Performing a catch-can test provides data on nozzle and sprinkler performance as it relates to application uniformity.

Does Your Irrigation System Make The Grade?

A guide to help evaluate factors influencing irrigation system performance.

by MIKE HUCK

MOST GOLFERS QUICKLY recognize poor irrigation coverage by the obvious — the number and size of both wet and dry areas throughout the course. However, very few understand the many factors that affect an irrigation system's ability to apply water uniformly.

First and foremost, proper design and installation are critical. Hydraulics, head spacing, nozzle selection, control capabilities, and climate all must be considered in the design process. If any one area is lacking, performance suffers. If one is fortunate enough to already have a good system in place, then routine maintenance should sustain acceptable performance. Annual adjustment of pumps, pressure regulators, leveling of low heads to avoid surrounding turf interference with spray patterns, and replacement of worn nozzles or any other damaged components must be ongoing.

Outdated systems present another set of problems with aging hardware resulting in major failures of pumps, controllers, mainlines, and fittings that can cause large areas of turf loss. To counter such problems, a daily ritual of many superintendents is to spot water, repair leaks, and continually adjust controllers — turning them up to reduce dry spots one day, and down the next to control wet spots. So much time is spent compensating for system inadequacies and inefficiencies that little time is left for other duties and the staff is constantly putting out fires. It is no wonder that irrigation systems are often nicknamed *irritation systems*!

The Report Card Evaluation

Understanding and evaluating factors that influence irrigation system performance is the first step towards improving overall performance. To understand the system's weaknesses and evaluate where improvement is needed, consider completing an irrigation system report card. The report card can help golf course decision makers understand the various factors affecting irrigation system performance and guide them in developing improvement plans. This suggested method 1) identifies a system that will satisfy your needs, 2) considers historical performance of the existing system, 3) evaluates the existing system's condition as compared to a state-of-the-art design, and 4) suggests actions to consider based upon a final grade point average (GPA).

Before beginning the process, assemble a rating team comprised of the golf course superintendent, green committee, general manager, and golf professional. The rating team then will evaluate several specific areas and assign grades from "A," reflecting excellent performance, to "F," indicating failure for each factor listed on the report card, a system we are all familiar with from our school days.

In most cases, one grade for performance of the entire irrigation system will be adequate, but in some cases a hole-by-hole grading may be necessary if:

1) Modifications affecting the irrigation system have been made on individual or various holes.

2) Significant elevation changes occur across the property that affect operating pressures.

3) More than one pumping plant or piping system services different segments of the golf course.

A grade average can be determined following each step and appropriate plans to bring the system up to an acceptable grade that will satisfy your overall needs (as identified in step one) can then be developed. Understand that it may not be possible to improve every factor to the highest possible "A" grade, but raising any particular area one or more letter grade can make a difference.

Is this system state of the art or in a state of disrepair? Evaluating your system is the first step in determining where improvements should be made or if the system needs to be upgraded or replaced.

Step 1: Determine the Grade of an Irrigation System That Will Satisfy Your Needs

The level of sophistication needed for an irrigation system varies regionally depending upon factors such as: 1) golfer expectations for turf quality and course conditioning, 2) labor and budget resources, and 3) climate. Not every location requires (or can justify) an "A" system that includes all the whistles, buttons, and bells that currently are available. Using the following factors, an average grade can be developed that should satisfy your overall needs.

Golfer Expectations: Golfers' expectations and acceptance of manual watering, wet and dry areas, general turf quality, and playing conditions are summarized as:

- A: Must look and play like the latest televised event. Golfers accept hand watering of greens only.
- B: Excellent conditioning, firm, fast conditions with an occasional wet or dry area. Golfers accept occasional spot watering on greens, tees, and fairways.
- C: Good conditions with moderate numbers of wet or dry spots. Golfers accept daily spot watering of fairways, tees, and greens to minimize problem areas.
- D: Fair to poor conditions, with numerous wet and dry areas developing when relying on sprinklers alone. Many hose-end sprinklers run during the day to maintain acceptable conditions.
- F: Very poor; large wet and dry areas that require manual irrigation of large areas daily. Uniform soil moisture and turf color are only possible with rain.

Labor and Budget: To offset system inefficiencies, use of manual irrigation with hoses and portable sprinklers is often necessary, and this can require significant labor and budget additions. The following criteria can be used to determine the grade of the system needed to provide acceptable conditions based upon budget and labor availability:

- A: Shoestring; must rely on the irrigation system entirely. Only have time to mow and set up the course for play.
- B: Limited; can hand water dry spots on greens and collars. Not much time to spot water tees or fairways.
- C: Moderate; can put out a few roller-base portable sprinklers on tees and fairways and hand water greens and collars as required.
- D: Large; can hide all the inefficiencies of the system with hand watering and numerous portable sprinklers.
- F: Infinite; we can hand water the entire property if necessary.

Climate: The sophistication of the irrigation system needed is directly related to the climate. The length of time between rainfall events and the amount of natural rainfall, along with peak daily ET (evapotranspiration) replacement requirements, must be considered. Based upon the following climate descriptions, the grade of irrigation system needed is:

Peak Daily ET Replacement in Inches	*Climate/ Expected Precipitation*
• A: >0.30	Dry desert climates, with several months between significant rain (<15" annually).

- B: 0.20-0.30 Interior plains and valleys with hot, dry summers. Regular showers are expected every three to four weeks (15"-25" annually).
- C: 0.15-0.20 Transitional regions with high summer temperatures and rain expected every one to two weeks (25"-35" annually).
- D: 0.10-0.15 Coastal climates with considerable fog, and northern temperate regions with moderate temperatures. Weekly rainfall (35"-45" annually).
- F: <0.10 Our course is located in a rainforest; we receive rain just about daily (>45" annually).

Step 2: Historical Performance

After determining the grade of a system that will satisfy your needs, establish an average grade for the overall performance of the irrigation system over the past five years. Ask questions such as: With the existing irrigation system, has the staff been able to a) keep the turf healthy all of the time, b) keep the course green most of the time, c) keep the course firm and playable most of the time? Has the system been reliable and not cost an excessive amount of money to maintain? In short, the irrigation system over the past five years has:

- A: Met or exceeded expectations at all times.
- B: Met expectations most of the time.
- C: Met expectations some of the time.
- D: Consistently fell below expectations.
- F: Never met expectations.

Step 3: Determine the Quality of the Existing System

The intended result of any irrigation system is to apply water uniformly, but it is a mistake to think that only "head-to-head coverage" is needed for uniform coverage. Uniform coverage is the end result of several factors combined, including:

1. Reasonable sprinkler spacing distances specified in the original design.
2. Uniformly installed spacing and proper configuration of sprinklers.
3. Sprinkler and nozzle performance that produces optimum coverage within the system's design parameters (i.e., spacing distance, layout, and system hydraulics).
4. Flexible controls with the ability to manage the amount of water applied based upon varying site requirements (plant and turf species, soil types, shade influence, slope, etc.).
5. Reasonable numbers of sprinklers assigned to control stations.
6. Proper hydraulic design (correct pipe and pump sizes, operating pressures, and flow rates).
7. Properly installed, reliable hardware components (controllers, fittings, thrust blocks, pipe pressure rating, etc.).

In summary, an irrigation system works on the "weakest link in the chain" theory. If any one of the above areas is lacking, undesirable results often occur. In the following section, each of the above areas will be graded against current state-of-the-art design standards.

Sprinkler Spacing Distances: Physics dictates that throwing water a short distance requires less energy (pressure) than discharging water a greater distance. Operating at lower pressures reduces operating costs and minimizes development of fine droplets that, when affected by wind, upset application patterns. This is why new irrigation systems are designed with closer spacing and with sprinklers that operate at lower pressures. Also, application uniformity generally is better when using smaller spacings. Assign a grade for the designed spacing of primary playing areas as follows:

- A: ≤ 65 feet
- B: 66-75 feet
- C: 76-85 feet
- D: 86-95 feet
- F: ≥ 96 feet

Spacing and Configuration Uniformity: Sprinkler spacing should be uniform in distance and configuration (equilateral triangles or squares). Spacing reduced in one direction to compensate for wind generally is not recommended because wind direction and velocity are usually different each day. The following criteria can be used to grade sprinkler spacing and uniformity:

- A: Equilateral triangles or squares, installed within 5% of designed spacing.
- B: Equilateral triangles or squares, installed within 10% of designed spacing.
- C: Uniformly sized non-equilateral triangles or rectangles.
- D: Single row, uniformly spaced (fairways).
- F: Varying spacing with no apparent plan considered.

Sprinkler/Nozzle Performance: If sprinkler and nozzle performance are not matched to the installed spacing and configuration, then application uniformity will never be achieved. To measure sprinkler distribution performance, conduct a catch-can test and evaluate the data. The basic procedure is as follows:

Maintaining level irrigation heads is a basic in sprinkler maintenance. The end result is improved water application uniformity.

1. Bring all sprinklers in the areas to be tested to a level grade.

2. Inspect nozzles of complementing heads. Replace mismatched or unusually worn nozzles.

3. Adjust pressure regulation valves (PRV) to specified operating pressures.

4. Check that sprinkler rotational speed is within the manufacturer's specifications. (Impact heads are controlled by properly tensioned return-spring adjustment, while stator and nozzle combinations control gear rotors.)

5. Place uniformly sized catch-cans five feet apart throughout the test area.

6. Operate each sprinkler influencing the area for 15 minutes.

7. Measure and record the depth of water in each container.

8. Evaluate the data.

Note: Data can be evaluated manually or with computer software to determine distribution uniformity (DU) and/or scheduling coefficient (SC). For additional information regarding these formulas or available software, contact The Center for Irrigation Technology (CIT) at Fresno State University, Fresno, California, (559) 278-2066. Request the references listed at the end of this article or visit http://www.atinet.org/CATI/rese/ .

Where high SC and low DU values result, operating pressure, sprinkler spacing, nozzle selection, and/or nozzle wear should be closely examined as potential problems. Where low SC and high DU values result, yet wet or dry spots persist when operating the system automatically, closer examination of controller programming, operational pressures, flow velocities, pipe sizing, soil compaction, and potential water chemistry problems that affect permeability (SAR and ECw) are warranted. The following criteria can be used to grade catch-can test results:

	SC	DU
• A:	≤ 1.2	> 85%
• B:	1.2-1.3	75-85%
• C:	1.3-1.5	65-75%
• D:	1.5-1.8	55-65%
• F:	> 1.8	< 55%

Automatic Controls: Properly programmed control systems help manage how much, when, and where water will be applied. They also can balance hydraulics, maintain maximum flow velocities, and optimize operating window time frames. The following criteria can be used to grade automatic controls:

• A: Computerized central controls with flow-managing software, solid-state satellites, on-site weather station, and hand-held radio controls.

• B: Computerized central controls with flow-managing software, electro-mechanical satellites, and access to public weather station data.

• C: Solid-state central control *without* flow-managing software.

• D: Electro-mechanical central and satellite controls.

• F: Satellite control only (no central).

Sprinkler Station Assignments: Reducing the total number of sprinklers controlled per satellite station increases flexibility. Individually controlled heads throughout the tees, fairways, and roughs, along with dual heads at greens (one set of heads directed at the putting surface, with a separate set of heads directed at the green surrounds) to allow more finite management of water have become common with new designs. The following criteria can be used to grade sprinkler station assignments:

• A: Individual sprinkler control throughout greens, tees, fairways, and roughs, with dual heads at green perimeters.

• B: Individual wires to all sprinklers. Individual sprinkler control at greens and tees and dual perimeter heads at greens. Fairways and roughs have not more than three sprinklers per station, with individual wires accessible within control cabinets to allow easy station reassignment.

• C: Single head control at greens, not more than two heads per station on tees, and not more than four heads per station in fairways and roughs. Station assignment wires are permanently spliced underground and require trenching to make changes in station assignments. Fairway and rough station assignments operate parallel to the direction of play.

• D: Two heads per station on greens, no more than five sprinklers per station on tees, fairways, or roughs. Tee, fairway, and rough heads operate parallel to direction of play.

• F: Any kind of control with more than two sprinklers operating per station on greens, or fairway sprinklers operating perpendicularly (from tree line to tree line), as opposed to parallel to fairways.

System Hydraulics, Flow Velocities, and "Operational Windows": To assure optimum operating pressures, efficiency, and the avoidance of water hammer, proper hydraulics must be designed into the system from the start. Hydraulic design and pipe sizing is based upon 1) the number of acres to be irrigated, 2) peak water replacement

This circle of green grass and surrounding brown turf is a classic symptom of poor irrigation coverage. The lack of a good irrigation system often results in the staff spending an inordinate amount of time compensating for the system's weaknesses.

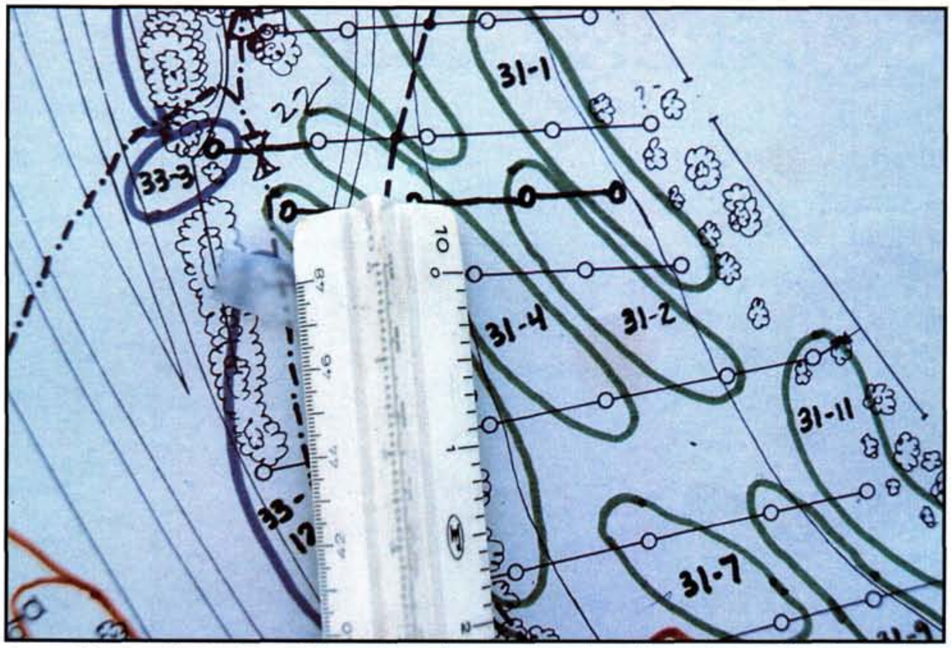
requirements, and 3) the number of hours available to complete an irrigation cycle during peak water replacement.

It is common for sprinklers to be added where deficiencies in the original design are noticed or as golfers' expectations increase. This can result in hydraulically overloading the system or extending the operating window into hours of daylight that interfere with play and maintenance. Overloading system hydraulics must be avoided, as it is similar to operating an electrical circuit with too many appliances. Eventually, something gives out! Overloaded electrical systems generate heat through resistance and blow fuses. Overloaded irrigation systems develop excessive flow velocities that create water hammer. Water hammer eventually fatigues and ruptures pipe. Excessive velocities also cause pressure losses that contribute to poor coverage and require extending the operational window to maintain proper operating pressures.

Therefore, evaluating the operational window is often a fair assessment of potential hydraulic problems, and poor performance in this area warrants consultation with an irrigation designer. To evaluate the overall hydraulics of the system, the operational window required to complete an automatic cycle at peak demand without exceeding flow velocities of 5 feet per second is:

- A: ≤ 7 hours
- B: 7-8 hours
- C: 8-10 hours
- D: 10-12 hours
- F: 12 hours or more

System Reliability: No matter how well a system distributes water, it must also be reliable. Chronic failures of lateral or mainline pipe, fittings, pumps, or control systems can be a sign of poor quality products, incorrect installation techniques, and/or aging components in need of replacement. Normal wear and tear failures should not become an issue until a system reaches more than 20 years of age. Frequent pipe failures occurring sooner can indicate that pipe and fittings of improper pressure rating were used, or pipe was not sized correctly and maximum flow velocities have regularly been exceeded. Additionally, if epoxy coated steel or PVC mainline fittings are utilized, chronic failure can be expected earlier in the life of the system. Their replacement with longer-lasting and far more durable ductile iron components is suggested. System reliability may be ranked accordingly by the number of major failures occurring each season:



A good hydraulic design with a uniformly spaced and configured sprinkler layout is the first step towards achieving an irrigation system worthy of an "A" grade.

- A: Zero to one
- B: Two to four
- C: Five to seven
- D: Eight to ten
- F: Eleven or more

Other Rating Factors: Some sites may require site-specific rating factors to be considered by the rating team. These could include the following:

- Pump output
- Well output
- Lake storage capacity
- Varying soil conditions
- Soil compaction
- Tree influences
- Water chemistry as it relates to permeability

Step 4: Implementing Changes or Seeking Additional Help

Changes to improve performance, such as adjusting pressure regulation valves, lifting and leveling low heads, replacing sprinkler nozzles or control systems, can offer reasonable improvements. Bringing in an irrigation design consultant to perform a more complete analysis is warranted where serious deficiencies are identified. Finally, it is important to understand that irrigation upgrades often require large capital expenditures to offer noticeable improvement. Recommendations based upon the grade point average derived from the various factors evaluated in Step 3 are:

Final GPA

- A: Excellent system; proper maintenance should maintain this status for a number of years.
- B: Good system; possibly beginning to show some age, but proper maintenance should prolong useful life expectancy, maintain efficiency, and possibly offer improvement.
- C: This system needs work, and improvement may be possible, depending upon the problems. The assistance of an irrigation designer may be helpful.
- D: Seek the advice of an irrigation designer for improvement.
- F: Get a good irrigation designer and get out the checkbook; nothing short of complete system replacement can likely help.

References

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MIKE HUCK *is the agronomist in the Southwest Region, where water use efficiency is of the utmost importance and the arid climate quickly shows an irrigation system with a failing grade.*