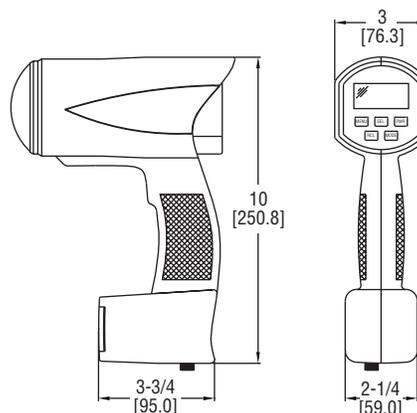




## Model RVM Portable Radar Wave Velocity Meter

### Specifications - Installation and Operating Instructions



The Model RVM Portable Radar Wave Velocity Meter uses Doppler Radar technology to accurately measure surface velocity of open channel flow. The "point-and-shoot" design along with automatic vertical angle compensation provides easy to use operation. Model RVM also has user-adjustable horizontal angle compensation of 5° increments to further reduce measurement error. Flow velocity can be measured bi-directionally with user-selectable directional modes (flows away, towards, or both in direction). Model RVM features a backlit LCD that indicates flow velocity in feet per second or meters per second. Model RVM includes the meter, rechargeable batteries, 12 VDC car charger, and a rugged case.

\*Wireless Guidelines in Accordance with FCC:

Changes not expressly approved by Dwyer Instruments, Inc. could void the user's authority to operate the equipment.

This product complies with FCC OET Bulletin 65 radiation exposure limits set forth for an uncontrolled environment.

Pursuant to FCC 15.21 of the FCC rules, changes not expressly approved by Dwyer Instruments, Inc. might cause harmful interference and void the FCC authorization to operate this product.

#### Canadian Government Guidelines:

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.

#### INFORMATION TO THE USER

**Power Output:** 7 mW nominal.

**Power Density:**  $\leq 1$  mW/cm.

**Operating Frequency:** 24.150 GHz nominal (K band).

**Beam Width:** 12° nominal.

**Polarization:** Linear.

**Power Density:**  $\leq 1$  mW/cm.

#### NOTICE

• Do not over voltage the radar velocity meter - it can damage the unit! See notes.

- If battery replacement is necessary, all 6 batteries should be replaced with new batteries even if only one cell is suspected to be defective.
- Use rechargeable Nickel-Metal-Hydrate batteries only.
- Model RVM is designed to operate off of conventional +12 VDC (+10.8 to +16.5 VDC) from the power cable. In addition, it is also designed to operate at 7.2 VDC from the internal batteries. Over voltage to the power cables or incorrect batteries can cause damage.
- Do not expose Model RVM to excessive moisture. Never submerge the device. If the device should accidentally get submerged, remove the batteries immediately.
- Do not drop Model RVM on hard surfaces since damage could occur.

#### SPECIFICATIONS

**Service:** Water.

**Range:** 0.1 to 43 FPS (0.3 to 13 m/s).

**Display:** Single-line, 5-digit, backlit LCD.

**Accuracy:**  $\pm 5\%$ .

**Power Requirements:** 6.1 to 8 VDC, (6) 1.2 V AA NiMH batteries, installed functional, user replaceable (12 VDC lighter plug power cable included).

**Power Consumption:** 0.18 A max.

**Serial Communications:** RS232.

**Temperature Limits:** -22 to 158°F (-30 to 70°C).

**Enclosure Rating:** IP55.

**Humidity Limit:** 90% RH @ 98.6°F (37°C).

**Enclosure Material:** ABS polycarbonate blend.

**Angle Compensation:**

Vertical: automatic via tilt sensor;

Horizontal: adjustable from 0 to 60° in 5° increments for cosine angle error.

**Weight:** 2.1 lb (907 g).

**Agency Approvals:** \*FCC compliance.

## Introduction

Model RVM Portable Radar Velocity Meter is a hand-held surface velocity radar gun specifically designed to measure the surface velocity of water. Features such as Recall allow the review of previous measurements. Other features are selectable through the menu option.

The radar gun features a tilt sensor system, which internally compensates for the cosine angle effect of the vertical (pitch-down) angle of the gun to the target. It is not necessary to manually set the tilt sensor.

## Battery Charging

Model RVM is designed to operate off of six (6) rechargeable Nickel-Metal-Hydride batteries (or off the DC power cord). Upon initial procurement, the batteries will need to be charged. Once the batteries have been fully charged, and if Model RVM is not used for 3-4 weeks, recharging of the batteries before use will be necessary in order to get the full run time.

## Removing the Battery Holder

The battery holder is located inside the handle of Model RVM and is accessed by means of a sliding door. When first received, the holder will have batteries pre-installed. To remove the battery holder, slide the battery cover to the right until the battery holder is released as shown in Figure 1. The door can be completely removed from the slide.

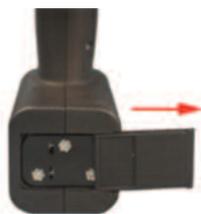


Figure 1

## Battery Installation

Insert the batteries into the battery holder following the polarity guide that is on the inside of the battery holder (Figure 2). Notice that the negative side of each battery goes to the spring contacts of the holder.

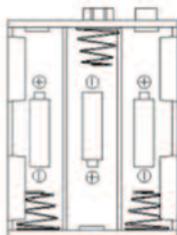


Figure 2

## Inserting the Battery Holder

The battery holder is designed so that it can only make contact with the power connections inside the meter if the battery holder is slid into the handle properly. The battery holder has positive and negative terminals which need to be inserted into the meter with the terminals located at the top as shown in Figure 3.

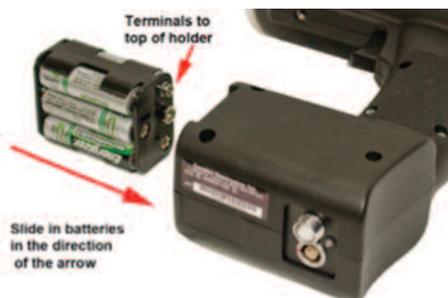


Figure 3

Once the batteries have been properly loaded into the holder and the holder has been inserted into the handle of the gun, then the door can be put back in place and slid closed. If the holder has been placed incorrectly into the handle, the door cannot be put back in place and closed.

## Charging the Batteries

The power cable included with Model RVM can be used to either power the unit directly from a vehicle receptacle or to charge the batteries. Once the batteries have been properly installed into the holder and inserted into the handle, plug the power cord into the power connector at the base of the handle by aligning the red dot on the power cord's plug with the red dot on the connector. Failure to align the plug with the connector properly will result in damage to the pins of the jack. Reference Figure 4 for proper alignment.



Figure 4

## Charge Status Indicator (LED)

The status of the charge can be determined by the Charge Status Indicator LED located on the bottom of the handle (See Figure 5). The LED indication status is described below.

- Fast blinking green light = checking battery condition
- Medium blinking green light = charging battery
- Solid green light = charged
- Solid red light = charging error



Figure 5

The normal charging sequence is fast blink for 60 seconds, medium blink until batteries are fully charged (approximately 2 hours for fully discharged batteries) and solid green once batteries are charged.

Model RVM can be left to charge indefinitely. The charging circuit will automatically shut off once charging is complete. The unit must be OFF or the batteries will not charge. You can not operate the unit and charge the batteries at the same time. Best performance from the batteries is obtained when recharged at temperature between 50°F (10°C) and 113°F (45°C). Recharging outside of the specified temperature range may result in reduced battery life or incomplete charging.

## Battery Run Time

The length of time Model RVM can operate between recharges depends upon several factors including the milliamp hour (mAh) capacity of the batteries, age of the batteries, and how the unit is used. Generally a set of 6 new 2500 mAh batteries fully charged should run for approximately 1 week between recharges given normal use.

## Auto Power Off

If no key press is detected, the Model RVM will automatically power off after 5 minutes in order to conserve battery life.

## Replacing Batteries

When replacing the batteries, only use rechargeable Nickel-Metal-Hydride batteries and replace ALL the batteries at the same time, even if only one battery is suspected to be failing.

## Connecting the Power Cord

If you choose to run off the power cord instead of the internal batteries, connect the power cord to the receptacle on the bottom of Model RVM being sure to properly align the plug on the power cord to the connector on the bottom of the unit's handle. Model RVM will automatically switch from the internal batteries to the power cord for power when the unit is turned on.

**Plug in the Power Cord**

Plug the radar's power cord into any vehicle's 12 V charging receptacle. If a separate battery pack is being used as a power source, plug Model RVM's power cord into the battery pack's receptacle.

**Control Panel Functions**

The operation of Model RVM is controlled by the five-button key pad, shown in Figure 6.



Figure 6

**MENU** - The MENU button lets you view the options you can change. Repeatedly pressing the MENU button advances through the programmable features.

**SEL** - The select (SEL) button lets you choose the settings in each of the mode options. To change a mode option, press the SEL button.

**PWR** - The PWR button turns the radar on and off. When first powered on, Model RVM will display the screen shown in Figure 6. When you power the unit off, the word OFF will appear in the display and the unit will power down.

**RCL** - When the RCL button is pressed, the unit will start the process of taking a reading.

**MODE** - The MODE button lets you change the resolution of the display. You can choose to have the speed displayed in 10ths or 100ths.

**Display**

The 5 large digits (88888) display the speed, figure 7. Resolution is determined by the placement of the decimal point. The icons indicate the status.

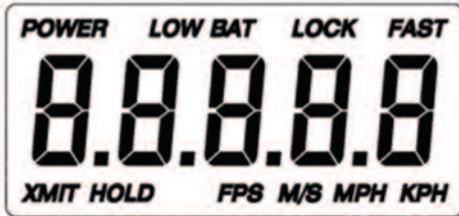


Figure 7

When first turned on, the Model RVM performs a segment check of the display to show that all segments and icons are working. The following icons will appear at the top and bottom of the display screen, however not all of the icons are for features used by the Model RVM. The icons that represent the features that are used by the unit are describe the following conditions:

**POWER** - When POWER appears, the power is on.

**LOW BAT** - The LOW BAT icon indicates that the internal batteries (or the separate battery pack) is low on power. The system will not transmit or display any new speeds while LOW BAT appears and the display will remain blank.

**XMIT** - XMIT means the radar is transmitting.

**HOLD** - HOLD indicates the system is not transmitting.

**FPS** - Indicates that the gun is set to display speeds in feet-per-second.

**M/S** - Indicates that the gun is set to display speeds in meters-per-second.

Once the segment check test is completed, the display will show the POWER, HOLD and the units of measure (FPS or M/S) icons along with 5 dashes ( - ) across the center of the display as shown in figure 8. Model RVM is now ready to use.

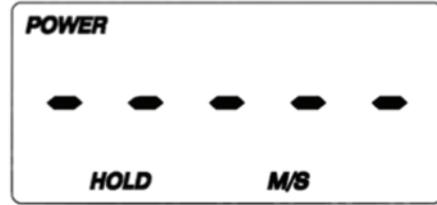


Figure 8

**Mounting Configurations**

The radar velocity meter is designed for hand-held operation. Optionally, it can be mounted to a standard camera tripod.

**Operating Modes**

The MENU and SEL buttons on the Model RVM Radar Velocity Meter control panel let you review and change programmable settings. The radar gun will remember the settings that were last set when it is turned off and will power up with them. The menu options are listed in Table 1.

Letters Displayed	Description	Setting Selection	How Default Setting is Displayed
bL	Backlight	On/Off (Default = Off)	<input type="checkbox"/> bL
COS	Horizontal Angle Compensation	0 to 60° in 5° increments (Default = 0°)	<input type="checkbox"/> COS
U	Unit of Measure	USA = FPS EUr = M/S (Default = M/S)	<input type="checkbox"/> U
A	Vertical Angle	Not adjustable verification only	<input type="checkbox"/> A
SEN	Sensitivity	1-10 (Default = 10)	<input type="checkbox"/> SEN

Table 1

**Display Function BL - Backlight**

Use the backlight function to turn Model RVM's display backlight on or off as shown in Figure 9. Turning the backlight off when not needed saves battery power.



Figure 9

### Display Function COS - Cosine Angle Correction

Use COS (cosine) to adjust the cosine correction angle for the horizontal (yaw) angle (the valid range is 0° to 60° in increments of 5°) as shown in Figure 10. The correction angle chosen will be saved and retained until it is changed again.



Figure 10

### Display Function - U

Sets the units of measure that speed will be displayed, as shown in Figure 11. Choose "EUr" to display for meters-per-second (m/s) or "USA" to display feet-per-second (f/s).



Figure 11

### Display Function SEN - Sensitivity Display and Adjustment

Higher numbers tell the gun to pickup surface velocity from a further distance. Lower numbers reduce the distance as shown in Figure 12. If the sensitivity is too high, the indicated velocity may be unpredictable and erratic. Choose a value that works best for where the measurements are being taken.



Figure 12

### Measuring Surface Velocity

#### NOTICE

Do not put the radar gun in the water. This will damage it. Model RVM measures the water surface only from outside the water.

To begin a velocity measurement, point the radar gun at the water and press the RCL button. The surface velocity can be measured flowing toward or away from the gun. A dash (-) on the left hand side of the display (as seen in Figure 13) will be shown and continue to flash until the velocity stabilizes.

The dash will stop flashing when Model RVM has performed enough measurements to display an averaged and reliable velocity. Model RVM will begin taking an additional 10 measurement starting with zero (0) and proceeding up to 9 as each measurement cycle is completed. Once all additional 10 measurements have been completed the average of all the measurements is displayed. This will take 60 seconds to complete.



Figure 13

### Taking a Measurement

- Turn Model RVM on by pressing the PWR button. Once the display segment check is completed the meter is ready to use.
- Push and release the RCL button. Model RVM will show a dash (-) on the left hand side of the display. The dash (-) keeps flashing, indicating that Model RVM is taking measurements. The velocity is updated once per second. This velocity may vary significantly while the meter focuses the data processing. Towards the end of the first 10 seconds, the displayed velocity will be accurate. (Do not press the RCL button again or the measurement cycle will be restarted.)
- After 10 seconds the dash (-) is replaced by the number "0" (zero) indicating that the next measurement cycle has started. The speed shown is the average velocity over the last 10 seconds and will remain in the display until the current measurement cycle is completed. The leading "0" will continue flashing.
- After 5 seconds the measurement cycle is completed and the "0" (zero) is replaced with the number "1", indicating that the next measurement cycle has started. The speed shown in the display is the average velocity over the last 15 seconds and will remain unchanged until this cycle is completed. The number "1" will continue flashing.
- After 20 seconds, the number in the left hand side of the display updates to "2" and runs the same speed measurement as described previously. Model RVM will continue to take velocity measurements every 5 seconds and display the new average speed, and update the number shown on the left hand side of the display until all measurement cycles have been completed.
- After 60 seconds have passed, the radar velocity meter will have completed ten separate 5-second batches of velocity measurements. The display will indicate the average of these measurements.
- Press the MODE button if you want to change the display resolution. The speed can be displayed in either 10ths or 100ths.

If the user presses the RCL button once the speed measurement cycles have finished, the reading will be canceled and Model RVM will begin taking a new measurement as shown in Figure 14.



Figure 14

**NOTE:** If there are fluctuations of more than 0.5 to 0.8 f/s (0.15 to 0.24 m/s) during a measurement interval, it is advised to review the final value. Consistent readings confirm the validity of the result, so it is recommended to take measurements more than once.

Because Model RVM measures the Doppler effect from the water surface, the meter requires a certain amount of return energy. Particulate material and/or floating debris (seeding) on the surface and surface water roughness provide this effect.

Model RVM easily measures the velocity at which the particulate material moves in high-flow conditions. This provides the accuracy of the surface flow. For velocities of more than 1 to 2 f/s (0.30 to 0.60 m/s), floating debris and particulate material provide an ample return signal to the radar gun for measurement. Water roughness also gives a good signal return. Ripples and crosscurrents produce velocities in all directions. During a measurement, Model RVM reads all the velocities and averages them into a resulting single value based on the amount of signal return to the antenna.

### Angle Compensation

Because surface velocity readings must be taken from a stationary, dry position, often a river bank or bridge, readings are necessarily affected by angle between the radar velocity meter's beam and direction of water flow (see the section on Angular Interference).

Model RVM compensates for this effect, referred to as cosine angle, both horizontally with user-programmable yaw correction and vertically with an automatic internal tilt sensor.

Model RVM's internal tilt sensor automatically compensates for the vertical angle at which the meter is aimed at the target, up to 60°. The vertical tilt sensor does not need to be manually set. However, you must hold the gun still at a constant vertical angle while taking a velocity measurement.

Model RVM indicates when the pitch-down angle exceeds 60° by displaying "tilt" as shown in Figure 15. While "tilt" appears in the display window, the radar gun does not record velocity measurements. To continue taking water surface velocity measurements, tilt the gun to an angle less than 60° until the "tilt" indicator no longer appears.



Figure 15

The vertical cosine angle will always be calibrated at the factory and should never need calibration in the field. However, the vertical angle of Model RVM can be verified as being correct at any time as shown in Figure 16.



Figure 16

### Horizontal Angle Compensation

Aiming the radar gun at the target at a horizontal angle greater than 0° creates a cosine error, which results in the radar displaying a spurious reading (Angles less than 9° impart an error of less than 1%). To eliminate or greatly reduce this error, set the horizontal angle compensation option to the angle that you plan to aim the radar gun to the target. Then aim and hold the gun at this set angle during the entire velocity measurement.

To set the horizontal angle compensation option, press the MENU button until COS (cosine) appears in the display. Then press the SELECT button.

Each time you press the SELECT button 00, 05, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, or 60 appears, representing the horizontal angle degrees in which you plan to hold the gun. Select the angle by displaying the number until the radar gun times out.

Now the meter is set at this angle selection and remains in this mode until you change it. This setting will appear the next time you enter this menu option.



Figure 17

### Programming/Communications Port

The Model RVM has a programming/communications port on the bottom of the handle. Use this port to upgrade the software as new releases become available, and to export data in a simple text file by means of a RS-232 communications cable (not included). Figure 18 illustrates the location.



Figure 18

The programming/communications port sends serial data and has the following characteristics (8:n:1):

- One (1) start bit
- Eight (8) data bits
- No parity
- One (1) stop bit
- Transmission at 19200 baud
- The unit transmits data as ASCII symbols.
- The update rate is once per second.
- The protocol is SSS.S<cr> (sent once every second during measurement cycle).

### Performance Tips

Understanding potential radar interference and what to do when it occurs can greatly increase the radar's performance. Determining a velocity begins with the radar gun transmitting and directing a beam of microwave energy (radio waves) at an approaching (or receding) target. When energy from this beam strikes the target, a small amount of energy from this beam is reflected back to the antenna in the radar device. The reflected signal frequency shifts by an amount proportional to the velocity of the target. This is known as the Doppler effect. The radar device then determines the target velocity from the difference in frequency between the transmitted and reflected signal. When the antenna transmits the beam of radio waves, the beam forms an elliptical pattern on the target area. The beam's size depends on the distance between the antenna and the target. The horizontal beam width is 12°. The detection area becomes larger as it becomes farther away from the antenna.

When Model RVM is pointed about 10 feet (3 meters) from the water surface, it measures an elliptical beam pattern of 2 feet (61 cm) in diameter. Keep this in mind when making measurements of a stream width. Take several readings to completely cover the full width of the stream.

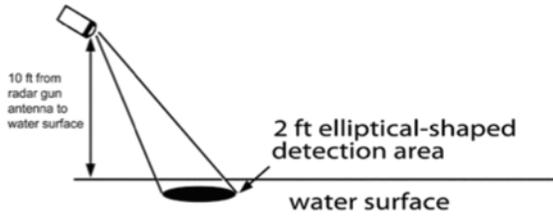


Figure 19

**Angle Interference (Cosine Effect)**

The cosine effect, as displayed in Figure 20, causes the radar device to display a velocity which is lower than the actual water surface velocity. This condition exists whenever the target's path (the water flow direction) is not parallel with the radar gun's antenna. As the horizontal (yaw) angle between the antenna and the target's directions of travel increases, the displayed velocity decreases. Ideally, an angle of zero (0°) is best.

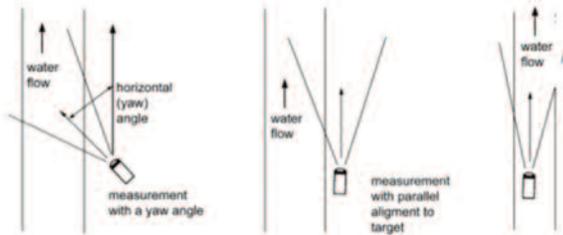


Figure 20

Small angles (less than 10°) have little effect on accuracy. As the angle increases, the displayed target velocity erroneously decreases, as Table 2 shows. At 90°, the target velocity is 0—grossly incorrect. Numbers such as these will be seen if the horizontal angle compensation option in the software menu is not set.

Table 2 shows the actual velocities (in the left column) and the velocity that displays (columns on the right) if the radar gun is not adjusted for the horizontal (yaw) angle. Note that for angles less than 10°, the cosine error effect on the velocity is minimal. Also, note that the table reflects only the cosine error from the horizontal angle. When a horizontal (yaw) angle and a vertical (pitch-down) angle is introduced into a measurement, both angles affect the final calculated display velocity.

Actual Velocity in f/s	0	1°	3°	5°	10°	15°	20°	30°	45°	60°	90°
	Displayed Speed:										
3	3.0	3.0	3.0	3.0	3.0	2.9	2.8	2.6	2.1	1.5	0.0
5	5.0	5.0	5.0	5.0	4.9	4.8	4.7	4.3	3.5	2.5	0.0
7	7.0	7.0	7.0	7.0	6.9	6.8	6.6	6.1	4.9	3.5	0.0
9	9.0	9.0	9.0	9.0	8.9	8.7	8.5	7.8	6.4	4.5	0.0
11	11.0	11.0	11.0	11.0	10.8	10.6	10.3	9.5	7.8	5.5	0.0
13	13.0	13.0	13.0	13.0	12.8	12.6	12.2	11.3	9.2	6.5	0.0
15	15.0	15.0	15.0	14.9	14.8	14.5	14.1	13.0	10.6	7.5	0.0
17	17.0	17.0	17.0	16.9	16.7	16.4	16.0	14.7	12.0	8.5	0.0
19	19.0	19.0	19.0	18.9	18.7	18.4	17.9	16.5	13.4	9.5	0.0
21	21.0	21.0	21.0	20.9	20.7	20.3	19.7	18.2	14.8	10.5	0.0
23	23.0	23.0	23.0	22.9	22.7	22.2	21.6	19.9	16.3	11.5	0.0
25	25.0	25.0	25.0	24.9	24.6	24.1	23.5	21.7	17.7	12.5	0.0

Table 2

**NOTE:** The vertical (pitch-down) angles that are less than 60° are automatically compensated for by the tilt sensor.

**Electromagnetic Interference (EMI)**

While operating, electric motors can produce EMI. EMI can produce spurious (erratic and unusually low or high) target velocities. To correct the interference, simply turn off the source of interference.

**Feedback Inference**

When the radar beam is directed at computer screens, streetlights, and other electronic devices, it can display spurious (erratic and unusually low or high) velocities. To correct the interference, move the radar gun's antenna away from the source of the interference.

**Scanning**

Model RVM is designed for use while attached to a solid mount or hand held in a steady position. Moving or "scanning" the antenna past stationary objects can cause the system to detect motion. Obtaining a velocity reading by scanning will not happen when properly using the radar meter.

**Environmental Factors: Wind, Rain, & Snow**

Wind moving across a water surface can produce waves, which result in movement differing from the main direction of the water flow. In high-velocity water flow, this effect is minimal or non-existent and does not affect the measurement.

However, in low water surface flow, such as conditions below 1 to 2 f/s (0.30 to 0.60 m/s), the wind's effect is dominant, so the measurement might not reflect the actual velocity movement. In wind, position the radar velocity meter toward a target area where wind does not affect or minimally disturbs the water surface, such as under a bridge or in a sheltered area.

Rain and snow can influence the accuracy of measurements. In slow water flow conditions, the vertical velocity component of rain or snow is dominant. Rain droplets passing in front of the measuring plane of the antenna and water surface roughness produced by rain droplets contacting the water surface cause this effect. However, in conditions of rapid water flow, these effects are minimal. The dominant effect is the surface water flow following the direction of the main open channel.

In these conditions, take measurements under a bridge, structure, or covered area where rain and snow do not dominate the measurement. Take measurements where the main channel flow is dominant. This eliminates the potential for errors from environmental factors.

**Care, Cleaning, and Storage**

- Avoid spilling food, beverages, and other liquids and substances on the radar device.
- When not using or transporting the device, store it in its original packaging.
- To clean the radar device, use a soft clean cloth, free of any cleaning solutions.

**MAINTENANCE/REPAIR**

Upon final installation of the Model RVM, no routine maintenance is required. The Model RVM is not field serviceable and should be returned if repair is needed. Field repair should not be attempted and may void warranty.

**WARRANTY/RETURN**

Refer to "Terms and Conditions of Sale" in our catalog and on our website. Contact customer service to receive a Return Goods Authorization number before shipping the product back for repair. Be sure to include a brief description of the problem plus any additional application notes.