00809-0100-4731
English
Rev. EA

APEX™ and APEX™ SENTRY Radar Gauges

ROSEMOUNT®

FISHER-ROSEMOUNT™

Product Manual

APEX and APEX Sentry Radar Gauges

NOTICE

Read this manual before working with the product. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this product.

Within the United States, Rosemount Inc. has two toll-free assistance numbers.

Customer Central: 1-800-999-9307(*7:00 a.m. to 7:00 p.m. CST)*
Technical support, quoting, and order-related questions.

North American1-800-654-7768 (*24 hours a day – Includes Canada)*
Response Center: Equipment service needs.

For equipment service or support needs outside the United States, contact your local Rosemount representative.

⚠CAUTION

The products described in this document are NOT designed for nuclear-qualified applications.

Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause inaccurate readings.

For information on Rosemount nuclear-qualified products, contact your local Rosemount Sales Representative.

Cover Photo: APEX002C

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Fisher-Rosemount satisfies all obligations coming from legislation to harmonise product requirements in the European Union.

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Introduction

USING THIS MANUAL

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

This manual provides installation, configuration, and maintenance information for the Rosemount® APEX™ and APEX Sentry™ Radar Gauges.

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SAFETY MESSAGES

Procedures and instructions in this manual may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the safety messages listed at the beginning of each section before performing an operation preceded by this symbol.

Section 2

Overview of APEX and APEX Sentry Radar Gauges

GETTING ACQUAINTED WITH THE APEX AND APEX SENTRY RADAR GAUGES

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

The APEX and APEX Sentry Radar Gauges use a radar signal to measure the level of liquid in a vessel. Because the radar gauge is mounted on top of a vessel and its components do not contact the product, it is a dependable alternative to a standard insertion device that can become broken or corroded when inserted into the process. The APEX Radar Gauge also works well in turbulent, aerated, solids-laden, viscous, or corrosive liquids, and thick pastes or slurries.

The advanced 24 GHz frequency technology in the gauges significantly increases the reliability of your level measurement for a wide range of tank level applications. The gauges use radar technology based on frequency modulated continuous wave (FMCW) transmission of microwaves. Radar (microwave) signals are sent from the gauge to the surface of the material and reflected back to the gauge receiver. The receiver evaluates the frequency difference between the transmitted and returned signals. The gauge analyzes the signals to determine the distance to the product surface.

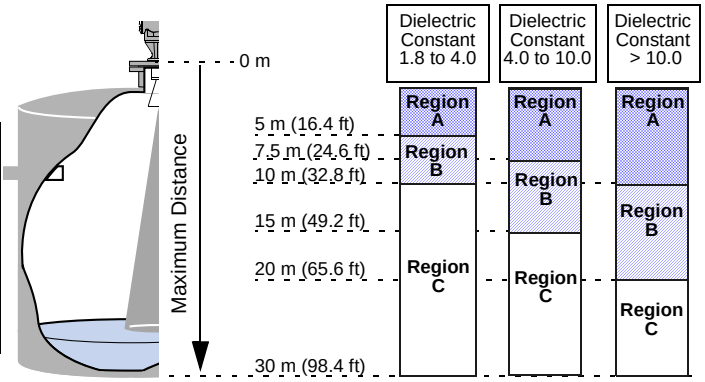
The 24 GHz frequency and advanced electronics allow the radar gauges to use a small antenna and maintain a narrow beamwidth. The small, lightweight antenna simplifies installation while the narrow beamwidth allows unwanted echoes from vessel obstructions such as agitators, heat exchangers, filling pipes, baffles, thermowells, and intermittent filling streams to be avoided. The narrow beam also increases mounting flexibility because the gauge can be mounted on existing flanges located close to tank walls.

SELECTING THE CORRECT RADAR GAUGE

Step 1. Dielectric vs. Distance

CHOOSE THE APPROPRIATE SHADED REGION FOR THE APPLICATION.

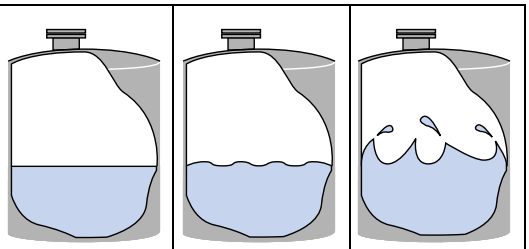
Dielectric Constant, ε_r	Liquid Examples
1.8 - 4.0	Hydrocarbons, petrochemicals, freons, vegetable oils, toluene, ...
4.0 - 10.0	Organic or concentrated acids, organic solvents, ...
> 10.0	Water-based fluids, alcohols, dilute acids, acetone, glycols, ...



Step 2. Liquid Surface Quality

Match surface quality →

with shaded region from Step 1. ↓



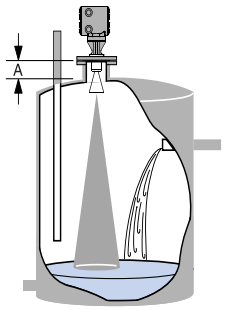
Dielectric vs. Distance Region	CALM No waves, storage	MOVING Mild rolling, no splashing, surface unbroken	TURBULENT Heavy agitation, vapors, filling, splashing, or reactions
Region A	Possible SENTRY- go to Step 3.	Possible SENTRY- go to step 3.	APEX
Region B	Possible SENTRY- go to step 3.	APEX	APEX
Region C	APEX	APEX	APEX

Step 3. Tank Geometry

Is flange height (A) ⩽ 0.5 m?

— AND —

Is the radar beam free of any obstructions, such as fill tubes, baffles, or exposed agitators?



YES	**APEX SENTRY**
NO	**APEX ONLY**

NOTE: To meet telecommunications requirements, the APEX and APEX Sentry Radar Gauges must be installed on enclosed or vented metal tanks. Other tank types may be approved in country of final destination. Refer to Telecommunications Agency Requirements on page 3-2 for detailed information.

See Antenna Selection Guidelines, Figure 6-1 on page 6-5.

LEVEL-Apex_07a, Apex_08a, Apex_011a

Figure 2-1. Radar Gauge Selection Guide

COMPONENTS OF THE APEX AND APEX SENTRY RADAR GAUGES

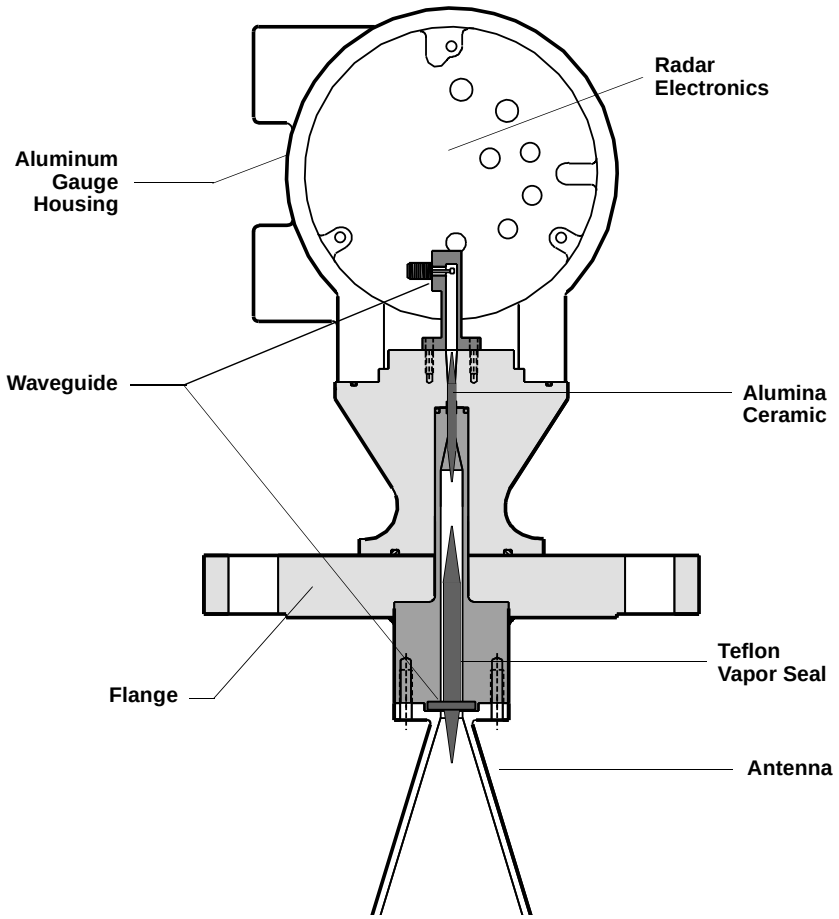
The top of the APEX and APEX Sentry Radar Gauges is an aluminum *gauge housing* (see Figure 2-2). The gauge housing includes advanced radar electronics for signal processing.

The *radar electronics* is the heart of the gauge. It produces an electromagnetic wave by using an oscillator that converts direct current (dc) power into a radar signal. It also receives the return signal.

The radar signal passes from the electronics through a *waveguide* containing an alumina ceramic process barrier. The waveguide is the entire path from the electronics to the antenna.

The *antenna* is a cone-shaped device made of stainless steel. The antenna controls the signal beamwidth by helping to keep the radar signal focused on its target (the product in the tank) so it does not spread out over the entire vessel and give false echoes. A larger antenna provides a more focused, narrow beam. (Refer to Appendix B: Theory of Operation for further information regarding beamwidth.)

Figure 2-2. Cross-sectional View of the APEX Radar Gauge

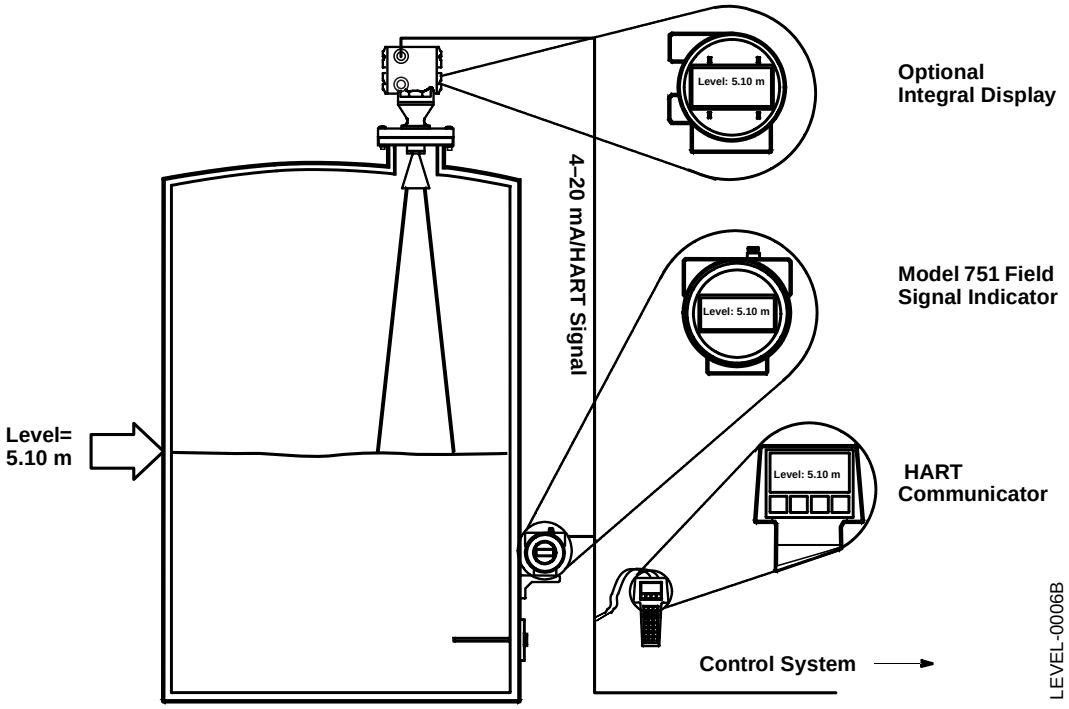


SYSTEM ARCHITECTURE

The output of the APEX and APEX Sentry Radar Gauges is a 4–20 mA analog signal superimposed with a digital HART signal. As a result, the primary variable (4–20 mA output) can be configured to represent either level (APEX and APEX Sentry Radar Gauges) or calculated volume (APEX Radar Gauge only), with up to three additional variables available through the HART signal.

In addition to using the HART Communicator, you can view level and volume variables using an optional Integral Display on the gauge or a Model 751 Field Signal Indicator as a remote display (see Figure 2-3).

Figure 2-3. APEX System Architecture and Display Options



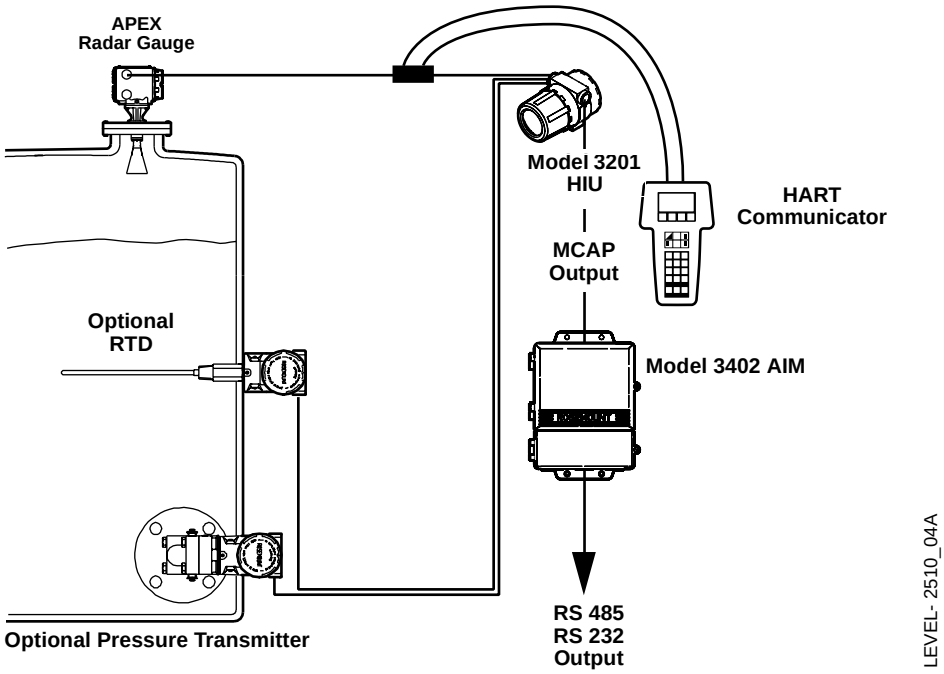
APEX /HYBRID SYSTEM OVERVIEW (APEX RADAR GAUGE ONLY)

To maximize the number of available on-line inventory measurements, you can install and combine an APEX Radar Gauge with a Rosemount industry-leading pressure transmitter to create a *hybrid system* (see Figure 2-4). A hybrid system offers the best advantages from both level-based and pressure-based tank gauging systems:

- Offers all the advantages of the APEX and HTG technologies
- Provides level, volume, mass, and true average density measurements
- Enhances plant safety since no manual operations are necessary
- Handles traditional problems such as density stratification

For further installation details, please see page 4-15, and refer to the certified wiring diagrams provided.

Figure 2-4. Hybrid System Option



ADDRESSING CONCERNS ABOUT EXPOSURE TO THE APEX AND APEX SENTRY RADAR GAUGES

The Federal Communications Commission has issued a bulletin called *Questions and Answers About Biological Effects and Potential Hazards of Radiofrequency Radiation* (OET Bulletin No. 56, Third Edition, January 1989). This document states a recommended power density limit of 5 mW/cm^2 in the frequency range of 1.5–100 GHz. This limit is based on a 1982 ANSI guideline for a time-averaged exposure for humans.

The maximum power density emitted from APEX and APEX Sentry Radar Gauges is approximately 1.1 mW/cm^2, which is below the ANSI guideline. When the gauge is mounted in a metal vessel, the emissions external to the vessel are much lower than the 1.1 mW/cm^2 measured at the antenna.

For additional information about the safety of radar signals, see Appendix B: Theory of Operation.

Section 3

Before You Begin

INTRODUCTION

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

This section includes information you should consider before installing the APEX and APEX Sentry Radar Gauges in the field. It includes information on the following:

- Telecommunications agency requirements
- Unpacking the gauge
- Mounting requirements
- Vessel and process characteristics to consider

For information about configuring the radar gauge using a HART Communicator, refer to Appendix A: HART Communicator.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠WARNING

Explosions could result in death or serious injury:

Verify that the operating environment of the gauge is consistent with the appropriate hazardous locations certifications.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

⚠WARNING

Failure to follow safe installation and servicing guidelines could result in death or serious injury:

Make sure only qualified personnel perform these procedures.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Do not perform any service other than those contained in this manual unless you are qualified.

⚠WARNING

As a matter of routine, shut off the APEX Radar Gauge and all other equipment in the tank before you enter the tank.

TELECOMMUNICATIONS AGENCY REQUIREMENTS

Rosemount APEX and APEX Sentry Radar Gauges have been approved for installation in closed metal tanks, including those that are vented to the atmosphere. (See "Tank Requirements" below.) Tanks must be closed (or vented) to contain radar emissions which can otherwise interfere with aeronautical aviation. Installation shall be done by trained installers. The radar gauges must be securely bolted to a standard tank flange in strict compliance with the manufacturer's instructions.

Failure to properly install the device could constitute an impermissible modification of the device. In such an event, the responsibility is placed on the modifying party to ensure compliance with telecommunications regulations, and Rosemount shall have no liability whatsoever resulting from unauthorized installation of the device.

Operation Requirements

The use of this device is on a “no-protection, no-interference” basis. That is, the user shall accept government operations of high-powered radar in the same frequency band which may interfere with or damage this device. On the other hand, devices found to interfere with Government operations will be required to be removed at the user's expense.

APEX and APEX Sentry Radar Gauges installed in the United Kingdom operate between 24.15-26.05 GHz. All other APEX and APEX Sentry Radar Gauges operate between 24.05 GHz and 26.05 GHz.

In certain countries, the radar gauge must be switched off when opening the access door to the tank. Any usage in tanks made of non-metallic materials is prohibited.

Underground tanks with all exposed surfaces metallized are sufficient to contain radar emissions.

Tank Requirements

In the United States only, APEX and APEX Sentry Radar Gauges may also be installed on enclosed or vented concrete tanks with a minimum wall thickness of 2.5 inches.

In purchasing an APEX or APEX Sentry Radar Gauge, you agree to install the device in accordance with these conditions.

At the time of this printing, Rosemount Inc. has received the appropriate telecommunications approval for sale in the countries shown in Table 3-1.

If you have any questions about what constitutes proper installation, please contact Rosemount Customer Central at 1-800-999-9307.

TABLE 3-1. Agencies Granting Telecommunications Approval

Country	Agency Granting Approval
Argentina	Comision Nacional de Comunicuciones
Australia	Australian Communication Authority
Austria	Zulassungsburo fur Fernmeldeanlagen
Belgium	Belgian Institute for Postal Services and Telecommunications (BIPT)
Bolivia	Bolivian Telecommunications Superintendent
Brazil	Agencia Nacional de Telecomunicacoes
Canada	Industry Canada - RSS210
Chile	Subsecretary for Telecommunications (Subtel)
China	Ministry Posts & Telecommunications
Colombia	Colombia Ministry of Communications
Croatia	Regulation Authority for Telecommunications and Post
Czech Republic	Cesky telekomunikacni urad
Denmark	Telestyreisen
Eire	Dept Transport, Energy & Communications
Egypt	No government approval needed.
Finland	Telecommunications Administration Centre
France	Ministry of Information Technology and Postal affairs (MITP)
Germany	RegTP (formerly BAPT/BMPT)
Hungary	Budapest Communication Inspectorate
India	Ministry of Communications
Indonesia	Directorate General of Post and Telecommunications
Ireland	See Eire
Italy	Ministero dele Poste e delle Telecomunicazioni
Jamaica	Post and Telecommunications Department
Kuwait	Ministry of Communications
Malaysia	Department of Telecommunications
Mexico	Federal Telecommunications Commission
Netherlands	Post and Telecommunications Department (HDTP)
New Zealand	Ministry of Commerce
Norway	Norwegian Post and Telecommunications Authority
Oman	Ministry of Posts, Telegraphs, and Telephones
Philippines	National Telecommunications Commision
Poland	Ministry of Communication Regulation and Development Department

Continued on Next Page

TABLE 3-1. Agencies Granting Telecommunications Approval

Country	Agency Granting Approval
Portugal *	Instituto das Comunicacoes (ICP)
Puerto Rico	Federal Communications Commission- Part 15
Romania *	Ministry of Communication's General Communication Inspectorate
Russia	State Commission of Radiofrequency at State Committee of Russian Federation of Communications and Information Exchange (SCRF)
Saudi Arabia	No government approval needed.
Singapore	Telecommunication Authority of Singapore
South Africa *	South African Telecommunications Regulatory Authority (SATRA)
South Korea	Ministry of Information & Communication - Article 56-2
Spain	Secretaria General de Comunicaciones
Sweden	National Post and Telecom Agency
Taiwan	Directorate General of Telecommunications R.O.C.
Thailand	Post and Telegraph Department
Trinidad and Tobago	Telecommunications Division of the Ministry of Information, Communications, Training and Distance Learning
Turkey	Ministry of Communications
United Kingdom *	Radiocommunications Agency
United States	Federal Communications Commission - Part 15
Venezuela	Comision Nacional de Telecomunicaciones (CONATEL)
*** Country requires site licenses.**	

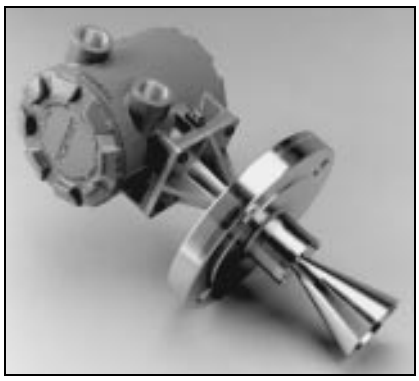
UNPACKING THE APEX AND APEX SENTRY RADAR GAUGES

1. Remove the gauge from the shipping container, taking care not to damage the contents.
2. Place the gauge on its side on a flat surface as in Figure 3-1.

NOTE
Do not stand the radar gauge upright on its antenna. Be careful not to damage any part of the antenna during bench inspection or installation.

3. Inspect the unit and report any shipping damage to the carrier.

Figure 3-1. APEX Radar Gauge



RADAR-003AB

INSTALLATION CONSIDERATIONS

Before you install an APEX or APEX Sentry Radar Gauge, be sure to consider your specific mounting requirements, vessel characteristics, and process characteristics. Review the following information to ensure a trouble-free, safe, and accurate installation.

The gauge has an Installation Category II (Overvoltage Category) with pollution degree 2 classification.

Mounting Considerations

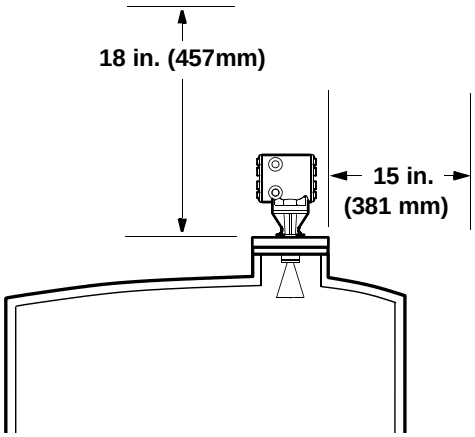
Flange Sizes

The radar gauge mounts on the top of a vessel using a 2-, 3-, 4-, or 6-inch ASME B 16.5 (ANSI) Class (DN 50, DN 80, DN 100, or DN 150) flange. (Flange size is specified at the time of order.)

Access Clearances

Recommended access clearances for the gauge are shown in Figure 3-2.

Figure 3-2. APEX and APEX Sentry Radar Gauge Access Clearances



Wall, Nozzle, or Standoff Clearance

If the radar signal comes in contact with a wall, nozzle, or standoff, it may cause noise in the level signal. Even though the advanced signal processing of the radar gauge is designed to filter out this noise, try to keep the noise level at a minimum by installing the gauge an acceptable distance from obstructions. To ensure the proper clearance for your vessel height and beamwidth, review Table 3-2 on page 3-6.

NOTE
When installing an APEX Sentry Radar Gauge, refer to Figure 2-1 on page 2-2 for further mounting requirements. 100% of the beam cone must contact the liquid surface for accurate measurement.

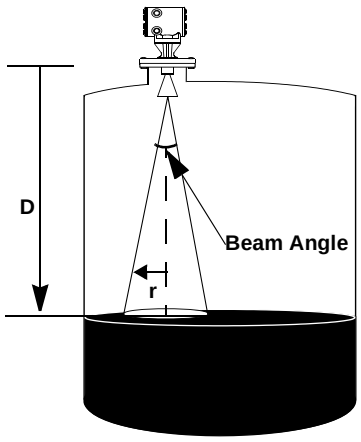
NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

NOTE
Do not mount the radar gauge in the top-center of a vessel. Off-center mounting is preferred.

TABLE 3-2. Beamwidth versus Distance from flange face to tank bottom

Distance (D) from gauge	Radius (r) from Flange Centerline to Beamwidth Edge		
	2-in. Antenna	3-in. Antenna	4-in. Antenna
ft (m)	ft (m)	ft (m)	ft (m)
2 (0.6)	0.4 (0.12)	0.2 (0.07)	0.2 (0.06)
4 (1.2)	0.8 (0.25)	0.5 (0.15)	0.4 (0.11)
6 (1.8)	1.2 (0.37)	0.7 (0.22)	0.6 (0.17)
8 (2.4)	1.6 (0.49)	1.0 (0.29)	0.7 (0.22)
10 (3.0)	2.0 (0.62)	1.2 (0.37)	0.9 (0.28)
15 (4.6)	3.0 (0.93)	1.8 (0.55)	1.4 (0.42)
20 (6.1)	4.1 (1.23)	2.4 (0.73)	1.8 (0.56)
25 (7.6)	5.1 (1.54)	3.0 (0.92)	2.3 (0.70)
30 (9.1)	6.1 (1.85)	3.6 (1.10)	2.8 (0.84)
35 (10.7)	7.1 (2.16)	4.2 (1.28)	3.2 (0.98)
40 (12.2)	8.1 (2.47)	4.8 (1.46)	3.7 (1.12)
45 (13.7)	9.1 (2.78)	5.4 (1.65)	4.1 (1.26)
50 (15.2)	10.1 (3.09)	6.0 (1.83)	4.6 (1.40)
55 (16.8)	11.1 (3.40)	6.6 (2.01)	5.1 (1.54)
60 (18.3)	12.2 (3.70)	7.2 (2.20)	5.5 (1.68)
65 (19.8)	13.2 (4.01)	7.8 (2.38)	6.0 (1.82)
70 (21.3)	14.2 (4.32)	8.4 (2.56)	6.4 (1.96)
75 (22.9)	15.2 (4.63)	9.0 (2.75)	6.9 (2.10)
80 (24.4)	16.2 (4.94)	9.6 (2.93)	7.4 (2.24)
85 (25.9)	17.2 (5.25)	10.2 (3.11)	7.8 (2.38)
90 (27.4)	18.2 (5.56)	10.8 (3.30)	8.3 (2.52)
95 (29.0)	19.2 (5.86)	11.4 (3.48)	8.7 (2.66)
100 (30.5)	20.3 (6.17)	12.0 (3.66)	9.2 (2.80)

Figure 3-3. Beamwidth vs. Distance from APEX and APEX Sentry Radar Gauge to Tank Bottom



Antenna Size	Beam Angle
2-in.	22.9°
3-in.	13.7°
4-in.	10.5°

Example: the beam radius (r) at the bottom of a 10-foot (3.05 m) (D) vessel would be 0.9 ft (0.28 m) for a 4-inch antenna.

LEVEL-0038A

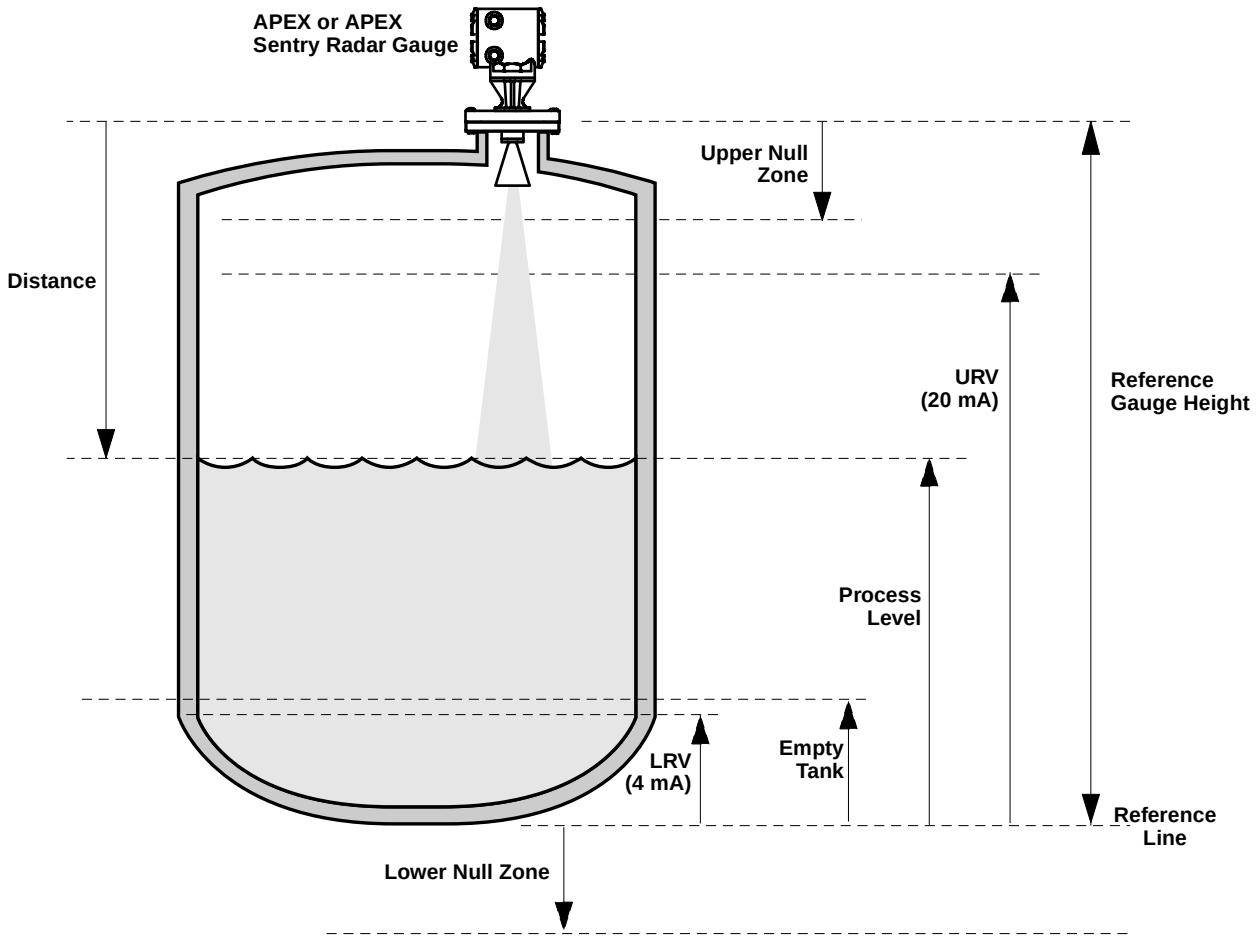
NOTE

A larger antenna yields a tighter and more concentrated signal. This is an important consideration when using the gauge in various applications with such characteristics as agitation and/or low dielectric constants.

Key Measurement Values

The values given in Figure 3-4 are key factors for installing and configuring the gauge. Please take a moment to familiarize yourself with the terms used below. These terms are used throughout this manual.

Figure 3-4. Key Measurement Values



Default Values	in. (mm)
Upper Null Zone(1)	19.6 (500)
Lower Null Zone(1)	-19.6 (-500)
Minimum Value	**in. (mm)**
Span (URV-LRV)(1)	19.6 (500)

(1) See "Null Zones" on page 3-11.

Reference Gauge Height

The *reference line* is a common point from which all level measurements are made. It is usually the bottom of the tank (see Figure 3-4). However, if there is a stationary object, such as a heat exchanger that is reflective, then that can serve as the reference line.

The *Reference Gauge Height* is the distance between the reference line and the face of the radar gauge flange, as shown in Figure 3-4. The Reference Gauge Height is the most critical setting for the radar gauge because it is the basis for all other calculations. The radar gauge measures the distance to the product surface and subtracts this value from the Reference Gauge Height to determine level. To keep level measurements within the stated accuracy specifications, the Reference Gauge Height must be within the ranges specified in Section 6: Specifications and Reference Data.

If the distance from the reference line (bottom) of the vessel to the gauge is unknown, you can do one of the following:

- Record the radar gauge level reading and compare it to another known reference level measurement, such as a hand dip. Enter the actual level during the configuration process (see Section 4: Installation).
  or
- If the radar gauge is installed when the tank is empty, measure the Reference Gauge Height (see Figure 3-4) and record the value. You can determine the Reference Gauge Height in one of two ways:
  – Use the engineering drawing of the vessel to calculate the distance from the mounting flange surface to the bottom of the tank.
  – If the tank has a flat bottom, use the HART Communicator to set Distance as the secondary variable and have the radar gauge measure it. The distance reading displayed on the HART Communicator is the Reference Gauge Height.

Minimum Clearance to Product Level

The minimum clearance from the gauge flange to the expected maximum product level must be at least 19.6 in(50 cm). The gauge cannot accurately measure levels at less than 19.6 in(50 cm) from the flange.

Maximum Range

The maximum measuring range for stated accuracies can be found in Section 6: Specifications and Reference Data.

Upper Range Value (20 mA Point)

When configuring the gauge, you must provide the *Upper Range Value* (URV). The URV must be at least 19.6 inches (0.5 m) *above* the lower range value.

Non-horizontal Mounting Surface

In most applications, it is acceptable to have the flange a few degrees off from the horizontal. In applications with low dielectric constants or long measuring ranges, mounting the radar gauge with the flange horizontal to the product level becomes more important in order to receive an adequate return signal. For more information regarding mounting considerations, contact Rosemount Customer Central at 1-800-999-9307.

Lower Range Value (4 mA Point)

When configuring the gauge, the *Lower Range Value* (LRV) must be provided and must be at least 19.6 inches (0.5 m) *below* the upper range value.

Vessel Characteristics

Heating Coils and Agitators

If the vessel contains heating coils or agitators (see Figure 3-5), the radar signal may bounce off and introduce noise in the return signal. The noise level is reduced if the signal contacts a non-flat surface (for example, round pipe, angled blade, etc.) that causes the signal to scatter rather than directing it back to the antenna. To avoid these problems, try to make sure that heating coils (A) or agitators (B) are below the minimum product level or within the null zones
(see Figure 3-4 on page 3-7 and Figure 3-7 on page 3-12).

Cables, Floats, Baffles, or Trays

Cables, floats, baffles, or trays (E) can introduce noise into the radar signal. A vertical cable or rounded surface causes minimal effect because the radar signal is scattered rather than directed back to the antenna. To reduce the amount of noise from cables, floats, baffles, or trays, position the gauge such that the beam will not contact them.

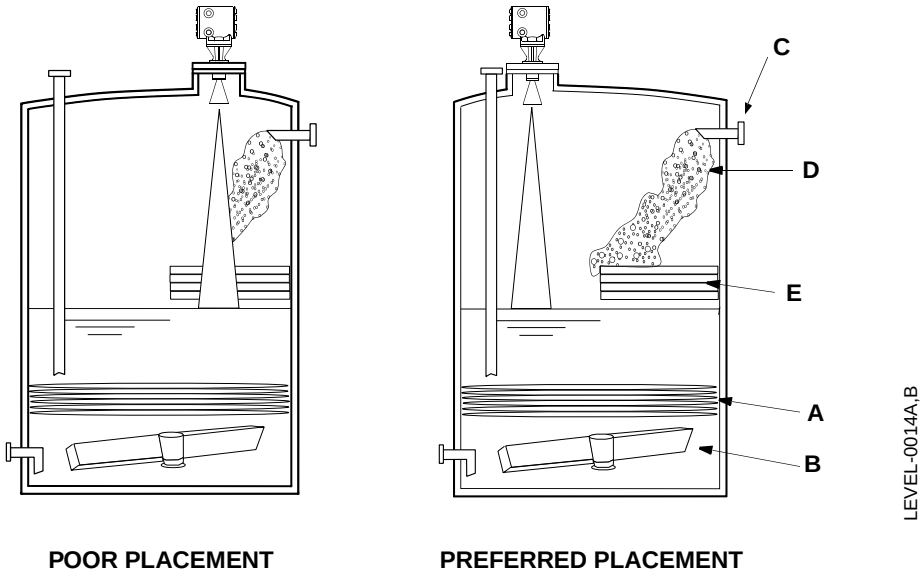
Inlet Pipes or Flows

The level reading may be affected by the process flowing into the vessel. To lessen the effects, mount the radar gauge so the beam signal does not contact the inlet pipe (C) or flow (D) (Figure 3-5).

NOTE
When using an APEX Sentry Radar Gauge, it is necessary for 100% of the beam cone to contact the liquid surface.
Refer to Figure 2-1 on page 2-2 for further information.

NOTE
Do not mount the radar gauge in the top-center of a vessel. Off-center mounting is preferred.

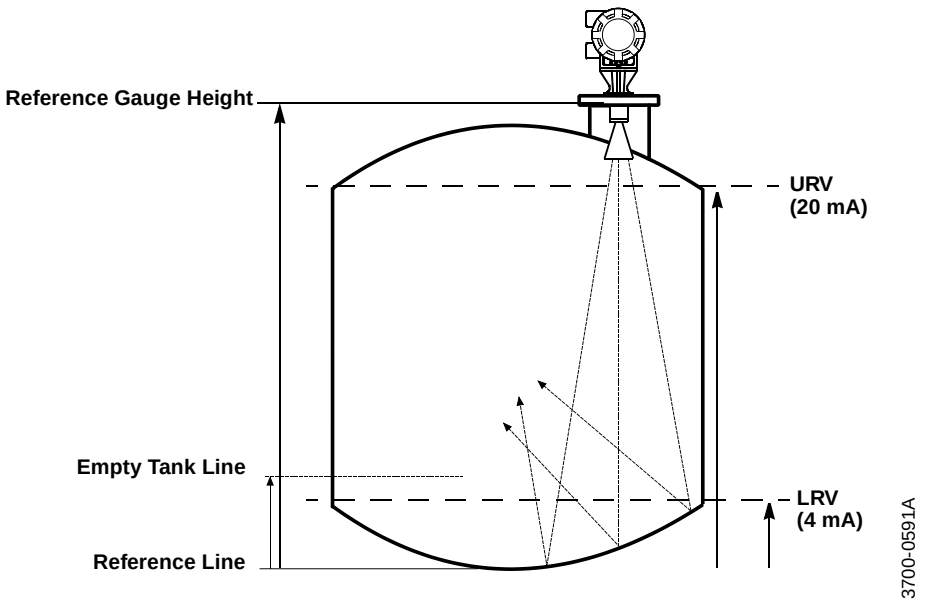
Figure 3-5. Vessel Characteristics That May Affect the Level Reading



Dish-bottom Tanks, Empty Tank Detection

Radar gauges require a horizontal surface, such as the product surface or the bottom of the tank, to reflect the signal back up to the antenna. When a dish-bottom tank is emptied and the surface is no longer horizontal, there may not be a sufficient amount of signal reflected to get a level reading (see Figure 3-6). If this happens, the radar gauge indicates a lost signal condition unless the empty tank detection zone is configured.

Figure 3-6. Reflecting the Signal in a Dish-Bottom Tank



The gauge has an empty tank setting designed to handle this situation. To prevent the gauge from indicating “Lost Signal” in empty tank situations, the empty tank setting forces it to report “Empty Tank” if the signal is lost when the level goes below the setting.

To activate the empty tank feature, use the HART Communicator and set the Empty Tank parameter to a value greater than zero, but less than 25% of the Reference Gauge Height (gauges with a serial number over 3217). If the empty tank parameter is not specified when the gauge is ordered, it will be set to approximately 10% of the Reference Gauge Height. If the signal is lost within this distance, the radar gauge will output LEVEL=0 and the mA signal corresponding to the zero level (usually 4 mA). The message will read “Empty Tank.”

If the signal is lost outside of this configured distance (that is, at higher levels in the tank), the radar gauge will go into alarm mode and indicate “Lost Signal” (see Section 5: Maintenance and Troubleshooting).

Null Zones

The gauge can be programmed to ignore signals that are outside of the normal operating span of the vessel. There are two user-configurable *null zones*—one at the top of the tank and one at the bottom—that, in conjunction with the gauge height, define the measurement limits for the gauge (see Figures 3-4 and 3-7). The gauge will ignore any signals reflected outside these null zones limits.

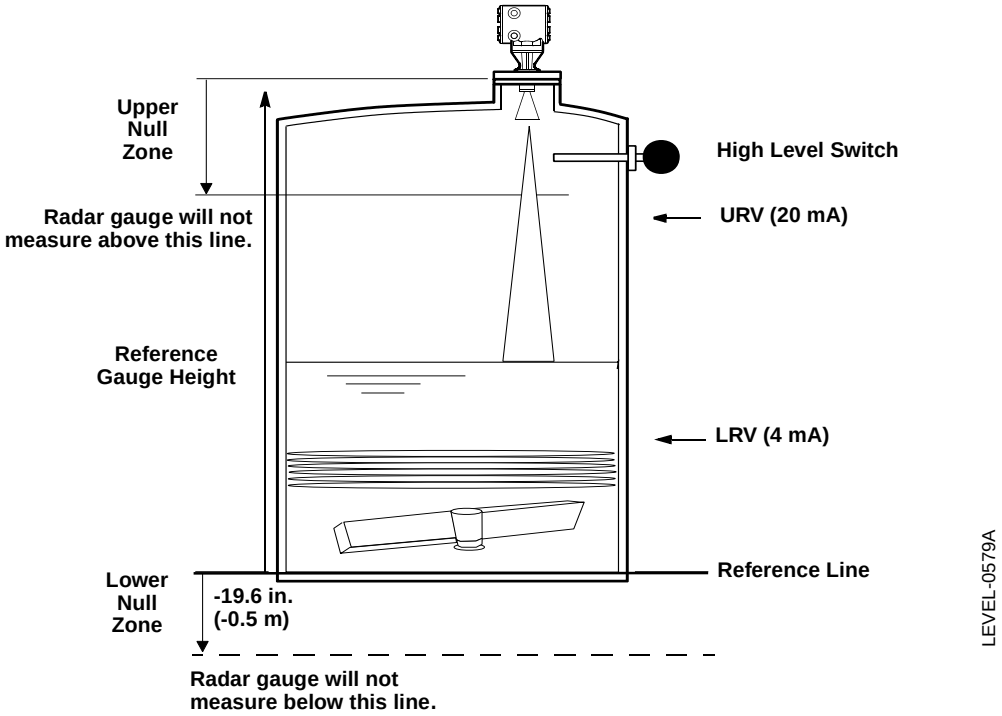
The upper null zone is measured from the face of the flange down. The factory default setting for the upper null zone is 19.6 in. (0.5 m). This setting means that the gauge will ignore all signals from closer than 19.6 in. (0.5 m). Typically, the upper null zone is at least the length of the gauge antenna and mounting nozzle. The nozzle length must **not** be the same as dimension “D” (see Figure 6-2 on page 6-7) or the signal will not generate properly.

The lower null zone is measured from the reference line and may be either a positive or negative number. The factory default setting for the lower null zone is –19.6 in. (–0.5 m). This setting allows the gauge to read a level *below* the reference line, although it would result in a negative value.

If the lower null zone is a positive value, the gauge will not read level below that point. This may be useful if there are any obstacles near the bottom of the tank that would give a false reading (see Figure 3-7). The overall level reading is still based on the reference line, however.

The null zone settings can be changed using a HART Communicator and the “Detailed Setup” procedure as outlined in Appendix A: HART Communicator.

Figure 3-7. User-Programmable “Null” Zones for APEX and APEX Sentry Radar Gauges



Process Characteristics

Dielectric Constant

Dielectric constant is a measure of a material's ability to reflect a radar signal. Materials with dielectric constants below 3.0 reflect only a small fraction of the radar signal. Therefore, special care must be taken when measuring low dielectric fluids.

The gauge can measure fluids with a dielectric constant as low as 1.8 if vessel conditions are favorable. For example, water-based compounds tend to have high dielectrics (water has a dielectric of approximately 80), while hydrocarbons are low (see Table 3-3). In cases with low dielectrics, it is important to verify that the dielectric is high enough for radar to measure. For information on dielectric constants when using an APEX Sentry Radar Gauge, refer to Figure 2-1 on page 2-2. If you are unable to determine the dielectric constant for your process, or if you are measuring a process with a dielectric constant lower than 3.0, contact Rosemount Customer Central at 1-800-999-9307 for assistance.

TABLE 3-3. Dielectric Constants for common fluids

Dielectric Constant Ranges for Chemicals Listed					
Less Than 1.8	**1.8 to 4.0**	**4.0 to 10.0**	**10.0 to 15.0**	**15.0 to 20.0**	**More than 20.0**
carbon dioxide cyclopentane ethylene methane jp4 (military fuel) nitrous oxide propane	acetylene asphalt benzene butane carbon tetrachloride cocaine freons kerosene napthalene octane oleic acid petroleum oils stearic acid styrene sulfur toluene vegetable oils	acetic acid bromobutane butyl alcohol chlorobenzene chloroform chlorotoluene cresol dibutyl phtalate dichlorobutane ethylamine nicotine phosphorus phosgene sulfur toluene diisocyanate	benzyl alcohol butyl nitrate carveol creosol dimethyl oxalate ethylene chloride hexanol iodine methylamine phenol pyridine tripropyl phosphate vinyl isocyanate	ammonia butanol cyclohexanol diacetone alcohol dichloro ethane isopropyl alcohol lactic acid methylamine methyl ethyl ketone nitroglycerin sulfur dioxide	acetone ethanol ethylene glycol glycerine glycol hydrazine hydrogen peroxide hydrogen cyanide latex methanol molasses propanol sorbitol water

Foam and Vapors

Foam may affect the gauge performance because it can reduce the radar signal being reflected. The effect is highly dependent on the particular characteristics of the foam. In general, the APEX Radar Gauge reads the top of the foam if it is sufficiently reflective. The APEX Sentry Radar Gauge is not for use in applications with foam.

Changing Density, Temperature, or Pressure

The level accuracy is not affected by changes in the density, temperature, or pressure of the product.

Turbulence or Vortices

The gauge uses advanced signal processing, reducing the effects of turbulence and vortices. However, the greater the turbulence or vortex the larger the effect because they disturb the product surface where the signal is being reflected. With vortices caused by agitators, you need to be aware of the “swell” effect. That is, the product surface will rise in the vessel when sufficiently agitated and the radar output will measure this rise. The APEX Sentry Radar Gauge is not for use in turbulent applications. Refer to Figure 2-1 on page 2-2 for further information.

Coating, Condensate, or Corrosion

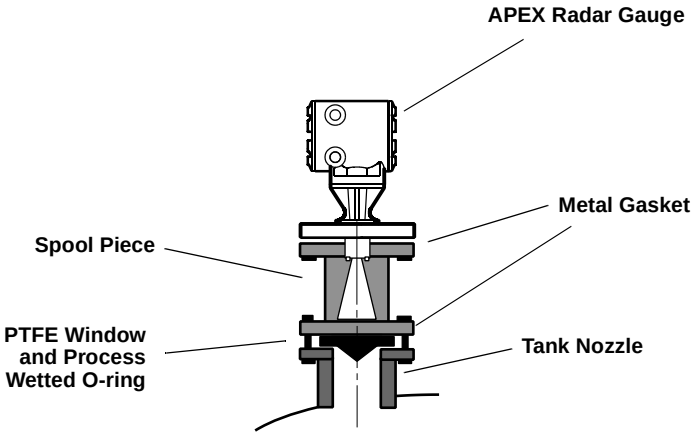
The functionality of the gauge may be affected by coating, condensate, or corrosion, depending on the type of process in the vessel. When conditions produce heavy condensation or coating, or when the process is corrosive to 316 SST or alumina ceramic, Rosemount suggests using a process “window” with the gauge to protect the antenna and waveguide.

The process window typically consists of a PTFE cone that goes below the gauge antenna and fits in the tank nozzle (see Figure 3-8).(1) Condensation and coating run off of the cone and corrosive processes cannot reach the antenna. Window installation requires a spool piece that surrounds the antenna. (See “Ordering Information” on page 6-10 for further information.)

(1) Further window information is detailed on page 4-6 and page 4-7.

Install the window as shown in Section 4: Installation.

Figure 3-8. Using a PTFE Process Window with the APEX Radar Gauge



NOTE
Make sure the metal gaskets are installed and the flange bolts are torqued properly to keep moisture out of the spool piece. Bolts should be re-tightened 24 to 48 hours after initial installation.

Consult the factory for temperature and pressure limits when using a process window. See page 6-6 for APEX Radar Gauge and process window pressure and temperature ratings.

Section 4

Installation

INTRODUCTION

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

This section contains instructions for installing the APEX and APEX Sentry Radar Gauges, including gauge mounting, wiring, and field configuration using the APEX integral display or a HART Communicator.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠WARNING

Explosions could result in death or serious injury:

Verify that the operating environment of the gauge is consistent with the appropriate hazardous locations certifications.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Do not remove the gauge cover in explosive atmospheres when the circuit is alive.

⚠WARNING

Failure to follow safe installation and servicing guidelines could result in death or serious injury:

Make sure only qualified personnel perform the installation.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Do not perform any service other than those contained in this manual unless you are qualified.

⚠WARNING

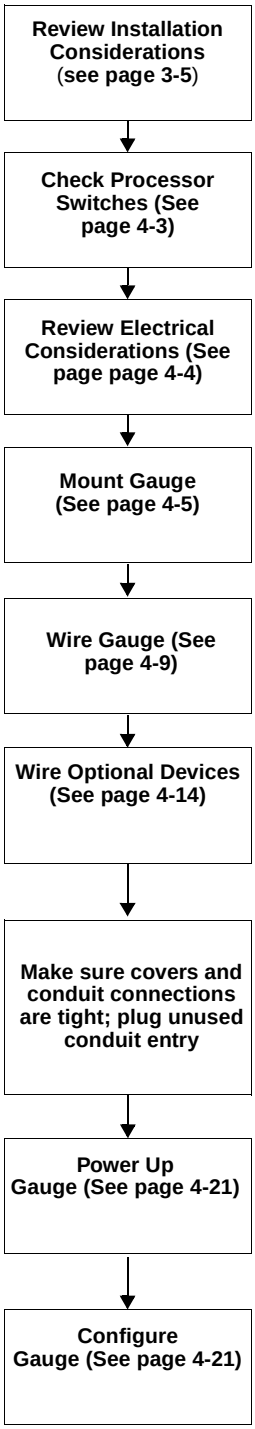
High voltage that may be present on leads could cause electrical shock:

Avoid contact with leads and terminals.

Make sure the main power to the APEX Radar Gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

BASIC FIELD INSTALLATION STEPS

Follow these steps for proper installation:



BEFORE YOU INSTALL

The APEX and APEX Sentry Radar Gauges are typically factory configured, so in most situations, gauge adjustments are minimal. To ensure proper operation, review the following information before installing the gauge. If, however, your gauge was not configured at the factory, or if you need to reconfigure the gauge for any reason, please note that the gauge can be configured on the bench prior to installation or in the field. (Refer to "Field Configuration Using the Integral Display (APEX Radar Gauge Only)" on page 4-21 or page 4-31.)

Check Processor Switches

Electronic boards are electrostatically sensitive. Failure to observe proper handling precautions for static-sensitive components can result in damage to the electronic components. Do not remove the APEX or APEX Sentry electronic boards. The gauges are calibrated with particular boards; swapping boards will negatively affect accuracy.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

TABLE 4-1. APEX Radar Gauge Switch Settings

Switch Bank	Description	Default Setting	Position Settings
Switch 1	4–20 mA Alarm Output	High (ON)	ON = High, OFF = Low
Switch 2	Security Write Protection	Disabled (OFF)	ON = Enabled, OFF = Disabled

TABLE 4-2. Analog Output: Standard Alarm Values vs. Saturation Values

Level	4–20 mA Saturation Values	4–20 mA Alarm Value
Low	3.9 mA	3.75 mA
High	20.8 mA	21.0 mA

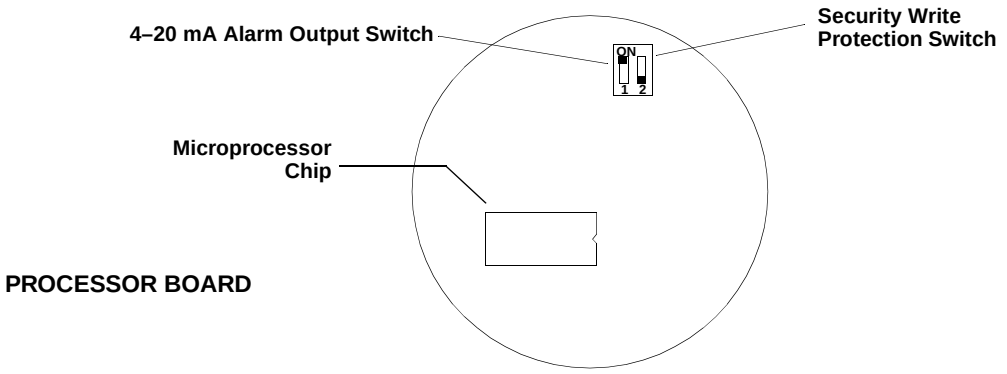
TABLE 4-3. Analog Output: NAMUR-Compliant Alarm Values vs. Saturation Values (option codes C4 or CN)

Level	4–20 mA Saturation Values	4–20 mA Alarm Value
Low	3.8 mA	3.6 mA
High	20.5 mA	21.0 mA

The gauge monitors its own operation. This automatic diagnostic routine is a timed series of checks repeated continuously. If the diagnostic routine detects a failure in the gauge, the 4–20 mA output is driven upscale (high) to 21 mA or downscale (low) to 3.75 mA, depending on the position of Switch 1.

Security write protection prevents unauthorized access to configuration data through the optional integral display or HART Communicator.

Figure 4-1. Radar Gauge Processor Switch Settings



To set the switches, follow these steps:

1. To access the switch bank on the microprocessor board (Figure 4-1), remove the cover opposite the terminal side, or remove the optional integral display (if installed) from the gauge. **Do not remove the gauge cover in explosive atmospheres when the circuit is alive**.
2. To set the 4–20 mA alarm output to low, move Switch 1 to the OFF position. High (ON) is the factory default setting (see Figure 4-1).
3. To enable the security write protection feature, move Switch 2 to the ON position (top). The OFF (low) option is the factory default setting (see Figure 4-1).
4. Reinstall the display (if necessary) or replace the cover.

Electrical Considerations

Conduit Connections

The electronics housing has two ports for 3/4–14 NPT conduit connections. Adapters are also available for PG 13.5 or CM20 conduit. These connections are made in a conventional manner in accordance with local or plant electrical codes. Be sure to properly seal unused ports to prevent moisture or other contamination from entering the terminal block compartment of the electronics housing.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

NOTE
In some applications it may be necessary to install conduit seals and arrange for conduits to drain to prevent moisture from entering the wiring compartment.

Refer to “Safety Messages” on page 4-1 for more information.

Grounding the Gauge Housing

The electronics housing should always be grounded in accordance with national and local electrical codes. Use the equipment only as specified in this manual. Failure to do so may impair the lightning and transient protection provided by the equipment. The most effective grounding method is to connect the grounding lug on the gauge directly to earth ground with 1 ohm or less impedance.

The Internal Ground Connection (Protective Ground Connection), located inside the FIELD TERMINALS side of the electronics housing, is the Internal Ground Connection screw. This screw is identified by a ground symbol: ⏚ .

NOTE
For all radar gauges with output code 2 (intrinsically safe output), the negative 4–20 mA (HART) terminal is grounded to the electronics housing. **Do not use another ground in the loop.** In installations where the intrinsically safe output (output code 2) will be used, an isolated barrier is required.

NOTE
Grounding the gauge case via threaded conduit connection may not provide sufficient ground.

Transient Protection

The APEX and APEX Sentry Radar Gauges include transient protection and comply with IEC 61000 4-5. Transient protection increases the ability of the APEX and APEX Sentry Radar Gauges to withstand electrical transients induced by lightning, welding, or heavy electrical equipment.

External Power Shut-off Switch

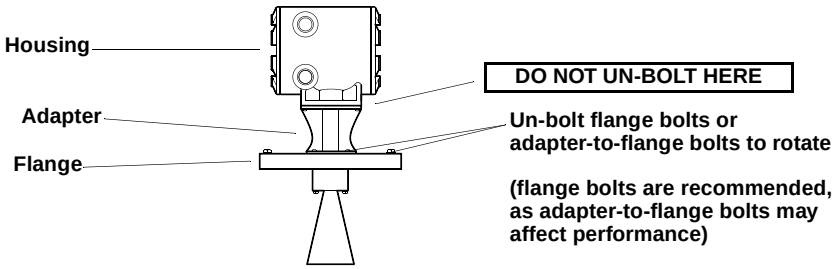
The wiring should include an external power shut-off switch or an external circuit breaker. This device should be located near the gauge.

MOUNTING THE GAUGE

NOTE
If the electronics housing needs to be rotated, **do not un-bolt the adapter-to-housing bolts!** Either un-bolt the flange bolts or the adapter-to-flange bolts and rotate as needed. If the housing is rotated at the housing-to-adapter connection, the gauge will be irreparably damaged, and the warranty invalidated. (See Figure 4-2.) Flange bolts are suggested for use; performance may be affected if adapter bolts are used.

Refer to “Safety Messages” on page 4-1 for more information.

Figure 4-2. Rotating the Electronic Housing



Mount the radar gauge vertically on a 2-, 3-, 4-, or 6-inch ANSI Class (DN 50, DN 80, DN 100, or DN 150) flange on top of the vessel. Make sure only qualified personnel perform the installation.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

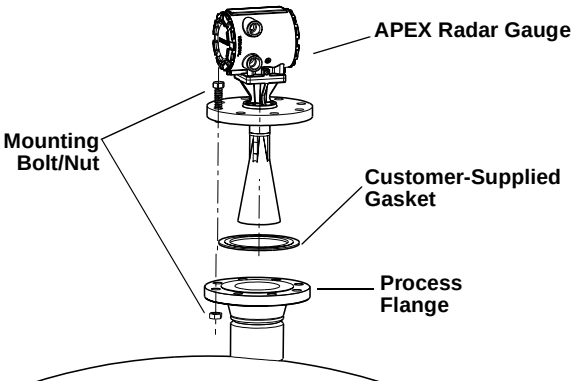
Installing without a Process Window

If you are installing the gauge *without* a process window, refer to Figure 4-3 and follow these steps:

1. Place a gasket on top of the tank flange. (Choose a gasket type according to process compatibility.)
2. Position the antenna into the tank flange standoff.
3. Check to see that the gauge is positioned so the conduit openings face the proper direction for wiring.
4. Secure the gauge flange to the tank flange.
5. Tighten the flange bolts when the gauge is properly positioned.

NOTE
The tightening torque is dependent on the strength of the stud bolts and the pressure rating of the vessel.

Figure 4-3. Diagram for Installation **without a Process Window**



Refer to "Safety Messages" on page 4-1 for more information.

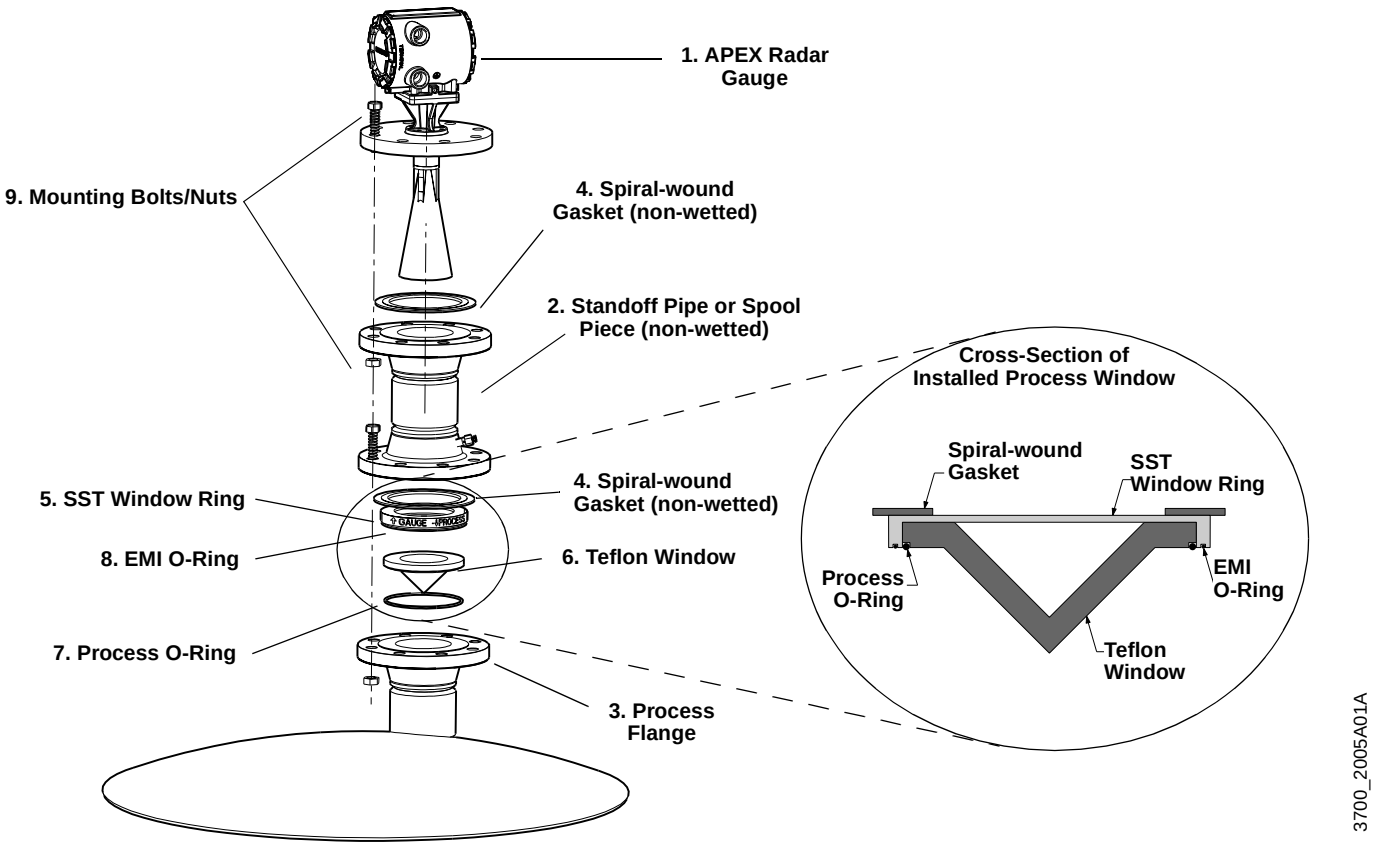
Installing with a Process Window

If you are installing the gauge *with* a process window, refer to Figure 4-4 and follow these steps:

NOTE
Make sure the metal gaskets are installed and the flange bolts are torqued properly to keep moisture out of the spool piece. Bolts should be re-tightened 24 to 48 hours after initial installation.

1. Seat the process O-ring (7) into the groove on the window (6), and center the window on the process flange without letting the O-ring slip out of its position in the groove.
2. Make sure that the EMI gasket (8) is seated in the stainless steel window ring (5), place the window ring over the window, and center a spiral-wound gasket (4) over the window ring.
3. Center the standoff pipe or spool piece (2) on the flange. Put two of the bolts (9) in opposite sides and hand tighten. Look inside the spool piece to verify that the Teflon window is centered on the flange. (See Figure 4-6 on page 4-9.) Once the Teflon window is centered, use the rest of the mounting bolts and nuts to finish attaching the spool piece to the tank flange. A misaligned window will severely hinder gauge performance. Tighten the bolts to 75-100 ft-lb (102-136 N-m).

Figure 4-4. Diagram for Installation **with a Process Window**



4. Center the second spiral-wound gasket (4) on top of the standoff pipe/spool piece.
5. Attach the radar gauge(1) to the standoff pipe or spool piece using the bolts and nuts as shown. Tighten the bolts to 75-100 ft-lb (102-136 N-m).

NOTE
When a process window is used, the window and spool piece heights will need to be incorporated into the Reference Gauge Height and Upper Null Zone. Refer to the definitions on page 3-8 for more information.

NOTE
It is possible to use a standoff pipe/spool piece supplied by a source other than Rosemount; however, it is suggested that when the APEX and APEX Sentry Radar Gauges are mounted, the end of the antenna be no more than 1-inch from the face of the window. For antenna lengths, refer to dimension "D" in Figure 6-2 on page 6-7.

Figure 4-5. Diagram for Installation **with a Process Window** (repeated figure)

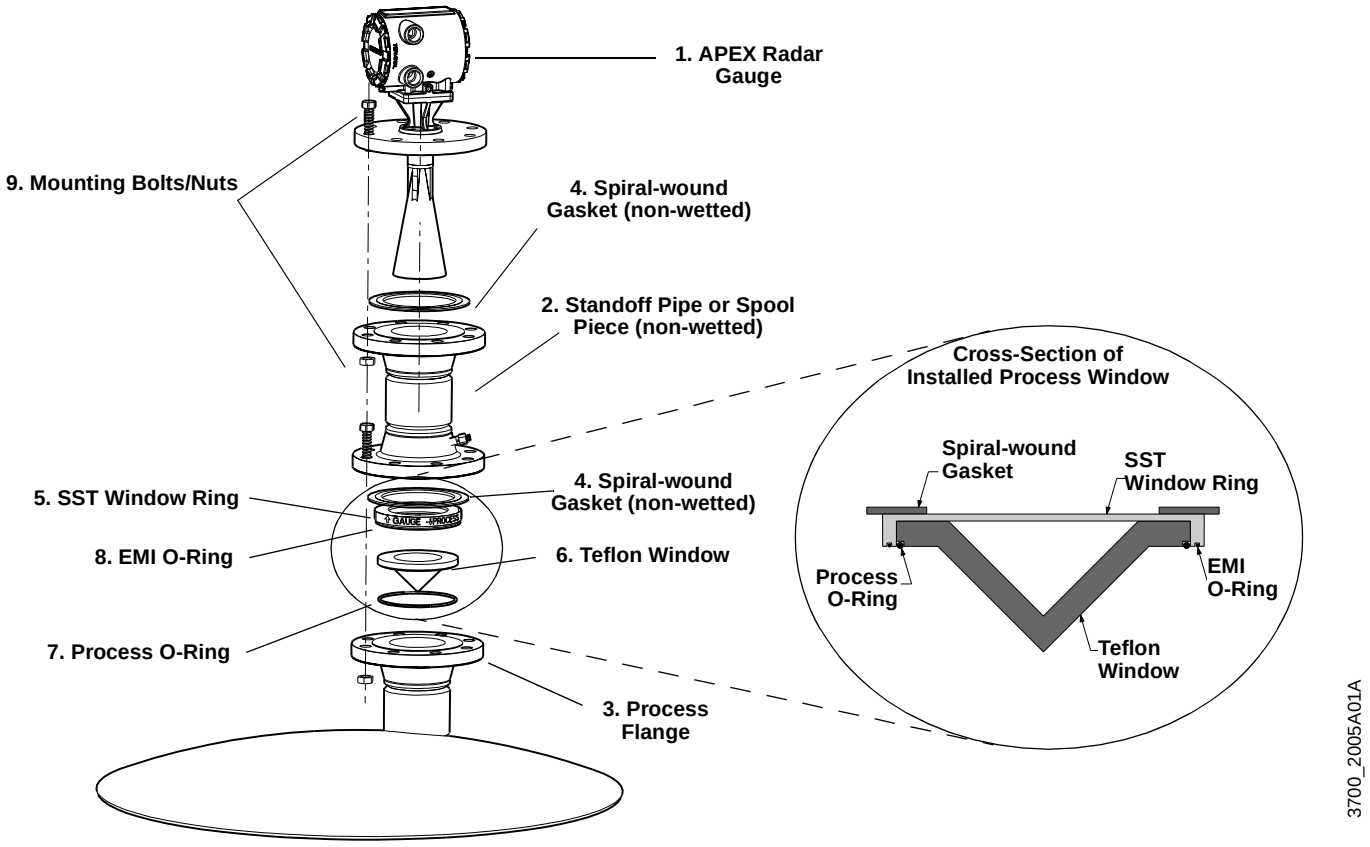
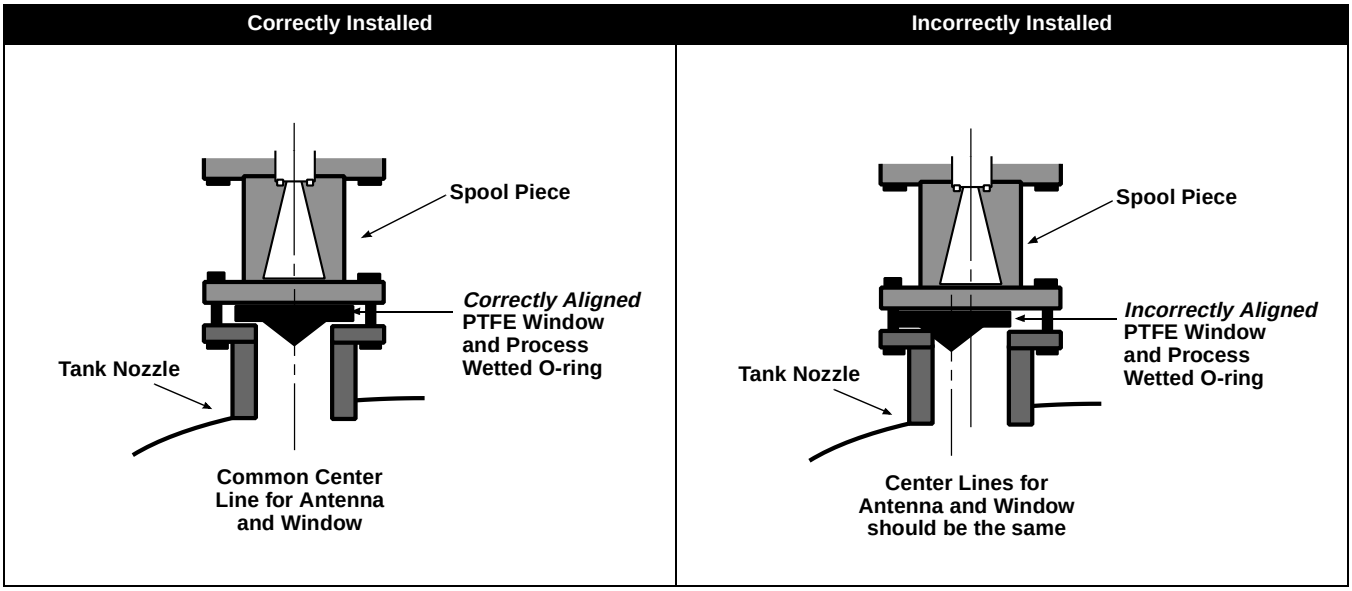


Figure 4-6. Window Centering – Radar Gauge with Installed Isolation Window



WIRING THE GAUGE

APEX and APEX Sentry Radar Gauges accept ¾–14 NPT male conduit fittings. PG 13.5 and CM 20 adapters are optional. If necessary and permissible, use flexible conduits close to the gauge.

The gauge output is 4–20 mA superimposed with a HART signal and shielded, twisted pair wiring is required.

NOTE
When wiring multiple devices, run separate wire pairs to each radar gauge—do not “daisy chain” or use common return wiring configurations. In other words, while it is acceptable to multidrop gauges in the 4–20 mA loop, it is not acceptable to multidrop the power supply loops.

Cable Selection

Power supply cables must be suitable for the supply voltage and approved for use in hazardous areas, where applicable. For instance, in the U.S., explosion-proof conduits must be used in the vicinity of the vessel. Use 12 AWG to 18 AWG wire. Using smaller than 18 AWG wire can cause too much voltage drop to the gauge. Refer to Figure 4-7 on page 4-10 to determine the correct wire size according to the length of the wire run and available supply voltage.

Use wire rated for the proper temperature application. For connections in ambient temperatures above 140 °F (60 °C), use a wire rated for 176 °F (80 °C).

Power Requirements

Screw terminals in the radar gauge provide connections for dc or ac power, secondary inputs and outputs, grounding, and loop testing.

Avoid contact with leads and terminals.

The operating current will vary depending on power supply size. For example, the operating current using a 24 vdc supply will equal 0.4375 amps:

$$\left(\frac{10.5W}{24V} = 0.4375amps\right)$$

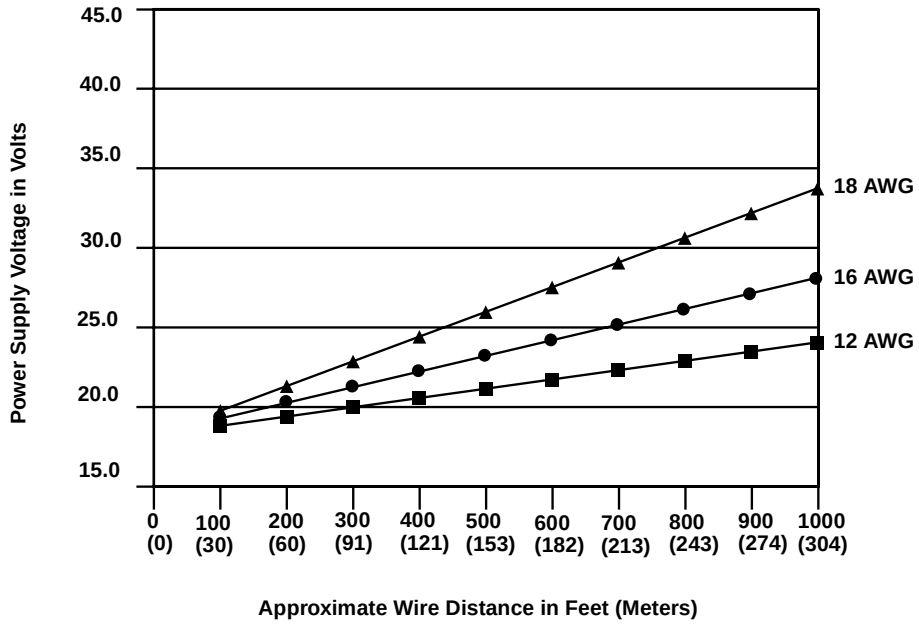
NOTE
The gauge requires an *additional* power supply (as indicated in Table 4-4 on page 4-10) to power the 4–20 mA loop.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

TABLE 4-4. APEX and APEX Sentry Radar Gauge Power Requirements

Power Supply	dc	ac
Main Power Supply	18–36 V dc	90–250 V ac 50/60 Hz
Loop Power Supply for 4–20 mA	10.5–55 V dc	10.5–55 V dc

Figure 4-7. Main Power Supply Voltage vs. Wire Length Required



Refer to "Safety Messages" on page 4-1 for more information.

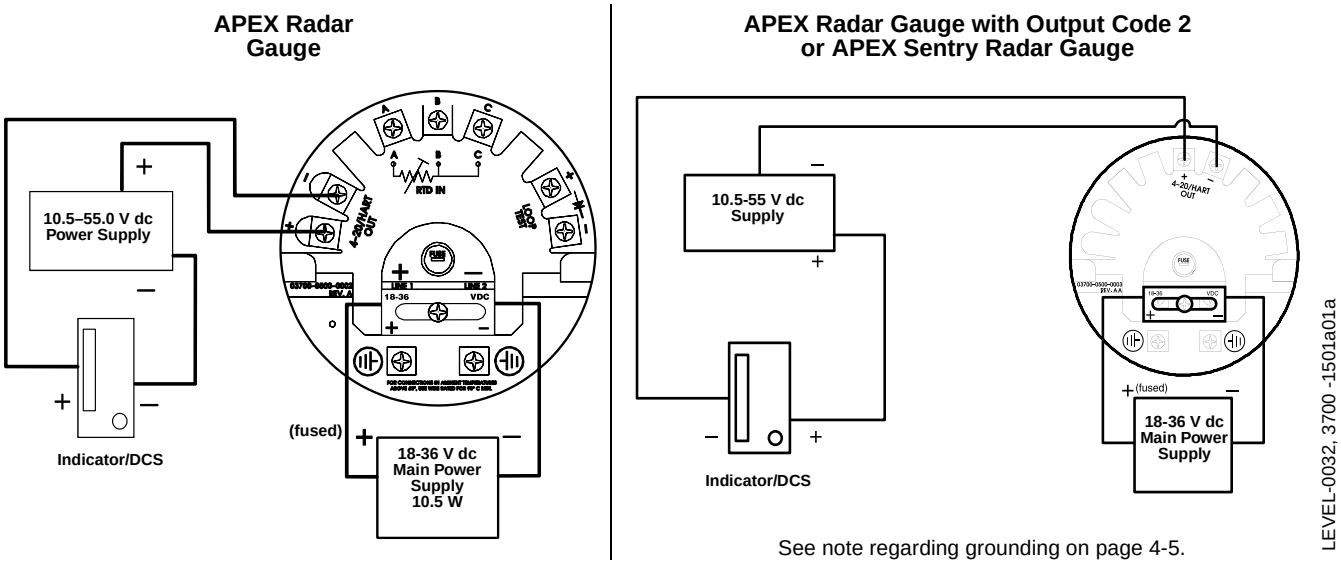
Hazardous Locations

APEX and APEX Sentry feature an explosion-proof housing. Each gauge is clearly marked with a label indicating the certification it carries. See Section 6: Specifications and Reference Data for specific approval information.

DC Main Power Supply with 4–20 mA Loop Power Supply

Wire the APEX and APEX Sentry Radar Gauges as shown in Figure 4-8, using an 18–36 V dc main power supply. Loop power is required for the 4–20 mA/HART output. Use a 10.5–55.0 V dc secondary power supply for the 4–20 mA/HART loop output. Refer to "Power Requirements" on page 4-10 to determine the power supply voltage required in the control room. Make sure the main power to the gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

Figure 4-8. DC Power Supply Connections with 4-wire Installation and Separate 4–20 mA Power Supply



See note regarding grounding on page 4-5.

The power terminals are located under a sliding safety cover on the terminal blocks. This sliding cover exposes only one terminal at a time to guard against electrical shock. The safety cover must be left on while wiring the radar gauge. If the cover has been removed, the word "DANGER" appears near the terminals.

DC Main Power Supply Fuse Size and Type

Be sure to use the proper fuse size and type. Failure to use the appropriate fuse could result in improper operation or damage to the gauge.

The radar gauge with a dc power supply uses the following fuse size and type (Rosemount Part No. C53323-0107):

- 2 AG Fuse, 1A, 250 V, Fast Action

Refer to "Safety Messages" on page 4-1 for more information.

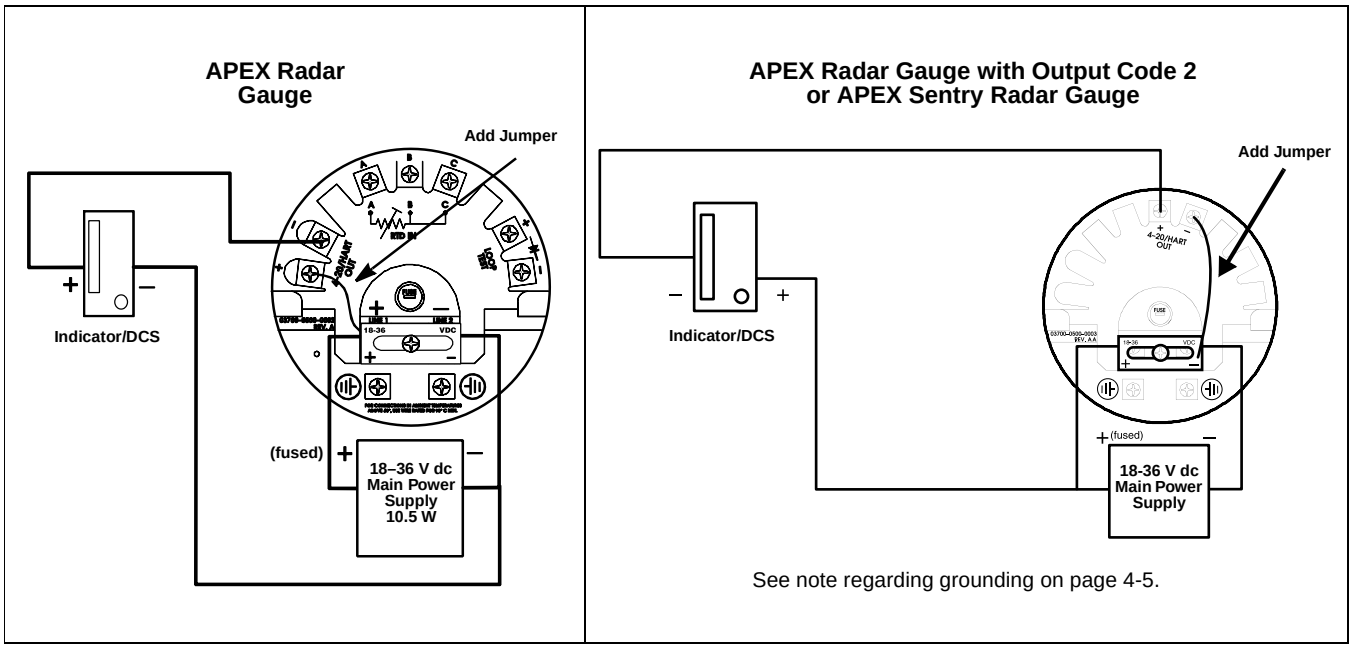
NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

DC Main Power Supply with No Loop Power Supply

You can also wire the gauge as shown in Figure 4-9, using one 18–36 V dc power supply capable of supplying 10.5 watts. Make sure the main power to the gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

NOTE
The APEX draws 1 amp at startup; it is not recommended that a DCS or channel card be used to power the gauge (the gauge has an operating draw of 0.4375 amp using a 24 vdc supply.)

Figure 4-9. DC Power Supply Connections



The power terminals are located under a sliding safety cover on the APEX terminal block. This sliding cover exposes only one terminal at a time to guard against electrical shock. The safety cover must be left on while wiring the APEX gauge. If the cover has been removed, the word “DANGER” appears near the terminals.

NOTE
The APEX will operate on 18–36 V dc at its power terminals. Refer to “Power Requirements” on page 4-10 to determine the power supply voltage required in the control room.

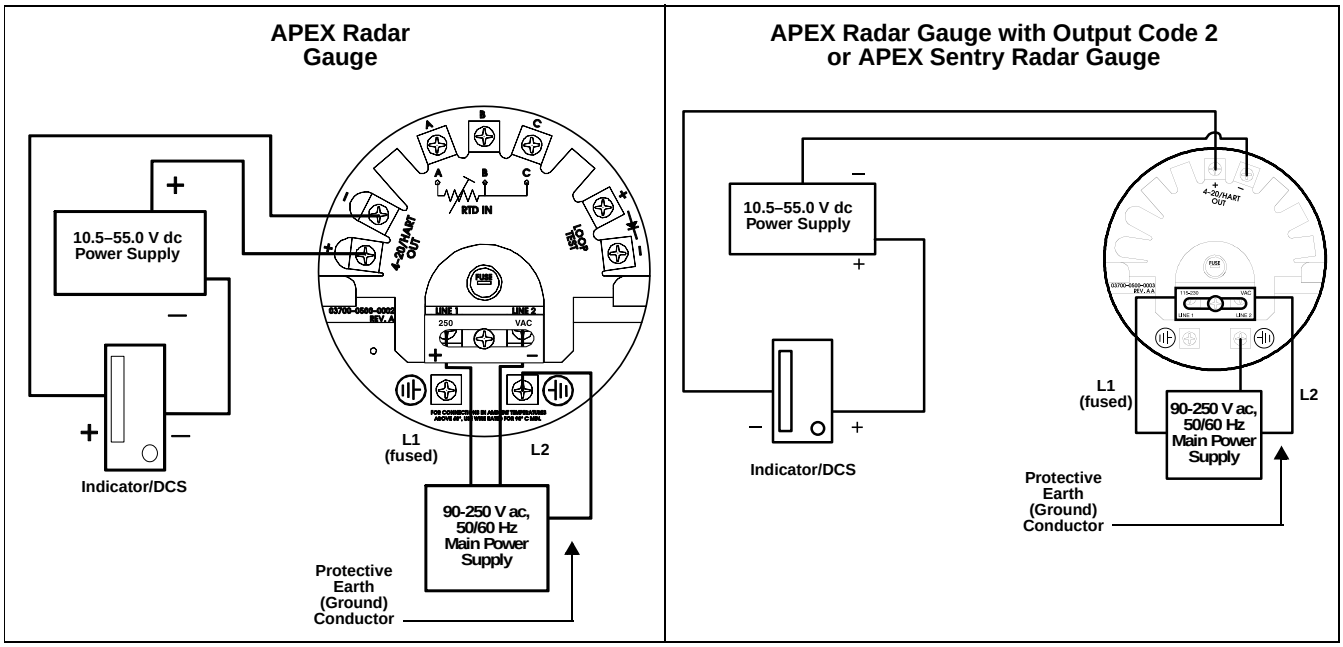
Refer to “Safety Messages” on page 4-1 for more information.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

AC Main Power Supply with 4–20 mA Loop Power Supply

Wire the gauge as shown in Figure 4-10, using a 90–250 V ac, 50/60 Hz power supply. Loop power is required for the 4–20 mA/HART output. Use an additional 10.5–55.0 V dc secondary power supply for the 4–20 mA/HART loop output. Make sure the main power to the gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

Figure 4-10. AC Power Supply Connections with Separate 4–20 mA Loop Power



The power terminals are located under a sliding safety cover on the terminal block. This sliding cover exposes only one terminal at a time to guard against electrical shock. The safety cover must be left on while wiring the gauge. If the cover has been removed, the word “DANGER” appears near the terminals.

AC Main Power Supply Fuse Size and Type

Be sure to use the proper fuse size and type. Failure to use the appropriate fuse could result in improper operation or damage to the gauge.

The gauge with an ac power supply uses the following fuse size and type (Rosemount Part No. C53323-1104):

- 2 AG Fuse, 3/8 A, 250 V, Time Delay

Refer to “Safety Messages” on page 4-1 for more information.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

WIRING OPTIONAL GAUGE DEVICES

Optional devices that can be used with the APEX and APEX Sentry Radar Gauges include the Model 751 Field Signal Indicator, a 3- or 4-wire RTD (Resistance Temperature Detector), such as the Series 58C, 68, or 78. The APEX Radar Gauge can also be used in conjunction with a model 3201 HIU to form a hybrid system.

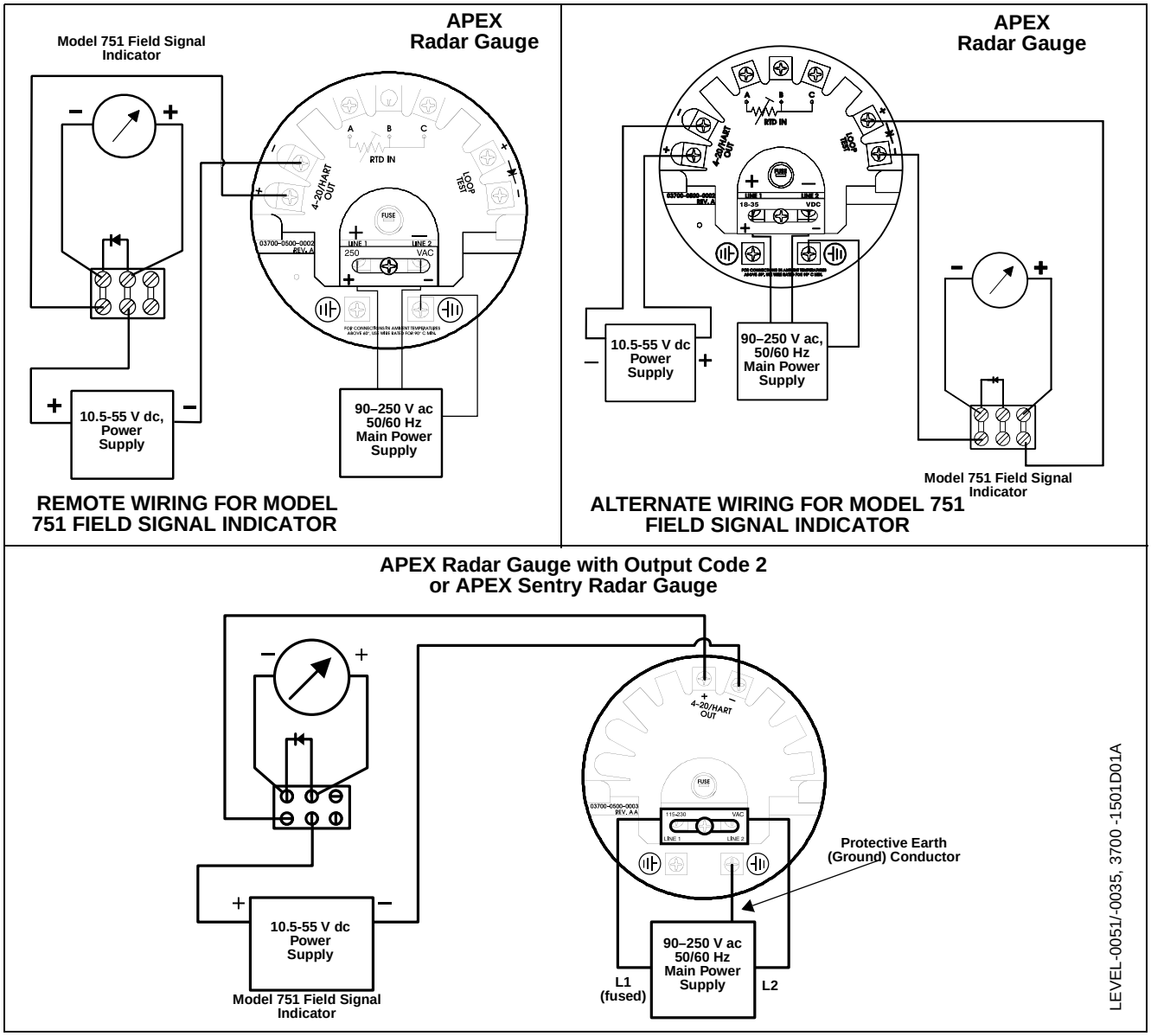
Model 751 Field Signal Indicator

(APEX Radar Gauge and APEX Sentry Radar Gauge)

If the gauge is to be used with a Model 751 Field Signal Indicator, wire the gauge using one of the options shown in Figure 4-11.
(If necessary, refer to the Model 751 Field Signal Indicator manual, 00809-0100-4378.) Make sure the main power to the gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

Refer to “Safety Messages” on page 4-1 for more information.

Figure 4-11. Wire Connection Options for the Model 751 Field Signal Indicator



APEX/Hybrid System Installation (APEX Radar Gauge Only)

Figure 4-12 and the wiring diagrams in Figures 4-13, 4-14, and 4-15 are provided to detail the proper methods of wiring the following tank gauging architectures:

- Figure 4-12: APEX Hybrid System (APEX interfacing with a Model 3201 HIU and Model 3402 AIM architecture)
- Figure 4-13: HART Polling addresses
- Figure 4-14: Model 3201 HART Device wiring diagram
- Figure 4-15: Multidropping Model 3201 HIU along the MCAP network

Based upon the specific type of system you are installing, Figures 4-12 through 4-15 should answer your installation wiring questions. For further details regarding each component of the system, please refer to each product's individual manual.

Product	Document Number
• Model 3001C Transmitters	00809-0100-4635
• Model 3201 HIU	00809-0100-4640
• Model 3202 SAM	00809-0100-4646
• Model 3402 AIM	00809-0100-4641

Figure 4-12. APEX Hybrid Installation

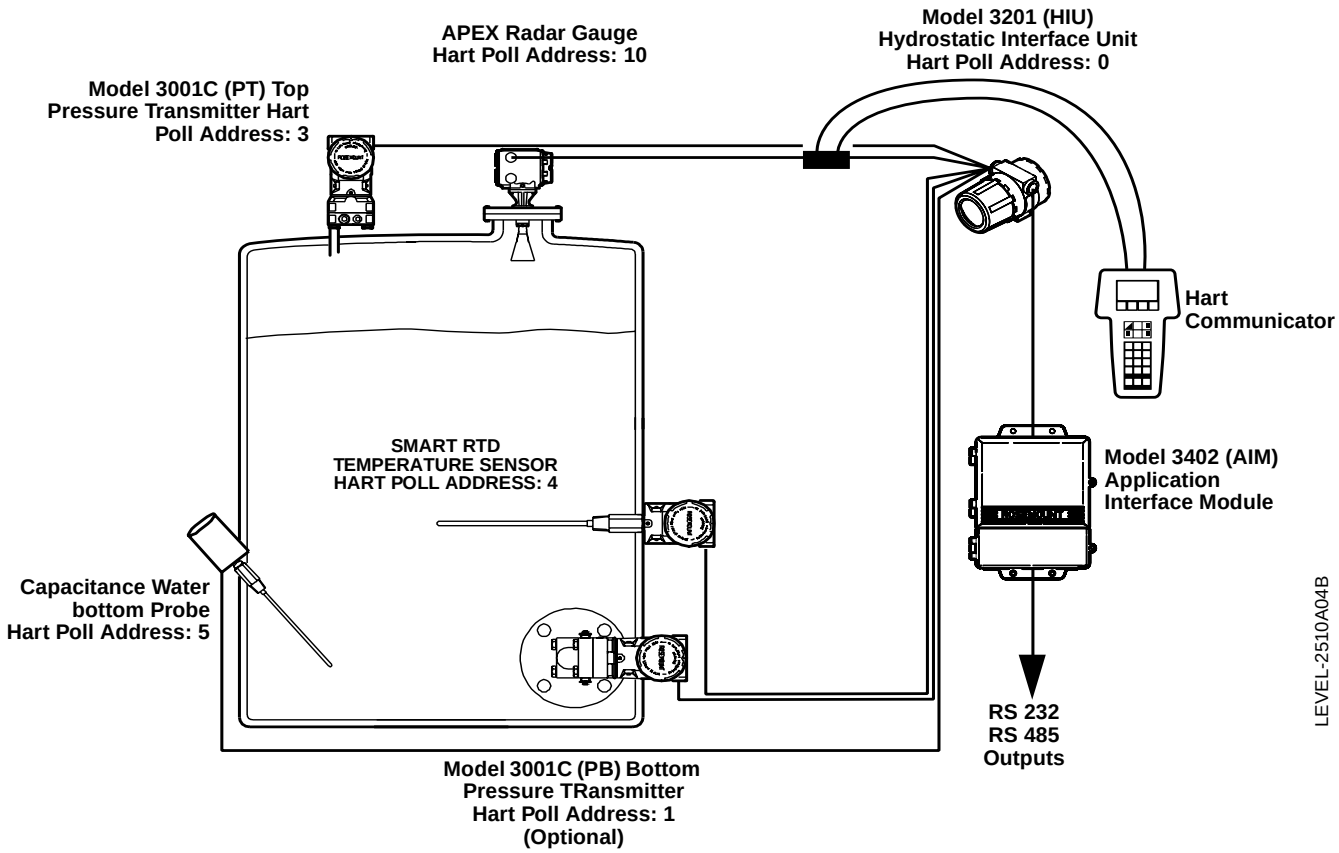


Figure 4-13. HART Polling Addresses

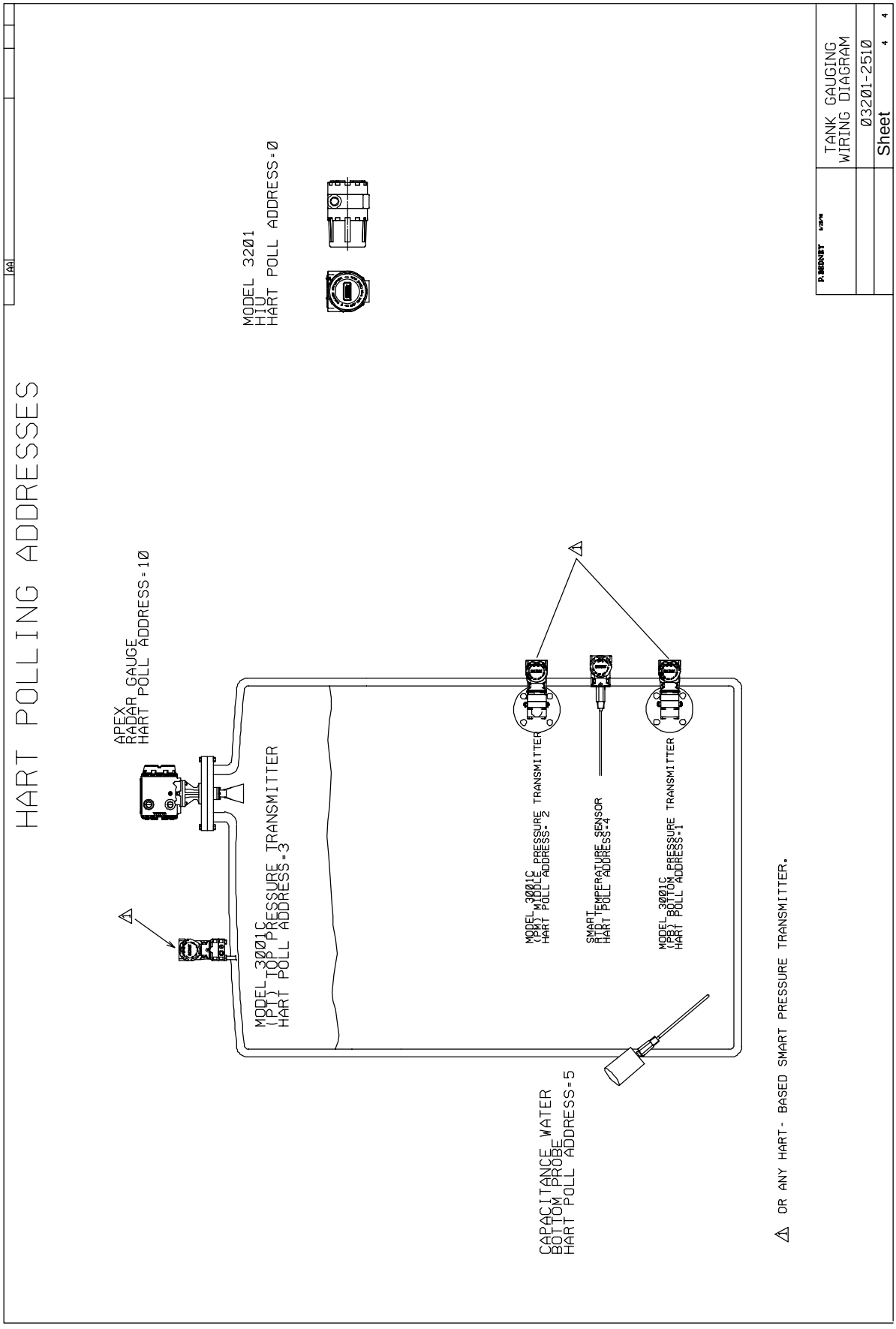


Figure 4-14. Model 3201 HIU HART Device Wiring Diagram

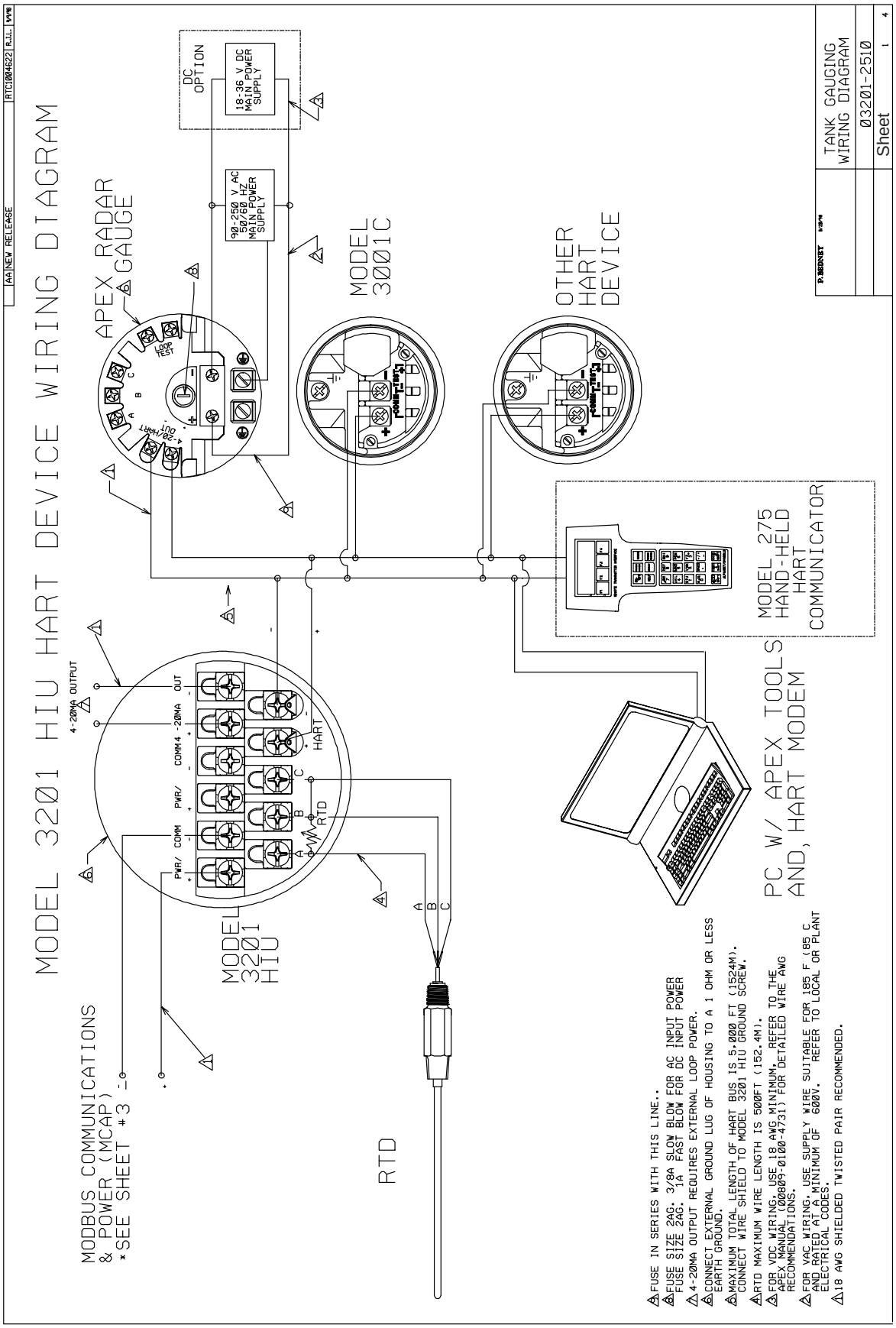
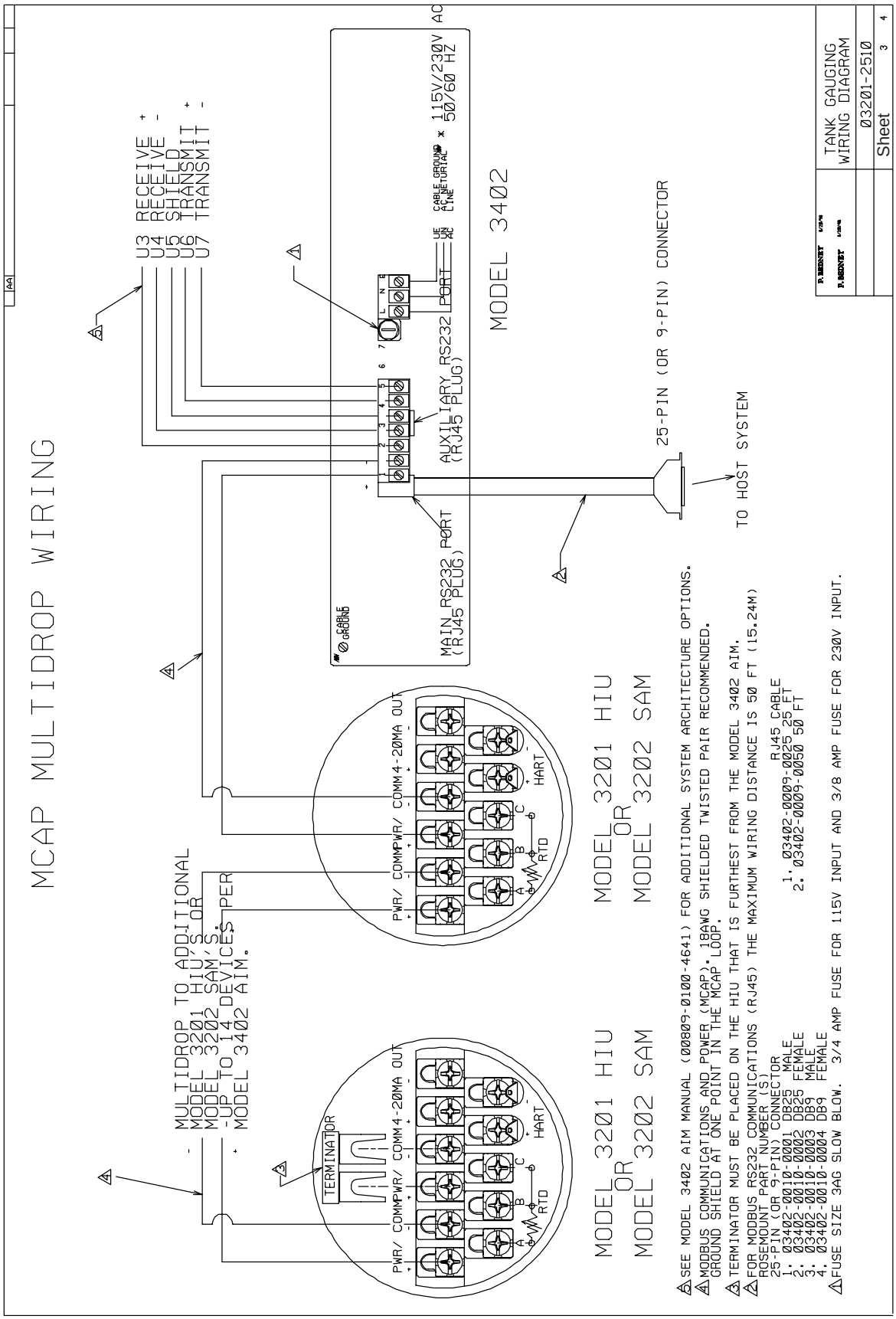


Figure 4-15. MCAP Multidrop Wiring



3201-2510A03A

3- or 4-Wire RTD (APEX Radar Gauge Only)

If your vessel is equipped with a 3- or 4-wire platinum 100 ohm RTD, wire the gauge as shown in Figure 4-16. Make a direct connection from the RTD to the gauge. The RTD may be mounted a maximum of 500 feet from the gauge.

1. Make sure the main power to the gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.
2. Connect three RTD wires directly from the temperature element to the gauge.

   Avoid contact with leads and terminals.
3. Wire the sensor across the gauge terminals A and B and the loop compensation across B and C.

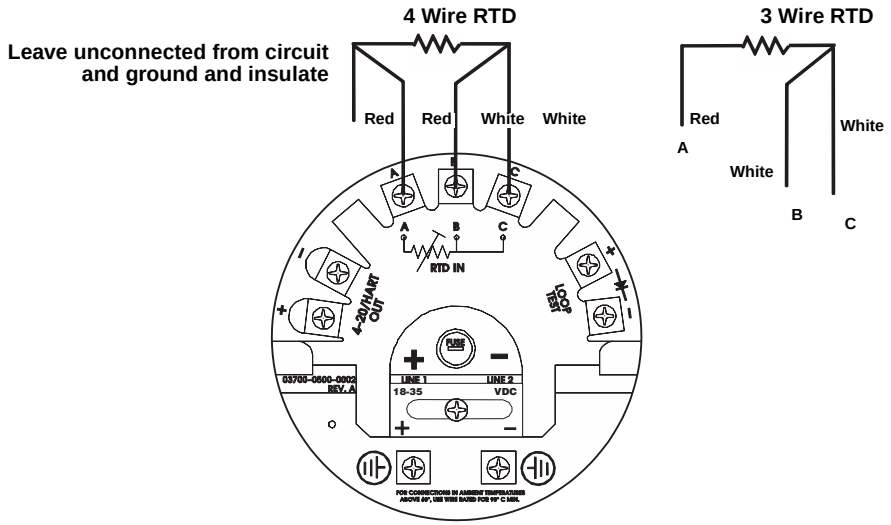
   Wires B and C are the same color code; wire A is a different color code. When using a 4-wire RTD, one wire (the same color as the wire connected to terminal A) is not used.

For more information about Rosemount RTDs, refer to Product Data Sheet No. 00813-0100-2654: Series 58C, 68, 68Q, and 78 Temperature Sensors, Assemblies, and Accessories.

NOTE
If RTD input is to be used, the gauge must have the RTD function enabled. This can be done at the factory, or it can be done in the field using a Model 275 Hart Communicator (see Appendix A: HART Communicator).

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

Figure 4-16. Wire Connections for a 3- and 4-wire RTD



Refer to "Safety Messages" on page 4-1 for more information.

POWERING UP

⚠ Be sure to make all of the APEX or APEX Sentry Radar Gauge connections before applying power to the system. Check the connections for the power to the gauge and the power supply for the 4–20 mA loop to be sure they are correct. Make sure the main power to the gauge is off and the lines to any other external power source are not powered while wiring the gauge.

Connect the gauge to either 18–36 V dc or 90–250 V ac 50/60 Hz power, depending on the model selected.

Power consumption by the gauge is approximately 10.5 watts.

After connecting power, configure the radar gauge using the APEX integral display (APEX Radar Gauge only) or the hand-held Model 275 Hart Communicator (APEX and APEX Sentry Radar Gauges). The remainder of this section provides information about field configuration using the optional integral display.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

FIELD CONFIGURATION USING THE INTEGRAL DISPLAY (APEX RADAR GAUGE ONLY)

NOTE
For information on configuring the APEX Radar Gauge using a Model 275 HART Communicator, refer to page 4-31. The same parameters will need to be entered regardless of which method you use to configure the gauge.

NOTE
To ensure long life for your radar gauge, and to comply with hazardous location installation requirements, tighten covers on both sides of the electronics housing to achieve metal-to-metal contact.

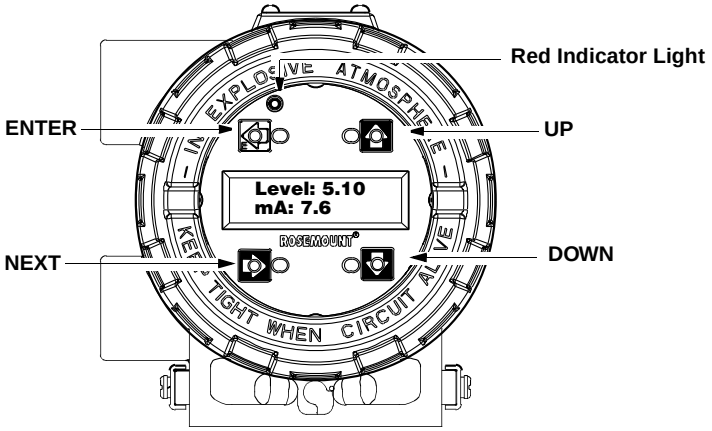
⚠ The gauge integral display may be used in explosion-proof areas. Verify that the operating environment of the gauge is consistent with the appropriate hazardous locations certifications. You do not need to remove the cover to operate the integral display.

To operate the integral display once it has been activated (see page 4-22), place your finger over one of the optical sensors—ENTER, NEXT, UP, or DOWN (see Figure 4-17). A light beam reflects off your finger and activates the sensor and the corresponding function. When you activate a sensor, a red light confirms that you made contact.

NOTE
An “A” displayed in the lower right corner of the display indicates that the gauge has gone into alarm mode (see Table 5-1 on page 5-3 for an explanation of error messages). The “A” will disappear once the unit is out of alarm mode.

Refer to “Safety Messages” on page 4-1 for more information.

Figure 4-17. Optional Integral Display and Optical Sensors



LEVEL-0025A

The sensors provide the following functions:

- The ENTER sensor (left arrow) sets a variable or selects an option.
- The NEXT sensor (right arrow) moves the cursor within the displayed variable.
- The UP and DOWN sensors change the displayed value of the variable or option.

Starting the Main Menu

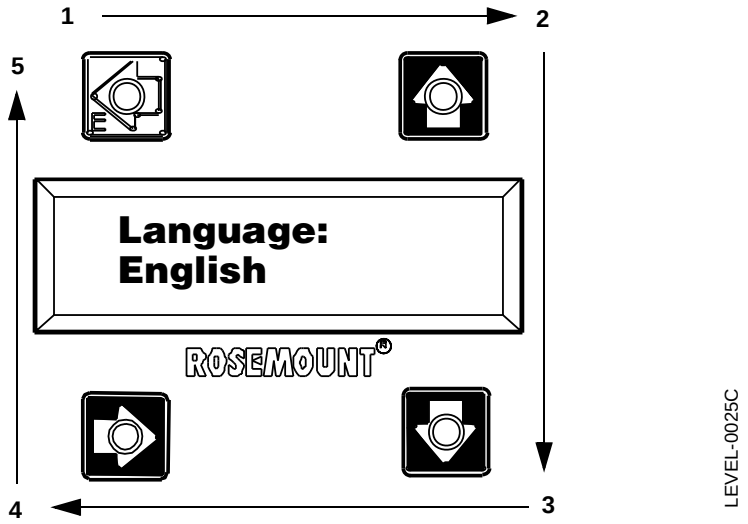
To start the main menu, follow these steps (refer to Figure 4-17 and Figure 4-18):

1. Press the ENTER sensor.
2. Press the UP sensor.
3. Press the DOWN sensor.
4. Press the NEXT sensor.
5. Press the ENTER sensor again to activate the main menu.

   The integral display shows the first variable, Language.

NOTE
If you do not activate any sensors for one minute, the display will time-out and exit the main menu without saving changes.

Figure 4-18. Main Menu Start Up Sequence



Setting Configuration Options

Once you start the main menu, you can set variables and configuration options. The integral display allows you to set the following:

- Language
- Output units
- Display units
- Reference height
- 4 mA calibration
- 20 mA calibration

The basic procedure for setting configuration options is as follows:

1. Press UP or DOWN to change the displayed value of the variable or option.

   If necessary, press NEXT to move the cursor to the digit you want to change.

2. Press ENTER to set the variable or select the option and move to the next option.

NOTE 1
When each configuration option first appears on the display, its current value is displayed below it.

NOTE 2
Configuration changes are not saved until you exit the main menu using the “Save Changes” selection.

The menu tree in Figure 4-19 on page 4-25 shows all of the variables and options you can configure using the integral display. Use the form on the next page to record the key pieces of information you need to configure the APEX gauge using the integral display.

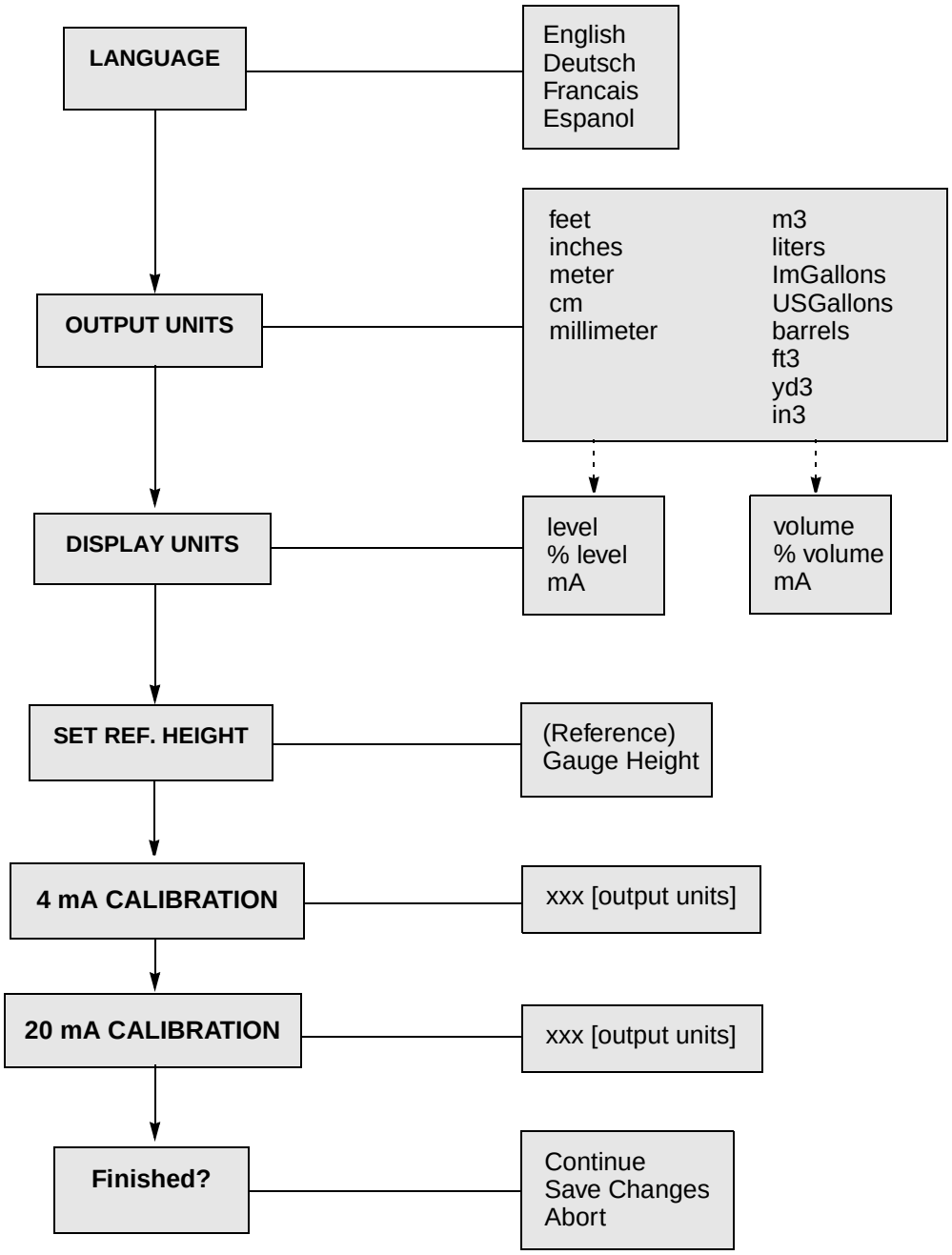
Configuration Options Form

Use this form to record the five key pieces of information you need before you begin to configure the gauge using the integral display. Getting this information ahead of time will help you get your gauge set up and operating quickly and accurately.

Mark the boxes next to your choices and fill in the requested information on this form.

1. **Language (select one)**	___ English ___ Deutsch	___ Francais ___ Espanol
2. **Output Units (select one)**	Level ___ ft ___ in ___ m ___ cm ___ mm	Volume ___ m^3 ___ liters ___ Imp gal ___ US gal ___ bbls ___ ft^3 ___ yd^3 ___ in^3
Note: Your choice of output units determins the choices available for display units		
3. **Reference Gauge Height:** **or** **Known Actual Level:**	_____ _____	(circle one: ft, in, cm, mm, m) (circle one: ft, in, cm, mm, m)
4. **4 mA Set Point:**	_____	
5. **20 mA Set Point:**	_____	

Figure 4-19. APEX Radar Gauge
Integral Display Menu Tree



Setting the Language

The first variable displayed is Language. Language options include English, Deutsch, Français, and Español. To set the language:

1. Press UP until the display shows the language you want to use.
2. Press ENTER to set the language.

   The menu then displays the Output Units option.

Setting the Output Units

Output unit options include level units and volume units. Level units are feet (*feet*), inches (*inches*), meters (*meter*), centimeters (*cm*), and millimeters (*millimeter*). Volume units are cubic meters (*m3*), liters (*liters*), Imperial Gallons (*ImGallons*), U. S. Gallons (*USGallons*), barrels (*barrels*), cubic feet (*ft3*), cubic yards (*yd3*), and cubic inches (*in3*).

NOTE
Volume output units should be selected only if tank type (*Tnk Typ*) Volume Geometry has been configured using the HART Communicator (refer to Appendix A: HART Communicator). To display accurate volumetric units, the tank dimensions and volume equations or a strapping table must be configured in APEX memory using the HART Communicator.

NOTE
If volume is the desired output, the gauge must first be configured in level units (see “Setting the Reference Gauge Height” on page 4-27).

To configure the unit for volume output, refer to page 4-31.

To set the output units:

1. Press UP until the display shows the output units option you want to use.
2. Press ENTER to set the output units.

   The menu then displays the Display Units option.

Setting the Display Units

The integral display has two display lines (see Figure 4-17). The display for the upper line can be selected via the integral display itself. The lower line scrolls through a series of options. It is programmed using the HART Communicator (refer to Appendix A: HART Communicator) or is pre-configured at the factory.

Display unit options for the upper line are *level*,*% level*, and *mA* if level units were selected for output units.

Display unit options for the upper line are *volume*,*% volume*, and *mA* if volume units were selected for output units.

To set the display units:

1. Press UP until the display shows the display units option you want to use.
2. Press ENTER to set the display units.

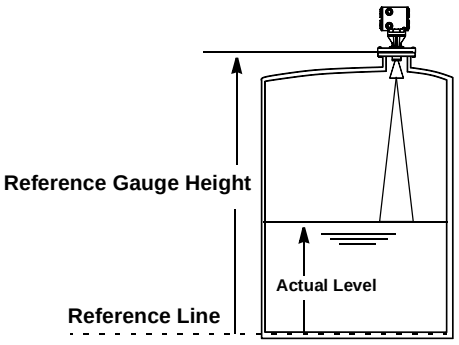
   The menu then displays the Reference Height option.

NOTE
The gauge can output up to four variables via the HART Signal. To configure these variables (Primary variable, Secondary, Tertiary, Quaternary), refer to Appendix A: HART Communicator.

Setting the Reference Gauge Height

The Reference Height options are Reference Gauge Height or Actual Level. The "Actual Level" option should be used only when there is a definite target for signal reflection. Flat-bottom tanks and flat, horizontal liquid surfaces reflect well. Slanted or turbulent surfaces may not provide sufficient reflection. **The Reference Gauge Height is the most critical setting for the gauge because it is the basis for all other calculations—choose it carefully!** (See **page 3-7** for further information on Reference Gauge Height.)

Figure 4-20. Reference Gauge Height



NOTE
The Reference Gauge Height must be set in level (linear) units. If you want volume output units on the integral display, you must first select level units, set the Reference Height, null zones, and empty tank settings and save the changes. You may then re-enter the menu and choose the desired volume display units.

Set the Reference Gauge Height:

NOTE
The empty tank setting must be less than or equal to 25% of the gauge height. When changing from a large gauge height to a smaller gauge height, it may be necessary to first change the empty tank setting to a smaller value using the Model 275 HART Communcator.

1. Press UP until the display shows the reference height option you want to use.
2. Press ENTER to select (reference) Gauge Height or Actual Level.

   If the dimension from the reference line (bottom) of the vessel to the gauge is unknown, do one of the following:

   - If the tank is empty and has a flat bottom, enter “0” for the actual level.

     or

   - Use the vessel drawing to determine the Reference Gauge Height.

     or

   - Use another known reference level measurement, such as a hand dip, and enter that value for Actual Level. The gauge will then calculate its height.
3. Press NEXT to move the cursor to the digit you want to change.
4. Press UP or DOWN to change the value.
5. Repeat steps 3 and 4 for each digit.
6. When finished, press ENTER to set the value of the Reference Gauge Height or Actual Level.

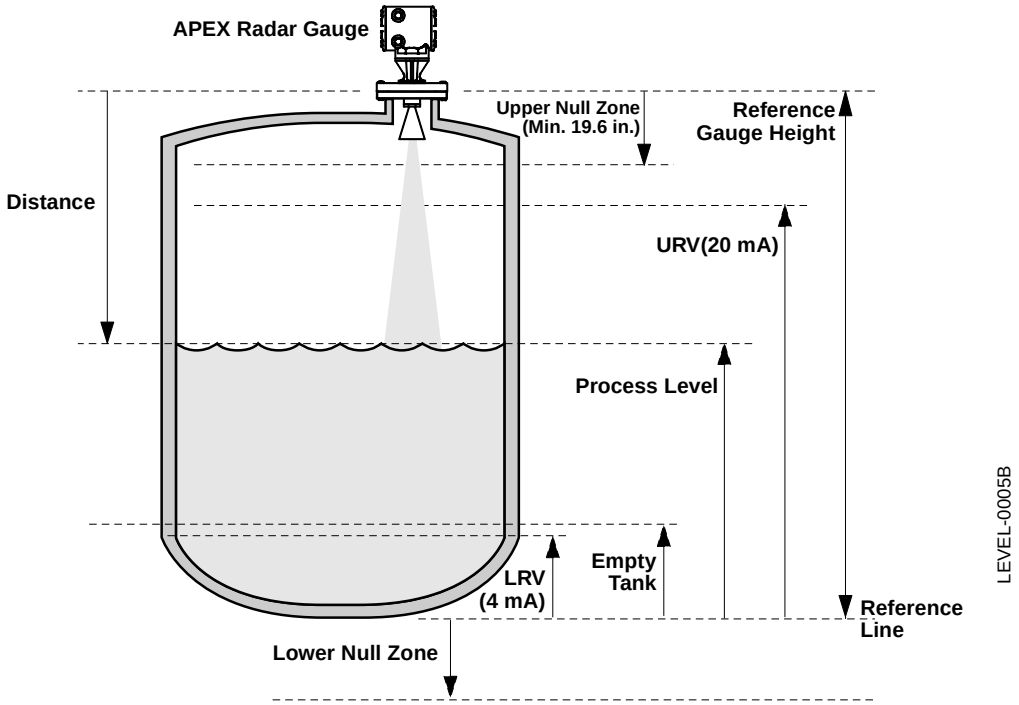
   The menu will contue to the next step.

Setting the 4 mA Calibration

The 4 mA calibration variable is expressed in terms of the configured output units. To set the 4 mA calibration:

1. Press NEXT to move the cursor to the digit you want to change.
2. Press UP or DOWN to change the value.
3. Repeat steps 1 and 2 to change the next digit.
4. When finished, press ENTER to set the desired 4 mA calibration. The menu then displays the 20 mA calibration variable.

Figure 4-21. Key Measurement Values



Setting the 20 mA Calibration

NOTE
When setting the 20 mA point, be sure to set it at least 19.6 in. (0.5 m) from the flange face and below the upper null zone. The gauge cannot accurately measure the product level closer than 19.6 inches.

The 20 mA calibration variable is expressed in terms of the configured output units. To set the 20 mA calibration:

1. Press NEXT to move the cursor to the digit you want to change.
2. Press UP or DOWN to change the value.
3. Repeat steps 1 and 2 to change the next digit.
4. When finished, press ENTER to set the desired 20 mA calibration.

The menu then displays the message “Finished?”

Exiting the Main Menu

To save the configuration information and exit the main menu:

1. Make sure the “Save Changes” message is displayed (press UP or DOWN if necessary).
2. Press ENTER.

To make additional changes, press UP or DOWN to display the message “Continue.”

- Press ENTER if you want to repeat the steps for changing each of the variables and configuration options.

  or

- To go to a specific option, continue pressing ENTER until you reach the option you want to change.

To discard the configuration changes:

1. Press UP or DOWN to display the message “Abort.”
2. Press ENTER.

FIELD CONFIGURATION USING A MODEL 275 HAND HELD COMMUNICATOR (APEX AND APEX SENTRY RADAR GAUGES)

NOTE
Remember, when using a model 275 hand held communicator, you must **send** the data before configuration changes will take effect.

NOTE
As a matter of routine, shut off the APEX Radar Gauge and all other equipment before you enter the tank.

LEVEL CONFIGURATION

To configure the APEX and APEX Sentry Radar Gauges to report LEVEL (analog output is linear to level) with the gauge wired as in Figure A-3 on page A-5, connect the Model 275 as shown.

Set Transmitter Units

HART Comm	1, 3, 2, 1

Set transmitter units:

- ft
- m
- in
- cm
- mm

Set Reference Gauge Height

HART Comm	1, 3, 4

When setting the Reference Gauge Height, keep in mind that this value is used for all measurements performed by the APEX. (Refer to "Setting the Reference Gauge Height" on page 4-27.)

Set 4 and 20 mA Points

HART Comm	1, 3, 3

When setting the range values, it is possible to enter the values directly, or to use actual values. Keep in mind that the 20 mA point must be at least 19.6 inches below the flange face.

NOTE
The primary variable must be set to *level* (factory default). Refer to Appendix A: HART Communicator if you suspect it has been changed.

VOLUME CONFIGURATION (APEX RADAR GAUGE ONLY)

To configure the gauge to report ACTUAL VOLUME (analog output is linear with volume) set transmitter units and Reference Gauge Height in level units as detailed above. The Reference Gauge Height must be set in linear units for the gauge to be able to read volume.

Set Volume Units

HART Comm	1, 3, 2, 2

You may choose one of the following:

- Gallons (gal)
- Liters (L)
- Imperial Gallons (Impgal)
- Cubic Meters (cum)
- Barrels (bbl)
- Cubic Feet (cuft)
- Cubic Inches (cuin)
- Cubic Yards (cuyd)

Set Primary Variable

HART Comm	1, 1, 1, 1

Select volume for volume measurements.

Set Range Values (4 and 20 mA points)

HART Comm	1, 3, 3

When setting the range values, it is possible to enter the values directly or to have the gauge read the values. If values are to be read by the gauge, set the desired tank type first.

Choose Tank Type

HART Comm	1, 4, 3, 1

Choose a tank with a standard shape, or select the strapping option. Standard shapes: Vertical Cylinder, Horizontal Cylinder, Vertical Bullet, Horizontal Bullet, or Sphere. (If primary variable is level, select “None”). If your tank is not one of the above, or if you have strapping table information, select “Strap Table.”

Enter Tank Dimensions

HART Comm	1, 4, 3

If a standard tank shape was chosen, enter the diameter and length (or height) for the tank.

Enter Strapping Table Information

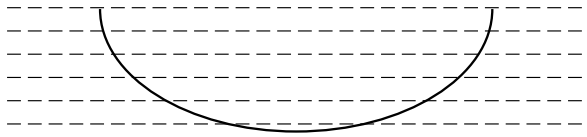
If tank type is strapping table.

HART Comm	1, 4, 3, 4

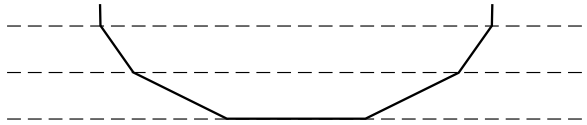
First tell the gauge how many entries you will have; the more entries you have, the better the gauge will be able to calculate the volume. The maximum number of strapping points you can enter is 10.

Next, input the actual level and volume points, starting at the bottom of the tank. It may be desirable to use most of the points in the areas of the tank that are the least “straight.” See Figure 4-22. Suggestion: Set first entry at zero level and zero volume to enable the gauge to track volume over the entire range.

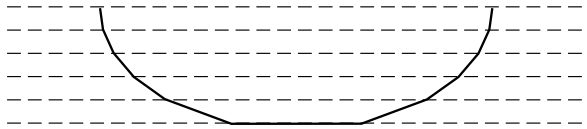
Figure 4-22. Tank Bottom Strapping Points



Actual tank bottom may look like this.



Using only 3 strapping points results in a level-to-volume profile that is more angular than the actual shape.



Using 6 of the points at the bottom of the tank yields a level-to-volume profile that is similar to the actual tank bottom.

LEVEL-APEX_05A

STANDARD VOLUME (APEX RADAR GAUGE ONLY)

If standard volume is desired, an RTD must be installed and wired to the APEX Radar Gauge (see Section 3: Before You Begin). First, configure the gauge for actual volume as outlined in the previous section and configure standard volume as the secondary variable.

Enable RTD Input

HART Comm	1, 3, 5

Enables the radar gauge to use the RTD input.

Enter Volume Coefficients

HART Comm	1, 4, 3, 4

Volume coefficients (K-Constants) are used to determine how temperature changes affect volume measurements. If you do not know K-Constants for your process and would like to measure standard volume, contact Rosemount Customer Central at 1-800-999-9307 for further assistance.

Section 5

Maintenance and Troubleshooting

INTRODUCTION

This section provides information on preventive maintenance and diagnostic and alarm messages displayed by the APEX and APEX Sentry Radar Gauges and the HART Communicator.

SAFETY MESSAGES

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠WARNING

Explosions could result in death or serious injury:

- Verify that the operating environment of the gauge is consistent with the appropriate hazardous locations certifications.
- Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- Do not remove the gauge cover in explosive atmospheres when the circuit is alive.

Failure to follow safe installation and servicing guidelines could result in death or serious injury:

- Make sure only qualified personnel perform these procedures.
- Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.
- Do not perform any service other than those contained in this manual unless you are qualified.

⚠WARNING

High voltage that may be present on leads could cause electrical shock:

- Avoid contact with leads and terminals.
- Make sure the main power to the APEX Radar Gauge is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

As a matter of routine, shut off the APEX Radar Gauge and all other equipment in the tank before you enter the tank.

⚠CAUTION

People who handle products exposed to a hazardous substance can avoid injury if they are informed and understand the hazard.

Return of Materials: If the product being returned was exposed to a hazardous substance as defined by OSHA, a copy of the required Material Safety Data Sheet (MSDS) for each hazardous substance identified must be included with the returned products.

PREVENTIVE MAINTENANCE

The APEX and APEX Sentry Radar Gauges have built-in diagnostics and self-tests that generate alarms if certain failures occur. In addition, there are a few basic things you may want to check periodically to prevent problems from occurring.

Use only the procedures and new parts specifically referenced in this manual to ensure specification performance and certification compliance. Unauthorized procedures or parts may affect product performance and the output signal used to control a process.

Product Buildup

If you have a process that produces condensate or is prone to coating, check the radar antenna for product buildup. If buildup appears on the inside or outside of the antenna, clean it with a solvent that will not damage the SST antenna material, flange, or PTFE/ceramic waveguide.

Performance

Check the level output from the radar gauge by comparing the gauge output with a hand dip or other means that is suitable for a level comparison.

Check the 4–20 mA output with a milliampere meter or read the signal on a current indicator. You can do this type of test by performing a loop test using the HART Communicator. Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Set the 4–20 mA current to 4 mA and measure or display the signal on the mA meter or indicator. Check the 20 mA in the same manner.

Check the ac or dc power supply that supplies operating power to the gauge to make certain it is still operating within specifications. If a separate dc power supply is used for the 4–20 mA output, check the dc power supply to make certain it is still operating within its specifications. Avoid contact with leads and terminals.

ALARM AND DIAGNOSTIC MESSAGES

Table 5-1 is a list of alarm and diagnostic messages that may be displayed on the Integral Display (if installed) or on the Model 275 HART Communicator.

Some of the messages involve the digital signal processor (DSP), which is one of the microprocessor boards. It simply indicates that this board originated the message. Also, you will see “APEX TOOLS” mentioned in the “Action” column of the table. This is a program used by service personnel to which customers do not need access.

Refer to “Safety Messages” on page 5-1 and for more information.

If any of these problems persist after performing the suggested action, contact Rosemount Customer Central at 1-800-999-9307.

If you encounter any of these messages immediately after start up, wait 30 seconds to allow the gauge to "lock on" to a signal. If, after 30 seconds, these messages are still displayed, follow the course of action listed below.

TABLE 5-1. Alarm and Diagnostic Messages

Displayed Message	Cause	Action
dspNotResponding	The DSP is not responding to a request to return the distance.	Verify that the gauge is getting enough power. See page 6-2 for power requirements Verify that the APEX gauge is properly installed; the target (product) must be within 98 ft (30 m) of the flange but no closer than 19.6 in. (0.5 m). Cycle power or use a Model 275, AMS, or APEX TOOLS to reset. See master reset on page A-3.
dspOutOfLimits	One of three conditions could cause this message: Level is returned as "Not a Number" (usually resulting from a "dspNotResponding" condition). Level is less than the lower null zone. Level is greater than (Reference Gauge Height – upper null zone).	This message most frequently appears during start-up; wait 30 seconds and if the message persists, follow steps 2 and 3. Verify that the Reference Gauge Height and null zones are set correctly. Check the Reference Gauge Height first because setting the Reference Gauge Height will cause the lower null zone to reset to its default value.
dspReportsError	The DSP has set one of its 32 error flags.	If other messages are present, follow recommended action(s) for those messages; verify configuration. Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3.
dspReportWarning	The DSP has set one of its 32 warning flags.	If other messages are present, follow recommended action(s) for those messages. Some warnings, especially #5, may appear for a few seconds when the APEX gauge is being configured. If it persists, verify configuration. Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3.
DSP Startup in Progress or DSP Error #6	Advisory	No action necessary; gauge is starting up.
DSP EEPROM failure or DSP Error #14	Electronics Failure	Call Rosemount Customer Central. The unit will most likely need advanced troubleshooting in the field or will need to be returned to the factory for repair.
eepromFactAreaFailure	Part of the EEPROM can be configured only at the factory. The checksum for this portion of the EEPROM does not match the contents.	Call Rosemount Customer Central for further assistance.
eepromUserChecks or eepromUserAreaFailure	Part of the EEPROM can be configured by the user, normally using a 275 or APEX TOOLS. The checksum for this portion of the EEPROM does not match the contents.	Use a 275 or APEX TOOLS to change some portion of the user EEPROM. (For example, change the message tag, descriptor, or date.) This causes the checksum to be updated. Verify 4-20 mA Settings, null zone configurations, Reference Gauge Height, empty tank detection zone, etc. Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3.
Factory Alg Param Invalid or DSP Warning #26	Configuration Warning	Verify 4-20 mA Settings, null zone configurations, Reference Gauge Height, empty tank detection zone, etc. If error persists, call Rosemount Customer Central.

TABLE 5-1. Alarm and Diagnostic Messages

Displayed Message	Cause	Action
High Signal Strength or Warning: Signal too strong or DSP Warning #0	Process Condition: Return signal is stronger than expected. The radar gauge is either too close to the product or there is a failure in the gauge. or The radar gauge is in a stilling well.	The product is too close to the gauge, the nozzle is obstructed, or there is a failure in the gauge. If the message persists throughout the measurement range and the beam is unobstructed, the gauge has failed. Call Rosemount Customer Central to arrange a return.
Incorrect Alg Lib Vers or DSP Error #25	Internal Software Error	Call Rosemount Customer Central. The unit will most likely need to be sent in for repair.
intTempOutOfRang or Internal PRT out of range	The APEX gauge internal temperature appears to be less than –40 °F (–40 °C) or greater than 185 °F (85 °C).	Take appropriate measures to ensure that the housing remains within the specified temperature limits. See Section 6: Specifications and Reference Data.
invalidConfigur	A background task that validates the APEX gauge configuration has found one or more discrepancies. This flag is also set if certain key items (polling address, LCD language, dynamic variable assignments, sample time) must be reset to reasonable values at start-up.	Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3. Verify configuration after Master Reset; verify 4-20 mA settings, null zone configurations, Reference Gauge Height, empty tank detection zone, etc.
Invalid DSP Command or DSP Error #26	Internal Software Error	Call Rosemount Customer Central. The unit will most likely need to be sent in for repair.
INVALID TEST CMD PARAM or DSP Warning #27	Configuration Warning	Verify 4-20 mA settings, null zone configurations, Reference Gauge Height, empty tank detection zone, etc. If error persists, call Rosemount Customer Central.
Low Signal Strength or DSP Warning #1 or DSP Error #5	Electronics Failure: Inadequate signal strength returning to gauge.	Cycle power or use a Model 275, AMS, or APEX Tools to reset. If error does not clear, call Rosemount Customer Central for additional troubleshooting. Unit may need repair.
lowTermVoltage	The power supply for the HART communications loop has dropped below 5 V; current will be fixed at 1 mA.	Provide a proper power supply for HART communications (10.5 - 55 vdc).
ramFailure	Write/read tests of RAM failed.	Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3.
romChecksum or romChecksumFailure	The checksum for the ROM code does not match the contents.	Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3.
rtdOutOfLimits or RTD out of sensor limits	RTD is missing, wired incorrectly, or returning invalid data.	If no RTD should be present, use a 275 or APEX TOOLS to disable the RTD. Otherwise, verify that the RTD is wired and working correctly.
softwareError	A stack overflow occurred in the transmitter.	Cycle power or use a 275 or APEX TOOLS to reset. See master reset on page A-3.
Target in null zone or DSP Warning #5	Process Condition: Target has moved into a null zone	Verify that null zones are configured correctly for your tank. (This message will only display for about one minute; the gauge will start to ignore the signal after that). Null zones may need to be adjusted; see page 3-11. After adjustment, Cycle Power or use a Model 275, AMS, or APEX TOOLS to reset. See master reset on page A-3. This will reset the alarm condition.

TABLE 5-1. Alarm and Diagnostic Messages

Displayed Message	Cause	Action
Target lost **or** **Error: lost signal** **or** **DSP Error #7**	Configuration or Process Error: APEX cannot find a target in the tank.	Verify that the unit is configured correctly and that the beam has a clear shot to the target.
Empty tank **or** **DSP Warning #7** **or** **Warning: Empty Tank** **or** **Empty Tank** **mode Active**	Process Condition: Target has moved into the empty tank detection zone, and the signal has been lost.	Is the tank empty? If so, the gauge is operating correctly; if not, reconfigure the empty tank detection zone (see page 3-11).
User Alg Param **invalid** **or** **USR ALG PAR OUT OF RNG** **or** **DSP Warning #25**	Configuration Warning: User entered parameter does not fit within suggested guidelines.	Verify 4–20 mA settings, null zone configurations, Reference Gauge Height, empty tank detection zone, etc. If error persists, call Rosemount Customer Central for further guidance.
VCO Cal **Failure #X** **or** **DSP Error #16, 17, 22, or 31**	Electronics Failure	Note failure number (#), and call Rosemount Customer Central. The unit will most likely need to be sent in for repair.
VCO Calibration **Retry** **or** **DSP Warning #18**	Internal Software Warning: This message will either go away in several seconds to be replaced by another or the unit will fail.	Cycle power; if the message does not disappear within 30 seconds, the unit has failed; call Rosemount Customer Central to arrange for repair.
volumeInputError	The level from which the volume would be computed is beyond the physical dimensions of the tank (one or more of the following): The level is less than zero. For a sphere or horizontal tank, the level is greater than twice the radius. For an upright tank, the level is greater than the height of the tank. If a strapping table is being used, an invalid number of strapping points has been defined (fewer than 2 or more than 10).	If no strapping table is being used, verify that the tank type, height, and width have been entered correctly. If a strapping table is being used, verify the following: Tank type = strapping table. Number of strapping table entries $\geq$ 2 and $\leq$ 10). All strapping entries are in ascending order. Any level to be measured is within the range of the strapping table entries.
DSP EEPROM failure **or** **DSP Error #14**	Electronics Failure	If error does not clear after power is cycled, call Rosemount Customer Central for further troubleshooting. The gauge may require service in the field.
DSP Error #3 **or** **DSP Error #4**	Hardware Failure	Cycle power; if the error does not clear, the gauge will need to be sent in for repair.
VCO Cal Failure #27 or 28 **or** **DSP Error #27 or 28**	Electronics Failure	Cycle power; if the message does not clear within three minutes, the gauge will need to be returned or serviced in the field.
VCO Cal Failure #18 or 19 **or** **DSP Error #18 or 19**	Electronics Failure	Cycle power; if the error is followed by other errors, follow instructions listed for those errors. If the error does not clear in five minutes, it will need to be returned to the factory for repair.
DSP Error #9 or 10	Electronics Failure	Cycle power; if error does not clear in a few minutes, the gauge will need to be repaired.
DSP Warning #19	Software Error	Cycle power; if error does not clear, call Rosemount Customer Central

TABLE 5-1. Alarm and Diagnostic Messages

Displayed Message	Cause	Action
DSP Warning #20	Advisory	The error will either clear in a few minutes or be accompanied by another error.
DSP Warning #9	Hardware Warning	This is probably an informational warning. If this message is not accompanied by any other messages, and the gauge seems to be functioning properly, this message can be ignored. If, however, it is accompanied by any other warnings, refer to these warnings.
****If you get an error message that is not listed here, it was not in use at this printing. Call Rosemount Customer Central (1-800-999-9307) for guidance.**		

HART COMMUNICATOR SOFTWARE DIAGNOSTICS

When using the HART Communicator to communicate with the APEX and APEX Sentry Radar Gauges, you may encounter software diagnostic messages. These messages may indicate problems with the equipment or mistakes made in entering data, while others act as reminders to you.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Appendix A: HART Communicator describes some of the messages displayed by the HART Communicator, generally explains why they occur, and provides instructions for responding to each message.

REMOVING THE GAUGE HOUSING FROM THE FLANGE

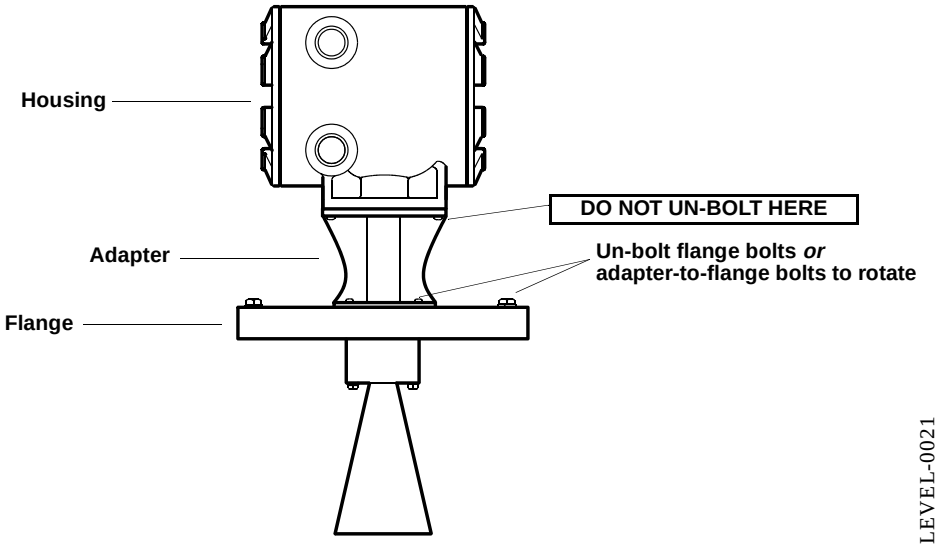
If rigid conduit is used, first remove the conduit from the gauge. If you have been instructed by a Rosemount representative to remove the gauge housing from the flange, without breaking the process seal, remove the four ¼–28 UNF–2A bolts at the base of the housing adapter (Figure 5-1). Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

NOTE

If the electronics housing needs to be rotated, **do not un-bolt the adapter-to-housing bolts!** Either un-bolt the flange bolts or the adapter-to-flange bolts and rotate as needed. If the housing is rotated at the housing-to-adapter connection, the gauge will be irreparably damaged, and the warranty will be invalidated.

Refer to "Safety Messages" on page 5-1 and for more information.

Figure 5-1. Removing the gauge housing from the flange



NOTE
To avoid damage to the APEX Radar Gauge, do not remove or handle the electronic components.

RETURN OF MATERIALS

If you have reason to believe that your APEX or APEX Sentry Radar Gauge may need to be returned for service, please contact a Level Applications Support Specialist at Rosemount Customer Central (1-800-999-9307). They will help you determine the best course of action, and may transfer you to either an Order Administrator or to the Rosemount North American Response Center (NARC) to arrange the return of your gauge for service or repair.

NOTE
Most radar problems encountered in the field are applications-related, and can best be dealt with while the gauge is installed.

The representative arranging the return will ask for product model and serial numbers, and will provide a Return Material Authorization (RMA) number. The center will also ask for the name of the process material to which the product was last exposed. If the the material to which the product was last exposed is a hazardous substance as defined by OSHA, a copy of the required Material Safety Data Sheet (MSDS) for each hazardous substance identified must be included with the returned products.

The representative arranging your return will detail the additional information and procedures necessary to return products exposed to hazardous substances.

Section 6

Specifications and Reference Data

SPECIFICATIONS

Equipment Description

APEX only

- Measures the level of liquids, slurries, or sludges that may have a variety of severe process conditions

APEX Sentry only

- Measures the level of liquids under less severe conditions

APEX and APEX Sentry

- Microprocessor-based radar level gauge with analog output, superimposed with a digital HART signal
- Small, lightweight, non-contact design that allows for installation on the top of most pressurized or nonpressurized tanks
- Uses Frequency Modulated Continuous Wave (FMCW) radar signaling technology at 24 GHz frequency

Performance

APEX only

- Accuracy: ±0.2 in. (5mm) for distances from 1.6 to 32.8 ft (0,5 to 10 m) or ±0.05% of measured distance from 32.8 to 98.4 ft (10 to 30 m)
- Measuring range: within accuracy specifications 1.6 to 98.4 ft (0,5 to 30 m) measured from the flange face
- Repeatability: ±.04 in. (1 mm)
- Resolution: ±0.02 in. (0,4 mm)
- Update time: at least once every second

APEX Sentry only

- Accuracy: ±0.4 in. (10 mm) for distances from 1.6 to 32.8 ft (0,5 to 10 m) or ±0.1% of measured distance from 32.8 to 65.6 ft (10 to 20 m)
- Measuring range: within accuracy specifications 1.6 to 65.6 ft (0,5 to 20 m) measured from the flange face
- Repeatability: ±0.1 in. (3 mm)
- Resolution: 0.04 in. (1 mm)
- Update time: at least once every 3 seconds

APEX and APEX Sentry

- Gauge meets the following minimum performance criteria, which are stated at Reference Conditions: free-space reflection from flat metal surface, ambient temperature 77 °F (25 °C), and atmospheric pressure conditions:

Environmental Conditions

APEX and APEX Sentry

- Humidity: 5 to 100% relative humidity (with covers on / tightened to achieve metal-to-metal contact)
- Electronics/Housing temperature ranges:
  Standard: –40 to 158 °F (–40 to 70 °C)
  With Integral Display: –4 to 131 °F (–20 to 55 °C)
- Enclosure rating: NEMA 4X, CSA Type 4X, IP 66
- To meet telecommunications requirements, the APEX and APEX Sentry Radar Gauges must be installed on enclosed or vented metal tanks. Other tank types may be approved in country of final destination.

Process Conditions

APEX and APEX Sentry

- Suitable for liquids, slurries, or sludges
- Nozzle Temperature Range: –40 to 374 °F (–40 to 190 °C)
- Process Pressure Range: full vacuum to 155 psi (10,69 bar)

Electrical

APEX only

- Connections for secondary inputs and loop testing available

APEX and APEX Sentry

- Gauge entry is ¾–14 NPT female conduit fittings
- Gauge is factory sealed; conduit seal not required to meet FM explosion-proof requirements
- Terminal block provides connections for ac or dc power and grounding
- Transient protection: APEX and APEX Sentry Radar Gauges comply with IEC standard 61000 4-5

Power Supply

APEX and APEX Sentry

- 90 to 250 V ac ±10%, 50/60 Hz or 18 to 36 V dc, 10.5 Watts

Input

APEX
(with non-intrinsically safe output only)

- Accepts one RTD signal (optional), as defined below:
  Input: Pt 100 3- or 4-wire RTD
  Range: -40 to 400 °F (-4 to 204 °C)
  Accuracy: ± 1.8 °F (± 1 °C)

APEX Sentry
(and APEX with intrinsically safe option code 2)

- No RTD input available

Output

APEX and APEX Sentry

- 4-20 mA analog signal (10.5 to 55.0 V dc powered), superimposed with a digital HART signal
- Default analog settings: minimum is 3.9 mA; maximum is 20.8 mA
- Available with optional intrinsically safe 4–20 mA output
- Installation (overvoltage) catagory II.

Calibration

APEX and APEX Sentry

- Continuous frequency self-calibration ensures stated level accuracy.

Software Functionality

APEX and APEX Sentry

- Gauge is capable of digital communication over the 4–20 mA output loop without disruption using the HART communications protocol.
- All configuration data and programs are retained in non-volatile memory. Upon power interruption, all data is available when power is restored.

Size

	Antenna	Flange Size	Flange Rating	Dimensions Height	Width	Depth
Example 1(1)	2-in.	2-in.	ASME B16.5 (ANSI) Class 150	14 in (356 mm)	8 in (203 mm)	8 in (203 mm)
Example 2(1)	3-in.	3-in.	ASME B16.5 (ANSI) Class 150	16.5 in (419 mm)	8 in (203 mm)	8 in (203 mm)
Example 3(1)	4-in.	4-in.	ASME B16.5 (ANSI) Class 150	18.5 in (470 mm)	9 in (229 mm)	9 in (229 mm)

(1) Other flange sizes and ratings available. Dimensions vary.

Weight

APEX and APEX Sentry

- Less than 19 lb (9 kg) with an ASME B.16 (ANSI) 2-in. Class 150 (DN 50, PN 16) flange
- Less than 23 lb (10 kg) with an ASME B.16 (ANSI) 3-in. Class 150 (DN 80, PN 16) flange
- Less than 30 lb (14 kg) with an ASME B.16 (ANSI) 4-in. Class 150 (DN 100, PN 16) flange

Materials of Construction

APEX and APEX Sentry

- Electronics housing: aluminum alloy
- Finish: polyester-epoxy paint
- Antenna/flange assembly: 316L stainless steel
- Waveguide process barrier: alumina, PTFE

Mounting

APEX and APEX Sentry

STANDARD	SIZE	RATING
ASME B.16 (ANSI)	2-in., 3-in., 4-in., 6-in.	Class 150, 300
DIN	DN 50, 80, 100, 150	PN 16, 40 (PN 16 not available with 0N50)

Hazardous Locations Certifications

APEX and APEX Sentry

Factory Mutual (FM) Approval

- **E5 With Output Option Code 1:** Explosion-proof for Class I, Div. 1, Groups C and D; Dust- Ignition proof for Class II, Div. 1, Groups E, F, and G; Dust-Ignition proof for Class III, Div. 1 Hazardous Locations; Non-Incendive for Class I Div. 2 Groups A, B, C, and D.
  Temperature Code T4A. (T_{amb} = –40 to 70°C) Factory Sealed.
- **E5 With Output Option Code 2**: Explosion Proof for Class I, Division 1, Groups C and D; Dust-ignition proof for Class II/III, Division 1, Groups E, F, and G; Non-incendive for Class I, Division 2, Groups A, B, C, and D, with Intrinsically Safe output for Class I, Division 1 Groups A, B, C, and D hazardous locations when installed in accordance with Rosemount Drawing 03700-2006
  Temperature Code T4A (T_{amb} = -40° to 70 °C). Factory Sealed

Canadian Standards Association (CSA) Approval

- **E6 With Output Option Code 1:** Explosion Proof for Class I, Division 1, Groups C and D; Dust-ignition Proof for Class II/III, Division 1, Groups E, F, and G; Suitable for Class I, Division 2, Groups A, B, C, and D hazardous locations, Temperature Code T4A (T_{amb} = 70°C). Factory Sealed
- **E6 With Output Option Code 2**: Explosion Proof for Class I, Division 1, Groups C and D; Dust-ignition proof for class II/III, Division 1, Groups E, F, and G; Suitable for Class I, Division 2, Groups A, B, C, and D, with Intrinsically Safe output for Class I, Division 1 Groups A, B, C, and D hazardous locations when installed in accordance with Rosemount Drawing 03700-2007
  Temperature Code T4A (T_{Amb} = -40° to 70 °C). Factory Sealed

KEMA/CENELEC ATEX Flameproof Certification Equipment Group II, Category 1/2 G (Category 1, formerly known as Zone O) (Ref. European Standard EN 50284)

- **ED With Output Option Code 1:** With Display: EEx d IIB+H2 T4 (T_{amb} = 55°C).
  Without Display: EEx d IIB+H2 T4 (T_{amb} = 70°C)
- **ED With Output Option Code 2**: With Display: EEx d [ia] IIB+H2 T4 (T_{amb} = 55 °C)
  Without Display: EEx d [ia] IIB+H2 T4 (T_{amb} = 70 °C)
- Other approvals pending for explosion-proof certifications

Options

APEX and APEX Sentry

- Model 751 Field Signal Indicator
- HART Communicator
- Guaranteed start-up at -50 °C
- NAMUR-specified analog alarm limits
- Material Traceability Certifications

APEX only

- Digital integral display and operator interface
- RTD temperature sensor, assemblies, and accessories
- The APEX can also be used in conjunction with a Model 3201 HIU as part of a hybrid system
- ±3mm level accuracy at reference conditions up to 49 ft (15m)

APEX Sentry only

- Digital integral display

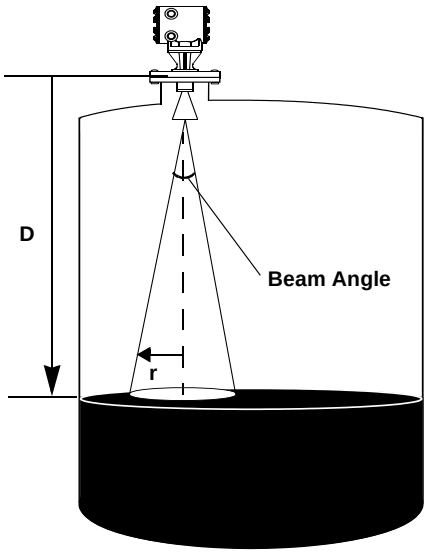
Figure 6-1. Antenna Selection Guidelines

Selecting an antenna size can be as simple as matching the available process opening to the antenna size. However, when selecting an antenna, consider the following:

- A larger antenna will yield the strongest, most concentrated signal. Fluids with low dielectric constants, such as many hydrocarbons and solvents, only reflect a small portion of the radar signal. A more focused beam that is provided by a larger antenna will yield a stronger signal. This is especially important as the distance to the fluid surface increases.
- Ideally, the beam should not be obstructed by the sides of the vessel or any other equipment in the tank. Consult the beamwidth table to determine the size of the beam at its maximum expected distance (lowest tank level). Since beamwidth decreases as the antenna size increases, the beam from a larger antenna is least likely to encounter obstructions.
- In stilling wells and bypass assemblies, the pipe will prevent dispersion of the beam and will yield a very concentrated signal. In those situations, a smaller antenna is suitable.
- In general, 3-in. and 4-in. antennas can be used in nozzles that have an unobstructed total length of up to 1 m (39 in.). It is recommended that 2-in. antennas be used only in nozzles where the total length is less than 0.35 m (14 in.). Consult the factory for assistance with exceptions.

Beamwidth vs. Distance from Gauge

Distance (D) from Gauge	Radius (r) from Flange Centerline to Beamwidth Edge		
	2-in. Antenna	3-in. Antenna	4-in. Antenna
ft (m)	ft (m)	ft (m)	ft (m)
2 (0,6)	0.4 (0,12)	0.2 (0,07)	0.2 (0,06)
4 (1,2)	0.8 (0,25)	0.5 (0,15)	0.4 (0,11)
6 (1,8)	1.2 (0,37)	0.7 (0,22)	0.6 (0,17)
8 (2,4)	1.6 (0,49)	1.0 (0,29)	0.7 (0,22)
10 (3,0)	2.0 (0,62)	1.2 (0,37)	0.9 (0,28)
15 (4,6)	3.0 (0,93)	1.8 (0,55)	1.4 (0,42)
20 (6,1)	4.1 (1,23)	2.4 (0,73)	1.8 (0,56)
25 (7,6)	5.1 (1,54)	3.0 (0,92)	2.3 (0,70)
30 (9,1)	6.1 (1,85)	3.6 (1,10)	2.8 (0,84)
35 (10,7)	7.1 (2,16)	4.2 (1,28)	3.2 (0,98)
40 (12,2)	8.1 (2,47)	4.8 (1,46)	3.7 (1,12)
45 (13,7)	9.1 (2,78)	5.4 (1,65)	4.1 (1,26)
50 (15,2)	10.1 (3,09)	6.0 (1,83)	4.6 (1,40)
55 (16,8)	11.1 (3,40)	6.6 (2,01)	5.1 (1,54)
60 (18,3)	12.2 (3,70)	7.2 (2,20)	5.5 (1,68)
65 (19,8)	13.2 (4,01)	7.8 (2,38)	6.0 (1,82)
70 (21,3)	14.2 (4,32)	8.4 (2,56)	6.4 (1,96)
75 (22,9)	15.2 (4,63)	9.0 (2,75)	6.9 (2,10)
80 (24,4)	16.2 (4,94)	9.6 (2,93)	7.4 (2,24)
85 (25,9)	17.2 (5,25)	10.2 (3,11)	7.8 (2,38)
90 (27,4)	18.2 (5,56)	10.8 (3,30)	8.3 (2,52)
95 (29,0)	19.2 (5,86)	11.4 (3,48)	8.7 (2,66)
100 (30,5)	20.3 (6,17)	12.0 (3,66)	9.2 (2,80)

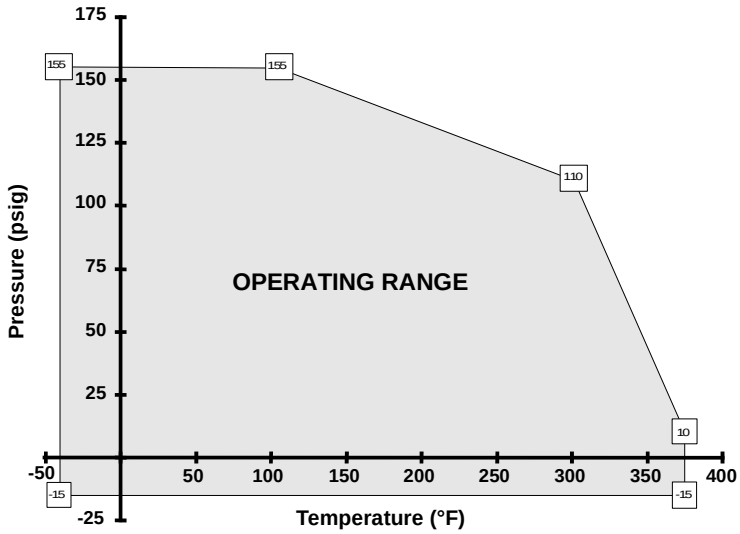


LEVEL-0038A

Antenna Size	Beam Angle
2-in.	22.9°
3-in.	13.7°
4-in.	10.5°

Example: the beam radius (r) at the bottom of a 10-foot (3,05 m) (D) vessel would be 0.9 ft (0,28 m) for a 4-inch antenna.

Temperature and Pressure Operating Range		
Nozzle Temperature	**Maximum Pressure**	**Pressure vs. Temperature**
–40°F to 104°F (–40°C to 40°C)	Up to 155 psig (up to 10,69 bar)	
302°F (150°C)	Up to 110 psig (up to 7,59 bar)	
374°F (190°C)	Up to 10 psig (up to 0,69 bar)	



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PTFE Window Temperature and Pressure Operating Range		
Nozzle Temperature	**Maximum Pressure**	**Pressure vs. Temperature**
–4°F (–20°C)	Up to 120 psig (up to 8,2 bar)	
104°F (40°C)	Up to 90 psig (up to 6,2 bar)	
212 to 302°F (100 to 150°C)	Up to 10 psig (up to 0,69 bar)	

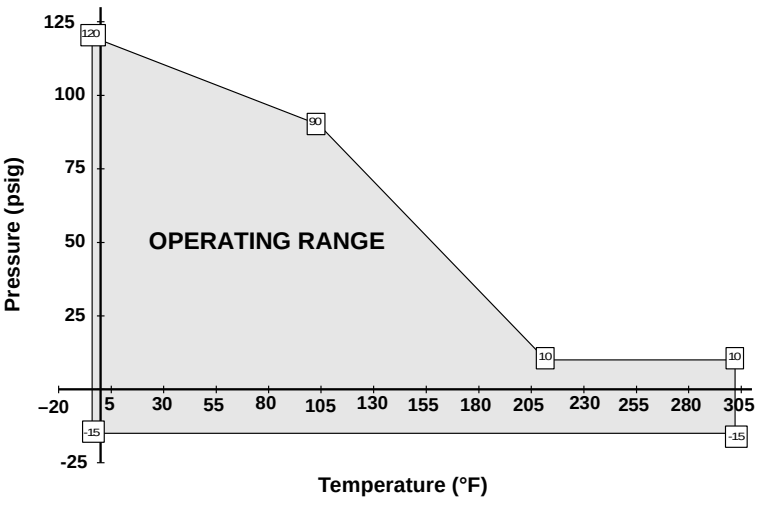

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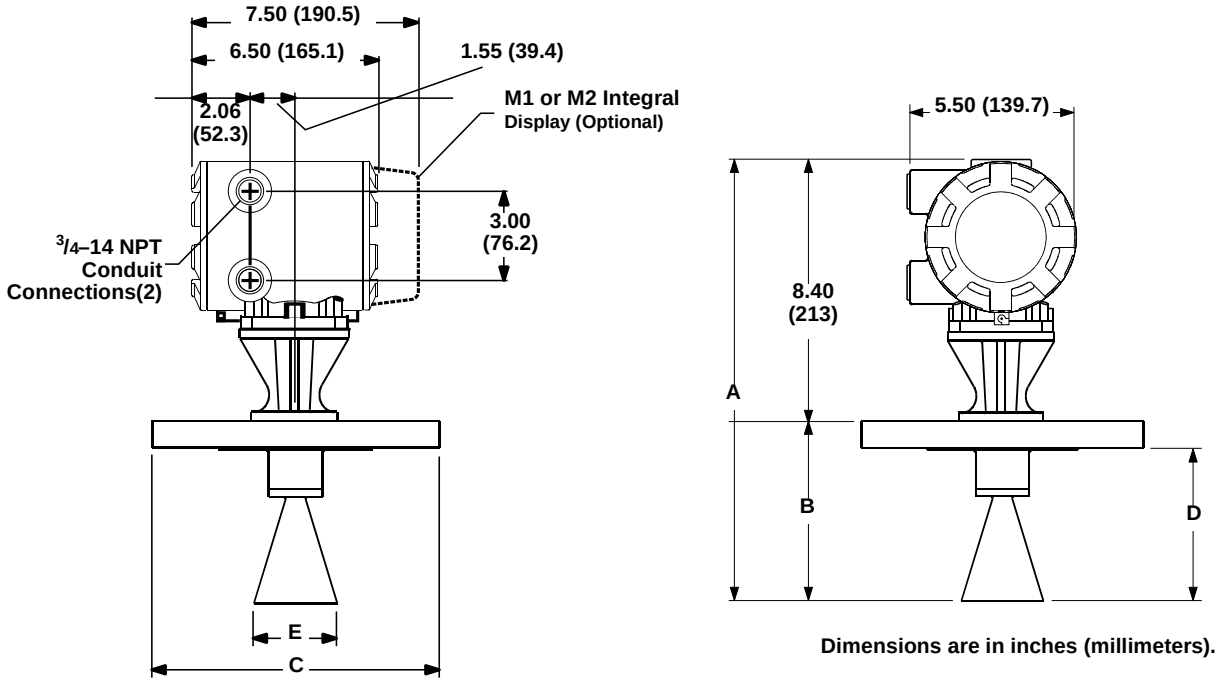
Figure 6-2. Dimensional Drawings

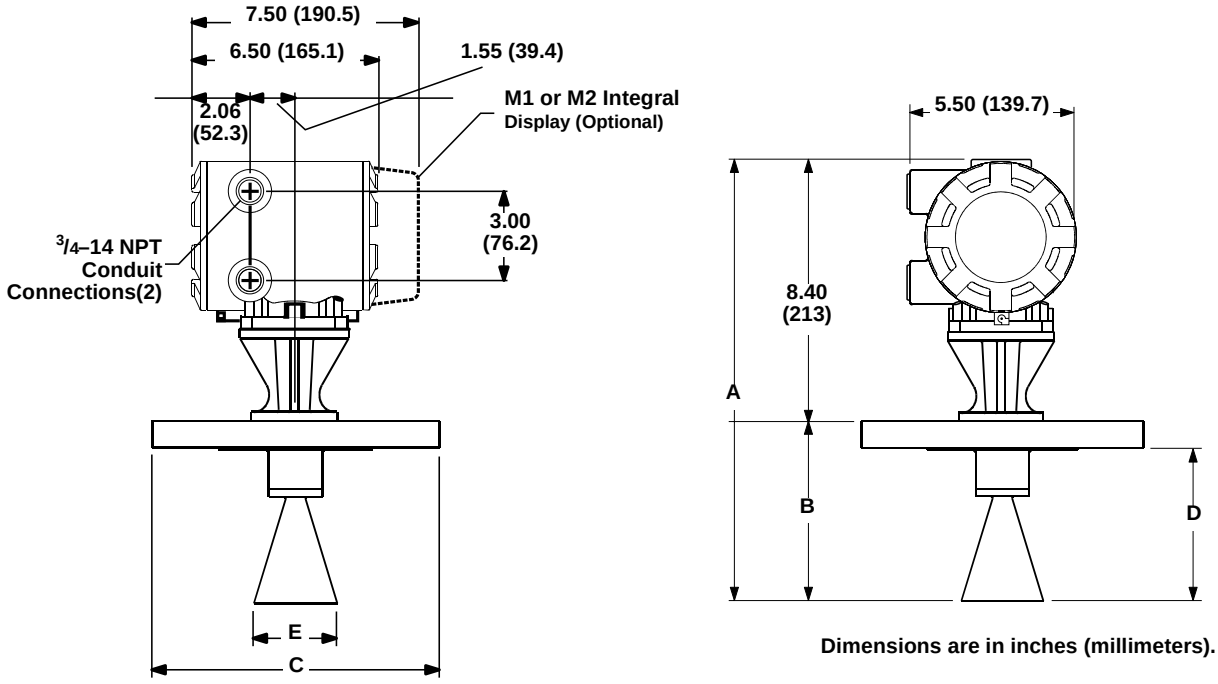


LEVEL-1501A01A, 1501B01A

Flange Size	Antenna Size	Dimensions are in inches (millimeters) A	B	C	D	E
2-inch ASME B.16 (ANSI) Class 150	2-inch	13.75 (349)	5.35 (136)	6.00 (152)	4.66 (118)	1.75 (44)
2-inch ASME B.16 (ANSI) Class 300	2-inch	13.75 (349)	5.35 (136)	6.50 (165)	4.53 (115)	1.75 (44)
3-inch ASME B.16 (ANSI) Class 150	2-inch	13.75 (349)	5.35 (136)	7.50 (191)	4.47 (114)	1.75 (44)
3-inch ASME B.16 (ANSI) Class 300	2-inch	13.75 (349)	5.35 (136)	8.25 (210)	4.29 (109)	1.75 (44)
3-inch ASME B.16 (ANSI) Class 150	3-inch (original)*	14.35 (364)	5.96 (151)	7.50 (191)	5.08 (129)	2.71 (69)
3-inch ASME B.16 (ANSI) Class 300	3-inch (original)*	14.35 (364)	5.96 (151)	8.25 (210)	4.90 (124)	2.71 (69)
3-inch ASME B.16 (ANSI) Class 150	3-inch (new)*	16.38 (416)	7.98 (203)	7.50 (191)	7.10 (180)	2.69 (68)
3-inch ASME B.16 (ANSI) Class 300	3-inch (new)*	16.38 (416)	7.98 (203)	8.25 (210)	6.92 (176)	2.69 (68)
4-inch ASME B.16 (ANSI) Class 150	2-inch	13.75 (349)	5.35 (136)	9.00 (229)	4.47 (114)	1.75 (44)
4-inch ASME B.16 (ANSI) Class 300	2-inch	13.75 (349)	5.35 (136)	10.00 (254)	4.16 (106)	1.75 (44)
4-inch ASME B.16 (ANSI) Class 150	3-inch (original)*	14.35 (364)	5.96 (151)	9.00 (229)	5.08 (129)	2.71 (69)
4-inch ASME B.16 (ANSI) Class 300	3-inch (original)*	14.35 (364)	5.96 (151)	10.00 (254)	4.77 (121)	2.71 (69)
4-inch ASME B.16 (ANSI) Class 150	3-inch (new)*	16.38 (416)	7.98 (203)	9.00 (229)	7.10 (180)	2.69 (68)
4-inch ASME B.16 (ANSI) Class 300	3-inch (new)*	16.38 (416)	7.98 (203)	10.00 (254)	6.79 (172)	2.69 (68)
4-inch ASME B.16 (ANSI) Class 150	4-inch	18.37 (467)	9.97 (253)	9.00 (229)	9.09 (231)	3.50 (89)
4-inch ASME B.16 (ANSI) Class 300	4-inch	18.37 (467)	9.97 (253)	10.00 (254)	8.78 (223)	3.50 (89)

*** Gauges with 3-inch antennas and serial number 3925 or higher have the 3-inch antenna length labelled "new."**

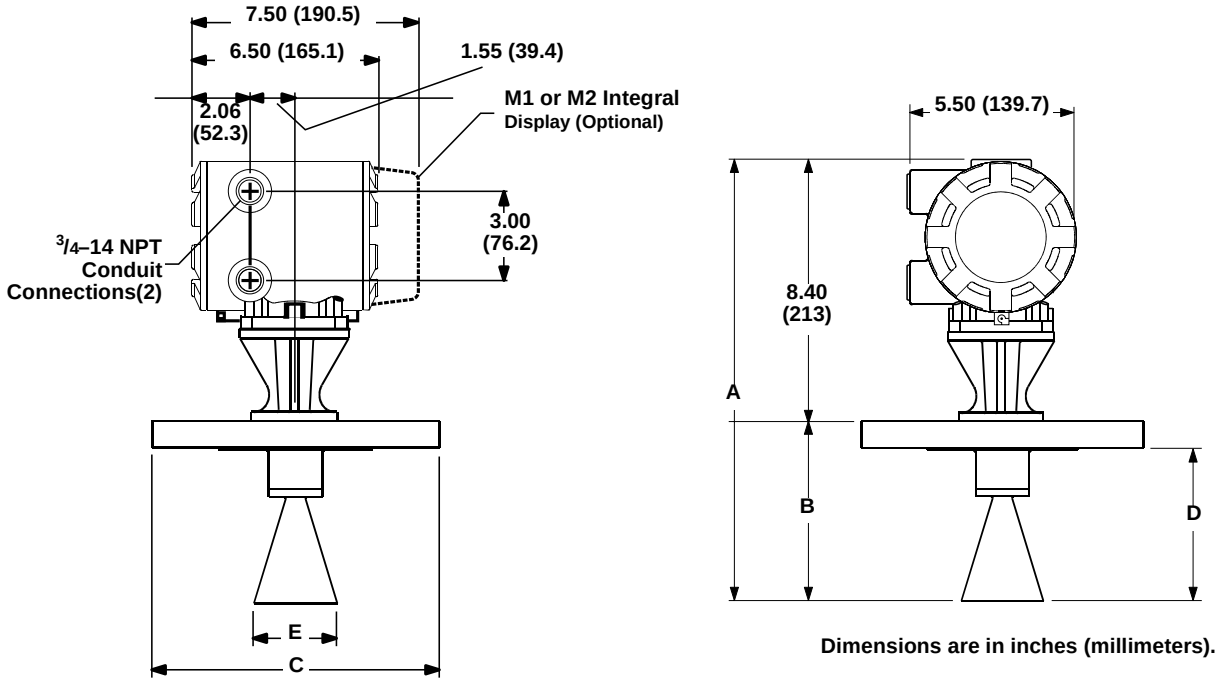
Figure 6-3. Dimensional Drawings (repeated figure)



Flange Size	Antenna Size	Dimensions in inches (millimeters)				
		A	B	C	D	E
6-inch ASME B.16 (ANSI) Class 150	2-inch	13.75 (349)	5.35 (136)	11.00 (279)	4.41 (112)	1.75 (44)
6-inch ASME B.16 (ANSI) Class 300	2-inch	13.75 (349)	5.35 (136)	12.50 (318)	3.97 (101)	1.75 (44)
6-inch ASME B.16 (ANSI) Class 150	3-inch (original)*	14.35 (364)	5.96 (151)	11.00 (279)	5.02 128)	2.71 (69)
6-inch ASME B.16 (ANSI) Class 300	3-inch (original)*	14.35 (364)	5.96 (151)	12.50 (318)	4.58 (116)	2.71 (69)
6-inch ASME B.16 (ANSI) Class 150	3-inch (new)*	16.38 (416)	7.98 (203)	11.00 (279)	7.04 (179)	2.69 (68)
6-inch ASME B.16 (ANSI) Class 300	3-inch (new)*	16.38 (416)	7.98 (203)	12.50 (318)	6.60 (168)	2.69 (68)
6-inch ASME B.16 (ANSI) Class 150	4-inch	18.37 (467)	9.97 (253)	11.00 (279)	9.03 (229)	3.50 (89)
6-inch ASME B.16 (ANSI) Class 300	4-inch	18.37 (467)	9.97 (253)	12.50 (318)	8.59 (218)	3.50 (89)
DN 50, PN 40	2-inch	13.75 (349)	5.35 (136)	6.50 (165)	4.68 (119)	1.75 (44)
DN 80, PN 16	2-inch	13.75 (349)	5.35 (136)	7.87 (200)	4.68 (119)	1.75 (44)
DN 80, PN 40	2-inch	13.75 (349)	5.35 (136)	7.87 (200)	4.53 (115)	1.75 (44)
DN 80, PN 16	3-inch (original)*	14.35 (364)	5.96 (151)	7.87 (200)	5.29 (134)	2.71 (69)
DN 80, PN 40	3-inch (original)*	14.35 (364)	5.96 (151)	7.87 (200)	5.14 (131)	2.71 (69)
DN 80, PN 16	3-inch (new)*	16.38 (416)	7.98 (203)	7.87 (200)	7.31 (186)	2.69 (68)
DN 80, PN 40	3-inch (new)*	16.38 (416)	7.98 (203)	7.87 (200)	7.16 (182)	2.69 (68)

*** Gauges with 3-inch antennas and serial number 3925 or higher have the 3-inch antenna length labelled “new.”**

Figure 6-4. Dimensional Drawings (repeated figure)



Flange Size	Antenna Size	Dimensions in inches (millimeters) A	B	C	D	E
DN 100, PN 16	2-inch	13.75 (349)	5.35 (136)	8.66 (220)	4.68 (119)	1.75 (44)
DN 100, PN 40	2-inch	13.75 (349)	5.35 (136)	9.25 (235)	4.53 (115)	1.75 (44)
DN 100, PN 16	3-inch (original)*	14.35 (364)	5.96 (151)	8.66 (220)	5.29 (134)	2.71 (69)
DN 100, PN 40	3-inch (original)*	14.35 (364)	5.96 (151)	9.25 (235)	5.14 (131)	2.71 (69)
DN 100, PN 16	3-inch (new)*	16.38 (416)	7.98 (203)	8.66 (220)	7.31 (186)	2.69 (68)
DN 100, PN 40	3-inch (new)*	16.38 (416)	7.98 (203)	9.25 (235)	7.16 (182)	2.69 (68)
DN 100, PN 16	4-inch	18.37 (467)	9.97 (253)	8.66 (220)	9.30 (236)	3.50 (89)
DN 100, PN 40	4-inch	18.37 (467)	9.97 (253)	9.25 (235)	9.15 (232)	3.50 (89)
DN 150 PN 16	2-inch	13.75 (349)	5.35 (136)	11.22 (285)	4.60 (117)	1.75 (44)
DN 150 PN 40	2-inch	13.75 (349)	5.35 (136)	11.81 (300)	4.37 (111)	1.75 (44)
DN 150 PN 16	3-inch (original)*	14.35 (364)	5.96 (151)	11.22 (285)	5.21 (132)	2.71 (69)
DN 150 PN 40	3-inch (original)*	14.35 (364)	5.96 (151)	11.81 (300)	4.98 (126)	2.71 (69)
DN 150 PN 16	3-inch (new)*	16.38 (416)	7.98 (203)	11.22 (285)	7.23 (184)	2.69 (68)
DN 150 PN 40	3-inch (new)*	16.38 (416)	7.98 (203)	11.81 (300)	7.00 (178)	2.69 (68)
DN 150 PN 16	4-inch	18.37 (467)	9.97 (253)	11.22 (285)	9.22 (234)	3.50 (89)
DN 150 PN 40	4-inch	18.37 (467)	9.97 (253)	11.81 (300)	8.99 (228)	3.50 (89)

*** Gauges with 3-inch antennas and serial number 3925 or higher have the 3-inch antenna length labelled "new."**

ORDERING INFORMATION

Model	Product Description	Availability
APEX	Radar Level Gauge for Tough Process Conditions	•
SENTRY	Radar Level Gauge for Less Severe Process Conditions	•
Code	**Software**	
B	Standard	•
Code	**Frequency Sweep**	
C	24 – 26 GHz	•
Code	**Outputs**	
1	4–20 mA with Digital Signal Based on *HART* Protocol	•
2	Intrinsically Safe 4–20 mA with Digital Signal Based on *HART* Protocol (Intrinsically safe output available only with hazardous location approval, Option Codes E5, E6, or ED) See Appendix C for hazardous locations drawings and examples of labels.	•
Code	**Power Supply**	
A	90 – 250 V ac	•
D	18 – 36 V dc	•
Code	**Conduit Threads**	
1	¾–14 NPT	•
2	CM20 Conduit Adapter	•
3	PG 13.5 Conduit Adapter	•
Code	**Materials of Construction: Flange/Antenna**	
S	316L Stainless Steel	•
Code	**Antenna Type**	
C	Cone	•
Code	**Antenna Size**	
2N	Fits 2-inch opening	•
3N	Fits 3-inch opening	•
4N	Fits 4-inch opening	•
Code	**Mounting Flange Size**	
02	2-inch ASME B 16.5 (ANSI) (DN 50) (Not available with Mounting Flange Rating option code D2.	•
03	3-inch ASME B 16.5 (ANSI) (DN 80)	•
04	4-inch ASME B 16.5 (ANSI) (DN 100)	•
06	6-inch ASME B 16.5 (ANSI) (DN 150)	•

Code	Mounting Flange Rating	
A1	ASME B 16.5 (ANSI) Class 150	•
A3	ASME B 16.5 (ANSI) Class 300	•
D2	DIN PN 16	•
D4	DIN PN 40	•

Code	Final Destination of Product (for Telecommunications License)	Availability
	North America	
01	United States	•
02	Canada	•
	Europe/Middle East/Africa	
03	Spain	•
04	Germany	•
05	The Netherlands	•
06	Sweden	•
07	Finland	•
08	Poland	•
09	Czech Republic	•
10	Oman	•
11	Kuwait	•
12	Eire	•
13	South Africa	•
14	Norway	•
15	United Kingdom	•
16	Croatia	•
17	Belgium	•
18	Romania	•
19	Hungary	•
20	Portugal	•
21	Turkey	•
22	Italy	•
23	Austria	•
24	Russia	•
25	Saudi Arabia	•
26	Denmark	•
27	France	•
28	Egypt	•

Code	Final Destination of Product (for Telecommunications License)	Availability
	Asia-Pacific	
40	Singapore	•
41	China	•
42	India	•
43	Malaysia	•
44	South Korea	•
45	Indonesia	•
46	Taiwan	•
47	Thailand	•
48	Australia	•
49	New Zealand	•
50	Philippines	•
	Latin America	
76	Argentina	•
77	Puerto Rico	•
78	Jamaica	•
79	Venezuela	•
80	Mexico	•
81	Chile	•
82	Brazil	•
83	Trinidad and Tobago	•
84	Bolivia	•
85	Colombia	•
86	Ecuador	•
99	Other Countries: Consult factory for availability	

Code	Options	APEX Radar Gauge	APEX Sentry Radar Gauge
C1	Factory Configuration (CDS 00806-0100-4731 required with order)	•	—
M1	Integral Display and Operator Interface	•	—
M2	Integral Display Only	—	•
E5	Factory Mutual (FM) Explosion Proof Approval	•	•
E6	Canadian Standards Association (CSA) Explosion Proof Approval	•	•
ED	CENELEC (KEMA) Flameproof Approval	•	•
R0001	Level Accuracy ±3 mm at Reference Conditions	•	—
R0002	Guaranteed Start-Up at -50 °C	•	•
R0003	Barcode tag with tag number and purchase order number	•	—
R0004	Combination of R0001 an R0002	•	•
Q8	Material Traceability Certification per EN 10204 3.1B (Option available for all pressure retaining parts of APEX or APEX Sentry waveguide assembly.)	•	•
C4(1)	Analog Output Levels Compliant with NAMUR Recommendation NE43, 27-June-1996	•	•
CN(1)	Analog Output Levels Compliant with NAMUR Recommendation NE43, 27-June-1996: Alarm Configuration–Low		
Example Model Numbers:	**APEX B C 1 A 1 S C 4N 04 A1 01 C1 M1 E5**		
	SENTRY B C 2 A 1 S C 3N 03 A1 04 M2 ED		

(1) NAMUR–Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.

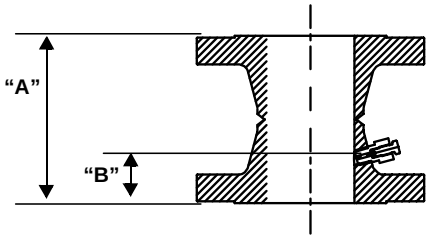
Window Kits, Spool Pieces, and Bolt Kits

Isolation Window Kits
(All window kits include PTFE window, process o–ring, non-wetted stainless steel ring, non-wetted EMI o–ring, and two spiral wound gaskets.)

Part Number	Process O-Ring Material	Fits Flange Size	Availability
03700-0620-1100	*Viton®*	2-in.	•
03700-0620-1200	Buna-N	2-in.	•
03700-0620-1300	Ethylene Propylene	2-in.	•
03700-0620-1400	Fluorosilicone	2-in.	•
03700-0620-1500	*Kalrez-4079®*	2-in.	•
03700-0630-1100	*Viton*	3-in.	•
03700-0630-1200	Buna-N	3-in.	•
03700-0630-1300	Ethylene Propylene	3-in.	•
03700-0630-1400	Fluorosilicone	3-in.	•
03700-0630-1500	*Kalrez-4079*	3-in.	•
03700-0640-1100	*Viton*	4-in.	•
03700-0640-1200	Buna-N	4-in.	•
03700-0640-1300	Ethylene Propylene	4-in.	•
03700-0640-1400	Fluorosilicone	4-in.	•
03700-0640-1500	*Kalrez-4079*	4-in.	•

Spool Pieces *(Includes spool piece only.)*

Dimensions “A” and “B” refer to spool piece dimensions listed below.



	Dimensions in. (mm)					
Part Number	A	B	Material	Fits Flange Size	Flange Rating	
03700-0263-0212	5 (127)	1.4 (35.6)	304 SST	2-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0213	5 (127)	1.4 (35.6)	CS Painted	2-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0232	5 (127)	1.4 (35.6)	304 SST	2-in.	ASME B 16.5 (ANSI) Class 300	•
03700-0263-0233	5 (127)	1.4 (35.6)	CS Painted	2-in.	ASME B 16.5 (ANSI) Class 300	•
03700-0263-0312	5.5 (139.7)	1.6 (40.6)	304 SST	3-in. (original)(1)	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0313	5.5 (139.7)	1.6 (40.6)	CS Painted	3-in. (original)(1)	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0352	7.5 (190.5)	1.6 (40.6)	304 SST	3-in. (new)(1)	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0353	7.5 (190.5)	1.6 (40.6)	CS Painted	3-in. (new)(1)	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0372	7.25 (184.2)	1.6 (40.6)	304 SST	3-in. (new)(1)	ASME B 16.5 (ANSI) Class 300	•
03700-0263-0373	7.25 (184.2)	1.6 (40.6)	CS Painted	3-in. (new)(1)	ASME B 16.5 (ANSI) Class 300	•
03700-0263-0412	9.5 (241.3)	1.9 (48.3)	304 SST	4-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0413	9.5 (241.3)	1.9 (48.3)	CS Painted	4-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0263-0432	9.5 (241.3)	1.9 (48.3)	304 SST	4-in.	ASME B 16.5 (ANSI) Class 300	•
03700-0263-0433	9.5 (241.3)	1.9 (48.3)	CS Painted	4-in.	ASME B 16.5 (ANSI) Class 300	•
03700-0263-0542	5.0 (127.0)	1.0 (25.4)	304 SST	DIN DN 50	DIN PN 40	•
03700-0263-0543	5.0 (127.0)	1.0 (25.4)	CS Painted	DIN DN 50	DIN PN 40	•

Spool Pieces Ordering Information Continued on Next Page

Window Kits, Spool Pieces, and Bolt Kits

(Spool Pieces continued)						
03700-0263-0822	5.75 (146.05)	1.1 (27.9)	304 SST	DIN DN 80 (original)(1)	DIN PN 16	•
03700-0263-0823	5.75 (146.05)	1.1 (27.9)	CS Painted	DIN DN 80 (original)(1)	DIN PN 16	•
03700-0263-0862	5.5 (139.7)	1.1 (27.9)	304 SST	DIN DN 80 (new)(1)	DIN PN 16	•
03700-0263-0863	5.5 (139.7)	1.1 (27.9)	CS Painted	DIN DN 80 (new)(1)	DIN PN 16	•
03700-0263-0882	7.5 (190.5)	1.6 (40.6)	304 SST	DIN DN 80 (new)(1)	DIN PN 40	•
03700-0263-0883	7.5 (190.5)	1.6 (40.6)	CS Painted	DIN DN 80 (new)(1)	DIN PN 40	•
03700-0263-1022	9.75 (247.65)	1.2 (30.5)	304 SST	DIN DN 100	DIN PN 16	•
03700-0263-1023	9.75 (247.65)	1.2 (30.5)	CS Painted	DIN DN 100	DIN PN 16	•
03700-0263-1042	9.5 (241.3)	1.2 (30.5)	304 SST	DIN DN 100	DIN PN 40	•
03700-0263-1043	9.5 (241.3)	1.2 (30.5)	CS Painted	DIN DN 100	DIN PN 40	•

Bolt Kits
(Each bolt kit includes two sets of bolts, nuts, and washers. One set connects the radar gauge to the top of the spool piece; the other connects the bottom of the spool piece to the process flange with window kit installed.)

Part Number	Material	Fits Flange Size	Flange Rating	
03700-0610-0009	CS(2)	2-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0610-0011	SST(3)	2-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0610-0001	CS(2)	3-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0610-0005	SST(3)	3-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0610-0003	CS(2)	4-in.	ASME B 16.5 (ANSI) Class 150	•
03700-0610-0007	SST(3)	4-in.	ASME B 16.5 (ANSI) Class 150	•

Meter Kits

Part Number	Description	
03700-0670-0001	APEX Meter Kit (includes cover)	•
03700-0670-0003	APEX Meter Kit (does not include cover)	•
03700-0670-0002	APEX Sentry Meter Kit (includes cover)	•
03700-0670-0004	APEX Sentry Meter Kit (does not include cover)	•
08732-0007-0002	APEX and APEX Sentry Meter Cover	•

(1) Gauges with a 3-in. (80 mm) antenna and serial number above 3925 will require one of the spool pieces labelled “new.”
(2) Per ASTM A193, A194
(3) Per ASTM F593

Appendix A HART Communicator

INTRODUCTION

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

This appendix provides an introduction to using the HART Communicator with the APEX and APEX Sentry Radar Gauges, including the HART Communicator keypad, connections, menu structure, and Fast Key sequence features.

The HART Communicator manual provides detailed instructions on the use and features of the HART Communicator. This brief summary will familiarize you with the HART Communicator but is not meant to replace the HART Communicator manual. For information on all the capabilities of the HART Communicator, refer to the HART Communicator Product Manual (document 00809-0100-4275).

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that potentially raises safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠WARNING

Explosions could result in death or serious injury:

- Verify that the operating environment is consistent with the appropriate hazardous locations certifications.
- Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- Do not make connections to the serial port or NiCad recharger jack in an explosive atmosphere.

⚠WARNING

Failure to follow safe installation and servicing guidelines could result in death or serious injury:

- Make sure only qualified personnel perform these procedures.
- Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.
- Do not perform any service other than those contained in this manual unless you are qualified.

As a matter of routine, the APEX Radar Gauge and all other equipment in your tank should be shut off prior to entering the tank.

Figure A-1. HART Communicator Menu Tree for the APEX and APEX Sentry Radar Gauges

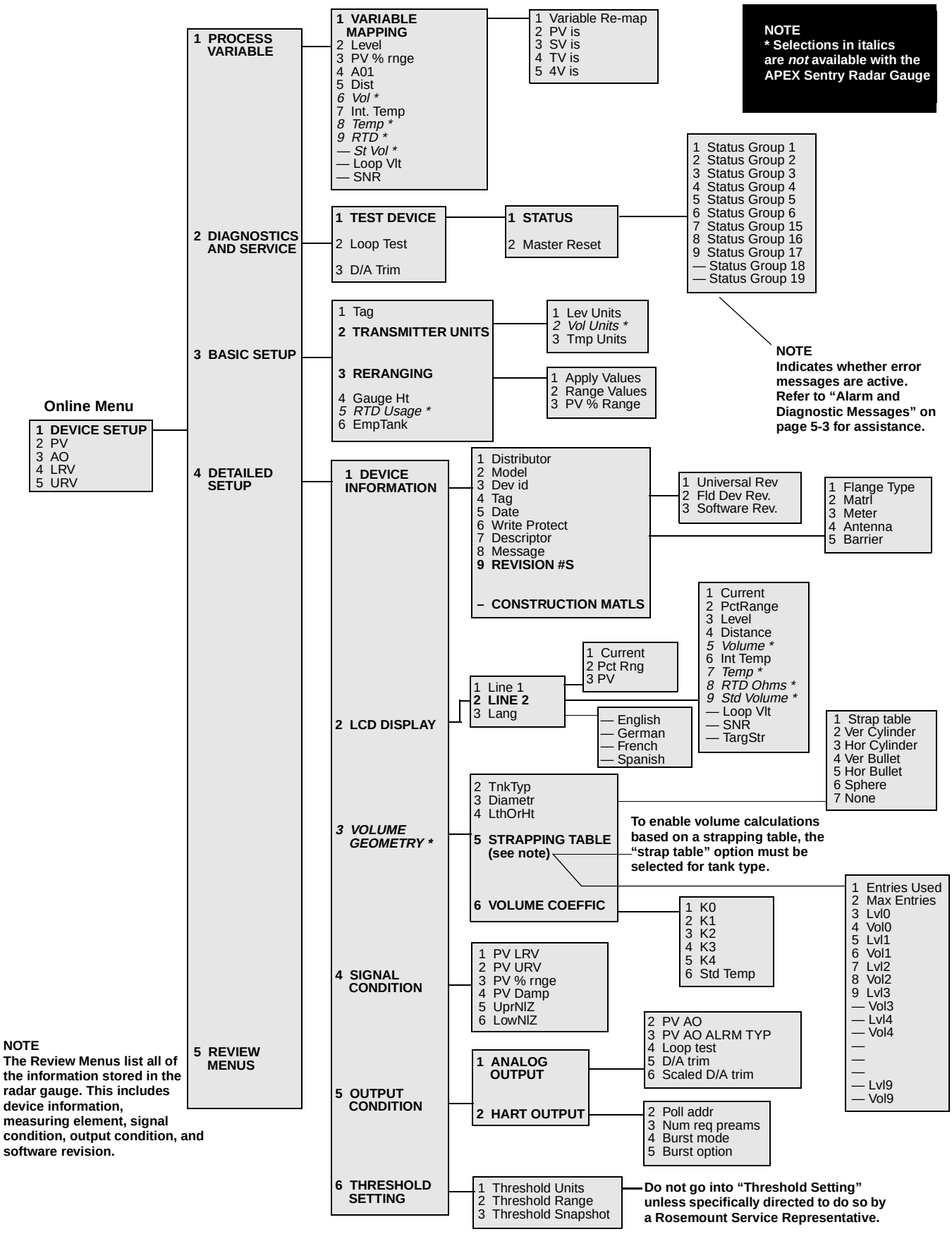


TABLE A-1. HART Fast Key Sequences

Function	HART Fast Key
Construction Materials	1, 4, 1, –
Device Information	1, 4, 1
Diameter (APEX Radar Gauge Only)	1, 4, 3, 2
Display Language	1, 4, 2, 3
Display Line 1	1, 4, 2, 1
Display Line 2	1, 4, 2, 2
Empty Tank	1, 3, 6
Length or Height (APEX Radar Gauge Only)	1, 4, 3, 3
Level Units	1, 3, 2, 1
Loop Test	1, 2, 2
Lower Null Zone	1, 4, 4, 6
Lower Range Value (LRV) (4 mA)	1, 3, 3
Master Reset	1, 2, 1, 2
Poll Address	1, 4, 5, 2, 1
Primary Variable	1, 1, 1, 1
Process Variable Damping	1, 4, 4, 4
Range Values	1, 3, 3, 2
Reference Gauge Height	1, 3, 4
Strapping Table (APEX Radar Gauge Only)	1, 4, 3, 4
Tag	1, 3, 1
Tank Type (APEX Radar Gauge Only)	1, 4, 3, 1
Temperature Units	1, 3, 2, 3
Upper Null Zone	1, 4, 4, 5
Upper Range Value (URV) (20 mA)	1, 3, 3
Variable Remapping	1, 1, 1, 1
Volume Coefficient (K Constants) (APEX Radar Gauge Only)	1, 4, 3, 5
Volume Units (APEX Radar Gauge Only)	1, 3, 2, 2

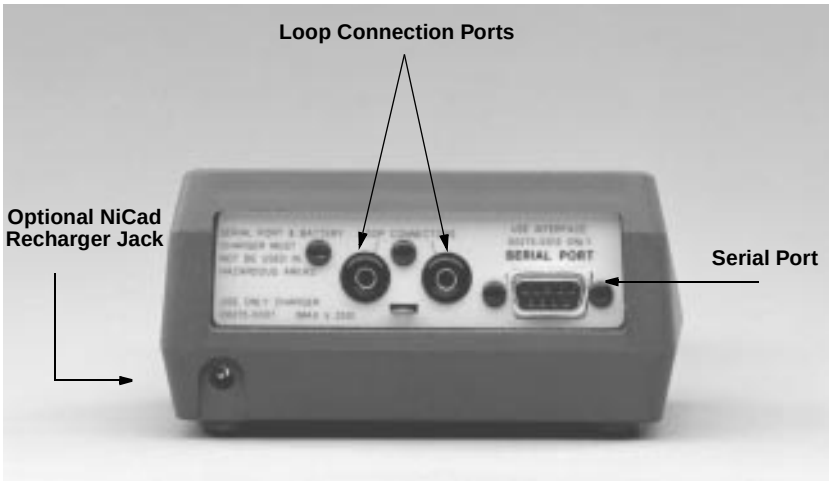
CONNECTIONS AND HARDWARE

The HART Communicator exchanges information with the APEX and APEX Sentry Radar Gauges from the control room, the instrument site, or any wiring termination point in the loop. The HART Communicator should be connected in parallel with the gauge. Use the loop connection ports on the rear panel of the HART Communicator (see Figure A-2). The connections are non-polarized.

⚠ Do not make connections to the serial port or NiCad recharger pack in an explosive atmosphere.

Refer to “Safety Messages” on page A-1 and for more information.

Figure A-2. Rear Connection Panel
with Optional NiCad Recharger Jack



Before connecting the HART Communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

NOTE
The HART Communicator needs a minimum of 250 ohms resistance in the loop to function properly. The HART Communicator does not measure loop current directly.

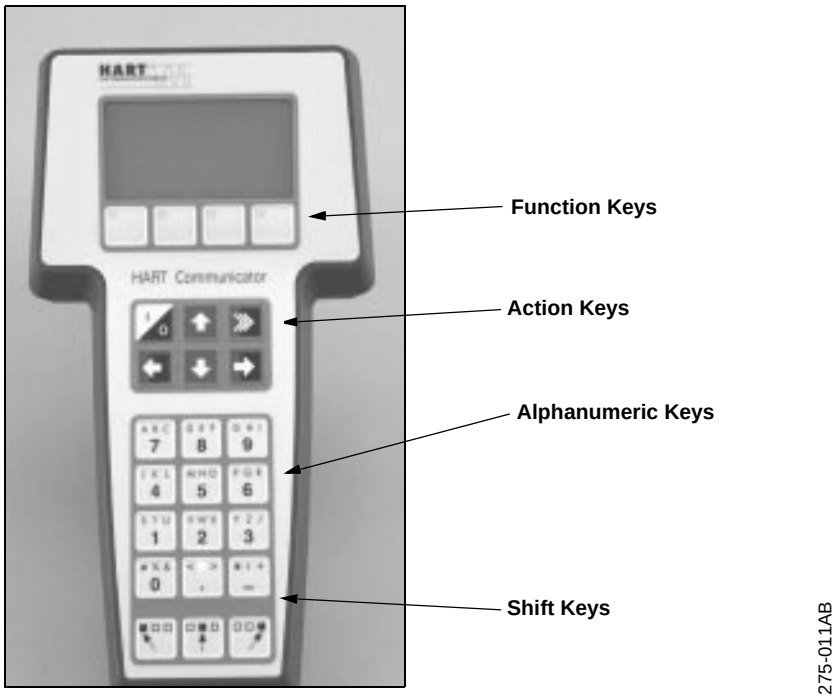
NOTE
Loop must be broken to insert the 250 ohm load resistor.

Refer to "Safety Messages" on page A-1 and for more information.

COMMUNICATOR KEYS

The keys of the HART Communicator include action keys, function keys, alphanumeric keys, and shift keys.

Figure A-3. The HART Communicator



Action Keys

As shown in Figure A-3, the action keys are the six blue, white, and black keys located above the alphanumeric keys. The function of each key is described as follows:

ON/OFF Key

Use this key to power the HART Communicator. When the communicator is turned on, it searches for a gauge on the 4–20 mA loop. If a device is not found, the communicator displays the message, “No Device Found. Press OK.”

If a HART-compatible device is found, the communicator displays the Online Menu with device ID and tag.

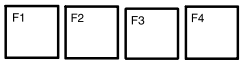
Directional Keys

Use these keys to move the cursor up, down, left, or right. The right arrow key also selects menu options, and the left arrow key returns to the previous menu.

HOT Key

Use this key to quickly access important, user-defined options when connected to a HART-compatible device. Pressing the Hot Key turns the HART Communicator on and displays the Hot Key Menu. See Customizing the Hot Key Menu in the HART Communicator manual for more information.

Function Keys



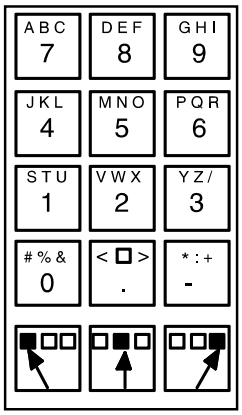
Use the four software-defined function keys, located below the LCD, to perform software functions. On any given menu, the label appearing above a function key indicates the function of that key for the current menu.

As you move among menus, different function key labels appear over the four keys. For example, in menus providing access to online help, the HELP label may appear above the F1 key. In menus providing access to the Home Menu, the HOME label may appear above the F3 key. Press the key to activate the function. See the HART Communicator manual for details on specific Function Key definitions.

Alphanumeric and Shift Keys

The Alphanumeric keys perform two functions: fast selection of menu options (refer to HART Fast Key Feature in this section) and data entry.

Figure A-4. HART Communicator Alphanumeric and Shift Keys



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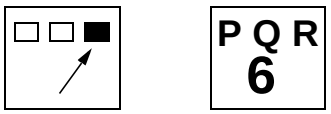
Some menus require data entry. Use the Alphanumeric and Shift keys to enter all alphanumeric information into the HART Communicator. If you press an Alphanumeric key alone from within an edit menu, the bold character in the center of the key appears. These large characters include the numbers zero through nine, the decimal point (.), and the dash symbol (–).

To enter an alphabetic character:

1. Press the Shift key that corresponds to the position on the Alphanumeric key of the letter you want.
2. Press the Alphanumeric key.

For example, to enter the letter R, first press the right Shift key, then the “6” key (see Figure A-5). Do not press these keys simultaneously, but one after the other.

Figure A-5. Data Entry Key Sequence



MENUS AND FUNCTIONS

The HART Communicator is a menu driven system. Each screen provides a menu of options that can be selected or provides direction for input of data, warnings, messages, or other instructions.

Main Menu

When the HART Communicator is turned on, one of two menus appears: the Online Menu or the Main Menu.

If the HART Communicator is connected to an operating loop, the communicator finds the device and displays the Online Menu.

If it is not connected to a loop, the communicator indicates that no device was found. When you press OK (F4), it displays the Main Menu.

The Main Menu provides the following options:

- *Offline* – The Offline option provides access to offline configuration data and simulation functions.
- *Online* – The Online option checks for a device and if it finds one, brings up the Online Menu. Online communication with the APEX Radar Gauge automatically loads the current gauge data to the HART Communicator.
- *Transfer* – The Transfer option provides access to options for transferring data either from the HART Communicator (memory) to the APEX Radar Gauge (device) or vice versa. Transfer is used to move offline data from the HART Communicator to the gauge, or to retrieve data from a gauge for offline revision.
- *Frequency Device* – The Frequency Device option displays the frequency output and corresponding pressure output of current-to-pressure transmitters.
- *Utility* – The Utility option provides access to the contrast control for the HART Communicator LCD screen and to the autopoll setting used in multidrop applications.

To select an option from the menu, you can use the up and down arrow keys and the select (right arrow) key or you can simply press the corresponding number on the alphanumeric keypad to “fast select” the option.

After selecting a Main Menu option, the HART Communicator provides the information you need to complete the operation. If further details are required, consult the *HART Communicator* manual.

Online Menu

The Online Menu can be selected from the Main Menu or it appears automatically if the HART Communicator is connected to an active loop and can detect an operating APEX gauge.

Online mode is used for direct evaluation of a particular meter, re-configuration, changing parameters, maintenance, and other functions.

When configuration variables are reset in online mode, the new settings are not activated until the data is sent to the gauge. Press SEND (F2) when it is activated to update the process variables of the APEX gauge.

NOTE
The Main Menu can be accessed from the Online Menu. Press the left arrow action key to deactivate the online communication with the gauge and to activate the Main Menu options.

HART Fast Key Feature

The HART Fast Key feature provides quick online access to gauge variables and functions. Instead of stepping your way through the menu structure using the Action Keys, you can press a HART Fast Key sequence to move from the Online Menu to the desired variable or function. On-screen instructions guide you through the rest of the screens.

The HART Fast Key sequences are made up of the series of numbers corresponding to the individual options in each step of the menu structure. For example, from the Online Menu you can change the **Date**. Following the menu structure, you would:

1. Press 1 to reach **Device Setup**.
2. Press 4 for **Detailed Setup**.
3. Press 1 for **Device Information**.
4. Press 5 for **Date**.

So, the corresponding HART Fast Key sequence is **1**, **4**, **1**, **5**.

HART Fast Keys are operational only from the Online Menu. If you use them consistently, you return to the Online Menu by pressing HOME (F3) when it is available. If you do not start at the Online Menu, the HART Fast Keys will not function properly.

Use Table A-1, an alphabetical listing of online functions, to find the corresponding HART Fast Keys. These codes are applicable only to the APEX and APEX Sentry Radar Gauges and the HART Communicator.

HART Communicator Diagnostic Messages

The following table is a list of messages used by the HART Communicator (HC) and their corresponding descriptions.

Variable parameters within the text of a message are indicated with <*variable label*>.

Reference to the name of another message is identified by <*message*>.

TABLE A-2. Hart Communicator Diagnostic Messages

Message	Description
Add item for ALL device types or only for this ONE device type.	Asks the user whether the hot key item being added should be added for all device types or only for the type of device that is connected.
Command Not Implemented	The connected device does not support this function.
Communication Error	Either a device sends back a response indicating that the message it received was unintelligible, or the HC cannot understand the response from the device.
Configuration memory not compatible with connected device	The configuration stored in memory is incompatible with the device to which a transfer has been requested.
Device Busy	The connected device is busy performing another task.
Device Disconnected	Device fails to respond to a command.
Device write protected	Device is in write-protect mode. Data can not be written.
Device write protected. Do you still want to shut off?	Device is in write-protect mode. Press YES to turn the HC off and lose the unsent data.
Display value of variable on hotkey menu?	Asks whether the value of the variable should be displayed adjacent to its label on the hotkey menu if the item being added to the hotkey menu is a variable.
Download data from configuration memory to device	Prompts user to press SEND softkey to initiate a memory to device transfer.
Exceed field width	Indicates that the field width for the current arithmetic variable exceeds the device-specified description edit format.
Exceed precision	Indicates that the precision for the current arithmetic variable exceeds the device-specified description edit format.
Field device has malfunctioned due to a Hardware Error or Failure	The APEX Gauge may simply be configured incorrectly (20 mA point in upper Null Zone, etc.) Verify the configuration.
Ignore next 50 occurrences of status?	Asked after displaying device status. Softkey answer determines whether next 50 occurrences of device status will be ignored or displayed.
Illegal character	An invalid character for the variable type was entered.
Illegal date	The day portion of the date is invalid.
Illegal month	The month portion of the date is invalid.
Illegal year	The year portion of the date is invalid.
Incomplete exponent	The exponent of a scientific notation floating point variable is incomplete.
Incomplete field	The value entered is not complete for the variable type.
Looking for a device	Polling for multidropped devices at addresses 1–15.
Mark as read only variable on hotkey menu?	Asks whether the user should be allowed to edit the variable from the hotkey menu if the item being added to the hotkey menu is a variable.
No device configuration in configuration memory	There is no configuration saved in memory available to re-configure offline or transfer to a device.
No Device Found	Poll of address zero fails to find a device, or poll of all addresses fails to find a device if auto-poll is enabled.
No hotkey menu available for this device.	There is no menu named “hotkey” defined in the device description for this device.
No offline devices available.	There are no device descriptions available to be used to configure a device offline.
No simulation devices available.	There are no device descriptions available to simulate a device.
No UPLOAD_VARIABLES in ddl for this device	There is no menu named “upload_variables” defined in the device description for this device. This menu is required for offline configuration.
No Valid Items	The selected menu or edit display contains no valid items.
OFF KEY DISABLED	Appears when the user attempts to turn the HC off before sending modified data or before completing a method.
Online device disconnected with unsent data. RETRY or OK to lose data.	There is unsent data for a previously connected device. Press RETRY to send data, or press OK to disconnect and lose unsent data.
Out of memory for hotkey configuration. Delete unnecessary items.	There is no more memory available to store additional hotkey items. Unnecessary items should be deleted to make space available.
Overwrite existing configuration memory	Requests permission to overwrite existing configuration either by a device-to-memory transfer or by an offline configuration. User answers using the softkeys.

TABLE A-2. Hart Communicator Diagnostic Messages

Message	Description
Press OK...	Press the OK softkey. This message usually appears after an error message from the application or as a result of HART communications.
Restore device value?	The edited value that was sent to a device was not properly implemented. Restoring the device value returns the variable to its original value.
Save data from device to configuration memory	Prompts user to press SAVE softkey to initiate a device-to-memory transfer.
Saving data to configuration memory.	Data is being transferred from a device to configuration memory.
Sending data to device.	Data is being transferred from configuration memory to a device.
There are write only variables which have not been edited. Please edit them.	There are write-only variables which have not been set by the user. These variables should be set or invalid values may be sent to the device.
There is unsent data. Send it before shutting off?	Press YES to send unsent data and turn the HC off. Press NO to turn the HC off and lose the unsent data.
Too few data bytes received	Command returns fewer data bytes than expected as determined by the device description.
Transmitter Fault	Device returns a command response indicating a fault with the connected device.
Units for <variable label> has changed. Unit must be sent before editing, or invalid data will be sent.	The engineering units for this variable have been edited. Send engineering units to the device before editing this variable.
Unsent data to online device. SEND or LOSE data	There is unsent data for a previously connected device which must be sent or thrown away before connecting to another device.
Use up/down arrows to change contrast. Press DONE when done.	Gives direction to change the contrast of the HC display.
Value out of range	The user-entered value is either not within the range for the given type and size of variable or not within the min/max specified by the device.
<message> occurred reading/writing <variable label>	Either a read/write command indicates too few data bytes received, transmitter fault, invalid response code, invalid response command, invalid reply data field, or failed pre- or post-read method; or a response code of any class other than SUCCESS is returned reading a particular variable.
<variable label> has an unknown value. Unit must be sent before editing, or invalid data will be sent.	A variable related to this variable has been edited. Send related variable to the device before editing this variable.

Appendix B Theory of Operation

WHAT IS RADAR?

Radar, an acronym for the phrase **ra**dio **d**etection **a**nd **r**anging, was applied to military use in the 1930s to detect the presence of aircraft. Today, radar has many useful applications. Examples of radar you are probably already familiar with include: detecting storms to help pilots and weather forecasters avoid and predict bad weather, measuring the speed of an automobile to help law enforcement officers, and using radar on small boats as a safety and navigational aid.

Radar is also similar to a familiar household device—the microwave oven. Radar devices and microwave ovens both produce *electromagnetic waves*. Whereas a microwave oven uses an electromagnetic wave to heat food, radar typically uses an electromagnetic wave to determine distance or speed.

As it relates to level measurement, radar has been used for more than 50 years to measure the level of liquids in chemical transport tankers. Here, radar is used to determine how much more cargo can be added without causing an overflow.

Since that time, some form of radar has been used for precision level measurement in both the process and inventory industries including: petroleum, power, chemical, food and beverage, pulp and paper, and pharmaceutical.

IS RADAR SAFE?

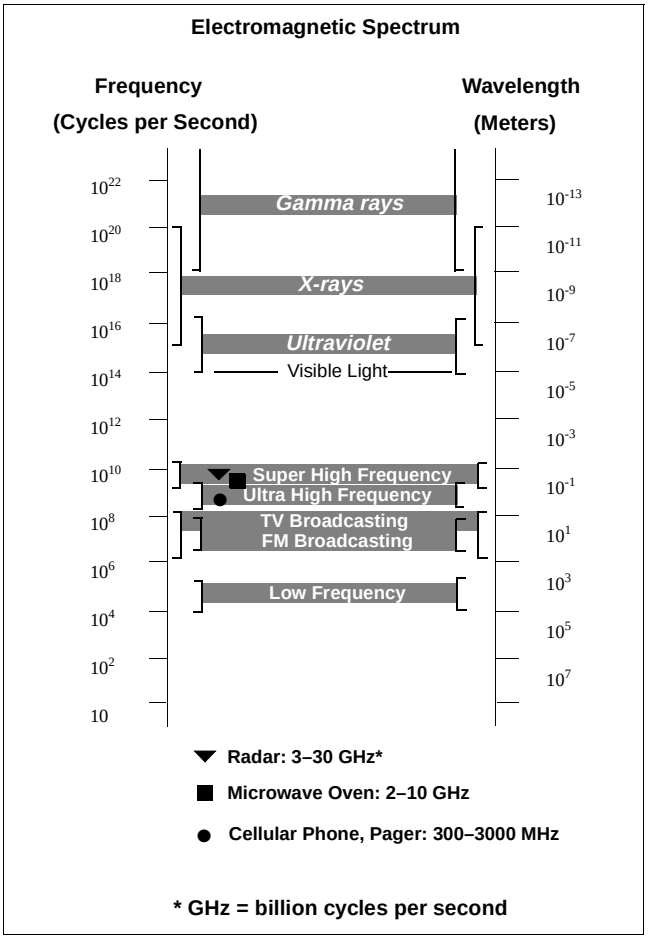
Radar is just as safe as the constant radio, TV, cellular, and other communication waves that surround us everyday.

A radar device transmits an electromagnetic wave powered by a source of electrical energy. The entire arrangement of electromagnetic waves is called the *electromagnetic spectrum*.

The spectrum defines the frequency and wave length of different types of electromagnetic waves. *Frequency* refers to the number of vibrations or waves transmitted per second and is measured in *Hertz*, or cycles per second. *Wave length* is a measure of the length of each complete wave and is expressed in meters.

Frequency and wave length are inversely proportional; an electromagnetic wave with a high frequency has a short wavelength, and one with a low frequency has a long wavelength. (See also page 2-5.)

Figure B-1. Electromagnetic Spectrum



The most familiar frequency classification in the spectrum is light, the band of electromagnetic waves to which the eye is sensitive. Other common frequencies include TV and radio (FM and AM). An FM radio station transmits at 88 to 108 MHz (megaHertz). In comparison, radar gauges transmit in the frequency range between 3 and 30 GHz (GigaHertz).

Most radar gauges today use the 5 to 10 GHz frequency range that was developed in military work over the past 50 years. Recent development has led to radar devices that use a frequency in the 24 GHz range. Use of the 24 GHz frequency allows the application of a much smaller antenna and beamwidth, which results in easier installation compared to the larger and bulkier gauges that use the 5 to 10 GHz frequency.

If you examine the entire electromagnetic spectrum (Figure B-1) you can see that the most harmful frequencies—gamma rays, x-rays, and ultraviolet light—are well above the frequency used by radar.

Another safety factor to consider is the amount of power used to transmit at a certain frequency. In this regard, a radar device is much safer than your microwave oven. The emitted signal of most radar level gauges is **less than three percent** of the maximum leakage allowed from a microwave oven, which is a common household appliance.

TYPES OF RADAR SIGNALS

The two most common types of radar waves or signals used for level measurement are *pulse radar* and *Frequency Modulated Continuous Wave*, or FMCW for short.

Pulse Radar

Pulse radar gauges, frequently referred to as time-of-flight radar, transmit a short, non-continuous pulse signal. The level of a product in a tank is based on the elapsed time it takes for the gauge to send a signal and receive the corresponding return signal.

Because all electromagnetic waves travel at the speed of light (approximately 186,000 miles per second), time must be measured in picoseconds (one trillionth of a second). It is difficult and expensive to build electronics that can measure time in picoseconds. This difficulty in measuring the time-of-flight precisely can cause accuracy errors.

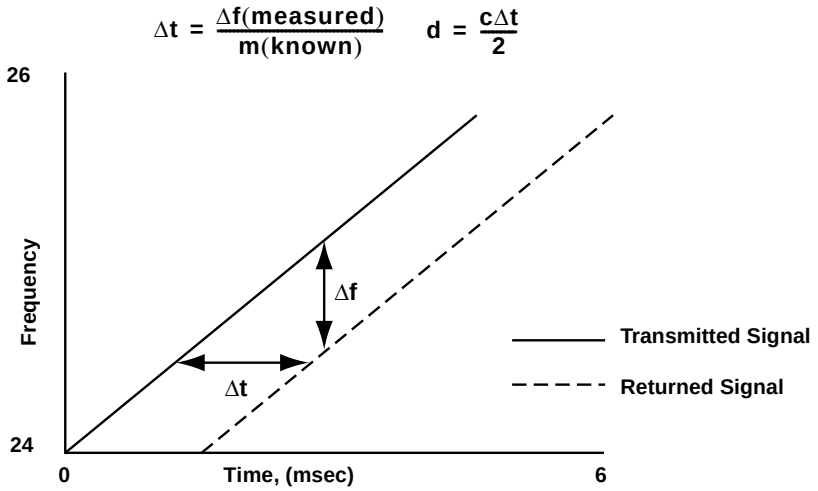
In addition, pulse-based radar systems have difficulty discriminating between multiple echoes and false return signals from things such as agitators, blades, ladders, and other obstructions within tanks.

FMCW Radar

Unlike pulse radar, FMCW radar gauges transmit a continuous signal that changes in frequency. When the signal reaches the surface of the material, the signal is echoed back to the radar gauge.

Instead of attempting to measure the time of flight, the receiver in the radar gauge evaluates the *frequency difference* between the transmitted signal and the return signal (Figure B-2). Plotting these frequency differences against the transmitted signal yields a result that is proportional to the distance to, and thus level of, the material in the tank.

Figure B-2. FMCW Signaling



RADAR SIGNAL CHARACTERISTICS

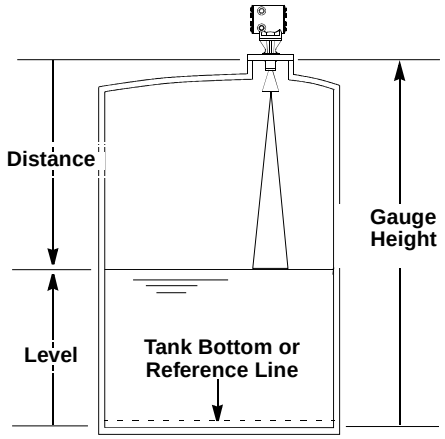
A basic principle of radar is its capability to reflect off the surface of materials based on the material's *dielectric constant*. The dielectric constant of a substance is proportional to the amount of electromagnetic energy that reflects from it. A vacuum has a dielectric constant of 1.0, which means it does not reflect a radar signal.

The higher the dielectric constant of the material, the more signal that is reflected and available for level measurement. On the other hand, radar signals tend to pass through materials that have a dielectric constant less than 1.8, such as air, vapor, certain gases, and some foam. That is why radar is an excellent technology for measuring the level of a material in a tank; the air, vapor, or gas has minimal effect on radar measurements, as compared with other level measurement technologies. In addition, changes in dielectric constants caused by changes in temperature or pressure have a minimal effect on the signal.

RADAR LEVEL MEASUREMENT

Radar gauges determine the level of a product in a tank by measuring the distance from the radar gauge mounting location to the surface of the material (Figure B-3). The level measurement is determined by subtracting the distance to the surface from the distance the radar gauge is mounted above the tank bottom (or Reference Gauge Height).

Figure B-3. Radar Measurement



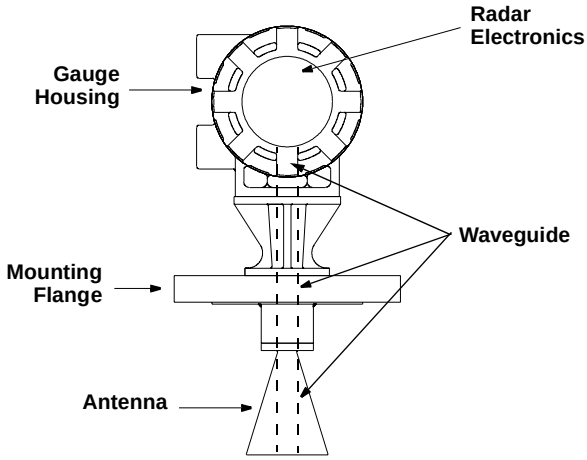
Level = Reference Gauge Height – Distance

The *Reference Gauge Height* is the fixed distance from the bottom of the tank (or reference line) to the face of the radar gauge mounting flange. The Reference Gauge Height establishes a reference point from which all level and calibration measurements are taken.

BASIC RADAR GAUGE COMPONENTS

At the top of a typical radar gauge, is the *gauge housing* (Figure B-4). The gauge housing includes specially designed electronics for signal processing.

Figure B-4. APEX Radar Gauge Components



The *radar electronics* is the heart of the radar gauge. It produces an electromagnetic wave by using an oscillator that converts direct-current (dc) power into a microwave frequency or signal. It also receives the return signal.

The signal passes from the electronics through a *waveguide*. The waveguide is the entire path from the electronics to the antenna.

The *antenna* is typically a cone-shaped device made of stainless steel. The antenna controls the signal beamwidth by helping to keep the signal focused on its target so it doesn't spread out over the entire tank and give false echoes. The size of the antenna is inversely proportional to the frequency; the higher the frequency the smaller the antenna needs to be to provide a given amount of signal.

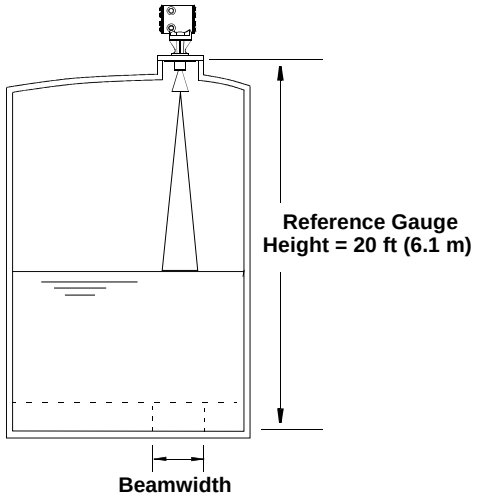
WHY FREQUENCY IS IMPORTANT

Radar gauges that operate in the 24 GHz frequency range provide significant advantages over lower frequency gauges. One advantage relates to beamwidth. The width of a radar beam is determined by using the formula:

$$\text{beam angle} = \frac{70 \times \text{speed of light}}{\text{frequency} \times \text{antenna diameter}}$$

To illustrate, assume the height of a tank, or Reference Gauge Height, is 20 feet (6.1 m).

Figure B-5. Frequency Beamwidth Example



Using the previous formula yields the following results for 5, 10 and 24 GHz frequencies (Table B-1):

TABLE B-1. Frequency Beamwidth Relationship

	FREQUENCY (GHz)	ANTENNA DIAMETER	BEAMWIDTH (at a distance of 20 ft.)
A	5	4 in. (102 mm)	14.4 ft (6.1 m)
B	10	4 in. (102 mm)	9 ft (3.0 m)
C	24	4 in. (102 mm)	3.6 ft (1.2 m)
D	5	16 in. (483 mm)	3.6 ft (1.2 m)
E	10	10 in. (254 mm)	3.6 ft (1.2 m)

Table B-1 shows that the lower frequencies (A, B) that use a 4-inch antenna transmit a wider beam; at 24 GHz (C), beamwidth is only four feet. To achieve an equal beamwidth, the lower frequencies require a much larger diameter antenna (D, E).

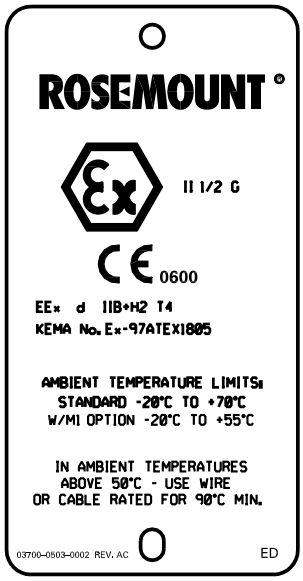
The narrower beamwidth helps to reduce unwanted signals from vessel obstructions such as agitators, heat exchangers, filling pipes, baffles, thermowells, intermittent filling streams, and other obstructions. It allows greater flexibility in mounting the gauge on existing flanges located close to tank walls, without any problems.

Another advantage of the 24 GHz frequency relates to the use of a smaller, and thus lighter weight, antenna. A smaller and lighter weight unit makes it easier to transport and install on top of the tank. In addition, the antenna more easily accommodates existing small flanges.

Appendix C Hazardous Approvals

EUROPEAN ATEX DIRECTIVE INFORMATION

The Rosemount Model APEX and APEX Sentry Radar Gauges that have the following labels attached have been certified to comply with Directive 94/9/EC of the European Parliament and the Council as published in the Official Journal of the European Communities No. L 100/1 on 19-April-1994.



LEVEL-APEX15A

The following information is provided as part of the label of the transmitter:

- Name and address of the manufacturer (Rosemount U.S.A.)
- CE Conformity Marking:

CE 0600

- Complete model number
- The serial number of the device
- Year of construction
- Marking for explosion protection:

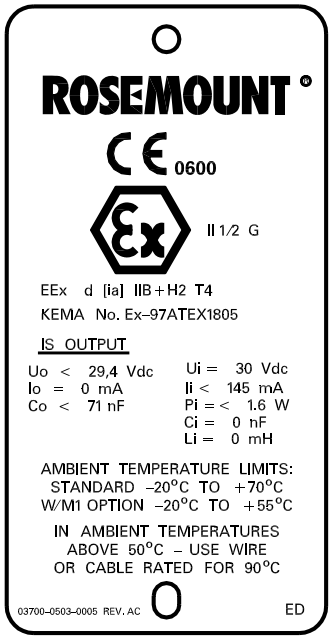
II 1/2 G

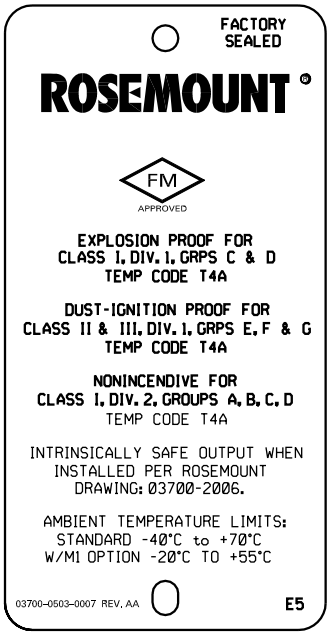
- EEx d IIB+H2 T4
- KEMA ATEX certificate number: 97ATEX1805.

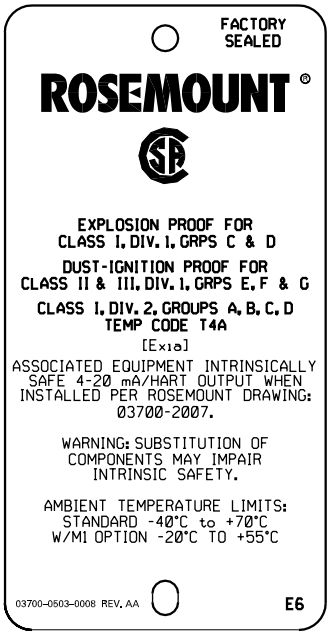
INTRINSIC SAFETY

Rosemount APEX and APEX Sentry Radar Gauges that have the following labels attached have been certified to comply with the requirements of the approval agencies noted.

Figure C-1. Approvals Labels: CENELEC (KEMA), Factory Mutual (FM), Canadian Standards Association (CSA)







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APPROVAL DRAWINGS

NOTE
All information included refers to both the APEX Radar Gauge and the APEX Sentry Radar Gauge unless otherwise stated.

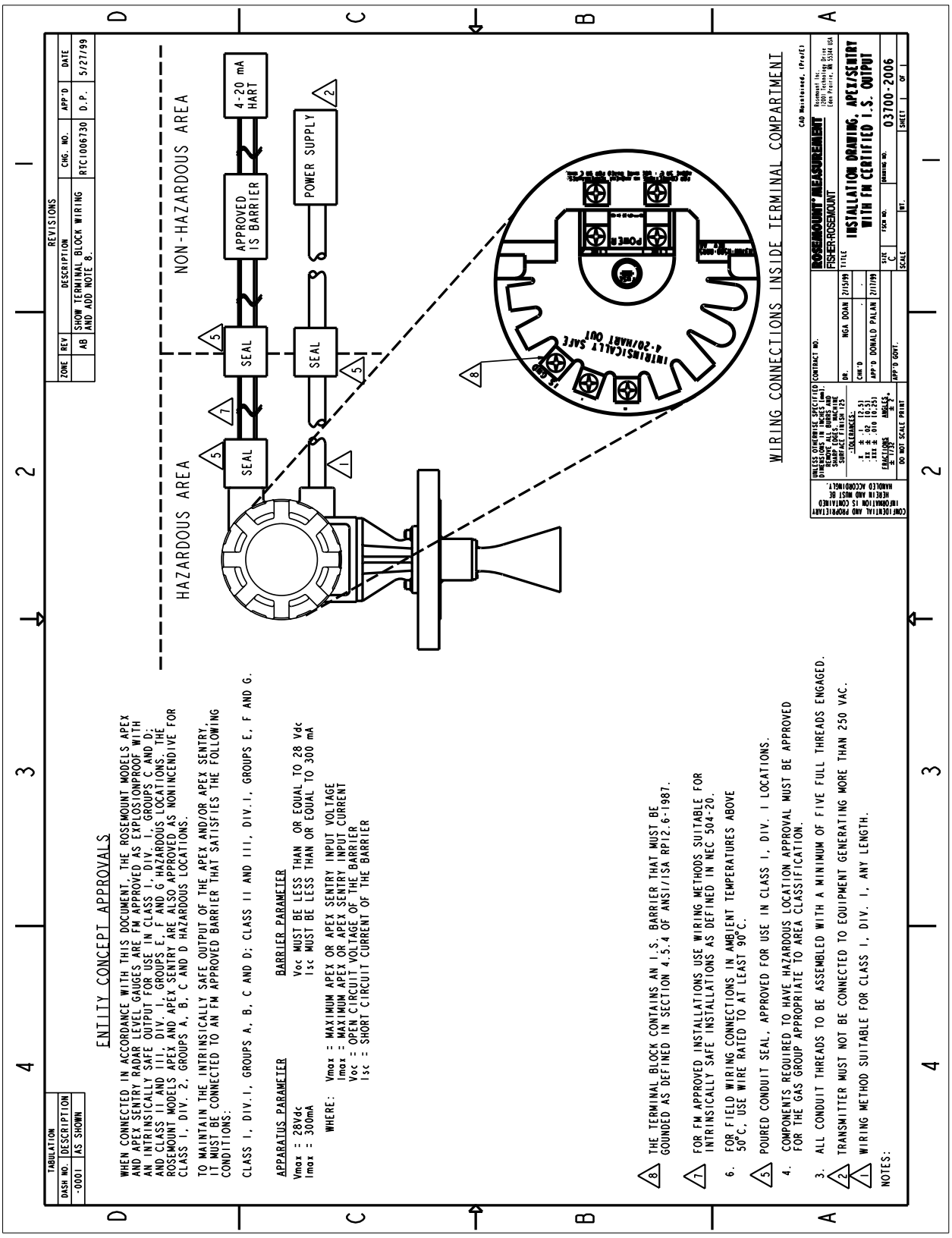
This section contains a Factory Mutual installation drawing and a Canadian Standards installation drawing. You must follow the installation guidelines presented in order to maintain certified ratings for installed transmitters.

This section contains the following drawings:

Rosemount Drawing 3700-2006, Rev AB:
Installation Drawing, APEX/Sentry With FM Certified I.S. Output.

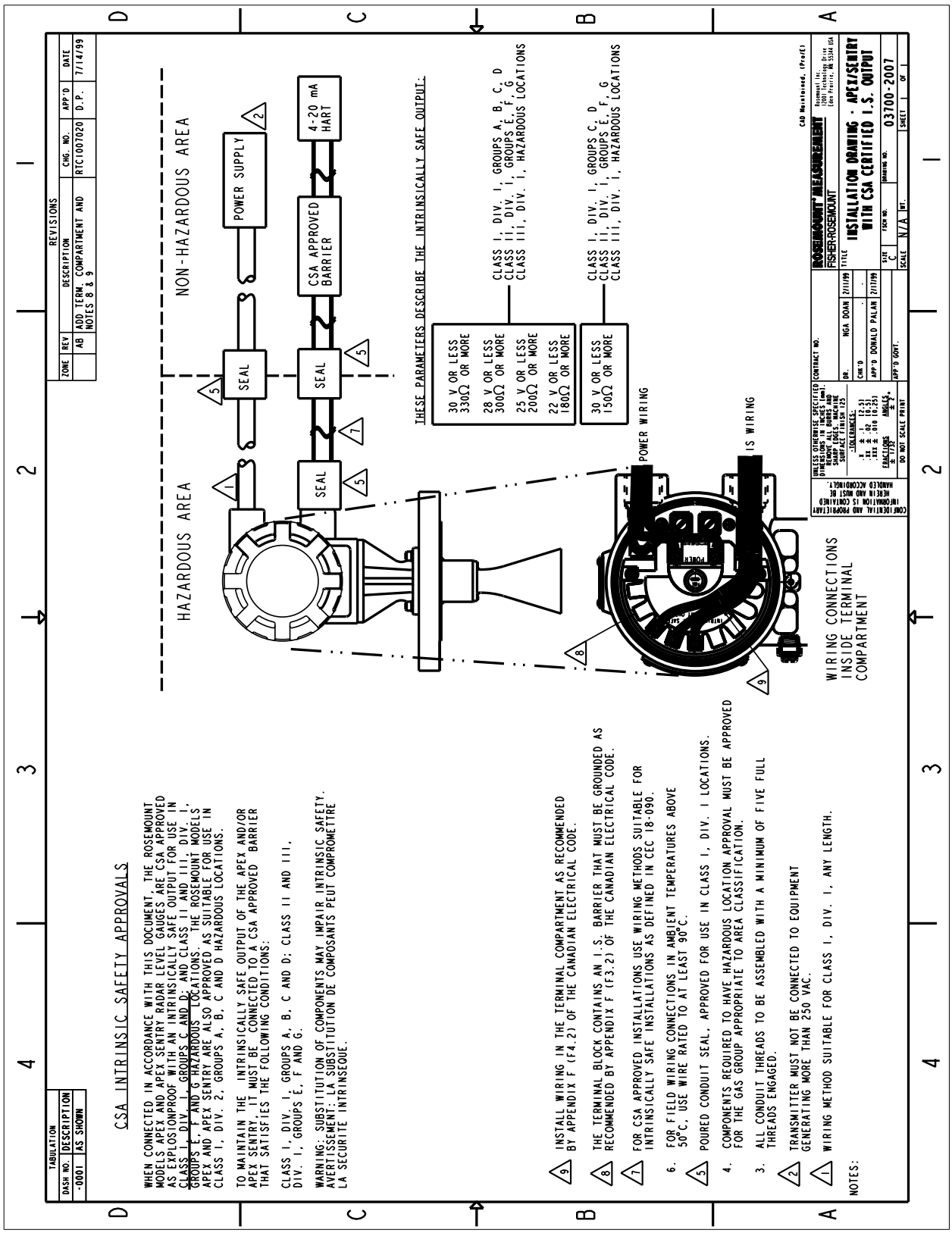
Rosemount Drawing 3700-2007, Rev AB:
Installation Drawing, APEX/Sentry with CSA Certified I.S. Output.

Figure C-2. Installation Drawing, APEX/Sentry With FM Certified I.S. Output



3700-2006a01a

Figure C-3. Installation Drawing - APEX/Sentry with CSA Certified I.S. Output



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