

IRROMETER[®]



Moisture Indicator Reference Book

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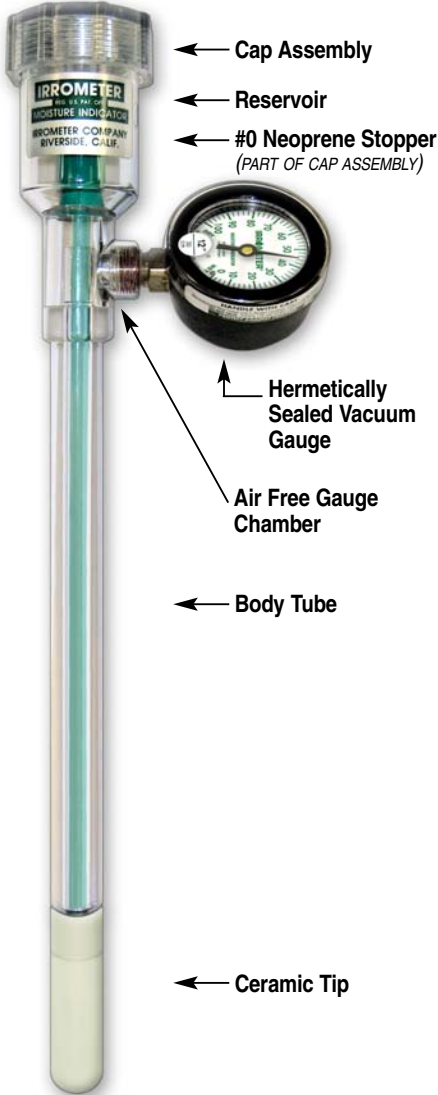
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Warranty BACK COVER

You have made an investment with your IRROMETER®, which will repay its cost many times over. This reference book will give you information that will insure the maximum benefit from your investment.

Hermetically Sealed Vacuum Gauge



REG. U.S. PAT. OFF.

Moisture Indicator

IRROMETERS are manufactured of the highest quality materials and workmanship. Whether you are using IRROMETERS in research, in the turf and landscape or on the farm, adherence to the suggestions given on the following pages will assure you years of trouble-free, accurate and reliable service from these instruments.

If you have questions that are not answered in this booklet, our staff is ready to assist you. Please call on us at any time.

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Checking In Shipments

Shipments should be unpacked carefully and checked in immediately upon arrival. Do not remove the plastic tip covering until preparing for installation.

Instruments are shipped dry and must be prepared for installation according to the instructions given below.

Preparing IRROMETERS for Installation

When instruments are received, it is necessary to prepare them for installation as outlined in steps 1 through 6 below.

1 Take the plastic wrappers off the tips and fill IRROMETERS with clean water. **Do not handle the ceramic tip.** Leave the instrument cap OFF and place the tip of the IRROMETER in clean water overnight (use clean non-rusting glass jar, plastic bucket or basin). Water in the instrument will drain through the tip and this operation may be repeated as often as time permits. After soaking and you are ready to install, protect the tip from air drying with wet paper towels, the plastic tip bag or insert into a bucket of wet sand while transporting to the installation site.

2 Prepare IRROMETER Field Solution as directed on the bottle label — (a scant capful of concentrated IRROMETER Fluid to one gallon of clean, de-aired water, such as distilled, rainwater, boiled water that has cooled or tap water that has been allowed to sit).

3 Remove the filler cap and fill the instrument, including reservoir, with IRROMETER Field Solution or distilled water. If the tube does not completely fill, it may be due to an “air lock” which has formed at the tube filler hole at the bottom of the reservoir. Tap the top of the reservoir with the palm of your hand to break this ‘air lock’ and facilitate complete filling of the tube. *See picture.* Using a plastic squeeze bottle makes filling easier as you can aim the flow of water into the body tube of the instrument. *See picture.*

4 Apply a strong vacuum to the IRROMETER with the hand vacuum pump. With the filler cap removed and the tip submerged in water or the bucket of wet sand, place the suction cup over the reservoir and pump vigorously until a reading of 80-85 shows on the gauge, usually 5 or 6 quick pulls. (*See page 9 -- ‘Hand Vacuum Pump.’*) At higher elevations, maximum vacuum will be lower (i.e. 70-75 at 4000' above sea level). Release the vacuum slowly, using the finger release valve on the suction cup, to avoid gauge damage. Repeat the above procedure to remove all air from the gauge, usually 2-3 times is sufficient. Replace filler cap by tightening until the neoprene stopper makes



contact with reservoir bottom, then turn the cap 1/4 turn. Do NOT over tighten, this can damage the IRROMETER gauge or stopper.

5 Remove the plastic tip cover on the instrument, or remove from the bucket of sand, and install the IRROMETER in the prepared hole. See section 'INSTALLATION' page 6.

6 Pump the IRROMETER as illustrated each day for 3 to 6 days or until no further air bubbles appear. Tapping the side of the instrument with cap assembly will facilitate air release. Refill the reservoir as necessary and replace filler cap. A well de-aired instrument increases sensitivity and reduces water use in maintaining reading.

NOTE: Small champagne type bubbles of air which appear during de-airing are not of concern.

If de-airing is more conveniently accomplished before installation, place the instruments in a large plastic container half filled with water and follow the above steps. Be sure to protect the tip from air drying when transporting IRROMETERS to installation site. See Note 2.

CAUTION for LT & MLT — with models 'LT' and 'MLT' carefully pull a vacuum to a reading of 30 to 35 on the gauge and be careful to bleed vacuum slowly. These gauges are very sensitive and can be damaged by a rapid release of vacuum or over-pumping. The MLT uses a syringe style vacuum pump, refer to supplemental instructions. See picture.

MODEL 'MLT' FILL & AIR REMOVAL INSTRUCTIONS — 1.

Remove cap, tip protector and plastic bag covering tip. 2. Place tip in clean water and soak overnight – you do NOT need to fill the instrument. Step 5 below will complete the filling process. 3. Make IRROMETER field solution by adding one drop of IRROMETER fluid to a cup of clean water. 4. Fill syringe half full with IRROMETER field solution. 5. To fill, place syringe tip loosely in O-ring seal (located in cap opening), depress syringe plunger to squirt water into the body tube of the MLT. Do not seat the syringe to the O-ring in this step as it could force the gauge needle against the stop. (RSU units do NOT have a gauge needle). 6. To remove air, place syringe tip in O-ring seal (located in cap opening), press in firmly to make a seal. With instrument at 45 angle (gauge or RSU down or on the underside), PULL GENTLY on syringe to create a partial vacuum on the gauge or RSU (on gauge model, do NOT exceed full scale of gauge or 40 kPa/CB) and release slowly. Pumping this way several times will get most of the air out of the gauge or RSU. 7. Remove syringe by slowly twisting while pulling out to avoid a rapid release of vacuum, fill instrument cap opening with water. 8. Replace cap – tighten until gauge needle moves toward



stop. 9. Tip (body) of instrument can be removed by pulling out from the top housing. Be sure to remove the cap before attempting to pull the tip (body) out to avoid damaging the gauge. Replacement tips (bodies) are available.

CAUTION for RSU — use the Test Pump service unit pump (with the gauge attached), as this model IRROMETER does not have a gauge. With the model 'RSU' carefully pull a vacuum to a reading of 80 to 85 for standard (white tip) IRROMETERS, 30 to 35 for LT (blue tip) IRROMETERS and 10 to 12 for MLT (miniature blue tip) IRROMETERS. Be very careful to bleed vacuum slowly. The transducer diaphragm is very sensitive and can be damaged by a rapid release of vacuum or over-pumping.

Selecting Locations for Installation

Careful selection of key locations for installation is of utmost importance with IRROMETERS, as with all other methods of soil moisture measurement. Except where there is very level, uniform soil and subsoil and very uniform distribution of water — as with sprinklers — do not install the instruments in a 'checkerboard' pattern. Almost invariably such factors as productivity in good and poor sections, topography, infiltration rate and water holding capacity of varying types of soil and subsoil will govern the location of 'stations'. With furrow or basin irrigation, instruments are usually placed near the lower end of the run. In very long furrows, a second station of instruments is sometimes installed at the upper end or at some intermediate point in the run.

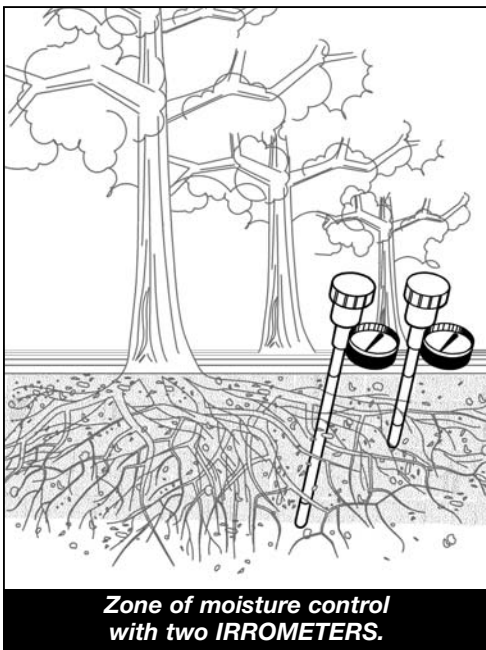
If, after an irrigation cycle or two, the appearance of the crop indicates that more critical areas exist, either move some of the instruments to these areas or install additional instruments.

The IRROMETERS should always be installed in the root zone of a vigorous plant or tree. Also, where the plants are large enough to shade part of the ground, it is customary to install all instruments in locations on the sunny side of the plant where ground surface evaporation losses are greatest.

When crops have a root system exceeding about 18", instruments should be installed at two depths — one at about 25% of root zone depth and one at about 75% depth.

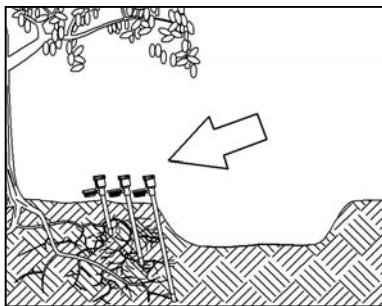
In making an initial installation, concentrate more instruments than you think will ultimately be required in a relatively small area. Later, instruments can be moved to other areas if they are not needed. Otherwise, leave instruments in permanent locations for the entire growing season, so there will be continuity in the seasonal chart curves. Most of the value of the charts is lost when instruments are moved. In starting out it is better to do a thorough job in a small area than to scatter a few instruments over the entire acreage.

NOTE: Due to many infield variations of soil types, it is best to use two 'locations' in a single irrigation block. Then 'average' the readings for a better overall picture.



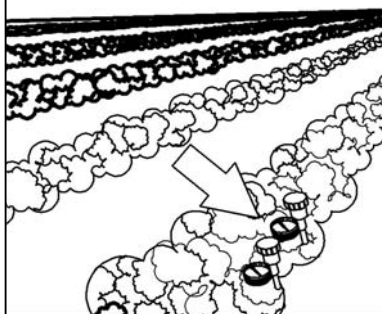
Placement of IRROMETERS in Furrow Irrigation

Place IRROMETERS approximately 2/3 of the way down the run with tips angled slightly towards the furrow. In tree crops the IRROMETERS are generally placed on the side of the tree which gets the afternoon sun. In row crops they would normally be placed in the row. Since lateral movement of water varies widely with different soils, the closer the tip is located to the side of the furrow, the more representative the results will be.



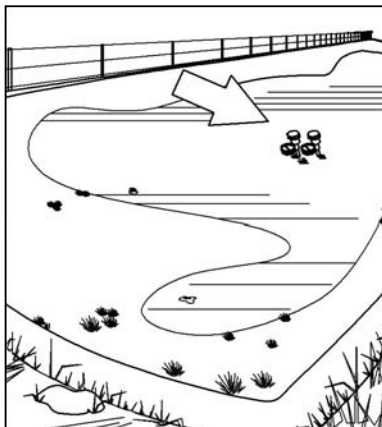
Placement of IRROMETERS in Flood or Border Irrigation

In flood or border method of irrigation, IRROMETERS are normally placed approximately 2/3 of the way down the run as this generally is the point most critical for adequate penetration. The general rule of locating at the drip line of the tree in tree crops or in the row for row crops, is best. It is also best to order IRROMETERS at least 6" longer than desired for placement so that the gauges can be set higher, above the water level when irrigating. In some cases it has proved beneficial to place IRROMETERS on the border itself, at an angle, so that the tips are located in the root zone of field crops.



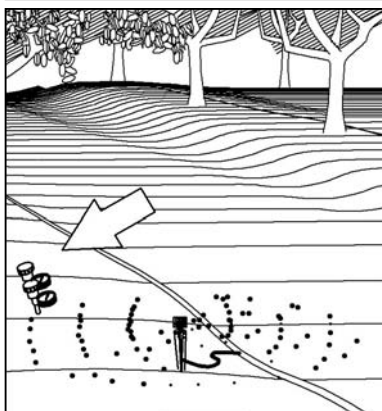
Placement of IRROMETERS in Sprinkler Irrigation

In sprinkler irrigation IRROMETERS are normally located on the side of the tree where the afternoon sun shines. Again, placement should be at the drip line of the tree. Special care should be exercised in tree crops to insure that limbs or heavy foliage do not obstruct the sprinkler pattern to the IRROMETER location or that they are not located beyond the normal pattern of the sprinkler. In row crops IRROMETERS are located in the row.



Placement of IRROMETERS in Drip Irrigation

In drip irrigation, IRROMETERS are normally located on the sunny side of the tree and essentially at the drip line of the tree. IRROMETERS are generally placed 12"-18" away from the emitter (24"-36" from the micro sprinkler or spray) to insure that they are in the wetted area. In newly planted trees, the shallow IRROMETERS should be placed in root ball of the tree regardless of emitter location. In row crops the IRROMETERS should be placed in the row. Additional IRROMETERS may be used to measure water movement away from the emitter but controlling IRROMETERS should be placed in representative locations 12" to 18" from the water source and in the root mass area.



Installation

A good contact between the buried portion of the IRROMETER and the soil is essential in order to obtain accurate readings.

If air is permitted to follow down the plastic tube, due to an oversize hole and reach the ceramic tip, false readings on the 'high' side will occur. If free water falls/follows down the tube, false readings on the 'low' side will occur. The specific suggestions below are offered to prevent either of these conditions.

In very loose soil, the shorter instruments can sometimes be installed by simply pushing them into the ground, without subjecting them to undue strain. This results in good contact with the soil and minimum disturbance to the soil structure and root system.

In most cases, however, it is necessary to prepare a hole before making installation. While IRROMETERS may be installed at any time, it is usually easier to prepare the hole when the soil is fairly moist.

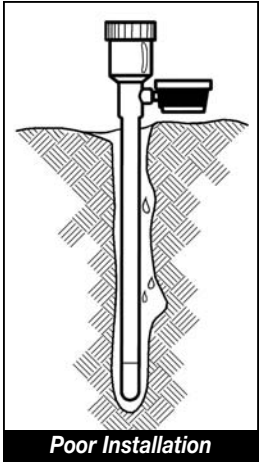
The diameter of the IRROMETER tube is 7/8" (22 mm). A pointed 7/8" (22 mm) steel rod or a standard piece of 1/2" galvanized pipe usually makes the most convenient installation tool and makes a hole the exact size of the IRROMETER. This assures good soil contact with minimum disturbance to roots or soil structure. Drive it into the ground to the exact depth at which the ceramic tip is to be installed. Avoid drilling the hole too deep as this permits air and water to collect in the hole below the tip and affects the accuracy of the readings.

A variety of installation tools are available which make installation easier in hard or rocky soil and with deep depths. For very coarse or gravelly soils, an oversized hole (1" - 1.25" [25 mm - 32 mm]) may be needed to prevent abrasion damage to the sensor membrane. In this case, auger a hole to the desired depth and make a thick slurry with the soil and some water. Fill the hole with this slurry and then install the sensor. This will 'grout in' the sensor to ensure a snug fit.

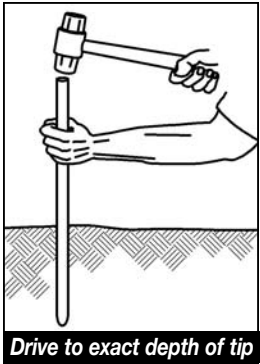
After the instruments are installed to the proper depth, the surface of the soil should be banked up around the plastic tube and packed to a depth of 3 or 4 inches, to ensure good contact between the soil and the instrument, and provide drainage for surface water away from the IRROMETER.

NOTE: In very light (coarse) soils, the access hole depth can be made 2" less than full depth. Pour some water in the access hole, set the instrument in hole and bear down on top of cap (NOT GAUGE) to push tip the last 2" into the soil. This helps establish a snug fit between tip and soil.

Handle the instruments carefully when installing or removing from the ground. Do not put a strain on the gauge connection by pushing or pulling on the gauge. Push straight down on the filler cap when installing. When removing from the ground, rotate the instrument first to break it loose from the soil. *NOTE: Always rotate IRROMETERS with threaded tips clockwise to avoid loosening the tips.* Then grasp the



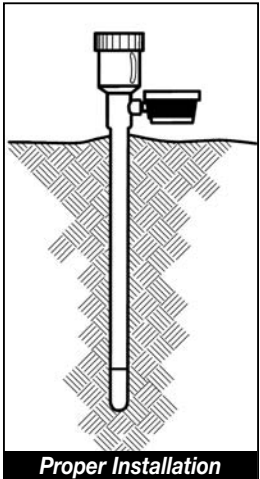
Poor Installation



Drive to exact depth of tip



Pushing on cap



Proper Installation

main tube and pull straight up. Always avoid a lever or a 'crow bar' action. It puts a strain on the ceramic tip connection.

Specify instruments of suitable lengths. There should be a minimum clearance of about 1 inch between the bottom of the gauge and the soil. This allows the gauge diaphragm to expand and contract freely with temperature fluctuations. Also, not more than about six inches of the main tube should project above ground to avoid damage.

In some cases, it is desirable to install the IRROMETERS at an angle. This allows the tip to be placed at specific depths without having too much of the IRROMETER body exposed above ground. In orchards, this helps to keep the exposed portion of the instrument under the canopy which offers better protection. Instrument bodies can even be bent to certain angles to make such installation easier. Consult factory for details. Always set the instrument so the gauge is in a downward position. After installation, fill the reservoir with IRROMETER Fluid, and release any air that may have accumulated below the reservoir. (See section on 'SERVICING'.)

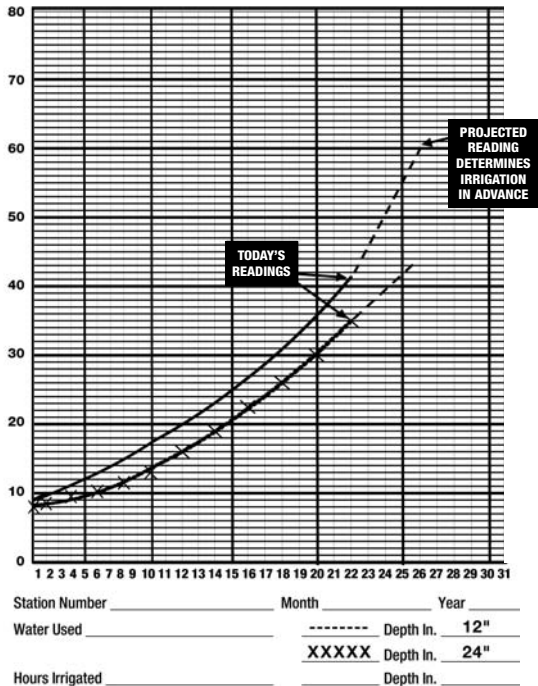
Installation of instruments invariably disturbs the normal soil structure and root system to some extent, yet in most soils IRROMETERS give an accurate indication of soil moisture content a few hours after installation. In rocky soils or when an oversize hole is drilled, it may take an irrigation to settle the soil normally around the ceramic tip and insure precise readings. De-airing the instruments thoroughly during the first 3-6 days after installation insures maximum sensitivity and accuracy. See the 'IRROMETER Instrument Installation' video at: IRROMETER.com/videos.html.

IRROMETER Charts

Just as a thermostat in your home guides you in maintaining the desired temperature, the IRROMETER guides you in maintaining desired soil moisture content. And just as you need to know when and how much fuel is needed to keep a safe reserve on hand to meet varying climatic conditions, it is necessary to know when and how much to irrigate to maintain soil moisture content within the desired range. This requires planning irrigations in advance based on seasonal use in the past.

The IRROMETER charts provide the simplest method of keeping records for this purpose. Special pocket size chart forms are included with each IRROMETER Service Unit. Readings are plotted directly in the field. The resulting curves give a picture of the rapidly fluctuating soil moisture conditions throughout the root zone, in each section, that can be visualized in no other way. 'Rate of change' may be the best indicator

of WHEN to irrigate. That is, if the reading increases 10-15 centibars (kPa) in just a few days, the soil is drying rapidly. Thus the charts provide a complete original record with an absolute minimum of clerical work. Projecting the seasonal curves for each section makes it easy for the grower, or executive in charge of larger operations, to plan irrigations in advance. Reference to past charts



A software program to plot readings is available at IRROMETER.com/sensors.html under the 'WATERMARK Meter Features' heading.

makes it possible to maintain the most desirable soil moisture content in each section, year after year. The charts are a very important factor in IRRROMETER irrigation control, and it is strongly recommended that they be kept up to date.

The charts are also useful to keep rainfall information, fertilizer applications and unusual weather conditions posted with moisture readings for future reference.

Use of dataloggers makes such record keeping easy and automatic. IRRROMETERS are available with electronic outputs for use with datalogging equipment.

Taking Readings

The frequency of charting readings depends upon how fast the soil dries out. In sandy soils or in hot weather, readings should be charted two or three times a week. In moderate climates, charting readings once a week is usually adequate. Even less frequent readings may be required in wet weather. After a few irrigation cycles, the charts will indicate how often readings are required in each section. It is best to chart the readings just before and just after an irrigation so that the maximum and minimum readings are recorded.

In areas where there are extreme daily fluctuations in temperature, readings should be taken the first thing in the morning. Especially during peak water use, readings can climb during the day and then drop back at night. Thus, early a.m. readings are usually most accurate. Tap the gauge lightly before taking a reading. The slight movement of the pointer will indicate whether the soil is drying out or soaking up moisture.

Usually the instruments are 'serviced' on the same round that readings are taken. Readings should always be taken before servicing.

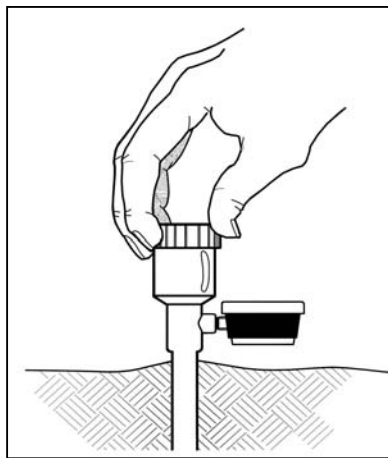
Field Servicing

It is normal for the fluid level just below the reservoir to fall as the soil dries out. A vacuum is created in this space. Following an irrigation, this vacuum draws moisture back out of the soil causing the fluid level to rise almost to its original level by the time the gauge reading indicates field capacity. However, with each cycle a little air is drawn in from the soil and collects below the reservoir. This air slows up response of the instrument to variations in soil moisture. It also tends to result in slightly lower than accurate readings.

The purpose of 'servicing' tensiometers is to remove the entrapped air in order to maintain optimum accuracy. Servicing is simple with IRRROMETERS. Loosening the cap allows air to escape by bubbling up out of the reservoir, whose water then drains back down to refill the instrument body. Fluid in the reservoir should be replaced as necessary. The instrument will not hold the same water it was installed with; it will have to be periodically refilled.

Unscrew the cap slowly with a slight downward pressure, whenever there is a high vacuum reading on the gauge, so that the pointer does not slap back against the stop, causing shock to the gauge. The large cap and resilient stopper make control of this operation easy. To re-seal, it is not necessary to exert excessive pressure to get a positive seal with this closure. The resiliency of the stopper can be prolonged by tightening the cap only about 1/4 turn after the stopper makes contact with the bottom of the reservoir. If the stopper hardens, replace with a new stopper.

When relatively moist soil conditions are maintained, very little air is drawn into the instrument and the supply of fluid in the reservoir usually lasts for several months. Where very high gauge readings occur,



and especially if they continue over considerable periods, much more frequent servicing is required. The maximum reading that can be reached is about 85. As this point is approached, a greater amount of air is drawn into the instrument. In this range, the instruments should be 'serviced' and the reservoir should be filled, if necessary, about once a week. If servicing is not performed, eventually all the water will be drawn out of the instrument and the vacuum will be lost, giving a 'FALSE' zero reading.

For most field applications, less frequent refilling of the reservoir is required and satisfactory results are obtained by 'servicing' only when air is visible in the portion of the instrument above ground, after gauge readings have dropped following an irrigation.

In research work, maximum accuracy and sensitivity are obtained if instruments are serviced every few days. This practice is also recommended for field use under saline conditions, as it ensures that almost all movement of fluid is outward. It thus reduces the amount of soluble salts drawn into the instrument from the soil, following an irrigation.

Provided IRROMETERS are kept in an upright position, the fluid seal on the gauge prevents air from entering the gauge, even though servicing is neglected for considerable periods. However, some air may accumulate in the pores of the ceramic tips or on the walls of the plastic, so the hand vacuum pump should be used in the field about every 30 to 60 days — particularly on instruments installed at an angle — to ensure that the instruments are maintained entirely air free. Tapping the reservoir lightly while the instrument is under vacuum from the pump helps to release any air present.

Make sure that there is considerable soil moisture, at ceramic tip depth, when using the hand vacuum pump and apply the vacuum for only a few seconds. (Excessive vacuum applied when the soil is dry, draws air into the instrument.)

Systematic servicing is essential to accuracy and quick response to irrigations. If this is done just after charting readings, the extra time required is almost negligible.

See the **'IRROMETER Instrument Fill and Service'** video at: IRROMETER.com/videos.html

Hand Vacuum Pump

This pump has a universal suction cup that fits all standard size models of the IRROMETER. Remove the IRROMETER filler cap and apply the hand vacuum pump. Four or five quick strokes of the piston will produce an 80 to 85 gauge reading, the maximum vacuum. The pump will then adhere to the instrument 'hands-off.' This is a great convenience, as it leaves one hand free to release air bubbles by tapping the main tube lightly. Refer to 'NOTES' on page 3 regarding LT, MLT and RSU IRROMETERS.

Always release the vacuum slowly so as to prevent shock to the gauge movement. The suction cup of the pump has a built-in finger release valve to facilitate slow release of the vacuum. Push the tip of the release valve gently in any direction to bleed off the vacuum slowly.

Periodic cleaning of the pump parts can be accomplished by disassembling the pump and flushing all parts with clean water. After drying, all parts, particularly the ball valve, should be lubricated with a silicone lubricant spray.

NOTE: See 'TEST PUMP' option on page 17.



Air removal



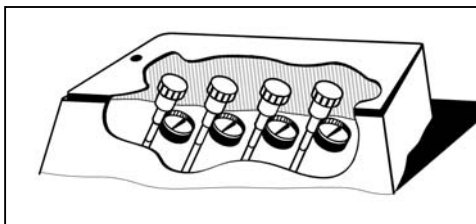
Release valve

Protection of IRROMETERS

Growers find that they protect their investment by protecting the instruments. The purposes of protection are:

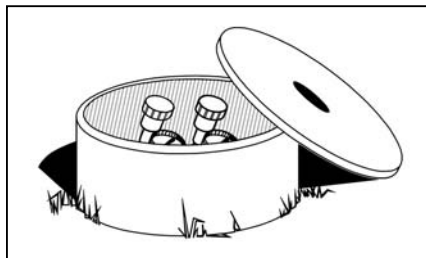
1. To prevent accidental damage to the instruments resulting from field operation.
2. To facilitate taking readings by keeping the gauge crystal clean.
3. To inhibit the growth of algae by keeping out of sunlight.
4. To provide a measure of frost protection. In areas where temperatures drop only a few degrees below freezing for short periods, protection makes it possible to keep the instruments in the ground all through the winter. In this case, mineral wool, straw or other insulation should be packed around the instrument.
5. To minimize temperature fluctuations which have a slight effect on gauge readings.

With tree crops or in other permanent installations where furrow or flood irrigation is used, sections of steel, concrete or PVC pipe, or wood boxes are recommended. The cover may either be a waterproof fertilizer sack or a wood lid.



When used in pastures, IRROMETERS should be protected with a heavy concrete or steel pipe and the instruments installed at an angle so that the tips extend beyond the protective covering.

Wherever IRROMETERS are installed, it is advisable to mark them plainly with a flag or stake to minimize the danger of accidental damage and to locate them easily when taking readings.



Starting Irrigations

It is impossible to give specific instructions as to when to start irrigations for all crops, all soils, all climatic conditions and all methods of irrigation. You will learn the best time to start irrigations for your particular crop and local conditions by following your charts after a few irrigation cycles. If you have not used IRROMETER control the following suggestions are offered as a starting point.

For most crops, a rule-of-thumb recommendation is to start irrigations at a gauge reading of about 50 (**except with drip or low volume irrigation – see below**).

In order to do this properly, you will need to allow a reserve of soil moisture as a safety factor, as few growers can wait until the last minute to irrigate. The following are typical of adjustments in irrigation treatments.

In hot, dry climates, irrigations start at the following readings for most crops:

10-35 in sandy soils / 35-50 in medium soils / 50-60 in fine textured soils

In cool humid climates – coastal areas, for example – it is often safe to delay irrigations until readings are 10 to 15 points higher in each case.

The concept of drip irrigation is to apply low volumes of water very frequently to maintain readily available water to the plant. To accomplish this, the IRROMETER located 12"-18" from the water source should be maintained at or near field capacity (3-20 reading on the gauge). This will assure outward and downward water movement in the soil as in a blotting action.

IT IS IMPORTANT when the emitter wets the entire root zone of a newly planted tree or plant that soil not be saturated (0-5 reading) for extended periods.

It is possible to grow some crops in some fine soils at even higher readings and get good yields. However, we know of no cases where yields or quality have been increased by starting irrigations at higher readings during the vegetable period of growth. On the other hand, there is considerable evidence that this practice results in a substantial loss of yield and delayed maturity with most crops.

In any case, the above adjustments should not be confused with the 'Soil Calibrations' required with other methods of measuring available soil moisture. The purpose of these adjustments is to maintain available moisture in accordance with the requirements of the particular crop and allow a safety factor in the event of delayed irrigations. This is necessary with every method of irrigation control. The use of 'Soil Calibration' charts involves an additional operation and complication.

NOTE: The trend or 'rate of change' can be as important as the IRROMETER reading in making irrigation decisions, as discussed under 'IRROMETER Charts.'

Accuracy of IRROMETERS

Exhaustive tests by leading soil scientists have demonstrated that IRROMETER type instruments provide the most accurate and most sensitive method of measuring soil moisture in the range in which most crops are grown. In fact, they are widely used as reference instruments to check the accuracy of soil moisture determinations made by other methods. The slightest variations in available soil moisture resulting from soil type or compaction, root density or other factors – variations too small to be measured easily by other methods – are automatically evaluated and registered on the IRROMETER gauge. This feature is very valuable in many research applications where precise measurement of soil moisture is required.

However, the same accuracy of control may not be practical nor necessary under field conditions. For example, if the objective is to start irrigations at a reading of 50, variations of 10 to 15 points in either direction are to be expected on instruments in various areas due to the extreme sensitivity of the IRROMETER. Soil moisture will still be maintained well within the range for the optimum crop growth. Even greater variations may occur for short periods without loss of yield or quality.

Interpreting IRROMETER Readings

The IRROMETER measures energy directly – the energy, that is, the roots must exert to extract moisture from the soil – whereas other methods of making soil moisture determinations measure the total amount of soil moisture and then in effect, convert it into root energy for each type of soil by means of soil calibration charts. Obviously then, the IRROMETER requires an entirely different unit of soil moisture measurement.

The IRROMETER gauge is graduated 0-100, the graduations representing hundredths of an atmosphere. The unit of measurement is centibars or kilopascals, with a gauge reading of 50 representing 1/2 atmosphere or about 7 pounds of negative pressure (vacuum). This reading is a direct measurement of how hard the root system has to work to extract water. If this seems complicated, think of your IRROMETER readings as you would a thermostat and schedule irrigations to maintain soil moisture within the desired 'comfort' range.

NOTE: Low Tension (LT & MLT) IRROMETERS have a gauge which is graduated from 0-40 centibars (kilopascals). This provides for better resolution in the very wet end of the soil water spectrum.



Average Percentage of Moisture Extraction from Normal Root Zones

1st Quarter – 40%

2nd Quarter – 30%

3rd Quarter – 20%

4th Quarter
10%

Irrigating with IRROMETERS

Your charts enable you to determine how soon and how much to irrigate after a rain. Most growers find surprising differences in penetration in different areas, due to variations in soil type and topography. Even in the same areas, infiltration rates often vary considerably depending upon how recently the soil has been cultivated and how wet the soil happens to be at the time rainfall occurs.

Wilt starts at the roots. By the time the leaves indicate stress, plant growth has either stopped or slowed. Unless the stress is severe, growth will resume following an irrigation, but some loss of production and delayed maturity will result. For this reason, most research workers recommend that irrigations start well before there is any evidence of stress.

Be sure to maintain plenty of soil moisture in the vital feeder root zone. Note that about 70% of the plants' moisture requirements are taken from the upper half of the root zone. Adequate soil moisture in the lower root zone helps to tide over temporary periods of stress but is not sufficient to promote maximum growth. IRROMETERS installed at two or more depths register soil moisture conditions at different root horizons and thus give a more accurate picture of the moisture profile than composite soil samples taken with a soil tube or auger.

With crops grown for the seeds or fruit, the same recommendation applies during the period of vegetative growth. For instance, research has demonstrated that yields with corn are reduced materially by even short periods of stress from seeding up through the dough stage. With some of these crops, research work indicates that irrigations should be reduced during the ripening period of growth. The amount that irrigation is reduced varies with the crop and climatic conditions.

With seasonal crops, you can expect to effect marked improvement the first year with IRROMETER control. With tree and perennial crops, that are in poor condition, it may take longer. In any case, you will find that IRROMETER control eliminates the most important variable affecting production — irrigation. This enables you to concentrate on improving other cultural practices that may be necessary to improve production.

Finally — if you have been irrigating by rule of thumb methods, based on the calendar, acre inches of water per crop or per year or any of the older concepts, be prepared to make very radical changes. They are usually indicated. The degree of change is often an index of the degree of improvement. You can rely upon the accuracy of your IRROMETERS in making these changes.

Discontinuing Irrigations

As soon as irrigation water penetrates to the ceramic tips, gauge readings will go down. Discontinue irrigations when the readings on the shorter instruments drop to the 0-15 range and readings on the 36" to 48" instruments drop to the 10-15 range. It is not necessary to continue irrigating until the readings reach 0. In poorly drained soils, discontinuing irrigations at reading of about 30 is advisable to avoid any possibility of water logged soils.

The gauge readings should begin to rise after gravity water has had time to seep down and the roots begin to take up moisture from the soil. Continuous readings in the 0-20 range indicate poor drainage and saturated soil. Irrigations should be discontinued or reduced until this condition is corrected.

Waterlogged Soils

Where there is poor drainage, three IRROMETERS per 'station' are used in critical areas. The third IRROMETER is of extra length and usually extends below the normal root zone. It provides a continuous check on the water table and helps to prevent over irrigation and waterlogged soils.

Increasing Profits

Investigate the possibility of using IRROMETER control to increase plant population per acre with your particular crops. Various agricultural experiment stations have demonstrated that this is possible with

a number of crops provided there is increased fertilization and proper irrigation. With corn, for example, increased fertilization alone produced no benefits, but with increased – and controlled – irrigation, yields were more than doubled.

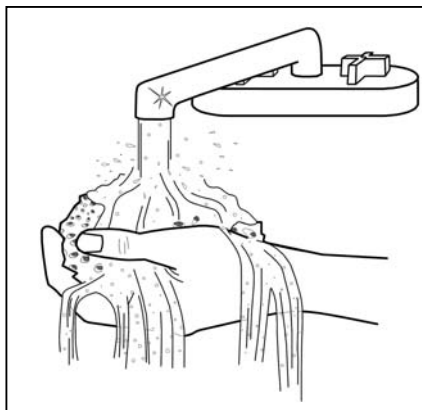
Controlled irrigation is just as beneficial in increasing quality and insuring early maturities as in increasing yields. IRROMETERS are used extensively by the United States Department of Agriculture, state experiment stations, and large commercial growers with fruits and vegetables, sugar cane, tobacco and other crops. In one project with sweet corn, yield was improved and the crop was ready for market two weeks earlier by increasing fertilization and maintaining readily available soil moisture during the critical early period of growth.

We are continually collecting data on progress in these fields which is available upon request.

Saving Water/Energy

It is never recommended that a direct attempt be made to save water by reducing soil moisture below optimum conditions for plant growth. The proper use of IRROMETERS allows you to eliminate the guesswork involved in irrigation scheduling and usually results in reducing irrigation cost.

Wetting soil might be compared to wetting a sponge. The sponge will hold only so much water and will absorb that water in a few seconds. Holding it under the faucet for an hour will neither cause it to absorb more water nor hold that water longer. Soils take longer to absorb water but the same principle applies. Any excess water applied is wasted by deep percolation or run-off. By far the greatest waste is usually due to percolation because this loss is not visible.



Probably the greatest saving in water affected by IRROMETER control results from saving unnecessary and excessively heavy irrigations. Most growers find that they had previously been holding certain sections “under the faucet” far longer than necessary at times, while other sections may have been short of water. Correcting these conditions – using water where, when and in the amount needed – often results in surprisingly large net savings of water at the end of the year. However, it is not unusual to find that more water is required, in some sections, during some periods.

In soils where there is a very slow rate of infiltration, seepage to the level of the ceramic tip on the ‘deep’ instrument may take two or three days. The drop in gauge readings will be delayed accordingly. Under these conditions, a substantial saving in water can be effected by applying half the water used previously and waiting to see whether this brings gauge readings on the ‘deep’ instruments down to field capacity, instead of continuing to irrigate right up to the time that penetration is registered on the gauge. Experience over two or three irrigation cycles will indicate the minimum amount of water required to insure penetration to the lower root zone. Also in these soils, there is usually a material saving in water, if irrigations start while there is still considerable moisture in the soil. Water penetrates moist soil much more rapidly than dry soil, so less water is required to infiltrate to the lower root zone.

It is usually found that gauge readings on the ‘shallow’ instrument rise much faster than on the ‘deep’ instrument, due to higher plant use of water in the feeder root zone and to surface evaporation. If readings on the deep instrument indicate that there is adequate soil moisture at this level, water is saved by applying only enough water to bring down the readings on the ‘shallow’ instruments.

Under some conditions, water is saved by irrigating alternate furrows, during at least part of the irrigation season.

In hillside plantings, IRROMETERS placed at upper and lower locations frequently indicate

unsuspected run off or subsoil drainage. Radical reduction or even discontinuance of irrigations in the lower sections during some periods often results in material saving in water and at the same time maintains better soil moisture content for crop growth.

In soils containing rock or gravel, frequent soil sampling is often either impractical or the cost is prohibitive, yet these are the soils where irrigation control is needed most. They dry out quickly in hot weather and to ensure adequate moisture, much water is often wasted to deep percolation by 'guesswork' irrigation. Charting IRROMETER readings frequently – even daily – often results in material water savings and in better soil moisture conditions for plant growth.

In many cases, the value of IRROMETER control goes far beyond cash savings on the monthly water bill. It makes a limited supply of water go farther and thus saves the investment required for developing new sources of supply.

Common Questions

The following are answers to questions that sometimes arise when IRROMETERS are used for the first time.

INSTRUMENTS ALWAYS READ ZERO

Soil is saturated from irrigation, rainfall or poor drainage.

Instrument has no water or lost suction due to low water level in the IRROMETER. Refill IRROMETER.

Check gauge calibration and fill the IRROMETER (gauge should read 80-85 with vacuum applied by hand vacuum pump, less with LT, MLT).

INSTRUMENTS DO NOT SEEM TO RECORD TRUE SOIL MOISTURE CONTENT

This is by far the most common question. Almost invariably it is due to the fact that actual soil moisture content is very different from what you thought existed. Taking soil samples within about 6" of an IRROMETER station and at the exact depth of the ceramic tips with a soil tube auger or shovel will usually demonstrate the instrument readings are accurate. Refer to the sections on 'GAUGES' and 'CERAMIC TIPS' on page 16.

INSTRUMENTS REQUIRE FREQUENT REFILLING

This usually indicates under-irrigation – readings in the upper range for periods of several days. Other occasional causes may be:

Improper installation – soil not properly packed around the instrument.

A leaky seal at the closure. Replace rubber stopper if it has hardened.

A leaky gauge connection.

INSTRUMENTS RESPOND SLOWLY TO IRRIGATIONS

This is usually due to a slow infiltration rate of the particular type of soil.

Make sure that the instrument is full of fluid and free of air. See section on 'FIELD SERVICING' on pages 8-9.

Ceramic tips partially sealed with salts. See section on 'CERAMIC TIPS' on page 16.

Gauge movement "sticky" due to minor damage. Tap the gauge lightly before taking readings.

If IRROMETERS are several years old or tip has been frequently dried by removing from the soil, factory reconditioning the IRROMETER is desirable. For a nominal cost, the IRROMETER tip, stopper and cap is replaced. The IRROMETER is returned to you as new.

WIDE VARIATIONS IN RATE OF CHANGE OF INSTRUMENT READINGS

This is to be expected. Almost all new users discover amazing variations in soil moisture content in different sections due to topography and different soil types. That is the reason that an adequate number of instruments is necessary for reliable irrigation control. Attempting to control irrigations on the basis of inadequate information can be misleading rather than helpful.

Storage of IRROMETERS – When not in use

When IRROMETERS are in continuous use, as with tree crops in moderate climates, they operate for years with no attention except for routine servicing. The few operating problems that have been experienced, have almost all occurred with instruments that have been used intermittently and have been improperly stored. Therefore, the following recommendations are very important.

1. Remove instruments from the ground immediately at the end of the growing season. This will prevent deposits of salts on the ceramic tip and frozen gauges.
2. Never let a ceramic tip partially air dry. Preparing a plastic container with 4" of fully saturated sand in the bottom provides for a convenient way of keeping tips wet while transporting them. Simply stick the instrument tip into the saturated sand with cap removed. Tips which are allowed to air dry usually will plug up badly and will require factory replacement.
3. See 'DRY' Storage Instructions (next page). Transport instruments to shop area and begin by shaking out all fluid in the tube. Then begin cleaning and flushing operation under 'Dry' storage.

Temporary Storage

When instruments are to be stored for only a few weeks, 'Wet' storage is recommended.

Fill and cap the instruments. Clean the exterior of the ceramic tips with a moist towel and immerse in IRROMETER Field Solution in a glass or plastic container.

Do NOT store in rusty or oily container. Maintain the level in the container high enough to keep the tips completely submerged at all times. If evaporation takes place add distilled water. This maintains a uniform concentration of solution as the active ingredients in IRROMETER Fluid are not volatile.

This method of storage keeps the instruments in operating condition and ready for immediate installation.

'Dry' Storage (Important)

When instruments are to be out of use for several months, 'Dry' storage as described below is preferable.

1. Clean the surface of the ceramic tip carefully with a handful of wet soil or a stiff brush. Wash all plastic surfaces with soap solution, rinse thoroughly and drain. After cleaning, it is advisable to flush the tip by filling the IRROMETER with clean water, with cap removed, and allow water to gravity-flow through the tip.
2. Replace caps loosely. Hang and store in a clean dust-free location which is heated adequately to avoid freezing temperatures.
3. If a frost-free location is not available, wash and drain the instruments as above, then evacuate water from the gauges using the hand vacuum pump or other source of vacuum. Hold the instrument in a horizontal position with the gauge upright. Each gauge holds about a teaspoonful of water.



Wet Storage



Tip Cleaning

4. Prepare the instruments for re-installation the same as new instruments. If a week or so is allowed for the ceramic tips to become thoroughly saturated, subsequent operations will be facilitated.

Care of Ceramic Tips

If the above directions are followed, years of trouble-free operation can be expected from the ceramic tips. If salt deposits do clog the pores of the tip, the speed of response to irrigations will be slowed. This is when factory reconditioning is recommended. To check response, prepare the instrument for installation, wipe the ceramic tip dry with an absorbent paper towel. Visually check the response to drying to 50 cb, by keeping a dry portion of the towel on the ceramic tip, then immerse in water and return gauge to zero. This should be able to be accomplished in minutes.

An additional test is to fill instrument with clean water to the very top of the reservoir and let drain for 24 hours with the cap removed. If a minimum of 1" of water drains through the tip in this period, the tip is responsive. If this drainage does not occur, the tips should be replaced at our factory.



Dry Storage

Vacuum Gauges

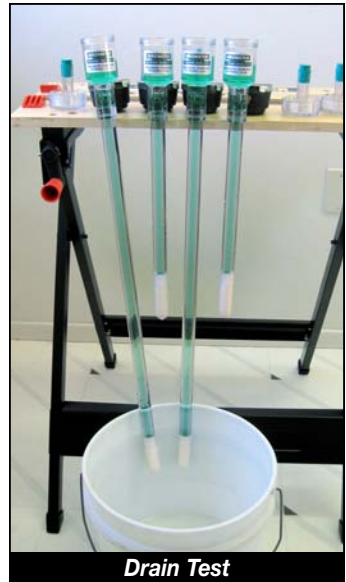
The IRROMETER vacuum gauge will give years of trouble-free service with reasonable care. It is sealed against dirt and moisture. The IRROMETER filler cap and hand vacuum pump are specially designed to prevent harmful compression and strain on the gauge movement. But it should be remembered that the gauge has a delicate movement, similar to a watch, and care should be exercised in handling to avoid shock or jarring.

Protect your gauges against freezing even more carefully than the radiator of your car. When short periods of cold weather start, the fluid in the instruments may already be at a relatively low temperature whereas the water in the radiator is likely to be hot.

If you suspect a gauge has been damaged, check as follows:

Remove the filler cap. The reading should drop to zero. With the instrument filled, apply the hand vacuum pump. It should be possible to obtain a gauge reading of 80-85 with the hand vacuum pump (less with LT and MLT). If the gauge passes both of these tests it is working. At higher elevations the maximum reading will be lower (i.e. 3,500 ft. elevation, 75 cb).

If the needle does not drop back within the box at zero or if it falls several points short of reaching 80-85, it indicates that the gauge has been jarred slightly out of calibration. A plus or minus correction may be made on the gauge crystal with wax pencil and appropriate adjustment made in recording future readings, if only a minor correction. This saves the cost of repair.



Drain Test



Evacuating Gauge

If the gauge needle sticks in one location, or is too far out of calibration it indicates the gauge has either been frozen or damaged. The gauge should be returned to the factory for repair or replacement, as necessary.

The presence of heavy condensation inside the gauge (under the plastic face cover) indicates the gauge seal has been broken. Reconditioning is advisable.

NOTE: The 'Test Pump' option affords the user the convenience of having a gauge mounted on the pump for comparing instrument gauges to the pump gauge. Assuming that the pump gauge is in good calibration, differences greater than 4-5 cb (kPa) between pump and instrument gauges should prompt factory service of gauges. The 'Test Pump Adaptor' can be purchased to convert a standard pump to a test pump.

Factory Service

Our policy is to produce an instrument that will give years of trouble-free operation, rather than rely upon sales of parts and repairs as a source of income. Repairs are made at a very modest cost, much less than the cost of a new instrument.

In case of accidental damage to an instrument, pack it carefully for shipment to the factory for repairs. This eliminates the possibility of damage to the gauge in transit.

If only the gauge is needed, we supply a special pipe thread dope on the replacement. Be careful not to cross thread the gauge and use a 9/16" open end wrench to both remove and replace gauge. Thread the replaced gauge to the next to last thread. **DO NOT FORCE.**

Your supplier can easily arrange for factory reconditioning of your instruments. Always allow 6-8 weeks lead time for this service, which is best accomplished over the winter when instruments are not being intensively used.

NOTE: Test Pump gauges will be recalibrated at a discount from regular cost of gauge recalibration.

When returning instruments to the factory for reconditioning or repair, ship them prepaid via United Parcel Service (UPS) to our street address:

1425 Palmyrita Avenue, Riverside, California 92507

— WARRANTY —

The IRROMETER COMPANY warrants its products against defective workmanship or materials under normal use for one year from date of purchase.

Defective parts will be replaced at no charge for either labor or parts if returned to the manufacturer during the warranty period. The seller's or manufacturer's only obligation shall be to replace the defective part and neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of or inability to use the product.

This warranty does not protect against abuse, shipping damage, neglect, tampering or vandalism, freezing or other damage whether intentionally or inadvertently caused by the user.

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