



Adobe Creek National Golf Course Percolation & Bacteria Tests

The Effect of Ozone and CO₂ Injections on Percolation Rate and the Reduction of Bacteria

Percolation Tests

The percolation tests, outlined in the tables below, were taken at the same location on each hole with the same amount of water each time. The holes designated with *asterisks* are later shown in photos.

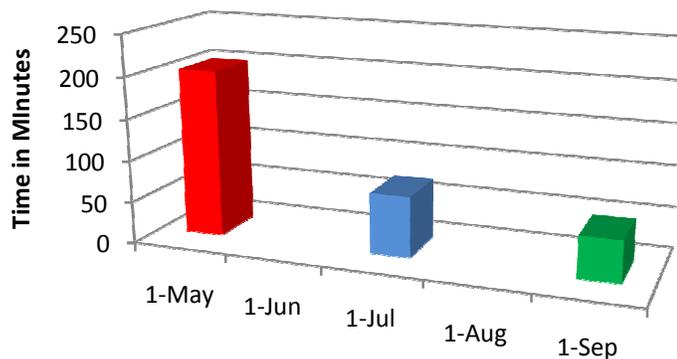
	May 15, 2008	July 22, 2008	September 5, 2008
Desert Course Hole 4	13.25 minutes	1.25 minutes	1.25 minutes
Desert Course Hole 9	27.5 minutes	12.25 minutes	6.5 minutes

	May 15, 2008	July 22, 2008	September 5, 2008
Mesa Course Hole 1	22.75 minutes	8.75 minutes	4.25 minutes
Mesa Course Hole 2	More than 30 minutes	8.5 minutes	4.75 minutes
Mesa Course Hole 9	17.5 minutes	8 minutes	3.75 minutes
Mesa Course 9 Green	More than 30 minutes	12.5 minutes	8.75 minutes

	May 15, 2008	July 22, 2008	September 5, 2008
Monument Course Hole 5	More than 30 minutes	11.5 minutes	11.5 minutes
Monument Course Hole 9	More than 30 minutes	9.75 minutes	8.75 minutes

	May 15, 2008	July 22, 2008	September 5, 2008
All holes	More than 200 minutes	72.5 minutes	49.5 minutes

Total Percolation Time



- Test taken before ozonated water was applied
- Test taken after 68 days of irrigating with ozonated water
- Test taken after 111 days of irrigating with ozonated water



Bacteria Tests

Below are two water tests showing the total coliform count and the aerobic plate count. These are the two tests used to measure the bacteria content in water. The bacteria content is a good measure of how dirty water actually is, as the amount of bacteria correlates directly with the amount of algae. As bacteria decreases, so does algae. These tests were done by Colorado State University Environmental Quality Laboratory.

#1: May 15, 2008 Water Test

Sample ID	Total Coliform / 100 ml	Aerobic Plate Count / ml
ACNGC Pump Lake	2	700
ACNGC #2 Mesa	4	280
ACNGC #5 Monument	9	1,600

The first water samples, in the table above, were taken from water around Adobe Creek National Golf Course to get a feel of the relationship between sample areas. Note the increases in the values from the pump lake to #2 and then to #5. The first water tests taken were before any ozone had been used.

#2: July 22, 2008 Water Test

Sample ID	Total Coliform / 100 ml	Aerobic Plate Count / ml
ACNGC Pump Lake	102	64,000
*ACNGC #2 Mesa	0	4,000
*ACNGC #5 Monument	0	1,000

*These samples have been treated with ozone

The second round of water samples taken show a drastic increase in bacteria levels from the pump lake which was not treated by ozone. However, that untreated water was cycled through ozone prior to arriving at the sprinkler heads #2 and #5. Note that the relationship between sample areas has changed. The water from the infected pump lake exhibits a zero coliform count once ozonated, and the aerobic plate counts decrease from the lake to #2 to #5 instead of increasing, as in the first table.

This study demonstrates, in a real-life example, the effectiveness of ozone as an oxidizer. The EPA states, "Ozone is more effective than chlorine in destroying viruses and bacteria."

May 15, 2008

**Percolation time:
17.5 minutes**



Here, we have the desiccation of the turf grass stand due to a hard layer of clay soil under the surface. This causes standing water, which leads to the build-up of bacteria. This bacteria then feeds the algae growth, which concentrates into surface and sub-surface black layer. The percolation time of 17 minutes, 30 seconds, recorded on May 15, 2008, was reduced to 8 minutes, 0 seconds after 10 weeks of treatment with irrigation water injected with ozone gas at rate of 120 grams per hour for approximately 12 hours a day. On September 5, 2008, a third percolation test was taken with a recorded time of 3 minutes, 40 seconds.

Through ozone gas injection, the percolation rate of the soil profile has allowed the over seeding and aerification to become more effective in reestablishing the lost stand of turf grass.

July 22, 2008

**Percolation time:
8 minutes**





May 15, 2008

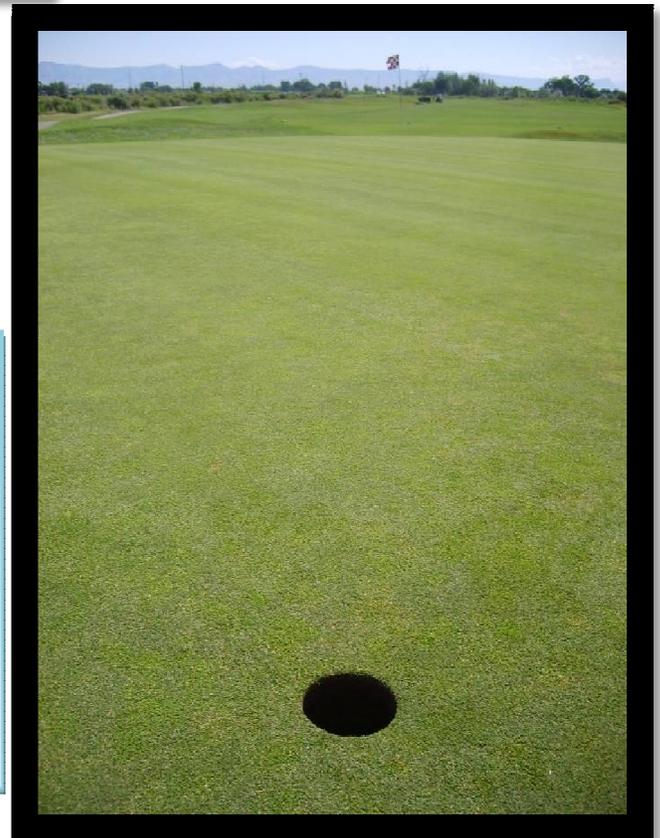
**Percolation time:
More than 30
minutes**

July 22, 2008

**Percolation time:
12.5 minutes**

This green is a push up clay/sand green which lost significant bent grass due to algae/black layer build up and created a percolation rate in excess of 30 minutes.

After 10 weeks of ozone gas injection through the irrigation system, the recorded time for percolation had been reduced to 12 minutes, 30 seconds with no visible signs of algae/black layer and the return of dense stand of bent grass. After 16 weeks of ozone gas injection through the irrigation system, the recorded time for percolation had been reduced to 8 minutes, 45 seconds with the turf grass color, texture and density back to a highly playable level.



May 15, 2008

**Percolation time:
More than 30
minutes**



Here we have nearly 100% desiccation of the turf stand with the whole fairway showing an off-color chlorotic look due to a recorded percolation time in excess of 30 minutes. This was reduced to 11 minutes, 30 seconds with the ozone gas injection through the irrigation system, creating a return of better color and the reestablishment of the turf grass stand through aerification and over seeding. The recorded time after 16 weeks remained about the same, at 12 minutes, 45 seconds. The slight increase is due to the location of this fairway not only geographically but also hydraulically from the location of the pump station, which has reduced the effect of the ozone gas. With the addition of a second ozone diffusion system at the second pump station, a higher concentration of ozone gas injection will take place through the irrigation system along with a greater residual effect.



July 22, 2008

**Percolation time:
11.5 minutes**

