calibration level and then enter the value, in the selected level engineering units, as described in **Paragraph 4.2.2.2** above. This level must be higher than the high level established above by the minimum input calibration span.

The instrument will then calibrate the constants used to convert the PFM input signal to a level measurement and store the values for future use. The instrument will return to the previous menu and pressing the **[ENTER]** key twice will return the instrument to normal operation.

SECTION V – OPERATION

5.1. GENERAL

This section describes the normal operating procedures for normal day to day usage. The procedures for initially placing the instrument into service are contained in **SECTION IV – SETUP & CALIBRATION**. The procedures covered in this section are based upon using the integral keypad and display panel located on the front panel of the instrument. The methods for using the keypad and display are detailed in Paragraph 4.2 above. These procedures can also be done over either of the optional serial communications interfaces and the details for using these options are contained in their associated manual supplement. A detailed description of the instrument's menu structure can be found in **Appendix B – MENU STRUCTURE** of this manual.

Changes made in the instrument's database during operation should be recorded on the "Setup & Calibration Worksheet", a copy of which can be found in **Appendix A – SETUP & CALIBRATION WORKSHEET** of this manual. It should also be noted that not all the operations described in the following paragraphs are applicable to all instrument configurations. Secondary variable related items are only available if the selected measurement mode includes the subject variable and PID control related items are only available if the PID control option is enabled.

It should also be noted that the instrument has provisions for loading a default database. This feature may cause changes in the settings and selections made during operations. There are also certain default variable settings that are made when an associated item is changed

5.2. DISPLAYING VARIABLES

The front panel of the Excalibur 7000 contains a set of variable displays located on the front panel of the instrument that are labeled in accordance with their normal functions. The operators ability to select the variables displayed are dependent upon the active "Access Level" and the available selections are determined by the instrument's configuration.

5.2.1 Process Variable Display

The upper display is labeled "PROCESS" and its primary function is to display the main measured variable (level, volume or flow). The units of the value being displayed are determined by the units selected for that variable. If the PID control option is enabled then this would logically be the variable being controlled. When the measurement mode is changed the variable to be displayed is automatically set. **Table 5.1** below shows the default settings for the displays. If the measurement mode is "Level Only" then no selection is possible for this display. If the measurement mode is "Level & Volume" then the default value is Volume, but level may be selected. If the measurement mode is "Level & Flow" the default value is Flow, but Level may be selected.

The "Access Level" must be set to "Full" in order for changes in the displayed PROCESS variable to be allowed. Any attempt to change the variable with the improper access level will result in the message *"—Warning-- / Write Access Denied"* being displayed momentarily.

The current selection is always available for viewing regardless of the access level. The current selection can be accessed from the normal operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT]** and **[ENTER]** keys in sequence. This will access the selection list and the **[NEXT]** and/or **[LAST]** keys can then be used to scroll amongst any available selections. The current selection will be indicated by a marker in the right most character position. When done the VFD display can be returned to the normal mode by pressing the **[CLEAR]** key as required.

5.2.2 Setpoint Variable Display

The lower display is labeled "SETPOINT" and its primary function is to display the PID control setpoint or the measured level when PID control is not enabled and a secondary measurement is available. The units of the value being displayed are determined by the units selected for that variable. When the measurement mode is changed the variable to display is automatically set, if PID control is not enabled. Changing the status of the PID control also can affect the variable selection. See **Table 5.1** below for the default settings. If PID control is disabled and the measurement mode is "Level Only" then "Level" and (none) are the only possible selections. If the measurement mode is "Level & Volume" then the default value is "Volume", but "Level" or (none) may be selected. If the measurement mode is "Level & Flow" the default value is "Flow", but "Level" or (none) may be selected.

The "Access Level" must be set to "Operator" or "Full" in order for changes in the displayed SETPOINT variable to be allowed. Any attempt to change the variable with the access level set to "Limited" will result in the message *"—Warning-- / Write Access Denied"* being displayed momentarily.

The current selection is always available for viewing regardless of the access level. The current selection can be accessed from the normal operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT]** and **[ENTER]**

keys in sequence. This will access the selection list and the **[NEXT]** and/or **[LAST]** keys can then be used to scroll amongst any available selections. The current selection will be indicated by a marker in the right most character position. When done the VFD display can be returned to the Normal mode by pressing the **[CLEAR]** key as required.

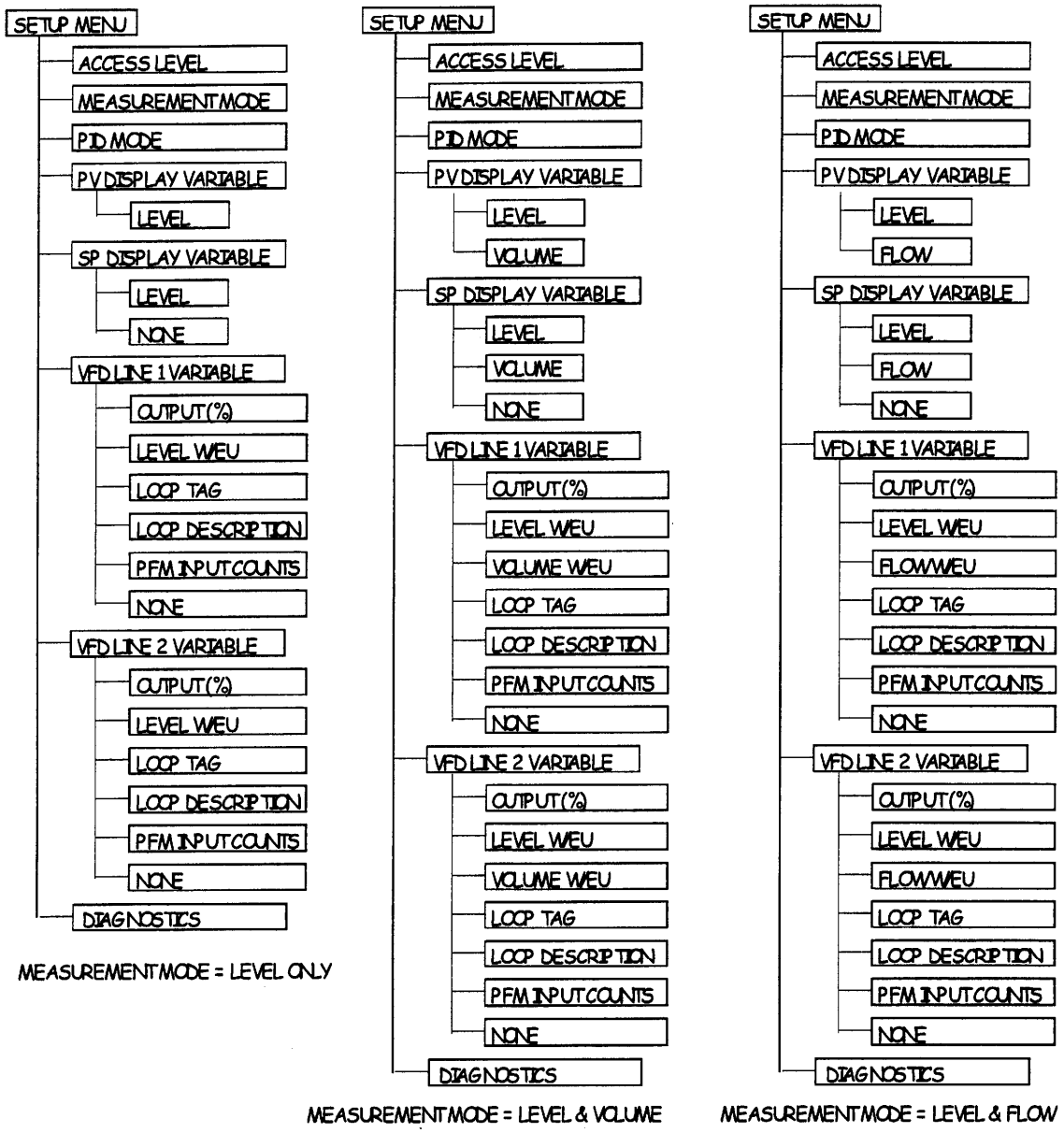


Figure 5.1 – Display Setup Menu Items
(Shown with PID Option Off)

Table 5.1 – Default Display Variable Settings

	Transmitter Mode (PID Control Disabled)			Controller Mode (PID Control Enabled)		
	Level Only	Level & Volume	Level & Flow	Level Only	Level & Volume	Level & Flow
Process	Level	Volume	Flow	Level	Volume	Flow
Setpoint	(none)	Level	Level	Setpoint	Setpoint	Setpoint
VFD Top Line	(none)	(none)	(none)	Output	Output	Output
VFD Botom Line	(none)	(none)	(none)	(none)	(none)	(none)

5.2.3 Vacuum Fluorescent Display

There is a two (2) line by 20 character vacuum fluorescent display, VFD, located just below the SETPOINT display on the front panel of the instrument. This display can be used to display two additional variables in the normal operating mode and is the display for the menu system used in setting up and calibrating the instrument. When the PID control state is changed the variable displayed on the top line of the display is changed to a default value, as shown in **Table 5.1**. The bottom line has no default setting.

The "Access Level" must be set to either "Operator" or "Full" in order for changes to the VFD displayed variables to be allowed. Any attempt to change the variable with the access level set to "Limited" will result in the *message "—Warning-- / Write Access Denied"* being displayed momentarily.

5.2.3.1 VFD Top Line Display Variable

When the PID control option is enabled this display line's primary function is to display the current analog, 4-20 mADC, output value, otherwise it can be used to display any of the available system variables. The variables that are available for display depend upon the current measurement mode. The available selections are shown in **Table 5.2** below.

The current selection is always available for viewing regardless of the access level. The current selection can be accessed from the normal operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT]** and **[ENTER]** keys in sequence. This will access the selection list and the **[NEXT]** and/or **[LAST]** keys can then be used to scroll amongst any available selections. The current selection will be indicated by a marker in the right most character position. When done the VFD display can be returned to the Normal mode by pressing the **[CLEAR]** key as required.

Table 5.2 – Available VFD Variables

Level Only	Level & Volume	Level & Flow
Analog Output (% of span)	**Analog Output** (% of span)	**Analog Output** (% of span)
Level (with units)	**Level** (with units)	**Level** (with units)
Loop Tag	**Volume** (with units)	**Flow** (with units)
Loop Description	**Loop Tag**	**Loop Tag**
PFM Input Period	**Loop Description**	**Loop Description**
(none)	**PFM Input Period**	**PFM Input Period**
	(none)	(none)

5.2.3.2 VFD Bottom Line Display Variable

This display line has no primary function and thus has no default display variable. The variables available for display are shown in **Table 5.2** above.

The current selection is always available for viewing regardless of the access level. The current selection can be accessed from the "Normal" operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT]** and **[ENTER]** keys in sequence. This will access the selection list and the **[NEXT]** and/or **[LAST]** keys can then be used to scroll amongst any available selections. The current selection will be indicated by a marker in the

right most character position. When done the VFD display can be returned to the Normal mode by pressing the **[CLEAR]** key as required.

5.3. SETTING ALARMS

The Excalibur 7000 has eight (8) possible alarms that may be configured based upon the options installed in the instrument. These alarms would normally be setup when the instrument is placed in service, but it may be desirable to later fine tune the setting after the instrument is in service and are thus included here. These alarms can be grouped into three (3) logical functional groups (process variables, PID setpoint and analog output). The alarms within each of these groups are identical.

Each alarm is provided with its own red light emitting diode, LED, indicator. These LED's are located to the right of the **PROCESS** and **SETPOINT** displays on the front panel of the instrument. The associated LED is lit while the alarm condition exists. The alarms automatically return to the normal condition when the alarm condition clears and thus no alarm acknowledgment is required. Alarm conditions are also available over the optional serial communications interfaces.

The instrument may also be equipped with up to four (4) optional alarm relays. When the alarm relays are installed the individual alarms can be setup to operate any single alarm relay and a single alarm relay can be operated by multiple alarms. The alarm relays are energized when the associated alarms are all in the normal, non-alarm state. If any of the associated alarms enter the alarm state the relay will become de-energized. This action provides for fail-safe operation on loss of supply power. The unit is also provided with a watchdog circuit that is used to detect an instrument failure and if a failure is detected the alarm relays will all become de-energized.

The "Access Level" must be set to "Full" in order for changes to the alarm settings to be allowed. Any attempt to change a setting with the "Access Level" set to "Limited" or "Operator" will result in the message *"—Warning-- / Write Access Denied"* being displayed momentarily

5.3.1 Process Variable (PV) Alarms

There are a total of four (4) Process Variable alarms available. These alarms are used to check the value of the primary or secondary measured variables. These alarms are applicable to all instrument configurations. In a typical installation these four alarms could be configured to provide High-High, High, Low and Low-Low alarms. Other possible configurations would be to use some of the alarms as actual alarms, but to use others for control purposes. The following paragraphs provide details on setting the individual parameters for a given Process Variable, PV, alarm. A single alarm is presented, but the information pertains to all four alarms.

5.3.1.1 Status

This setting is the primary entry for the alarm. It determines whether, or not, the alarm is active. The state is determined by selecting either the "Disable" (Off) or "Enable" (On) setting from the menu. All disabled alarms are set to their normal, non-alarm, state.

When the instrument's database is initialized all PV alarms are enabled.

5.3.1.2 Measurement

This setting is used to select the measurement value to be checked for an alarm condition. The available selections are determined by the current measurement mode. If the measurement mode is "Level Only" then there is no selection to be made. If the "Measurement Mode" is "Level & Volume" then the default selection is "Volume", but "Level" may be selected. If the measurement mode is "Level & Flow" then the default selection is "Flow", but "Level" may be selected.

If the measurement mode is changed then the "Measurement" selection will automatically be changed to the default value for that mode.

5.3.1.3 Fail-Safe Mode

This setting is used to determine the type, High or Low, alarm action desired. The "LLFS", low level fail-safe, selection is used for low and low-low alarms. The "HLFS', high level fail-safe, selection is used for high and high-high alarms.

A "LLFS" alarm is one which the alarm state is entered when the selected measurement is below the low alarm setpoint. The alarm condition is exited when the measurement rises above either the low alarm setpoint by the fixed deadband or above the high setpoint as determined by the alarm type selection. A "HLFS" alarm is one which the alarm state is entered when the selected measurement is above the high alarm setpoint. The alarm condition is exited when the measurement falls below either the high alarm setpoint minus the fixed deadband or below the low setpoint as determined by the alarm type selection.

When the instrument's database is initialized all PV alarm fail-safe modes are set to "HLFS" mode.

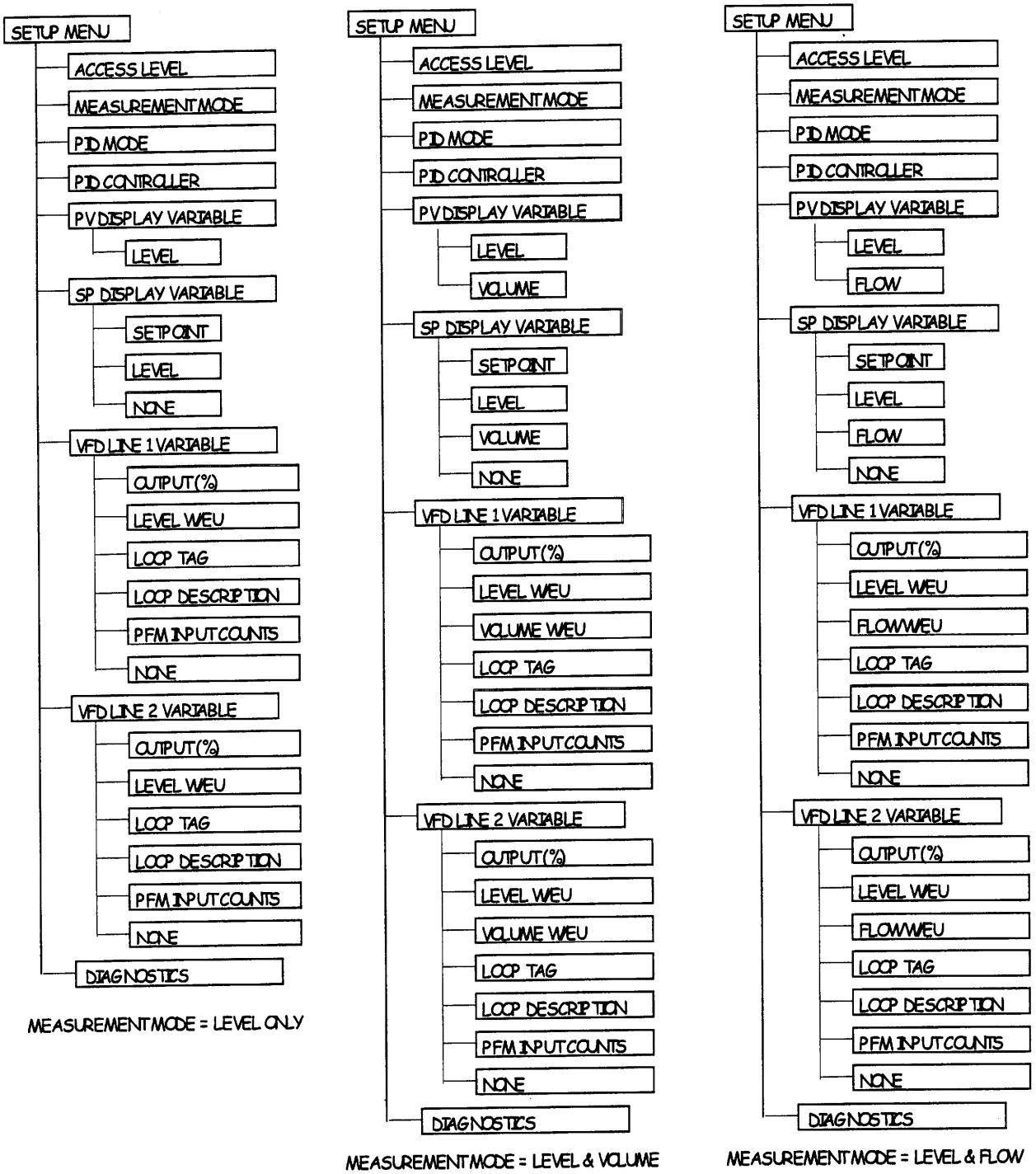


Figure 5.2 –Display Setup Menu Items
(Shown with PID Option On)

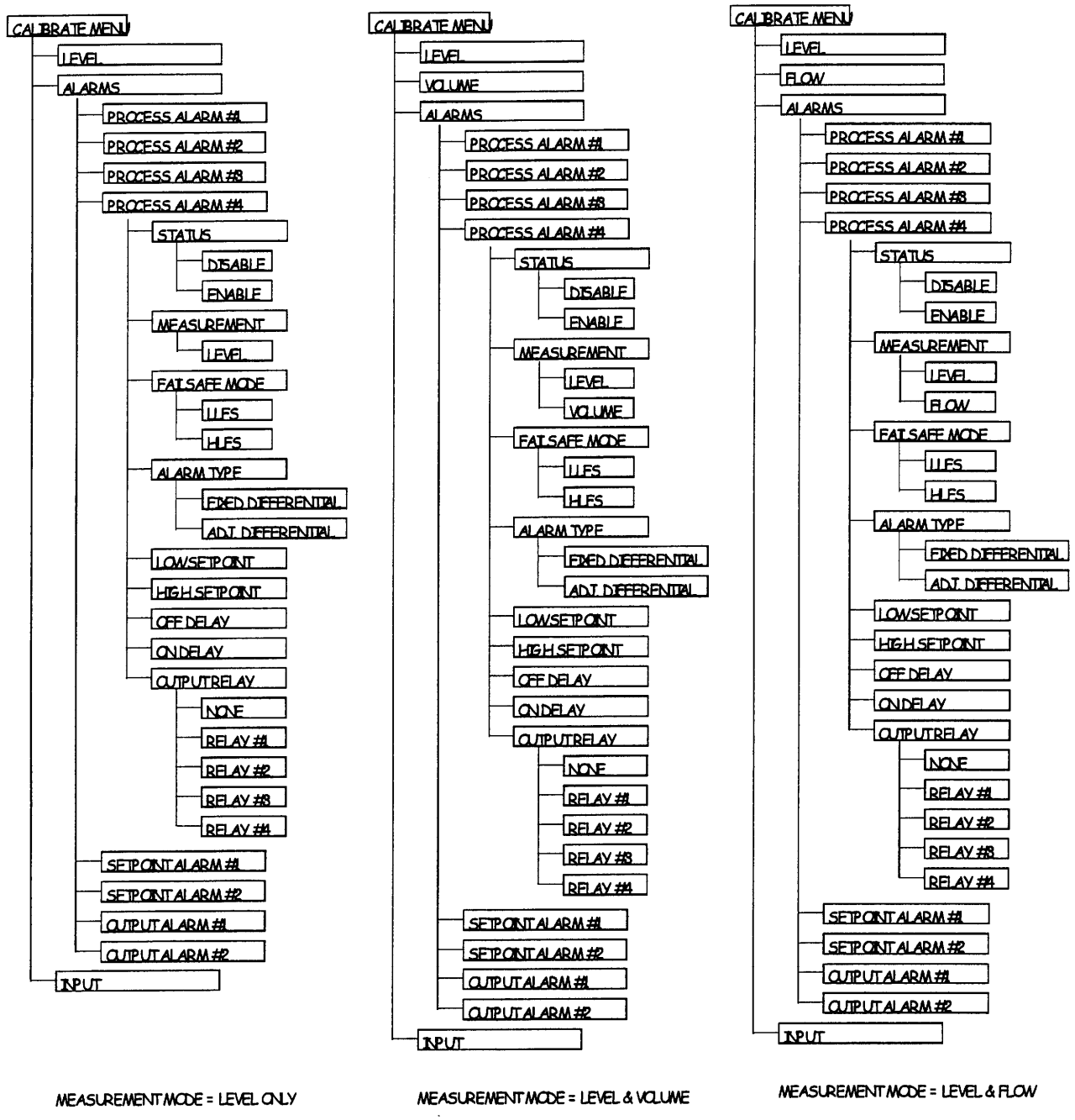


Figure 5.3 – Process Alarm Menu Items

5.3.1.4 Alarm Type

This setting is used to determine the deadband action to occur when checking an alarm for the return to normal condition. The deadband setting is used as one way to prevent nuisance alarm trips when the measurement is noisy and at the alarm setpoint. There are two selections for the alarm deadband. When an alarm is used for control purposes the deadband also determines the control range.

"Fixed Differential" provides for a predetermined deadband and only requires a single alarm setpoint. The instrument has a fixed differential of 0.5% of the selected measurement's span. "Adjustable Differential" requires setting both alarm setpoints and the differential is then the amount between the two setpoints.

When the instrument's database is initialized all PV alarm types are set to "Fixed Differential".

5.3.1.5 Low Setpoint

This entry is only required when the "Fail-Safe Mode" is "LLFS" or when the Fail-Safe Mode is "HLFS" and the Alarm Type is "Adjustable Differential". In the "LLFS" mode this is the value that when the measurement falls below it an alarm is activated. In the "HLFS" mode, with adjustable differential, this is the value which the measurement must fall below before the alarm is de-activated.

This entry is made in the units of the measurement being checked by the alarm. This value is stored internally as a percentage of the measurement span so that if the alarm's measurement source is changed the alarm setpoint will be at the same relative value.

When the instrument's database is initialized all PV alarm low setpoints are set to 0.00% of span.

5.3.1.6 High Setpoint

This entry is only required when the "Fail-Safe Mode" is "HLFS" or when the Fail-Safe Mode is "LLFS" and the Alarm Type is "Adjustable Differential". In the "HLFS" mode this is the value that when the measurement rises above it an alarm is activated. In the "LLFS" mode, with adjustable differential, this is the value which the measurement must rise above before the alarm is de-activated.

This entry is made in the units of the measurement being checked by the alarm. This value is stored internally as a percentage of the measurement span so that if the alarm's measurement source is changed the alarm setpoint will be at the same relative value.

When the instrument's database is initialized all PV alarm high setpoints are set to 90.00% of span.

5.3.1.7 Off Delay

This entry is used to specify the amount of time, seconds, that the measurement must be in the return to normal condition before the alarm is deactivated. This entry provides a means of preventing nuisance alarms due to a noisy measurement and/or process.

Care should be taken not to set this entry to an excessively long time because it can deaden the alarm action.

When the instruments database is initialized all PV alarm off delays are set to 0.0 seconds.

5.3.1.8 On Delay

This entry is used to specify the amount of time, seconds, that the measurement must be in the alarm condition before the alarm is activated. This entry provides a means of preventing nuisance alarms due to a noisy measurement and/or process.

Care should be taken not to set this entry to an excessively long time because it can deaden the alarm action.

When the instruments database is initialized all PV alarm on delays are set to 0.0 seconds.

5.3.1.9 Output Relay

This setting determines which output relay is activated in association with the alarm. A single relay can be operated by an alarm, but multiple alarms can operate a single relay. The relay selected will be in the energized state when no alarm is present, but de-energized when any associated alarm is present.

This setting can be made in any instrument configuration, but it does not have any meaning if the associated optional output relay is not installed. The possible selections for the output relay are "None", "Relay #1", "Relay #2", "Relay #3" or "Relay #4".

When the instrument's database is initialized all PV alarm output relays settings are set to their equivalent relay number.

5.3.2 PID Setpoint (SP) Alarms

There are a total of two (2) PID Setpoint alarms available. These alarms are used to check the value of the setpoint for the PID Control option and thus are only meaningful if the option is enabled. When the PID Control option is disabled these alarms are also disabled and are not present in the menu structure. These alarms can be configured as High-High, High, Low and Low-Low alarms. The following paragraphs provide details for setting the individual parameters for a given PID Setpoint, SP, Alarm. A single alarm is presented, but the information pertains to both alarms.

When the instrument's database is initialized all SP alarms are disabled.

5.3.2.1 Status

This setting is the primary entry for the alarm. It determines whether, or not, the alarm is active. The state is determined by selecting either the "Disable" (Off) or "Enable" (On) set-

ting from the menu. All disabled alarms are set to their normal, non-alarm state.

When the instrument's database is initialized all SP alarms are disabled.

5.3.2.2 Fail-Safe Mode

This setting is used to determine the type, High or Low, alarm action desired. The "LLFS", low level fail-safe, selection is used for low and low-low alarms. The "HLFS', high level fail-safe, selection is used for high and high-high alarms.

A "LLFS" alarm is one which the alarm state is entered when the setpoint is set below the low alarm setpoint. The alarm condition is exited when the setpoint is set above either the low alarm setpoint by the fixed deadband or above the high setpoint as determined by the alarm type selection. A "HLFS" alarm is one which the alarm state is entered when setpoint is set above the high alarm setpoint. The alarm condition is exited when the setpoint is set below either the high alarm setpoint minus the fixed deadband or below the low setpoint as determined by the alarm type selection.

When the instrument's database is initialized all SP alarm fail-safe modes are set to HLFS mode.

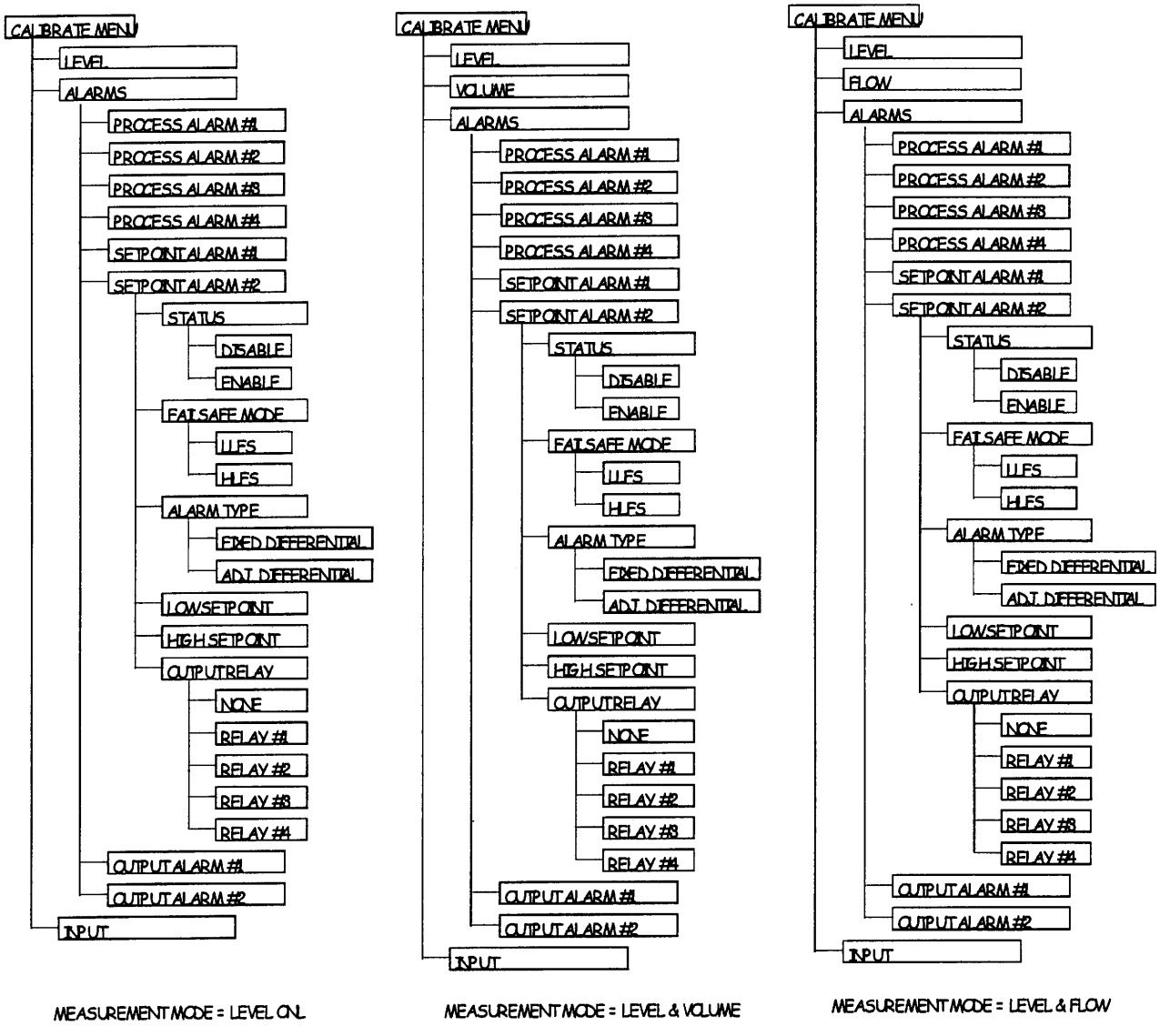


Figure 5.4 – Setpoint Alarm Menu Items

5.3.2.3 Alarm Type

This setting is used to determine the deadband action to occur when checking an alarm for the return to normal condition.

"Fixed Differential" provides for a predetermined deadband and only requires a single alarm setpoint. The instrument has a fixed differential of 0.5% of the setpoint's span. "Adjustable Differential" requires setting both alarm setpoints and the differential is then the amount between the two setpoints.

When the instrument's database is initialized all SP alarm types are set to Fixed Differential.

5.3.2.4 Low Setpoint

This entry is only required when the "Fail-Safe Mode" is "LLFS" or when the Fail-Safe Mode is "HLFS" and the Alarm Type is "Adjustable Differential". In the "LLFS" mode this is the value that when the setpoint is set below it an alarm is activated. In the "HLFS" mode, with adjustable differential, this is the value which the setpoint must be set below before the alarm is de-activated.

This entry is made in the units of the measurement being used for PID control. This value is stored internally as a percentage of the measurement span so that if the PID control's measurement source is changed the alarm setpoint will be at the same relative value.

When the instrument's database is initialized all SP alarm low setpoints are set to 0.00% of span.

5.3.2.5 High Setpoint

This entry is only required when the "Fail-Safe Mode" is "HLFS" or when the Fail-Safe Mode is "LLFS" and the Alarm Type is "Adjustable Differential". In the "HLFS" mode this is the value that when the setpoint is set above it an alarm is activated. In the "LLFS" mode, with adjustable differential, this is the value which the setpoint must be set above before the alarm is de-activated.

This entry is made in the units of the measurement being used for PID control. This value is stored internally as a percentage of the measurement span so that if the alarm's measurement source is changed the alarm setpoint will be at the same relative value.

When the instrument's database is initialized all SP alarm high setpoints are set to 100.00% of span.

5.3.2.6 Output Relay

This setting determines which output relay is activated in association with the alarm. A single relay can be operated by an alarm, but multiple alarms can operate a single relay. The relay selected will be in the energized state when no alarm is present, but de-energized when any associated alarm is present.

This setting can be made in any instrument configuration, but it does not have any meaning if the associated optional output relay is not installed. The possible selections for the output relays are "None", "Relay #1", "Relay #2", "Relay #3" or "Relay #4".

When the instrument's database is initialized all SP alarm output relays settings are set to "None".

5.3.3 Analog Output (O) Alarms

There are a total of two (2) analog output alarms available. These alarms are used to check the value of the analog, 4-20 mADC, output. The analog output can represent either the measured value, transmitter mode, or the PID control output, controller mode. These alarms can be set even though the optional analog output is not installed. These alarms can be configured as High-High, High, Low and Low-Low alarms. The following paragraphs provide details for setting the individual parameters for a given analog output, O, alarm. A single alarm is presented, but the information pertains to both alarms.

If the instrument is configured as a transmitter (PID control not enabled) then the value represented by the analog output is determined by the measurement mode, but if it is configured as a controller the analog output is the PID control output. If the measurement mode is "Level Only" the output is derived from the level measurement. If the "Measurement Mode" is "Level & Volume" then the output is derived from the volume measurement and if the measurement mode is "Level & Flow" the output is derived from the flow measurement.

When the instrument's database is initialized all O alarms are disabled.

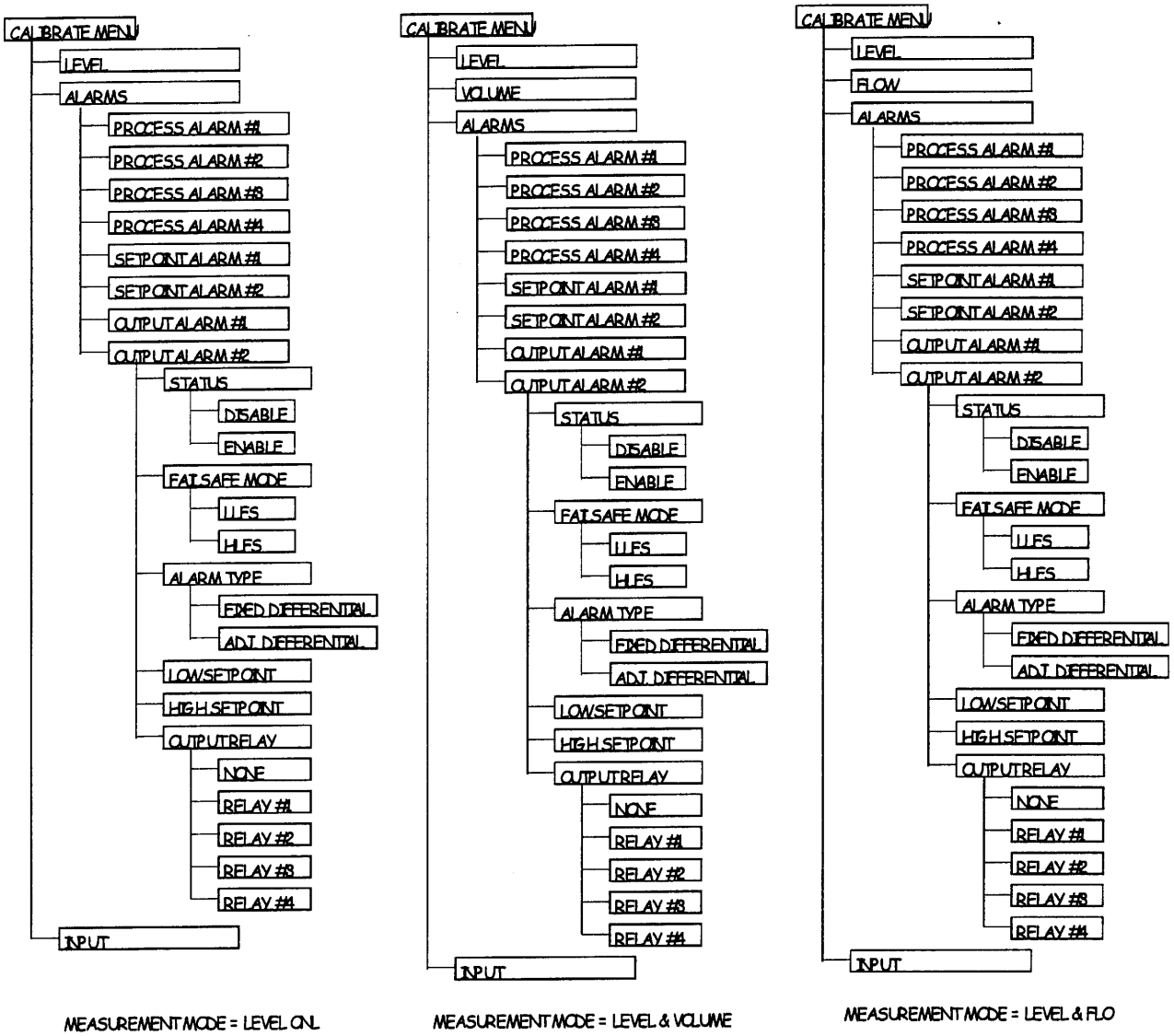


Figure 5.5 – Output Alarm Menu Items

5.3.3.1 Status

This setting is the primary entry for the alarm. It determines whether, or not, the alarm is active. The state is determined by selecting either the "Disable" (Off) or "Enable" (On) setting from the menu. All disabled alarms are set to their normal, non-alarm, state.

When the instrument's database is initialized all O alarms are enabled.

5.3.3.2 Fail-Safe Mode

This setting is used to determine the type, High or Low, alarm action desired. The "LLFS", low level fail-safe, selection is used for low and low-low alarms. The "HLFS', high level fail-safe, selection is used for high and high-high alarms.

A "LLFS" alarm is one which the alarm state is entered when the analog output value is below the low alarm setpoint. The alarm condition is exited when the analog output value rises above either the low alarm setpoint by the fixed deadband or above the high setpoint as determined by the alarm type selection. A "HLFS" alarm is one which the alarm state

is entered when the selected analog output value is above the high alarm setpoint. The alarm condition is exited when the analog output value falls below either the high alarm setpoint minus the fixed deadband or below the low setpoint as determined by the alarm type selection.

When the instrument's database is initialized all O alarm fail-safe modes are set to HLFS mode.

5.3.3.3 Alarm Type

This setting is used to determine the deadband action to occur when checking an alarm for the return to normal condition. The deadband setting is used as one way to prevent nuisance alarm trips when the analog output value is noisy and at the alarm setpoint. There are two selections for the alarm deadband. When an alarm is used for control purposes the deadband also determines the control range.

"Fixed Differential" provides for a predetermined deadband and only requires a single alarm setpoint. The instrument has a fixed differential of 0.5% of the selected analog output value's span. "Adjustable Differential" requires setting both alarm setpoints and the differential is then the amount between the two setpoints.

When the instrument's database is initialized all O alarm types are set to Fixed Differential.

5.3.3.4 Low Setpoint

This entry is only required when the "Fail-Safe Mode" is "LLFS" or when the Fail-Safe Mode is "HLFS" and the Alarm Type is "Adjustable Differential". In the "LLFS" mode this is the value that when the analog output value falls below it an alarm is activated. In the "HLFS" mode, with adjustable differential, this is the value which the analog output must fall below before the alarm is de-activated.

This entry is made in percent, %, of span of the analog output.

When the instrument's database is initialized al O alarm low setpoints are set to 0.00% of span.

5.3.3.5 High Setpoint

This entry is only required when the "Fail-Safe Mode" is "HLFS" or when the Fail-Safe Mode is "LLFS" and the Alarm Type is "Adjustable Differential". In the "HLFS" mode this is the value that when the analog output value rises above it an alarm is activated. In the "LLFS" mode, with adjustable differential, this is the value which the analog output value must rise above before the alarm is de-activated.

This entry is made in percent, %, of span of the analog output.

When the instrument's database is initialized all O alarm high setpoints are set to 100.00% of span.

5.3.3.6 Output Relay

This setting determines which output relay is activated in association with the alarm. A single relay can be operated by an alarm, but multiple alarms can operate a single relay. The relay selected will be in the energized state when no alarm is present, but de-energized when any associated alarm is present.

This setting can be made in any instrument configuration, but it does not have any meaning if the associated optional output relay is not installed. The possible selections for the output relay are "None", "Relay #1", "Relay #2", "Relay #3" or "Relay #4".

When the instrument's database is initialized all O alarm output relay settings are set to "None".

5.4. USING PID CONTROL

The Excalibur 7000 has a user selectable PID control function. This PID control uses the optional analog output and can be configured to control either the primary measured variable, level, or secondary interpolated variable, volume or flow.

5.4.1 Enabling the PID Control Function

Enabling the PID control function changes the basic operation of the Excalibur 7000 from a transmitter/indicator to a controller and because of this making this change will have significant effects on the operation of the instrument. When turning the PID control option's state, either "On" to "Off" or "Off" to On" the user must be sure that he or she understands the impact this change will have on the operation of the instrument and the process it is monitoring. **Paragraph 4.3.3.1** of this manual details the procedure for making this change and its impact on the displayed variables.

When the PID control function is enabled the PID control status is set to "Manual", autotuning is set "Off" and the control mode is set to "Proportional Only". The PID controlled variable is set to the Primary variable as determined by the "Measurement Mode", level, volume or flow, and the loop Setpoint, SP, is set to mid-scale. The Proportional Gain constant, KG, is set to 2.00 and the analog output is remapped to be driven by the PID calculation rather than a process measurement. The analog output is setup with a

range of 0.00 % to 100.00 % and a span of 0.00 % to 100.00 %.

These initialized values will result in the analog output remaining at the value it had prior to enabling PID control, but this may, or may not, result in a process upset. The actual results will be determined by the loop configuration and is installation dependent.

5.4.2 Setting Up the PID Controller

If the PID control function is enabled then a sub-menu will exist that is accessible through the **[SETUP]** key. This sub-menu provides access to the setup and tuning parameters for PID control. The setup items will require the "Access Level" to be set to "Full". The procedure for setting the "Access Level" is described in **Paragraph 4.3.1** of this manual.

5.4.2.1 Selecting the Controlled Variable

The first setup item is the determination of the variable to be controlled. The selections possible for this item are determined by the "Measurement Mode" of the instrument. If "Level Only" is the selected mode then there is no selection to be made for this item. When the PID control function is enabled the PID controlled variable will automatically be set to "Level" and this is the only possible variable. If "Level & Volume" is the selected mode then either level or volume can be selected as the controlled variable. When the PID control function is enabled "Volume" will be selected as the controlled variable, but the user may change this selection to "Level". If "Level & Flow" is the selected mode then either level or flow can be selected as the controlled variable. When the PID control function is enabled "Flow" will be selected as the controlled variable, but the user may change this selection to "Level".

The menu selection to select the controlled variable can be accessed by pressing the **[SETUP]**, **[NEXT]**, **[NEXT]**, **[NEXT]** and **[ENTER]** keys in sequence. The instrument will respond by displaying *"Controlled Variable/Level"* on the VFD. The **[NEXT]** and **[LAST]** keys can then be used to scroll between the possible selections. The current selection will be indicated by an indicator in the extreme right-hand character position of the bottom line. If it is necessary to make a change then scroll until the desired variable is displayed on the bottom line and the press the **[ENTER]** key to make it the current selection. The **[CLEAR]** key can be used to return to the previous display.

5.4.2.2 Setting the Output Direction

The last setup item is to determine the "direction" of the PID control function. The PID control has an output range of 0.00% to 100.00% and the direction of the PID control is set by mapping these values to the 4.00 to 20.00 mADC output. When the PID control function is enabled the mapping is set so that 4.00 mADC is output when the PID output is 0.00% and 20.00 mADC is output when the PID output is 100.00%.

Since the PID control calculation results in an output value that decreases as the measured value increases this initial mapping results in "Reverse" action. In order to obtain "Direct" action the mapping must be reversed so that 4.00 mADC is the output when the PID output is 100.00% and 20.00 mADC is the output when the PID output is 0.00%. It should be noted that if desired the PID control output can be mapped across any portion of the 4.00 to 20.00 mADC output as long as at least 10.00% of the analog output span is used. "Direct" action is still obtained by setting the 4.00 mADC point above the 20.00 mADC point.

5.4.2.2.1 Setting the 4 mADC Point

The menu selection to enter the 4 mADC point for the PID controller output (LRV) can be entered from the previous menu item by pressing the **[NEXT]** key. It can also be entered from the normal operating mode by pressing the **[SETUP]**, **[NEXT]**, **[NEXT]**, **[NEXT]**, **[ENTER]**, **[NEXT]** and **[ENTER]** keys in sequence. The instrument will respond by displaying *"Cal Analog Output/4 mA Point (%)"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"4 mA Point (%)/xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in percent, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in Paragraph 4.2.2.2 of this manual.

This value is the PID controller output value at which the analog output value will be 4.00 mADC. The analog output is scaled linearly between this value and the following entry. This value must be between 0.00% and 100.00% and must differ from the next value by at least 10.00%.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

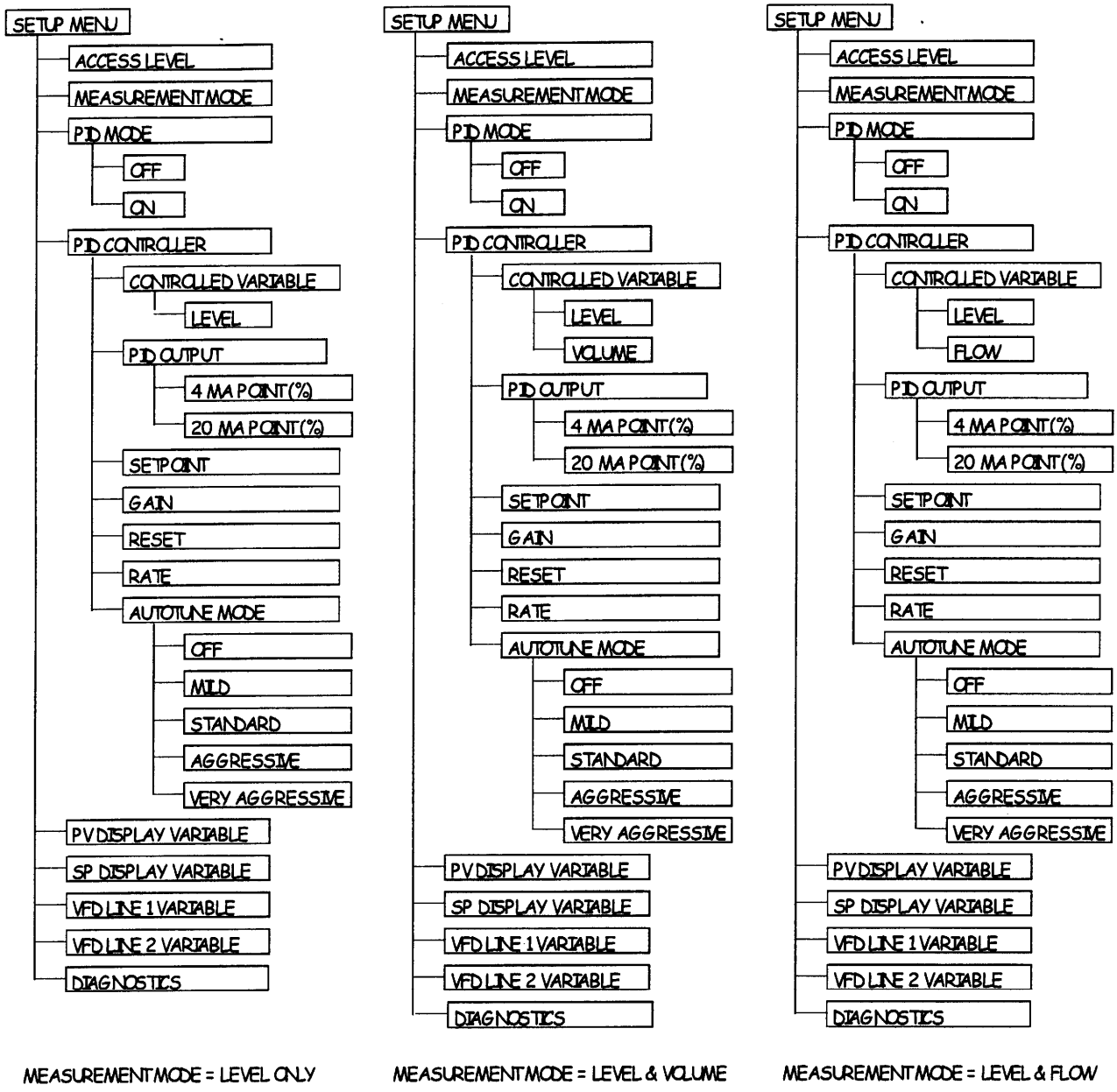


Figure 5.6 – PID Control Function Setup/Tuning Menu Items

5.4.2.2.2 Setting the 20 mADC Point

The menu selection to enter the 20 mADC point for the PID controller output (URV) can be entered from the previous menu item by pressing the **[NEXT]** key. It can also be entered from the normal operating mode by pressing the **[SETUP]**, **[NEXT]**, **[NEXT]**, **[NEXT]**, **[ENTER]**, **[NEXT]**, **[ENTER]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"Cal Analog Output/20 mA Point (%)"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"20 mA Point (%)/xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in percent, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in Paragraph 4.2.2.2 of this manual.

This value is the PID controller output value at which the analog output value will be 20.00 mADC. The analog output is scaled linearly between this value and the previous entry.

This value must be between 0.00% and 100.00% and must differ from the next value by at least 10.00%.

Once the desired value has been entered the instrument will respond by returning to the previous menu.

5.4.3 Selecting the PID Controller Operating Mode

The PID control function has two distinct operating modes, "Automatic" and "Manual". In the "Automatic" mode the instrument compares the operator entered setpoint value to the current value of the selected measured variable and then uses the tuning parameters (Gain, Reset and Rate) to calculate the required analog output value. When the PID function is in the "Manual" mode instead of entering a setpoint value the operator directly enters the analog output value. The "AUTO/MANUAL" key on the front panel is used to toggle between these two modes and the "MANUAL" LED is illuminated when the PID control function is in the "Manual" mode. When PID control is first enabled the operating mode is set "Manual".

When in the "Manual" operating mode pressing any numeric key on the front panel will cause the instrument to display *"PID Output/ xxx.xx ->* ___" on the VFD. The "xxx.xx" will be the current setting, in percent, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** of this manual. The value entered must be between 0.00% and 100.00%.

When in the "Automatic" operating mode pressing any numeric key on the front panel will cause the instrument to display *"PID Setpoint/ xxx.xx ->* _____" on the VFD. The "xxx.xx" will be the current setting, in the engineering units of the controlled variable, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** of this manual. The value entered must be within the span of the controlled variable.

It should be noted that changing the auto/manual mode requires that the "Access Level" be set to either "Operator" or "Full".

5.4.4 Placing the Controlled Variable Under Automatic Control

Placing the controlled variable under automatic control for the first time requires that certain steps be taken in the proper sequence. The user must first decide upon which PID control configuration is applicable to the process being controlled. The possible modes are as follows:

- Proportional Only (P)
- Proportional + Reset (PI)
- Proportional + Rate (PD)
- Proportional + Reset + Rate (PID)

Most level control loops will benefit the most from Proportional + Reset (PI) control. As previously stated when the PID control function is enabled the automatic control mode is configured to be Proportional Only. The mode can be changed by making the required entries into the tuning constants as described in the following paragraphs.

The first step is to adjust the manual output to obtain a stable measurement that is close to the desired operating setpoint. The procedure for adjusting the manual output is described in **Paragraph 5.4.3** above. Once stable operation is obtained then either the manual or automatic tuning procedures that follow can be used to set the proper constants.

NOTE

It is not the purpose of this manual to teach the user how to tune the PID control function, but rather to instruct him, or her, in the steps and procedures necessary to enter the tuning constants and setting up the control function.

There are many texts available on the subject of tuning PID controllers, such as:

CONTROLLER TUNING AND CONTROL LOOP PERFORMANCE
A Primer by David W, St. Clair

Published by:
STRAIGHT-LINE CONTROL COMPANY, INCORPORATED
3 Bridle Brook Lane
Newark, DE 19711-2003
(302) 731-4699, fax (302) 545-8599

5.4.4.1 Manual Tuning

In order to better understand the functioning of the PID control option **Figure 5.2** shows the general form of the PID algorithm employed by the Excalibur 7000. The equation shows that "Reset" and/or "Rate" portion of the calculation can be eliminated by effectively setting KI and/or KD to zero (0.00). It also shows that manual reset is effectively accomplished by retaining the manual output at the time automatic control is initiated. Cv is the calculated output of the PID control function and Cv_0 is manual output value when the loop was transferred to automatic control.

$$Err = Sp - Meas$$

$$Cv = KG(Err_t + KI\sum_{0}^{t} Err + KD * (Err_t - Err_{t-1})) + Cv_0$$

Figure 5.7 – PID Equation

Now that the loop is in stable operation, the control mode determined and the tuning constants estimated the constants can be entered and the loop performance tested. The performance can best be tested by making setpoint changes, within the constrains dictated by the process, and monitoring the process response. This most likely will be an iterative process until the desired process response to an upset is obtained. Depending upon the process dynamics this tuning process could take from several hours to several days.

5.4.4.1.1 Gain Constant (KG)

The gain constant is a dimensionless number that affects all terms in the PID calculation. All PID modes require a gain setting. The gain constant is found in the "Setup" menu in the "PID Controller" sub-menu.

The menu selection to enter the gain constant (KG) can be entered from the previous menu item by pressing the **[NEXT]** key. It can also be entered from the normal operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"PID Controller/Gain"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PID Gain Constant/xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** of this manual. The value entered must be in the range of 0.000 to 1999.99.

5.4.4.1.2 Reset Constant (KI)

The reset constant is a time value that affects the integral, "I", term of the PID calculations. The reset constant value determines if the integral action is active or not. For the Proportional Only (P) and Proportional + Rate (PD) modes the reset term is disabled by setting its value equal to the maximum value, 1999.99 minutes. For the other modes the reset constant is set to a value between 0.01 minutes and 1999.98 minutes.

The menu selection to enter the reset constant (KI) can be entered from the previous menu item by pressing the **[NEXT]** key. It can also be entered from the normal operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"PID Controller/Reset"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PID Reset Constant/xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in minutes, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** of this manual.

5.4.4.1.3 Rate Constant (KD)

The rate constant is a time value that affects the derivative, "D", term of the PID calculations. The rate constant value determines if the derivative action is active or not. For Proportional Only (P) and Proportional + Reset (PI) modes the rate term is disabled by setting its value equal to the minimum value, 0.00 minutes. For the other modes the rate constant is set to a value between 0.01 minutes and 1999.99 minutes.

The menu selection to enter the reset constant (KI) can be entered from the previous menu item by pressing the **[NEXT]** key. It can also be entered from the normal operating mode by pressing the **[SETUP]**, **[NEXT]**, **[NEXT]**, **[NEXT]**, **[ENTER]**, **[NEXT]**, **[NEXT]**, **[NEXT]**, **[NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"PID Controller/Rate"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"PID Rate Constant/xxx.xx ->* _____*"* on the VFD. The "xxx.xx" will be the current setting, in minutes, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** of this manual.

5.4.4.2 Automatic Tuning (AutoTune)

In Order to relieve the user of the burden of manually tuning the PID control option the Excalibur 7000 has an automatic tuning option called "AutoTune". In order to use the AutoTune, AT, option the user only needs to determine the desired control mode and place the loop in a stable operating condition.

The initial step required to AutoTune the controller is to determine the required operating mode and then make the appropriate entries into the tuning parameters (KG, KI & KD). Some typical values for the initial tuning parameters are shown in the table below:

Table 5.3 – Sample Initial Tuning Constants

Constant	Value	Units
KG (Gain)	2.000	(none)
KI (Reset)	1,000.00	minutes
KD (Rate)	1.00	minutes

It is recommended that the controller be in the "Manual" mode, **MANUAL** LED illuminated, while this is being done. In order to retain stable operation when the controller is placed in the "Auto" mode it is suggested that conservative entries be made in the active constants.

Once the tuning constants are set then the controller's manual output should be adjusted until stable operation is obtained. When the process has stabilized place the PID control in "Auto", using the **[MANUAL/AUTO]** key. The **MANUAL** LED should not be illuminated.

The AutoTune function can also be used to update the controller tuning when process conditions have changed, not just at loop startup. Examples of changing process conditions are a change in the operating setpoint or a change in product characteristics. In this case stable operation must still be obtained prior to initiating AutoTuning.

When AutoTuning is initiated the Excalibur 7000 first checks to see that there is enough span available to allow for a ±8.333% change in measured variable. If not the AutoTune function is aborted and the loop returned to automatic control. If there is enough span available the controller output is set to its maximum value to cause an increase in the measured variable and the measurement is monitored to detect when it reaches the desire value. When the maximum value is reached a set of calculations are made to determine temporary tuning constants. These constants are then used to return the controlled variable back to its original value. Once the measurement has stabilized the output is set to its minimum value to cause a decrease in the measured variable and the measurement is monitored to detect when it reaches the desire value. After the minimum value is reached calculations are performed to determine the final tuning constants and the loop is returned to automatic control.

The user should be aware that using the AutoTune function creates a disturbance in the process and it is his, or her, responsibility to determine that this will not result in unsafe operation. Also, the length of time required for the AutoTune cycle to complete is a function of the process dynamics and could vary from minutes to hours.

5.4.4.2.1 AutoTune (AT) Mode

AutoTuning is initiated, on-demand, by the operator. In order to use the AutoTune feature the "Access Level" must be set to either "Operator" or "Full" and the process variable being controlled must be in a stable condition and the PID control function must be operating in the "Auto" mode. See the preceding paragraphs for the procedures for placing the variable into a stable condition. Also, be aware that the AutoTune process will cause a process disturbance of ±8.333%.

Verify that the PID control function is enabled by observing that the **MANUAL** LED is <u>not</u> illuminated and that an AutoTune cycle is not in progress by observing that the **AUTOTUNE** LED is <u>not</u> illuminated. The AutoTune mode menu selection can be accessed from the normal operating mode

by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *'PID Controller/Autotune Mode"* on the VFD.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Autotune Off"* on the VFD. The **[NEXT]** and/or **[LAST]** keys can then be used to scroll between the possible AutoTune modes (Off, Mild, Standard, Aggressive and Very Aggressive). Each mode will result in a faster control response than the preceding one, but faster response will result in more over-shoot when responding to a process upset, or setpoint change. When the desired mode is displayed on the bottom line of the VFD pressing the **[ENTER]** key will initiate an AutoTune cycle. The display will return to the preceding menu display and the **[CLEAR]** key can be used to return to the normal display mode.

If there is enough span available to support the required process "bump", plus a 5.00% cushion the **AUTO-TUNE** LED will illuminate and stay illuminated until the AutoTune cycle completes. At the end of the cycle the original PID constants will be replaced by the new ones calculated as a result of AutoTuning.

5.4.5 Normal PID Operation

Once the controller has been tuned, either manually or AutoTuned, the PID control function is ready for normal operation. After tuning, the instrument's "Access Level" should be returned to the desired level.

If the normal operating level is "Limited" then there will be no front panel access to any of the PID control related menu selections and the **[AUTO/MANUAL]** key will also be disabled. These items will still be accessible remotely by either the HART or MODBUS communications options.

If the normal operating access level is "Operator" then there will be access to the PID constants and the **[AUTO/MANUAL]** key will be active. These items will also be accessible remotely by either the HART or MODBUS communications options.

If the normal operating level is "Full" then there will be unlimited access to all PID related menu items and the **[AUTO/MANUAL]** key will be active. These items will also be accessible remotely by either the HART or MODBUS communications options.

5.4.5.1 Changing the PID Operating Mode (Automatic/Manual)

The PID control function has two basic operating modes, automatic or manual, and the mode is selected by pressing the **[AUTO/MANUAL]** key on the front panel. The operating mode toggles between automatic and manual.

Changing the PID control operating mode from "Auto" to "Manual" causes the **MANUAL** LED to be illuminated and the manual output is set equal to the current output value from the PID calculation. PID calculations are also suspended. The value displayed on the **SETPOINT** LED's is also remapped to be the manual output value. The PID manual output can be changed as described below.

Changing the PID control operating mode from "Manual;" to "Auto" causes the **MANUAL** LED not to be illuminated. The PID setpoint is set equal to the current measurement and the initial PID calculated output is set equal to the manual output. PID calculations are re-enabled. The value displayed on the **SETPOINT** LED's is also remapped to be the setpoint value. The PID setpoint can then be changed as described below.

5.4.5.2 Changing the PID Control Output

If the PID control operating mode is "Manual" pressing any numeric key on the front panel will cause the instrument to respond by displaying *"PID Output/xxx.xx ->_____"* on the VFD. The "xxx.xx" will be the current manual output, in percent (%) of span, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in Paragraph 4.2.2.2 of this manual and must be in the range of 0.00% to 100.00%.

5.4.5.3 Changing The PID Setpoint (SP) Value

If the PID control operating mode is "Auto" pressing any numeric key on the front panel will cause the instrument to respond by displaying *"PID Setpoint/xxx.xx ->_____"* on the VFD. The "xxx.xx" will be the current setpoint value, in the engineering units of the controlled variable, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value is entered as described in **Paragraph 4.2.2.2** of this manual and must be in the range of the controlled variable.

The PID control setpoint can also be accessed from the normal operating mode by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT]** and **[NEXT]** keys in sequence. The instrument will respond by displaying *"PID Setpoint/xxx.xx ->____"* on the VFD. The "xxx.xx" will be the current setpoint value, in the engineering units of the controlled variable, and the blank space to the right of the "->" is reserved for the entry of a new value. A new value Is entered as described in **Paragraph 4.2.2.2** of this manual and must be in the range of the controlled variable.

SECTION VI – DIAGNOSTICS

6.1. GENERAL

The Excalibur 7000 Level Controller has validity checks that are always active and either prevent the user from making invalid entries or issue a warning when associated entries are not valid. There are also hardware diagnostics that constantly check the instruments operating condition. In addition to these checks there a series of on-demand diagnostics that can be executed at the users discretion.

6.2. Validity Checks

The purpose of the validity checks is to prevent the operator from making a numeric entry that is outside the acceptable range for numeric value being adjusted. If the value entered is outside the limits for the variable then when the **[ENTER]** key is pressed the value entered is cleared from the VFD and the entry process is re-initiated. In most cases the details of the variable entry discussed in previous sections also gives the range of acceptable values.

6.2.1 Warnings

In some cases when an entry causes a calculation to be made the instrument will check the result of that calculation and display a warning message, if the result is outside the expected norms. A warning is also displayed if the variable the user is trying to access requires a higher access level.

6.2.1.1 Entry Requires Higher Access Level

If the menu item being selected requires a higher access level than is currently set the instrument will momentarily display the message *"—Warning -- / Write Access Denied"* on the VFD. In order to gain access to the item the access level must be increased, by someone having the proper password access. This message is displayed when the **[ENTER]** key is pressed to access a menu selection.

6.2.1.2 Wrong Password Entered When Changing the Access Level

In order to change the access level the user must enter the current password. If the password entered from the keypad does not match the current password the instrument will momentarily display the message *"—Warning -- / Write Access Denied"* on the VFD. The access level will remain unchanged.

6.2.1.3 Wrong Password Entered When Changing the Password

In order to change the password the user must enter the current password. If the password entered from the keypad does not match the current password the instrument will momentarily display the message *"—Warning -- / Write Access Denied"* on the VFD. The password change process will return to the previous step.

6.2.1.4 Password Change Validation Failure

In order to change the password the user must enter the new password twice to validate the change before the change takes effect. If the second entry of the new password does not match the first the instrument will momentarily display the message *"—Warning -- / Password Unchanged"* on the VFD. The password change process is aborted.

6.2.1.5 Analog Output Span Too Low

When entering the Upper Range Value, URV, or Lower Range Value, LRV, for the analog output associated with a measured value (level, volume or flow) a check is performed to verify that the resultant span would be greater than the minimum allowed. The minimum span requirement varies with the variable. If the minimum span requirements are not met the instrument will momentarily display the message *"—Warning -- / Input Span Too Low"* on the VFD. The new range value is not accepted and the entry process is aborted.

6.2.1.6 PFM Input Count Span Too Low During Calibration

When performing an input calibration, either single point or two point, a check is also made to see that span of the PFM input counts is greater than the minimum required. If the minimum requirements are not met the instrument will momentarily display the message *"—Warning -- / Input Span Too Low"* on the VFD. The new calibration data is not accepted and the process is aborted.

6.2.1.7 PID Output Span Too Low

When entering the Upper Range Value, URV, or Lower Range Value, LRV, for the analog output associated with the optional PID control a check is performed to verify that the resultant span would be greater than the minimum recommended. If the minimum span recommendation is not met the instrument will momentarily display the message *"Output Span Too Low"* on the bottom line of the VFD. The new range value is accepted anyway.

6.2.1.8 Flow Element Excessive Head Level

When the instrument initializes its database, the measurement mode changes or a flow element variable changes the maximum head level is checked. The maximum head level for the selected flow element is assumed to be the level Upper Sensor limit, USL. The instrument has a table that contains the maximum recommended head level for each type of open channel flow element and if the level upper sensor limit exceeds this recommended value the instrument will display momentarily display the message *"—Warning -- / Excessive Head Level"* on the VFD. The instrument will still calculate a maximum flow rate based on the level USL.

6.2.1.9 Sensor Span Too Low Warning

When storing a new Upper Sensor Limit, USL, the instrument checks to see that resulting span is greater than the minimum recommended. At the time the check is made the new USL has already been stored so a warning is displayed. The instrument will momentarily display the message *"—Warning -- / Span Too Low"* on the VFD.

6.2.2 Error/Fail Indicators

During normal operation there are a number of on-line checks performed upon the performance of the instrument. The results of these checks are displayed using LED's that are located on the front panel of the instrument and on the CPU/ Display printed circuit board assembly, PCA. The LED's located on the front of the instrument are visible through the window located in the front door of the instrument, but those located on the PCA require opening the front door and the front panel. The combination of LED's that are illuminated can be used to determine the exact error that was detected.

6.2.2.1 ERROR LED

This red LED is located on the front panel of the instrument. It can be the only LED illuminated, or it can be illuminated at the same time as another LED to indicate various error conditions.

If this is the only LED illuminated it indicates that the analog output value is saturated. This means that the value calculated to be the output is greater than 20 mADC or less than 4 mADC. The LED will remain illuminated until the value comes back within range.

6.2.2.2 PFM Fail LED

This red LED is located on the CPU/Display PCA. It is the center LED of the three (3) located on the lower right-hand edge of the PCA. When this LED is illuminated it indicates that the instrument is not receiving a valid pulse from the PFM transmitter.

NOTE

The absence of a valid input from the PFM transmitter is also responsible for the lack of updates of the front panel displays. If the unit has the power removed and re-applied this will be evident by the fact that both the **PROCESS** and **SETPOINT** displays will be blank.

Possible causes of the lack of a valid input are no PFM transmitter connected or a wiring error between the transmitter and controller. The detection of this input failure will not cause the **ERROR** LED to be illuminated.

6.2.2.3 Cal Error LED

This red LED is located on the CPU/Display PCA. It is the left-hand LED of the three (3) located on the lower right-hand edge of the PCA. When this LED is illuminated it signifies that a volume calibration minimum span recommendation has been violated. It will stay illuminated until a valid calibration is obtained. The detection of a calibration failure will not cause the **ERROR** LED to be illuminated.

If the error condition is the result of a front panel entry the user will have had a warning message displayed when the error was detected.

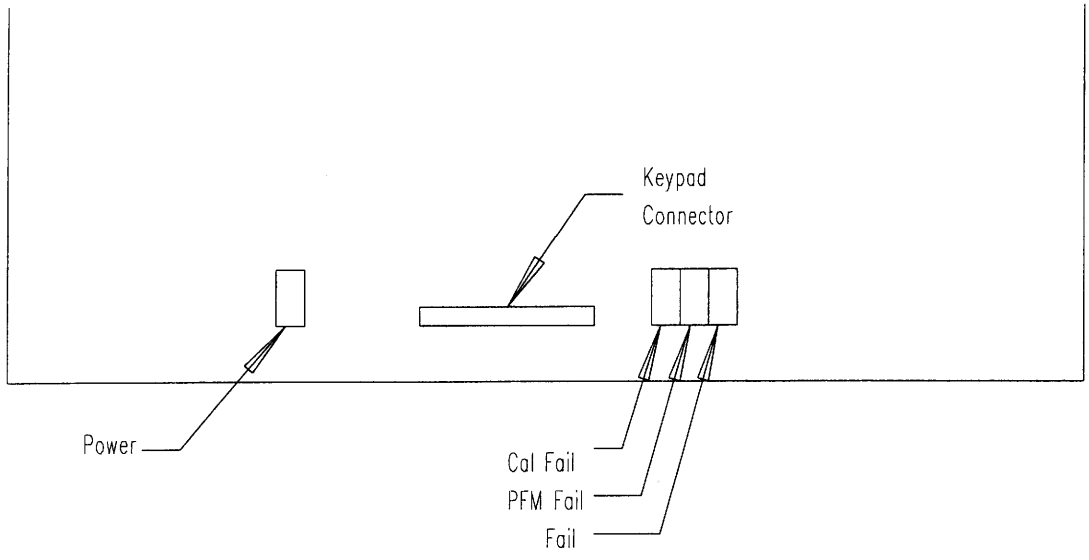


Figure 6.1 – Failure LED Locations
(CPU/Display PCA)

6.2.2.4 Instrument Failure

This red LED is located on the CPU/Display PCA. It is the right-hand most LED of the three (3) located on the lower right-hand edge of the PCA. When this LED is illuminated it indicates that a hardware failure has been detected. This failure is detected by the watchdog timer and indicated that the instrument is no longer cycling through its program. This LED will remain illuminated until proper operation is restored.

The detection of an instrument failure will also cause any optional alarm relays installed to go to the "Alarm" state.

6.3. On-Demand Diagnostics

There are a number of diagnostic functions that can be executed on-demand by the user. These diagnostic functions all require some evaluation of the results by the user and thus could not be automated. All of these diagnostics require that the "Access Level" be set to "Full".

6.3.1 PFM Input Test

The PFM Input Test function is an on-demand diagnostic tool that is used to verify the condition of the PFM transmitter, the interconnecting wiring and the controller input circuitry. It should be noted that while this test is in progress normal instrument functions are suspended. Because of this the diagnostic requires that the current "Access Level" be set to "Full"

This diagnostic is entered from the normal operating mode by pressing the **[SETUP], [LAST],** and **[ENTER]** keys in sequence. Alternately it can be entered by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT]** and **[ENTER]** keys in sequence. The unit will respond by displaying *"Diagnostics/PFM Input Test"* on the VFD. Pressing the **[ENTER]** key will cause the instrument to check the PFM input signal and then respond by displaying

either *"Input Pulse Width/ xxxxxxx usec"* or *""Input Pulse Width/PFM Input Failure"* on the VFD. The "xxxxxxx" in the first message represents the timing of the PFM input signal and is the same value that would be displayed if "PFM Input Period" were the selected variable on either line of the VFD. If the second message is displayed it indicates that a valid input signal is not present. In either case the test will abort after a short time and the instrument will return to normal operation.

6.3.1.1 Trouble Shooting the PFM Input

CAUTION

The following procedures involve working in the **Intrinsically Safe** portion of the instrument. If the instrument is used in an intrinsically safe application proper safety precautions must be taken.

If the failure message is displayed open the protective cover over TB701 on the PFM Input PCA, 044KX246, and measure the DC voltage across the terminals. Based upon the reading obtained the following table can be used to diagnose the fault.

Table 6.1 – PFM Input Trouble Shooting Procedure

Voltage Reading (VDC)	Corrective Action
12.00±10%	Measure voltage at the PFM transmitter. • If voltage is present – replace the transmitter PCA. • If the voltage is not present – wiring is "open" and needs to be repaired.
>12.00+10%	Replace the PFM Input PCA
<12.00-10%	Disconnect field wiring and repeat measurement • If voltage is present – wiring is shorted or the transmitter has failed • If the voltage is not present –. Replace the PFM Input PCA

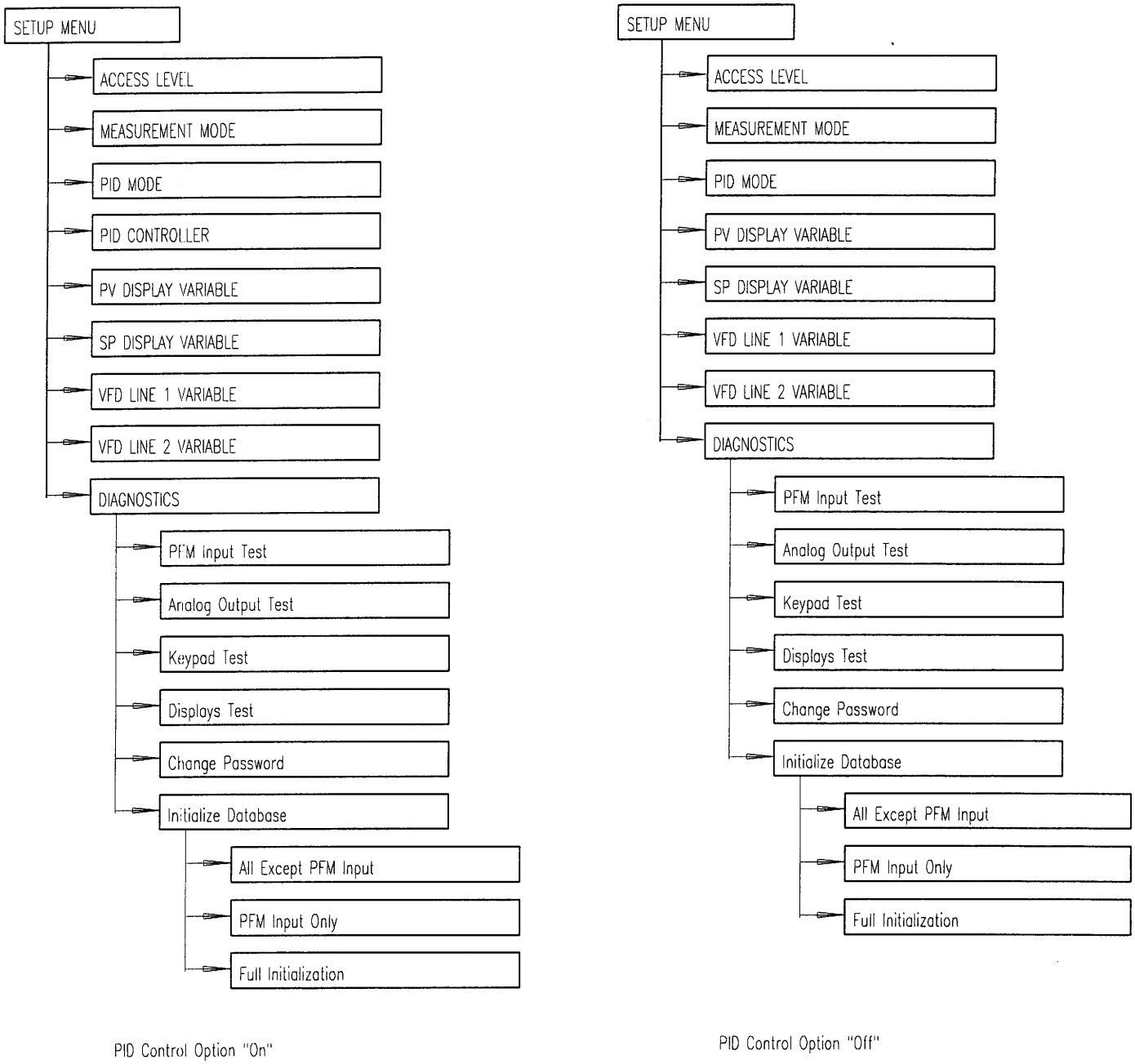


Figure 6.2 – Diagnostic Functions Menus

6.3.2 Analog Output Test

The Analog Output Test function is an on-demand diagnostic tool that is intended to provide a means to verify the operation of the analog, 4-20 mADC, output of the instrument.

CAUTION

The use of this diagnostic will affect the analog output value. If the PID Control option is active or the analog output is feeding other control devices these control loops should be placed into a safe mode before using this diagnostic.

This diagnostic is entered from the normal operating mode by pressing the **[SETUP], [LAST], [ENTER]** and **[NEXT]** keys in sequence. Alternately it can be entered by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [ENTER]** and **[NEXT]** keys in sequence. The unit will respond by displaying *"Diagnostics/Analog Output Test"* on the VFD. Pressing the **[ENTER]** key will cause the instrument respond by displaying either *"New AO Value (mADC)/4.000 ->* _____*"* on the VFD. The space to the right of the "->" is reserved for the entry of the desired output current. A value is entered as described in **Paragraph 4.2.2.2** above.

Pressing the **[CLEAR]** key will cause the instrument to set the output to the default value shown to the left of the "->" and increment the next default value by 4.000 mADC, or 25%, of span. This procedure allows the user to increment the output through its range in steps of 4.000 mADC, 25%, by pressing the **[CLEAR]** key. It should be noted that when the output reaches 20.000 mADC it wraps back to 4.000 mADC and repeats the previous steps. At any point the user can enter a value between 4.000 and 20.000 mADC and the output will be set to that value when the **[ENTER]** key is pressed. The diagnostic is exited by entering an output value of 0.000 mADC.

There are no adjustments associated with the analog output option, so if the measured output current does not match the value set then the Analog Output PCA should be replaced. It should be noted that this diagnostic can be executed even if the analog output option is not present, but it will have no effect.

6.3.3 Keypad Test

The Keypad Test is an on-demand diagnostic tool that is used to verify the functionality of the keys that are a part of the instrument front panel. It does not affect the operation of the instrument, but it does affect the information being displayed on the VFD

This diagnostic is entered from the normal operating mode by pressing the **[SETUP], [LAST], [ENTER], [NEXT]** and **[NEXT]** keys in sequence. Alternately it can be entered by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT]** and **[NEXT]** keys in sequence. The unit will respond by displaying *"Diagnostics/Keypad Test"* on the VFD. Pressing the **[ENTER]** key will cause the instrument respond by displaying either *Keypad Test)/*_____*"* on the VFD. The blank bottom line is reserved for echoing the value of the last key pressed. The keys echo the values shown in the following table in all 20 character positions on the bottom line of the VFD:

The test is terminated by pressing the **[CLEAR]** key twice consecutively.

Table 6.2 – Key Pressed vs. Displayed Character

Key	Value	Key	Value	Key	Value	Key	Value
Auto/ Manual	0	Local/ Remote	R	Setup	S	Calibrate	C
1	1	2	2	3	3	Enter	e
4	4	5	5	6	6	Next	▲
7	7	8	8	9	9	Last	▼
-	-	0	0	.	.	Clear	c

6.3.4 Displays Test

The Displays Test is an on-demand diagnostic tool that is used to verify the functionality of the various front panel displays. It does not affect the operation of the instrument, but it does affect the information being displayed on the VFD.

respond by executing the display diagnostic. This diagnostic begins by testing the VFD. The VFD test consists of first displaying the numeric characters and then the upper case letters. Each character is displayed in all displayable character positions of the VFD. After this sequence is completed the test moves to the LED's. The LED test pattern consists of 'rolling 8's" on the digits and an alternating pattern on the alarm and status LED's. The instrument will continue to cycle between the VFD and LED tests until the **[CLEAR]** key is pressed.

6.3.5 Change Password

This function provides the means to change the user password. The password is used to prevent unauthorized changes to the "Access Level".

This function is entered from the normal operating mode by pressing the **[SETUP], [LAST], [ENTER], [NEXT], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. Alternately it can be entered by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. The unit will respond by displaying *"Diagnostics/Change Password"* on the VFD. Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Current Password?/******* -> _____"* on the VFD. The space to the right of the "->" is reserved for entering the current user password. The password is entered as described in **Paragraph 4.2.2.2** above. It should be noted that the password being entered is displayed with "*" substituted for the number key pressed.

When the password is correctly entered the instrument will respond by displaying *"New Password?/******* -> _____"* on the VFD. The space to the right of the "->" is reserved for entering the new user password. The new password must be a number in the range of 1 to 65535, but it is recommended that it contain a minimum of 3 digits (no decimal points allowed). The password is entered as described in **Paragraph 4.2.2.2** above. It should be noted that the password being entered is displayed with "*" substituted for the number key pressed.

When the password is correctly entered the instrument will respond by displaying *"Verify New Password?/******* -> _____"* on the VFD. The space to the right of the "->" is reserved for re-entering the new user password. It should be noted that again the password being entered is displayed with "*" substituted for the number key pressed. If the re-entered value matches the initial entry the function exits. An error at any point will cause the instrument to momentarily display the message *"--- Warning --- /Password Unchanged"* and exit with the password unchanged.

WARNING

If the password is lost you will not be able to change the password so be sure to record the new password in a secure location for future reference.

6.3.6 Initialize Database

These functions provide a means for restoring the database items stored in nonvolatile memory to known values. These functions are useful when an instrument is being moved from one application to another. They can also be used to recover when the setup and/or calibration process has resulted in non-optimal operation and a large portion of the database needs to be changed. There are two partial database restoration functions in addition to the full database initialization function. The details of using these functions are contained in the following paragraphs.

CAUTION

Using these functions will affect the outputs of the instrument. It is recommended that the controlled device(s) be placed in a safe mode before using these functions.

This function is entered from the normal operating mode by pressing the **[SETUP], [LAST], [ENTER], [NEXT], [NEXT], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. Alternately it can be entered by pressing the **[SETUP], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [NEXT], [ENTER], [NEXT], [NEXT], [NEXT], [NEXT]** and **[NEXT]** keys in sequence. The unit will respond by displaying *"Diagnostics/Initialize Database"* on the VFD.

6.3.6.1 All Except PFM Input

This function initializes the database, but keeps the existing PFM input calibration values. This function is useful when it is desirable to return the instrument to a known condition before setting up alarms, PID Control, etc., but it is known that the input calibration is correct.

Pressing the **[ENTER]** key will cause the instrument to respond by displaying *"Initialize Database/All Except PFM Input"* on the VFD. Pressing the **[ENTER]** key will cause the instrument to make the following settings in its database.

Setup Variables

Function	Initial value
Access Level	Operator
Measurement Mode	Level Only
PID Mode	(not affected)
PV Display Variable	Level
SP Display Variable	(depends on PID mode)
VFD Top Line Variable	(depends on PID mode)
VFD Bottom Line Variable	(none)

General Measurement Calibration Values

Variable	Level	Volume	Flow
Display Units	inches	gallons	gallons/minute
Upper Sensor Limit (USL)	120.00	940.16	32805.70
Lower Sensor Limit (LSL)	0.00	0.00	0.00
Minimum Span	10.00	0.43	86.67
Upper Range Value (URV)	120.00	varies	3.86
Lower Range Value (LRV)	0.00	0.00	0.00
Damping (seconds)	0 seconds		
PFM Transmitter S/N	0		

Strapping Table Values

Point	Level (%)	Volume/ Flow (%)	Point	Level (%)	Volume/ Flow (%)	Point	Level (%)	Volume/ Flow (%)
0	0.00	0.00	7	35.00	35.00	14	70.00	70.00
1	5.00	5.00	8	40.00	40.00	15	75.00	75.00
2	10.00	10.00	9	45.00	45.00	16	80.00	80.00
3	15.00	15.00	10	50.00	50.00	17	85.00	85.00
4	20.00	20.00	11	55.00	55.00	18	90.00	90.00
5	25.00	25.00	12	60.00	60.00	19	95.00	95.00
6	30.00	30.00	13	65.00	65.00	20	100.00	100.00

Vessel Parameters

Variable	Value
Type	Horizontal Cylinder
Length	12.00 inches
Radius	24.00 inches
End Depth	00.00 inches

Flow Element Parameters

Variable	Value
Type	Parshall Flume
Throat Size	6.00 inch
V-Notch Angle	90 Deg.
Crest Length	1.00 foot

Alarm Parameters

Variable	PV #1	PV #2	PV #3	PV #4	SP #1	SP #2	O #1	O #2
Status	Enable	Enable	Enable	Enable	Disable	Disable	Disable	Disable
Source	Level	Level	Level	Level				
Mode	HLFS	HLFS	HLFS	HLFS	HLFS	HLFS	HLFS	HLFS
Differential	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Low SP	0.00 in	0.00 in	0.00 in	0.00 in	0.00 in	0.00 in	0.00 %	0.00 %
High SP	108.00 in	108.00 in	108.00 in	108.00 in	120.00 in	120.00 in	100.00 %	100.00 %
TD Off	0.00 sec	0.00 sec	0.00 sec	0.00 sec				
TD On	0.00 sec	0.00 sec	0.00 sec	0.00 sec				
Relay	1	2	3	4	(none)	(none)	(none)	(none)

It should be noted that the PID Control option status, on or off, is not changed and that the display variable assignments other than PV are made based upon the PID mode. Also, the PID Control parameters are not affected unless the PID Control Option is on. The initialized PID control parameter and display variable assignments were detailed previously.

It should also be noted that the password will be set to the default value, "12345", and should be reset to the user selected value as defined in **Paragraph 6.3.5** above.

6.3.6.2 PFM Input Only

This function initializes only the PFM Input. It is intended as recovery from a bad user calibration or when the type of transmitter has changed.

This function can be accessed from the main Initialize Database menu, see **Paragraph 6.3.6** above, by pressing the **[NEXT]** key. The instrument will respond by displaying *"Initialize Database/PFM Input Only"* on the VFD. Pressing the **[ENTER]** key will cause the instrument to set the PFM Input high and low calibration points to the default values.

6.3.6.3 Full Initialization

This function is a combination of the preceding two database initialization options.

This function can be accessed from the main Initialize Database menu, see **Paragraph 6.3.6** above, by pressing the **[NEXT]** key twice. The instrument will respond by displaying *"Initialize Database/Full Initialization"* on the VFD. Pressing the **[ENTER]** key will cause the instrument to perform the described database initialization.

It should also be noted that the password will be set to the default value, "12345", and should be reset to the user selected value as defined in **Paragraph 6.3.5** above.

6.4. Spare Parts

The following table lists the user serviceable parts that make up the Excalibur 7000 level controller. It is intended that the repair of the unit be accomplished on a printed circuit assembly, PCA, basis. Also, not all PCA's are applicable to all units (See **Paragraph 1.3** for model identification).

Table 67.3 – Spare Parts List

Robertshaw Part Number	Description
044KX232	PCA, RS-232/485 Communications
044KX234	PCA, Analog Output (4-20 mADC)
044KX236	PCA, Analog Output (4-20 mADC) w/HART
044KX238	PCA, Power Supply & Interconnect
044KX240	PCA, Quad Relay
044KX242	PCA, Dual relay
044KX244	PCA, CPU/Displays
032KB396	Cable Assy, 30 Pin Ribbon
032KB397-03	Cable Assy, Ground Strap
190KB040-01	Fuse, 1/4Amp Slo-Blo

6.5. Schematics

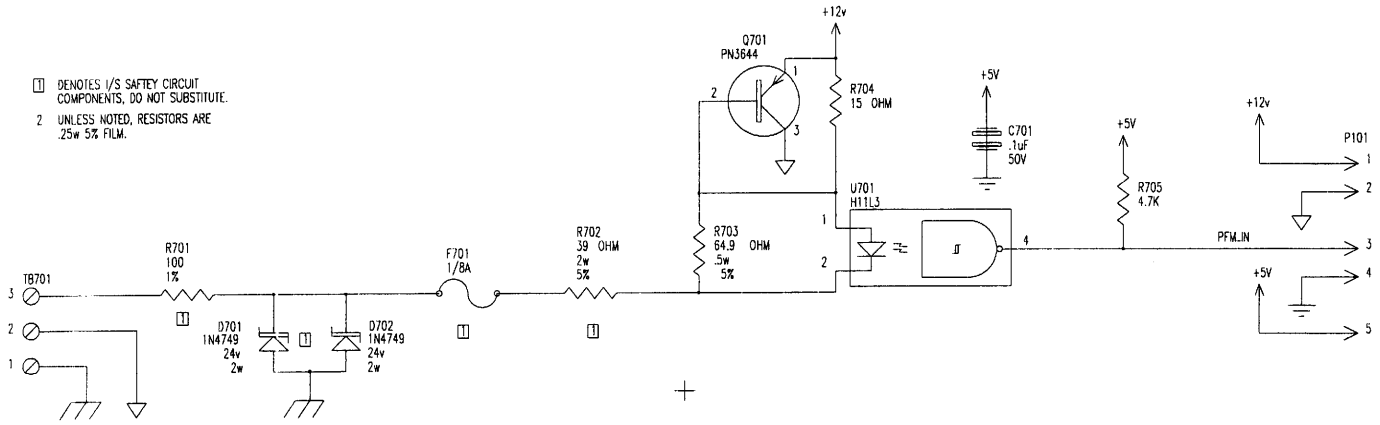


Figure 6.3 – Schematic, PFM Input

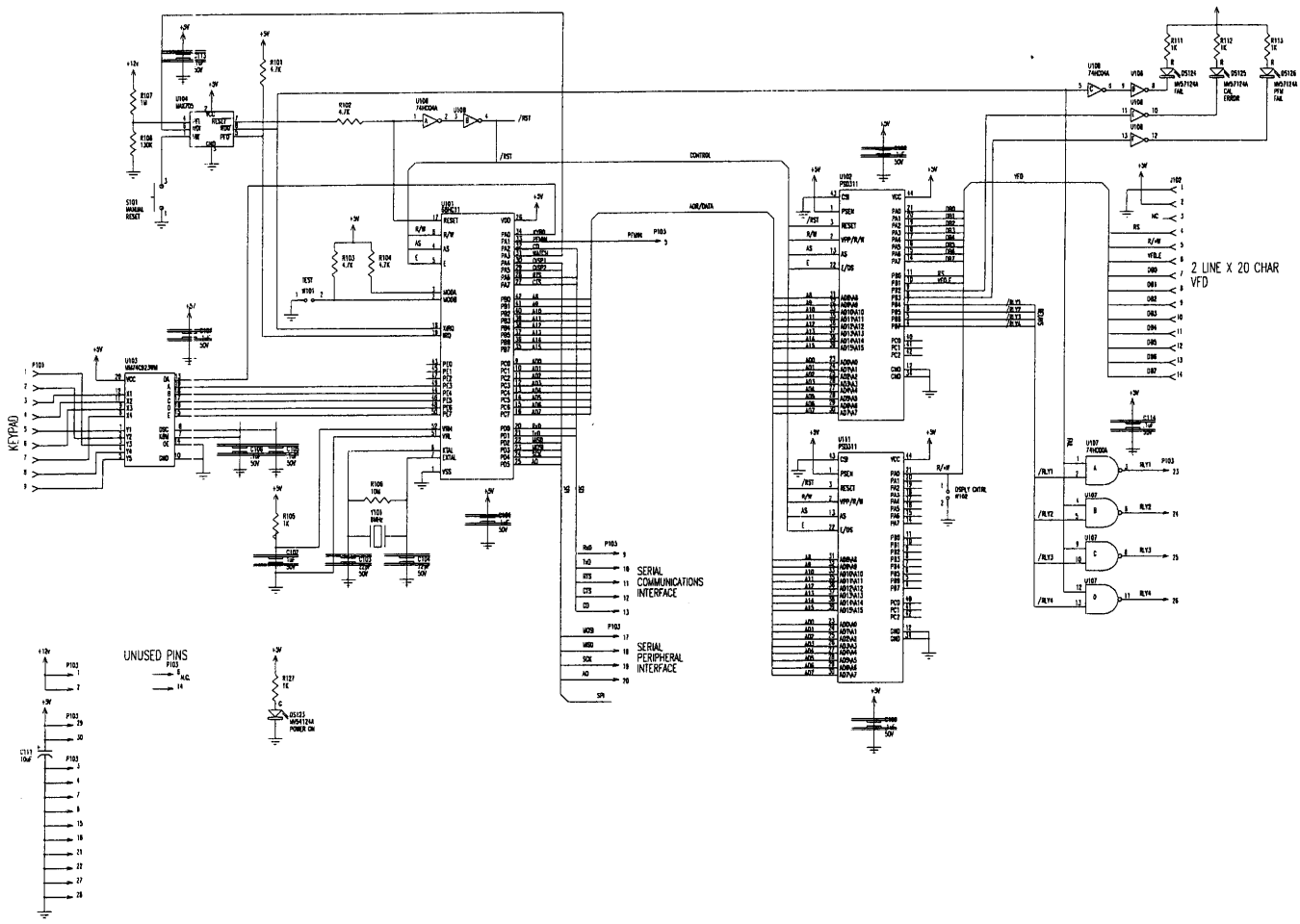


Figure 6.4 – Schematic, CPU/Display, Logic Section

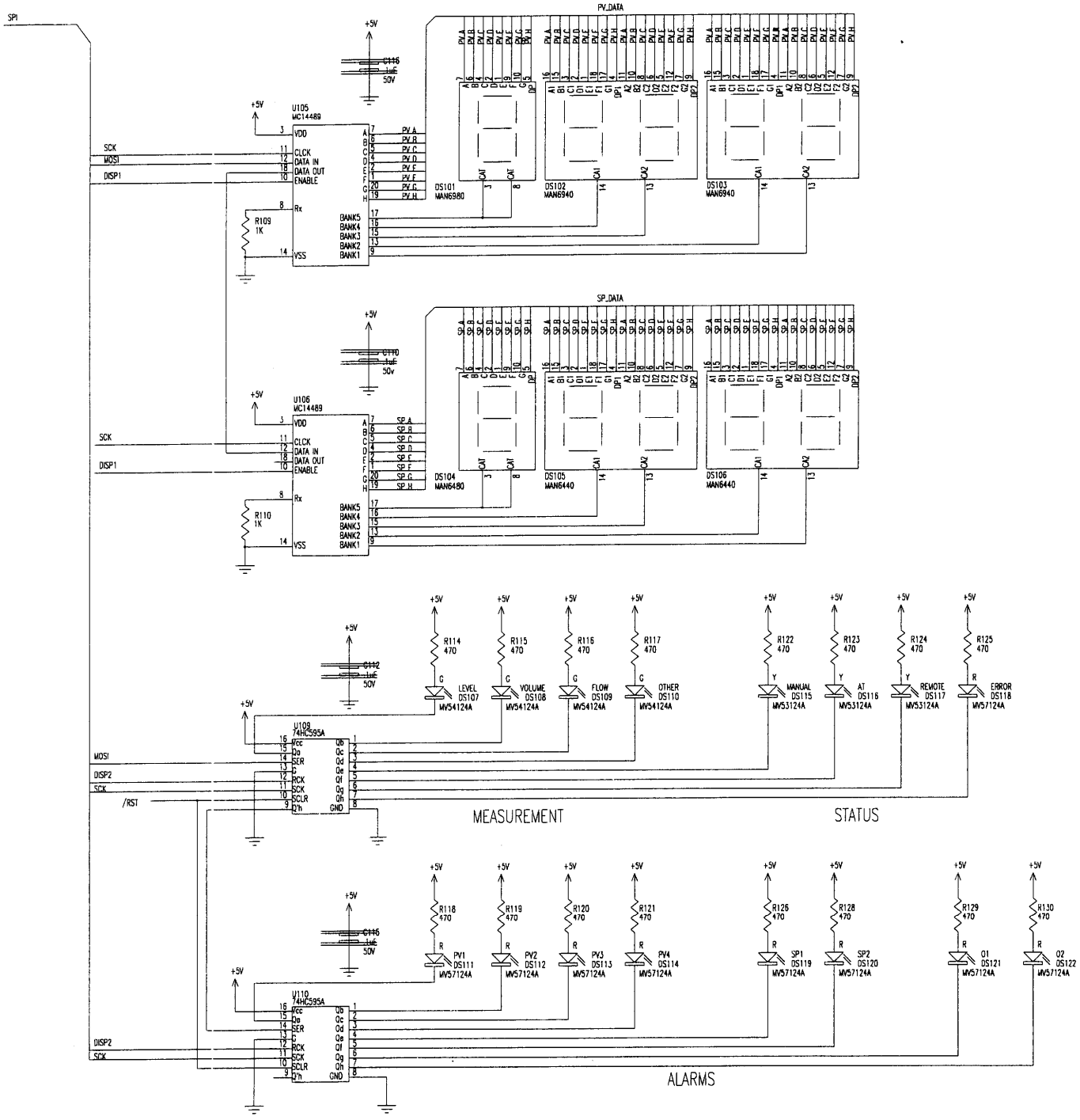


Figure 6.5 – Schematic, CPU/Display, Display Section

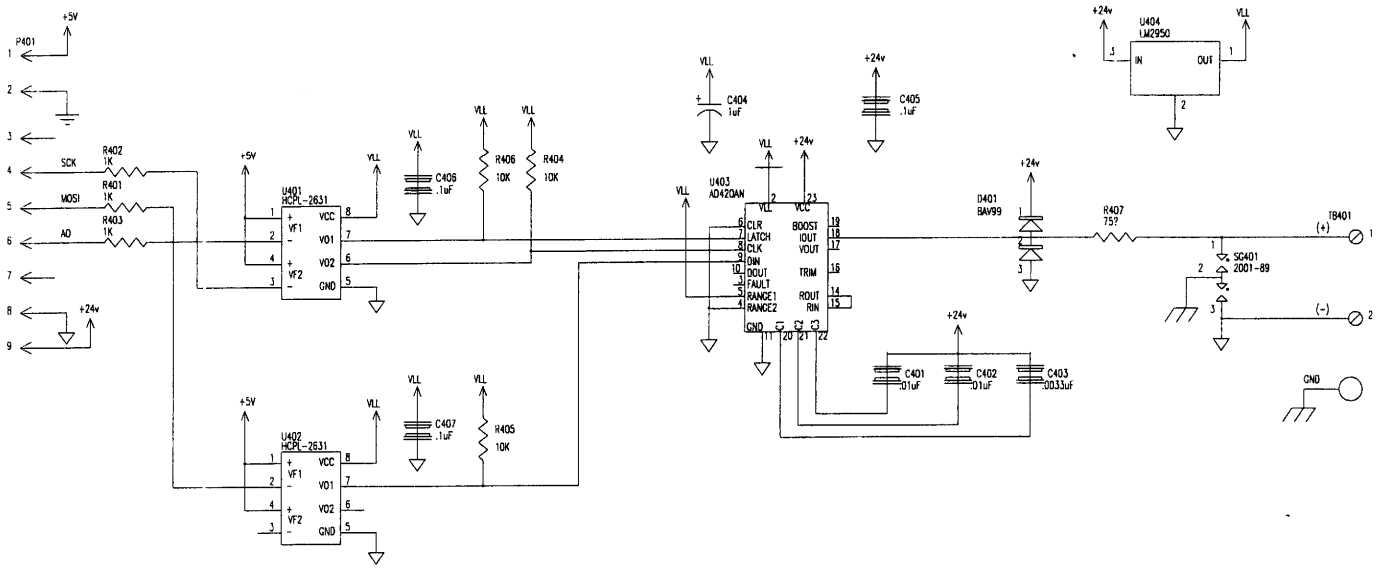


Figure 6.6 – Schematic, Analog (4-20 mADC) Output

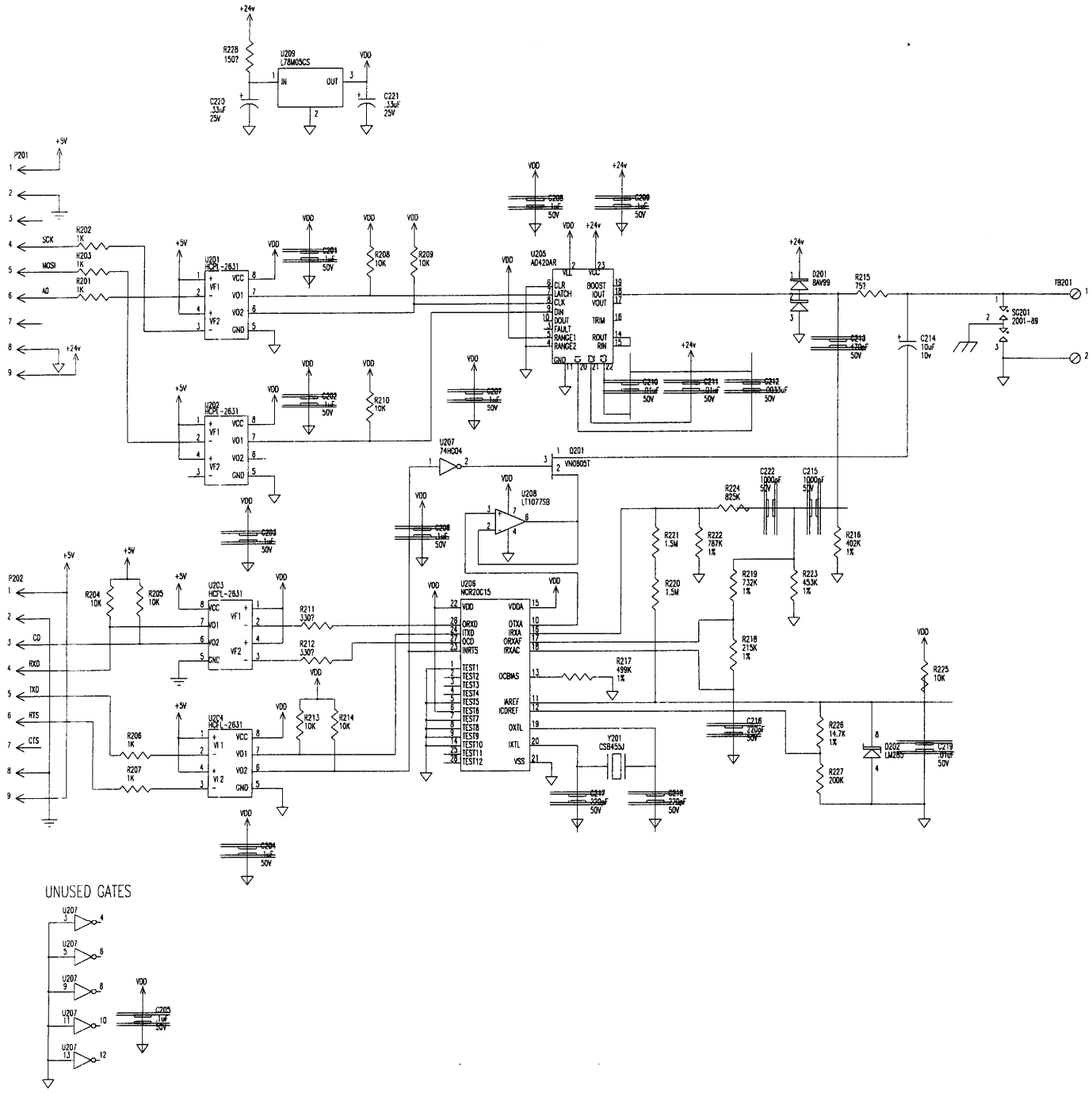


Figure 6.7 – Schematic, Analog (4-20 mADC) Output w/HART Communications

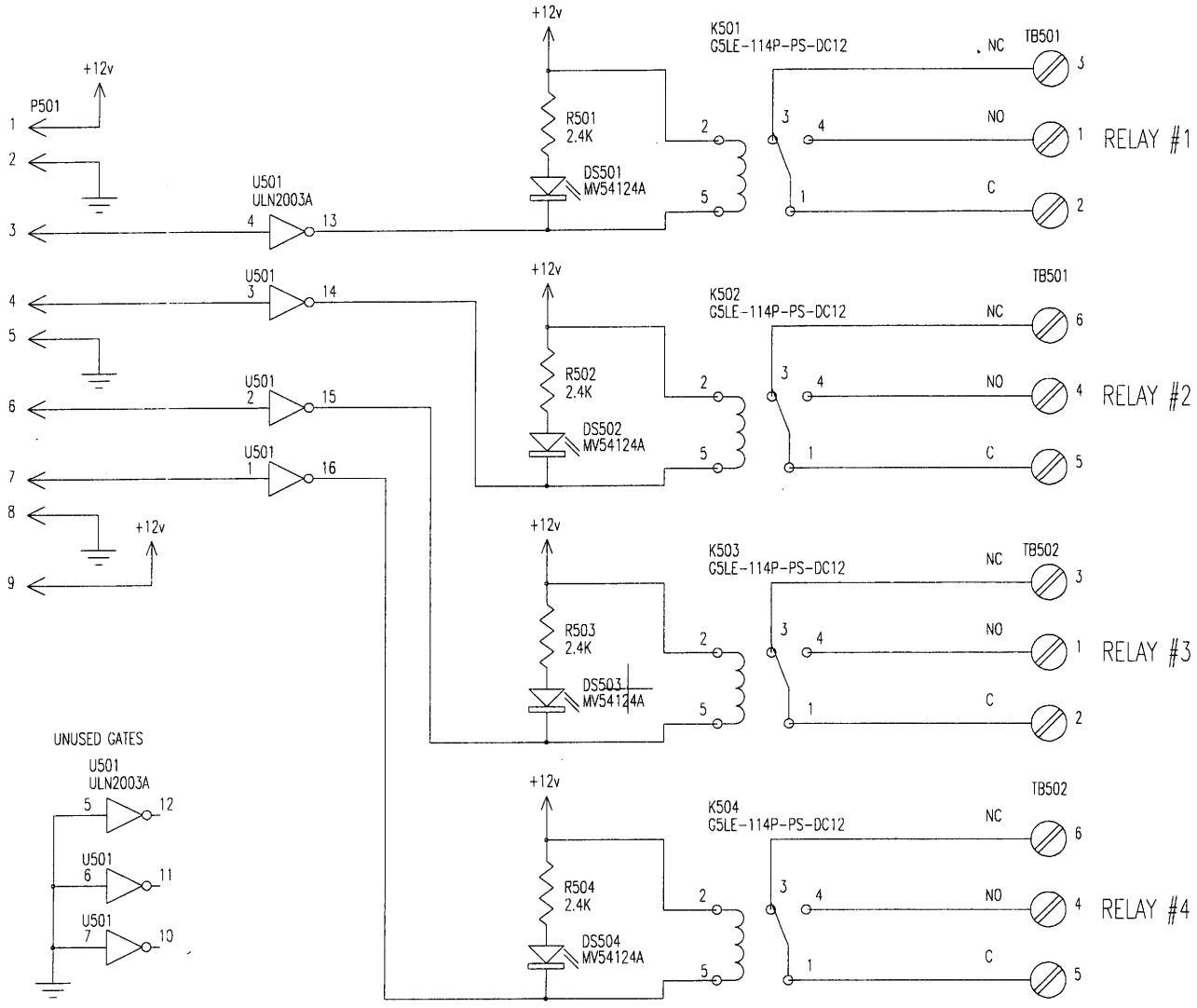


Figure 6.8 – Schematic, Quad Relays

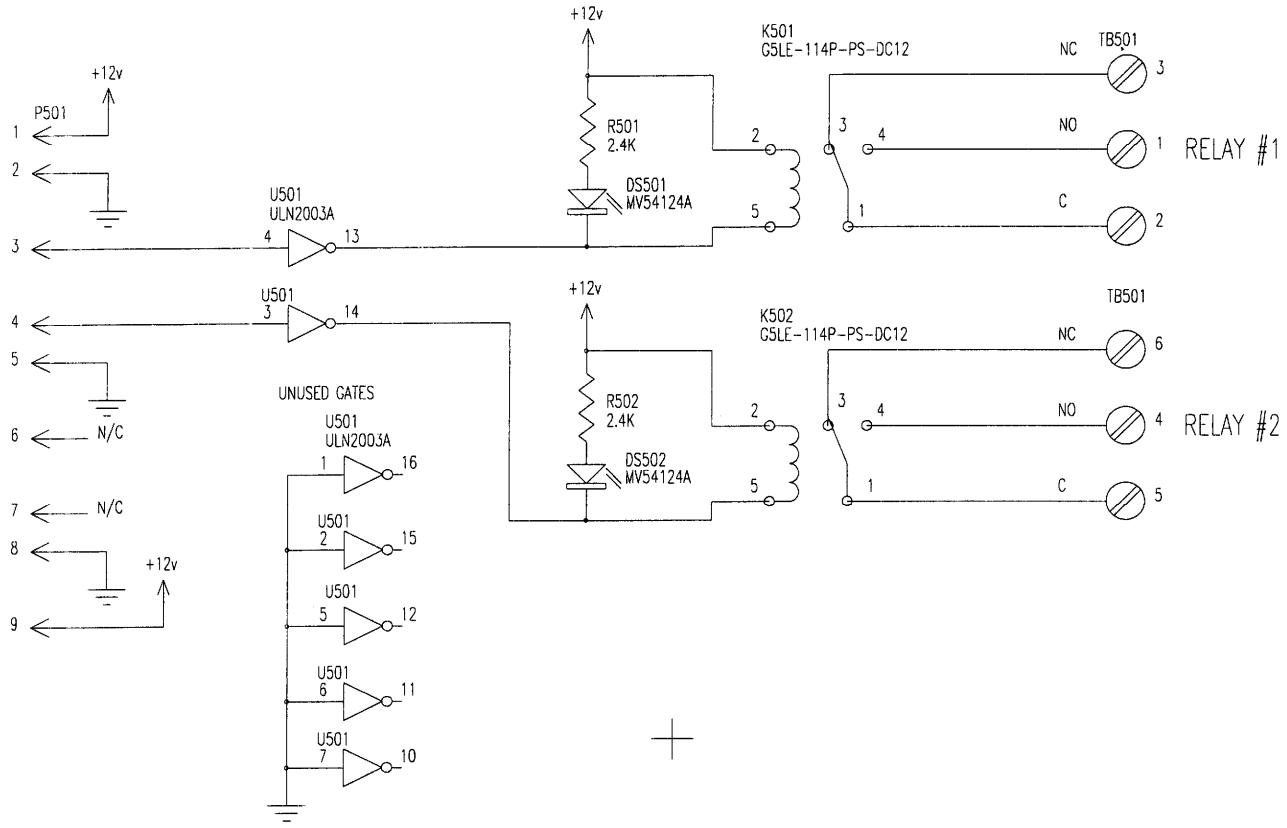


Figure 6.9 – Schematic, Dual Relays

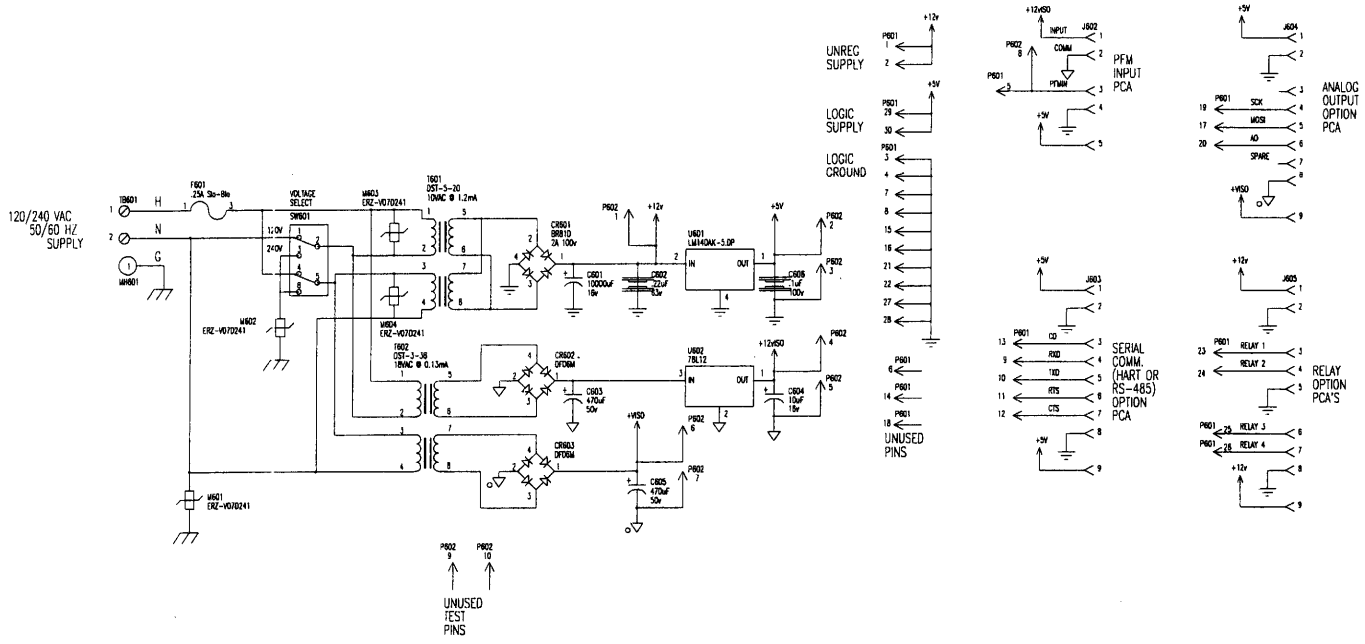


Figure 6.10 – Schematic, Power Supply & Interconnect

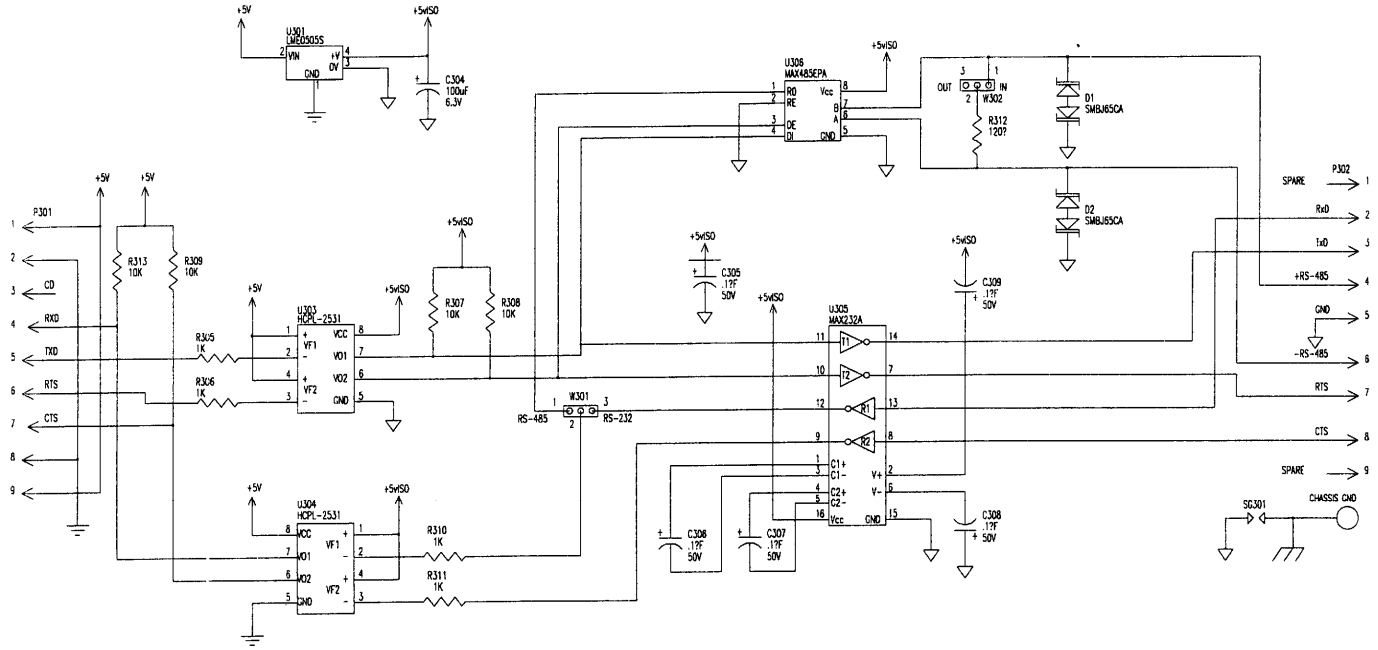


Figure 6.11 – Schematic, RS-232/485 Serial Communications

Appendix A – Setup & Calibration Worksheet

Setup Menu Settings

Access Level	
○	Limited
○	Operator
○	Full

Measurement Mode	
○	Level
○	Level & Volume
○	Level & Flow

PID Controller		
Status		
○	Off	
○	On	
Controlled Variable		
○	Level	
○	Volume	
○	Flow	
PID Output		
4mA Pt		%
20mA Pt		%
Setpoint		
Gain		
Reset		
		min/ repeat
Rate		
		minutes
Autotune Mode		
○	Off	
○	Mild	
○	Standard	
○	Aggressive	
○	Very Aggressive	

Setup Menu - cont'd

PV Display Variable	
○	Level
○	Volume
○	Flow

SP Display Variable	
○	Setpoint
○	Level
○	Volume
○	Flow
○	None

VFD Top Line Variable	
○	Output (%)
○	Level w/EU
○	Volume w/EU
○	Flow w/EU
○	Loop Tag
○	Loop Description
○	PFM Input Counts
○	None

VFD Btm Line Variable	
○	Output (%)
○	Level w/EU
○	Volume w/EU
○	Flow w/EU
○	Loop Tag
○	Loop Description
○	PFM Input Counts
○	None

Diagnostics	
	PFM Input Test
	Analog Output Test
	Keypad Test
	Display Test
	Change Password
	Initialize Database

Note: The diagnostic sub-menu is shown for reference only. No setup or calibration is required

Calibration Menu Settings

Calibrate Level	
Units	
○	inches
○	feet
○	millimeters
○	centimeters
○	meters
Maximum Level	
Lower Range Value	
Upper Range Value	
Damping Time	
	sec

Calibrate Volume	
Units	
○	gallons
○	liters
○	imperial gallons
○	barrels
○	cubic feet
○	cubic yards
○	cubic meters
Vessel Type	
○	Vert Cylinder
○	Vert w/Cone Btm
○	Horz Cylinder
○	Horz w/Ellip Ends
○	Horz w/Sphere Ends
○	Sphere
○	User defined

Volume calibration continued on the next page

Calibrate Volume - cont'd	
Vessel Dimensions	
Length	
Radius	
End Depth	
Note: Not all dimensions are required by all tank geometry's	

Calibrate Flow	
Units	
○	cubic feet/second
○	cubic feet/minute
○	cubic feet/hour
○	gallons/second
○	gallons/minute
○	gallons/hour
○	million gallons/day
○	cubic meters/sec.
○	cubic meters/min.
○	cubic meters/hour
○	liters/second
○	liters/minute
○	liters/hour
○	million liters/day
○	imp gallons/second
○	imp gallons/minute
○	imp gallons/hour
○	million imp gal/day
Element Type	
○	V-Notch Weir
○	Parshall Flume
○	Rectangular Weir
○	Contracted Weir
○	Cipolletti Weir
○	User Defined

Calibrate Flow - cont'd	
V-Notch Angle	
○	22-1/2 Degrees
○	30 Degrees
○	45 Degrees
○	60 Degrees
○	90 Degrees
○	120 Degrees
Flume Throat size	
○	1 inch
○	2 inch
○	3 inch
○	6 inch
○	9 inch
○	12 inch (1 ft)
○	18 inch
○	24 inch (2 ft)
○	36 inch (3 ft)
○	48 inch (4 ft)
○	60 inch (5 ft)
○	72 inch (6 ft)
○	96 inch (8 ft)
○	120 inch (10 ft)
○	144 inch (12 ft)
Weir Crest Length	

Note: Not all sizing information applies to all flow element types.

PV Alarm #1	
Status	
○	Disable
○	Enable
Measurement	
○	Level
○	Volume
○	Flow
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Off Delay	
	sec.
On Delay	
	sec.
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

PV Alarm #2	
Status	
○	Disable
○	Enable
Measurement	
○	Level
○	Volume
○	Flow
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Off Delay	
	sec.
On Delay	
	sec.
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

PV Alarm #3	
Status	
○	Disable
○	Enable
Measurement	
○	Level
○	Volume
○	Flow
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Off Delay	
	sec.
On Delay	
	sec.
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

PV Alarm #4	
Status	
○	Disable
○	Enable
Measurement	
○	Level
○	Volume
○	Flow
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Off Delay	
	sec.
On Delay	
	sec.
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

SP Alarm #1	
Status	
○	Disable
○	Enable
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

Note: The setpoint alarms can only serve a practical function when the PID control option is turned 'On'

SP Alarm #2	
Status	
○	Disable
○	Enable
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

Output Alarm #1	
Status	
○	Disable
○	Enable
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

Note: The output alarms can only serve a practical function when the analog output option is present

Output Alarm #2	
Status	
○	Disable
○	Enable
Failsafe Mode	
○	LLFS
○	HLFS
Alarm Type	
○	Fixed Differential
○	Adj. Differential
Low Setpoint	
High Setpoint	
Output Relay	
○	None
○	Relay #1
○	Relay #2
○	Relay #3
○	Relay #4

Input Calibration	
	Two Point
	Low Point
	High Point

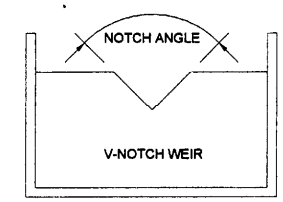
Note: The input calibration sub-menu is shown for reference only. The calibration values used are determined at calibration time and can be recorded below.

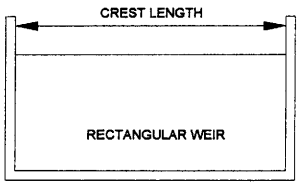
Calibration Levels		
High		
Low		

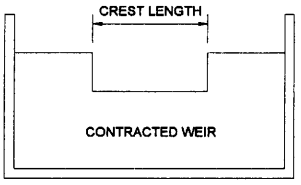
User defined conversion data

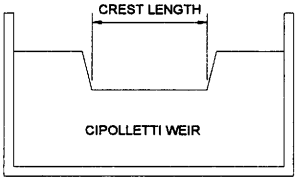
Max EU Value	
Volume	
Flow	

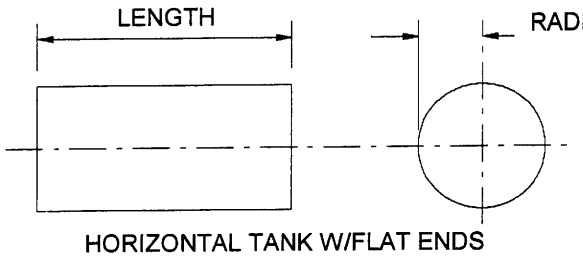
User Defined Table	
Level (%)	Vol/Flow (%)
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	
95	
100	



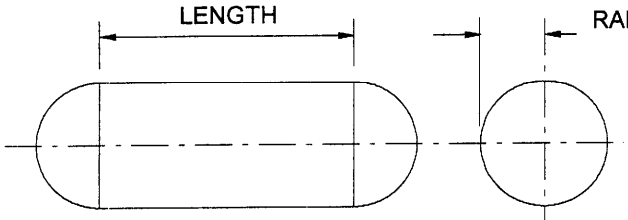




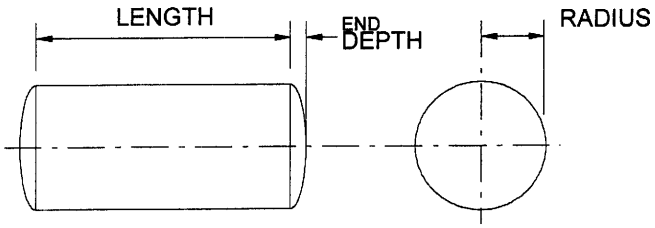




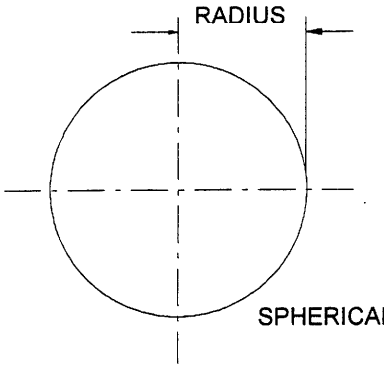
HORIZONTAL TANK W/FLAT ENDS

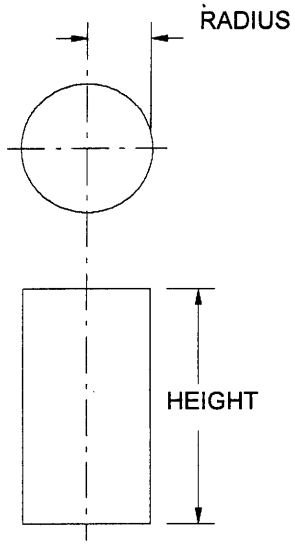


HORIZONTAL TANK W/SPHERICAL ENDS

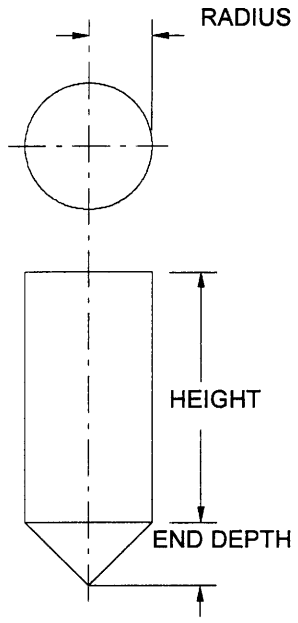


HORIZONTAL TANK W/ELLIPTICAL ENDS





VERTICAL CYLINDER



VERTICAL CYLINDER
W/CONICAL BOTTOM

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