Tech Brief

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Jar Testing

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Photos by Julie Black, courtesy of Morgantown Utility Board

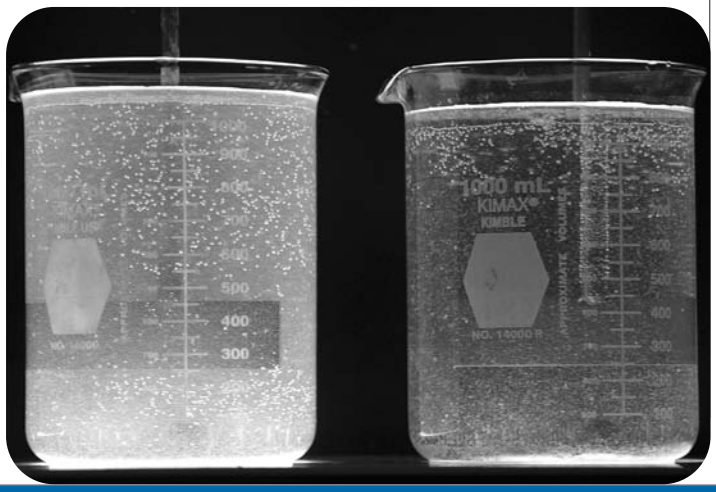
Summary

Jar testing is a pilot-scale test of the treatment chemicals used in a particular water plant.It simulates the coagulation/flocculation process in a water treatment plant and helps operators determine if they are using the right amount of treatment chemicals, and, thus, improves the plant's performance.

What is jar testing?

Jar testing is a method of simulating a full-scale water treatment process, providing system operators a reasonable idea of the way a treatment chemical will behave and operate with a particular type of raw water. Because it mimics full-scale operation, system operators can use jar testing to help determine which treatment chemical will work best with their system's raw water.

Jar testing entails adjusting the amount of treatment chemicals and the sequence in which they are added to samples of raw water held in jars or beakers. The sample is then stirred so that the formation, development, and settlement of floc can be watched just as it would be in the full-scale treatment plant. (Floc forms when treatment chemicals react with material in the raw water and clump together.) The operator then performs a series of tests to compare the effects of different amounts of flocculation agents at different pH values to determine the right size floc for a particular plant. (The right size of floc depends upon the system's filter dimensions and other considerations.)



The jar testing process can be summarized as follows:

- For each water sample (usually raw water) a number of beakers (jars) are filled with equal amounts of the water sample;
- Each beaker of the water sample is treated with a different dose of the chemical;
- Other parameters may be altered besides dosage, including chemical types, mixing rate, aeration level/time, filtration type, etc.;
- By comparing the final water quality achieved in each beaker, the effect of the different treatment parameters can be determined; and
- Jar testing is normally carried out on several beakers at a time, with the results from the first test guiding the choice of parameter amounts in the later tests.

Frequency of Jar Testing

Jar testing should be done seasonally (temperature), monthly, weekly, daily, or whenever a chemical is being changed, or new pumps, rapid mix motors, new floc motors, or new chemical feeders are installed. There is no set requirement for how often jar testing should be conducted, but the more it's done the better the plant will operate. Optimization is the key to running the plant more efficiently.

Why perform jar tests?

In the spring 1993 *On Tap* article "Jar Testing: Getting Started on a Low Budget," David Pask, former National Environmental Service Center engineer, wrote, "By performing jar tests, you can try alternative treatment doses and strategies without altering the performance of the full-scale treatment plant and easily compare the results of several different chemical treatments for time of formation, floc size, settleability, and, perhaps, filtration characteristics. One cannot make such comparisons with the full plant's treatment."

Another important reason to perform jar testing is to save money. One of the common problems in water treatment is overfeeding or overdosing, especially with coagulants. This may not hurt the quality of water, but it can cost a lot of money. One of the easiest things an operator can do for optimization of the plant is jar testing, and jar testing is a must when looking at best available technologies.

According to the Phipps and Bird Web site, "We often hear from treatment plants that they want to jar test; they know they should be jar testing; but they just can't seem to justify the cost of the equipment. Granted, a good, dependable six-station jar tester isn't cheap. The price of a complete set-up can be $2,000 or more. In many cases, that can be a big chunk of a small system's annual equipment budget. . . .What many operators fail to realize is that jar testing, in most cases, saves money and in many cases a lot of money—so much money, in fact, that the initial cost of jar testing equipment is often recovered in less than one year. In many plants where jar testing is not done, there is a tendency to dose a little extra 'just to be sure.' This overdosing can result in on-going, unnecessarily high, coagulant expenses."

Jar Testing Procedures

The following jar test procedure uses alum (aluminum sulfate) a chemical for coagulation/flocculation in water treatment, and a typical six-gang jar tester. The results of this procedure can help optimize the performance of the plant.

- First, using a 1,000 milliliter (mL) graduated cylinder, add 1,000 mL of raw water to each of the jar test beakers. Record the temperature, pH, turbidity, and alkalinity of the raw water before beginning.

Jar Testing: Getting Started on a Low Budget

David Pask, former National Environmental Services engineer, wrote an article, "Jar Testing: Getting Started on a Low Budget," in the spring 1993 issue of *On Tap*. This article outlines a procedure for how to build a two-jar jar tester. You can obtain this article by visiting NESC's Web site at this link: *www.nesc.wvu.edu/ndwc/pdf/OT/OT_sp93.pdf* for a pdf. You also may call us at (800) 624-8301 and ask for a copy via fax, email, or snail mail.

- Next, prepare a stock solution by dissolving 10.0 grams of alum into 1,000 mL distilled water. Each 1.0 mL of this stock solution will equal 10 mg\L (ppm) when added to 1,000 mL of water to be tested.

- Using the prepared stock solution of alum, dose each beaker with increased amounts of the solution. See **Table #1** below for an example of the increments and dosage:

Table 1

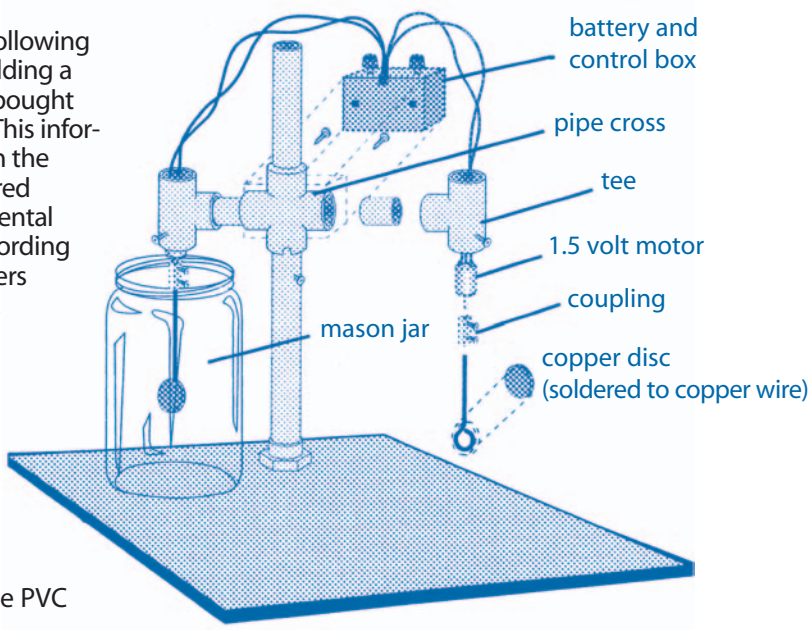
Jar #	mL Alum Stock Added	mg\L Alum Dosage
1	1.0	10.0
2	1.5	15.0
3	2.0	20.0
4	2.5	25.0
5	3.0	30.0
6	3.5	35.0

- After dosing each beaker, turn on the stirrers. This part of the procedure should reflect the actual conditions of the plant as much as possible. Meaning, if the plant has a static mixer following chemical addition, followed by 30 minutes in a flocculator, then 1.5 hours of settling time before the filters, then the test also should have these steps. The jar test would be performed as follows: Operate the stirrers at a high RPM for 1 minute to simulate the static mixer. Then reduce the speed of the

How to Build a Simple Jar Tester

If a new jar tester isn't in the budget, the following illustration and instruction will help in building a two-jar "jar tester" from parts that can be bought at a local hardware and electronics store. This information comes from an article published in the spring 1993 *On Tap* newsletter and authored by **David Pask**, former National Environmental Services Center Engineering Scientist. According to Pask, these two-jar or two-gang jar testers can be assembled for a relatively low cost.

Figure 1 - Stirrer Assembly



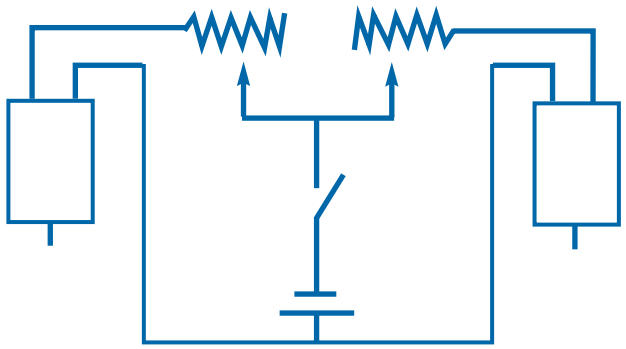
Parts List:

- Base—one piece of 18-mm ply baseboard—or 3/4-inch plywood, Plexiglas, old piece of counter top, or similar material that is at least 12 inches x 8 inches
- Two clear, square, quart "Mason" pre-serving jars
- One 24-inch piece of 3/4-inch, white PVC water line. Cut into four pieces:
  - One – 5-inch long
  - One – 12-inch long
  - Two – 3.5-inch long
- Two 3/4-inch PVC Tees
- One 3/4-inch fitting cross or plus
- Two 1.5 volt motors to fit into the tees
- Two couplings for the motors like an electrical connector to fit over motor spindles
- Two pieces of straight-solid copper wire 6 to 7 inches with loop on one end for the stirrer
- Two copper discs the size of a penny for soldering to the loops on the stirrers
- Eight 1/2-inch long, sheet metal screws.
- One 20-inch piece of 18-gauge (American Wire Gauge awg) red wire cut into two even pieces or standard "bell" wire
- One 20-inch piece of 18-awg black wire cut into two even pieces or standard "bell" wire
- One alkaline "D"-cell battery
- One D-cell battery mount
- Two 25 ohm x 2 watt variable resister one for each motor
- One plastic electrical junction box to house the electrical components
- One DC slide or toggle switch
- One 3/4-inch PVC flange socket couple to attach pipe to base

Tools needed:

- Drill
- 1/8-inch drill bit
- Phillips and straight screw drives
- Wire cutters
- Solder
- Soldering gun
- Hack saw
- Old hack saw blade or dermal motor tool to ream the horizontal connections of the cross
- Wire strippers
- Tape measure

Figure 2 - Electrical Circuit

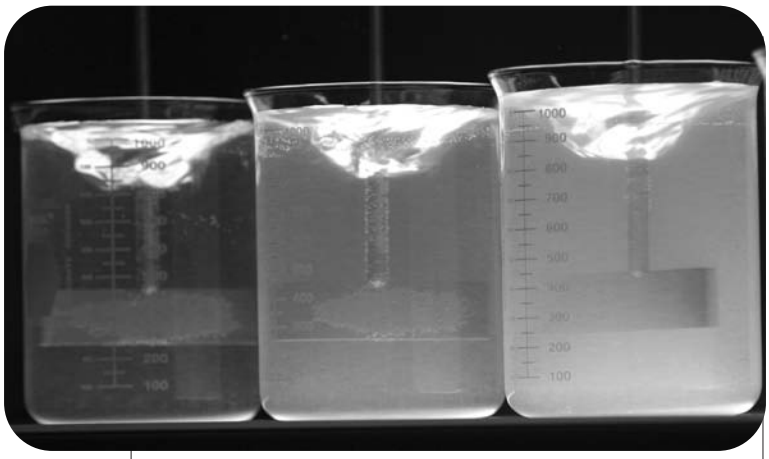


Assembly

The only awkward part of building the stirrers is the reaming out the horizontal connections of the cross, so it will slide easily onto the 3/4-inch pipe. One way to do this you can take a piece of hack saw blade and set it into a slot that is cut in the end of a section of pipe (see **Figure 1** above).

The 1.5-volt motors are not really designed to operate at such a low speed; however, they will work if each is controlled with a 25 ohm, two watt, variable resistor (see **Figure 2** above).

I recommend not gluing any of the fittings together but to use a sheet metal screw as a set screw to hold the fittings in place.



stirrers to match the conditions in the flocculator and allow them to operate for 30 minutes. Observe the floc formation periodically during the 30 minutes. At the end of the 30 minutes turn off the stirrers and allow settling. Most of the settling will be complete after one hour.

- Now, look at the beakers and determine which one has the best results (if any). If no results were noticeable, then increase the dosage using the table above for the next six jars. An underfeeding will cause the sample in the beaker to look cloudy with little or no floc and no settling or very little. An overfeeding will cause a dense fluffy floc to form and will not settle well, meaning it stays in suspension and floats. The beaker that looks like it has the appropriate dosage of alum (coagulant) will have floc that has settled to the bottom, and the water above it will be relatively clear (remember this is before the filtering process of the water treatment plant). The best way to determine which sample is the clearest would be to check the turbidity of each beaker and record this information. Use a pipette to draw a portion from the top of each beaker one at a time not stirring or disturbing the sample. If none of the beakers appear to have good results, then the procedure needs to be run again using different dosages until the correct dosage is found.

Larry Rader, former program manager for the West Virginia Rural Water Association and consultant for NESC, noted an example of how jar testing can save money:

The operator of a small system (700 to 800 customers) attended one of Rader's jar testing training workshops. After learning the procedure, the operator returned to his plant and began jar testing daily. The results were both instantaneous and dramatic: Alum dosage went from 127 pounds per day to 53 pounds per day; lime dosage dropped from 42 pounds to under 5 pounds per day. This translated into a 58 percent reduction in alum usage and an 88 percent decrease in lime consumption.

According to Rader, the system experienced a $1,700 savings during the first three months. Their annual alum and lime expenses had been in excess of $11,000: They are now averaging under $4,000. That's a savings of $7,000 per year, or a 60 percent reduction in cost.

He also reported that the town clerk thought something was amiss. They hadn't purchased chemicals in more than two months, and their suppliers were calling to inquire as to why they had lost the business. In short, this particular system saved enough money in the first three months to pay for their jar tester in full. The ensuing savings can be used to help fund other much-needed equipment or plant improvement projects. And importantly, the quality of the water improved.

References

Pask, David. 1993. "Jar Testing: Getting Started on a Low Budget." *On Tap*: National Environmental Service Center.

Lafleur, Tina. 1997. "Jar Testing." *www.rpi.edu/dept/chem-eng/Biotech-Environ/Environmental/WATER/jar.html*. Accessed 12/8/2004.

www.citywater.com.au/WT_JarTesting.html. Accessed 12/10/2004

www.wecleanwater.com/pdf/Jar%20Testing.pdf. Accessed 12/10/2004

www.phippsbird.com/cantaff.html. Accessed 12/8/2004

Before joining NESC's technical services unit, Engineering Scientist **Zane Satterfield** worked as a district engineer with the West Virginia Bureau of Public Health.

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