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Commercial and Industrial MACH 10[®] Ultrasonic Meter Installation and Maintenance Guide



Commercial and Industrial MACH 10[®] Ultrasonic Meter
Installation and Maintenance Guide

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This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- 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 to 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.



Changes or modifications not expressly approved by the party responsible for compliance could void the users' authority to operate the equipment.

Professional Installation

In accordance with section 15.203 of the FCC rules and regulations, the Neptune Meter Interface Unit (MIU) must be professionally installed by trained meter installers. Changes or modifications not expressly approved by the party responsible for compliance void the user's authority to operate the equipment.

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This Class B digital apparatus meets all requirements of the Canadian Interference Causing Equipment Regulations. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

Cet appareillage 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.

Commercial and Industrial MACH 10[®]
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Chapter 1: Product Description

This chapter provides a general description of the 3-inch to 6-inch Neptune® Commercial and Industrial MACH 10® Ultrasonic Meter (C&I MACH 10).

Introduction

Ultrasonic technology:

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



The MACH 10 solid state meter uses ultrasonic transit-time technology and solid state electronics. The C&I meter register is contained in a compact, totally encapsulated, weatherproof, and ultraviolet (UV) resistant housing for commercial and industrial applications.

The C&I MACH 10® ultrasonic water meter features solid state ultrasonic technology including a factory-calibrated, replaceable unitized measuring element (UME) with no degradation of accuracy over time.

Combined with a corrosion-resistant, lead free, high-copper alloy maincase, the C&I MACH 10 is built to withstand any demanding service condition and deliver sustained accuracy over the life of the meter.

The C&I MACH 10 provides a Neptune E-CoderPLUS output signal to Neptune R900® and other Automatic (or automated) Meter Reading (AMR) / Advanced Metering Infrastructure (AMI) endpoints.

The meter's electronics and battery are fully potted to eliminate the intrusion of moisture, dirt, or other contaminants. It is suitable for installation in all environments including meter pits subject to continuous flooding.



Figure 1 – 3-Inch Commercial and Industrial MACH 10® Ultrasonic Meter

Understanding Ultrasonic Technology

An ultrasonic water meter uses high-frequency sound waves to measure the velocity of an acoustically-conductive fluid moving through it. The velocity of the fluid is then converted to volume throughput using sophisticated algorithms and electronics.

Transit-Time Technology

The MACH 10 utilizes *transit-time* ultrasonic technology. This technology takes advantage of the principle that an acoustic signal travels faster with the flow than against the flow of the fluid. These meters use transducers that are essentially transceivers, sending and receiving the acoustic signals.

In the following image, the dashed lines show the acoustic path.

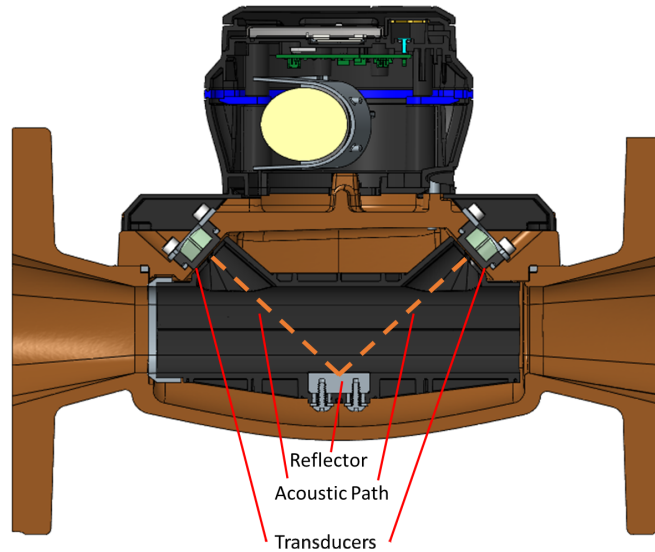


Figure 2 – Cross-Section of a 3-Inch Commercial and Industrial MACH 10®

The difference between the downstream and upstream transit time—the time it takes for the signal to travel from one transducer set to the other—is proportional to the flow rate.

The calculated velocity of the water is then converted to volume based on the area of the measurement section.

Summary

The MACH 10 meter is a transit-time ultrasonic flow meter with wetted transducers. Designed as an alternative for mechanical meters, the MACH 10 meter utilizes traditional utility pipe connectors and lay lengths. It is totally self-contained. The C&I MACH 10 battery, processor circuit, and electronic display are fully potted and housed in a replaceable UME. The UME is totally self-contained which not only minimizes field maintenance, but also eliminates the need to remove the main case from service.

The MACH 10 meter provides an E-CoderPLUS output signal to Neptune R900[®] and other AMR / AMI endpoints. The MACH 10[®])R900i[™] contains a MACH 10 meter and an integrated R900 radio for transmitting meter reading data.



Figure 3 – Unitized Measuring Element

Chapter 2: Commercial and Industrial MACH 10[®] Specifications

This chapter provides the specifications for the C&I MACH 10[®] Ultrasonic Meter.

Environmental and Performance Specifications

This table defines environmental specifications that apply to the C&I MACH 10 meters.

Table 1 – Environmental Specifications

Specification	Description
Operating temperature	14° to 149° F (-10° to 65° C)
Storage temperature	-40° to 158° F (-40° to 70° C)
Water temperature*	33° to 122° F (+0.5° to 50° C)
Operating humidity	0 to 100% condensing

* Meets AWWA C-715 accuracy specifications for water temperatures from 33° to 122° F (+0.5 C to 50° C).

This table defines performance specifications that apply to C&I MACH 10 meters.

Table 2 – Performance Specifications

Meter Size	Extended Low Flow @ 100% Accuracy (U.S. gpm, ± 3%)	Normal Operating Range @ 100% Accuracy (U.S. gpm, ± 1.5%)	Safe Maximum Operating Capacity (U.S. gpm)	
			Standard	Fire Services
3 inch	0.50	.75 to 500	500	420
4 inch	0.75	1.5 to 1250	1250	1100
6 inch	1.0	2.0 to 2000	2000	1800

Weight and Dimension Specifications

The following tables define the weight and dimension specifications for the C&I MACH 10 meter.

**Table 3 – Commercial and Industrial MACH 10®
Meter Weight Specifications**

Meter Size	Length (in Inches)	Weight
3 Inch	12	39 lbs.
	17	42 lbs.
4 Inch	14	51 lbs.
	20	57 lbs.
6 Inch	18	79 lbs.
	24	91 lbs.

Dimensions

This section defines the dimensions of the Commercial and Industrial MACH 10 meter.

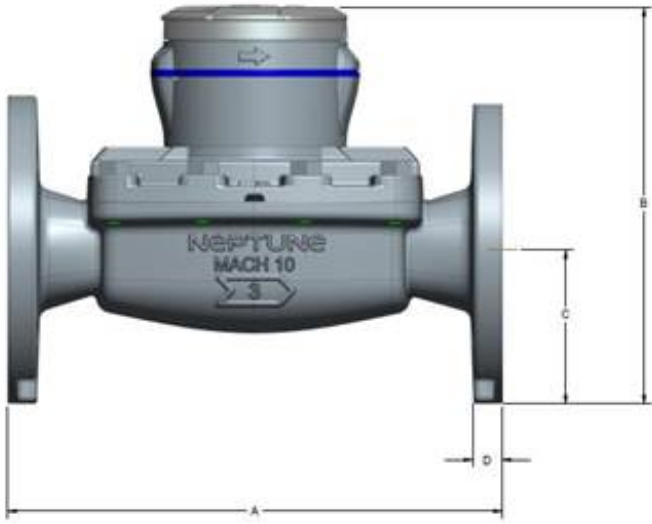


Figure 4 – Commercial and Industrial Meter Dimensions – Side View

The following table defines the dimensions for the MACH 10 meter. All measurements are in inches.

Table 4 – Commercial and Industrial MACH 10® Meter Dimensions

Meter Size	A	B	C	D	E
3 inch	12.00 or 17.00 inches	9.65 inches	3.75 inches	0.71 inches	7.50 inches
4 inch	14.00 or 20.00 inches	10.94 inches	4.50 inches	0.71 inches	9.00 inches
6 inch	18.00 or 24.00 inches	12.73 inches	5.50 inches	0.71 inches	11.00 inches

Additional Specifications

The following specifications are for the 3-inch to 6-inch C&I meters.

Table 5 – Additional Specifications

Specification	Description
Maximum operating pressure of meter housing	175 psi (12 bar).
Register type	Straight reading, permanently sealed electronic Liquid Crystal Display (LCD); digits are 0.28" (7 mm) high.
Register display	<ul style="list-style-type: none"> • Consumption (up to nine digits). • Rate of flow. • Alarms. • Unit of measure factory programmed for gallons, cubic feet, or cubic metres.
Battery	3.6 volt lithium thionyl-chloride; battery is encapsulated within the replaceable UME.

Fluid Compatibility

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

Maincase

The C&I MACH 10 meter maincase is manufactured using lead free bronze and is a pressure vessel that supports the UME. The UME is a replaceable assembly that contains all the elements necessary for accurate measurement and registration of water, such as the transducers, battery, electronics, and register.

Transducers

The piezoelectric transducer is the heart of the system. Although these transducers are very small, they have very high measurement dynamics.

The meter uses dual signal paths. The transducers are permanently installed and the path length and angles are fixed. Each meter is uniquely calibrated at the factory and the calibration data is permanently stored in the meter.

Battery Requirement

Solid state metering technologies require a battery to power the transducers and electronics. With the continued improvements made in battery technology, electronic metering utilizing internal batteries is practical today. The MACH 10 uses lithium thionyl-chloride battery technology.

Chapter 3: General Installation Guidelines

This chapter defines tools, materials, and general installation information for the C&I MACH 10®.

Tools and Materials

The following tables show the recommended tools and materials you need to successfully install the C&I MACH 10 and replace the Unitized Measuring Element (UME).



The tables in this chapter do not contain complete lists of tools and materials.

Table 6 – Recommended Tools and Materials for Meter Installation

Item	Description / Recommendation	Use
Site Work Order	Documentation provided by your utility.	Receiving and recording information about the work site.
Tool Kit	Contains standard tools including: <ul style="list-style-type: none">• Screwdrivers.• Pliers.• Socket or open-face wrenches.• Replacement gaskets.	Performing various installation procedures.
Spacers (optional)	N/A	If non-compatible lay length of replacement meter.
Flashlight	N/A	Activating the LCD.
Moisture Protection Compound	Novagard® sealant Part No: 96018-072.	Connecting the pit antenna to the Meter Interface Unit (MIU).
Magnet	<ul style="list-style-type: none">• 6 lb force.• Part No: 12287-0001.	Activating the MIU (if required).

Table 7 – Recommended Tools for Unitized Measuring Element Replacement

Item	Description / Recommendation	Use
Tool Kit	Contains standard tools including: <ul style="list-style-type: none">• Screwdrivers.• ¾" socket or open-face wrenches.• Replacement gaskets (provided with UME kit).	Performing various replacement procedures as outlined in the instructions. Note that a ¾" open-face wrench is required on 3" and 4" R900i UME replacements for the two bolts directly under the radio.
Flashlight	N/A	Activating the LCD.

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.
- Follow all industry and company safety guidelines and procedures.
- Verify that the site is safe for you and your equipment.
- If applicable, notify the customer of your presence, and tell the customer that you need access to the water meter.
- Write the ID number of the MACH 10 meter you are about to install on the site work order. If the site work order already has a MACH 10 ID number, verify that it matches the ID number on the MACH 10 you are about to install.

Installation and Application Considerations

This section provides information to consider before installing the C&I 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 operating temperature between 33° F and 122° F (or 0.5° C and 50° C) measuring applications.

Meter Installation

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

For installations that use test spools, strainers, and elbows, it is recommended that you follow best practices and guidelines defined for mechanical meters.

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 wetted. In this situation, the meter displays an Empty Pipe icon () on the register LCD and no measurement occurs.

Should this occur, purge all air from the pipes at the time of test or installation. You can achieve this by loosening the meter bleed screw (see the figure below) located on top of the C&I meter maincase one to two turns to release air through the screw opening until water begins to flow from the screw location. It is not recommended that you loosen the screw past one or two turns. If you have trouble purging the air, increase the exit pressure and flow rate through the meter. After water is flowing, fully re-tighten the meter bleed screw.



Figure 5 – Bleed Screw Location

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 following table lists the maximum flow rates for the C&I MACH 10 meter.

Table 8 – Maximum Flow Rates

Meter Size	Safe Maximum Operating Capacity
3 inch	500 U.S. gpm
4 inch	1200 U.S. gpm
6 inch	2000 U.S. gpm

Chapter 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 meter is installed and the meter measuring pipe is full.

Installation Instructions for MACH 10[®] Meters

This section defines the step-by-step instructions for installing the MACH 10 meter.

Prior to Installation

This section defines the processes to perform before you install the meter.

Storage

After receipt, inspect the shipping containers for damage and inspect the contents of any damaged cartons prior to storage. After completing the inspection, store the cartons in a clean, dry environment. See Table 1 on page 5.

Unpacking

After unpacking the MACH 10 meter, inspect it for damage. If the meter appears to be damaged, notify your Neptune territory manager or distributor. If a meter requires reshipment, use the original cardboard box and packing material.

Handling the Meter

Only use nylon straps with appropriate weight capacity to lift the meter from its installed lift brackets (found on either side of the register).



DO NOT:

- Lift the meter by the electronic housing unit.
- Carry the meter by its lid.
- Use bolt holes for grip when carrying the meter.
- Position the meter on its electronic housing unit.

Upstream and Downstream Requirements

Neptune is in the process of characterizing the performance of the MACH 10 meter under various upstream and downstream installation configurations, such as with the use of strainers, elbows, gate valves, and test tees for the purpose of providing installation guidelines. Until these characterizations are completed, Neptune recommends that you use industry-accepted mechanical meter practices for similar type installations.

Installation – Commercial and Industrial

Following are the steps to install the C&I MACH 10 meter.



Although lighter than traditional mechanical meters, take care when moving and lifting the Commercial and Industrial MACH 10 meters. Lift brackets are provided on meters greater than 3” to aid in lifting the meter. Use proper company and government safety guidelines when lifting.

1. Flush the service line prior to meter installation in order to remove debris and air in the line.
2. If required by company practices, place an electrical grounding strap on the service line, connecting the inlet and outlet service lines on either side of the meter setting.
3. If you are installing the meter in a vault or enclosed area, be sure to follow all utility and industry confined-spaces safety guidelines.
4. Be sure that no debris enters the meter during installation.
5. Place the coupling gaskets, and set the meter in the line.
6. Install the mounting bolts and turn the coupling or flange nuts by hand, then use a wrench to tighten sufficiently to prevent leakage.
7. Slowly open the inlet-side valve to pressurize the meter while the outlet-side gate valve is closed.
8. Slowly open the outlet-side gate valve until the downstream line is pressurized.
9. Rotate the meter's bleed screw one to two turns to dissipate any entrained air, until water begins to flow from the screw location. For bleed screw location and instructions, see Figure 5 in chapter 3.
10. Allow water to flow from the screw location for a short period, then fully re-tighten the meter bleed screw. (In practice, some air may still be escaping when you see water. Allowing it to flow for a little while helps guarantee a good purge.)
11. Check to see if the meter is operating correctly while the valve is open.
12. Turn OFF the downstream valve and check the meter installation for leaks.



The C&I MACH 10 may take longer to completely remove air from the meter, particularly when flow rates are less than 25% of the maximum flow rate of the meter.

Wiring the MACH 10®

The following table defines the steps to wire the MACH 10 meter to an MIU while you are in the field.



If the meter is not a MACH 10 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.

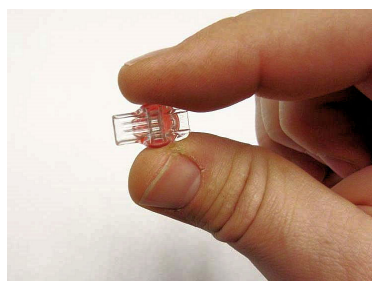


Figure 6 – Scotchlok™ Connector

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.

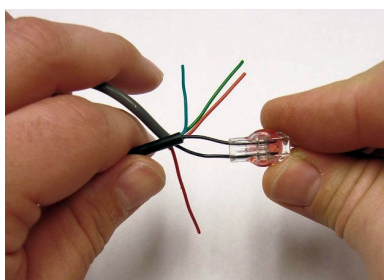


Figure 7 – Seat the Connector Wires



Do not strip the colored insulation from the wires, or strip and twist the bare wires before inserting them into 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.

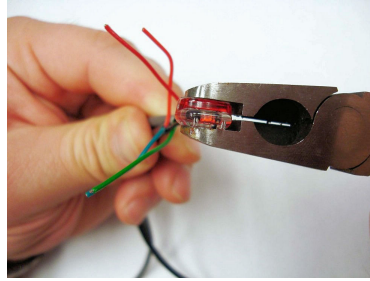


Figure 8 – Crimping Tool

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

The following table provides the wiring color schemes for wiring the MACH 10 to various MIU providers.

Table 9 – Color Codes for Wires

MIU Wire Color / MACH 10® Wire Color	MIU Type
Black/B Green/G Red/R	R900®
Black/G Green/R Red/B	Sensus
Black/B White/G Red/R	Itron
Black/G White/R Red/B	Aclara
Black/G Green/B Red/R	Elster®
Black/G Green/R Red/B	Badger

Completing the Wiring

Follow these steps to wire the MACH 10.

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

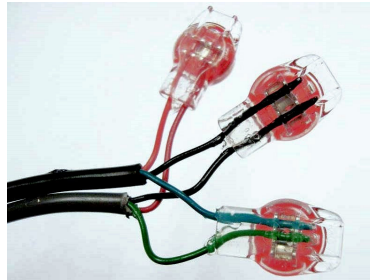


Figure 9 – Three Colored Wires Connected

2. Take all three connected Scotchloks and push them into the splice tube until fully enclosed by the silicone grease.



Figure 10 – Splice Tube

3. Separate each gray wire and place them into the slots on each side.



Figure 11 – Gray Wires in Slot

4. Snap the cover closed to finish the installation.



Figure 12 – Cover in Place

Chapter 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 activates the power for the Liquid Crystal Display (LCD) panel.



Figure 13 – Commercial and Industrial MACH 10[®] Meter

Timeout Period

Typically, the display is OFF. The meter includes a light sensor used to activate the LCD when you open the meter lid. You cannot reactivate a timed out LCD just by shining a light on the light sensor. To reset the LCD, close and re-open the lid.

Meter Display

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

LCD Panel

Following is an example of the MACH 10 LCD panel. The table on the following page provides a description of each icon.

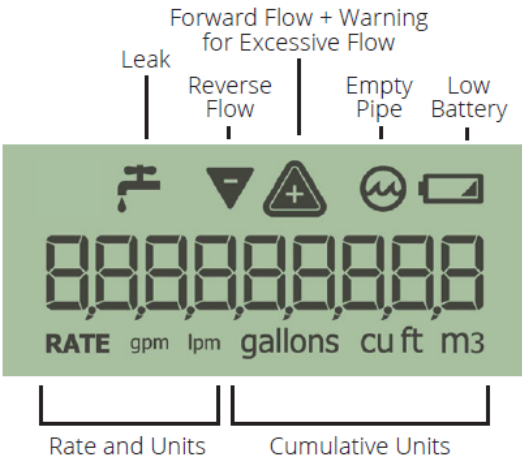


Figure 14 – MACH 10® LCD Panel



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.

How to Read the Meter

It is important to become familiar with the information available from the meter. The icons and displays provide helpful information.





Alarms

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

LCD Icons

The following table defines the MACH 10 LCD icons and the status they indicate.

Table 10 – MACH 10® Icons and Displays

Icon	Description	Status	Explanation
Leak 	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 ninth digit on the LCD.	OFF	Number of 15-minute intervals where flow was registered.
		Flashing	Number of 15-minute intervals where flow was registered.
		Continuous ON	Number of 15-minute intervals where flow was registered.
Forward and reverse flow 	Icons used to indicate the forward and reverse direction of flow.	OFF	No flow is detected.
		Continuous ON	The meter has detected flow.
High flow warning 	Icon used to indicate excessive flow which can be a burst pipe.	OFF	Rate of flow < Maximum defined by normal flow range specifications.
		ON	Rate of flow exceeds normal operating flow limits.
Empty pipe 	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.	OFF	Typically OFF. Meter is operating normally.
		ON	Turned ON if no receive signal is seen for 1 minute.
Battery status 	Icon used to indicate time and voltage of remaining battery life.	OFF	> One year of battery life remaining. Time since first power ON < 9 years.
		Continuous ON	< One year of battery life remaining or time since first power ON > 9.5 years.
		Continuous FLASHING	Low battery or time since first power ON > 10 years.

Consumption and Unit of Measure – Commercial and Industrial

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

Table 11 – Consumption and Units of Measure – Commercial and Industrial

Meter Size	Volume Resolution				Capacity			
	Gallons	Cubic Feet	Cubic Metres	Imperial Gallons	Gallons	Cubic Feet	Cubic Metres	Imperial Gallons
3 inch	0.1	0.01	0.001	0.1	100,000,000	10,000,000	1,000,000	100,000,000
4 inch	0.1	0.01	0.001	0.1	100,000,000	10,000,000	1,000,000	100,000,000
6 inch	1	0.1	0.01	1	1,000,000,000	100,000,000	10,000,000	1,000,000,000

Rate of Flow

The rate of flow is factory programmed for either gallons per minute or litres 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 the LCD panel.

The direction of flow arrows on the LCD are activated when the meter detects any amount of flow. If the volume of the flow is below a predetermined measurement threshold in a given time period, the meter does not accumulate flow.

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 high resolution E-CoderPLUS protocol. It communicates status indicators to the Neptune R900 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® eight digit or E-CoderPLUS 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 for the encoding reading.

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Chapter 6: Testing the Commercial and Industrial MACH 10[®]

Bench Testing the Commercial and Industrial MACH 10[®] Meter

Unlike other solid state meters introduced to the market, the Neptune MACH 10 Ultrasonic Meter is designed to be bench tested as a traditional mechanical meter. However, there are certain best practices you should adhere to when testing the C&I MACH 10 meter. A summary of these are in the following sections.

Meter Accuracy Testing Guidelines

Following are guidelines for testing meter accuracy:

- Conduct meter accuracy tests at a stable flow rate, and keep the variation in flow rates to a minimum during the test.
- Minimize the time it takes to start and stop the test flow rate. Starting the flow should be quicker than stopping the flow to prevent water hammer during the valve closing.
- MACH 10 meters have remarkable low-flow sensitivity. Conducting meter accuracy tests at low-flow rates on a test bench designed to test large meters is challenging, so take care to ensure reliable and consistent results.
- Regularly inspect the test bench to ensure there are no leaks or leaking valves downstream of the meter. Any slight diversion of water away from the tank makes it appear that the meters are over-registering.
- If you test over a range of flow rates, start at the highest flow rate and end with the lowest. This helps ensure that all air is purged before reaching the more critical low flow tests.
- AWWA C-715 specifies visual reading capacity requirements, which dictates the value of the most significant digit. The MACH 10 has a nine-digit LCD display that together with the AWWA capacity requirement determines the resolution of the least-significant digit. Consequently, to ensure that reading errors are acceptably low, run sufficient volumes of water during low-flow testing. Refer to "Test Data " on page 28 for Neptune's recommended test volumes.
- To achieve necessary tank volume precision, low-flow testing should use the smallest practicable tank.
- Best practice is to test three times at each flow rate and average the three results to report the meter accuracy at that flow.

- If you use scales to record the weight of water from a test, be sure to check the scales at regular intervals. Converting from weight to volume is necessary and requires a density value. While this is somewhat dependent upon water temperature, a density of 8.34 pounds per gallon is generally used. Therefore, determine the test volume using the following equation when testing in U.S. gallons:

$$Volume [gal] = \frac{Weight [lbs]}{8.34 \left[\frac{lbs}{gal} \right]}$$

Use the following equation to compute test volume in cubic feet:

$$Volume [cu. ft] = \frac{Weight [lbs]}{62.38 \left[\frac{lbs}{cu. ft} \right]}$$

Test Bench Setup Procedure

The C&I MACH 10 does not have a special test mode it is ready to test out-of-the-box.



To achieve the expected test results, ensure all air is removed from the meter and test system. Neptune recommends flushing the test system multiple times to assure no air is retained within the system. If the test bench uses a recirculating system, after the inlet water reservoir tank is refilled from the test tank, allow time for any entrained air to dissipate.

1. When filling the test bench after meters are first installed, close the outlet valves and partially open the bench fill valve. This allows the line to pressurize slowly and avoid a rapid in-rush of water which can damage meters.
2. Open the C&I MACH 10 bleed screw one to two turns to help air escape. Keep the bleed screw open during the test set-up procedure.
3. After the line is completely filled and pressurized, completely open the fill line.
4. Slowly open the downstream valve to establish the expected high flow rate for the meter. This helps force any remaining air from the system.
5. After you observe only water (no air) escaping from the bleed screw, secure it by hand-tightening.
6. Allow water to run through the test line at or near each meter's expected high flow rate for several minutes to expel any trapped air from the system. If the test bench has a "flush" or "purge" setting, Neptune recommends running this a minimum of five times.
7. Adjust the input pump's speed (output percentage) until the pressure at the exit of the last meter in the line is acceptable. Neptune recommends a minimum of 30 psig.
8. Adjust the outlet valves (flow valves) to achieve the high flow rate desired for testing. Return to the previous step for additional adjustments, if necessary.

9. Once the desired high flow is established at an acceptable static pressure, do not adjust the outlet valves. To lower the flow rate for additional testing, only adjust the input pump speed to ensure the static pressure remains adequate for testing.



While applicable piping standards ensure that the resultant static pressure in the Commercial and Industrial MACH 10 meters are acceptable in field installations, take care during laboratory testing to ensure that prevailing static pressure in the test bench is not artificially low. Such low pressures can lead to improper meter operation and poor meter test results.



Neptune recommends the static pressure, measured at the meter outlet, is 30 psig or higher especially during high-flow testing. If there are multiple meters on the same test line, the pressure should be measured at the exit of the last meter. You can achieve this when setting test flow rates by partially closing the outlet valves while increasing the input pump speed.

Test Procedure

This section provides the steps to test the Commercial and Industrial MACH 10 meter.

1. Install the meter in the test bench with the flow arrow pointing downstream.



If you test more than one meter at a time, allow as much space between them as practical, but at least a minimum distance equivalent to 10 pipe-diameters. As an example, if testing 4-inch meters, make sure that a minimum of 40 inches (4 x 10) is between adjacent meters.

2. Fill and flush the test line as described in "Test Bench Setup Procedure" on the previous page.
3. Set the test flow rate while meeting the static pressure equipments as described in "Test Bench Setup Procedure" on the previous page.
4. Allow the tank to drain, and then close the tank drain valve.
5. If you use a scale, which is recommended, set it to read zero.
6. Read and record the registered volumes from the Meters Under Test (MUT).
7. Start the flow of water. It may be necessary for the input pump to achieve desired pressure before you open the downstream flow control valve. Be sure to observe downstream static pressure requirements.

8. After you collect the required volume of water (see Table 12 - Table 14), stop the flow of water by closing the downstream flow control valve deliberately, but not fast enough to cause a water hammer.
9. While the water in the tank settles, read and record the volume registered on the MUT.
10. After the water in the tank settles and the scale reading has stabilized, read and record the tank weight.
11. Open the tank drain.
12. Calculate each meter's accuracy using the following formula:

$$Accuracy_{MUT} [\%] = \frac{Volume_{MUT}}{Volume_{tank}} \times 100$$

13. To repeat the test, return to step 4. If moving to another flow rate, return to step 3.

Test Data

The tables in this section show optimal test volumes for 3-inch to 6-inch C&I MACH 10 meters.

Table 12 – Full Flow Testing

Reading Resolution				Test Volume				
Size [in]	Gallons	Cu. Ft.	m ³	Rate [gpm]	Gallons	Cu. Ft.	m ³	Accuracy [%]
3	0.1	0.01	0.001	500	1500	150	5	100 +/- 1.5
4	0.1	0.01	0.001	1100	1500	150	5	100 +/- 1.5
6	1	0.1	0.01	2000	2000	200	7.5	100 +/- 1.5

Table 13 – Intermediate Flow Testing

Reading Resolution				Test Volume				
Size [in]	Gallons	Cu. Ft.	m ³	Rate [gpm]	Gallons	Cu. Ft.	m ³	Accuracy [%]
3	0.1	0.01	0.001	500	500	50	1.5	100 +/- 1.5
4	0.1	0.01	0.001	100	1000	100	2.5	100 +/- 1.5
6	1	0.1	0.01	200	1500	150	5	100 +/- 1.5

Table 14 – Low Flow Testing

Reading Resolution				Test Volume				
Size [in]	Gallons	Cu. Ft.	m ³	Rate [gpm]	Gallons	Cu. Ft.	m ³	Accuracy [%]
3	0.1	0.01	0.001	0.75	50	5	0.5	100 +/- 1.5
4	0.1	0.01	0.001	1.5	50	5	0.5	100 +/- 1.5
6	1	0.1	0.01	2.0	500	50	5	100 +/- 1.5

Test Troubleshooting

Conditions such as those defined in the following table can occur.

Table 15 – Meter is Under Registering

Possible Cause	Remedy
Air in Line	Flush the meter a little longer with a higher back pressure and flow rate if possible, then try again. To flush the meter, loosen the meter bleed screw (See Figure 5 "Bleed Screw Location" on page 11) located on top of the meter one to two turns. Release air through the bleed screw until water begins to flow from the screw location. After this occurs, fully re-tighten the meter bleed screw.
Incorrect Start Read or End Read	Confirm reference reads and the test bench are correct. Test the meter again. If using a volumetric test tank, be sure to "wet" the tank before conducting the meter test.
Insufficient Resolution on the Register	Increase test quantity size. For more detailed explanation of register resolution, "Activating and Reading MACH 10® Ultrasonic Meters" on page 19.
Improper Purge of Lines	It is important to have all air removed from the water lines prior to initiating the tests. See the above instructions for Air in the Line to purge the water lines.
Improper Back Pressure	To properly test the meter, be sure there is at least 30 psig of back pressure on the meter.

Table 16 – Meter is Over Registering

Possible Cause	Remedy
Leak Downstream of the Meter	Inspect test bench to ensure it is free of leaks.
Incorrect Start Read or End Read	Confirm reference reads and the test bench are correct. Test the meter again. If using a volumetric test tank, be sure to “wet” the tank before conducting the meter test.
Insufficient Resolution on the Register	Increase test quantity size. For more detailed explanation of register resolution, see "Activating and Reading MACH 10® Ultrasonic Meters" on page 19.
One Isolation Valve on Test Bench is Partially Open	Ensure valves that are not in use are turned to the off position.

Table 17 – Meter Stops Registering During a Test

Possible Cause	Remedy
Air in Line	When air is in the line, the registered flow may stop or decrease. Air must be purged completely, or test results continue to be uncertain. Purging air can be achieved by loosening the meter bleed screw (See Figure 5 on page 11) located on top of the meter by one or two turns. Release air through the bleed screw until water begins to flow from the screw location. After this occurs, fully re-tighten the meter bleed screw.

Table 18 – Meter Does Not Register Water When Running a Test

Possible Cause	Remedy
Air in Line	Flush the meter a little longer with a higher back pressure and flow rate if possible, then try again. To flush the meter, loosen the meter bleed screw (See Figure 5 on page 11) located on top of the meter one to two turns. Release air through the bleed screw until water begins to flow from the screw location. After this occurs, fully re-tighten the meter bleed screw.

Table 19 – Meter Does Not Register on Automated Test Bench

Possible Cause	Remedy
Bench Configuration	Consult your test bench supplier to modify / adjust the test bench profile to conform to the test conditions outlined in this guide.

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Chapter 7: Maintenance and Troubleshooting

This chapter provides information for maintaining and troubleshooting the MACH 10[®] meter.

Maintenance

Typically, mechanical meters are subject to wear and are often rebuilt to extend their life. The electronic MACH 10 meter does not have moving parts and requires no maintenance. The C&I MACH 10 meter is designed with the electronics, transducers, battery, and display all as part of a unitized measuring element (UME) which you can replace on the meter without removing the meter maincase from service, eliminating maintenance time and cost.

Unitized Measuring Element (UME) Maintenance

When maintenance is necessary, you can quickly and easily interchange the complete UME with a factory-calibrated unit. The UME includes the register, cover, batteries, and measurement transducers.

Following are the steps to replace the UME.

1. Close all valves (mainline and bypass).
2. Open the bleed screw on top of the meter to vent air.
3. Make sure the meter is depressurized.
4. Remove the cover bolts.
5. Remove the UME from the maincase.
6. Install the factory-calibrated UME into the maincase as shown in the following image.

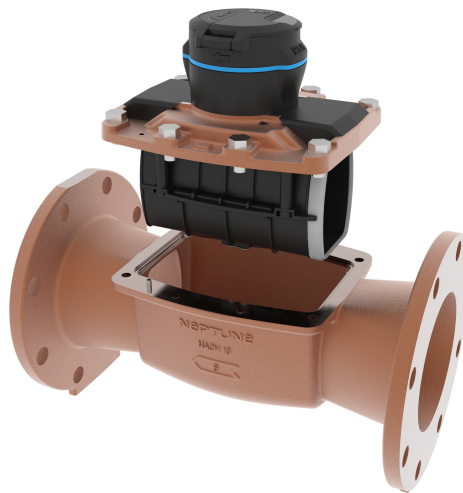


Figure 15 – Unitized Measuring Element Commercial and Industrial MACH 10[®] Meter

7. Replace the supplied UME gasket, if necessary.
8. Replace the cover bolts as shown in the previous image.
9. Tighten the cover bolts.
10. Open the valves.

All new UMEs have been factory tested and do not require field testing. If no spare unit is available, you can purchase a factory-calibrated UME directly from Neptune or one of its authorized distributors. Neptune encourages all customers to purchase a spare UME to avoid service interruptions.

Replacement Parts

If the plastic meter lid becomes damaged or broken, it can be replaced. The UME assembly may also be replaced, but there are no other replacement parts for the MACH 10 ultrasonic meter.

General Troubleshooting

The following tables provide steps for troubleshooting common issues with the MACH 10 meter.

Table 20 – LCD Display Does Not Illuminate

Possible Cause	Remedy
Environment is too dark	Shine a flashlight on the face of the register. Remove the light after the display wakes up.
LCD has timed out	<ul style="list-style-type: none">• Close the lid of the register.• After a few seconds open the lid. If the LCD still does not come on, see “Possible Cause: Environment is too dark” above.
Photo-eye is blocked	Clean the face of the register to remove any dirt and debris, and then follow the steps in “Possible Cause: LCD has timed out” above.

Table 21 – MIU or LCD Display Reports Errors

Possible Cause	Remedy
Intermittent or continuous flow	Depending on the application of the meter, intermittent or continuous flow may be expected. If such flow is unexpected, check the integrity of the line downstream the meter.
Reverse flow	Some reverse flow may be expected depending on your configuration. You may need to install a backflow preventer upstream of the meter if significant negative flow is reported.

Table 21 – MIU or LCD Display Reports Errors (continued)

Possible Cause	Remedy
Excessive Forward Flow	Excessive flow may cause the MIU to report question marks (?) and the display to read zero flow. The unit displays the last known valid volume. Ensure the meter is installed in an application that is within the Normal Operating Flow Range for its size.
Empty Pipe	Remove all air from the meter during installation. Neptune recommends flushing the line multiple times to ensure no air is retained within the system. Trapped air may cause the display and MIU to report values that do not reflect actual usage.
Low Battery	If the battery is low, consider replacing the UME.

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 A.M. to 5:00 P.M. Central Standard Time, by telephone or email.

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:
 - 1 if you have a Technical Support Personal Identification Number (PIN).
 - 2 if you do not have a Technical Support PIN.

3. Enter the six-digit PIN and press #.
4. Select one of the following options:
 - 2 for Technical Support.
 - 3 for maintenance contracts or renewals.
 - 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 Email

To contact Neptune Support by email, send your message to support@neptunetg.com.

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[®] radio technologies in one register that collects 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 a Radio Frequency (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 to 20 seconds. This allows the meter to be read by a hand held 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 a fixed R900 Gateway.

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

- Increases meter reading accuracy.
- Eliminates reading difficulties.
- Protects utility liability by increasing meter reader safety.
- Requires no external wiring or programming.
- Provides enhanced eight-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 includes a header, data packet, and an error detection mechanism that reduces the erroneous data.

MACH 10®)R900i™ Specifications

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

Dimensions – Commercial and Industrial

The following images show the dimensions of the C&I MACH 10®)R900i.

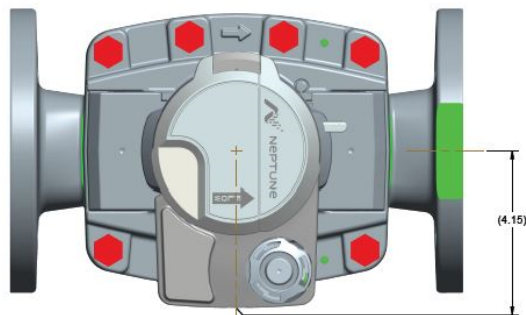


Figure 16 – Commercial and Industrial MACH 10®)R900i™ – Top View

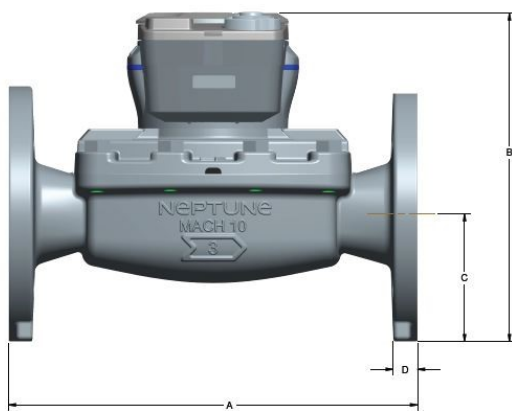


Figure 17 – Commercial and Industrial MACH 10®)R900i™ – Front View

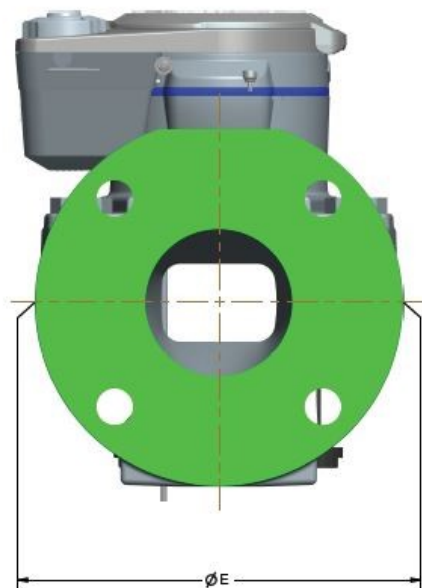


Figure 18 – Commercial and Industrial Meter Dimensions – End View



The width dimension of the meter with an installed R900i integrated radio only affects the three-inch and four-inch sizes. The six-inch meter is not affected as the communications module does not exceed the meter case.

The following table defines the dimensions of the Commercial and Industrial MACH 10)R900i meters. All dimension measurements are in inches.

Table 22 – MACH 10® R900i™ Meter Dimensions – Commercial and Industrial

Meter	A	B	C	D NSPM	E (external antenna)
3 inch	12.00" or 17.00"	9.65"	3.75"	.71"	7.50"
4 inch	14.00" or 20.00"	10.94"	4.50"	.71"	9.00"
6 inch	18.00" or 24.00"	12.73"	5.50"	.71"	11.00"

Electrical Specification

Power is provided by a lithium thionyl-chloride battery.

Transmitter Specifications

The following table defines the specifications for the MACH 10)R900i transmitter.

Table 23 – Transmitter Specifications

Specification	Description
Transmit Period	<ul style="list-style-type: none"> Every 14 to 20 seconds – standard mobile message. Every 7½ minutes – standard, high power, fixed network message.
Transmitter Channels	50
Channel Frequency	910 to 920 MHz
Output Power	Meeting FCC Part 15.247
FCC Verification	Part 15.247

Functional Specifications

The following table defines the functional specifications for the MACH 10)R900i.

Table 24 – Functional Specifications

Specification	Description
Register Reading	<ul style="list-style-type: none"> Eight digits (AMR). Nine digits (Visual).
MIU ID	10 digits.

Appendix B: MACH 10[®])R900/™ Flags

The three tables in this appendix describe the volume represented by the eighth digit by meter size and the flags used by the MACH 10[®])R900*i* (digits) and MACH 10[®])R900*i* (minutes).

Table 25 – Eighth Digit Resolution by Meter Size – Commercial and Industrial

Register Size	Eighth Digit Resolution - Least Significant Digit
3 inch and 4 inch	1 U.S. Gallon or 1/10 Cubic Feet
6 inch	10 U.S. Gallons or 1 Cubic Foot

Table 26 – MACH 10[®])R900/™ Flags (digits)

Backflow Flag (Resets After 35 Days)	
Based on reverse movement of the eighth digit; eighth digit is variable based on the meter size.	
No backflow event	Eighth digit reversed less than one digit.
Minor backflow	Eighth digit reversed more than one digit up to 100 times the eighth digit.
Major backflow event	Eighth digit reversed greater than 100 times the eighth digit.

Table 27 – MACH 10®)R900i™ Flags (minutes)

Leak Status Flag (Resets After 35 Days)	
Based on total amount of 15-minute periods recorded in the previous 24-hour period.	
Leak icon off	Eighth digit incremented less than 50 of the 96 15-minute intervals.
Flashing leak icon	Eighth digit incremented in 50-95 of the 96 15-minute intervals.
Solid leak icon	Eighth digit incremented in all of the 96 15-minute intervals.
Consecutive Days with Zero Consumption Flag (Resets After 35 Days)	
Number of days the leak status was at a minimum value.	

A

AMI

Advanced Metering Infrastructure. A system that captures, stores, and provides to the utility at frequent intervals detailed consumption and other information, such as, usage, leak, and flow status, to support advanced applications.

AMR

Automated or Automatic Meter Reading.

AWWA

American Water Works Association.

C

C&I

Commercial and Industrial.

E

Empty Pipe

Condition whenever the measurement section of the meter is not completely filled with water.

L

LCD

Liquid Crystal Display.

light sensor

Component located under the recess that is used to activate the Liquid Crystal Display (LCD).

M

MIU

Meter Interface Unit.

MUT

Meter Under Test.

P

psig

Pressure in pounds per square inch (psi) relative to atmospheric pressure, as typically shown on a pressure gauge.

S

serial number

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.

T

transceiver

Device that transmits and receives communications, in particular a combined radio transmitter and receiver.

transducer

Device that converts one form of energy to another form of energy.

transit-time

Technology that takes advantage of the principle that an acoustic signal travels faster with the flow than against the flow.

U

ultrasonic flow

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.

ultrasonic meter

Electronic meter using ultrasonic technology and solid state electronics contained in a compact, totally encapsulated, weatherproof, and ultraviolet (UV) resistant housing for residential and light commercial applications.

UME

Unitized Measuring Element.

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