MACH 10® Residential Ultrasonic Meter Installation and Maintenance Guide
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FCC Notice
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this
device may not cause harmful interference, and (2) this device must accept any interference received, including
interference that may cause undesired operation.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device,
pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against
harmful interference in a residential installation. This equipment generates, uses, and can radiate radio
frequency energy and, if not installed and used in accordance with the instructions, may cause harmful
interference to radio communications. However, there is no guarantee that interference will not occur in a
particular installation. If this equipment does cause harmful interference to radio or television reception, which
can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference
by one or more of the following measures:
• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and receiver.
• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
• Consult the dealer or an experienced radio/TV technician for help.

RF Exposure Information
This equipment complies with the FCC RF radiation requirements for uncontrolled environments. To maintain
compliance with these requirements, the antenna and any radiating elements should be installed to ensure that
a minimum separation distance of 20cm is maintained from the general population.

Changes or modifications not expressly approved by the party responsible for compliance void the
user’s authority to operate the equipment.

Professional Installation
In accordance with section 15.203 of the FCC rules and regulations, the MIU must be professionally installed
by trained utility meter installers. Changes or modifications not expressly approved by the party responsible for
compliance void the user’s authority to operate the equipment.
Industry Canada

This Class B digital apparatus meets all requirements of the Canadian Interference Causing Equipment Regulations. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Cet appareil numérique de la classe B répond à toutes les exigences de l'interférence canadienne causant des règlements d'équipement. L'opération est sujette aux deux conditions suivantes: (1) ce dispositif peut ne pas causer l'interférence nocive, et (2) ce dispositif doit accepter n'importe quelle interférence reçue, y compris l'interférence qui peut causer l'opération peu désirée.
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<td>MACH 10)R450i</td>
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<td>MACH 10)R900i Flags (digits)</td>
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<td>20</td>
<td>MACH 10)R900i Flags (minutes)</td>
<td>36</td>
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Notes:
1 Product Description

This chapter provides a general description of the Neptune MACH 10® Ultrasonic Meter (subsequently referred to as the MACH 10).

Introduction

The MACH 10 solid state meter uses ultrasonic technology and solid state electronics. The meter is contained in a compact, totally encapsulated, weatherproof, and ultra violet (UV) resistant housing for residential and light commercial applications. Ultrasonic technology features:

- Contains no moving parts
- Provides long-term accuracy
- Eliminates measurement errors due to sand, suspended particles, and pressure fluctuations

The MACH 10 provides a Neptune E-Coder® PLUS output signal to Neptune R900®, R450™, and other AMR/AMI endpoints. The MACH 10®R900™ contains a MACH 10 meter and an integrated R900 radio for transmitting meter reading data. The MACH 10®R450™ contains a MACH 10 meter and an integrated R450 radio for transmitting meter reading data.

The meter electronics and battery are permanently sealed to eliminate the intrusion of moisture, dirt, or other contaminants. It is suitable for installation in all environments, including meter pits subject to continuous submergence.

The MACH 10 meter can be installed using horizontal or vertical piping with no straight pipe requirements before or after the meter.

Figure 1  MACH 10 Ultrasonic Meter
Advantages of the MACH 10

The MACH 10 offers the following advantages over traditional mechanical technologies.

- Extended measuring range
- High accuracy sustained over the meter's life
- High repeatability
- High durability
- Minimal intrusion in the flow stream
- Unaffected by particles in the water
- Bidirectional flow capable
- Free of maintenance

Understanding Ultrasonic Technology

An ultrasonic water meter uses technology to measure the velocity of an acoustically-conductive liquid moving through it. The velocity of the water is then converted to volume throughput using sophisticated algorithms and electronics. The MACH 10 utilizes transit-time ultrasonic technology.

Transit-Time Technology

Transit-time technology takes advantage of the principle that an acoustic signal travels faster with the flow than against the flow. These meters have a pair of transducers that are essentially transceivers, sending and receiving the acoustic signals.
The transducer on the upstream side of the meter generates an acoustic signal that travels through the pipe along a predetermined path.

![Figure 3 Transducer - Upstream](image3)

The downstream transducer receives the signal, and the meter calculates how long it took to travel from one transducer to the other. This is referred to as \( t_1 \) or *time-down*.

![Figure 4 Transducer - Downstream](image4)

Next, the downstream transducer generates a signal that travels upstream along the same predetermined path. This is referred to as \( t_2 \) or *time-up*.

![Figure 5 Transducer - Back Upstream](image5)
The signal is received by the upstream transducer and the meter calculates how long it took to travel in the upstream direction. The difference between the downstream and upstream transit time is proportional to the flow rate.

The calculated velocity of the water is then converted to volume based on the meter size (pipe diameter) and by the algorithms and electronics in the register head and displayed on the liquid crystal display (LCD).

![Figure 6 Transducer - Calculated Velocity](image)

**Transducers**

In ultrasonic flow meters, high frequency sound waves are generated by applying a small voltage to the piezoelectric transducer in the meter. The opposite also occurs: an ultrasonic signal received by the transducer is converted to an electrical signal.

The transducer is simply a device that converts one type of energy to another. In this case, it converts the electrical energy to acoustical energy and vice versa. The actual frequency of the ultrasonic signal is determined by the characteristics of the transducer used in the specific application.

The ultrasonic signal propagates at the speed of sound. But the speed of sound is variable and depends on the medium through which it is traveling and the temperature of that medium. Therefore, ultrasonic meters are calibrated for a specific liquid and temperature range.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Speed (feet/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (0°C)</td>
<td>4599</td>
</tr>
<tr>
<td>Water (20°C)</td>
<td>4862</td>
</tr>
<tr>
<td>Water (25°C)</td>
<td>4898</td>
</tr>
</tbody>
</table>

Table 1 Speed of Sound (Approximate) in Water
Summary

The Neptune MACH 10 meter is a transit-time ultrasonic flow meter with wetted transducers. Designed as an alternative for small mechanical meters, the MACH 10 meter utilizes traditional utility pipe connectors and lay lengths. It is totally self-contained. The battery, processor circuit, and electronic display are fully potted and permanently sealed as an integral unit. The MACH 10 meter provides an E-CoderPLUS output signal to Neptune R900, R450, and other AMR/AMI endpoints. The MACH 10)R900i contains a MACH 10 meter and an integrated R900 radio for transmitting meter reading data. See Figure 18 on page 27. The MACH 10)R450i contains a MACH 10 meter and an integrated R450 radio for transmitting meter reading data. See Figure 20 on page 30.
2 MACH 10 Specifications

This chapter provides the specifications for the MACH 10.

Environmental Specifications

This section provides environmental specifications.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>-22° to 122°F (-30° to 50°C)</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-16° to 158°F (0° to 70°C)</td>
</tr>
<tr>
<td>Water temperature range</td>
<td>33° to 122°F (50°C)</td>
</tr>
<tr>
<td>Operating humidity</td>
<td>0 to 100% condensing; meter is capable of operating in fully submerged environments</td>
</tr>
</tbody>
</table>

Performance Specifications

This section provides performance specifications for the MACH 10.

<table>
<thead>
<tr>
<th>Table 2 Performance Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter Size</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>5/8 inch</td>
</tr>
<tr>
<td>3/4 inch</td>
</tr>
<tr>
<td>1 inch</td>
</tr>
</tbody>
</table>
Dimensions and Weight

This section provides the weight (see Table 3) and dimensions (Figure 7 and Table 4) of the MACH 10.

Table 3  Meter Weight

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8 inch</td>
<td>1.57 lbs</td>
</tr>
<tr>
<td>3/4 inch x 3/4 inch</td>
<td>2.9 lbs</td>
</tr>
<tr>
<td>1 inch x 1 inch</td>
<td>3.6 lbs</td>
</tr>
</tbody>
</table>

Figure 7  MACH 10 (5/8 inch) Dimensions

Table 4  MACH 10 Dimensions

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D NSPM</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8 inch</td>
<td>7-1/2 inch</td>
<td>4-7/8 inch</td>
<td>2-17/32 inch</td>
<td>1.030</td>
<td>0.69 inch</td>
</tr>
<tr>
<td>5/8 inch x 3/4 inch</td>
<td>7-1/2 inch</td>
<td>4-7/8 inch</td>
<td>2-17/32 inch</td>
<td>1.290</td>
<td>0.69 inch</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>9 inch</td>
<td>4-7/8 inch</td>
<td>2-19/32 inch</td>
<td>1.290</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>3/4 inch SL</td>
<td>7-1/2 inch</td>
<td>4-7/8 inch</td>
<td>2-19/32 inch</td>
<td>1.290</td>
<td>0.755 inch</td>
</tr>
</tbody>
</table>
MACH 10 Specifications

Additional Specifications

The following specifications are for the 5/8 inch and 5/8 inch x 3/4 inch meters.

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D NSPM</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch x 1 inch</td>
<td>9 inch</td>
<td>4-7/8 inch</td>
<td>2-19/32 inch</td>
<td>1.626</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>1 inch</td>
<td>10-3/4 inch</td>
<td>4-7/8 inch</td>
<td>2-19/32 inch</td>
<td>1.626</td>
<td>1 inch</td>
</tr>
<tr>
<td>1 inch x 1-1/4 inch</td>
<td>10-3/4 inch</td>
<td>4-7/8 inch</td>
<td>2-19/32 inch</td>
<td>1.865</td>
<td>1 inch</td>
</tr>
</tbody>
</table>

**Fluid Compatibility**

The MACH 10 meter is designed and calibrated for potable, combination potable and fire service, and reclaimed water across a defined temperature and velocity range.

**Maincase**

The meter maincase is manufactured using lead free bronze, and contains the wetted elements of the meter: two transducers, pressed in mirrors, and the flow conditioner.
Transducers

The piezoelectric transducer is the heart of the system. Although these transducers are very small, they have very high measurement dynamics. The transducers generate four 1-MHz ultrasonic signals every second, and the timing circuits are able to measure in the nanosecond range. This sampling rate offers superior accuracy to other solid state residential meters on the market today.

The signal path utilizes two stainless steel reflectors located in the center of the maincase. The transducers are permanently installed and the path length and angles are fixed. Each meter is factory calibrated. The calibration data is permanently stored in the meter.

The electronic circuity triggers the transducers, which generate and receive the ultrasonic signals. In addition, the circuitry provides highly-accurate time measurements through the use of enhanced algorithms and digital signal processing.

Battery Requirement

Solid state metering technologies require a battery to power the transducers and electronics, just like a radio MIU requires a battery to perform its functions. With the continued improvements made in battery technology, electronic metering utilizing internal batteries is practical today. The lithium thionyl-chloride battery technology used in the MACH 10 is designed for a 20-year life.
3 General Installation Guidelines

This chapter describes tools, materials, and general installation information for the MACH 10.

Tools and Materials

Tables 4 and 5 show the recommended tools and materials you need to successfully install the MACH 10.

Table 5 and Table 6 are not a complete list of tools and materials.

<table>
<thead>
<tr>
<th>Table 5 Recommended Tools</th>
<th>Description/Recommendation</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool Kit</td>
<td>Contains standard tools including:</td>
<td>Performing various installation procedures</td>
</tr>
<tr>
<td></td>
<td>• Screwdrivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pliers</td>
<td></td>
</tr>
<tr>
<td>Flashlight</td>
<td></td>
<td>Activating the LCD</td>
</tr>
<tr>
<td>Magnet</td>
<td>6 lb. force Part No: 12287-001</td>
<td>Activating the MIU</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6 Recommended Materials</th>
<th>Description/Recommendation</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Protection Compound</td>
<td>Novaguard sealant Part No: 96018-072</td>
<td>Connecting the pit antenna to the MIU</td>
</tr>
<tr>
<td>Site Work Order</td>
<td>Documentation provided by your utility</td>
<td>Receiving and recording information about the work site</td>
</tr>
</tbody>
</table>
Safety and Preliminary Checks

Observe the following safety and preliminary checks before and during each installation:

- Verify that you are at the location specified on the site work order.
- Verify that the site is safe for you and your equipment.
- Notify the customer of your presence, and tell the customer that you need access to the water meter.
- Write the ID number(s) of the MACH 10 meter(s) you are about to install on the site work order. If the site work order already has a MACH 10 ID number on it, verify that it matches the ID numbers on the MACH 10 you are about to install.

Installation and Application Considerations

This section provides information to consider before installing the MACH 10.

Water Temperature

The temperature range of the water is a factor in the selection of an ultrasonic meter, since the meter is calibrated to operate within a specified range. The MACH 10 meter is calibrated for water temperature (between either 33°F and 122°F or 1°C and 50°C) measuring applications.

Meter Installation

The MACH 10 meter can be installed using horizontal or vertical piping applications. The meter features standard laying lengths for ease of retrofit of mechanical meters. A flow direction arrow is visible on the side of the meter and on the top of the meter to aid in installation in the proper direction.

Water Flow

The MACH 10 meter is unable to measure flow when an empty pipe condition is detected. An empty pipe is defined as a condition when the ultrasonic sensors are not fully submerged. In this situation, the meter displays an alarm and no measurement occurs.

An ultrasonic meter is designed to sample the flow by sending ultrasonic signals at regular intervals. The MACH 10 meter samples the downstream and upstream flow multiple times per second. The sampling rate is set to maximize accuracy while balancing battery life.
Meter Sizing and Selection

Traditional meter sizing methods apply to both electronic meters and mechanical meters. That is, the maximum flow and maximum continuous flow rate requirements should be considered when selecting a meter. Mechanical meters allow a temporary flow at a rate higher than the maximum continuous flow. However, since electronic meters have no moving parts, these two specifications are identical: the maximum flow rate is also the maximum continuous flow rate.

The MACH 10 meter features a wider measuring span as compared to a positive displacement meter, including both a lower extended low flow rate and a higher maximum continuous flow rate.

Minimum Flow Rates

The MACH 10 has no moving parts and is capable of monitoring considerably lower flow rates accurately.
4 Installing MACH 10 Ultrasonic Meters

All MACH 10 ultrasonic meters are delivered activated and ready to be installed. When the meter lid is opened, the meter shows the empty pipe icon and the latest volume on the LCD. The empty pipe icon clears immediately after the condition is corrected and the pipe is full.

Installation Instructions for MACH 10 Meters

In outdoor settings, the meter and service line should be located deep enough in the ground to prevent freezing.

New Meter Installation

The following are steps for installation of the MACH 10 meter.

1  Flush the service line prior to meter installation in order to remove debris in the line.

2  Place an electrical grounding strap on the service line, connecting the inlet and outlet service lines on either side of the meter setting.

Install suitable inlet and outlet meter valves and couplings/setters if they are not already present. Allow appropriate space in the line for the meter laying length and two coupling gaskets. Align the pipe ends sufficiently so that the coupling and meter threads can engage without binding or cross-threading.

3  Remove the thread protectors and spud caps before installing the meter.

4  Be sure that no debris enters the meter during installation.

Use caution; the meter threads are sharp.

5  Place the coupling gaskets inside the coupling nuts and set the meter in the line.

The direction of flow marked on the meter must agree with the direction of water flow.
Installing MACH 10 Ultrasonic Meters

6 Start turning the coupling nuts by hand then use a wrench and tighten sufficiently to prevent leakage.

Be careful not to cross-thread the connections.

7 Open the upstream inlet valve.

8 Open the meter outlet valve slowly.

9 Open a downstream faucet and run enough water to dissipate entrained air and flush the line.

10 Check to see if the meter is operating correctly, while the faucet is open.

11 Turn OFF the faucet and check the meter installation for leaks.

Wiring the MACH 10 in the Field

If the meter is not a MACH 10)R900i, MACH 10)R450i or the stand alone version shipped prewired and potted to an MIU, complete the following steps to wire the MACH 10.

1 Hold the Scotchlok between the index finger and thumb with the red cap facing down. See Figure 8.

Figure 8 Scotchlok Connector

2 Take one non-stripped black wire from the pigtail and one from the receptacle/MIU.

3 Insert the wires into the Scotchlok connector.

4 Insert the insulated color wires directly into the Scotchlok connector until fully seated. See Figure 9.

Figure 9 Seating Connector Wires

Do not strip the colored insulation from the wires or strip and twist the bare wires prior to inserting in the connector. Insert the insulated colored wires directly into the Scotchlok connector.
5 Place the connector red cap side down between the jaws of the UR crimping tool as shown in Figure 10.

6 Check to ensure that the wires are still fully seated in the connector before crimping the connector.

Figure 11 illustrates improper connections due to wires not fully seated.

7 Squeeze the connector firmly with the proper crimping tool until you hear a pop, and the gel leaks out the end of the connector.

8 Repeat steps 1 through 5 for each color wire. See Table 7.

---

### Table 7 Color Codes for Wires

<table>
<thead>
<tr>
<th>MIU Wire Color / MACH 10 Wire Color</th>
<th>MIU Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/B Green/G Red/R</td>
<td>R900</td>
</tr>
<tr>
<td>Black/B Green/G Red/R</td>
<td>R450</td>
</tr>
<tr>
<td>Black/G Green/R Red/B</td>
<td>Sensus</td>
</tr>
<tr>
<td>Black/B White/G Red/R</td>
<td>Itron</td>
</tr>
<tr>
<td>Black/G White/R Red/B</td>
<td>Aclara</td>
</tr>
<tr>
<td>Black/G Green/B Red/R</td>
<td>Elster</td>
</tr>
<tr>
<td>Black/G Green/R Red/B</td>
<td>Badger</td>
</tr>
</tbody>
</table>
Completing the Wiring

1. After you connect all three color wires, read the encoder register to ensure proper connections and the receptacle/MIU is functioning properly. See Figure 12.

2. Take all three connected Scotchlok’s and push into the splice tube until fully enclosed by the silicone grease. See Figure 13.

3. Separate each gray wire and place in the slots on each side as shown in Figure 14.

4. Snap the cover closed to finish the installation as shown in Figure 15.
5 Activating and Reading MACH 10 Ultrasonic Meters

This chapter explains the operations of the MACH 10 ultrasonic meter.

Activating the LCD Meter Display

The light sensor is located in the center of the faceplate of the MACH 10, and it supplies the power for the LCD panel. See Figure 16.

![MACH 10 Faceplate](image)

Figure 16  MACH 10 Faceplate

Timeout Period

Typically, the display is OFF. The meter includes a light sensor used to activate the LCD when you open the meter. A timed out LCD can not be reactivated just by shining a light on the light sensor. In order to reset the meter, close and re-open the lid.

Meter Display

The Neptune MACH 10 ultrasonic meters use a nine-digit LCD to show consumption, flow rate, and alarm information.
**LCD Panel**

Figure 17 shows the LCD panel with the icons and their descriptions.

![MACH 10 LCD Panel](image)

The LCD can display commas or decimals, depending on the configuration of each register, to show digits in the tens position, ones position, tenths position, and so forth. For example, some registers display 1,234,567.89. Others display 123,456.789, 12,345,678.9 or 1,234,567,89 depending on the need of the meter/register combination. (Zeros are not shown on the screen.)

**How to Read**

It is important to become familiar with the information available from the meter. The icons and displays provide helpful information. See Table 8 on page 19.

**Alarms**

Indicators and alarms appear in the display as symbols that illuminate when the condition is active and disappear when the alarm condition is eliminated.

**LCD Icons**

Table 8 on page 19 shows the LCD icons on the MACH 10, a description of each one, and describes how they are status indicators.
Consumption and Unit of Measure

The consumption display contains all nine digits, including leading zeros and a decimal point. The value displayed is the sum of the forward flow minus the reverse flow. The dial face framing the LCD has black and white markings to represent the equivalent of white and black number wheels on mechanical registers.

### Table 8 MACH 10 Icons and Displays

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
<th>Status</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak</td>
<td>Icon used to indicate a leak. Leak status is determined by keeping track of the number of 15-minute intervals where the volume consumption exceeds Vmin in the previous 24-hour period. Vmin is factory programmed depending on meter size. It is defined as a change of the 9th digit of the LCD.</td>
<td>OFF</td>
<td>Number of 15-minute intervals &lt;50.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flashing</td>
<td>50 ≤ Number of 15-minute intervals &lt; 95.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous ON</td>
<td>Number of 15-minute intervals ≥ 95.</td>
</tr>
<tr>
<td>Forward and reverse flow</td>
<td>Icons used to indicate the forward and reverse direction of flow.</td>
<td>OFF</td>
<td>Rate of flow &lt; 0.01 GPM.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous ON</td>
<td>Rate of flow &gt; 0.01 GPM.</td>
</tr>
<tr>
<td>High flow warning</td>
<td>Icon used to indicate excessive flow which can be a burst pipe.</td>
<td>OFF</td>
<td>Rate of flow &lt; 20 GPM.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ON</td>
<td>Rate of flow exceeds 20 GPM for more than 30 minutes.</td>
</tr>
<tr>
<td>Empty pipe</td>
<td>Icon used to indicate if the pipe is empty or there is excessive air in the line. If this occurs, there is no receive signal in the expected time window.</td>
<td>OFF</td>
<td>Typically OFF. If the icon has been ON, it is switched OFF if &gt;10 correct samples are received in a row.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ON</td>
<td>Turned ON if no receive signal is seen for 1 minute.</td>
</tr>
<tr>
<td>Battery status</td>
<td>Icon used to indicate time and voltage of remaining battery life.</td>
<td>OFF</td>
<td>&gt;1 year of battery life remaining. Time since first power ON &lt; 19 years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous ON</td>
<td>&lt;1 year of battery life remaining. Time since first power ON &gt; 19 years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous FLASHING</td>
<td>Low battery or time since first power ON &gt; 20 years.</td>
</tr>
</tbody>
</table>
Activating and Reading MACH 10 Ultrasonic Meters

The unit of measure and resolution are factory programmed and options include gallons, cubic feet, and cubic meters.

For 5/8 inch through 1 inch meters, totalized flow displays up to one million gallons with a resolution of 0.01 gallons, one hundred thousand cubic feet with a resolution of 0.001 cubic feet, or ten thousand cubic meters with a resolution of 0.0001 cubic meters. See Table 9.

### Table 9 Consumption and Units of Measure

<table>
<thead>
<tr>
<th>Size</th>
<th>Gallons</th>
<th>Cubic Feet</th>
<th>Cubic Meters</th>
<th>Gallons</th>
<th>Cubic Feet</th>
<th>Cubic Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>10,000,000</td>
<td>1,000,000</td>
<td>100,000</td>
<td>0.01</td>
<td>0.001</td>
<td>0.0001</td>
</tr>
<tr>
<td>3/4</td>
<td>10,000,000</td>
<td>1,000,000</td>
<td>100,000</td>
<td>0.01</td>
<td>0.001</td>
<td>0.0001</td>
</tr>
<tr>
<td>1</td>
<td>10,000,000</td>
<td>1,000,000</td>
<td>100,000</td>
<td>0.01</td>
<td>0.001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

#### Rate of Flow

The rate of flow is factory programmed for either gallons per minute or liters per minute. The LCD displays both the unit of measure and rate of flow. The rate of flow display also serves as the flow finder indicator. The rate of flow display is shown without leading zeros. When rate of flow is displayed, it is updated every two seconds.

#### Flow Direction

An arrow on the electronic register housing shows the direction of flow. Current flow direction can be viewed on LCD panel.

#### AMR/AMI Output

The Neptune MACH 10 ultrasonic meter is a compact design where the electronic register is fully potted and permanently sealed to the meter maincase. The meter provides E-CoderPLUS protocol which is high resolution. It communicates status indicators to Neptune R900 and R450 RF endpoints as part of the extended encoder/meter reading message. The meter also provides ProRead™ protocol for third-party endpoints that are not capable of reading E-Coder 8-digit or PLUS protocol.
Endpoint Reading Resolution

The reading resolution sent to the reading software is dependent on the endpoint to which the encoder is connected. Readings reported from the endpoints are the left-most significant digits of the encoder reading. See Table 10.

### Table 10 Reading Resolution

<table>
<thead>
<tr>
<th>Size</th>
<th>Gallons</th>
<th>Cubic ft</th>
<th>Cubic m</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>10</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>3/4</td>
<td>10</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Wiring Chart

Refer to Table 11 for wiring considerations.

### Table 11 MACH 10 Wiring Chart

<table>
<thead>
<tr>
<th>MIU Wire Color / MACH 10 Wire Color</th>
<th>MIU Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/B White/G Red/R</td>
<td>Itron</td>
</tr>
<tr>
<td>Black/G Green/B Red/R</td>
<td>Elster</td>
</tr>
<tr>
<td>Black/G Green/R Red/B</td>
<td>Aclara</td>
</tr>
<tr>
<td>Black/G White/G Red/R</td>
<td>Sensus</td>
</tr>
<tr>
<td>Black/G Green/R Red/B</td>
<td>R450</td>
</tr>
<tr>
<td>Black/B Green/G Red/R</td>
<td>R900</td>
</tr>
</tbody>
</table>
Bench Testing the Meter

Unlike other solid state meters that have been introduced to the market, the Neptune MACH 10 ultrasonic meter has been designed to be bench tested as a traditional PD meter.

More Information

See Appendix A on page 25 for information on the MACH 10)R900i meter. See Appendix B on page 29 for information on the MACH 10)R450i.
6 Maintenance and Troubleshooting

This chapter provides information for maintaining and troubleshooting the MACH 10.

Maintenance

Mechanical meters are subject to wear and are often rebuilt to extend their life. On the other hand, the electronic MACH 10 meter does not have moving parts and requires no maintenance. The meter enclosure, which contains electronics, transducers, battery, and display, is completely potted and permanently sealed eliminating any maintenance. At the end of its twenty-year life, the meter is simply replaced.

Replacement Parts

There are no replacement parts for the MACH 10 ultrasonic meter. If the plastic meter lid becomes damaged or broken, it can be replaced.

Troubleshooting

There are some conditions that can occur such as the following:

- Battery is at low power.
- Meter starts sending colons.
- Communication stops.

Checklist

Before leaving the installation site, be sure to do the following.

- Record the MIU ID for each register.
- Verify that you have followed all requirements of this Installation and Maintenance Guide.
- Verify that you have recorded all required information.
- Clean up any installation debris.
- Verify that the requirements of the Site Work Order have been completed.
- Inform the customer that you have completed your work. If you were unable to finish, inform the customer when you are returning to complete the project.
Contact Information

Within North America, Neptune Customer Support is available Monday through Friday, 7:00 AM to 5:00 PM Central Standard Time, by telephone, email, or fax.

By Phone

To contact Neptune Customer Support by phone, complete the following steps.

1. Call (800) 647-4832.

2. Select one of the following options:
   - Press 1 if you have a Technical Support Personal Identification Number (PIN).
   - Press 2 if you do not have a Technical Support PIN number.

3. Enter the six-digit PIN number and press #.

4. Select one of the following options.
   - Press 2 for Technical Support.
   - Press 3 for maintenance contracts or renewals.
   - Press 4 for Return Material Authorization (RMA) for Canadian Accounts.

You are directed to the appropriate team of Customer Support Specialists. The specialists are dedicated to you until the issue is resolved to your satisfaction. When you call, be prepared to give the following information.

- Your name and utility or company name.
- A description of what occurred and what you were doing at the time.
- A description of any actions taken to correct the issue.

By Fax

To contact Neptune Customer Support by fax, send a description of your problem to (334) 283-7497. Please include on the fax cover sheet the best time of day for a customer support specialist to contact you.

By Email

To contact Neptune Customer Support by email, send your message to hhsupp@neptunetg.com.
Appendix A: MACH 10)R900i

This appendix provides a general description of the MACH 10)R900i.

Product Description

The MACH 10)R900i is manufactured by Neptune and is an integrated register that contains both the MACH 10 meter and the R900 technologies in one register that collects meter reading data. It then transmits the data for collection by the meter reader. A Neptune walk-by, mobile, or R900® Gateway fixed network data collection system receives the data and stores it to be downloaded into the utility billing system for processing.

The MACH 10)R900i is easily installed and operates within an RF band, which does not require an operating license. The MACH 10)R900i meets FCC regulations part 15.247 allowing higher output power and greater range. The MACH 10)R900i uses frequency-hopping spread spectrum (FHSS) technology to avoid RF interference and enhance security. The transmitted data is updated at 15-minute intervals. It transmits a mobile message that includes the meter reading data and the unique 10-digit MACH 10)R900i ID every 14 seconds. This allows the meter to be read by a handheld unit (HHU) or mobile data collection unit. The MACH 10)R900i also transmits a high power fixed network message every seven and one-half minutes on an interleaved basis to an R900® Gateway.

The MACH 10)R900i is designed to offer advantages to utility organizations of all sizes.

- Increases meter reading accuracy
- Eliminates hard-to-read meters
- Protects utility liability by increasing meter reader safety
- Requires no external wiring or programming
- Provides enhanced 8-digit AMR meter reading
- Provides proactive customer service benefits (leak, tamper, and backflow detection)

MACH 10)R900i Programming

The MACH 10)R900i is not field-programmable. Each MIU is given a unique 10-digit serial number/identification number.

RF Protocol Error Detection

The RF protocol is comprised of a header, data packet, and an error detection mechanism that reduces the erroneous data.
RF Frequency Control Algorithm

The MIU’s FHSS has a sequence of at least 50 different channels for transmitting data. Associated with the 50 channels are 50 frequencies that are preselected in a pseudo-random manner. These 50 frequencies are coded into the software.

RF Transmission Period and Randomness

The random period generation uses the same random seed created for the channel definition to generate the transmission randomness. The randomness algorithm is defined so that no two consecutive transmissions from two MIUs interfere with one another.

MACH 10)R900i Specifications

This section provides you with the specifications for the MACH 10)R900i.

Electrical Specification

- Power: Lithium battery

Transmitter Specifications

- Transmit Period:
  - Every 14 seconds - standard mobile message.
  - Every seven and one-half minutes - standard, high power, fixed network message.

- Transmitter Channels: 50
- Channel Frequency: 910-920 MHZ
- Output Power: Meeting FCC Part 15.247
- FCC Verification: Part 15.247

Environmental Conditions

- Operating temperature: -14º to 149ºF (-10º to +65ºC)
- Storage temperature: -40º to 158ºF (-40º to 70ºC)
- Operating humidity: 0 to 100% condensing (pit only)

Functional Specifications

- Register Reading: 8 digits (AMR), 9 digits (Visual)
- MIU ID: 10 digits
Dimensions

The dimensions of the MACH 10)R900i are shown in Figure 18 and Figure 19.

![MACH 10)R900i Top View](image)

![MACH 10)R900i Side View](image)

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D NSPM</th>
<th>E</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8 inch</td>
<td>7-1/2 inch</td>
<td>6-5/8 inch</td>
<td>2-17/32 inch</td>
<td>1.030</td>
<td>3.25 inch</td>
<td>0.69 inch</td>
</tr>
<tr>
<td>5/8 inch x 3/4 inch</td>
<td>7-1/2 inch</td>
<td>6-5/8 inch</td>
<td>2-17/32 inch</td>
<td>1.290</td>
<td>3.25 inch</td>
<td>0.69 inch</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>9 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.290</td>
<td>3.25 inch</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>3/4 inch SL</td>
<td>7-1/2 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.290</td>
<td>3.25 inch</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>3/4 inch x 1 inch</td>
<td>9 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.626</td>
<td>3.25 inch</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>1 inch</td>
<td>10-3/4 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.626</td>
<td>3.25 inch</td>
<td>1 inch</td>
</tr>
<tr>
<td>1 inch x 1-1/4 inch</td>
<td>10-3/4 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.865</td>
<td>3.25 inch</td>
<td>1 inch</td>
</tr>
</tbody>
</table>
Notes:
Appendix B: MACH 10)R450i

This appendix provides a general description of the MACH 10)R450i. The MACH 10)R450i by Neptune is an integrated register that contains both the MACH 10 meter and R450 technologies in one register that collects meter reading data. It then transmits the data for collection by the meter reader. A Neptune fixed network data collection system receives the data and stores it to be downloaded to the utility billing system for processing. The MACH 10)R450i can be upgraded and configured. At the factory, serial numbers are programmed into the MACH 10)R450i. Each MACH 10)R450i has a unique serial number/identification number. Custom serial numbers are not available.

RF Protocol Error Detection

The RF protocol is comprised of a header, data packet, and an error detection mechanism that reduces the erroneous data.

Low Battery RF Emissions

The MACH 10)R450i does not produce out-of-band emissions under low battery conditions. The MACH 10)R450i is easy to install and requires a Federal Communications Commission (FCC) license to operate. For information on obtaining an FCC license, refer to “FCC Licensing” in the R450™ System New Customer Guide.

MACH 10)R450i Specifications

This section provides you with the specifications for the MACH 10)R450i.

Environmental Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>-14º to 149ºF (-10º to +65ºC)</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-40º to 158ºF (-40º to 70ºC)</td>
</tr>
<tr>
<td>Operating humidity</td>
<td>0 to 100% condensing</td>
</tr>
</tbody>
</table>

Functional Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register reading</td>
<td>8 digits (AMR)</td>
</tr>
<tr>
<td></td>
<td>9 digits (Visual)</td>
</tr>
<tr>
<td>MACH 10)R450i ID</td>
<td>10 digits</td>
</tr>
</tbody>
</table>
Dimensions and Weight

This section provides the dimensions of the MACH 10)R450i.

![Top View](image1.png)

**Figure 20  MACH 10)R450i Top View**

![Side View](image2.png)

**Figure 21  MACH 10)R450i Side View**

<table>
<thead>
<tr>
<th>Meter Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D NSPM</th>
<th>E</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8 inch</td>
<td>7-1/2 inch</td>
<td>6-5/8 inch</td>
<td>2-17/32 inch</td>
<td>1.030</td>
<td>3.00 inch</td>
<td>0.69 inch</td>
</tr>
<tr>
<td>5/8 inch x 3/4 inch</td>
<td>7-1/2 inch</td>
<td>6-5/8 inch</td>
<td>2-17/32 inch</td>
<td>1.290</td>
<td>3.00 inch</td>
<td>0.69 inch</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>9 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.290</td>
<td>3.00 inch</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>3/4 inch SL</td>
<td>7-1/2 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.290</td>
<td>3.00 inch</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>3/4 inch x 1 inch</td>
<td>9 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.626</td>
<td>3.00 inch</td>
<td>0.755 inch</td>
</tr>
<tr>
<td>1 inch</td>
<td>10-3/4 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.626</td>
<td>3.00 inch</td>
<td>1 inch</td>
</tr>
<tr>
<td>1 inch x 1-1/4 inch</td>
<td>10-3/4 inch</td>
<td>6-5/8 inch</td>
<td>2-19/32 inch</td>
<td>1.865</td>
<td>3.00 inch</td>
<td>1 inch</td>
</tr>
</tbody>
</table>
Activating the MACH 10)R450i

Complete the following steps to activate and test the MACH 10)R450i.

1. Position the magnet over the magnetic area on MACH 10)R450i, as shown in Figure 22.

2. Start at the bottom of the register box and bring the magnet up towards the top.

Result of Activation

After the MACH 10)R450i is activated:

- The MACH 10)R450i transmits its configuration packet to the collector approximately 30 seconds following the magnet swipe.

- The MACH 10)R450i sends the register reading to the collector approximately 15 seconds following the configuration packet.

- When the collector receives the configuration packet, the host sends an email or Short Message Service (SMS) confirmation to the installer to allow for verification of proper installation and MACH 10)R450i location. The following is an example of the email text.

Example of MACH 10)R450i Config Email
Subject: 1224/G/-89/US 29/MIU Config
MIU RSSI.................Pass[-93]
Collector RSSI........Pass[-89]
Register................Valid Read
Collector..............US 29
Signal/Noise............37
Noise...................126
MIU ID.................110001224
================================

During the 30 seconds before the configuration transmission, the MACH 10)R450i acquires the strongest R450 Data Collector (R450 DC) for that location.
The subject line of the email provides a quick summary of the detailed information which is included. Table 14 provides a breakdown of the highlights of the email.

### Table 14 Config Email Subject Line Breakdown

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1224</td>
<td>Last 4 digits of MIU ID</td>
</tr>
</tbody>
</table>
| G     | Valid read. There are three types of reads:  
|       | • G = Valid read  
|       | • B = Bad read  
|       | • N = No register |
| -89   | R450 DC Received Signal Strength Indicator (RSSI) |
| US 29 | Data Collector name. |

#### RSSI Values and R450™ System Capabilities

Signal Strength (RSSI value) is a key indicator of the R450 System health as well as the communication capabilities of the MACH 10)R450i to and from the R450 DC.

These values are associated with *Uplink*, the ability of the R450 DC to hear reading information from the MACH 10)R450i, and *Downlink*, the ability of the MACH 10)R450i to hear instructions from the R450 DC.

The MACH 10)R450i Config Email provides feedback on the RSSI values between the MACH 10)R450i and the collector following MIU activation. Depending on the RSSI values recorded, the system indicates the following values:

- Pass
- Marginal
- Fail

RSSI values in the Pass range are required for both *Uplink* and *Downlink* to ensure full, two-way capabilities of the MACH 10)R450i as part of the R450 System. See Table 15 and Table 16 on page 33.
Other Sample Configuration Emails

**RSSI Validation Test Failed**

If a MACH 10)R450i fails the validation test for RSSI during the installation process, an installer receives an email or SMS showing a *Marginal* or *Failed* RSSI value. In the following example email, note the *Failed* downlink value (-107) as well as the *Marginal* uplink value (-107).

Subject: 0042/G/-107/ Collector One/MIU Config
MIU <- Coll............... Failed[-107]
Coll <- MIU................. Marginal[-107]
Register................... Valid Read
Collector................. Collector One
Signal/Noise.............. 23
Noise...................... 130
MIU id..................... 110500042

<table>
<thead>
<tr>
<th>RSSI Description</th>
<th>RSSI Values</th>
<th>Result in Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>RSSI &gt;= -105</td>
<td>Reliable daily readings and profile</td>
</tr>
<tr>
<td>Marginal</td>
<td>-115 &lt;= RSSI &lt; -105</td>
<td>Occasionally missed daily readings and profile data</td>
</tr>
<tr>
<td>Fail</td>
<td>RSSI &lt; -115</td>
<td>Very poor readings performance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RSSI Description</th>
<th>RSSI Values</th>
<th>Result in Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>RSSI &gt;= -95</td>
<td>Full capability</td>
</tr>
<tr>
<td>Marginal</td>
<td>-105 &lt;= RSSI &lt; -95</td>
<td>Occasional two-way capability - not reliable</td>
</tr>
<tr>
<td>Fail</td>
<td>RSSI &lt; -105</td>
<td>MACH 10)R450i not capable of two-way communications</td>
</tr>
</tbody>
</table>
Register Test Failed

If a MACH 10)R450i fails the error-check test on the register read during the installation process, an installer receives the email below. This indicates that there is a problem with the wiring to the register.

Subject: 1776/B/-117/Collector Four/MIU Config
MIU <- Coll............. Failed[-109]
Coll <- MIU............. Failed[-117]
Register................. Register Connectivity Problem
Collector................. Collector Four
Signal/Noise............. 13
Noise................... 130
MIU id................... 11018177

Completing the Activation

Perform one or all of the following actions to complete activation.

<table>
<thead>
<tr>
<th>If...</th>
<th>Then...</th>
</tr>
</thead>
<tbody>
<tr>
<td>A valid register connection and acceptable RSSI values are reported.</td>
<td>Proceed to “MACH 10)R450i Specifications” on page 29.</td>
</tr>
<tr>
<td>The MACH 10)R450i does not report acceptable RSSI values.</td>
<td>Check the antenna.</td>
</tr>
<tr>
<td>The register connection is returned as invalid.</td>
<td>Proceed to &quot;Checklist&quot;.</td>
</tr>
</tbody>
</table>

Completing the MACH 10)R450i Installation

This sections provides a check list for completing installation,

Checklist

Before leaving the installation site, be sure to do the following.

- Record the MACH 10)R450i ID for each register.
- Verify that you have followed all requirements of this installation and maintenance guide.
- Verify that you have recorded all required information.
- Clean up any installation debris.
- Verify that the requirements of the Site Work Order have been completed.
- Inform the customer that you have completed your work. If you were unable to finish, inform the customer when you will be back to complete the project.
Appendix C: MACH 10)R900i Flags

Description of Flags

Two tables in this appendix describe the volume represented by the 8th digit by meter size, and the flags used by the MACH 10)R900i.

Table 18 8th Digit Resolution by Meter Size

<table>
<thead>
<tr>
<th>Register Size</th>
<th>8th Digit Resolution - Least Significant Digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (5/8 inch - 1 inch T-10)</td>
<td>1/10 Gallon or 1/100 Cubic feet</td>
</tr>
<tr>
<td>Light Commercial and Industrial (1-1/2 inch - 4 inch HPT)</td>
<td>1 Gallon or 1/10 Cubic feet</td>
</tr>
<tr>
<td>Large Commercial and Industrial (6 inch - 12 inch HPT, HPPII and TRU/FLO)</td>
<td>10 Gallons or 1 Cubic feet</td>
</tr>
<tr>
<td>Large Commercial and Industrial (16 inch - 20 inch HPT)</td>
<td>100 Gallons or 10 Cubic feet</td>
</tr>
</tbody>
</table>

Table 19 MACH 10)R900i Flags (digits)

<table>
<thead>
<tr>
<th>Backflow Flag (Resets After 35 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on reverse movement of the 8th digit; 8th digit is variable based on the meter size</td>
</tr>
<tr>
<td>No backflow event</td>
</tr>
<tr>
<td>Minor backflow event</td>
</tr>
<tr>
<td>Major backflow event</td>
</tr>
</tbody>
</table>
### Table 20  MACH 10)R900/ Flags (minutes)

<table>
<thead>
<tr>
<th>Leak Status Flag (Resets After 35 Days)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak icon off</td>
<td>8th digit incremented less than 50 of the 96 15-minute intervals</td>
</tr>
<tr>
<td>Flashing leak icon</td>
<td>8th digit incremented in 50-95 of the 96 15-minute intervals</td>
</tr>
<tr>
<td>Solid leak icon</td>
<td>8th digit incremented in all of the 96 15-minute intervals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consecutive Days with Zero Consumption Flag (Resets After 35 Days)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days the leak status was at a minimum value</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>empty pipe</td>
<td>Condition whenever the measuring element is not completely filled with water.</td>
</tr>
<tr>
<td>light sensor</td>
<td>Component located under the recess that is used to activate the LCD. See Liquid Crystal Display.</td>
</tr>
<tr>
<td>Liquid Crystal Display (LCD)</td>
<td>Component where the meter reading and value-added icons are displayed.</td>
</tr>
<tr>
<td>MIU</td>
<td>Meter Interface Unit.</td>
</tr>
<tr>
<td>piezoelectric</td>
<td>Generation of electricity or of electric polarity in dielectric crystals subjected to mechanical stress, or the generation of stress in such crystals subjected to an applied voltage.</td>
</tr>
<tr>
<td>register read time</td>
<td>Default time is once an hour for ProRead and 15-minute intervals for E-Coder (ARB VII). Custom time is not available.</td>
</tr>
<tr>
<td>serial number</td>
<td>Unique identification number given to each meter at the factory. The default value is the last programmed plus one. Custom serial numbers are not available.</td>
</tr>
<tr>
<td>time-down</td>
<td>Length of time a signal takes to travel downstream from one transducer to the other.</td>
</tr>
<tr>
<td>time-up</td>
<td>Length of time a signal takes to travel upstream along the same predetermined path.</td>
</tr>
<tr>
<td>transceiver</td>
<td>Device that transmits and receives communications, in particular a combined radio transmitter and receiver.</td>
</tr>
<tr>
<td>transducer</td>
<td>Device that converts one form of energy to another form of energy.</td>
</tr>
<tr>
<td>transit-time</td>
<td>Technology that takes advantage of the principle that an acoustic signal travels faster with the flow than against the flow.</td>
</tr>
<tr>
<td>transmission time</td>
<td>Time between MIU transmissions. The default is approximately 14 seconds. Custom time is not available.</td>
</tr>
<tr>
<td>ultrasonic flow</td>
<td>Use of ultrasonic technology to measure the velocity of an acoustically conductive liquid or gas moving through it. The velocity of the water is then converted to volume throughput using sophisticated algorithms and electronics.</td>
</tr>
<tr>
<td>ultrasonic meter</td>
<td>Electronic meter using ultrasonic technology and solid state electronics contained in a compact, totally encapsulated, weatherproof, and ultra violet (UV) resistant housing for residential and light commercial applications.</td>
</tr>
<tr>
<td>Vmin</td>
<td>Change of the 9th digit of the LCD. It is factory programmed depending on meter size.</td>
</tr>
<tr>
<td>wetted</td>
<td>Process of covering or touching with liquid, moisten.</td>
</tr>
</tbody>
</table>
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