

# Density Monitor Systems

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1	DESCRIPTION
2	THEORY
3	INSTALL/START
4	OPERATION
5	CALIBRATION
6	DETECTOR
7	ELECTRONICS
8	OPTIONS
9	REGULATIONS
10	DRAWINGS



**Chapter 1** provides a general overview of Ronan's Retrofit Units.

In most cases, Retrofit Units supply Ronan Detectors and Electronics to existing source/holders.

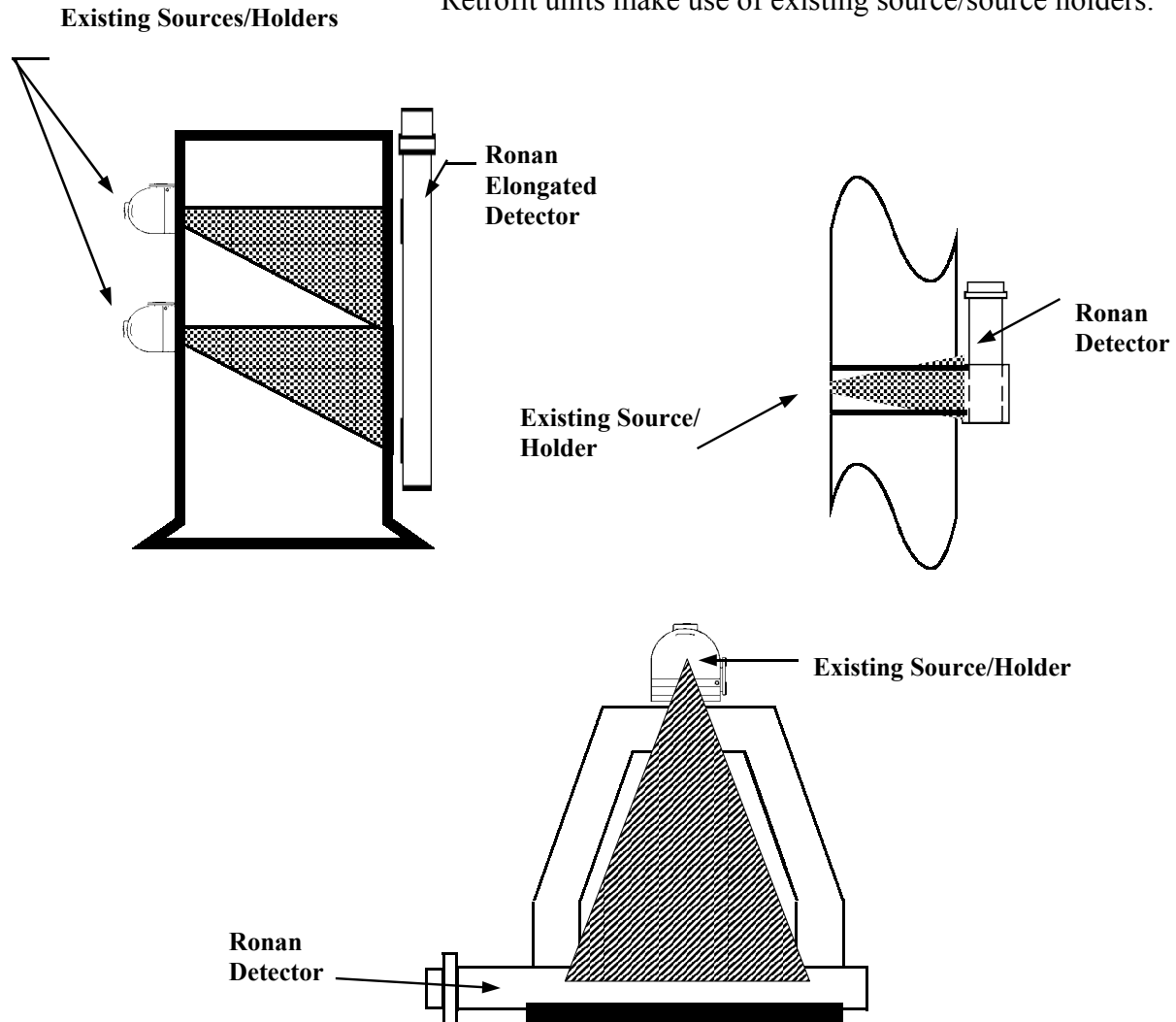
- 1.0 System Description
- 1.1 System Configuration/Components
  - Detector
  - Microprocessor
  - Cable

<b>REV NO.</b>	<b>DATE</b>	<b>PAGE NO.</b>	<b>DESCRIPTION</b>
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## System Configuration

The user's application determines the system configuration requirements. Ronan's detector and electronics can be retro-fitted to update Level, Density, and Weight monitoring systems.

Retrofit units make use of existing source/source holders.



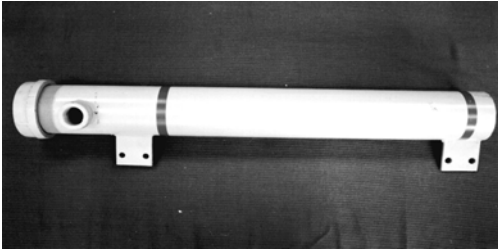
## System Components

Many system configurations are available for a number of different retrofit applications. However, in most cases there are at least three major components included with each Retrofit Unit:

- Detector
- X96N Microprocessor
- Interconnect Cable

## Detector

The detector, which may be either an ion chamber or scintillator, is mounted in a protective housing. When radiation from the source strikes the "active" length of the detector a signal is generated.

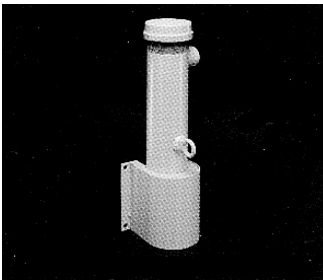


The active length of the detector corresponds to the full measurement range of interest, and is designated by bands of tape at the top and bottom of the detector housing.



The *ion chamber* detector produces a picoampere current that is converted into a voltage signal, amplified, and sent to the microprocessor.

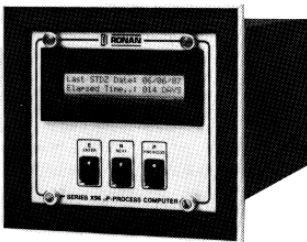
The *scintillation* detector produces a light pulse that is detected by a phototube, converted into an electrical pulse, amplified, and sent to the microprocessor.



Chapter 6 contains more information about the detector that is supplied with your retrofit unit.

## X96N Microprocessor

Ronan's X96N Microprocessor electronically manipulates the detector output signal and displays the results in a useful format.

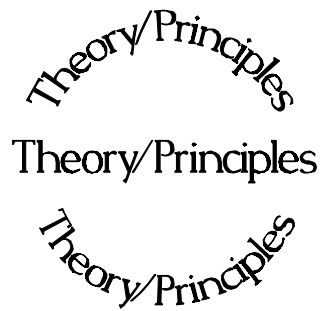


With just three push buttons, a liquid crystal display screen, and pre-programmed menus, the process level, density, or weight is continuously monitored with minimal operator effort.

Chapter 7 contains details about the hardware used in the X96N, and Chapter 4 explains the software used for this application.

## Interconnect Cable

The interconnect cable provides a signal from the detector to the X96N Microprocessor. The cable is supplied with a pre-wired MS connector.



**Chapter 2** gives a simplified explanation of how radiation gages work.

The "Theory of Radiation Gaging" Section reviews the concepts of radiation transmission and absorption.

The "Principles of Operation" Section explains signal processing and the reference/calibration procedure.

- 2.0 Theory / Principles
- 2.1 Theory of Radiation Gaging
- 2.2 Principles of Operation
  - Signal Processing
  - Calibration

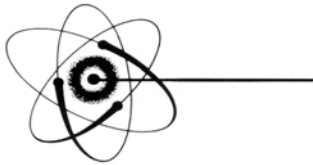


## Theory of Radiation Gaging

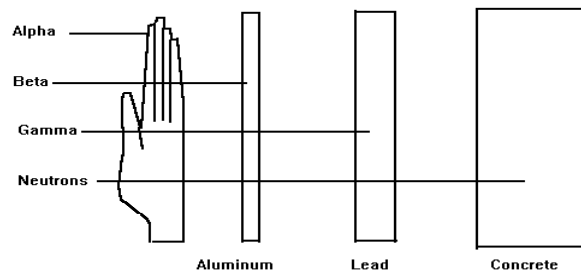
Radiation gages operate on the principle of radiation absorption and transmission.

A beam of gamma radiation is directed from the source holder, through the vessel and its process material, and onto the surface of the detector.

Some amount of radiation is *absorbed* by the material through which it passes, and some of the radiation is *transmitted* to the surface of the detector.

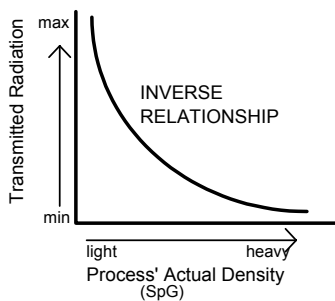


### Absorption / Transmission



#### Gamma's advantages:

- Passes through process material
- Does not make material radioactive
- Does not change the material
- Can be shielded by lead

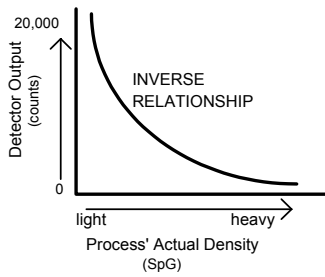


Process measurement is possible because the amount of radiation *absorbed and transmitted* is predictable.

The absorbed radiation is directly related to the density (or mass) of process in the pipe while the transmitted radiation is inversely related to the density (or mass) of process in the pipe.

**Therefore, an increased process density results in a decrease of transmitted radiation.**



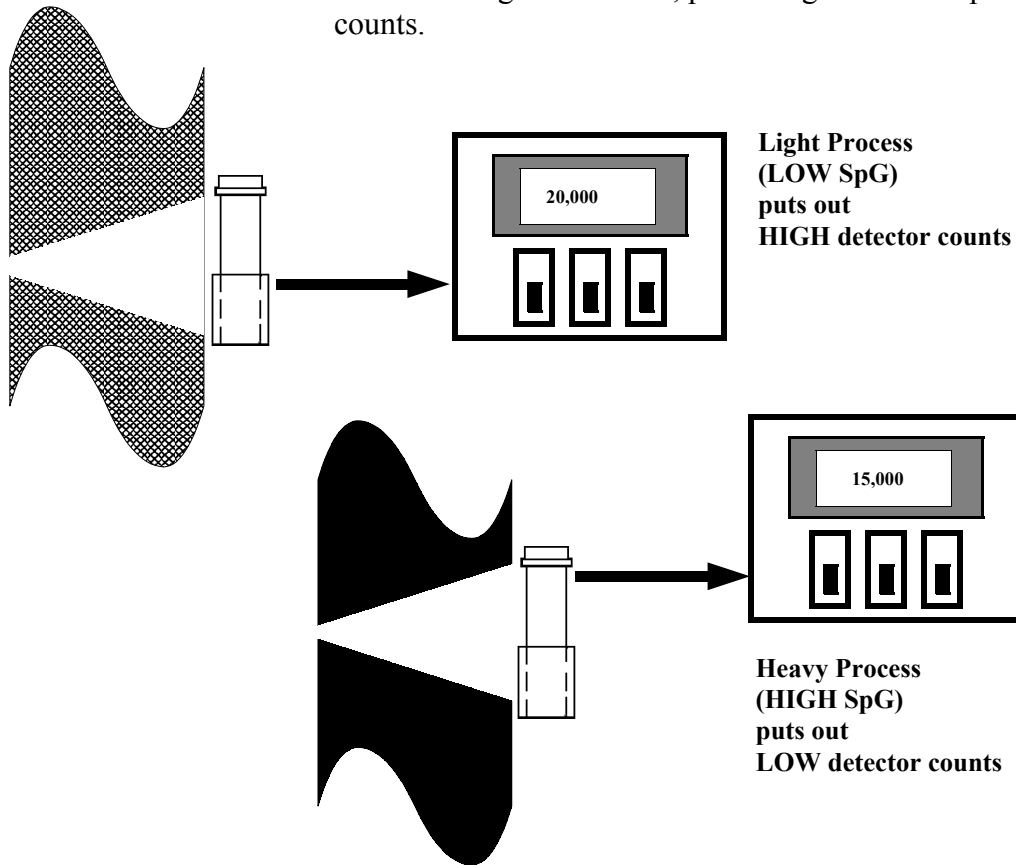


Since the radiation that's not being *absorbed* is being *transmitted*, the process density can be inferred by measuring the amount of radiation reaching the detector at any point in time.

The detector's output signal, in counts, also *varies inversely* to the process density. Shown here is a typical response curve for a density application.

When the process is light ( low density) the detector is exposed to a maximum amount of radiation which produces a HIGH output of counts.

When the process is heavy (high density) the process material "shields" the detector and prevents radiation from reaching the detector, producing a LOW output of counts.



**Ronan's Density Monitor is used to replace the lab sampling process since the gage output, when accurately calibrated, will correlate to the density values of process taken from samples near the gage location.**

## Principles of Operation

The detector's raw output signal is processed through several stages of software in the X96N.

Some of the more significant stages of signal processing are:

- Units Conversion (Channel 1 only)
- Measurement Range
- Digital Filtering
- Dynamic Tracking
- Source Decay Compensation
- Calibration (Referencing)

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## Units Conversion

The X96N Microprocessor converts the detector signal in Channel 1 to user's measurement units of SpG, percent solids, Baume H, Baume L, API, or percent steam.

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Channel 2 is factory set to units of SpG.

## Measurement Range

The X96N displays the output measurement range in the selected user units. Channel 1 and Channel 2 can be set independently. For both channels, the "zero" of the measurement range represents the lowest density of interest, while the "span" of the measurement range ~~represents the highest density of interest.~~

## Digital Filtering

Reduction of the signal "noise" due to radiation statistics is handled in the stage of signal processing known as digital filtering. Digital filtering is a form of statistical averaging used to smooth, or dampen, random radiation as well as process-related noise. Increasing the digital filter's "time constant" decreases signal noise.

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## Dynamic Tracking

Dynamic tracking permits the gage response to temporarily by-pass the digital filter. This is helpful in some processes where sudden or drastic step changes in process must be observed in their true, or unfiltered, state.

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## Source Decay Compensation

Software also compensates for the decay of the radioactive source activity. On-going adjustments are made automatically for the rate of decay, or source half-life.

## Calibration

The Calibration (or Referencing) procedure relates detector output (in counts) to numeric values that accurately represent the actual process density.

### Calibration Constant

The density algorithm (or curve) used by the X96N software is an exponential function. That is, the relationship between the detector output and the process density is mathematically expressed as:

Transmission/Absorption Table

t	ut	1/ut
2"	0.4	2.5
3"	0.6	1.6
4"	0.8	1.25
5"	1.0	1.0
6"	1.2	0.825
8"	1.6	0.625
10"	2.0	0.5

$$I_d = I_0 e^{-ut(d-d_0)}$$

Where:

$I_d$  = detector signal with process density (d)

$I_0$  = detector signal with process density ( $d_0$ ) in pipe

u = the absorption coefficient

t = pipe internal diameter

d = density usually expressed in SpG

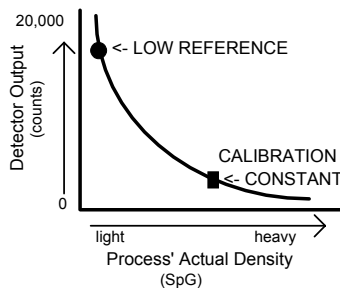
$d_0$  = reference density

t = mat'l thickness (pipe I.D.)  
 u = absorption coefficient  
 = 0.2 for Cs137  
 1/ut = calibration constant

The "calibration constant" (1/ut) is used by the X96N software to calculate process density. ~~Shown here is a~~

### Low Reference (Single Point Calibration)

The simplest calibration technique is the "Single Point Calibration" where ONE reference sample is taken from a convenient or easily obtained process condition. This initial reference sample can be any process density in the range of interest.



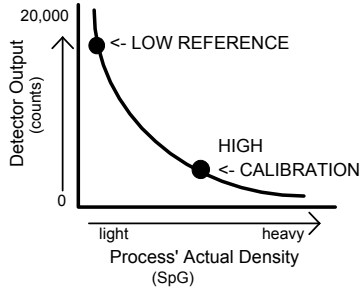
The conveniently drawn process sample is analyzed in the lab so the known density value can be entered into the X96N as the reference density ( $d_0$ ).

Next, the manually calculated calibration constant (1/ut) value, from a table like the one above, is entered into the X96N software.

These two values, the reference density ( $d_0$ ) and the calibration constant (1/ut), are used by the X96N algorithm to calculate process density (d).

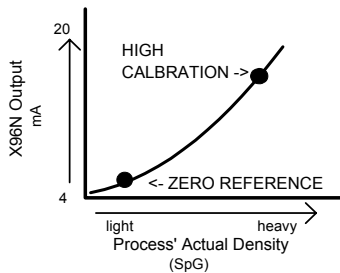
**High Calibration  
(Dual Point Calibration)**

An alternate calibration technique is the "Dual Point Calibration" where samples of TWO different process densities ( $d_{01}$  and  $d_{02}$ ) are drawn , analyzed, and entered into X96N software.



With the addition of a second reference density ( $d_{02}$ ) the X96N software can now compute very accurately the value of  $1/ut$  which it uses to determine the process density.

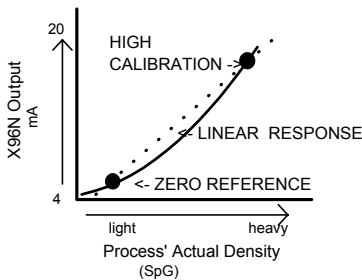
**Calibration Curve**



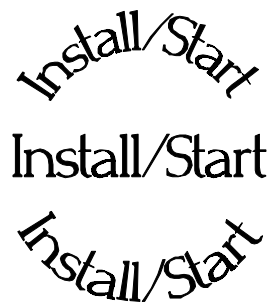
The calibration procedure also reverses the relationship between detector counts and actual process density. Now, a direct relationship exists, so that as the process density changes from light to heavy, the X96N's display screen indicates an increase in user units from minimum to maximum - (example: 1.1 SpG to 1.25 SpG.)

**AND** the transmitter output signal also increases from minimum to maximum - (usually 4 to 20 mA).

**Linearization**



The exponential algorithm used by the X96N software ensures an accurate measurement and eliminates the need for linearization through a separate stage of signal processing.



- 3.0 Installation
- 3.1. Unpacking/Inspection/Storage
- 3.2 Precautions
- 3.3 Mounting
  - Mechanical
  - Electrical
- 3.4 Microprocessor Verification
  - Identification/Documentation
  - Power-up
  - Pushbuttons

**Chapter 3** covers preliminary information that will help prepare for equipment installation and power-up.

Read the section on "Safety Precautions" before beginning to unpack or install the equipment.

The push-button guide and menu overview will familiarize you with how the X96N functions.

The specific and detailed installation instructions are provided on the Installation Drawings which are included in Chapter 10 of this manual.



**Caution**

Ronan's Monitor Systems use a sealed radioactive cesium (Cs-137) source which is safe if handled properly.

**Specific License**

Most Level Monitors are mounted to large vessels. Installations on vessels that permit personnel access require a specific license. Your company's specific license will name a Radiation Safety Officer (RSO) or Radiation Protection Officer (RPO). The RSO for your company must be notified immediately upon receipt of the gage. DO NOT proceed with unpacking, storage, or installation without the RSO's authorization.

**General License**

Other monitor systems, such as Density Monitors, are mounted to small-diameter process pipes. Those applications do not require a specifically licensed person to unpack or mount the equipment, as long as the source holder remains padlocked in the OFF position. Only a specifically licensed individual is permitted to remove the padlock and turn the source holder to the ON position.

Ronan's field service personnel are available for advice or assistance. (606) 342-8500.

**Unpacking**

All equipment manufactured by Ronan is carefully packaged to prevent shipping damage. Unpack the equipment in a clean, dry area.

Examine the contents and compare them to the packing list. Immediately report any discrepancy or damage to Ronan, the company's RSO, and the carrier. File a claim with the carrier.

**Storage**

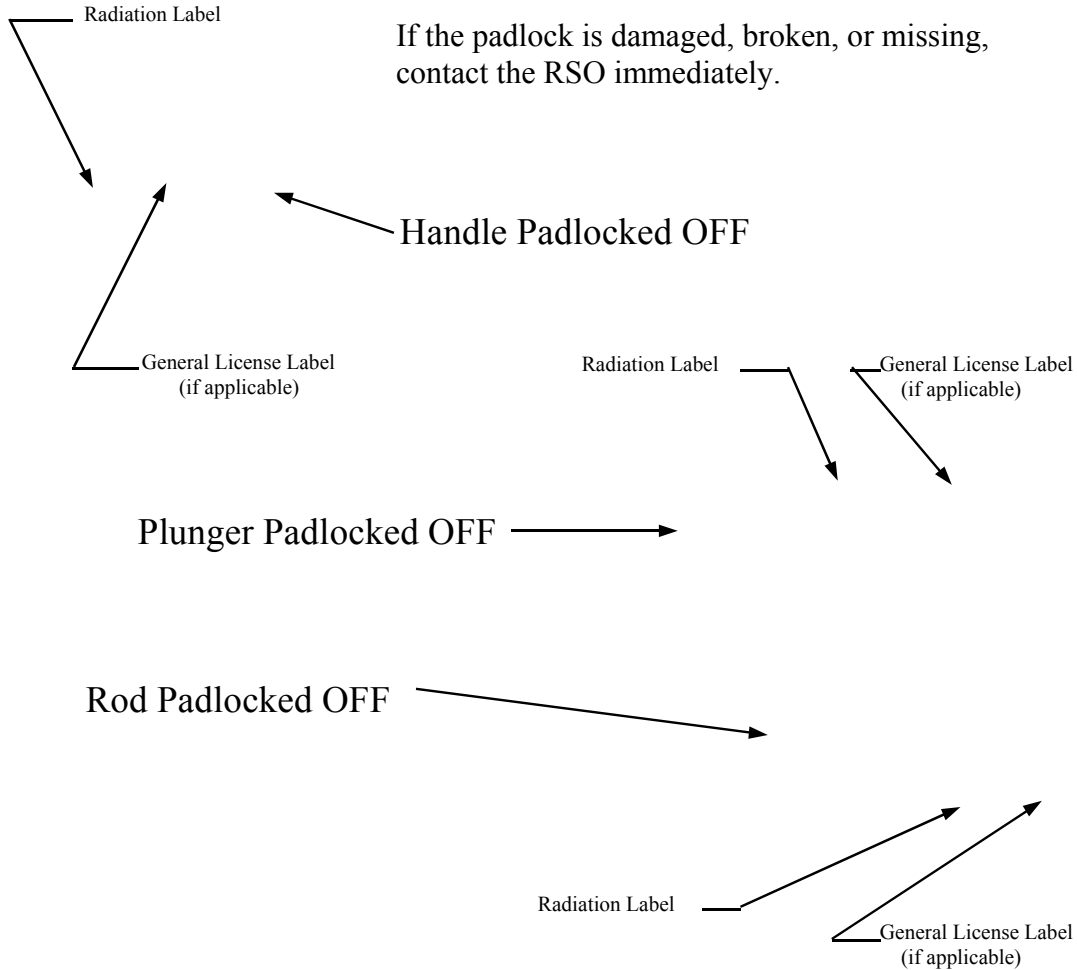
If it is necessary to store this equipment before mounting, the RSO will assign a safe and secure location with no personnel access.

During storage avoid temperatures below freezing, and areas with excessive humidity, moisture, or dirt.

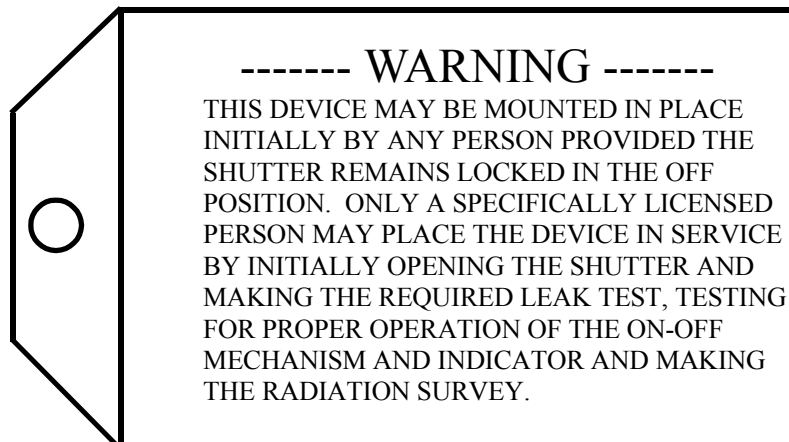
### Inspection

The source holder is equipped with an ON/OFF mechanism. During shipment and storage the mechanism **MUST BE SECURED** in the OFF position with a padlock.

If the padlock is damaged, broken, or missing, contact the RSO immediately.



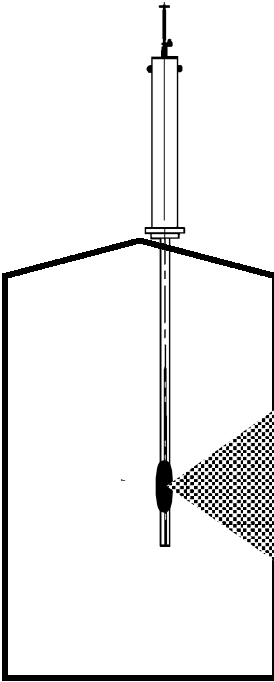
### Lock Tag





## Safety Precautions

During installation the RSO will provide guidelines to assure safety. Consider the information presented in the Regulation/Safety Chapter of this manual, as well as the following general guidelines:



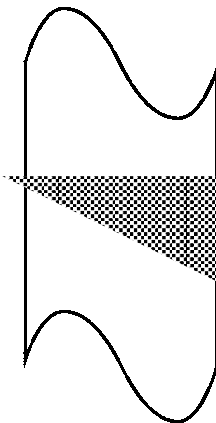
The source holder must remain padlocked in the OFF position until installation is complete.

Take all necessary precautions to assure that the source holder is not dropped or damaged.

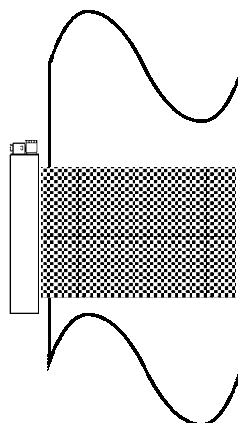
**A specifically licensed individual MUST inspect the installation** prior to placing the source holder in the ON position.

Always turn the source holder to the OFF position when working around it, the detector, or the area between these two components which is referred to as the "measuring gap."

When the source holder is placed in the ON position, avoid the "active beam."



**A  
V  
O  
I  
D**



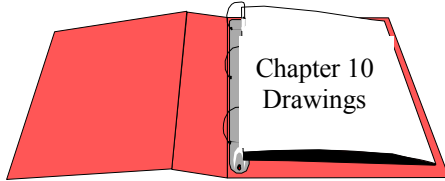
**A  
C  
T  
I  
V  
E**

**B  
E  
A  
M**

## Mechanical Mounting

Review the Configuration Drawing which is included in the Drawing Chapter of this manual.

Please reference the dimensional drawings located in Chapter 10 when installing the equipment.



Consider the following general guidelines when mounting the sensor and detector:

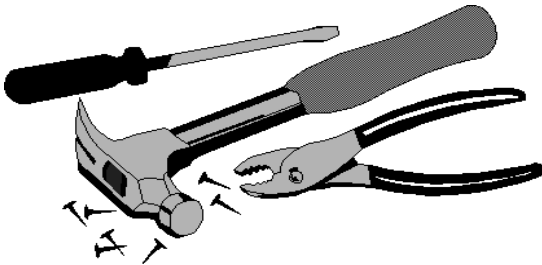
Avoid internal vessel obstructions such as baffles, agitators, manways, heater/cooler tubes, etc. which could interfere with the transmission through the vessel of the radiation's "active beam."

Drawings:  
Configuration  
Installation

The source and detector must be rigidly mounted so they do not move with respect to each other. Such movement will destroy the system's calibration and/or its measurement.

Insulation must be used at the point of installation IF:

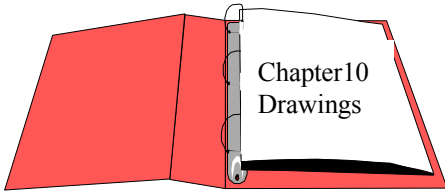
- the temperature of the process pipe at that spot exceeds 131°F (55°C), or
- the voltage transmission through the pipe could interfere with the signal transmission from the source to the detector.



## Electrical Installation of Interconnect Wiring

DO NOT APPLY POWER until wiring is carefully checked.

Wire the equipment according to the detailed interconnect drawing which is included in the Drawing Chapter of this manual.



Follow local and national electrical codes for all interconnections.

Consider the following guidelines before making any electrical connections:

Drawings:  
Interconnect

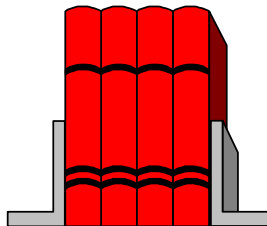
Use continuous conduit runs and protect housing junction boxes from dripping of condensed moisture off of conduit.

Plug unused conduit holes to prevent entry of dirt and moisture.

Run the interconnect cable in a separate conduit. Feed the cable through the conduit starting at the detector end and terminate at the microprocessor end.

DO NOT run AC power cable in the same conduit with any of the low-level cables (signal, mV, mA, etc.)

Maintain transient-free AC power sources between 105-130 VAC for the microprocessor. DO NOT use a line that is connected to a large motor, welding equipment, solenoids, etc.

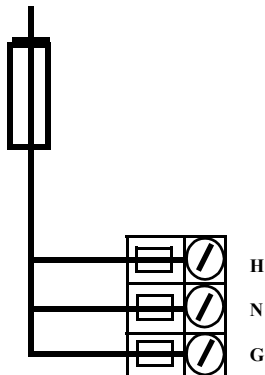


LOCAL CODE  
NATIONAL CODE

WITH POWER OFF - - -

Connect cable pre-wired MS connector to detector.

Immediately replace lid of detector housing to keep out water and dirt.

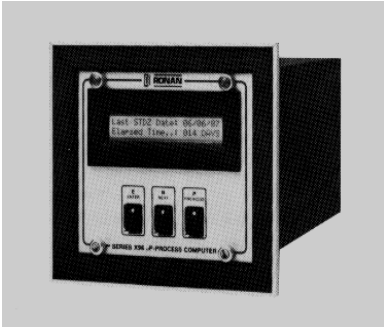


POWER INPUT

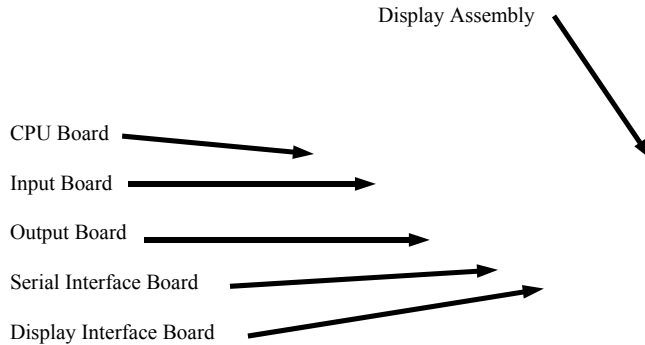
Check connections at microprocessor chassis terminals. Verify that all wires are fully inserted in terminal sockets and the screws firmly tightened.

## Microprocessor Verification

Loosen the four thumb screws to open the front cover and check the board and cable connections. Identify the CPU and other major boards from the drawing below. **Optional configurations are possible.**



Press the push/pull latch to eject the CPU Board.

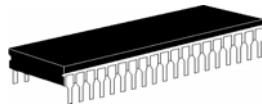
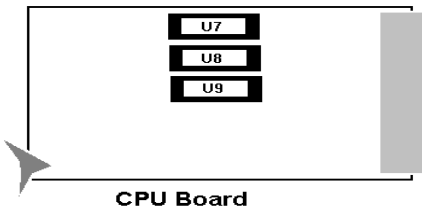


**NOTE:**  
These boards are interchangeable in the frame's slots, but the ribbon cables **MUST** be connected to the correct boards.

- Some Hardware Options:**
- No Serial Board
  - 2 Serial Boards
  - No Input Board
  - 2 Input Boards
  - No Output Board

## Identification/Documentation

The Ronan X96N Microprocessor can be programmed for a variety of applications and configurations. *The specific application supplied with each system is determined by the combination of software EPROMS located on the CPU Board and the unique hardware configuration used to support these EPROMS.* See Chapter 7 for details about your specific hardware configuration.



### CPU BOARD EPROMS:

- U7 \_\_\_\_\_
- U8 \_\_\_\_\_
- U9 \_\_\_\_\_

Your own set of EPROMS (U7, U8, U9) will be labeled with a specific Software Version Number. This software identification number should be documented for future reference.

Replace the CPU Board back into the X96N's frame. Verify all boards are fully seated and cable connections fully inserted.

**Power-up**

Before applying power, ensure all boards are fully seated in frame's slots and ribbon cables fully inserted. Close front door of the X96N and tighten the thumbscrews.

When power is applied the X96N runs a self-diagnostic program.

RONAN (MONITOR SYSTEM)  
VERSION XXXXXX

First the software version number is displayed.

RONAN (MONITOR SYSTEM)  
SELF TEST OK

The LED's flash and the X96N scrolls through an operation guide.

OPERATION GUIDE  
N - DISPLAY NEXT FIELD

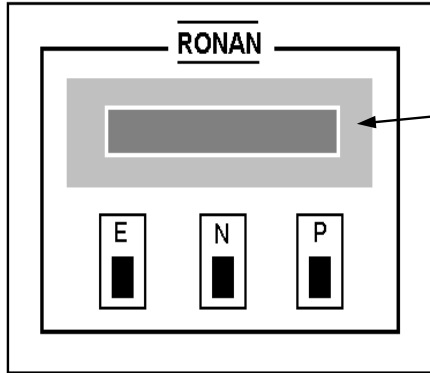
(P - PREVIOUS FIELD )  
(E - ACCESS FIELD)

**Press <N>**

OPERATION GUIDE  
TO START PRESS N

NOTE: If the operator does not Press <N> as instructed within one minute, X96N automatically goes to the first status display.

(Status Display #1)



LIQUID CRYSTAL DISPLAY SCREEN  
STATUS DISPLAYS  
PROGRAMMABLE FUNCTIONS (MENUS)

### Pushbutton Guide

This list summarizes the functional uses for each of the three pushbutton.

- to:**
- Press <E>**
- Access the programmable functions from the status displays (ACCESS CODE REQUIRED).
  - Access the programmable function named on a menu.
  - Exit from the last programmable function back to the status displays.
  - Enter a choice (or number) from a menu (FLASHING LED).
- Press <N> to:**
- Advance to the NEXT status display.
  - Advance to the NEXT programmable function .
  - Answer "NO" to a question.
  - Increase a given number (FLASHING LED).
- Press <P> to:**
- Return to the PREVIOUS status display.
  - Return to the PREVIOUS programmable function.
  - Answer "YES" to a question.
  - Decrease a given number (FLASHING LED).

### Displays/Menus

The programmed software, supplied to each system will determine the series of menus that are presented on the X96N display screen. Chapter 4 gives details about the software.



**Chapter 4** gives details about the software used to program the microprocessor.

It includes an overview of the menus as well as detailed information about each of the status displays and the programmable functions.

- 4.0 Software Operation (DEN-STD)
- 4.1 Getting Started
- 4.2 Status Displays
- 4.3 Programmable Functions
  - Level A - Customer
  - Level B - Factory

REV NO.	DATE	PAGE NO.	DESCRIPTION
0	11/94	ALL	ISSUED



$$\text{xxx.xx \% - SpG} = \text{x.xxxx}$$
**EXAMPLES:****IF** Measurement Range of

Channel 1 = 1.00 to 1.40 SpG

Channel 2 = 1.10 to 1.30 SpG

**AND** Present density = 1.2030 SpG**THEN** Status Display #1 reads:
$$050.76 \% - \text{SpG} = 1.2030$$
**IF** density goes to 1.3250 SpG**THEN** Status Display #1 reads:
$$081.39\% - \text{SpG} = 1.3250$$

TOP LINE...

Current process density in user selected units and in percent of full range (span).

BOTTOM LINE....

Current process density in SpG and in percent of full range (span).

If the current density rises above the value set as the high end of the measurement range for either channel, the message reads: "OVER-RANGE "

If the current density falls below the value set as the low end of the measurement range, the message reads: "UNDER-RANGE"

**Press <N>**

Time Constant = xxx.xx sec

**TIME CONSTANT:**  
Filter Time Constant (in seconds) that is being applied to the measurement.

**SPAN of Measurement Range:**  
Channel 1's Output Range (in user units). The high and low points of the measurement range.

**Press <N>**

(\*) RTD Type: Nickel/Platinum

The detector's signal to the microprocessor is formatted in "COUNTS." See Chapter 2.

TOP LINE:  
Type of RTD probe (nickle  
or platinum)

BOTTOM LINE:  
Raw counts from  
temperature probe

**Press <N>**

(\*) THESE SCREENS AVAILABLE ONLY IF  
TEMPERATURE COMPENSATION IS ENABLED.

Pins 2, 4 = DET. TEMP.

Pins 2 to 4 = Detector Temperature OR Process Temperature if using a 4-20 mA signal.

Pins 9 to 10/11 = Process Temperature or Pressure if using constant current resistance (RTD probe) signal.

Pins located on Input Terminal Strip "A" (TB-A)

**Press <N>**

(\*) Process Temp: +/- xxx.x °C

CURRENT PROCESS  
TEMPERATURE in  
selected units.

REFERENCE  
TEMPERATURE recorded  
during last "referencing"  
procedure.

**Press <N>**

(\*) THESE SCREENS AVAILABLE ONLY IF  
TEMPERATURE COMPENSATION IS ENABLED.

(\*) Process Pres. = xxxx PSI

The detector's signal to the microprocessor is formatted in "COUNTS." See Chapter 2.

PROCESS PRESSURE:  
Current reading

PRESSURE COUNT:  
Counts currently being  
received from pressure  
transducer.

**Press <N>**

(\*) THIS SCREEN AVAILABLE ONLY IF  
PRESSURE COMPENSATION IS ENABLED.

Time: XX:XX:XX

TIME:  
Current time of day in  
24-hour format

DATE:  
Current date in  
MM-DD-YY format.

**Press <N>**

Ln (Ref. Count) : x.xxx

Radiation transmission is an exponential function ( $I=I_0e^{-\mu t}$ ). Natural log values are used to compensate for the non-linear relationship between the detector signal and the process density. This signal processing technique "linearizes" the response curve. (See Chapter 2).

Natural Logrithm of the Counts recorded during last "Referencing" procedure.

Natural Logrithm of the UNFILTERED counts being received currently.

**Press <N>**



Output 1 . . . . : xx.xx mA

CHANNEL 1:  
Output Transmitter value in  
milli-amps

CHANNEL 2:  
Output Transmitter value in  
milli-amps

**Press <N>**

Ch2 Span x.xxx - x.xxx

SPAN (of Measurement Range):  
Channel 2's Output Range (in SpG). The high and low points of the measurement range.

DIAGNOSTIC:  
First value = Present Detector Temperature (in degrees K \* 10).

Second value = Detector's FILTERED output (in counts)

**Press <N>**

Last Ref Date: xx/xx/xx

REF DATE:  
Date system was last  
referenced.

ELAPSED TIME:  
Number of days since the  
last reference was  
performed.

**Press <N>**

**Getting Started**

This chapter explains how to use the X96N Microprocessor's software.

**Menu Overview**

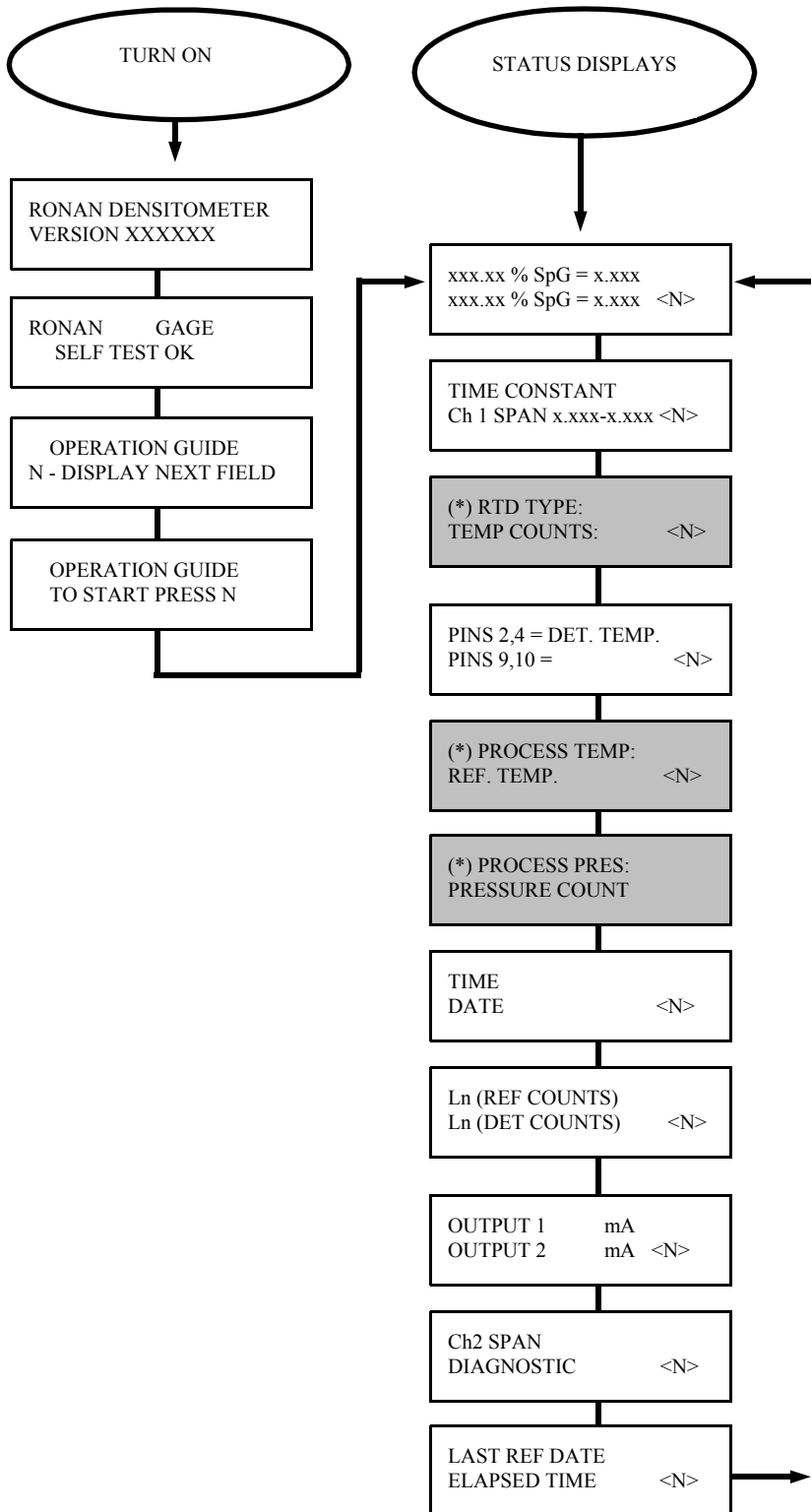
The programmed software supplied to each system will determine the series of menus that are presented on the X96N display screen. The menu overview on the next page shows all possible displays. Your own system may not require all of these displays and menus. Your series of screens may vary depending upon the hardware and software configurations required by your application. Details follow for the software displays which are included in your own system.

**Status Displays**

Status Displays are the system "reporters." Incoming measurements from the detector, settings used by the system, and output variables are among the information you can observe on the status displays.

**Programmable Functions**

Programmable functions are more than "reporters." The programmable functions series of menus are used to enter and change information that's required to configure your system.



(\* Temperature / Pressure Options Only

PROGRAMMABLE FUNCTIONS (A)

Press <E>  
Press<N N P N N P>

- TIME <N>
- DATE <N>
- TIME CONST <N>
- REF. CONSTANTS <N>
- REFERENCING <N>
- CALIBRATION <N>
- RANGE <N>
- DISPLAY UNITS <N>
- TEMP UNITS <N>
- TEMP COMP <N>
- PRES COMP <N>
- DYN TRACK <N>

- REF PROMPT <N>
- ALARM LIMITS <N>
- PRINT TIME <N>
- AUTO REF <N>
- DETECTOR TYPE <N>
- EMPTY CLAMP <N>
- Press E to Exit <E> <N>

PROGRAMMABLE FUNCTIONS (B)

Press <E>  
Press<N N P N P P>

- SOURCE TYPE <N>
- REF MODE <N>
- CAL CONST <N>
- CAL VERIFY <N>
- PRINTER <N>
- Press E to Exit <E> <N>

xxx.xx% SpG = x.xxx  
xxx.xx% SpG = x.xxx <N>

## Programmable Functions

The programmable functions are more than information "reporters." The programmable function menus allow you to change the settings, limits, and parameters that govern your measurement system. There are two levels of programmable functions: customer and factory.

### Customer-Programmable

Ronan factory personnel tested the equipment using settings, limits, and parameters that closely approximate your circumstances. However, your specific equipment and process conditions will produce their own unique results.

The programmable functions permit you to re-configure the measurement output to accommodate your own specific process conditions and customized measurement needs.

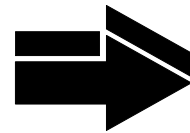
A code is required to access the programmable function menus.

To *access* the customer-programmable functions, do this:

Press <E> LEDs flash



Press <N N P N N P>



#### NOTE:

To *exit* the customer-programmable-functions, do this:

Press <N> **or** <P> until the display reads  
"Press E to Exit"

Press <E> to return to Status Display #1

TIME            E = Access

HH:MM:SS

**TIME:**

The X96N keeps the current time in 24-hour format. Use this module to change the time.

A small lithium battery maintains the time in the event of a power loss.

Hours:Minutes:Seconds

**Press <N>**

DATE            E = Access

MM/DD/YY

**DATE:**

The X96N increments the date each day at midnight. Use this module to change the date.

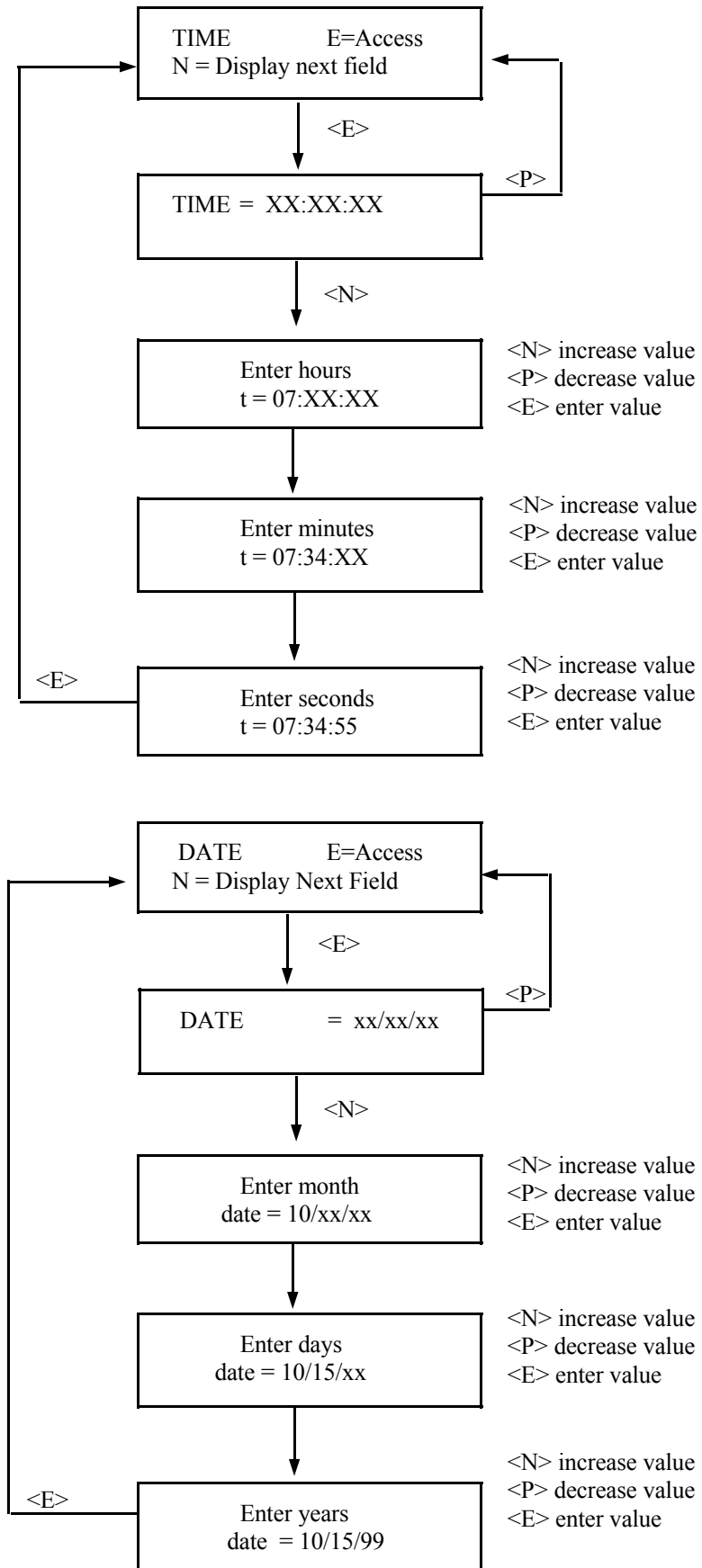
The date is stored as the "Last Cal Date" in the Status Display each time the system is calibrated.

Battery back-up maintains the date during power loss.

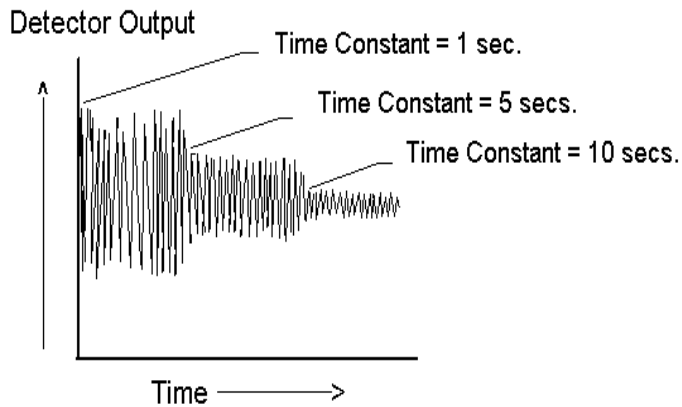
Month/Day/Year

**Press <N>**





TIME CONST    E = Access



**NOTE:**

Values from 0.40 to 250.00 seconds can be used as the time constant entry.

**TIME CONSTANT:**

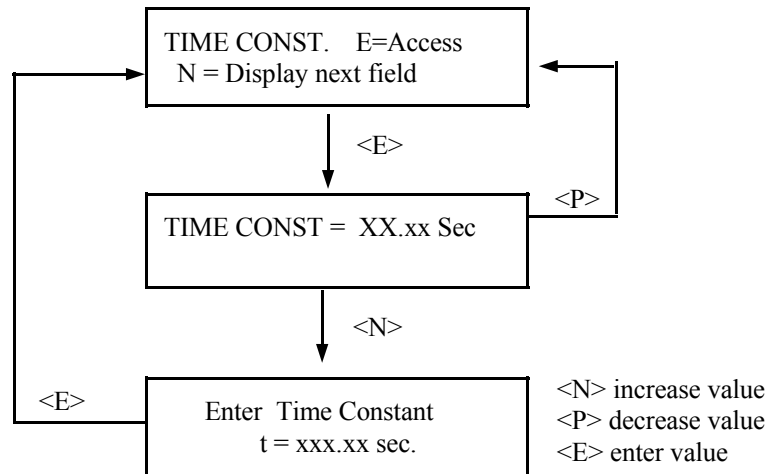
Counts received from the detector are fed into a digital filter module. This digital filter uses statistical averaging to smooth, or dampen, any random, radiation, and process related noise.

The statistical averaging is adjusted through a time constant setting in this module. Increasing the time constant will increase the filter time and decrease the noise.

The digital filter is bypassed during calibration (See CALIB. module) .

The digital filter is also bypassed if dynamic tracking is enabled and process interruptions occur that exceed the established threshold. (See DYN. TRACK. module).

**Press <N>**



Ref. Constant

E= Access

**Reference Time** - the length of time (in seconds) spent by the system doing the reference and calibration. This is the actual amount of time the gage will spend averaging counts from the detector.



The signal noise band determines the value that should be entered here. Typically it is set at seven (7) times the digital filter time constant (entered in the Time Constant Module).

**% Dev** - the difference in counts you want to allow between the last reference and the next one. Depending on how you want to limit this deviation, there are three ways to calculate the value:

- (1) If you know the limit of change in counts, calculate the percent. EXAMPLE: If last reference counts were 15,000 and you want to limit the change to 500 counts, then  

$$500/15,000 = .033 = 3\%$$
- (2) If you know the limit of change in percent, simply enter that percentage as the % deviation.
- (3) If you want to disable the system from checking this parameter, set the % dev. to 100%.

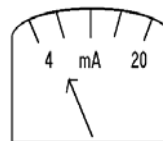
**Fault Count Low** - the minimum number of counts expected from the detector during calibration. This count should be set at a value no greater than half the background counts but not less than 1. Factory default setting is 10.

**Fault Count High** - the maximum number of counts expected from the detector calibration. Set to a value no smaller than twice the background counts plus the highest normal operating counts. Factory default setting here is 20,000.

**NOTE:** If you do not have the ability to determine the actual background and the normal operating counts, use the factory default setting of 10 for Fault Count Low and 20,000 for Fault Count High.

**NOTE:** The HIGH fault counts are used to trigger the EMPTY CLAMP feature - if enabled.

**Span Zero** - the low transmitter output signal (in mA). This value should match the selection made during setup of the transmitter output board. Typically - 4mA.



**Span Max** - the high transmitter output signal (in mA). This value should match the selection made during setup of the transmitter output board. Typically - 20mA.

**NOTE:** All of these settings are stored for use during the calibration procedure.

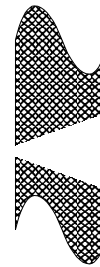
**REF. CONSTANT:**  
This module lets you make settings that are applied during the calibration procedure.

REFERENCE TIME

PERCENT DEVIATION

FAULT COUNT -  
LOW/HIGH

SPAN - ZERO/ MAX

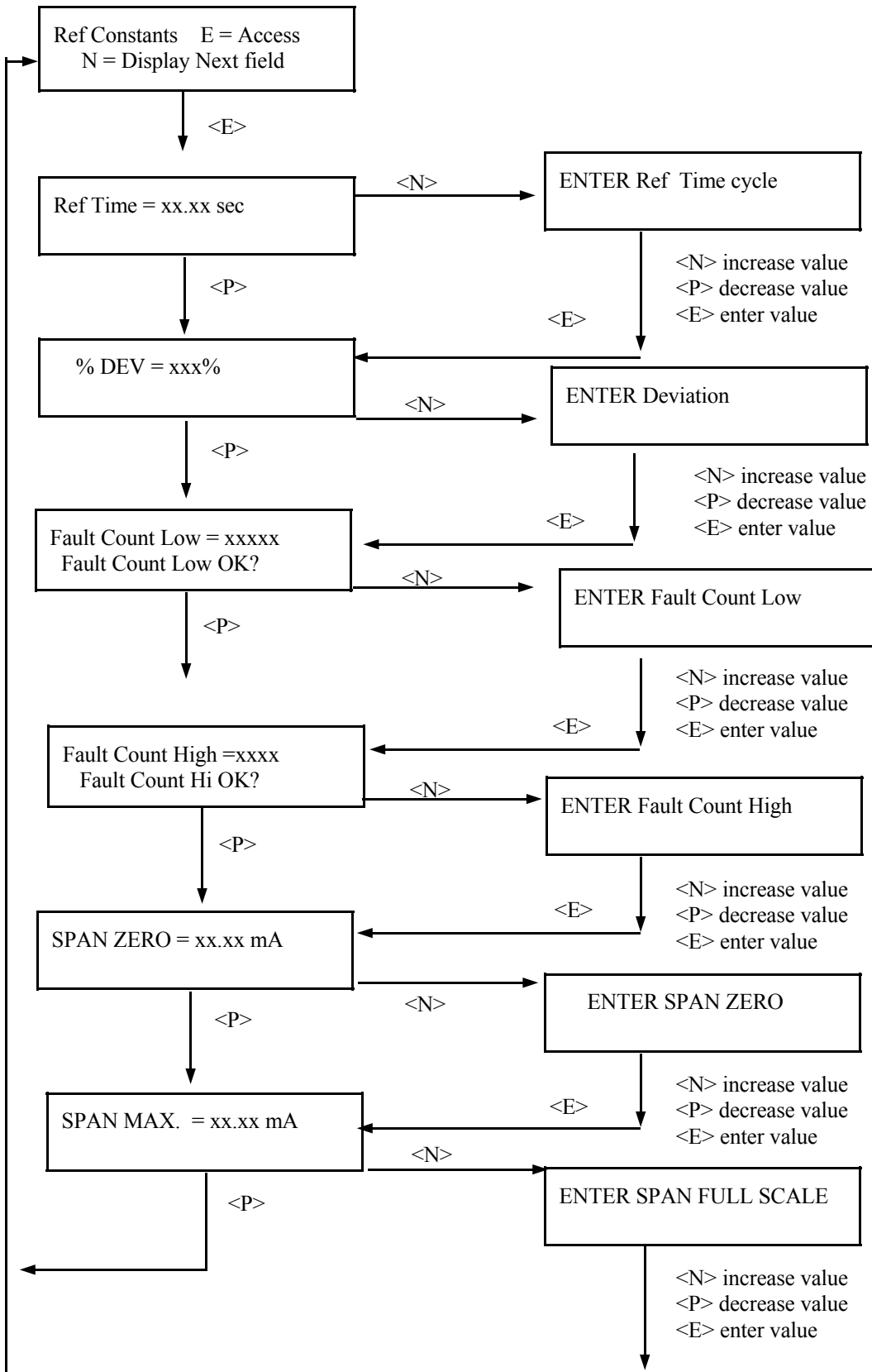


**LIGHT  
PROCESS  
(Low SpG) =  
HIGH  
COUNTS**



**HEAVY  
PROCESS  
(High SpG) =  
LOW  
COUNTS**

Press &lt;N&gt;



## Referencing      E = Access

**NOTE:** Four things will cause the system to abort the referencing cycle:

- 1) The average counts received during the cycle is below the LOW FAULT count entered in REF. CONST. module.
- 2) The average counts being received during the cycle is above the HIGH FAULT count entered in REF. CONST. module.
- 3) The difference between the last reference counts and the average of the current reference counts exceeds the % DEVIATION set in the REF. CONST. module.
- 4) A key on the front panel of the X96N is pressed to manually abort the referencing.

After referencing is successfully completed, the system will automatically do these things:

- 1) Save reference counts
- 2) Save reference SpG
- 3) Save reference temperature (if enabled)
- 4) Save reference pressure (if enabled)
- 5) Save reference date
- 6) Set "Days to last Reference" to zero
- 7) Return to Status Display #1

**NOTE:** On the first successful referencing procedure, the limit relays may cause some clicking sounds upon deactivation.

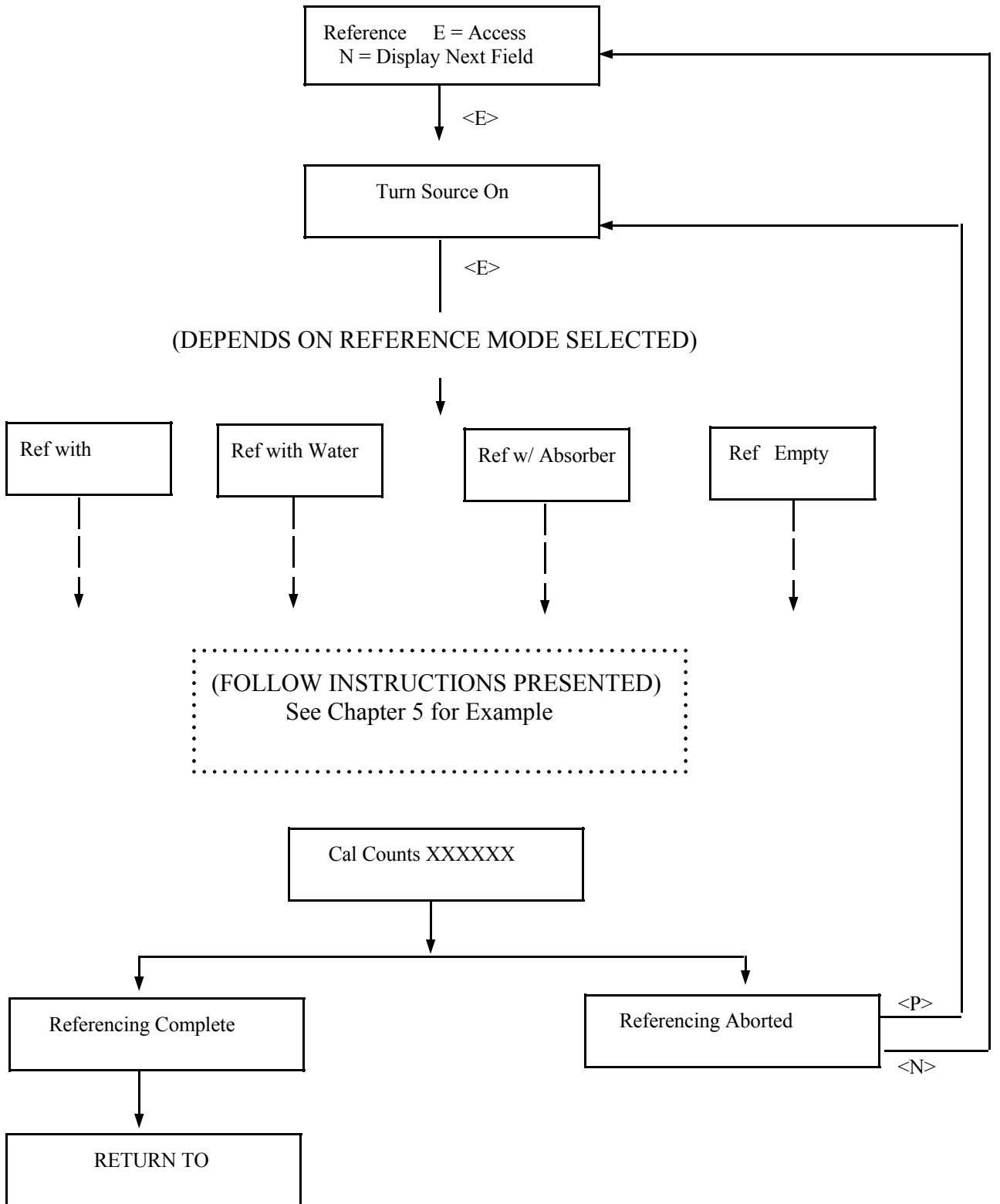
### REFERENCING:

This module allows you to establish the system's first reference point. It relates the counts from the detector to an actual process density. This is usually a LOW density value.

The series of screens presented during the referencing procedure will vary depending on which mode of referencing is selected. (See REF MODE module for more information).

During referencing the digital filter is by-passed so the system can use the actual counts received during the full referencing time period. After referencing, the counts are set to the averaged counts, and the digital filter is enabled again. (See TIME CONSTANT module).

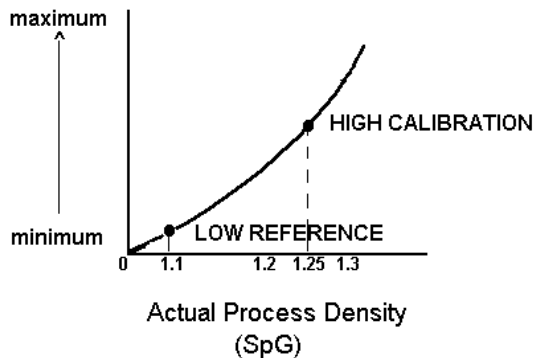
**Press <N>**



## Calibration

E = Access

X96N Output (Calibrated)



Chapter 5 gives details about the calibration procedure.

**NOTE:** Four things will cause the system to abort a calibration cycle:

- 1) The average counts being received during the cycle is below the LOW FAULT count entered in REF. CONST. module.
- 2) The average counts received during the cycle above the HIGH FAULT count entered in the REF. CONST. module.
- 3) The average of the counts being received is within 20 counts of the low reference counts during LOW REFERENCING.
- 4) A key on the front panel of the X96N is pressed to manually abort the calibration.

**CALIBRATION:**

This module allows you to establish a second density reference point (usually at the HIGH end of the measurement range). The dual-point calibration allows the X96N to calculate a very accurate calibration constant(1/uT).

(See Chapter 2)

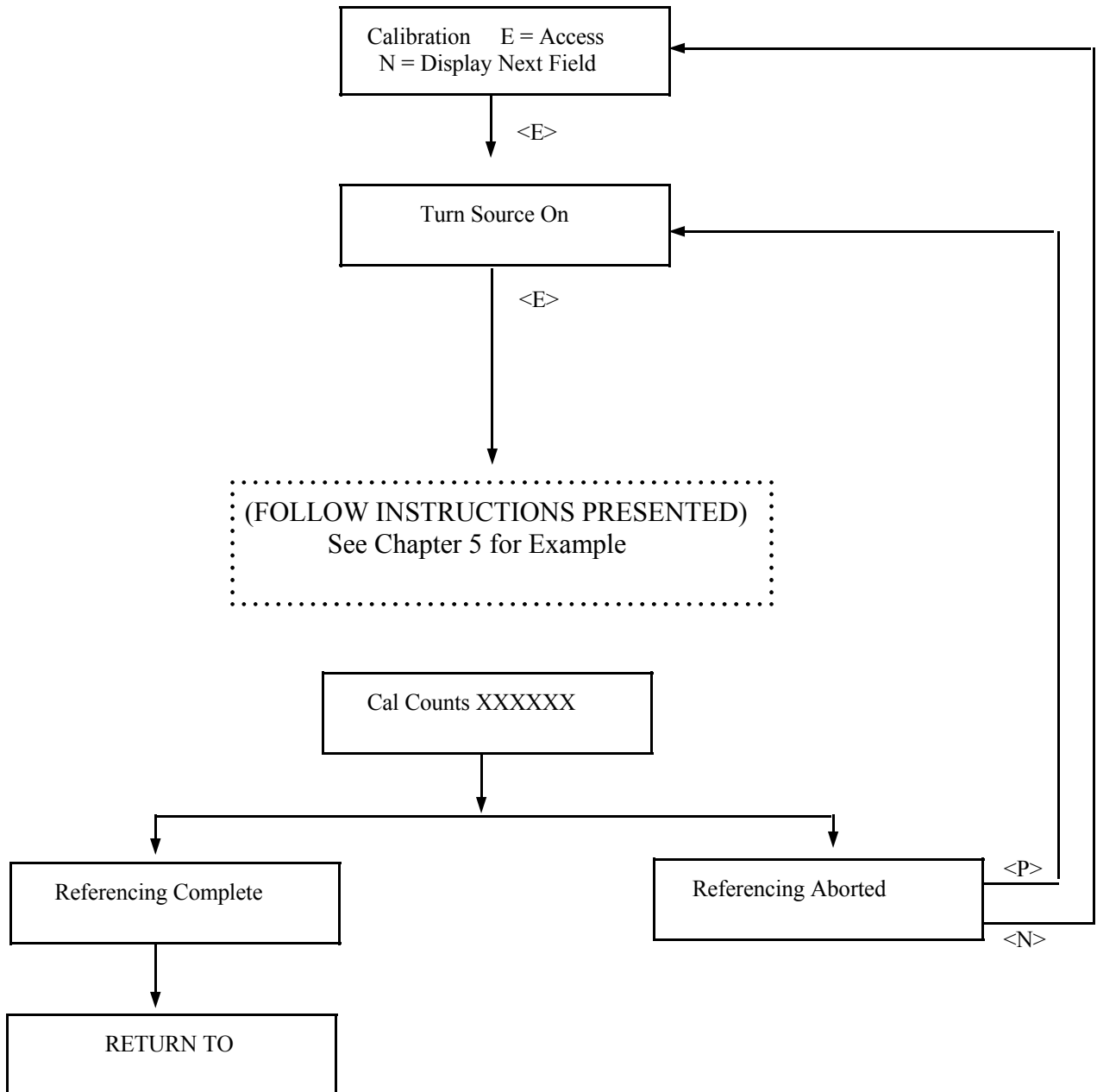
When used, the calibration must be performed on a known density of process, and cannot be the same density that was used to do the Referencing procedure.

During calibration the digital filter is by-passed so the system can use the actual counts received during the full calibration time period. After calibration, the counts are set to the averaged counts, and the digital filter is enabled again. (See TIME CONSTANT module).

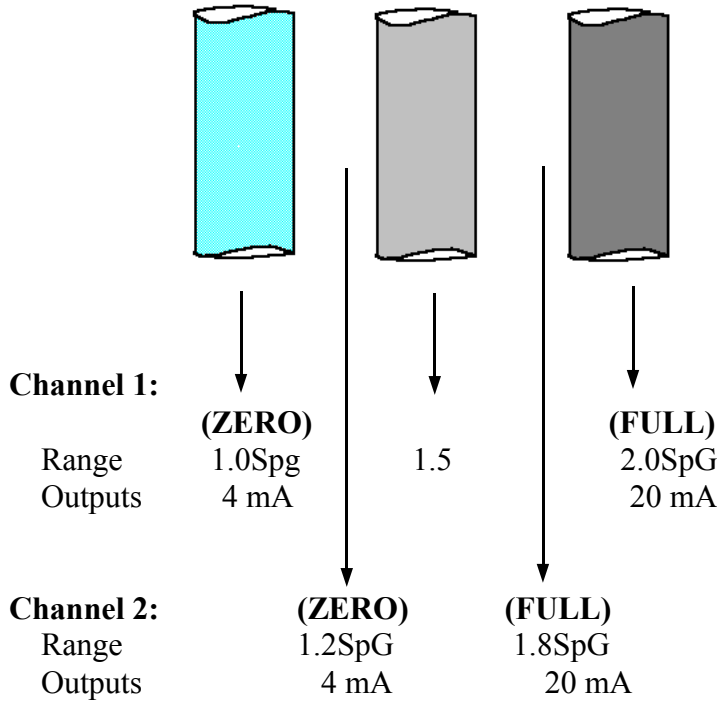
As explained in Chapter 2, an alternative to performing the Dual-Point Calibration would be to manually calculate and enter the calibration constant value into the CAL CONST module.

**Press <N>**





Range      E = Access



**RANGE:**  
 This module permits you to enter a separate measurement range for each output channel.

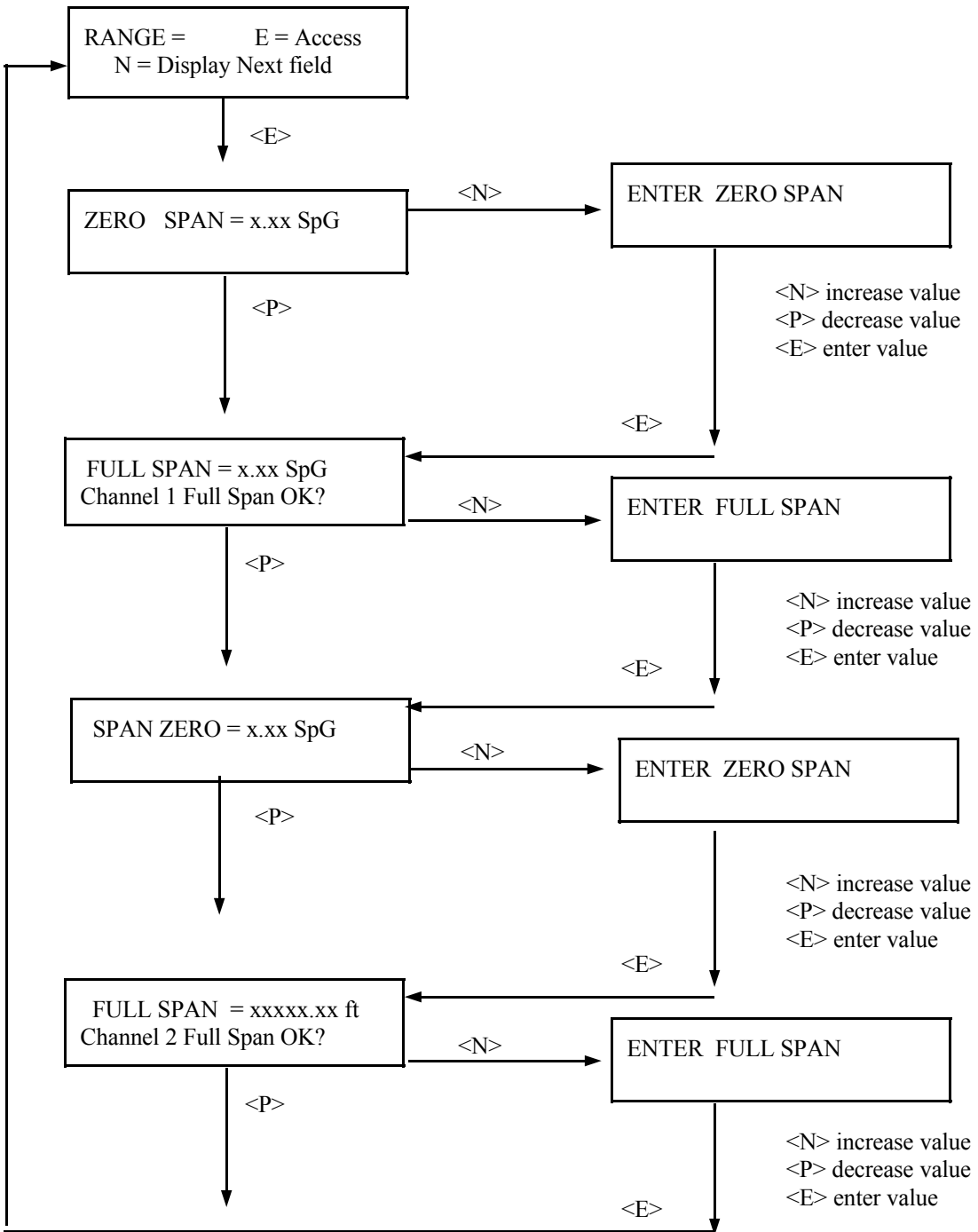
The measurement range for both Channel 1 and 2 is entered in units of specific gravity.

(NOTE: This means that if you selected Baume as the display units for Channel 1, you would have to convert the Baume range to SpG for entry in this module).

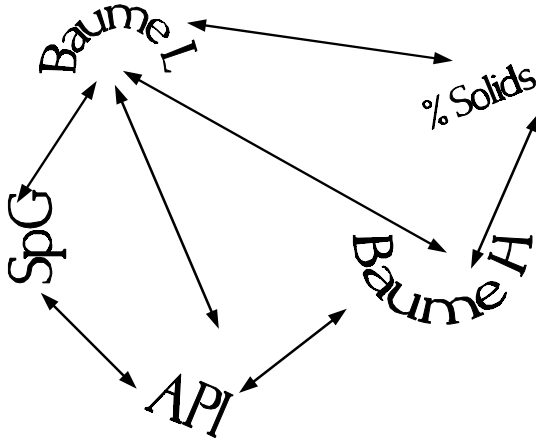
This module first asks for Channel 1 information - the "zero span" which is the low end of the measurement range, and the "full span" which is the high end of the measurement range.

It presents the same series of questions about Channel 2.

**Press <N>**



Display Units      E = Access



PERCENT SOLIDS requests this additional information:

Carrier SpG \_\_\_\_\_  
 Solids SpG \_\_\_\_\_  
 Optional Solution  
 Solubility Factor \_\_\_\_\_

Press <N>

Equations for converting SpG to PERCENT SOLIDS:

Ds = Solids Density  
 Dm = Mixture or Slurry Density  
 DI = Carrier Density  
 P = Percent Solids

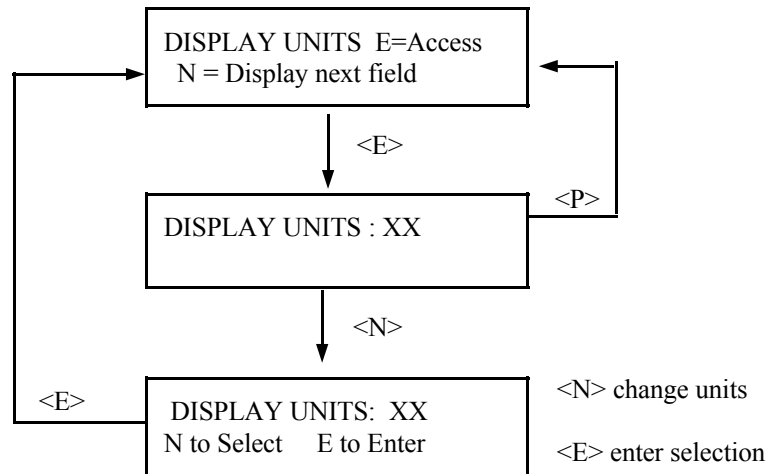
$$P = \frac{100(Dm - DI)Ds}{(Ds - DI)Dm}$$

$$Ds = \frac{PDmDI}{PDm - 100(Dm - DI)}$$

$$Dm = \frac{100DIDs}{PDI + (100 - P)Ds}$$

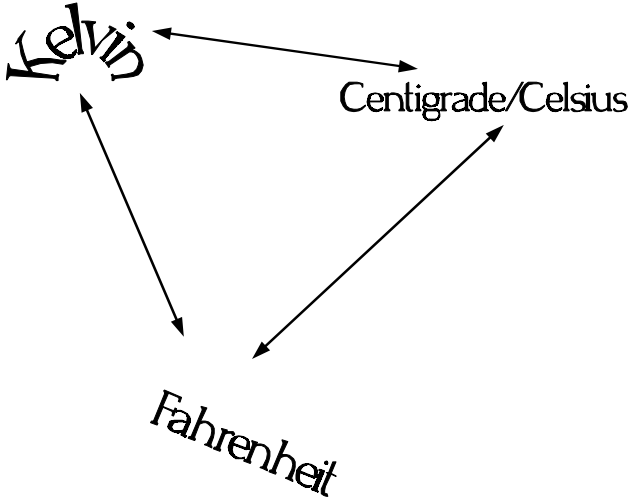
$$DI = \frac{Ds(100 - P)Dm}{100Ds - PDm}$$

Density of Water = 62.43 lb/ft<sup>3</sup> = 1.0 SpG = 8.35 lb/gal



Temp Units

E = Access

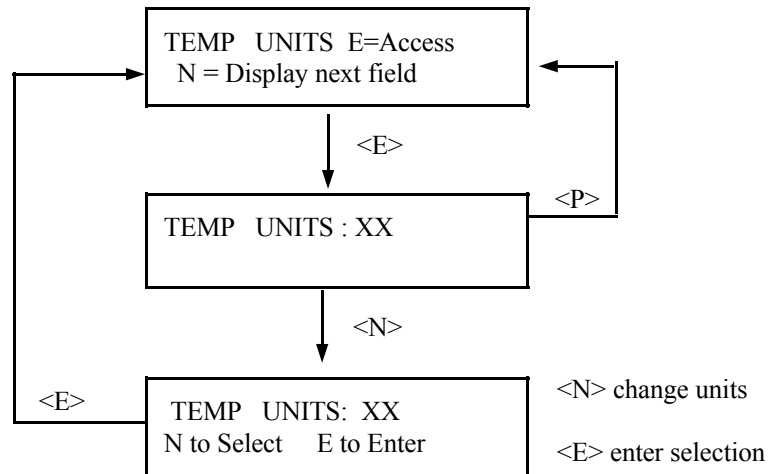


**TEMPERATURE UNITS:**  
This module determines the temperature units being displayed.

Choose from Kelvin, Centigrade/Celsius, or Fahrenheit.

The selection has no affect on the system's operation. Only the status displays are affected.

**Press <N>**



**Temp Comp      E = Access**  
**(MUST BE ENTERED AS POSITIVE VALUES)**

## TEMPERATURE COMPENSATION:

The system applies the temperature compensation entry to the calculated density to correct for process temperature variations.

This module is used to enable temperature compensation and to set up parameters for its application.

The system requires a known reference temperature to use for comparison purposes. The reference temperature can be obtained in one of two ways:

- 1) If the Calibrate Temperature equals the Reference Temperature, you can let the system read the temperature for you while you are Referencing the system. In that case, a reference has to be done AFTER temperature compensation is enabled.
- 2) You can also read the process temperature just prior to Referencing the system, and then enter the value when asked to do so.

Use the Linear Compensation column of values when process temperature varies 10°C or less.

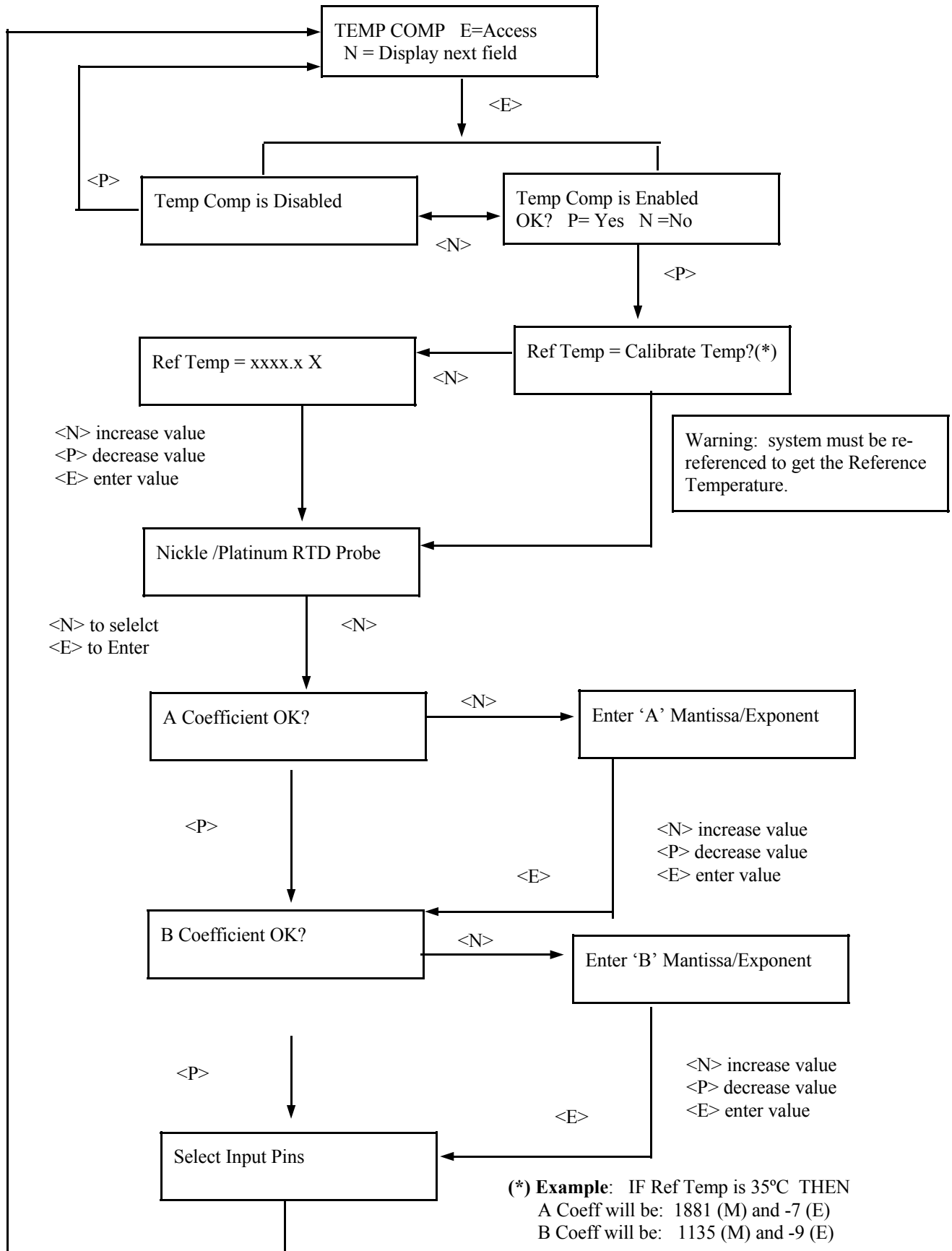
Use the Quadratic Compensation column of values when process temperature varies more than 10°C.

RECOMMENDED TEMPERATURE COMPENSATION COEFFICIENTS for WATER-BASED SLURRIES				
Reference Temp. °C	Linear Compensation		Quadratic Compensation	
	A Coef Mantissa/Exponent	B Coef Mantissa/Exponent	A Coef Mantissa/Exponent	B Coef Mantissa/Exponent
4	+7.2900 E - 5	0.0000 E - 0	+8.7576 E - 5	+3.4367 E - 6
10	+8.600 E - 5	0.0000 E - 0	+8.040 E - 5	+1.160 E - 6
15	+1.500 E - 4	0.0000 E - 0	+1.063 E - 4	+1.133 E - 6
20	+2.060 E - 4	0.0000 E - 0	+1.304 E - 4	+1.111 E - 6
25	+2.560 E - 4	0.0000 E - 0	+1.515 E - 4	+1.106 E - 6
30	+3.010 E - 4	0.0000 E - 0	+1.699 E - 4	+1.121 E - 6
35	+3.430 E - 4	0.0000 E - 0	+1.881 E - 4	+1.135 E - 6
40	+3.810 E - 4	0.0000 E - 0	+2.075 E - 4	+1.134 E - 6
45	+4.170 E - 4	0.0000 E - 0	+2.280 E - 4	+1.118 E - 6
50	+4.520 E - 4	0.0000 E - 0	+2.463 E - 4	+1.121 E - 6
55	+4.830 E - 4	0.0000 E - 0	+2.657 E - 4	+1.104 E - 6
60	+5.140 E - 4	0.0000 E - 0	+2.846 E - 4	+1.089 E - 6
65	+5.430 E - 4	0.0000 E - 0	+3.042 E - 4	+1.062 E - 6
70	+5.700 E - 4	0.0000 E - 0	+3.228 E - 4	+1.061 E - 6
75	+5.980 E - 4	0.0000 E - 0	+3.422 E - 4	+1.071 E - 6
80	+6.240 E - 4	0.0000 E - 0	+3.611 E - 4	+1.076 E - 6
85	+6.490 E - 4	0.0000 E - 0	+3.799 E - 4	+1.094 E - 6
90	+6.730 E - 4	0.0000 E - 0	+3.984 E - 4	+1.095 E - 6
95	+6.960 E - 4	0.0000 E - 0	+4.143 E - 4	+1.081 E - 6

- NOTES:** 1) Other values should be extrapolated.  
 2) Non-water-based slurries should consult standard physics tables for correct density/temperature coefficients.  
 3) **Coefficients are in units of 1/C°.** If using units of F°, multiply A Coef by 0.555 and B Coef by (0.555)<sup>2</sup>

**Press <N>**





Pres Comp

E = Access

**PRESSURE****COMPENSATION:**

The system applies a pressure compensation to the density calculation to correct for process pressure variations.

This module is used to enable and to set up parameters for the pressure compensation.

The system requires an expected low and high reference pressure. The reference pressures can be obtained in one of two ways:

1) If the Calibrate Pressure equals the Reference Pressure, you can let the system read the pressure for you while you are Referencing the system. In that case, a Reference procedure has to be done **AFTER** the Pressure Compensation is enabled.

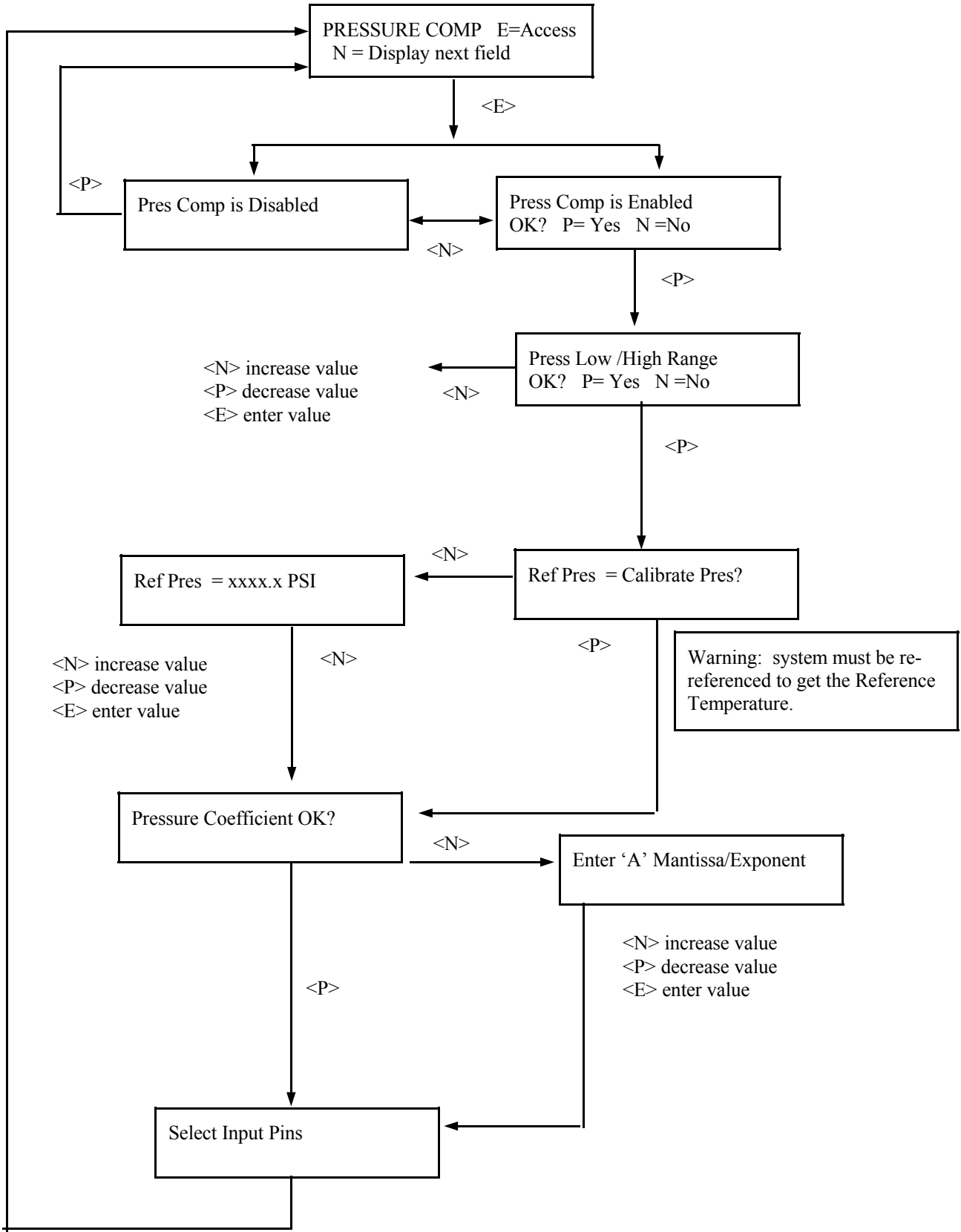
2) You can also read the process pressure just prior to Referencing the system, and then enter the value when asked to do so.

**Press <N>**

**NOTE:**

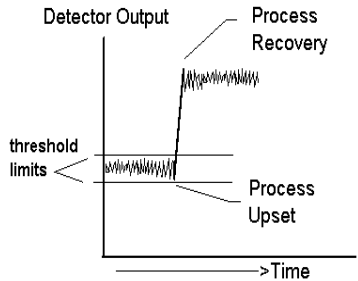
If Pressure Compensation is enabled and tied to Pins 2 and 4, the process temperature will be automatically disabled.

← Use pins 2,4 for a 4-20 mA  
← pressure signal.

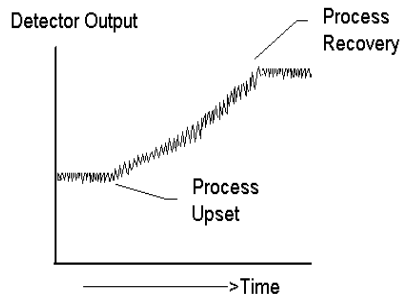


DYN TRACK

E = Access



Time Constant = 10 secs.  
Dynamic Tracking Enabled



Time Constant = 10 secs.  
Dynamic Tracking Disabled

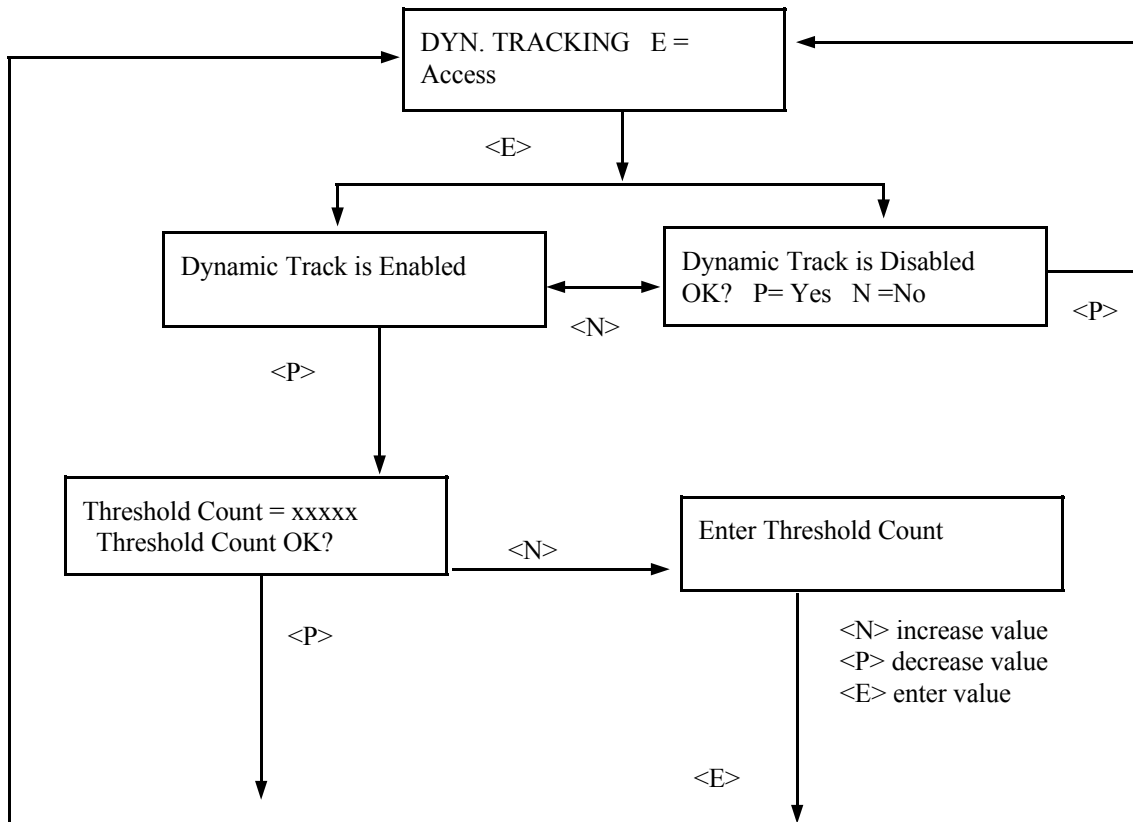
**DYNAMIC TRACKING:**  
This feature permits sudden process step changes to bypass the digital filter so they can be observed in their "unfiltered" state.

This menu requests if dynamic tracking is desired. If enabled, a response threshold value is entered in "detector counts" and is adjustable so that the normal process fluctuations can be considered.

If a sudden process change occurs that exceeds the set threshold, the filter is bypassed and the actual response is displayed.

Upon process recovery, the time constant filter is resumed.

**Press <N>**



Ref Prompt	E = Access
------------	------------

**REFERENCE PROMPT:**  
This module permits you to set the length of time until a prompt is issued that reminds you to re-calibrate the gage.

The factory default setting here is 31 days. However, routine re-calibration is usually not required.

Some conditions which may require a re-calibration are:

Change in Product

Change in Slurry

Change in ambient temperature conditions which may necessitate the use of the Temperature Compensation feature

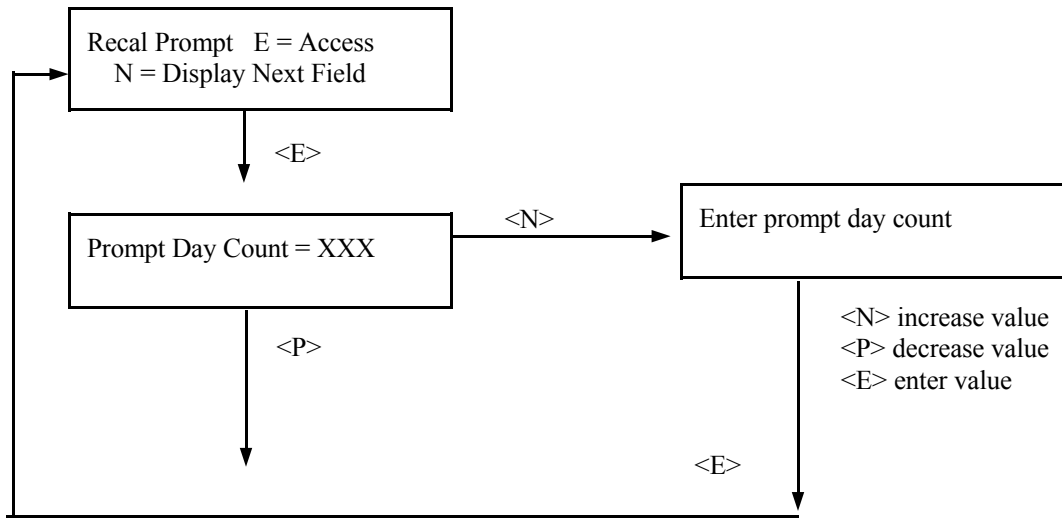
Change or adjustment to the physical configurations of the gage/process pipes

When the set number of days since the last calibration has elapsed, Input Terminal (TB-A), pin 14 will be enabled and the system will remind you to perform the re-calibration.

Once the calibration is completed, the number of days since Last Ref is reset to zero and the system begins counting over again.

**Press <N>**

← Pin 14 - open collector  
Max = 50mA at 24V



Alarm Limits	E = Access
--------------	------------

**EXAMPLE:**

Measurement RANGE (SpG):

Zero Span = 1.00

Full Span = 4.00

LOW ALARM SETPOINT: = 1.2

HIGH ALARM SETPOINT: = 3.8

HYSTERISIS: 1% (of the density span)  
(1% of 3 = 0.03)

THEN the system would issue these alarms:

**HIGH ALARM** at 3.77 to 3.83 SpG ( $3.8 \pm .03$ )**LOW ALARM** at 1.23 to 1.17 SpG ( $1.2 \pm .03$ )**ALARM LIMITS:**

The alarms set in this module are based on the density calculated by the X96N software. These software generated open collector alarms are output from the Input Terminal Strip (TB-A) with pin 12 as the high alarm and pin 13 as the low alarm.

This module asks for a lower alarm limit, upper alarm limit, and a hysteresis percent which is always a percent of the measurement range.

The hysteresis ensures that a signal wandering about the alarm limit will not cause the alarm output to oscillate.

**Press <N>****NOTE:**

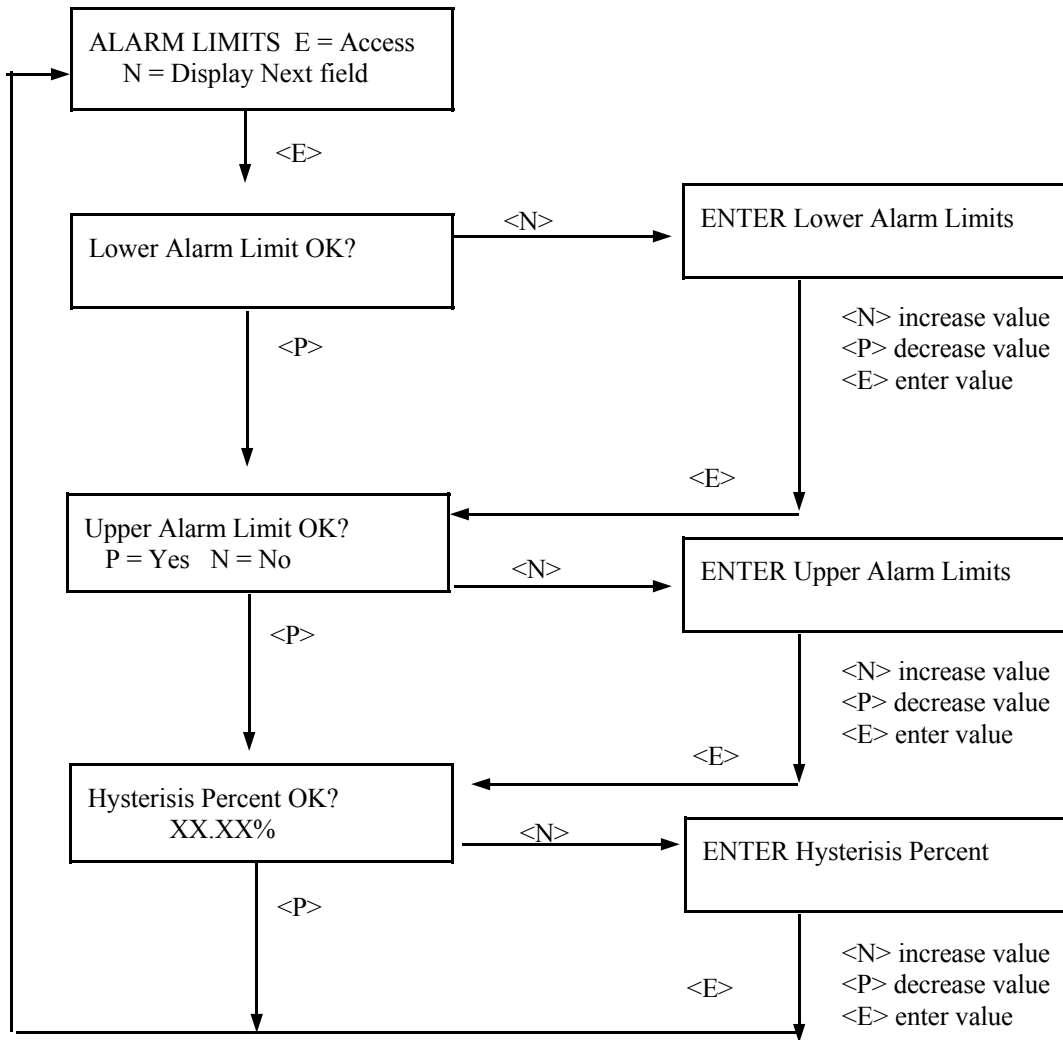
A second set of alarms use relay contacts and must be set up based on the 4-20 mA output signal.

See Alarm Trip Setup in the Chapter 7, Electronics, for details.

← Pin 12 = HIGH  
 ← Pin 13 = LOW

Open Collector  
 Max = 50mA at 24 V





**Print Time****E = Access****NOTE:**

The report gives a good record of events for gage setup or for process conditions to help analyze trends or identify problem areas.

**PRINT TIME:**

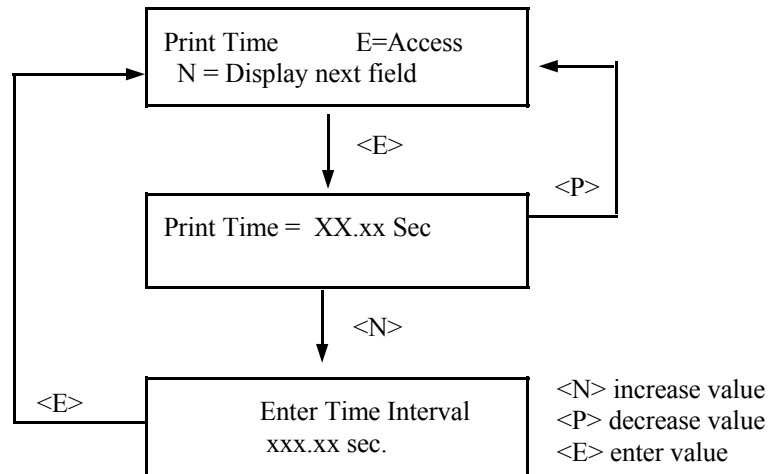
This feature applies only to systems that use the optional serial link interface printer and board.

This module lets you specify the time interval (in seconds) between printed reports. An entry of zero (0) turns off the print function.

The report prints these fields:

TIME  
DETECTOR COUNTS  
SpG  
SELECTED UNITS  
DETECTOR  
TEMPERATURE  
PROCESS  
TEMPERATURE

**Press <N>**



**NOTE:** This menu does not operate unless a printer is attached to the system's optional serial link.

Auto Ref

E = Access

This feature cannot be used unless the REF MODE is set to "Empty" or "Water." The other two choices for REF MODE (Absorber and Process) require careful preparation and monitoring of the process which prohibits the use of the Auto-Ref feature.

Auto-ref will only be executed when one of the Status Displays is showing on the screen. If a Programmable-function module/menu is being displayed, Auto-Ref will not be executed.

If the contact is still closed when the Auto-Ref is completed, the system asks if you want to disable Auto-Ref or open the contact. If no response is received in one minute, the system automatically disables Auto-Ref.

Process conditions will NOT abort the Auto-Ref. The system assumes that once contacts are closed for the set time and the status displays are showing that process conditions (empty pipe OR water) are also present and will proceed with the Auto-Ref.

**AUTO REFERENCE:**  
This features provides a method to Reference the system without going through the keyboard/display procedure.

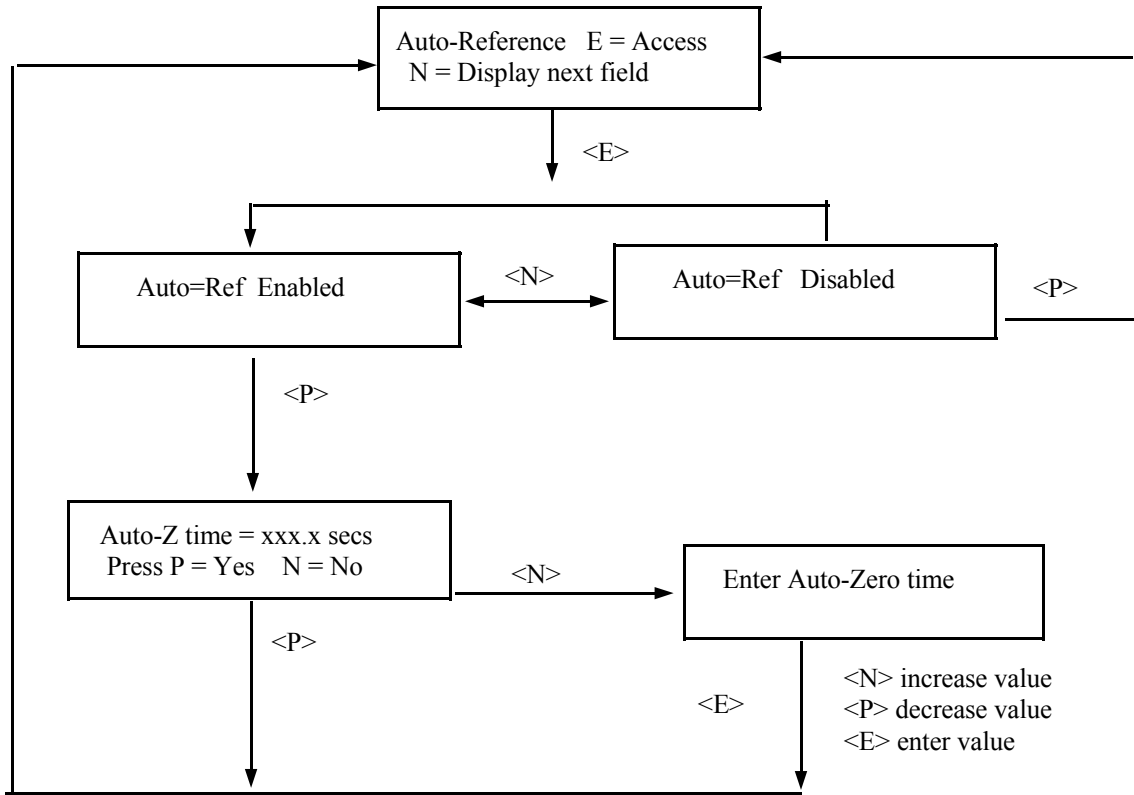
It requires a set of dry, normally open contacts connected to the X96N.

This module is only enabled when REF MODE is set to "water" or "empty." At that time, you will be asked to specify a "TIME" which serves as a trigger-delay. That is, if the dry contacts are closed and then opened before the set time has elapsed the auto-ref is delayed. In that case, the system resets the timer and waits for the contacts to close again.

**Press <N>**

pin 2 (-)

pin 5 (+)



**NOTE:** Reference Mode must be set to Empty or Water for Auto-Ref to activate.

Detector Type	E = Access
---------------	------------

Choose one of these detectors:

ION Chamber  
Scintillator

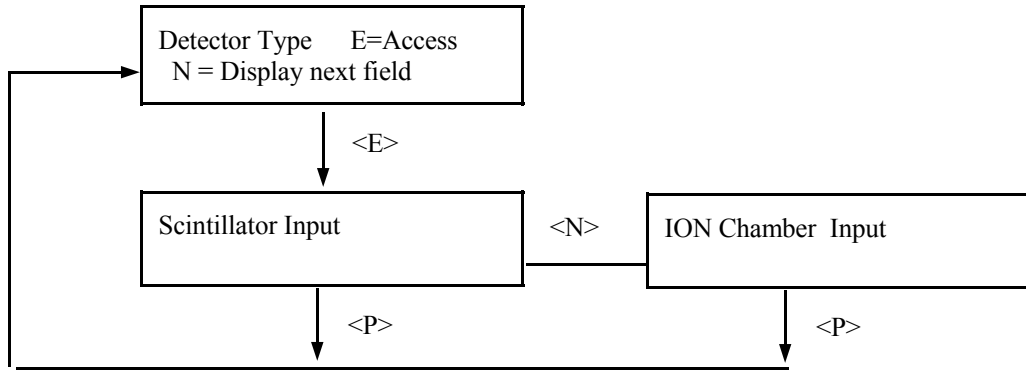
**DETECTOR TYPE:**

The choice of a detector is a factory setting that should not have to be changed.

The scintillation detector will usually have the "Empty Pipe Clamp" feature enabled. See EMPTY CLAMP module which follows.

Chapter 8 contains more details about the detector.

**Press <N>**



Empty Clamp	E = Access
-------------	------------

The scintillation detector's PMT could become damaged if saturated with high doses of radiation for an extended period of time. The "Empty Clamp" feature is designed as a safeguard to prevent that from happening.

**EMPTY PIPE CLAMP:**  
This module enables an alarm that signals an empty pipe condition. It is tied to the HIGH FAULT count setting in the REF CONST. module.

Used with scintillation detectors, this feature senses a loss of process in the pipe and signals the power cut-off to the detector.

After being enabled, the module requests entry of two time periods:

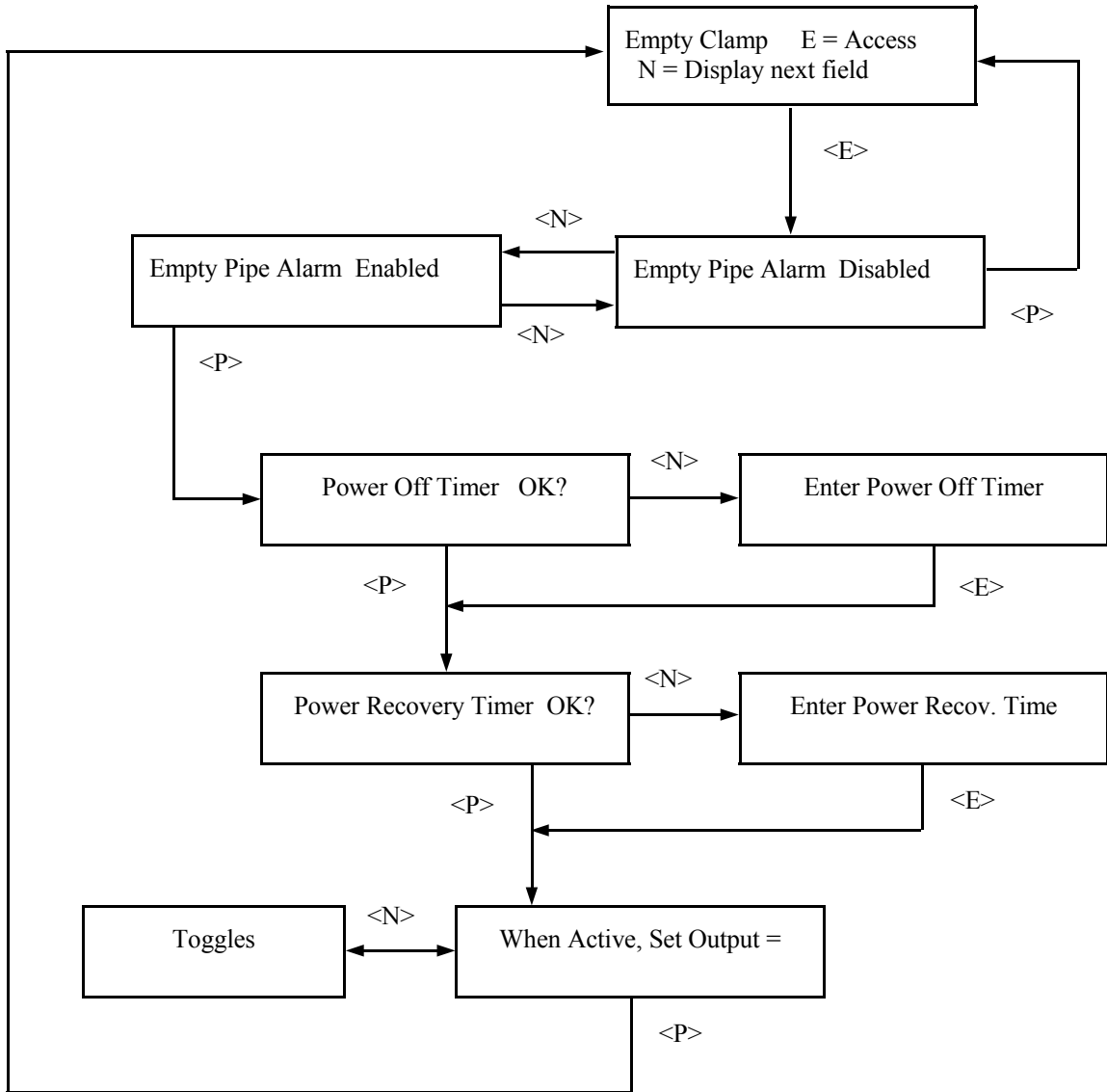
**Power-Off Timer** is period of time system waits after power-off before turning on again. (120 sec default)

**Power Recovery Timer** is period of time system waits after power-on to check for normal detector counts. (30 sec default)

**When Active, Set Output** will drive the transmitter output the one of three selectable states during the empty pipe condition. **Normal** will hold the last density before the empty pipe condition occurred. **Maximum** will drive the output to 20mA. **Minimum** will set the output to 4mA.

**Select Output <N>**  
**Press <P> to Exit**





**Factory-Programmed**

Some of the programmable functions were set at the factory based on information provided at the time your Monitor System was ordered.

Usually these settings will be appropriate and will NOT require revision. However, if one or more of the parameters need to be re-configured, a code is required to access the menus.

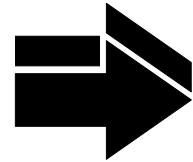
To *access* the factory-programmed functions, do this:



Press <E> LEDs flash



Press <N N P N P P>

**NOTE:**

To *exit* the factory-programmed functions, do this:

Press <N> **or** <P> until the display reads  
"Press E to Exit"

Press <E> to return to Status Display #1.

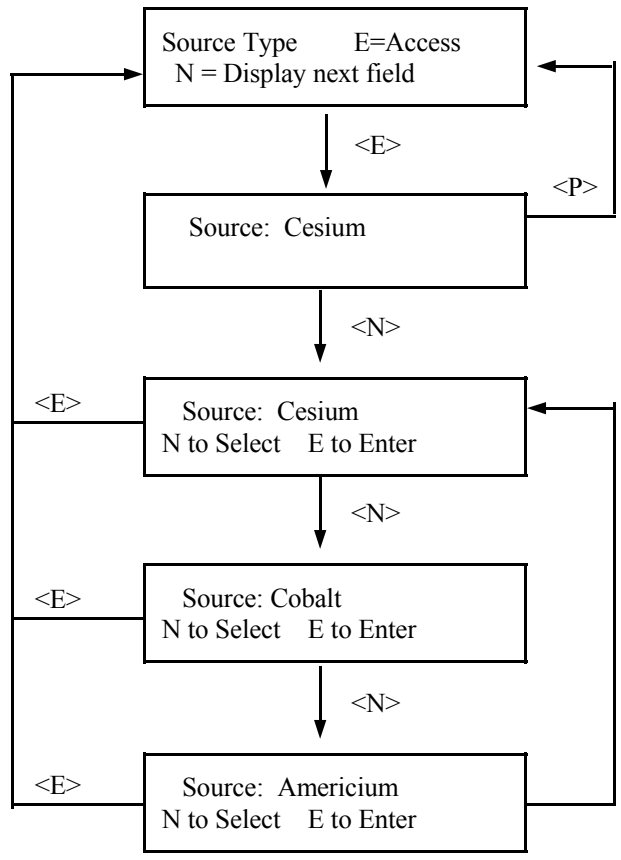
SOURCE TYPE    E = Access

Choose one of these source types:

CESIUM  
COBALT  
AMERICIUM

**SOURCE TYPE:**  
Selects radioisotope being used. This permits the appropriate source decay factor to be applied through software signal processing.

**Press <N>**



Ref Mode E = Access

Choose one of these four reference modes:

WITH PROCESS (low reference value requested)

EMPTY (low reference set to 0 SpG)

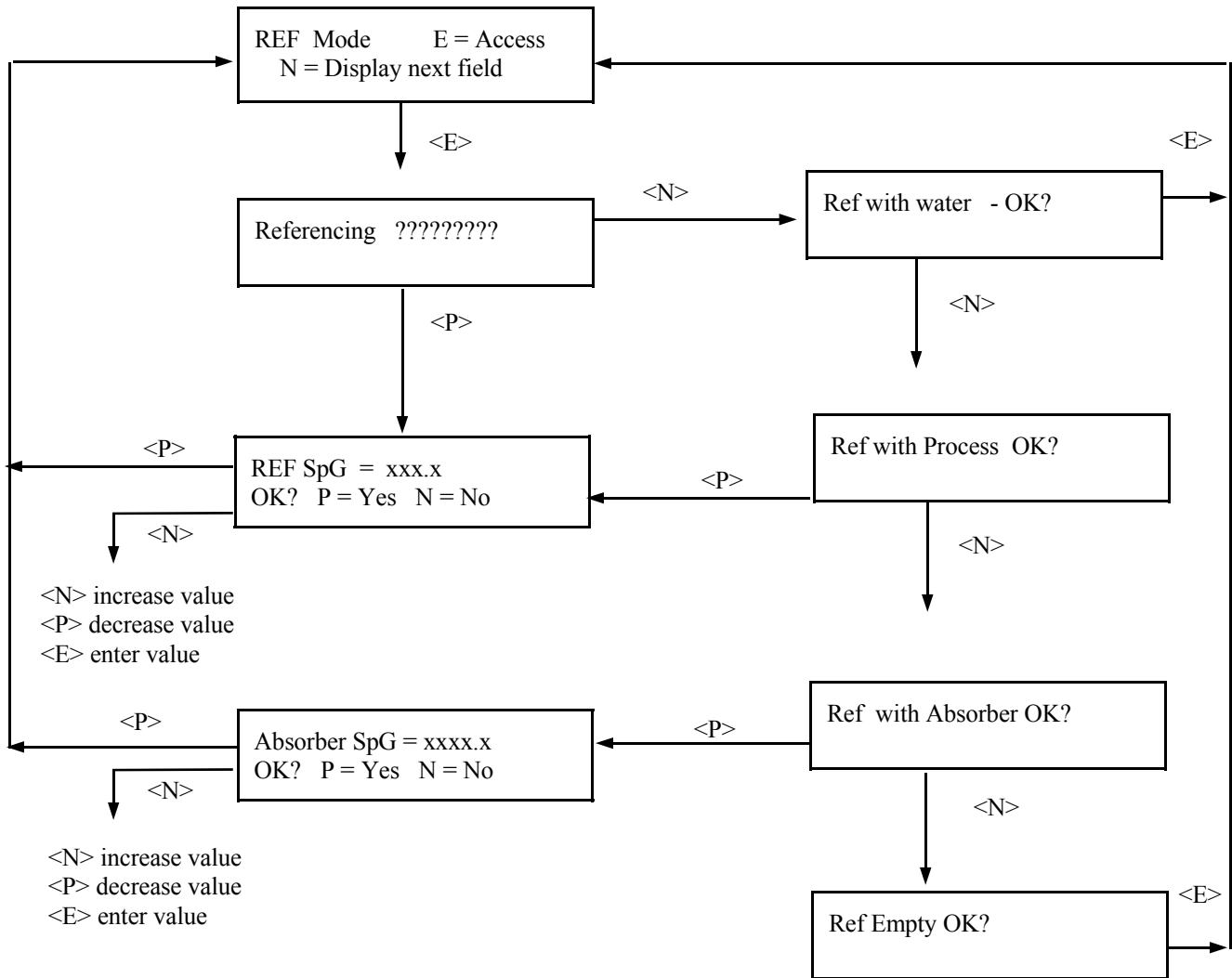
WITH WATER (low reference set to 1.0 SpG)

WITH ABSORBER (low reference value  
requested)

REFERENCE MODE:  
Permits selection from four  
modes used to reference  
the system.

Auto-Ref available ONLY  
with "water" and "empty"  
modes.

**Press <N>**



Cal Const

E = Access

Changing this value causes the computed density to change. IF the system computed 1/uT needs to be modified, it may require modification each time the gage is calibrated.

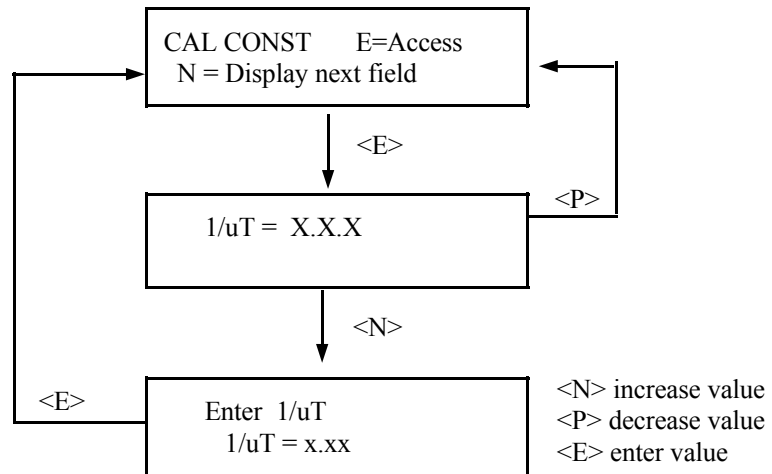
$$\frac{1}{\mu T} = \frac{1}{0.2 \text{ ( pipe ID")}}$$

**CAL CONST:**

This module stores the Calibration Constant (1/uT) for your process/pipe diameter. Using the <N> and <P> keys, you can input a new value to correct/change the value calculated by the system.

(See CALIBRATION Module.)

**Press <N>**





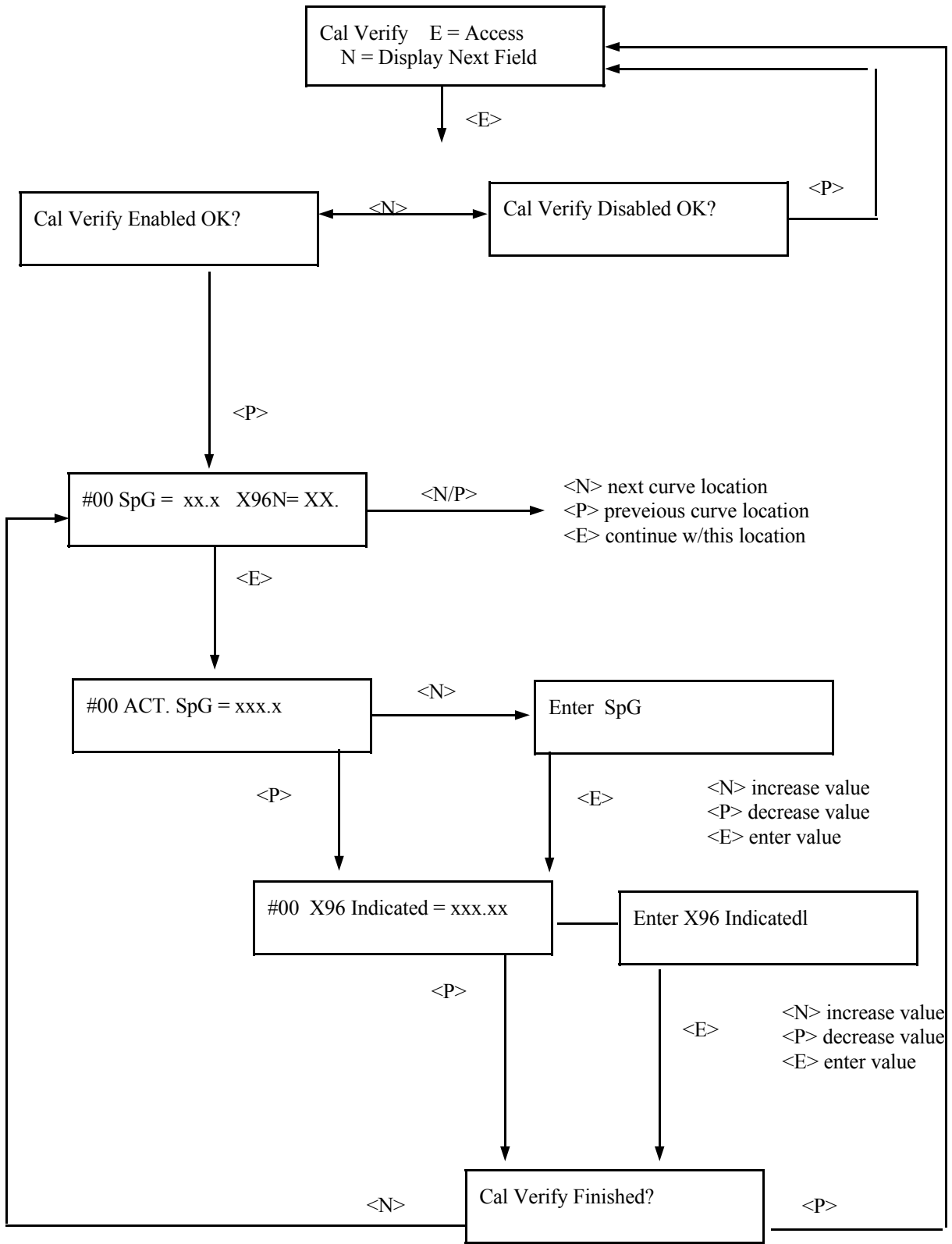
**Cal Verify****E = Access**

Refer to LN/LN status display.

**CAL VERIFY:**

This module permits entry of values used for computing a linearizer curve. Most density applications do not use this feature since the Natural Log Linearizer, computed by the system, is usually satisfactory.

**Press <N>**

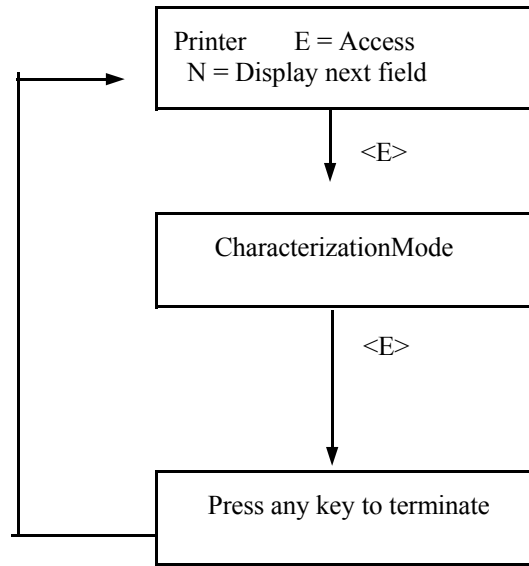


Printer

E = Access

**PRINTER:**  
Requires the optional serial link interface printer and board.

**Press <N>**





**Chapter 5** describes calibrating the Density Monitor System.

The calibration procedure is detailed, with step-by-step instructions.

**Careful attention to drawing a representative sample of density for precise laboratory analysis will produce the most accurate measurement results.**

Document all changes you make to the factory-default settings\* that are active in your system.

- 5.0 Calibration
- 5.1 Reconfiguring the System
- 5.2 Factory-Default Settings
- 5.3 Temperature Compensation
- 5.4 Calibration
  - Preparation for Calibration
  - Sampling
  - Dual-Point Calibration Procedure
- 5.5 Documentation
- 5.6 Example

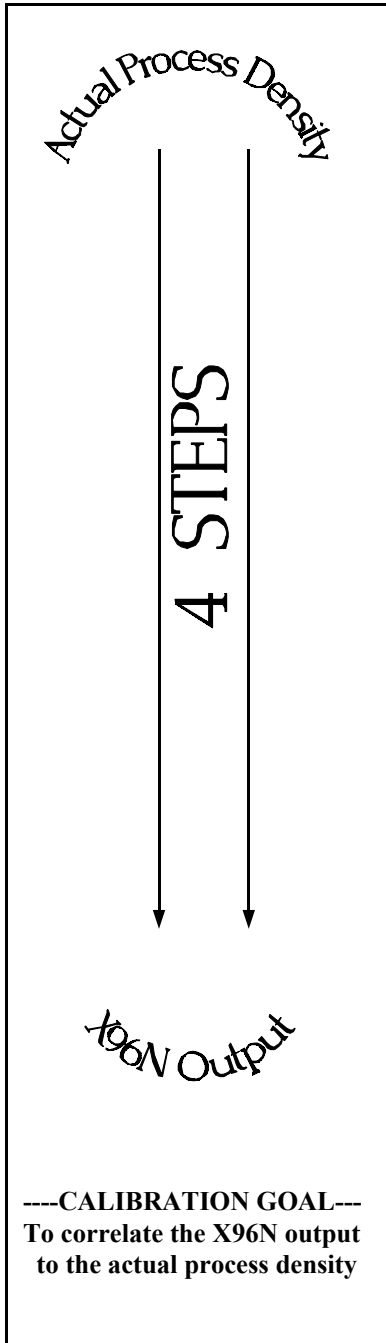
\* See "Factory Configuration and Inspection Sheets" filed in Chapter 10 with drawings.



## Reconfiguring the System

Ronan ships the Density Monitor System with factory-default software settings. Those settings are responsible for the information that initially appears on the status displays.

After installation at your site, you will want to reconfigure the system to fit your application. The goal is to correlate the X96N output with your lab sampling, so the X96N density monitor can replace the time-consuming task of manual lab-sampling. The list below summarizes the activities that are detailed in the remainder of this chapter:

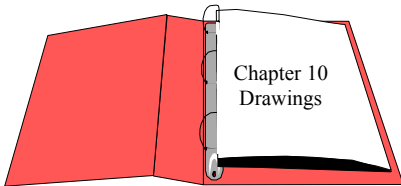


- 1 Check the factory-default settings to be sure they are appropriate for your circumstances. IF NOT, make the necessary changes and document those changes for future reference.
- 2 Enable and setup temperature compensation before doing the calibration.
- 3 Perform an initial calibration to correlate the X96N's output to the actual process density as determined by laboratory sampling.
- 4 Document detector output counts at calibrated percent consistency to assist in troubleshooting. Also, record changes you make to factory-default settings. Keep this information for future reference.

# 1 Factory-Default Settings

Locate the Factory Configuration Sheets which are filed with the drawings in Chapter 10 of this manual. That information will indicate how the system operated under factory conditions.

Those settings were made based on information provided at the time your Density Monitor System was ordered. In most circumstances these settings should be appropriate for your circumstances.



You can check these settings through the X96N display modules by entering the programmable-functions access code: Press <E>  
 Press <N N P N N P>  
 Press <N> to reach the function....

Reference: :  
 Factory Configuration Sheet

**DOCUMENT ALL CHANGES**

- REF MODE
- TIME CONSTANT
- REF CONSTANTS
  - Reference Time
  - Fault Counts (high/low)
  - Output Span (zero/max, Channels 1 & 2)
- RANGE (zero/full span - Channels 1 & 2)
- ALARM LIMITS

## Reference MODE

One of your first tasks will be to calibrate the system. The first step in the calibration procedure is to "reference" the gage on some known value. The steps involved in the referencing procedure will vary slightly depending upon the *mode* selected as the constant.

**NOTE:** Instructions which follow are for a "Referencing with Process" mode. *Your own mode* may be different, in which case your own screens may vary slightly from the example shown on the following pages. In that case, follow the prompts on your screen and enter the information requested for your own circumstances.

One of these four REFERENCE MODES will be active on your system:

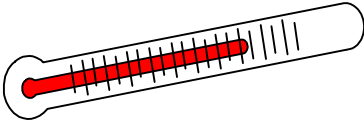
- Referencing EMPTY (SpG = 0)
- Referencing with WATER (SpG = 1)
- Referencing with PROCESS OF KNOWN DENSITY
- Referencing with ABSORBER

**Most applications use the "Reference with Water" OR the "Reference with Process" Mode.** Changing the REFERENCE MODE requires access to the Factory-Programmable Functions.



## 2 Temperature Compensation

If temperature compensation is required for your measurement accuracy, you will want to enable that feature before doing the calibration.



### WHY is Temperature Compensation Used?

Process temperature variation will cause a change in process density. If the change in density due to temperature variation is significant, the measurement could be influenced. In those cases, temperature compensation is used to offset the influence.

#### EXAMPLE:

IF:  $\Delta T = 25^\circ \text{C}$   
 AND: Density Span = 0.6  
 THEN:  $50 * 0.6 = 30 > 25$

THEREFORE:  
 Temp comp IS NOT needed.

HOWEVER:  
 IF:  $\Delta T = 25^\circ \text{C}$   
 AND: Density Span = 0.1  
 THEN:  $50 * 0.1 = 5 < 25$

THEREFORE:  
 Temp comp IS needed

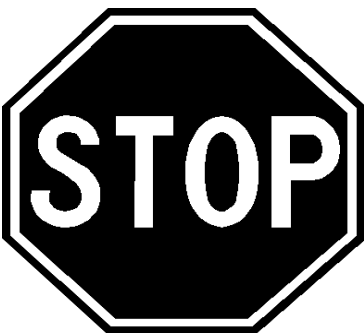
### WHEN is Temperature Compensation Needed?

In general, WIDE temperature variations over NARROW measurement spans usually require temperature compensation.

For example, a  $25^\circ\text{C}$  change in process temperature over a measurement span of 0.6 SpG would NOT require temperature compensation. However, a  $25^\circ\text{C}$  change in process temperature over a measurement span of 0.1 SpG would require temperature compensation.

As a rule-of-thumb, follow this guideline:

**If your change in process temperature (in  $^\circ\text{C}$ ) is greater than 50 times your density span, you will need to use temperature compensation.**



IF YOUR DENSITY MONITOR SYSTEM IS EQUIPPED WITH THE TEMPERATURE COMPENSATION FEATURE, TURN TO **CHAPTER 8** FOR DETAILED INSTRUCTIONS ON "TEMP. COMP. SETUP" BEFORE CONTINUING WITH GAGE CALIBRATION.

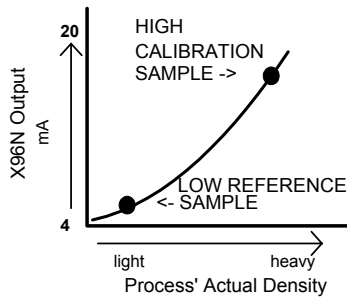
# 3 Calibration

Calibration correlates the X96N's output to your actual process density. It instructs the microprocessor to read and store the detector counts for a low and high density of process. Once the system is conditioned to recognize the low and high density, it will provide a 4-20 mA output over the entire range of interest.

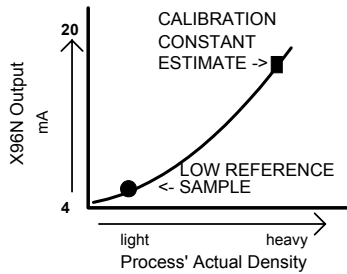
## Preparation for Calibration

### WHAT type of Calibration is needed?

Two types of Calibration are available for Ronan's Density Monitor.



← **Dual-Point Calibration** requires an accurate laboratory analysis of truly representative samples of **two** process densities. Dual-Point Calibration is preferred when the process can be varied to obtain two process densities (one at each end of the measurement range).



← **Single-Point Calibration** requires an accurate laboratory analysis of a truly representative sample of **one** process density. Single-Point Calibration is used as an alternative method when it is not physically or economically practical to vary the process density. In these cases, a second point is estimated based on the mathematical formula for radiation transmission/absorption. The table below, based on the inside diameter of the pipe, is used for density calibration.

t	ut	1/ut
2"	0.4	2.5
3"	0.6	1.6
4"	0.8	1.25
5"	1.0	1.0
6"	1.2	0.825
8"	1.6	0.625
10"	2.0	0.5

t = mat'l thickness (pipe I.D.)  
 u = absorption coefficient  
 = 0.2 for Cs137  
 1/ut = calibration constant

**Sampling**



**What type of process sample is needed?**

Any conveniently obtained process density that is within the range of interest can be used. For example, water-based slurries could use water as the reference sample. Sub-water slurries could use an empty pipe for the reference condition.

**WHAT type of sampling procedure is needed?**

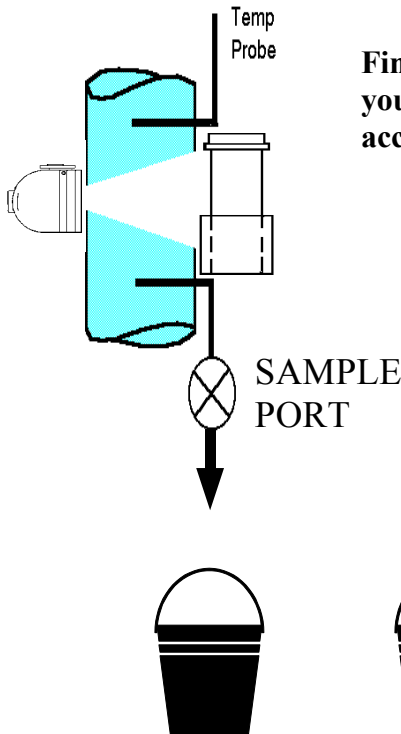
The sampling procedure will depend upon your own process. You will have to do what is necessary to obtain a truly representative sample of the density(ies) on which you are calibrating. Pull a minimum of three samples of each density. (This means at least three samples of one density for single-point calibration, and at least three samples of two densities for dual-point calibration). Take necessary precautions to preserve the integrity of each sample.

**EQUIPMENT SHOULD BE RUNNING AT NORMAL ENVIRONMENTAL CONDITIONS - TEMPERATURE, PRESSURE, PROCESS FLOW, ETC.**

**WHAT type of laboratory analysis is required?**

Precise laboratory analysis will produce the most accurate and useful results. If the results are temperature compensated, you will need to enter the uncompensated values(s) into the X96N software.

**Final gage measurements can be only as accurate as your sampling and analysis technique and level of accuracy.**



**Dual-Point Calibration Procedure**

The dual-point calibration uses two separate modules in the X96N software. First you will **REFERENCE** the system at some known low density, and then you will **CALIBRATE** the system at some higher density.

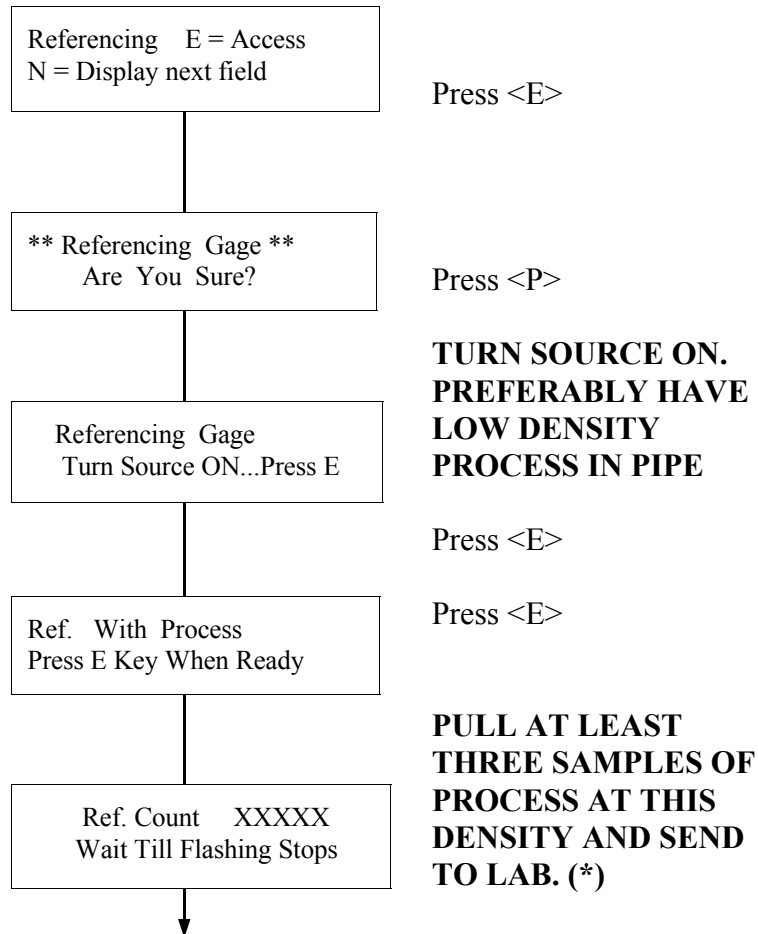
The **REFERENCING** module is located in the customer-programmable functions.

**NOTE:** The series of screens presented during the referencing procedure will vary depending on which mode of referencing is selected. (See REF MODE module for more information).

Begin by entering the access code:

- Press <E> LEDs flash
- Press <N N P N N P>
- Press <N> to reach REFERENCING

If your system is set for a Referencing Mode different from "Ref with Process" you will be asked for information slightly different from what is shown on this series of screens. In that case, follow your own prompts - enter the requested information, and press the indicated key.



X96N Results \_\_\_\_\_

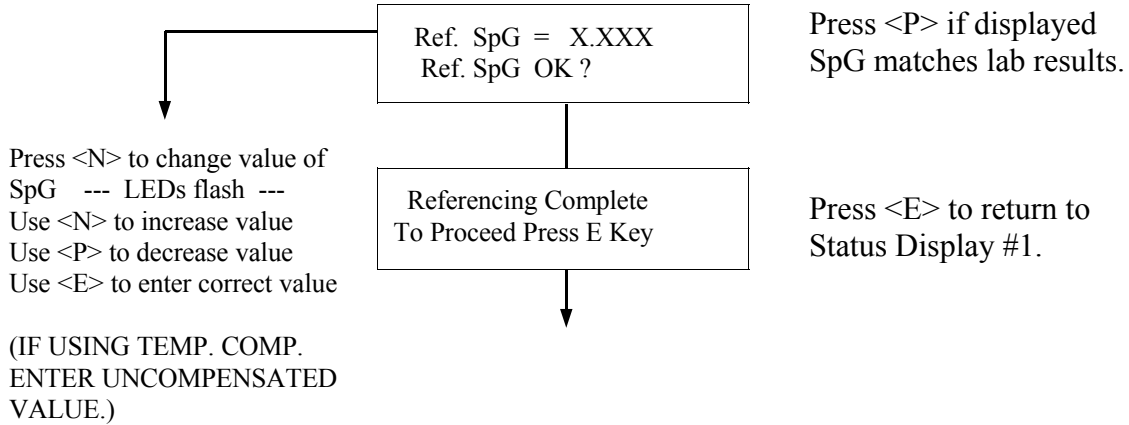
Lab Results \_\_\_\_\_

Method \_\_\_\_\_

Temperature Compensated?

YES/NO

← (\*) Have the Lab report results to you immediately and note the method they used to determine the SpG (or % solids) as well as if their results are temperature compensated.



**(\*) ALTERNATE 1/uT METHOD:**

As an alternative, the single-point calibration can be used. In that case, the results of the first sampling procedure are used in conjunction with a manually- calculated calibration constant where:

$$\frac{1}{\mu T} = \frac{1}{(0.2) (\text{pipe I.D.})}$$

(pipe diameter in inches)

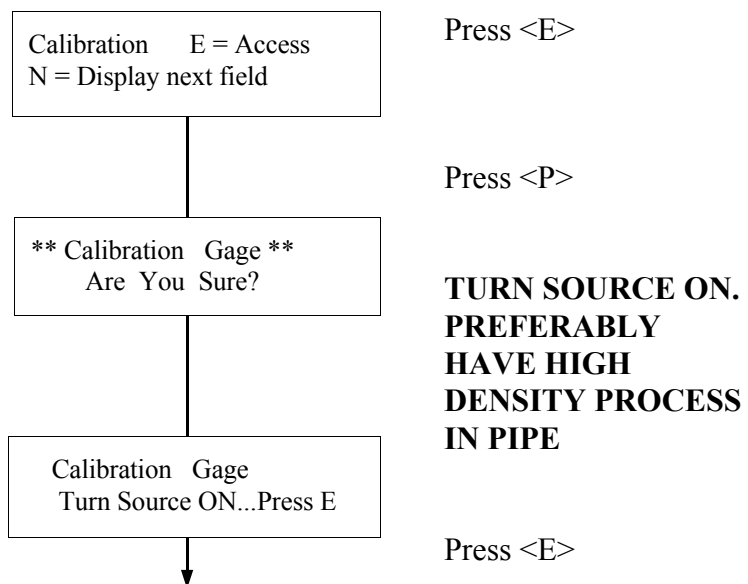
The calculated result is entered into the system through the CAL CONST module in "Factory-Programmable Functions."

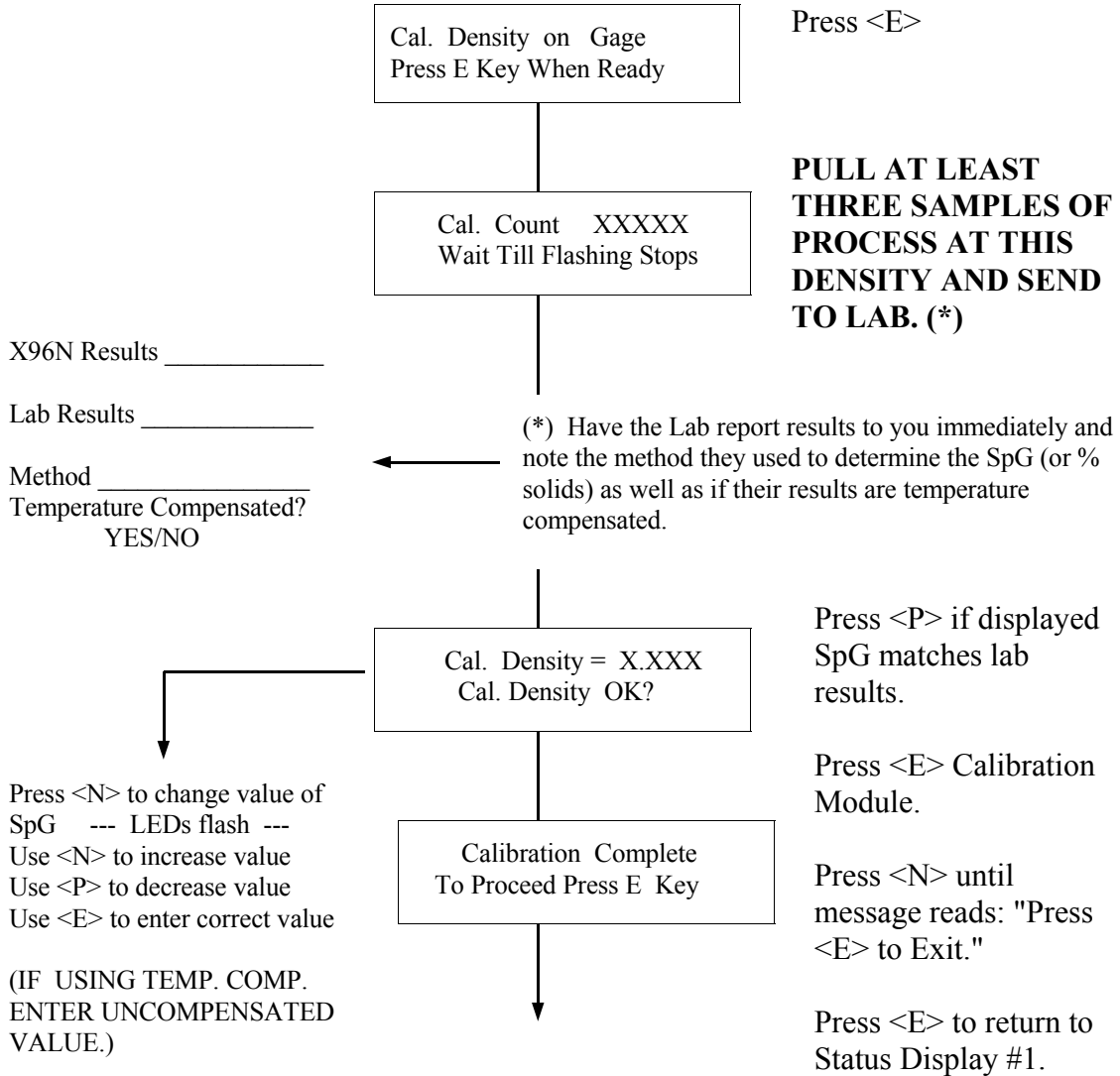
In this alternate method, the CALIBRATION module sequence

The second part of the dual-point calibration will permit your system to calculate a "calibration constant" (1/uT) for your process. This can be done through the CALIBRATION module sequence, which is located in the customer-programmable functions.(\*)

Begin by entering the access code:

Press <E> LEDs flash  
 Press <N N P N N P>  
 Press <N> to reach CALIBRATION

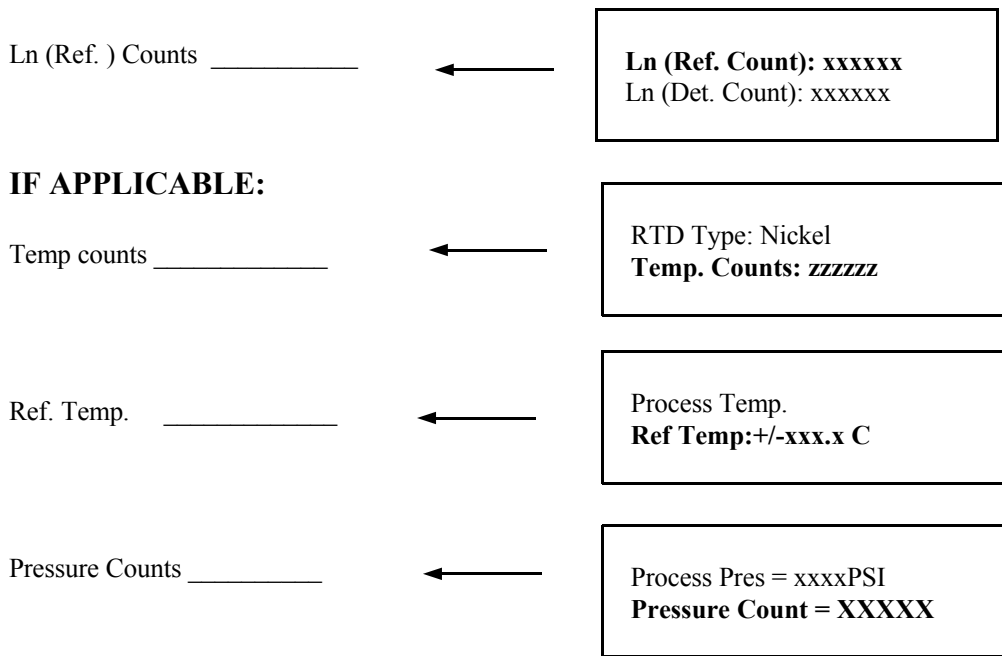




# 4 Documentation

For future reference, document these items:

- (a) Environmental/process conditions (densities, temperatures, etc.) that influence the reference/calibration. The next time a calibration is performed, you will need to duplicate the conditions, or account for the differences.
- (b) All changes made to factory-default settings such as time constant, reference constants, gain, etc.
- (c) The information from status displays shown below. A record of "counts" being received from the detector may assist with future troubleshooting efforts.



Also, for Ion Chamber detectors (analog input) with the source turned "ON" and the process at, or near LOW DENSITY, use a voltmeter to measure and record these two voltage readings from the Input Terminal (TB-A). This information may assist future troubleshooting efforts.

TB-A pin 6+ to 2- \_\_\_\_\_ ←

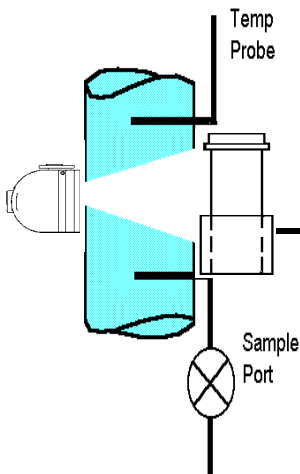
TB-A pin 7+ to 2- \_\_\_\_\_ ←

**Example**

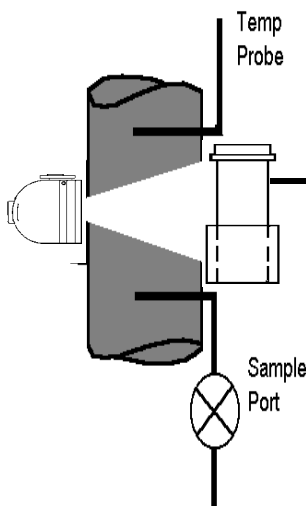
A typical example of a calibration using two known densities is shown here:

Measurement Range for Channels 1 & 2 =  
1.0 - 1.5 SpG.

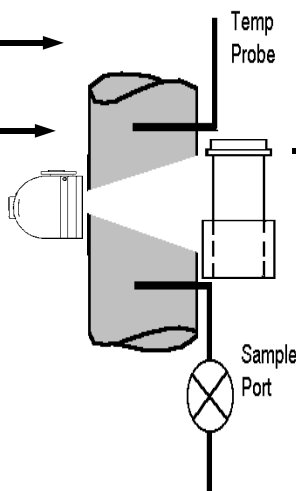
**(A)** IF SYSTEM IS REFERENCED ON DETECTOR OUTPUT OF 20,000 COUNTS WHICH REPRESENTED LOW DENSITY PROCESS



**(B)** THEN SYSTEM IS CALIBRATED ON DETECTOR OUTPUT OF 15,000 COUNTS WHICH REPRESENTED HIGH DENSITY PROCESS



**(C)** NOW, WHEN THE PROCESS ARRIVES AT 1.222 SpG, THE DETECTOR COUNTS WOULD BE 17,600 AND MICROPROCESSOR DISPLAYS WOULD INDICATE THE FOLLOWING:



044.45 % - SpG = 1.222  
044.45 % - SpG = 1.222

Time Constant = xxx.xx sec  
Ch 1 Span 1.000 - 1.500

Output 1 . . . . . : 11.11 mA  
Output 2 . . . . . : 11.11 mA

Ch 2 Span 1.000 - 1.500  
Diagnostic xxxx/ 17600

Ln (Ref Count) : 9.903  
Ln (Det Count) : 9.776

NOTE: Ln 20,000 = 9.903  
Ln 17,600 = 9.776



Technical

**Scintillator**

Technical

**Chapter 6** contains technical information and reference drawings for the detector.

The Scintillation Detector is NOT field servicable.

Instructions are given for replacing the detector.

- 6.0 Technical
- 6.1 Detector Description
- 6.2 Detector Service
- 6.3 Detector Replacement
- 6.4 Notes/Drawings



## Scintillator Detector Description

The Ronan scintillation detector consists of three main components: The plastic scintillation crystal, the photomultiplier tube (PMT), and the associated electronics.

### Scintillation Crystal

The crystal (3) used for the Continuous Level Monitor System is polyvinyltoluene (PVT) plastic. The crystal produces light pulses which are proportional to the incident radiation events striking it.

Typically mounted in a stainless steel shell the entire crystal assembly is sealed against moisture and dirt and is non-repairable. An integral flange serves to mount the crystal to the PMT. A special silicone membrane serves as an optical coupling (19) medium between the crystal and the PMT.

---

### Photomultiplier Tube

The PMT (6) is a light sensitive vacuum tube with a photosensitive layer that converts the light pulses to an electrical current. Light pulses from the crystal strike the photosensitive layer and release electrons. A high voltage power supply connected to the photosensitive layer accelerates the electrons through stages of current amplification.

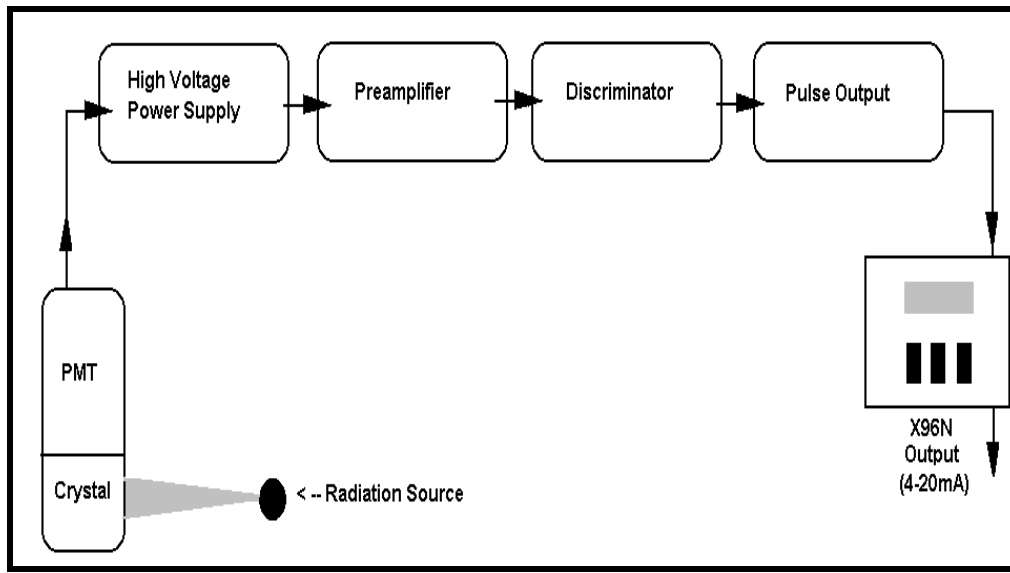
The PMT and its associated components are housed in a special magnetic shield. The tube is shock-mounted internally, with an interface plate at the top which also mounts the electronics and the outer shell (7).

---

### Electronics

Four boards, housed in a stainless steel shell, comprise the electronics and their functions.

- \* High Voltage Power Supply
- \* Preamplifier
- \* Discriminator
- \* Pulse Output

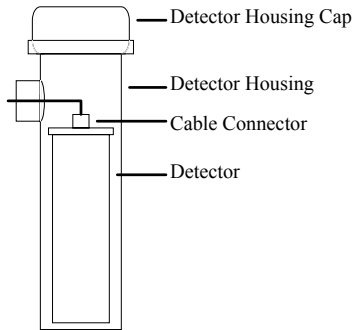


### Detector Service

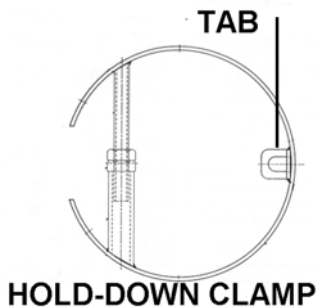
The critical components of the electronic circuit and the PMT/Crystal Assembly are aligned before leaving the factory. (See Factory Configuration and Check Out Sheets, Chapter 10). If any component of the Scintillation Detector is adjusted or replaced, the performance of the entire system will be adversely affected and will require realignment before continued use is possible.

Therefore, the **scintillation detector IS NOT field servicable**. Should a problem arise with the detector, the entire Detector Assembly should be returned to Ronan for repair/replacement.

## Detector Removal/ Replacement



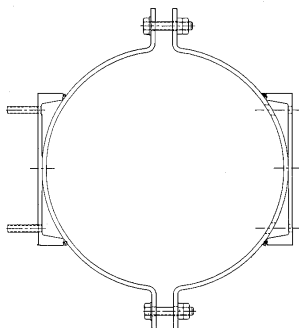
- 1) Check NOTES below for illustrations and cautions that apply to your specific equipment.
- 2) Unscrew cap on detector housing.
- 3) Unscrew connector on top of detector.
- 4) Remove detector from housing.
- 5) Carefully install replacement detector in housing.
- 6) Screw connector back onto detector.
- 7) Immediately replace detector housing cap.
- 8) Follow instruction to REFERENCE or CALIBRATE new detector.



### ELONGATED DETECTOR NOTES:

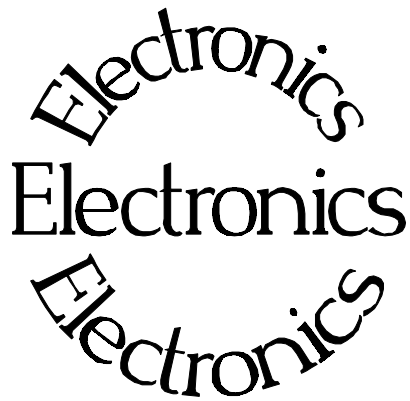
To avoid damage in shipment or installation, the elongated detectors are packaged separate from the housing. Avoid subjecting detectors to mechanical shock. Avoid supporting detector by its chain handle, or other lifting devices, for prolonged periods of time.

When detector is properly seated on the bottom of the housing, the hold-down clamp "tab" will engage and the extension rod screw can be adjusted to tighten detector assembly into housing.



### DETECTOR HOUSING/ BRACKET ASSEMBLY NOTES:

Many detectors are shipped inside the housing/bracket assembly. Bolts at the top and bottom of the C-Clamp are used to adjust the assembly around a pipe.



B-9742-K

**Chapter 7** contains information about the Electronics used in your Density Monitor System.

Troubleshooting tips are also included.

Most measurement problems can be isolated to one of four areas:

- \* Accessory related
- \* Installation related
- \* Process related
- \* Monitor System  
Equipment

- 7.0 X96N Microprocessor
  - Board Setup
  - Alarm Trips
  - Reference Drawing
- 7.1 Troubleshooting Tips - Isolate Problem
  - Accessories/Configuration/  
Process/Measurement Equipment
- 7.2 Using X96N Status Displays to Troubleshoot

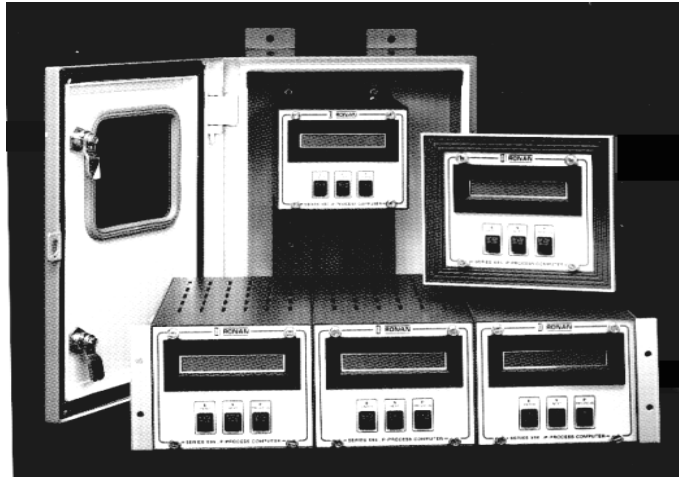


### X96N Microprocessor

### Power Supply Assembly

**Input: 24VDC**  
 110VAC +/-15% 50/60Hz  
 220VAC +/-15% 50/60Hz

**Output: +/-15VDC**  
 +5VDC



To remove fuse for inspection,  
**PUSH IN** and **TWIST**  
 COUNTERCLOCKWISE:



Test the power supply with a voltmeter by temporarily disconnecting all input wiring from TB-A. Do not allow the wires to touch other terminals or chassis. Suspect power supply problems if:

- +15V, -15V or +5V LEDs are NOT illuminated.
- +15V is NOT measured across pins 1 and 2 of TB-A.
- 15V is NOT measured across pins 2 and 3 of TB-A.

If necessary, access the power supply assembly by removing the four screws around the **OUTSIDE** edge of the panel.

Four screws around outside edge of panel will access Power Supply Assembly.



Temporarily disconnect TB-A input wiring.



Check LEDs





**X96N Microprocessor Boards**

Most troubleshooting of the X96N can be done to the board level. Loosen the four thumbscrews from the front cover of the display/keypad. Open the front cover and refer to Drawing B-9742-K for board identification.

Reference:  
B-9742-K

Each board can be easily removed and replaced. Replacement part numbers are given on the Factory Checkout and Test Sheets in Chapter 10.

**NOTICE:**

---

The boards are interchangeable in the chassis slots, however each ribbon cable **MUST** be plugged into the correct board.

---

**CPU Board**

The central processor unit (CPU) consists of the Intel 8088 Microprocessor, clock generator, the RAM, ROM and E<sup>2</sup> ROM memory devices and the buffers providing the interface to the input and output busses.

Suspect CPU board problems if readings on the display screen are incorrect or erratic.

Before replacing the entire board, check to be sure the EPROMS are positioned correctly. Also, try replacing EPROMS on U7, U8, and U9.

**Input Board**

---

The input board provides analog-to-digital conversion to condition the detector output and signal(s) for processing by the CPU.

Suspect problems with input board if any of the following conditions arise:

-15/+5V LEDs on back panel are not illuminated.

Detector input (analog or pulse) is not being converted to counts on the display screen.

The open collector outputs from TB-A do not function properly. (Measured at TB-A pins 12,13,14).

**Output Board**

The output board converts digital values of active units to two transmitter outputs (4-20 mA or 10-50 mA.) Also, two alarm trips with single setpoints providing two SPST contact outputs each. A fail-safe relay, supervised by the system watchdog, transfers if the unit fails or if it loses power.

The output board may need to be replaced if a problem arises with either one of the output signals, or if the alarm trips are not initiating properly.

---

**Display Interface Board**

The display interface board connects the main bus to the display board. It contains decoder/buffers, power failure battery back-up, and the real-time clock.

This board may need replaced if the Time and Date on the X96N do not work correctly.

---

**Display Assembly**

The display assembly is comprised of the Display Board, LCD Board, and Switch board. This assembly contains the operator display screen and three pushbuttons.

Suspect problems here if the pushbutton inputs send errant signals to the microprocessor.

---

**Serial Interface Board**

The *optional* serial interface module provides output facilities to a hard-copy printer or a computer.

Suspect problems here if devices external to the X96N are setup with correct system parameters, but are still not receiving a communication signal.

## X96N Transmitter Output Board Setup

The output range (normally 4-20 mA) is entered in the REF CONST. menu of the X96N and should match the selection on the output board.

Reference:  
B-9742-K

Two methods for setting up the transmitter output are given on the following pages:  
Setup Using a Calibrator and  
Setup Using the Gage Signal

---

## Transmitter Output Board Setup Using a Calibrator

Reference:  
B-9742-K

1. Temporarily disconnect the yellow wire from input terminal (TB-A) at pin6. DO NOT allow it to touch other terminals or chassis.
2. Connect the calibrator to TB-A at pin6 (+V) and pin2 (-V).
3. Select Status Display #1.
4. Set the calibrator until Status Display #1 indicates UNDERRNG (around 3.00V)
5. Refer to drawing B-9742-K for ZERO control.  
COUNTER-CLOCKWISE INCREASES ZERO SPAN
6. Adjust the transmitter zero control (Z1) for channel 1 and (Z2) for channel 2 to obtain an output current/voltage corresponding to ZERO of range. (eg. 4mA)
7. Set the calibrator until Status Display #1 indicates OVERRANGE (around 0.00V)
8. Refer to drawing B-9742-K for SPAN control.  
CLOCKWISE INCREASES FULL SPAN
9. Adjust the transmitter span control (SP1) for channel 1 and (SP2) for channel 2 to obtain an output current/voltage corresponding to SPAN of range. (eg. 20mA)
10. Disconnect the calibrator and replace yellow wire input terminal TB-A at pin6. RESUME NORMAL OPERATION!

pin 2 (-)

pin 6 (+)

### Transmitter Output Board Setup Using the Gage Signal

Reference:

B-9742-K

- 1 (-) Ch 1
- 2 (+) Ch 1
- 3 (-) Ch 2
- 4 (+) Ch 2

1. Calibrate the gage.
2. Empty the process or establish a "Cal LO" condition.
3. Turn source ON.
4. Using a millimeter for current output or a voltmeter for voltage output, monitor the gage signal in series directly across the output terminal (TB-B) for channel(s):  
 Channel 1: pin 1(-), pin 2(+)  
 Channel 2: pin 3(-), pin 4(+)
5. Select Status Display #1 and record the reading(s) in units and %.
6. Access the RANGE module and record the ZERO SPAN value (s) for Channel(s). Temporarily reset this value to some number higher than what was recorded in Step #5.
7. Return to Status Display #1 and verify it now indicates "UNDERRNG"
8. Refer to drawing B-9742-K for ZERO control.  
 COUNTER-CLOCKWISE INCREASES ZERO SPAN.
9. Adjust the output zero control (Z1) for channel 1 and (Z2) for channel 2 to obtain an output current/voltage corresponding to the zero span of range (eg. 4mA).
10. Turn the source OFF.
11. Select Status Display #1 and record the reading(s) in units and %.

RECORD FOR REFERENCE:

- Step # 5 (Ch1) \_\_\_\_\_ ←
- (If Used-Ch2) \_\_\_\_\_ ←
- Step # 11(Ch1) \_\_\_\_\_ ←
- (If Used-Ch2) \_\_\_\_\_ ←

12. Again access the RANGE module and record the FULL SPAN value(s) for Channel(s). Temporarily reset this value to some number lower than the reading in Step # 11.
13. Return to Status Display #1 and verify it now indicates "OVERRNG"
14. Refer to drawing B-9742-K for SPAN control.  
 CLOCKWISE INCREASES FULL SPAN
15. Adjust the output span control (SP1) for channel 1 and (S2) for channel 2 to obtain an output current/voltage corresponding to the full span of range (eg. 20 mA).
16. Turn the source ON.
17. Access the RANGE module a third time and reset channel(s) ZERO and FULL SPAN to the original values as recorded in Steps #5 and Step #11. RESUME NORMAL OPERATION!

## Alarm Trip Setup Using a Calibrator

Reference:  
B-9742-K

Ch 1: 7 = C  
8 = NC  
9 = NO  
Ch 2: 10 = C  
11 = NC  
12 = CO

pin 2 (-)

pin 6 (+)

1. The alarm trip set-points are normally field-calibrated after the system's process measurement calibration is completed. Periodic re-calibration of these modules is NOT normally required.
2. The alarm output controls two relays. Each relay has normally open and normally closed contacts. Output terminal (TB-B)  
Channel 1: alarm pin7 (C), pin8 (NC) and pin9 (NO)  
Channel 2: alarm pin10 (C), pin11 (NC) and pin12 (NO)
3. Temporarily remove the yellow wire from TB-A, pin 6. Do not allow it to touch other terminals or the chassis.
4. Connect the calibrator to TB-A pin 6(+) and pin 2 (-).
5. Select Status Display #1.
6. Set the calibrator until Status Display #1 indicates the desired setpoint value (3.00 to 0.00V = 0-100% of gage measurement output.)
7. Refer to drawing B-9742-K.  
COUNTER-CLOCKWISE DECREASES SETPOINT
8. Adjust the SETPOINT control (TP1) for Channel 1 on the alarm trip until the alarm just occurs indicated by the red LED on keypad.
9. Set the hysteresis (HS1) to the desired value.  
COUNTER-CLOCKWISE INCREASES HYSTERESIS.  
  
The hysteresis starts at 5% of input span and adds about 1.5% of span each turn.
10. Repeat Steps 6-9 for Channel 2 using (TP2) and (HS2).
11. Disconnect calibrator and replace yellow wire input terminal TB-A at pin 6. RESUME NORMAL OPERATION!

## ION Chamber Detector Signal Gain

Reference:  
B-9742-K

If Low Reference counts are below 10,000 or above 20,000 counts, the signal gain may need adjusted. Follow this procedure:

RefLo xxxxxx RefHi xxxxxxx Det Counts xxxxxx
---

Diagnostic Test xxxx / 15000
---------------------------------

1. Obtain empty vessel or low level condition.
2. Turn source ON.
3. Observe the "Diagnostic Test" status display.
4. Refer to drawing B-9742-K.
5. Adjust (R2) control on Input Board until the display reads between 10,000 and 20,000 counts

**Isolate Problem**

Most problems can be isolated to one of four overall causes. Eliminate each, one at a time, until the cause is determined.

**Accessories**

Begin by disconnecting potentiometers, recorders, and controllers from the system. Accessories, when operating properly, should have NO effect on the X96N display.

**Configuration/  
Installation**

If the problem is not affected by the accessories, consider configuration changes that may have occurred since the Measurement System was installed.

When troubleshooting, it is important to consider the "Theory and Principles of Operation" information in Chapter 2. Process measurement is possible due to the principles of radiation transmission and absorption. The total mass of material between the radiation source and the detector (i.e. "active beam") will affect the final measurement. You must eliminate possible configuration/installation type of changes as causes.

For example, consider these possibilities:

- Did the pipe insulation expand due to absorbed moisture during a wash down or absorbed process during a spill? This condition would increase the total mass of material in the "measuring gap" and would therefore, indicate a higher level.
- Did something happen to compress the pipe insulation and therefore change the total mass of material.
- Could dust from process material or surrounding environment be collecting in "dead space" between the radiation source and detector? This would also indicate a higher level.
- Are changes taking place to the process or environmental temperatures that could be impacting the measurement results?

**Process Conditions**

~~If configuration causes are eliminated, consider the process conditions themselves.~~

For example, entrained air or gas bubbles in the process material present pockets of minimum mass (i.e. low vessel conditions). If the amount of entrained gas remains constant, the system's calibration procedure will automatically allow for its effect. However, if the amount of entrained gas increases or decreases, the system will indicate lower or higher process levels.

## Measurement Equipment

After eliminating the accessories, installation/configuration, and process conditions as possible causes of the problem, you will want to consider the measurement equipment. The X96N Microprocessor itself will be of great help in this troubleshooting procedure.

If the problem is traced to the Detector, Chapter 6 contains technical information that may help to further isolate the problem.

If the problem is traced to the Optional Accessories the information in Chapter 8 may assist you.

## Using the X96N Status Displays

The X96N continuously monitors system operation. The following Status Displays will help to uncover the cause of system malfunctions.

### ALL STATUS DISPLAYS:

Begin by ensuring the displays are operational. If all of the **display screens are blank** consider these possible causes:

- Power off - Check AC power line or fuses.
- Total system failure - Check for faulty power supply  
Check for faulty CPU board.
- Faulty display board - Check for shorts at X96N:  
TB-A pins 1-2 and 2-3  
TB-B pins 1-2 or 3-4

If all display screens begin flashing:

- Empty Clamp feature may have sensed a loss of process in the pipe - ENABLED WITH SCINTILLATION DETECTORS ONLY.

(blank display)

(flashing display)

Under-RNG - SpG=1.033  
Under-RNG - SpG=1.033

**STATUS DISPLAY #1:**

Detector signal below calibration range  
(UNDERRANGE):

- Process condition
- Empty vessel
- Calibration error
- Faulty input board

Over-RNG - SpG=3.992  
Over-RNG - SpG=3.992

Detector signal above calibration range  
(OVERRANGE):

- Process condition
- Source OFF
- Calibration error
- Faulty input board

????? % - SpG=??????  
????? % - SpG=??????

Detector signal erratic:

- Response time too fast - increase time constant.
- Dynamic tracking threshold too low - increase threshold.
- Radiation field varying independent of process - check to ensure source holder handle is secured in the ON position.

**COUNTS STATUS DISPLAY:**

Detector counts greater than Reference (low) counts:

Ln (Ref. Count): x.xxx  
Ln (Det. Count): > x.xxx

- Density measurement below limits - check for calibration error.
- IF Ion Chamber Detector. check detector signal adjustment

**OUTPUT STATUS DISPLAY:**

**Output always 4.0** - Detector signal is below the calibration range:

Output 1 ....: 04.00 mA  
Output 2 ....: 04.00 mA

- Process condition
- Calibration error
- Empty vessel/pipe



Output .... 20.00 mA  
Output ... 20.00 mA

**Output always 20.00** - Detector signal is above the calibration range:

- Process Conditions
- Calibration error
- Source OFF

Output ..: ??????  
Output .... ??????

**Erratic output:**

- Response time too fast: increase time constant.
- Dynamic tracking threshold too low - increase threshold.
- Radiation field varying independent of process - check to ensure source holder handle is secured in the ON position.

**DIAGNOSTIC TEST DISPLAY:  
(First Value - Density applications)**

Ch 2 Span x.xx - x.xx  
Diagnostic Test **3333**/-----

Detector temperature exceeding high limit:

- Faulty temperature controller or sensor

Ch 2 Span x.xx - x.xx  
Diagnostic Test **2333**/-----

Detector temperature exceeding low limit:

- Faulty temperature controller or sensor.
- Open heater blanket
- No heater power

**DIAGNOSTIC TEST DISPLAY:  
(Second Value)**

Ch 2 Span x.xx - x.xx  
Diagnostic Test ----/**00000**

No detector signal:

- Faulty detector
- Faulty detector amplifier
- Faulty +/- 15V power
- Faulty cabling
- Source OFF

Ch2 Span x.xx - x.xx  
Diagnostic Test-----/**32767**

Detector signal above expected limit of counts:

- Calibration error
- Faulty detector/detector amplifier

Accessories/Options

Accessories/Options

Accessories/Options

**Chapter 8** includes details about optional features, accessory equipment, and other special items that may be included with your gage.

The information in this chapter applies only to the Density Monitor Systems that use these options.

- 10.0 Accessories/Options
- 10.1 RTD Calibration
- 10.2 Temperature Compensation Setup



## RTD Calibration

Resistant Temperature Device (RTD) option applies only if:

- 1) Your system uses Temperature Compensation
- 2) Temperature input through TB-A, pins 9 and 10.

Reference:

B-9742-K (Chapter 7)

The following procedure is required **only upon initial installation**. Further adjustment to Input Board control should NOT be required.

- 1) RTD is factory-calibrated and should NOT required re-calibration.
- 2) Temporarily remove RTD wires from pins 9, 10, and 11 on Input terminal (TB-A)
- 3) Jumper pins 9 and 10 together.
- 4) Connect a 100 Ohm resistor across pins 9 and 10.
- 5) Go to X96N Status Display for RTD type and Temperature Counts.
- 6) Adjust the R28 control on X96N Input Board until the counts displayed are equal to 6633.
- 7) Remove resistor and jumper from TB-A pins and replace RTD wires.

← Pins 9, 10,  
and 11

RTD Type: Nickle (Platinum)  
Temp. Counts: 6633

## Temperature Compensation Set-up

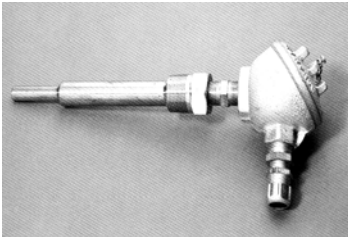
The temperature compensation feature will neutralize the effect of temperature extremes on a process's measured density.

### WHEN is Temp-Comp needed?

Generally speaking, WIDE temperature variations over NARROW measurement spans usually require temperature compensation.

As a rule-of-thumb, follow this guideline:

**If your change in process temperature (in °C) is greater than 50 times your density span, you will need to use temperature compensation.**



### WHAT'S required to use Temp Comp?

Some method of reading the process temperature and relaying the signal back to the X96N Microprocessor is required.

The Resistance Temperature Device (RTD) shown here is one possibility. This temperature "probe," is inserted into the process pipe as close as possible to the detector and wired into the X96N. The X96N uses the temperature input to compensate the density measurement for variations in process temperature.

### WHAT type of Temperature Compensation is Needed?

Two types of Temperature Compensation are available on Ronan's Density Monitor:

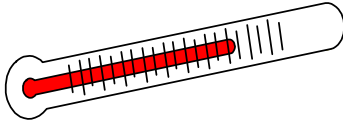
**Linear Compensation** (A coefficient only) is used when change in process temperature is 10°C or less.

**Quadratic Compensation** (A & B coefficients) is used when change in process temperature is greater than 10°C.

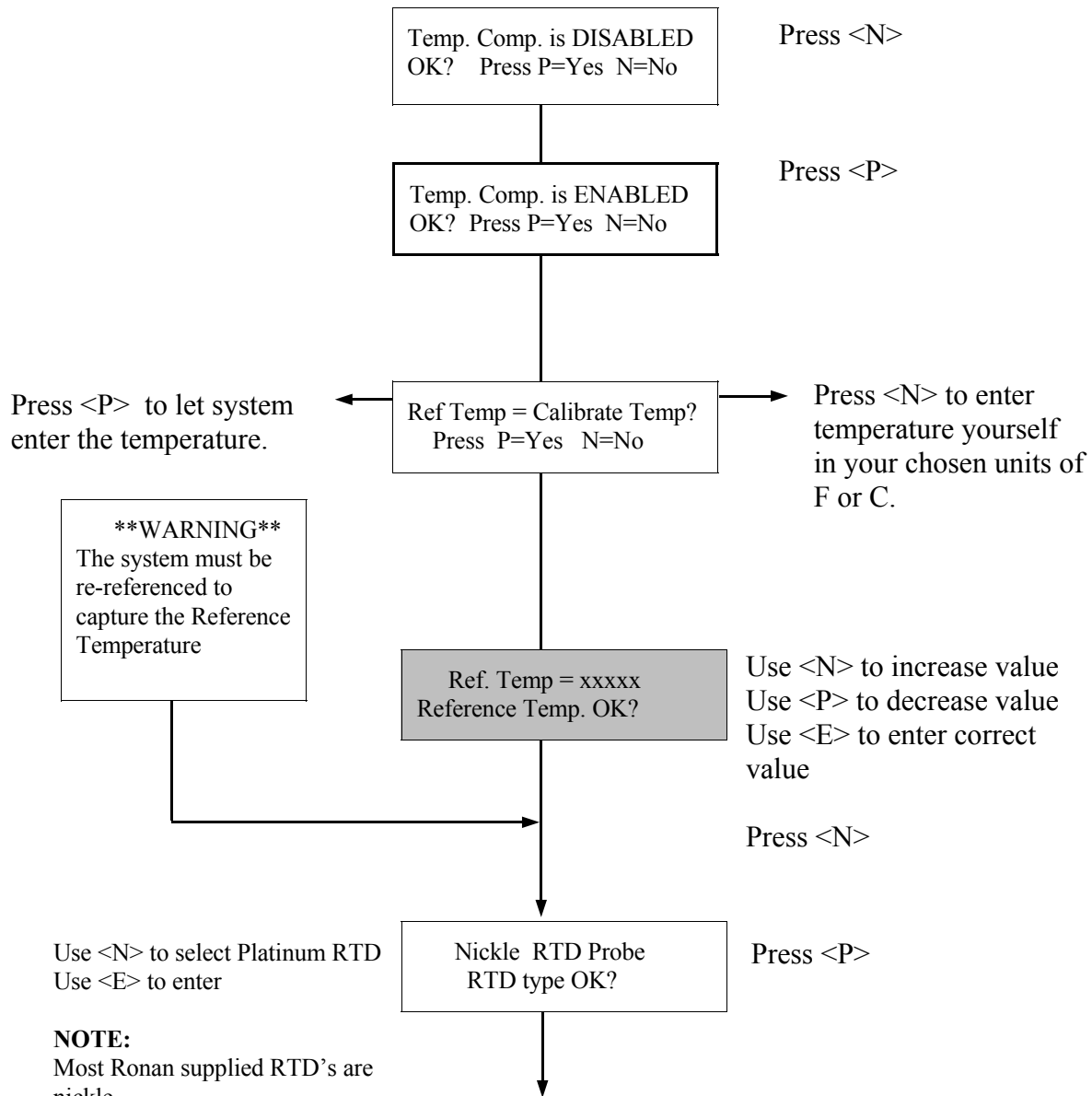
See the TABLE in Chapter 4 under TEMP COMP menu for details.

### HOW is Temperature Compensation Setup?

The TEMPERATURE COMPENSATION module is located in the customer-programmable functions.



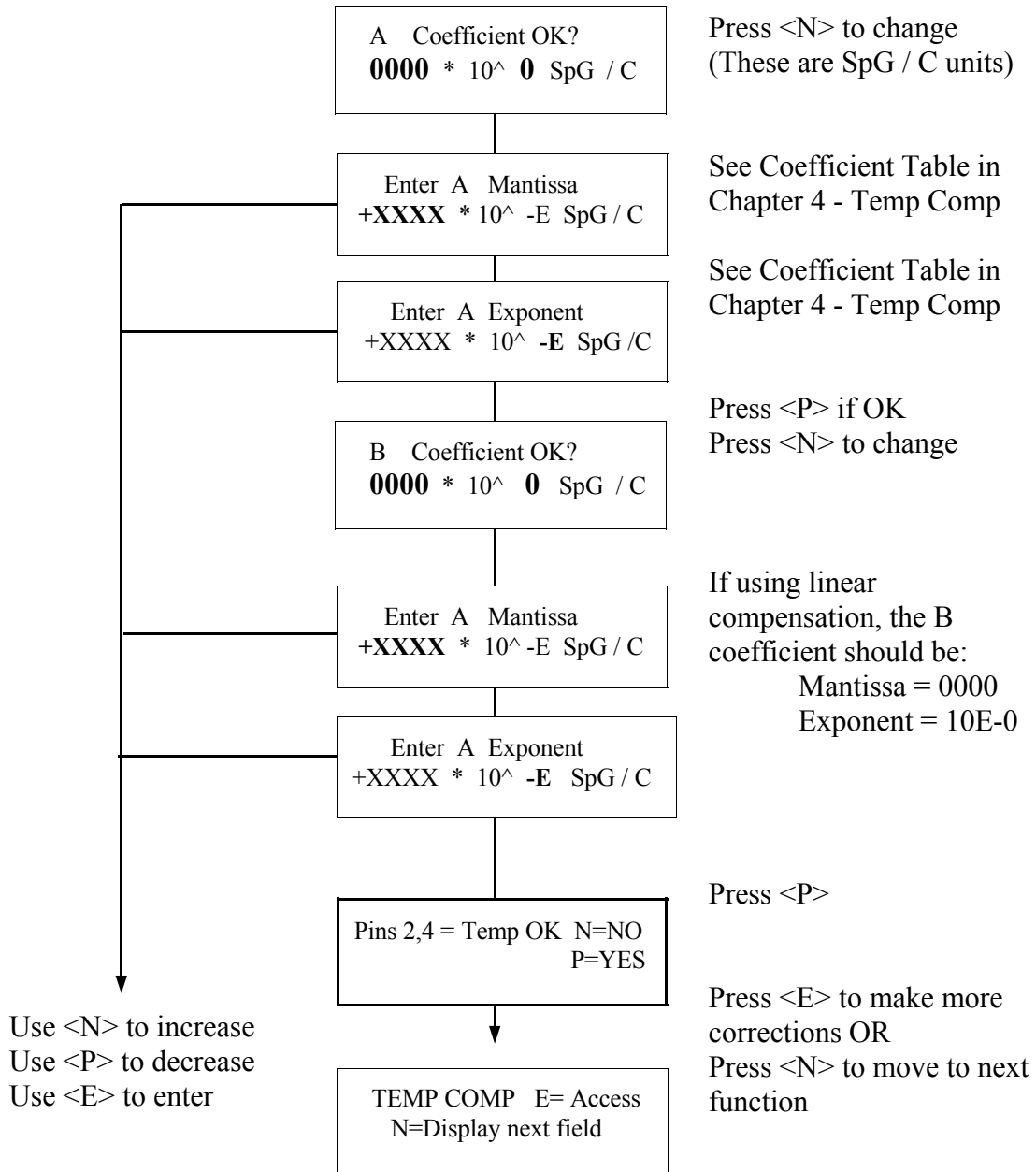
Begin by entering the access code:  
 Press <E> LEDs flash  
 Press <N N P N N P>  
 Press <N> to reach TEMP. COMP.



Use <N> to select Platinum RTD  
 Use <E> to enter

**NOTE:**  
 Most Ronan supplied RTD's are nickle.

Next Page



EXAMPLE:

Based on the TABLES in Chapter 4 ...  
 If selected Temp Units are °F and Ref Temp is 35°C  
 Then A Coeff would be: +1881 for Mantissa and -7 for Exponent  
 And (if required) B Coeff would be: +1135 for Mantissa and -9 for Exponent



**Chapter 9** contains a summary of personnel safety issues that pertain to radiation gages.

An example is provided for determining radiation field intensity, with Dose Rate, RAD, and REM calculated.

Source holder shutter and leak testing is reviewed.

Current regulations are subject to change. You **MUST** obtain a copy of the current Regulations that apply to the State or Country in which your gage is used.

- 9.0 Radiation Safety
- 9.1 Introduction
- 9.2 ALARA
- 9.3 Calculations
- 9.4 Leak Test







Many personnel safety issues can be addressed by one basic principle - limit access to the source of radiation, and thereby reduce personnel exposure. The primary goal is to maintain exposure levels "As Low As Reasonably Achievable."

Known as the principle of ALARA, this basic philosophy is the United States Nuclear Regulatory Commission's overriding guideline for limiting radiation exposure in the workplace.

A basic understanding of the principles of radiation transmission can help in meeting ALARA guidelines and other National and Local regulatory requirements.

A<sub>s</sub>

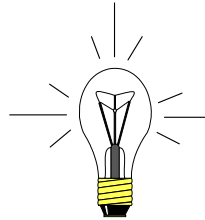
L<sub>ow</sub>

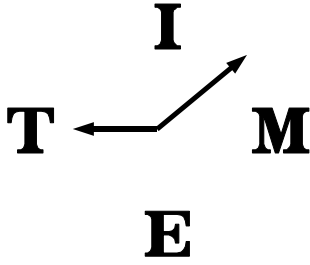
A<sub>s</sub>

R<sub>easonably</sub>

A<sub>chievable</sub>

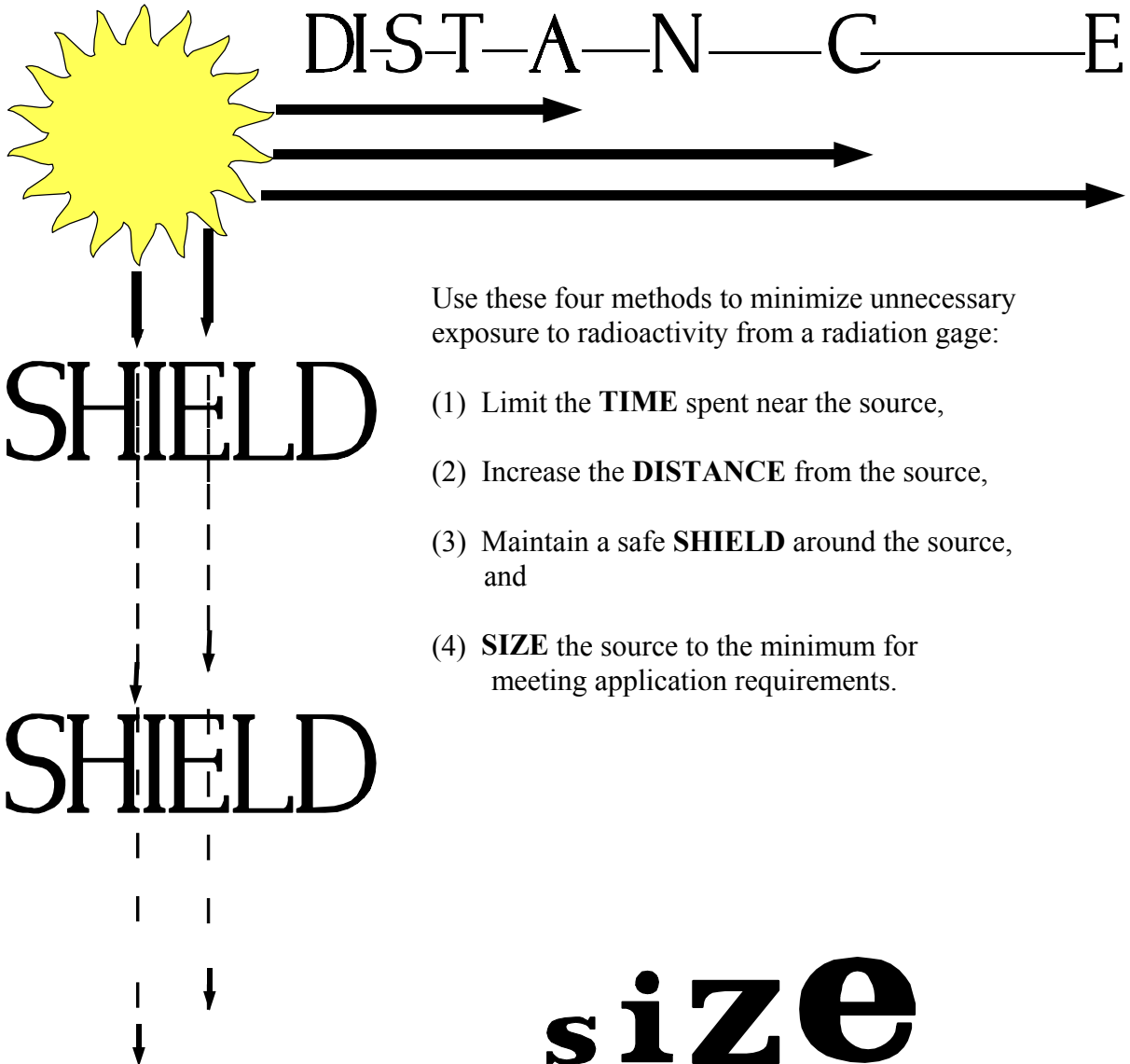
**RADIATION TRANSMISSION:** For example, if we consider the light energy radiating from an incandescent bulb, we can understand the need for these precautions. Many of us work under light from an incandescent bulb on a daily basis. We are surrounded in many rooms by this type of radiated energy with no ill-effects. The glass "shield" prevents us from contact with the filament which could cause a harmful shock. We can even hold our hand directly on a small-wattage bulb for a few seconds without causing discomfort. If, however, we come too close to a high-wattage bulb for an extended period of time we will suffer immediate pain and injury.





Gamma radiation emits electromagnetic energy which is similar to light, except that it readily penetrates opaque materials. Its ability to pass through dense materials is advantageous for applications such as radiation gaging, however, it does require some additional safety precautions for the personnel who are working in the immediate vicinity of the radioactive source.

The precautions required in the case of the light bulb, on the previous page, are similar to those required when working near a radioactive source:



Use these four methods to minimize unnecessary exposure to radioactivity from a radiation gage:

- (1) Limit the **TIME** spent near the source,
- (2) Increase the **DISTANCE** from the source,
- (3) Maintain a safe **SHIELD** around the source, and
- (4) **SIZE** the source to the minimum for meeting application requirements.

## Calculating the Intensity of the Radiation Field

### Dose Rate in milliRoentgen per hour (mR/hr)

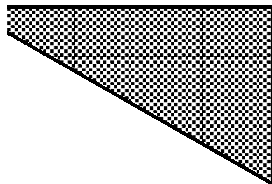
k = constant:

Cs-137 = 0.50

Co-60 = 2.000

### Roentgen (R):

Measure of field intensity in AIR.



Using a calibrated survey meter to measure the radiation field intensity provides the most accurate result. However, it is also possible to mathematically calculate the radiation field intensity with this equation:

$$D = \frac{(k) (mCi)}{d^2} * 1000$$

Where:

D = Dose rate (mR/hr)

mCi = source activity (mCi)

d = distance from source (inches)

k = constant for radioisotope

### EXAMPLE:

Suppose the source holder from a radiation gage is involved in an industrial accident. The Ronan source holder is not damaged and remains firmly attached to the vessel 20 feet above ground. However, workers cannot immediately reach the top of the vessel to turn the source "OFF." We know the source capsule is 10 millicuries of Cesium (Cs-137). What is the field intensity at ground level in the direct path of the radiation's "active beam?"

$$\text{Dose Rate} = \frac{(k) (mCi)}{d^2} * 1000$$

$$\text{Dose Rate} = \frac{(0.5) (10)}{(20*12)^2} * 1000$$

$$\text{Dose Rate} = 0.087 \text{ mR/hr}$$

This exposure dose rate is expressed in milli Roentgen (mR) per hour and is a measure of field intensity in AIR.

Now, how do we determine the EFFECT that produces on a human being?

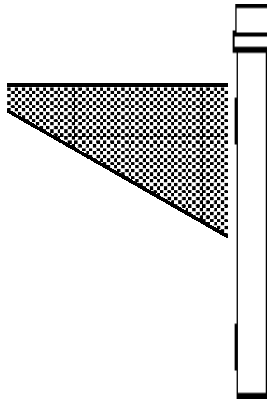
## Calculating the Effect on Man

First, it's important to distinguish between the concept of "RAD" and "REM."

The **RAD** is used to express the amount of energy imparted to matter. It is the dose absorbed by any matter over a specified period of exposure time.

**RAD:** Dose absorbed by MATTER

The **REM** is the Roentgen Equivalent Man. It is a measure of radiation absorbed by the body AND it takes into consideration the effects on human tissue. It is a biological dose.



This distinction is necessary because not all radiation affects the body in the same manner. The type of radiation must be taken into account when attempting to calculate the biological effects.

EXAMPLE:

In our example on the previous page, suppose we had to calculate the potential exposure to a worker who spends one and one-half (1-1/2) hours working on the ground below the source holder before it can be turned "OFF."

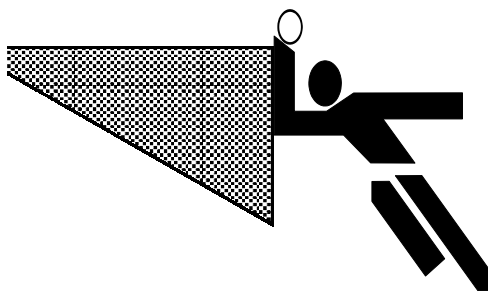
First we would calculate the absorbed dose by factoring in the time (t):

$$\text{Absorbed Dose} = (t) (\text{Dose Rate})$$

$$\text{Absorbed Dose} = \frac{90 \text{ min}}{60 \text{ min/hr}} * 0.087 \text{ mR/hr}$$

$$\text{Absorbed Dose} = 0.13 \text{ milli RAD}$$

**REM:** Biological effect on MAN



And now to determine the biological effect on the worker, we must multiply the absorbed dose by the Quality Factor (Q). Q is the modifying factor used to derive dose equivalent from absorbed dose. In the case of gamma radiation the Q=1. Therefore:

$$(0.13 \text{ milli RAD}) (1) = 0.13$$

milli REM

## Leak Test/ Shutter Test Requirements

The integrity of the containment and shielding around a radioactive source must be verified at periodic intervals specified by your own governing authority.

For example, the U.S. NRC regulations involve verifying two conditions: (1) the integrity of the source capsule and (2) the function of the ON/OFF mechanism (shutter).

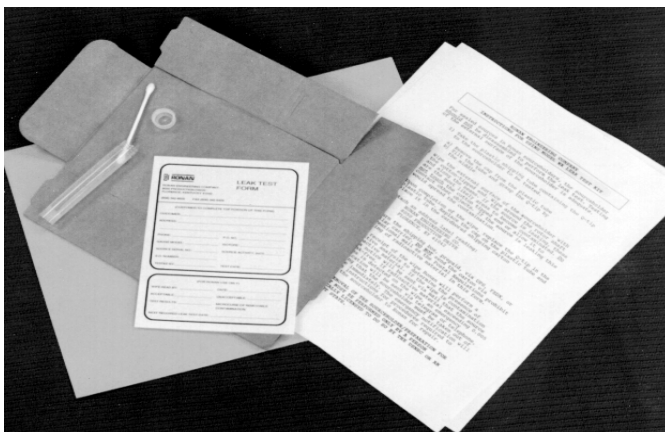
Ronan provides leak test training and a leak testing service to assist in meeting these requirements. The service can be purchased on a contract basis for each individual source. After the source holder is wiped by the customer, the kit is returned to Ronan for analysis. Ronan issues a report and maintains a record of the results.

You **MUST** abide by the regulations issued by your own national and local governing authority.

---

## Leak Test Kit

The leak test procedure described here applies only to the Leak Testing Kit (WPTST) purchased from Ronan. As part of the service Ronan provides a leak test kit consisting of these items:



A small plastic tube containing a cotton swab (Q-tip).

A Leak Test Form for processing the leak test.

Instructions for using the cotton swab and completing the form.

A cardboard shipping container for returning the plastic tube, Q-tip, and Leak Test Form to Ronan for processing. (The cardboard shipping container requires easy assembly)

## Preparing for the Leak Test

DO NOT disassemble the sealed source assembly.

Test only the external, or exposed, portion of the source holder.

Keep the cotton swab inside the plastic tube while carrying it to the source holder.

Place the source holder shutter in the OFF or LOCKED position. See Figure 1.

DO NOT touch the cotton swab to any surface other than the one source holder being tested.

## Leak Test Procedure

Remove the cap from the plastic tube.

Tilt the plastic tube and grasp the cotton swab by the wooden end.

With the cotton-tipped end wipe the external surface of the source holder, covering at least  $100\text{ cm}^2$  of the surface. (Approximately

## Completing the Leak Test

With the cotton tip DOWN, replace the cotton swab in the plastic tube.

Replace the cap on the plastic tube.



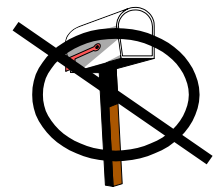
Check the Radiation Label attached to the source holder AND copy the information from that label onto the top portion of the Leak Test Form.

Place the plastic tube AND the completed Leak Test Form into the cardboard shipping tube.

Seal the cardboard shipping tube.

## Returning the Leak Test

Label the cardboard shipping tube as follows:  
 Ronan Engineering Company  
 8050 Production Drive  
 Florence, KY 41042 USA



DO NOT mail the completed leak test by conventional mail. U. S. Postal Regulations prohibit mailing radioactive material.

Return the leak test to Ronan in the cardboard shipping tube, prepaid, by a parcel express service such as UPS, FEDX, or similar carrier.

## Processing the Completed Leak Test

Upon receipt of the leak test, Ronan will perform a sensitive analysis to determine the presence of radioactive material. If the cotton swab is contamination-free, Ronan will mail a certificate to the user indicating the results of the leak test. If radioactive material exceeding 0.005 micro Curies is detected on the cotton swab, Ronan will issue an emergency notification to the user, via telephone or FAX, advising that the source holder must be taken out of service and sent back for repair.

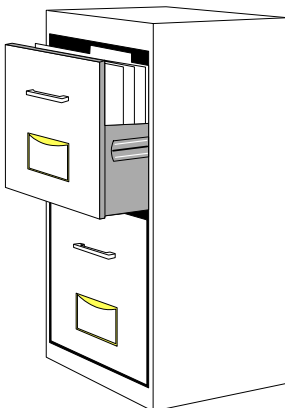
The emergency notification will contain detailed instructions for removing and shipping the source holder. Only Specifically Licensed individuals can remove a source holder and prepare to ship it.

Ronan maintains a record of each leak test analysis they perform. The record will include:

## Records Requirement

- Name and address of the customer
- Date the leak test was performed
- Name of person performing the leak test
- Name of person performing the analysis
- Date the analysis was performed
- Unique identification of the source being tested
- Source serial number
- The radioactive material and mass number of the source
- The leak test results expressed in microCuries

YOU are also responsible for maintaining records:



Transfer Documents shipped with gage.

Initial Radiation Survey.

Periodic Leak/Shutter Tests.

Others documents as required by Federal, State, and/or local agencies.

## Keep Records !