IN8P-W Turf-Tec Heavy Duty Tall Infiltration Rings with Ports

(6 and 12 inch diameter by 7 inches tall)

The new Turf-Tec Heavy Duty Tall Infiltration Rings allow the field infiltration rates to be measured. This tool conforms to the new 2006 Pennsylvania Stormwater Best Management Practices Manual.

The Turf-Tec Heavy Duty Tall Infiltration Rings have a 7 inch height, 6 inch inner ring and a 12 inch outer ring with a gripped rubber handle welded across the rings to keep them concentric, allowing easy insertion into, and removal from, the soil. Rings come complete with two ports to attach optional Mariotte Tubes (IN12-W). These rings are ideal for hard soil types.

Rings shown with optional (IN6-W) driving plate

Now, for the first time, a field instrument to measure the rate of water infiltration on all areas. This instrument determines the downward flow of water through the soil. The rings are centered by the welded handle on the top of the unit; this ensures the rings stay in place while driving them into the soil. The double ring ensures accuracy.

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Check Infiltration on:

- Soil Evaluation
- Retention ponds
- Wetlands
- Drain fields
- Forestry
- Site Planning
- Storm water recharge areas
- Golf courses
- Sports fields
- New construction

Specifications:

- Six inch and twelve inch rings (15.24 cm X 30.48 cm)
- Height of seven inches (17.78 cm)
- Sturdy construction
- Rust proof galvanized metal 16 Gauge (.060 inch)
- Double ring
- Rings are welded into place to ensure proper placement
- Economical
- Easy to use
- Unit has half inch ports added to allow IN12-W Mariotte Tubes to be attached (IN12-W Purchased separately)

Photo showing IN8P-W Turf-Tec Heavy Duty Tall Infiltration Rings - 6 and 12 inch diameter by 7 inches tall with ports for optional Mariotte Tubes - Ports are located three inches from bottom of rings allowing three inch insertion into the soil and five inches of water on top of soil.

IN8P-W Turf-Tec Heavy Duty Tall Infiltration Rings 6 and 12 inch diameter by 7 inches tall with Ports for IN12-W Mariotte Tubes (sold separately)

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TURF-TEC 6 and 12 INCH INFILTRATION RINGS INSTRUCTIONS (IN7-W & IN8-W)

Outline of Uses The Turf-Tec Infiltration Rings were specifically designed to give infiltration readings directly on site. They can give you a reading on the rate of water percolation through grass, thatch, mat and soil, as well as directly on bare soil.

Use a heavy jack under the back end of a truck to drive rings as an alternative to the sledge method

1. Position the Turf-Tec IN6-W driving plates over the IN8P-W - 6 and 12 inch Infiltration rings, so the center bar is in the center of the two plates as shown.

2. Center a suitable wood block across the Turf-Tec IN6-W Steel Driving Plates.

3. Center a jack on the driving plate or wood blocks. Place the top of the jack and the assembled items vertically under the previously positioned end of a truck body and apply force to the ring by means of the jack and truck reaction.

4. With a rubber mallet, tap near the edges, or near the center of the ring.Slight tapping and vibrations will reduce hang-ups and tilting of the ring.

5. Check the rings with the level, correcting the attitude of the rings to be vertical, as needed.

Reliability of testing and reducing variables

Saturated test (The most reliable test method)

The most reliable test method for measuring infiltration is called a saturated test. This method is performed by placing the Turf-Tec Infiltration Rings directly into the soil to be tested and filling the rings 2-3 times, allowing the water to infiltrate into the soil between fillings. Once the soil is saturated, you can perform the test.

Moisture Sensing (The quickest test method)

Another reliable method for testing infiltration is to use a Moisture Sensor. The readings of the soil to be tested using a Turf-Tec Moisture Sensor should be taken at one, two, three and four inch levels, and recorded. The infiltration test can then be performed on that area. This method should be repeated for each test area. In addition, be sure the Moisture Sensor readings are in the exact same range before testing the same area the next time it is to be tested for infiltration. This will eliminate any variables and still produces a reliable test.

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Testing on irrigated areas

Another way to insure a proper infiltration reading on irrigated areas is to use this instrument approximately one hour after irrigation. A visual indication of soil moisture should also be noted by using a Soil Profile Sampler. When using this method, be sure no rainfall has occurred within 48 hours of the test to remove this variable.

Correlating your readings

If the results from your Turf-Tec Infiltration Rings show that the soil readings are one inch of water absorbed per hour, this should be recorded. This reading should not be used as a conclusive result for all areas because each area tested most likely will have different variables, like vegetative cover, soil organic matter content, soil physical properties, compaction, soil texture and other factors. These variables all impact infiltration rate.

Each infiltration reading should be duly recorded, so comparisons can be made periodically. You will probably find wide differences in infiltration rates from area to area, especially when testing newly constructed areas or areas where the soil has been disturbed, compared to areas where the soil has remained unchanged. The best way to ensure infiltration results will be consistent is to record the infiltration rate on each area so that you can compare any changes. Use this standard for each particular area only.

Monitoring Golf Greens

If readings on the Turf-Tec Infiltration Rings are less than one inch per hour, the area is considered to be in very critical range. When the infiltration rate drops 10% or more, check your topdressing and management practices. Topdressing can sometimes drastically change infiltration rates, especially if even a slight change in the mixture occurs.

When infiltration decreases are detected, the formations of layers in the soil profile are beginning. However, major problem can be avoided if layers are diagnosed with the Turf-Tec Infiltration Rings and can be corrected with aerification and proper topdressing.

Putting your readings to use - Turfgrass Areas

The results of your Infiltration rate readings can then be used to regulate the amount of water applied from each sprinkler zone. Irrigation can then be adjusted to apply only the amount of water that should be applied per hour.

To check irrigation rates, Turf-Tec precipitation / uniformity gauges can be purchased from Turf-Tec International and placed in the soil (spaced every 1 1/2 to 3 feet between two sprinkler heads). The irrigation clock should be set for a 15 minute cycle and the amount of water in each rain gauge should be recorded. This will give you the actual amount of water applied.

Applying only the amount of water that the soil will absorb saves water lost by surface runoff and reduces fertilizer loss. This will help prevent waterlogged soils, reducing oxygen levels in the soil. Excessive surface water will also reduce root systems and can also contribute to increased disease problems. Wet soils can become compacted more easily and, in severe cases, harmful anaerobic conditions can be created.

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How to get the most out of the Turf-Tec Infiltration Rings on Turfgrass areas

Areas can be tested before and after certain management practices have been used. These include aerification, Verti-cutting, and topdressing, along with all the other practices that can change the water infiltration rate.

Monitoring Drain fields

The Turf-Tec Infiltration Rings can be used to install drain fields. The double ring is much more accurate than just using a single ring or an excavated cavity to test for infiltration. However, please check with your local ordinances to see if an ASTM Infiltration test is required. If one is required, you may need to use the Turf-Tec 12 and 24 Inch Infiltration Rings.

Environmental testing

The Turf-Tec Infiltration Rings can be used to perform various types of environmental tests. They can be used for testing fuel tank containment areas as well as spill clean-up times. The Turf-Tec Infiltration Rings can also be used for measuring urban runoff. They have also been successfully used for storm water soil evaluations, forestry soil assessments, and for groundwater recharge areas.

Monitoring test pits

When monitoring test pits, be sure you use the saturated method of testing, repeating the tests in several areas. Furthermore, when testing in the bottom of test pits, be sure the soil has not been disturbed by the digging equipment. This is usually accomplished by machine excavating to within 2 to 4 inches of your desired testing depth and then removing the last portion digging with a flat shovel by hand before taking your readings. This will ensure you are taking readings on undisturbed soils. If the soil is disturbed, you can re-tamp the area and confirm consistency in compaction with a Penetrometer before testing infiltration.

Particular Specifications - Reason for the double ring

The Turf-Tec Infiltration Rings are equipped with a double ring. During use, both rings are filled up with water, but only the inner ring is measured. You may notice during operation, one ring may infiltrate much faster than the other sincedue to lateral movement of water around the cutter blade. This action will also create a seal for the inner ring, giving a much more accurate indication of the actual rate of infiltration.

Accuracy of testing the soil on the area in question

This tool is designed to test soil infiltration right on the area in question. It differs from lab results because it is representative of all the conditions that naturally occur on that area. The Turf-Tec Infiltration Rings account for the vegetative cover, soil organic matter content, soil physical properties, compaction, soil texture, and other factors. The variables all come into consideration when using this tool to determine infiltration.

Checking infiltration at lower depths in the soil profile

If the Infiltration rate needs to be determined at lower levels in the soil profile, a post hole digger can be used to remove the turf, thatch and mat. The Turf-Tec Infiltration Rings can then be lowered into the hole and the rate of infiltration can be determined at that level. Maximum depth of the Turf-Tec Infiltration Rings is approximately two feet. If readings are needed at lower levels, a backhoe can be used for excavation.

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INFILTRATION RINGS
MONITORING RECORD

We suggest recording your results along with these certain variables on this page:
* MAKE A COPY OF THIS PAGE FOR EACH AREA TO BE TESTED.

PLACE: _____ DATE: _____

TIME: _____ EXACT LOCATION: _____

FORMER RAINFALL / IRRIGATION INFORMATION

PENETROMETER (COMPACTION) READINGS: ( ) %

MOISTURE SENSOR READINGS AT DIFFERENT LEVELS

MOISTURE AT 1" INCH LEVEL : ( ) %
MOISTURE AT 2" INCH LEVEL : ( ) %
MOISTURE AT 3" INCH LEVEL : ( ) %
MOISTURE AT 4" INCH LEVEL : ( ) %

INNER RING INFILTRATION RATE ACTUAL	INNER RING INFILTRATION RATE CALCULATED
1 MINUTE : ( ) ML X 60 =	( ) ML PER HOUR
5 MINUTES : ( ) ML X 12 =	( ) ML PER HOUR
15 MINUTES : ( ) ML X 4 =	( ) ML PER HOUR
30 MINUTES : ( ) ML X 2 =	( ) ML PER HOUR
60 MINUTES : ( ) ML X 1 =	( ) ML PER HOUR

ANNULAR SPACE INFILTRATION RATE ACTUAL	ANNULAR SPACE INFILTRATION RATE CALCULATED
1 MINUTE : ( ) ML X 60 =	( ) ML PER HOUR
5 MINUTES : ( ) ML X 12 =	( ) ML PER HOUR
15 MINUTES : ( ) ML X 4 =	( ) ML PER HOUR
30 MINUTES : ( ) ML X 2 =	( ) ML PER HOUR
60 MINUTES : ( ) ML X 1 =	( ) ML PER HOUR

A free Excel spreadsheet that will auto-calculate this page can be downloaded at www.turf-tec.com

INFILTRATION RINGS
MONITORING RECORD (SAMPLE PAGE)

We suggest recording your results along with these certain variables on this page:

PLACE: **Drainage Project # 4** DATE: **7/31/12**

TIME: **6:30 am** EXACT LOCATION: **Northwest corner of property**

FORMER RAINFALL / IRRIGATION INFORMATION
No rainfall, past 48 hours 1/4 inch irrigation, 28 hours ago.

PENETROMETER (COMPACTION) READINGS: (55) %

MOISTURE SENSOR READINGS AT DIFFERENT LEVELS

MOISTURE AT 1" INCH LEVEL : (35) %
MOISTURE AT 2" INCH LEVEL : (50) %
MOISTURE AT 3" INCH LEVEL : (60) %
MOISTURE AT 4" INCH LEVEL : (80) %

INNER RING INFILTRATION RATE ACTUAL	INNER RING INFILTRATION RATE CALCULATED
1 MINUTE : ( ) ML X 60 =	( ) ML PER HOUR
5 MINUTES : ( ) ML X 12 =	( ) ML PER HOUR
15 MINUTES : (100) ML X 4 =	(400) ML PER HOUR
30 MINUTES : (150) ML X 2 =	(300) ML PER HOUR
60 MINUTES : (300) ML X 1 =	(300) ML PER HOUR

ANNULAR SPACE INFILTRATION RATE ACTUAL	ANNULAR SPACE INFILTRATION RATE CALCULATED
1 MINUTE : ( ) ML X 60 =	( ) ML PER HOUR
5 MINUTES : ( ) ML X 12 =	( ) ML PER HOUR
15 MINUTES : (175) ML X 4 =	(700) ML PER HOUR
30 MINUTES : (300) ML X 2 =	(600) ML PER HOUR
60 MINUTES : (600) ML X 1 =	(600) ML PER HOUR

A free Excel spreadsheet that will auto calculate this page can be downloaded at www.turf-tec.com

Turf-Tec 6 and 12 inch Infiltration Rings
Operating Instructions

1. **You will need:** Mariotte Tubes, a stop watch; ruler and water supply before testing can begin. (An IN6-W Driving plate, bottle jack, and a dead blow hammer should be used in hard soils.) If you are comparing infiltration rates over a period of time (or not doing a saturated test), a Moisture Sensor and a Penetrometer reading should be taken as well.
2. Before checking infiltration rate, check the soil moisture at the one, two, three and four inch levels and record on the monitoring chart. To determine the percentage of compaction at each test location, a Penetrometer reading should also be taken and recorded .
3. Place the double ring cutting blades on the area to be tested. (Silicone spray may be applied to the cutter edges to allow easier and cleaner removal of tool.)
4. Push down on handle while slightly turning instrument back and forth until the rings are approximately two inches into the soil. **(Do not move the instrument side to side, or twist too much because the soil will be disturbed. Also, excessive twisting can cause incorrect infiltration rates.)**
5. If harder soils are being tested, you can use the **IN6-W Infiltration Test Ring Driving Plate** or a board and dead blow hammer to insert the rings into the soil. Be sure to use care as to not damage or bend the rings with excessive force.
6. If you are using the **IN6-W Infiltration Test Ring Driving Plate**, a pickup truck bumper can be placed over the ring with the driving plate and a bottle jack to apply downward pressure on the plate and rings, ensuring an even insertion into the soil.
7. Once inserted to a depth of two inches deep, fill both the outer and inner ring with clean water until they slightly overflow. (This is accomplished easiest by filling the inner ring first and allowing it to spill over and fill the outer ring.)
8. Attach Mariotte tubes to ports provided on the IN8-W and adjust the height of the Mariotte tubes until the water stabilizes inside the rings.
9. When the water has stabilized at the correct height inside the inner ring and the annular space, start the timer immediately.
10. After fifteen minutes, anotate the amount of water in ML that has been replaced by the Mariotte Tubes. Record this number in the monitoring chart.
11. To calculate hourly infiltration rate, multiply the inches that have infiltrated into the soil by 4. Record this information in the monitoring chart as well.
12. To remove the instrument from the soil, use the hand grips to lift the instrument straight out of the soil. The handles may also require slight turning while lifting the tool out of the ground. Extract the tool slowly in order not to disturb the soil surface.
13. It is best to get several readings on an area to get the average infiltration rate.
14. If the infiltration rate is slow, a one hour test may be desired. If the Infiltration rate is fast (as with new sand construction), a five minute test may be sufficient.
15. After using your Turf-Tec Infiltration rings, wash the rings, dry them and spray with **silicone spray.** (This will help the infiltration rings to remove a clean plug.)

To see more tips on infiltration, visit our website at WWW.TURF-TEC.COM

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Mariotte Tubes Instructions

IN12-W Mariotte Tubes

Outline of Instructions for using IN10-W and IN14-W with Mariotte Tubes (Read First)

Installation of Tubes:

To prevent the Mariotte Tubes from gravitationally forcing water into the rings, be sure they are installed at a proper level in relation to the Turf-Tec Infiltration rings.

Each Mariotte tube comes with a calibrated sight glass located on the side. When setting up the test, use the Mariotte tube height to regulate the amount of water that fills up the inner and outer ring until a constant flow is achieved. This is described in section 8.6.3 through 8.6.12 and Figure 2 located on page 9 and Figure 4 on page 13. If the top valve is open and you are using the Mariotte Tubes as a graduated cylinder, the bottom valve can also be opened to different positions to allow more or less water to flow into the Turf-Tec Infiltration rings.

Maintenance of Mariotte Tubes:

Mariotte tubes should be cleaned out with a 5% bleach and 95% water solution before storing.

Source of subsequent instructions:

Many portions of the following instructions are from the ASTM Publication Designation: D-3385-03, from the Annual Book of ASTM Standards. To view it in its entirety, a full copy of the standards should be purchased at www.astm.org. Note the 6 and 12 inch infiltration rings do not comply with ASTM D-3385-03. Only the IN10-W and IN14-W (12 and 24 inch) rings comply with the ASTM D-3385-03.

1. Scope

1.1 This test method describes a procedure for field measurement of the rate of infiltration of liquid (typically water) into soils using double-ring Infiltrometer.

1.2 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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2. Referenced Documents

2.1 ASTM Standards:

D 3385-03 Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer
D 653 Terminology Relating to Soil, Rock, and Contained Fluids
D 1452 Practice for Soil Investigation and Sampling by Auger Borings
D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D 5093 Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed Inner Ring

3. Terminology

3.1 Definitions:

3.1.1 Incremental infiltration velocity— the quantity of flow per unit area over an increment of time. It has the same units as the infiltration rate.

3.1.2 Infiltration—the downward entry of liquid into the soil.

3.1.3 Infiltration rate—a selected rate, based on measured incremental infiltration velocities, at which liquid can enter the soil under specified conditions, including the presence of an excess of liquid. It has the dimensions of velocity (that is: $cm^3\ cm^{-2}\ h^{-1} = cm\ h^{-1}$).

3.1.4 Infiltrometer—a device for measuring the rate of entry of liquid into a porous body, for example, water into soil.

3.1.5 For definitions of other terms used in this test method, refer to Terminology D 653.

4. Summary of Test Method

4.1 The Turf-Tec double-ring Infiltrometer method consists of driving the apparatus into the ground, partially filling the rings with water or other liquid, and then maintaining the liquid at a constant level. The volume of liquid added to the inner ring, to maintain the liquid level constant, is the measure of the volume of liquid that infiltrates the soil. The volume infiltrated during timed intervals is converted to an incremental infiltration velocity, usually expressed in centimeter per hour or inch per hour, and plotted versus elapsed time. The maximum-steady state, or average incremental infiltration velocity depending on the purpose/application of the test, is equivalent to the infiltration rate.

5. Significance and Use

5.1 This test method is useful for field measurement of the infiltration rate of soils. Infiltration rates have application to such studies as liquid waste disposal, evaluation of potential septic-tank disposal fields, leaching and drainage efficiencies, irrigation requirements, water spreading and recharge, and canal or reservoir leakage, among other applications.

5.2 Although the units of infiltration rate and hydraulic conductivity of soils are similar, there is a distinct difference between these two quantities: They cannot be directly related or reliably estimated unless the hydraulic boundary conditions are known (such as hydraulic gradient andthe extent of lateral flow of water).

5.3 The purpose of the outer ring is to promote one-dimensional vertical flow beneath the inner ring.

5.4 Many factors affect the infiltration rate, for example the soil structure, soil layering, condition of the soil surface, degree of saturation of the soil, chemical and physical nature of the soil and of the applied liquid, head of the applied liquid, temperature of the liquid, and diameter and depth of embedment of rings. Thus, tests made at the same site are not likely to give identical results and the rate measured by the test method described in this standard is primarily for comparative use.

Figure 1
IN8P-W Turf-Tec 6 and 12 inch Infiltration rings and Mariotte Tubes

5.5 Some aspects of the test, such as the length of time the tests should be conducted and the head of liquid to be applied, must depend upon the experience of the user, the purpose for testing, and the kind of information that is sought.

6. Apparatus

6.1 Turf-Tec International Infiltrometer Rings—Cylinders approximately 200 mm (20 in.) high and having diameters of about 150 and 300 mm (6 and 12 inch) ***(See Figure 1)***

6.2 Driving Plate—Disks of 2.6mm (1 in.) thick plywood, preferably having a recessed groove about 10 mm (0.4 in.), should be made for the cross braces on top of the Turf-Tec Infiltration rings, allowing the wooden driving cap to sit flush upon the top cross braces of the Infiltration rings while also touching the surface of the rings. The driving caps should be slightly larger than those of the Infiltrometer rings, or about 25 inches in diameter. The Turf-Tec International IN6-W Driving Plates are specially designed to fit over the IN8P-W Infiltration rings and cross braces. ***(See Figure 3)***

6.3 Driving Equipment—A 1 kg (2.2 lb.) dead blow hammer, the Turf-Tec IN6 Driving Plates and a 600 or 900 mm (2 or 3 ft.) length of wood approximately 50 by 100 mm or 100 by 100 mm (2 by 4 in. or 4 by 4 in.), or a jack and reaction of suitable size. **(The jack method is preferred)**

6.4 Liquid Containers:

6.4.1 One 200 L (55 gal.) barrel for the main liquid supply anda length of rubber hose to siphon liquid from the barrel to fill the calibrated head tanks (see 6.9.3).

6.4.2 A 13 L (5 gal.) bucket for initial filling of the Infiltrometers.

6.4.3 Two Turf-Tec IN12-W Mariotte Tubes having a minimum volume capacity of about 3000 mL and 10000 mL (See Notes 1 and 2 and Figures 2 and 2A).

NOTE 1—It is useful to have one head tank with a capacity of three times that of the other because the area of the annular space between the rings is about three times that of the inner ring.

NOTE 2—In many cases, the volume capacity of these calibrated head tanks must be significantly larger than 3000 mL, specially if the test has to continue overnight. Capacities of about 50 L (13 gal.) would not be uncommon. These large volume IN13-3 Mariotte Tubes are also available from Turf-Tec International.

6.5 Liquid Supply—Water, or preferably liquid of the same quality and temperature as that involved in the problem being examined. The liquid used must be chemically compatible with the Turf-Tec Infiltration rings and other equipment used to contain the liquid.

NOTE 3— To obtain minimum infiltration rates, the liquid should be free from suspended solids and the temperature of the liquid should be higher than the soil temperature. This will tend to avoid reduction of infiltration from blockage of voids by particles or gases coming out of solution.

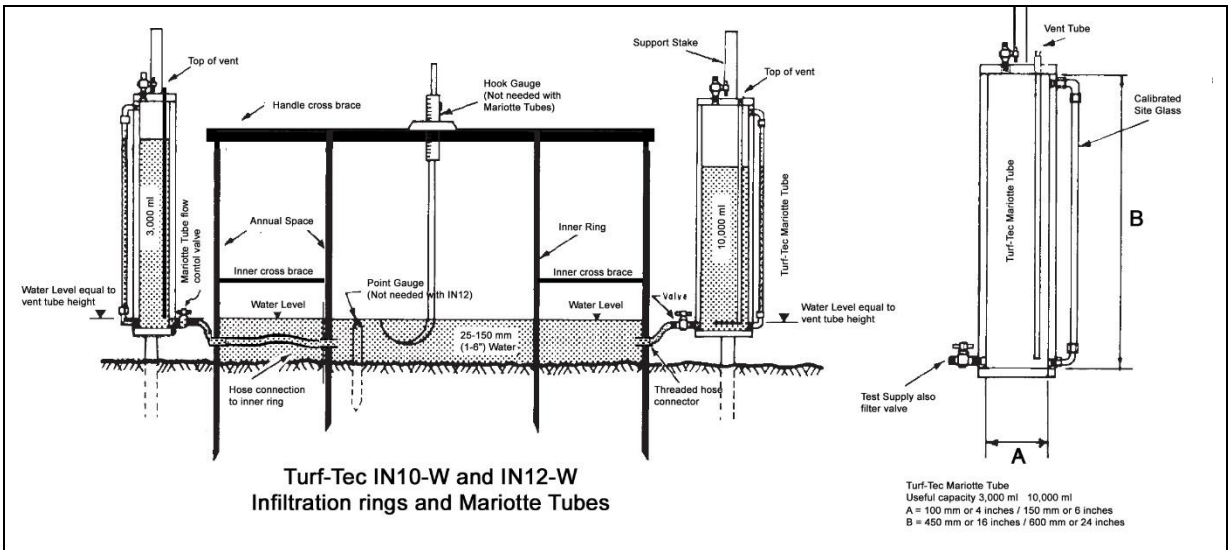

Figure 2 - Relationship of height of Mariotte tube to achieve a constant head of water inside Infiltration rings (To see this relationship, see Figure 4 and read section 8.6.8 to 8.6.12)

Figure 2A
IN12 - Mariotte Tubes are shown - Now both Mariotte tubes are connected to the outside of the unit

6.6 Watch or Stopwatch—A stopwatch would only be required for high infiltration rates.

6.7 Level—A carpenter's level or bull's-eye (round) level.

6.8 Thermometer—With accuracy of 0.5° C and capable of measuring ground temperature and water temperature.

6.9 Rubber Hammer (mallet).

6.10 A digital pocket pH Pen-type meter.

6.11 Recording Materials—Record books and graph paper, or special forms with graph section (***See Pages 18 and 19***).

7. Calibration

7.1 Rings:

7.1.1 Inspect the Turf-Tec Infiltration rings: determine the area of each ring and the annular space between rings before initial use and before reuse after anything has occurred, including repairs, which may affect the test results significantly.

7.1.2 Determine the area using a measuring technique that will provide an overall accuracy of 1%.

7.1.3 The area of the annular space between rings is equal to the internal area of the 300 mm (12 in.), ring minus the external area of the 150 mm (6 in.) ring. These areas are included in the attached Excel spreadsheets.

7.2 Liquid Containers—For each graduated Mariotte tube, establish the relationship between the change in elevation of liquid (fluid) level and change in volume of fluid. This relationship shall have an overall accuracy of 1%. (***See Fig. 2 and Figure 4***)

8. Procedure

8.1 Test Site:

8.1.1 Establish the soil strata to be tested from the soil profile determined by the classification of soil samples from an adjacent auger hole.

NOTE 4—For the test results to be valid for soils below the test zone, the soil directly below the test zone must have equal or greater flow rates than the test zone.

8.1.2 The test requires an area of approximately 3 by 3m (10 by 10 ft.) accessible by a truck.

8.1.3 The test site should be nearly level, or a level surface should be prepared.

8.1.4 The test may be set up in a pit if infiltration rates are desired at depth rather than at the surface.

8.2 Technical Precautions:

8.2.1 For long-term tests, avoid unattended sites where interference with test equipment is possible, such as sites near children or in pastures with livestock. Also, evaporation of fluid from the rings and unsealed reservoirs can lead to errors in the measured infiltration rate. Therefore, in such tests, completely cover the top of the rings and unsealed reservoirs with a relatively airtight material, but vented to the atmosphere through a small hole or tube. In addition, make measurements to verify that the rate of evaporation in a similar test configuration (without any infiltration into the soil) is less than 20% of the infiltration rate being measured.

8.2.2 Make provisions to protect the test apparatus and fluid from direct sunlight and temperature variations large enough to affect the slow measurements significantly, especially for test durations greater than a few hours or those using a Mariotte tube. The expansion or contraction of the air in the Mariotte tube above the water due to temperature changes may cause changes in the rate of flow of the liquid from the tube, which will result in a fluctuating water level in the Turf-Tec Infiltration rings.

8.3 Driving Turf-Tec Infiltration Rings with a Sledge:

NOTE 5—Driving infiltration rings with a Jack is preferred see 8.4

8.3.1 Place Turf-Tec IN11-W Steel Driving Plate, or suitable wooden driving cap, on the Turf-Tec Infiltration rings and center it on them. Be sure driving cap is flat against the surface of both rings to prevent damage. Place the wood block (see 6.3) on the driving cap.

Figure 3
IN11-W Driving Plate shown with IN8P-W Infiltration Rings

8.3.2 Drive the Turf-Tec Infiltration rings into the soil with blows of a sledge on the wood block to a depth that will prevent the test fluid from leaking to the ground surface surrounding the ring. A depth of about 50 mm (2 in.) on the outer ring is usually adequate. Use blows of medium force to prevent fracturing of the soil surface or damage to the rings. Move the hammer and wood block around the edge of the driving cap every one or two blows so that the ring will penetrate the soil uniformly. A second person standing on the wood block and driving cap will usually facilitate driving the ring, and reduce vibrations and disturbance.

8.4 Driving Turf-Tec Infiltration Rings with Jacks:

8.4.1 **Use a heavy bottle jack under the back end of a truck to drive rings as an alternative to the sledge method (see 8.3).**

8.4.2 Position a suitable wood block across the center of the Turf-Tec IN6-W Driving Plates, or wooden driving cap of the ring. Center a jack on the driving plate with a wood block between the driving plate and the jack, or on wood blocks. Place the top of the jack and the assembled items vertically under the previously positioned end of a truck body and apply force to the ring by means of the jack and truck reaction. Also, tap near the edges or near the center of the ring with the rubber mallet, since slight tapping and vibrations will reduce hang-ups and tilting of the ring.

8.4.3 Check the rings with the level, correcting the attitude of the rings to be vertical, as needed.

8.5 Tamping Disturbed Soil:

8.5.1 If the surface of the soil surrounding the wall of the ring(s) is excessively disturbed (signs of extensive cracking, excessive heave, and the like), reset the ring(s) using a technique that will minimize such disturbance.

8.5.2 If the surface of the soil surrounding the wall of the ring(s) is only slightly disturbed, tamp the disturbed soil adjacent to the Inside and outside wall of the ring(s) until the soil is as firm as it was prior to disturbance.

8.6 Maintaining Liquid Level:

8.6.1 The best way to maintain a constant head (liquid level) within the inner ring and annular space between the two rings is by using the IN12-W Turf-Tec Mariotte tube. (***See Figure 2A***)

8.6.2 Install the large 10,000 ml Mariotte Tube to the port in the Turf-Tec Infiltration rings that leads to the annular space between the two rings as shown in ***Figure 3A***. Attach the small 3,000 ml Mariotte Tube to the port on the Turf-Tec Infiltration rings that leads to the inner ring as shown in ***Figure 3B.***

Figure 3A
Photo showing the 10,000 ml Mariotte Tube attached to the port leading to the annular space

Figure 3B
Photo showing the 3,000 ml Mariotte Tube attached to the port leading to the inner infiltration ring

8.6.3 Fill both the Turf-Tec Mariotte Tubes with water to the top of the site glass. This is accomplished easiest by attaching a positive flow 1/2" ID x 5/8" OD vinyl tubing from an elevated poly-tank, or water supply, to the top valve located on the top cap of the Mariotte Tube. Next, the top valve is fully opened, as well as opening the petcock, also located on the top cap (Figure 3C and 3D). Proceed filling the Turf-Tec Mariotte tube through the top valve allowing air to escape through the petcock. (Do not fill the unit while testing unless the bottom valve is completely closed) After re-filling and before opening the bottom valve and restart testing, close the top valve and the petcock fully.

Figure 3C
Photo showing the Petcock on the top of the Mariotte tube

Figure 3D
Photo showing opening the Petcock on the top of the Mariotte tube to vent air while filling

8.6.4 Install the Mariotte tubes as shown in ***Figure 3A*** and ***Figure 3B*** in such a manner that the reference head will be at least 25 mm (1 in.) and not greater than 150 mm (6 in.) above the soil surface. Select the head on the basis of the permeability of the soil; the higher heads being required for lower permeability soils.

8.6.5 Cover the soil surface within the center ring and between the two rings with splash guards, 75-mm or 3-in. square pieces of burlap or rubber sheet, to prevent erosion of the soil when the initial liquid supply is poured into the rings.

8.6.6 Use a pail to fill both rings with liquid to the same desired depth in each ring; do not record this initial volume of liquid. Remove the splash guards.

8.6.7 Start flow of fluid from the IN12-W Mariotte Tubes. As soon as the fluid level becomes basically constant, determine the fluid depth in the inner ring and in the annular space to the nearest 2 mm (1/4 in.) using the ruler or tape measure. Record these depths. If the depth between the inner ring and annular space varies more than 5 mm (¼ in.), raise the depth gage, or Mariotte tube, with the shallowest depth.

8.6.9 To prevent flow of fluid from one ring to the other, maintain the liquid level at the selected head, in both the inner ring and annular space between rings, as near as possible throughout the test..

NOTE 6—This most likely will require either a continuing addition of water from graduated cylinders, or the use of the IN12-W Turf-Tec Mariotte Tubes. **See figure # 2 and #2A** to see the relationship between the height of Mariotte tubes and the height of the constant head of water inside the Turf-Tec Infiltration Rings. A rapid change in temperature may eliminate use of the Mariotte tube.

8.6.10 To see the relationship of the vent tube and water level, follow the below procedure.

8.6.11 First, fill the Mariotte tube completely and then close the top valve.

8.6.12 Next, insert a piece of clear tubing at the bottom valve and slowly open the valve allowing the water to drop in the site glass about 2-3 of the line markings. This will allow some pressure to build up in the unit and start the siphon. (You will also hear bubbling sounds in the vent tube)

8.6.13 Next, close the bottom valve and raise the tube attached to the valve as shown in the photo below.

8.6.14 Re-open the bottom valve and the water in the tube attached to it will maintain a constant level equal to the bottom level of the vent tube.

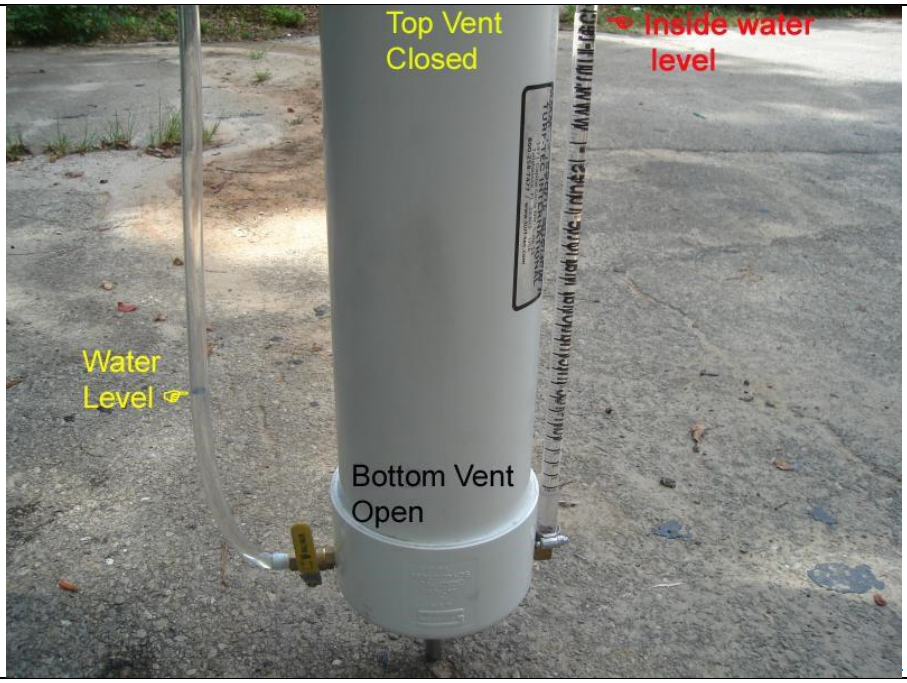

Figure 4
Relationship of vent tube and water level

8.6.15 You may want to mark the approximate level of water in the site glass directly on the Mariotte Tubesince this is the bottom of the site glass and will aid in setting up the actual test.

8.7 Measurements:

8.7.1 Record the ground temperature at a depth of about 300 mm (12 in.), or at the mid-depth of the test zone.

8.7.2 To determine and record the volume of liquid that is added, maintain a constant head in the inner ring and annular space during each timing interval by measuring and reading the site glass the change in elevation of liquid level in the Mariotte tube. After recording how much water was been siphoned from the Mariotte tube, move the rubber water height marker to the new water level position. **(Figure 5)** Record the temperature of the liquid within the inner ring.

8.7.3 For average soils, record the volume of liquid used at intervals of 15 minutes for the first hour, 30 minutes for the second hour, and 60 minutes during the remainder of a period of at least 6 hours (or until after a relatively constant rate is obtained).

Figure 5
IN12 - Mariotte Tubes water height marker is shown

8.7.4 The appropriate schedule of readings may be determined only through experience. For high-permeability materials, readings may be more frequent, while for low permeability materials, the reading intervals may be 24-hours or more. In any event, the volume of liquid used in any one reading interval should not be less than approximately 25 cm^3.

8.7.5 Place the driving cap, or some other covering, over the rings during the intervals between liquid measurements to minimize evaporation (see 8.2.1).

8.7.6 Upon completion of the test, remove the rings from the soil by lightlyhammering on the sides with a rubber hammer.

9. Calculations

9.1 Convert the volume of liquid used during each measured time interval into an incremental infiltration velocity, for both the inner ring and annular space, using the following equations:

9.1.1 For the inner ring, calculate as follows:

$$V_{1R} = \Delta V_{1R} / (A_{1R} \cdot \Delta t)$$

Where:
V_{1R} = inner ring incremental infiltration velocity, cm/h
ΔV_{1R} = volume of liquid used during time interval to maintain constant head in the inner ring, cm^3
A_{1R} = internal area of inner ring, cm^2 Δt = time interval, h

9.1.2 For the annular space between rings, calculate as follows:

$V_A = \Delta V_A / (A_A \cdot \Delta t)$

Where:
V_A = annular space incremental infiltration velocity, cm/h
ΔV_A = volume of liquid used during time interval to maintain constant head in the annular space between the rings, cm^3
A_A = area of annular space between the rings, cm^2
Δt = time interval, h

10. Report

10.1 Report the following information in the report, field records, or both:

10.1.1 Location of test site.

10.1.2 Dates of test, start and finish.

10.1.3 Weather conditions, start to finish.

10.1.4 Name(s) of technician(s).

10.1.5 Description of test site, including boring profile, see 10.1.11.

10.1.6 Type of liquid used in the test, along with the liquid's pH. If available, a full analysis of the liquid should also be recorded.

10.1.7 Areas of rings and the annular space between rings.

10.1.8 Volume constants for graduated cylinders or Mariotte tubes.

10.1.9 Depth of liquid in inner ring and annular space.

10.1.10 Record ground and liquid temperatures, incremental volume measurements, and incremental infiltration velocities (inner ring and annular space) versus elapsed time. The rate of the inner ring should be the value used if the rates for inner ring and annular space differ. The difference in rates is due to divergent flow.

10.1.11 If available, depth to the water table and a description of the soils found between the rings and the water table, or to a depth of about 1 m (3 ft.).

10.1.12 A plot of the incremental infiltration rate versus total elapsed time ***(See Page 18)***.

10.2 An example field record ***(See Page 19)***.

10.3 See Appendix X1 for information on the determination of the moisture pattern.

11. Precision and Bias

11.1 No statement on precision and bias can be made due to the variability in soils tested and in the types of liquids that might be used in this test method. Because of the many factors related to the soils, as well as the liquids that may affect the results, the recorded infiltration rate should be considered only as an index value.

APPENDIX

(Nonmandatory Information)

X1. DETERMINATION OF MOISTURE PATTERN

X1.1 Although not considered a required part of the test method, the determination of the moisture pattern in the moistened soil beneath the Turf-Tec infiltration rings commonly provides information useful in interpreting the movement of liquid through the soil profile. For example, horizontal liquid movement may be caused by lower-permeability layers and will be identified by a lateral spreading of the wetted zone. Thus, the exploration of the soil moisture pattern below an infiltration test in an unfamiliar area may identify subsurface conditions that may have affected the test and later applications of the data.

X1.2 If the investigator wishes to make such a study, dig a trench so that one wall of the trench passes along the center line of the former position of the rings. Orient the trench so that the other wall is illuminated by the sun, if the day is sunny. If feasible, dig the trench large enough to include all of the newly moistened area. Collect samples from the shaded wall of the trench for determination of water content. If preferred, an auger, such as the orchard barrel type, may be used to determine the approximate outline of the moistened area below the rings and to collect samples for water content. A Turf-Tec Moisture sensor can also be used to determine soil moisture percentages from www.turf-tec.com.

X1.3 Plot the visibly moistened area on graph paper or on the cross-section part of the report form. If samples were collected and water contents were determined, contours of water content also can be plotted on the graph. This data can be inserted into the Excel spreadsheet also contained on the enclosed disk or CD.

Turf-Tec International - Record Chart for IN10-W - (12 & 24 Inch Infiltration Rings)

www.turf-tec.com

Project Identification:		Constants	Area cm2	Depth of Liquid (cm)	Liquid Container Number	Liquid Container Volume Vol/ Chg H (cm2/ cm)
Test Location:		Inner Ring				
Liquid Used:	pH:	Annular Space				
Tested By:		Liquid level maintained using:	( ) Flow Valve ( ) Float Valve (X) Mariotte Tubes			
Depth to water table:		Penetration Depth of Outer Ring:				

					Flow Readings					Inner Infiltration Rate		Ground Temperature		Remarks
Trial #	Start / End	Date	Time HR:MIN	Elapsed Time Chg/ (Total) Min	Inner Ring Reading cm	Inner Ring Flow cm3	Annular Space Reading cm	Annular Space Flow cm3	Liquid Temp C	Inner Infiltration Rate cm/h or ml/h	Annular Infiltration Rate cm/h or ml/h	Ground Temp Depth (cm)	Temp at Depth (c)	Weather conditions Etc...
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