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This manual previously formed part of the original jar stirrer operator manual.

The calculations shown within this document relate to the jar and paddle configurations of the following stirrers:

JarStar, JarStar*II*, JarStar*3*, *Infinity*, *JarMaster* stirrers.

COAGULATION AND FLOCCULATION SIMULATION (Jar Tests)

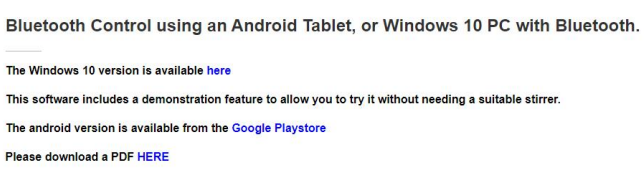
https://www.boltac.co.nz bruce@boltac.co.nz

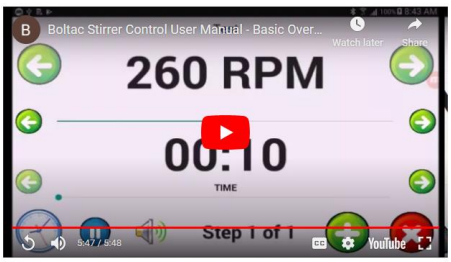
Control software- free download

Boltac Stirrer Commander Play Store https://play.google.com for Android users.

Boltac Stirrer Commander on https://apps.apple.com > app > Boltac for iPad users.

An audio/visual demonstration is available on https://www.boltac.co.nz/infinity-jar-stirrer/





COAGULATION AND FLOCCULATION – an insight

Probably the most pivotal and important/influential function of a water treatment process that has coagulation and flocculation as the prime operation.
Get these steps wrong and the whole process is affected, often badly.
Get it right and the plant will perform with less "downstream" problems, waste, (and costs).

If an adjustment to the dose rate in a treatment plant is to be made without first ascertaining the amount or direction of the change, costly, (sometimes embarrassing) errors can be made.
The practised and frequent use of the jar stirrer can lead to chemical savings, adherence to performance criteria, and will be a definite aid to Quality Assurance auditing.
Note/s-
Just because a jar test may not give you the results you were expecting, or wanting, do not think the jar test, (or the jar stirrer) is a waste of time. There are many factors influencing the differences in outcomes when comparing a jar test result and treatment plant performance.

Differences may be (and often are), coagulant concentration where the plant could be running a 40% mix and the jar test involves perhaps 1% concentration to facilitate accuracy of dose.
Usually, the 40% solution will produce the same floc size, but at a much (much) slower rate.
Dilution errors (however minute) can disrupt outcomes.

An often-overlooked aspect is plant flow rate variations. The time interval between dose points DOES vary with plant flow rate changes, the jar test needs to be adjusted to accommodate those changes, especially the duration of flash mix times.

Flash mix intensity- Unless you're experimenting, use the same mixing intensity and time (G.t. Value) as the plant flash mixer. There's merit in considering "G.t" as a concept. That's G x time (in seconds). There's no point in running the jar stirrer at 300 G for 3 minutes when the plant flash mixer is running 200 G and the water is only in the mix zone for 45 or 60 seconds. It's common for flash mixers to run at or around 200 G.

Approximate "Rule-of-thumb":
Higher flash mix rpm tends to create smaller, harder floc.
Slower rpm tends to create larger, lighter floc particles.
Dosing dilute solutions tends to make floc quicker.
Dosing neat (stronger) solutions tends to create floc more slowly but gets there in the end.

Not always appreciated:
The initial coagulation takes place in 2 – 3 milliseconds -the blink of an eye! (It takes something like 10 milliseconds for a human to react to a shock from an electric fence).
Mixing and floc growth occur later.

pH change takes 2 – 3 seconds, involving about 14 parameters (six of them "major").
Before we begin to argue, there's a difference between "time to change" and "time to show up on the pH meter"!
(Hendricks 2006). *Hendricks, D. 2006. Water Treatment Unit Processes - Physical and Chemical. Edition 1. Taylor and Frances. Pg 277-379.*

Jar Stirrer vs PCA (Particle Charge Analyser).

STOP RIGHT THERE.

BEST to be COMBINING their uses/features, NOT separating them!

Both instruments are well-established and well-proven in water treatment.

It's noted that some PARTICLE CHARGE ANALYSER manufacturers and instrument agents/resellers state that a PCA "Replaces a Jar Stirrer" or "Replaces JAR TESTs". Maybe true, but not true, but not the best technical statement to make (and let's face it, water treatment technicians, engineers, and operators are technical people).

True - A PARTICLE CHARGE ANALYSER test can be done quickly, more quickly than a JAR TEST.

A PARTICLE CHARGE ANALYSER is a PARTICLE CHARGE ANALYSER, not a Jar Stirrer***!***

A Jar Stirrer s a Jar Stirrer, not a PARTICLE CHARGE ANALYSER***!***

Both instruments have their place and value in water treatment.

A PCA test tell the operator "**How**", the JAR TEST tells the operator "**Where" or "Why**."

A PARTICLE CHARGE ANALYSER will indicate the charge neutralisation point of a solution (the iso-electric point- that's it, the "How." From there, the dose rate can be ascertained by correlating the amount injected into the PARTICLE CHARGE ANALYSER during the test- still not a JAR TEST. The PARTICLE CHARGE ANALYSER only provides the charge neutralisation point, which may, or may not be the optimum performer.

What a PARTICLE CHARGE ANALYSER does NOT provide is a view of floc formation and settleability.

A Jar Stirrer (JAR TEST) acts on 4 or six individual jars of sample simultaneously to determine the best dose rate of coagulant, relying on subsequent "eye-ometer" for floc formation and settleability, NTU measurements for turbidity/clarity and other selected test regimes to determine the optimum dose. This takes longer than using the PCA but does provide the "Where" or "Why."

COMBINING PARTICLE CHARGE ANALYSER and JAR TEST

If an operator determined the charge neutralisation point using the PARTICLE CHARGE ANALYSER., followed by a JAR TEST with coagulant dose rates slightly above, and slightly below the PARTICLE CHARGE ANALYSER indicated charge neutralisation point, the optimum floc formation and settling rates can be observed, win, win.

Eyeometer vs Instrumentation – Spectrophotometer analysis.

Sometimes there's a requirement for a quick assessment of how the plant coagulation and flocculation is going, or how it may be dragged back from the brink to being better!
It's these occasions that viewing the floc size and settling rate is a totally acceptable and successful way of getting the treatment process back on track.

There are several conditions that can upset the result of plant flocculation etc., organics is one of them.
A quick method to determine organics being present in the supernatant coming off the sedimentation tanks is to use a spectrophotometer if you have one.
Take slightly more than the required volume of sample and syringe it through a 0.45-micron syringe filter into the spectrophotometer tube. Select UV254 and following the machine instructions read/note the presence/absence of organics. You will need to compare these results with the prescribed level that is acceptable in the plant, or the client's requirement etc.

JAR TEST CONSIDERATIONS

Reasons why a jar test might be used:
Investigating for new plant- tests might be conducted monthly for up to 2 years!
Altering plant design – a good way to see what “might happen”.
Emergency attention required – due to rapid source changes, or plant failure.

Background
The purpose of the jar test is to use the results that it produces to effectively optimise the performance of a water treatment plant. Essentially the jar tester is a series of 4, 5, or 6 (or in the case of Boltac JarMaster, up to 8) mini clarifiers. The essence of getting the best out of a jar test is to know how to relate the results obtained back to the operation of the plant.
A jar test may or may not be a precise tool for estimating the correct dose rate for any given plant or scenario. However, it is a very good (safe, and reliable) tool for pointing you in the right direction about dose rate/regime changes.

Consider the jar stirrer, (or the jar test) your “mistake centre”. Make the dose rate changes in the plant based on results from the jar test in the laboratory.
If the result is not precise, it will at least give you a direction (increase or decrease) indication. Think of it as an archer’s bow, fitted with 4, 5, or six differing arrows (doses). No-one knows which arrow is the best until it lands (result)! Result is based on real-time/condition observations.

In 2020, Boltac released it’s 5-place stirrer. The philosophy behind “5-place” is that in times of urgency (plant dosing failure, lost blanket control etc.,) an operator’s task can be simplified if they do not have to consider what is being dosed into each jar and what it might mean. Imaging entering the previously known, or current dose rate into the middle of the five jars (jar 3), increased doses to the right and decreased doses to the left. From that point on, the results become “visual” and without numerical value. As soon as a visible “trend” is noticed, indication either an upward or downward dose rate change, the operator has had free “mind-time” to assess what else may be happening. An immediate change in dose rate can be followed up shortly after a subsequent jar test to assess a more accurate rate, but the operator has at least made an unencumbered decision as to direction of dosage change.

The ”5-jar” philosophy can be adapted to the 6-place stirrer. Add coagulant only to jars 2 through 6, leaving the No 1 jar as a “comparator” to see the difference/improvement (or not) due to result/s of the test.
Consider using jar 3 as the “pivot”. This time, consider adding the raw water sample ONLY to jar #1 (remember to mark/label the untreated jar). Why? An operator may observe something they’ve not seen before- natural settling, or something else. After the jar test, it may be apparent that the untreated jar may have settled more solids than first thought, but the result might indicate need to remove colour, who knows, live, and learn.

Items required for a jar test.

Jar Stirrer- 4, 5, or 6-place.

Beakers (preferably Square Jars).
1 Litre – 100 ml graduations from 500 ml to 1000 ml. **(Standard with all Boltac stirrers).**
Our bench testing has proved that in a round 1-litre beaker, it takes approximately twice the paddle rpm to create the same G Value as in a 1-litre square jar, using water at the same temperature.
Syringes for administering various amounts into jars
Pipettes for administering various amounts into jars.
Small bottles or pots for preparation/storage of coagulant and polyelectrolytes etc.
Small scales for weighing coagulant and polyelectrolyte powders etc.

Optional
Micropipettes for accurately administering various amounts into jars

Correct method of holding the micropipette for aspiration.
In laboratory work, pre-analytical errors are often overlooked, but a little awareness can significantly enhance the effectiveness of our daily tasks.

Micro pipetting Tip of the Day: Your Angle Matters More Than You Think!

The position of your micropipette directly impacts your accuracy, precision, and overall data quality? The following insights illustrate how depth and angle can alter your results, even with the same set volume.

✅ Vertical & shallow depth (~1 cm)
👉 Best accuracy: 0.2–0.4%
🔍 Why? At shallow depth, the pressure inside the pipette balances with atmospheric pressure, allowing the correct volume of liquid to enter the tip without excess suction or trapped air, ensuring the most accurate measurement.

⚠️ Deeper immersion (~3 cm)
👉 Accuracy drops slightly: 0.6–0.8%
🔍 Why? Increased hydrostatic pressure at deeper depths forces more liquid into the tip than intended, leading to over-aspiration and a slight distortion of the final volume.

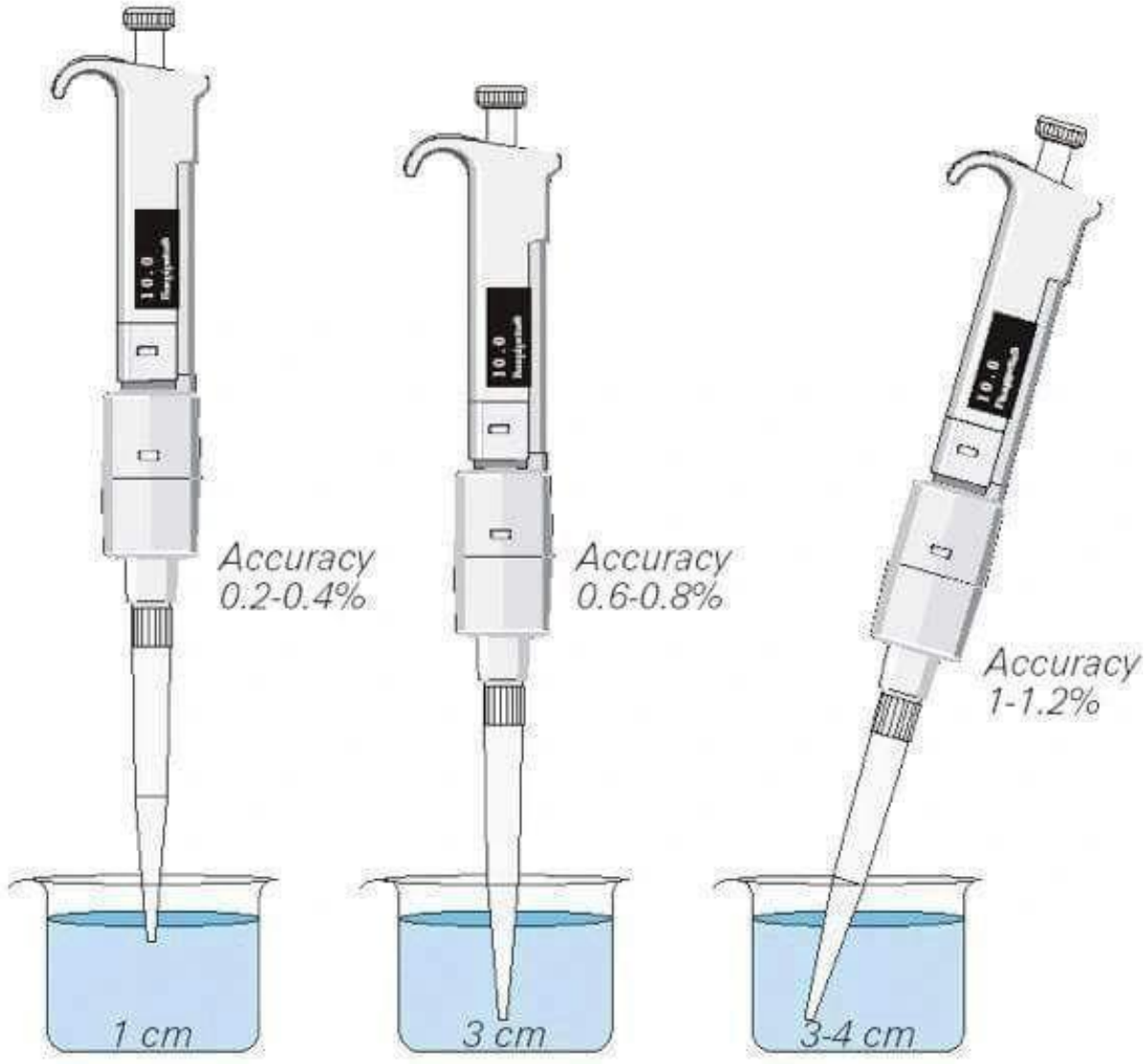
❌ Angled pipetting (3–4 cm depth)
👉 Accuracy reduces further: 1–1.2%
🔍 Why? Pipetting at an angle causes:
• Uneven air entry
• Unstable liquid flow
• Distorted meniscus
These factors lead to inconsistent aspiration and delivery, resulting in poor reproducibility and unreliable results.

🔬 Key Takeaway for Every Scientist & Technician:

- ✓ Always keep your pipette vertical
- ✓ Maintain minimal immersion depth
- ✓ Avoid tilting when aspirating
- ✓ Remember: small technique errors = big data errors!

Whether in molecular biology, clinical diagnostics, forensic DNA analysis, teaching labs, or biotechnology, mastering this technique is crucial for protecting the integrity, accuracy, and credibility of your results.

The effect of the pipetting position (e.g. using a 2-10 ml pipette)



Using Micro Pipettes

Using micro pipettes gives a great deal of accuracy, coupled with absolute repeatability (if used and maintained correctly). Tips supplied by Boltac Industries are either blue or natural colour opaque polypropylene and cannot be sterilised. A range of coloured knob caps are supplied in a small maintenance pack with the micro pipettes supplied by Boltac Industries.
Always read the small booklet supplied with the pipette, always ensure that the items are well maintained.

There are some very important **DON'T'S** when using the micro pipette.
Do not allow moisture into the pipetting mechanism.
Never pipette liquid without attaching a tip to the pipette.
Don't use excessive force when setting the adjustment knob, it could jam the mechanism if an attempt to set outside the adjustment range.

Volume setting
Turning the faceted knob on the top of the pipette anticlockwise increases the volume and clockwise, decreases the volume.
Make sure the volume you select "clicks" on to the setting required. Ensure that the digits in the screen are all visible and that the volume selected is within the device range of volume.

Sealing and ejecting tips.
Make sure the mounting area on the pipette is clean and free of scratches etc.
Press the tip on to the nose cone of the pipette, a good seal is when a visible "ring" appears around the fit area.
When ejecting a tip from the pipette, press firmly down on the ejector (not the pipetting knob).

Pipetting Techniques

Pipetting Recommendations
Hold the thumb vertical when filling and dispensing liquid.
Pre-wet the tip by filling/emptying 5 times, important when dispensing liquids with a different viscosity to water.
Always control filling and dispensing with the thumb to maintain consistency.
If pipetting solutions that vary from the ambient temperature, pre-wet the tip 5 times.
Always store wet pipette/tips vertically to prevent moisture getting into the pipette mechanism.

Forward Technique
For best possible accuracy, push and release the button slowly, especially if thicker solutions are being measured.
Never allow the button to "snap" backwards.
Holding the pipette vertical, press the knob slowly to the first stop.
Dip the tip about 2 – 3cm below the surface of clean solution being used and slowly release the knob fully.
Withdraw from the liquid, touch the tip against the wall of the container to remove excess solution.
Dispense the solution slowly, pressing to the first stop. After one or two seconds, press through to the second stop- this will empty the tip.
Release the button to be ready for the next operation.

Reverse Technique (more suitable for thicker solutions, or very small volumes).
For best possible accuracy, push and release the button slowly, especially if thicker solutions are being measured.
Never allow the button to “snap” backwards.
Holding the pipette vertical, press the knob slowly to the second stop.
Dip the tip about 2 – 3cm below the surface of clean solution being used and slowly release the knob fully.
Withdraw from the liquid, touch the tip against the wall of the container to remove excess solution.
Dispense the solution by pressing slowly to the first stop, some liquid will stay in the tip and should not be used as part of the delivery.
Either return the excess to the solution container or discard.

Optional Tapped (or valved) Jars.
1 Litre – 100 ml graduations from 500 ml to 1000 ml.
Standard jars, with a plastic valve, secured and sealed through the side of the jar.
Note- when drawing samples from tapped jars, remember to draw off a small “flush” sample from each jar valve to eliminate the possibility of settled floc causing an error in turbidity reading of sample.

Optional Simuldose Rack.
(Manually operated) Test tube rack holds 4, 5, or six 20 ml test tubes for simultaneous manual dosing of predetermined volumes of coagulant or polyelectrolyte into each of the jars. Can be paced conveniently in front of machine ready for use.

Working Solution Preparation for jar test

Remember: Because the plant is adding grams per cubic metre (weight/volume) - when calculating dose rates, use weight/volume (g/m^3 or mg/L)

	1 g/m^3	=	1 mg/L or 1 g/m^3
	1000 litres	=	1 m^3 (1 cubic metre)
Dosing into	1 litre	=	1 mg/litre = mg/L or 1 g/m^3

ALUM
Boltac jar testers have 1 Litre jars. For this reason, a 10,000 g/m^3 Alum solution is the ideal strength for most jar test methods.
Alum working solutions can be made up using the following methods:

* Solid Alum
Simply weigh out 10 g of the solid alum with an accurate balance and dissolve into 1 litre of clean water (distilled or de-ionised if possible).

ALUM strength/s?

* Liquid Alum (as delivered)

FOR "AS DELIVERED" STRENGTH, ALWAYS CHECK WITH YOUR SUPPLIER.

Deciding on which denomination for alum should we use in the jar test/dosing calculations procedure, 47% or 620,500 g/m^3?

There's an age-old discussion as to whether 47% is correct or is 620,500 g/m^3 the way to go.

* Liquid Alum (as delivered)

The solution strength of liquid Alum supplied is usually 47% by weight (w/w). So, 1 tonne (not cubic metre) of liquid Alum has 470 kg of Solid Alum dissolved in it.

The Alum molecule $Al_2(SO_4)_3$ aq weighs more than the water molecule H_2O, meaning that a tonne of liquid Alum is not 1000 litres. It is in fact 757.5 litres.

To express delivered liquid Alum in terms of ppm (g/m^3) – w/vol we have:

470,000 grams (weight) of Alum in 0.7575 cubic metres of water (volume).

$$\text{i.e.:} \quad \frac{470{,}000 \text{ grams}}{0.7575 \text{ m}^3} = 620{,}500 \text{ (g/m}^3\text{)}$$

620,500 g/m^3 is the same as 620,500 mg/litre, or 620.5 g/L.

As we administer alum into our water stream as "g/m^3" we should use 620,500 g/m^3 as our base for standard calculation.

NOTE-

S.G. does not feature, nor does it need to when given that the weights and volumes have been specified.

To dilute this down to 10,000 g/m^3 you should approximate by diluting 16 mls into 1 litre of water, (distilled or deionised if possible).

$$\text{i.e.:} \quad 620{,}500 \text{ PPM} \times \frac{16}{1000} = 9928 \text{ g/m}^3 \sim 10{,}000 \text{ g/m}^3$$

If you want to be more precise, use 16.12 mls. If you do opt to use 16.12 mls, then always use 16.12 mls***!*** Or at least indicate that on a note sheet or display board for others to see that you've done this.

POLY ALUMINIUM CHLORIDE

(Solid PACl)

As with solid alum, simply weigh out 10 g of the solid poly aluminium chloride with an accurate balance and dissolve into 1 litre of clean water (distilled or de-ionised if possible).

(Liquid PACl)
If the Liquid PACl is supplied as 35% solution. Like the alum molecule, the PACl molecule $[Al_2(OH)_5\ Cl_2\ (6SO_4)]n$, weighs more than water.

For the delivered tonne of Liquid PACl you have:
350,000 grams of PAC in 0.8333 cubic metres of water
i.e.: $\frac{350{,}000 \text{ grams}}{0.8333\ m^3} = 420{,}000\ g/m^3$

To dilute this down to 10,000 g/m^3 you should approximate by diluting 24 mls to 1 litre of water: (*to be more exact use 23.81 instead of 24*).

i.e.: $420{,}000\ g/m^3 \times \frac{24}{1000} = 10{,}080\ g/m^3$ or ~ $10{,}000/m^3$

Adding 10,000 g/m^3 coagulant to each jar:
1 ml = 10 g/m^3, 1.5 ml =15 g/m^3, 2 ml = 20 g/m^3, 2.5 ml = 25 g/m^3, 3 ml = 30 g/m^3, 3.5 ml = 35 g/m^3 PACl.

Reaction formula:
$Al_2(OH)_3Cl_3 \rightarrow Al2(OH)_3^{3+} + 3Cl^- + 3H_2O \rightarrow 2Al(OH)_3 + 3H^+ + 3Cl^-$

PACl Solution Storage
10,000 g/m^3 PAC deteriorates on storage, prepare jar test working solutions daily. For this reason, during full plant operation, some suppliers recommend that LiquiPAC be dosed **neat** to avoid this problem.

Aluminium Chlorohydrate (ACH)
The typical ACH dose in water treatment plants is around 10 - 30 g/m^3. Due to the requirement for lower doses of ACH compared to other traditional coagulants, an ideal working solution strength to use in jar testing of ACH is 10 mg/ml.

ACH has an S.G. of between 1.33 and 1.35 g/ml and has a higher charge density than most traditionally used coagulants.
To prepare an ACH stock solution, accurately measure 5 ml of ACH into 670 ml of accurately measured distilled or deionised water. This produces a stock solution of 10 mg/ml of “as supplied” ACH.

Dosing of this ACH stock solution to 1 litre raw water samples provides the following:
1 ml ACH stock solution = 10 g/m^3, 1.5 ml = 15 g/m^3, 2 ml = 20 g/m^3, 2.5 ml = 25 g/m^3 ACH, 3 ml = 30 g/m^3.
FOR “AS DELIVERED” STRENGTH, ALWAYS CHECK WITH YOUR SUPPLIER.

POLYELECTROLYTE
The typical Polyelectrolyte dose in most water treatment plants is around 0.1 g/ m3. Due to the low doses, the ideal solution strength to use in a jar test is only 100 g/ m3. Such a weak solution is often difficult to make up without the aid of a modern analytical balance. For the operator the best way to make up a 100 g/ m3 is to dilute down some Polyelectrolyte from the dosing tank.

For example:
Say you add 2 kg of Polyelectrolyte to a 1,000-litre tank.

You have a: $\frac{2000\ g}{1\ m^3}$ = 2,000 g/ m^3 solution

Then dilute 50 mls to 1 litre of water.

i.e.: $\frac{2000}{1}$ g/ m^3 x $\frac{50}{1000}$ = 100 g/ m^3

Dose 1 ml = 1 g/ m^3

Working Solution Storage

Alum solutions at 10,000 g/ m^3 are stable for at least a week and should be stored in a dark, cool place, or a refrigerator.

Liquid Alum – 10 g/L for a 1% working solution, dose 1 ml = 10 g/ m^3

PACl solution at 10,000 g/ m^3 should be prepared daily as it deteriorates on storage. For this reason, during full plant operation, some suppliers recommend that LiquiPAC be dosed **neat** to avoid this problem.

Liquid PACl – 10 g/L for a 1% working solution, dose 1 ml = 10 g/ m^3

ACH solution at 10 mg/ml should be prepared daily.
10 mg/ml ACH stock solution 1 ml = 10 g/m^3

Polyelectrolyte solution at 100 g/ m^3 should be kept no longer than two days and stored in a dark, cool place or refrigerator.

Polyelectrolyte– 1 g/L for a 0.11% solution, dose 1 ml = 1 g/ m^3

A BASIC JAR TEST METHOD

As much as possible, the jar test is a mimic of the treatment plant. As every treatment plant is different, every jar test should also be different. The operator, prior to doing a jar test, should first have calculated the delay times between each chemical addition point. For ease of explanation however, we will outline the jar test for a "typical" plant that is often encountered.

NOTE- Different flow rates will alter durations and intervals, the jar test needs to mimic these.

i.e.:	From dose point to exit of flash mixer	Varies 20 – 60 seconds.
	From coagulant dose point to polyelectrolyte dose point	Varies 2-3 mins.
	From Polyelectrolyte dosing point to entering clarifier	Varies 1 minute.
	Resident time in clarifier	Varies 1 hour.

NOTE-

The 10,000 g/ m^3 *solution strength for use in the jar test is suggested as a maximum dilution- don't go higher than 10,000 as this may cause the active product in the coagulant/s to "hydrolyse out" creating potential chemical inefficiencies, leading to inaccurate dose rates and assessment.*

1. Fill the tester jars with 1 litre of the raw water to be tested.

2. Set the jar tester speed to approximately 200 RPM. Typically, this is when there is a small vortex forming in the jars. The best results are often obtained if the vortex does NOT reach the paddle area when the stirrer is running. Also, too fast a speed could break up the flocs as they form. Too slow a speed may not mimic the plant and will not produce sufficient mixing of the coagulant. The coagulant is Alum or PAC. With a 10,000 g/ m^3 solution strength and a 1 litre jar, a 1 ml addition to the jar equals a dose of 10 g/ m^3. It is recommended that while we sometimes provide syringes, pipettes and/or micropipettes are more accurate.

While the jar tester is running, add different quantities of 10,000 g/ m^3 coagulant to each jar. i.e.: 1 ml = 10 g/ m^3, 1.5 ml =15 g/ m^3, 2 ml = 20 g/ m^3, 2.5 ml = 25 g/ m^3, 3 ml = 30 g/ m^3, 3.5 ml = 35 g/ m^3 Alum. If you are using the manually operated Simuldose rack, pre-dose the appropriate amounts into the test tube that is held in front of each jar.

3. Allow the jar tester to run for 20-30 seconds and then reduce the speed down to say 60-80 rpm for 2-3 minutes, then a slow stir of around 20 or 30 RPM.

4. Run at this slow speed to allow the coagulant only floc to develop fully. This can take up to 30 minutes, (although typically 10 to 15 minutes is common), then stop the jar tester.

5. If the floc that has developed looks even, with good water clarity, pick the jar with the best result to set the plant coagulant to. If you have underdeveloped, or pin floc repeat the test with different doses until the best result is obtained. Remember that pin floc can result from either over or under dosing.

6. Once the optimum coagulant dose has been determined the Polyelectrolyte dose can then be found. Firstly, dose the optimum coagulant dose to every jar (fresh raw water) and run at 200 RPM for 20-30 seconds (flash mixing).

7. After "flash mixing" is completed, run the stirrer at 100 rpm., add the Polyelectrolyte and continue running for another minute and then reduce to a slow speed of around 30 rpm.

Typically, expect doses around 0.05 g/ m3 to 0.2 g/ m3. Remember, 1 ml = 0.1 g/ m3.
i.e.: add 0.5 ml = 0.05 g/ m3, 1.0 ml = 0.1 g/ m3, 1.5 ml = 0.15 g/ m3, 2.0 ml = 0.2 g/ m3, 2.5 ml = 0.25 g/ m3, 3.0 ml = 0.3 g/ m3 of 100 g/ m3 stock solution.

8. Again, allow the floc to develop then stop. The best Polyelectrolyte dose will result in larger flocs than with coagulant only. Floc should be even, and the settling rate enhanced.

9. Remember, a floc particle settling in a jar is different to a floc particle "trying to settle" in an up-flow clarifier.

10. Having obtained optimum coagulant and Polyelectrolyte dosage now apply these doses back to the plant's operation.

Tapped jars

When using tapped jars, ALWAYS flush to waste through the valve prior to taking the actual sample, especially for reliable turbidity representation.
When washing the tapped jars, always flush clean water through the valve and leave valve open.

Relate Jar Test result to PLANT OPERATION

From the jar test you will have obtained two optimum dosages:
X g/m^3 of Coagulant (Alum, ACH, or PAC)
Y g/m^3 of Polyelectrolyte
To relate these doses back to the plant you will need to dose- time your dosing pumps, know the strengths of your dosing solutions and the flow rate of water through the plant.
For Example:

Assuming a plant is treating/producing 200 m^3/hr of water requiring 20 g/ m3 Alum and 0.15 g/ m3 Polyelectrolyte.
The Alum tank content is 20% by volume Alum and the Polyelectrolyte is at 0.2%.
COAGULANT

$$\text{Pump Rate} = \frac{\text{Coagulant Dose (g/m}^3\text{) x Flow rate (m}^3\text{/hr)}}{\text{Alum tank strength (g/l)}}$$

$$\text{i.e.: Pump Rate} = \frac{20\ \text{g/m}^3 \times 200\ \text{m}^3\text{/hr}}{200\ \text{g/l}}$$

$$= 20\ \text{l/hr}$$

POLYELECTROLYTE

$$\text{Pump rate} = \frac{\text{Polyelectrolyte Dose (g/l) x Flow rate (m}^3\text{/hr)}}{\text{Polyelectrolyte Tank Strength (g/l)}}$$

$$\text{i.e.: Pump Rate} = \frac{0.15\ \text{g/l} \times 200\ \text{m}^3\text{/hr}}{2\ \text{g/l}}$$

$$= 15\ \text{l/hr}$$

Remember-
The object of the jar test is to "guide" an operator in what should be the optimal direction of dose adjustment in the plant.
Whatever style of jar test procedure you decide to use, ALWAYS USE IT. Consistency is key.
If there is to be a change in the procedure, notify all others in the team that might be affected.

There are many influences that can cause anomalies in the dose train.
*If water is lifted/pumped to the flash mixer/clarifier, the pump NPSH (Net Positive Suction Head) efficiency- and pump delivery may alter when the source water level raises or lowers.
*The flow measuring sensor (or display) may have an error.
*The flow pacing of the pump to flow may not be spanned correctly.
*If a diaphragm pump is not operating in its mid-range, adjustments may not be proportional.
*Mixing of the coagulant “Day Tank” may not have been done accurately.
*Dose pump valves/diaphragm/delivery piping may be defective.

Note-
After relating the results/adjustments to the plant, be prepared adjust the final dose rate up or down in small increments as a fine-tune to accommodate any effect caused by *items above.

pH Optimisation method for the jar test.

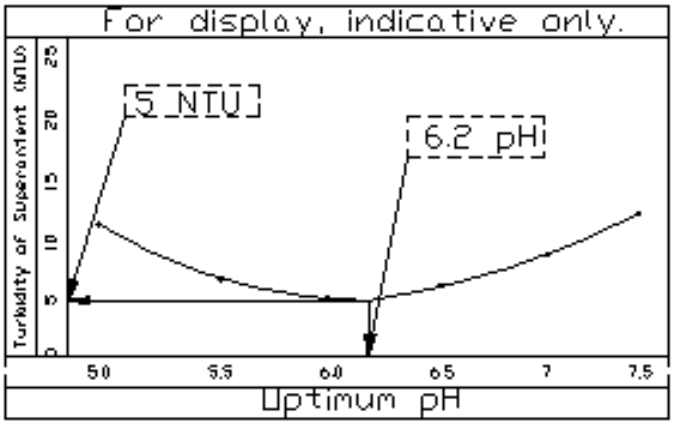
This pH optimization can guide the operator toward determining which pH the coagulant works best at -iso-electric point, (no current flowing across the molecules). If there is doubt as to whether say 4 drops or 6 drops works best, retry with 4, 5, and 6 drops. Bear in mind, it may be that the extra drop works better.

Approximation of pH drop using 1 Mol HCl into tap water with pH of 7.6:
1 drop of 1 M HCL = pH 7.0
2 drops of 1 M HCL = pH 6.6
3 drops of 1 M HCL = pH 6.3
4 drops of 1 M HCL = pH 6.2
5 drops of 1 M HCL = pH 6.0
6 drops of 1 M HCL = pH 5.7
7 drops of 1 M HCL = pH 4.9

Fill all the jars with raw water sample.
While mixing at 100 to 150 rpm., adjust pH of the jars while mixing using HCl (1 Mol) to lower pH., or NaOH/lime to raise pH: 5.0; 5.5; 6.0; 6.5; 7.0; 7.5.
For a simple, indicative indication, try adding the acid/alkali dropwise, 2, 4, 6, 8, 10 drops in successive jars- noting each jar dose rate. The pH will not be important at this stage, (the difference between jars is the important thing) selecting of a jar number “X” can be quickly replicated with a new jar dosed with X number of drops can be checked for pH.

Again, while mixing each jar at 100 to 150 rpm for 1 minute, add Coagulant dose: 5 or 10 mg/L (same dose to each jar). *This is a lower dose than normal, perhaps enhancing the difference in final product clarity between jars*. Liken this to cleaning an already clean window- it’s difficult to see the “before and after difference”, so, differentiating between slightly murky and murky would be easier.

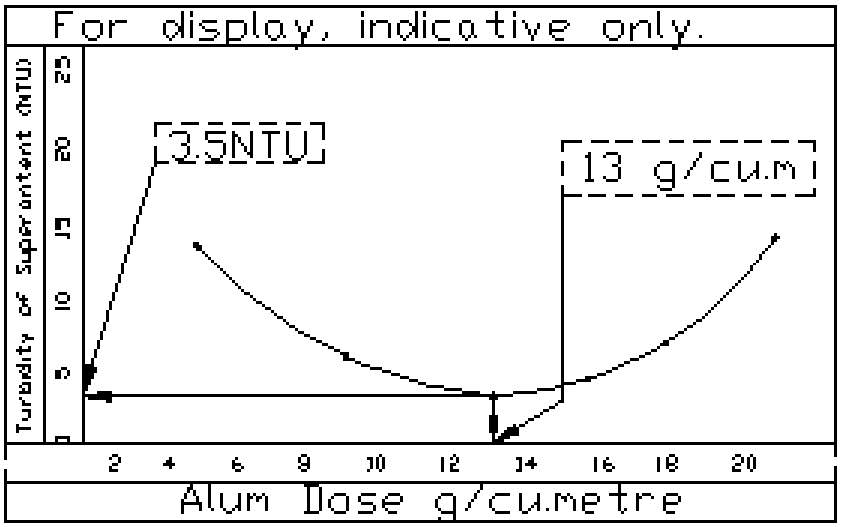
Reduce the stirring speed to 25 to 30 rpm and continue mixing for 15 to 20 minutes.
This slower mixing speed helps promote floc formation by gently enhancing particle collisions, which leads to larger flocs.
Turn off the mixers and allow flocs to settle for approximately 30 minutes.
Measure the final residual turbidity in each jar.



Plot residual turbidity against pH.

Optimum for this sample is pH 6.2, (*example only*).
This doesn't provide an acceptable final water; it's designed to prove the optimum pH.

Optimum Coagulant Dose
Repeat all the previous steps, this time mixing H_2SO_4 or NaOH/lime, adjust pH of all jars at optimum (6.3 found from first test).
Add different doses of the selected coagulant (aluminium sulphate or ferric chloride etc) to each jar (Coagulant dose: to suit current coagulant usage is a good place to start, current dose applied somewhere nearer the centre of the jar layout on the stirrer.
Rapid mix each jar at 100 to 150 rpm for 1 minute. The rapid mix helps to disperse the coagulant throughout each container.
Reduce the stirring speed to 25 to 30 rpm for 15 to 20 mins.
Turn off the mixers and allow flocs to settle for 30 to 45 mins.
Then measure the final residual turbidity in each jar.
Plot residual turbidity against coagulant dose.



The coagulant dose with the lowest residual turbidity will be the optimum coagulant dose.

G Value Calculations. G Value and Water Treatment

Boltac has included G Value in the discussion because temperature changes in the water creates differences in how well mixing occurs. The paddle/jar dimensions in the Infinity stirrer are the same as all other Boltac stirrers, results from other Boltac stirrers will be comparable to the results from any other Boltac stirrer!
To obtain an approximate G Value for a particular powered mixer **Use G = $\sqrt{P/\mu Vol}$**

Where G is G Value (in units per second).
Power is watts rating of mixer drive.
μ is viscosity (water 1.3 x 10^{-3} N.s/m^2) at 20^0 C.
Volume is the mixing chamber volume in M^3.

Note
Do not use total kW of drive for calculation, try 85% to accommodate drive losses through motor/gear/belt drives.

Illustration of temperature effect on water viscosity

Below is a photograph of two stirrer paddles running at precisely the same speed in clean water at different temperature.

*The photo on the left clearly shows the vortex reaching down almost to the top edge of the paddle in the jar with water at ambient temperature.
*The right photo, although not so clear due to misting of the jar containing the “iced water” shows the vortex reaching down to 100 mls of volume above the top edge of the paddle.

Summary Product Description

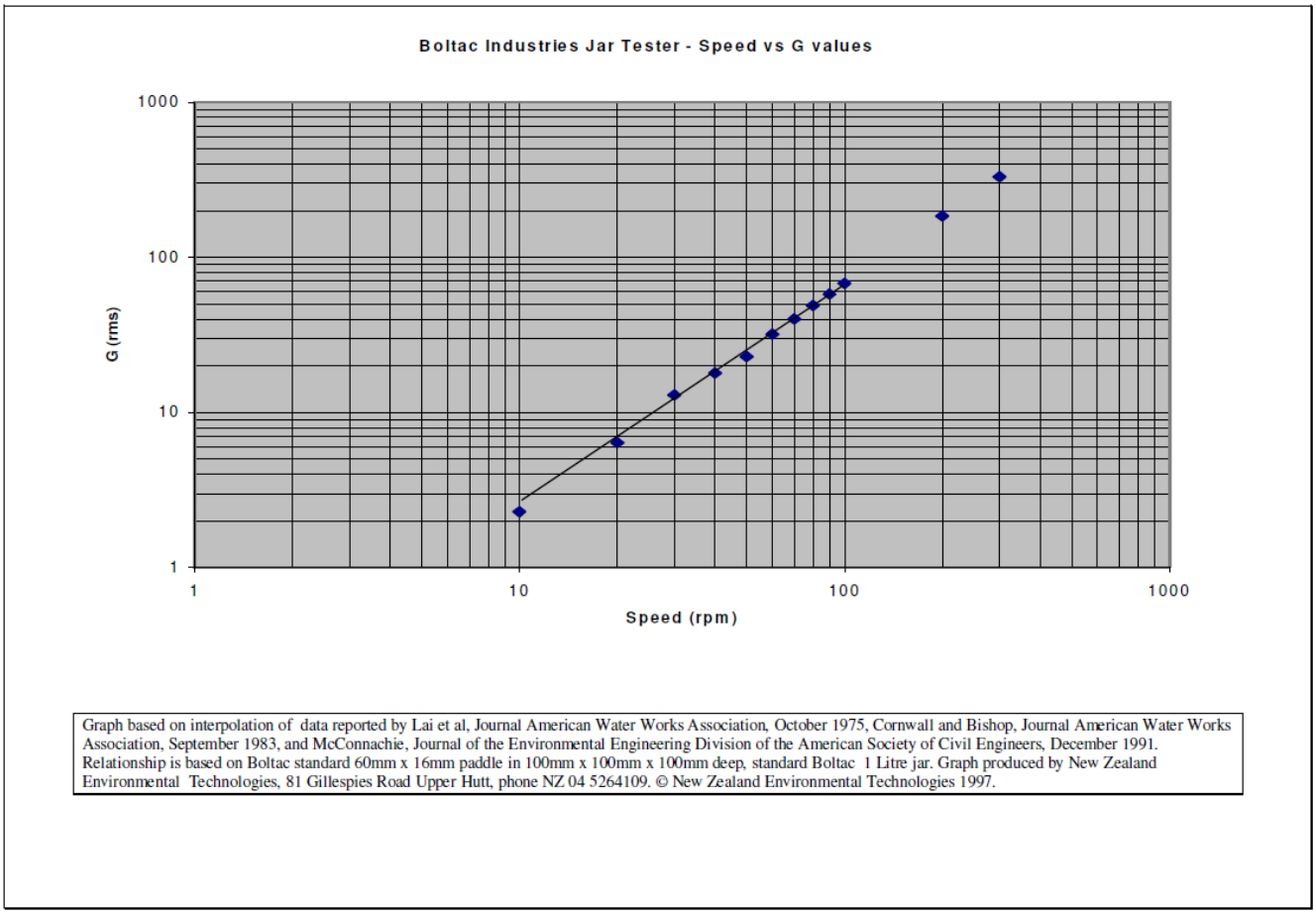
The Boltac JarStar3 FS Series stirrer has been developed in relation to, and follows the very successful JarStar, JarStar*II,* Infinity, and JarMaster stirrers. Used to simulate the process by which water is treated via coagulation and flocculation. The JarStar3 has all the control features of its predecessor, the JarStar*II* but with the added advantage of improved control, Blue Tooth 5, and the ability to alter lighting intensity for improved viewing of the jar contents.

The addition of both primary and secondary coagulants and coagulant aids can be simulated in the Boltac machines, (otherwise known as a Jar Stirrer or Jar Tester, or alternatively as a Floc Tester).
Knowing how to relate the results of a jar test back to the plant operation is the key to success. An example of the jar test method is located within this manual. This example can be adapted to suit your needs.

The process being simulated is normally taking place in underground pipes, flash mixers, vast settling tanks or clarifiers, in which millions of litres could be in process at one time, this process often taking hours to complete.

Once proficient, an operator can gain accurate results using 4 to 6 litres per test. Depending on the design of the process being simulated, the jar test can show results in as little as **15 to 20 minutes**, compared to hours when monitoring the actual process.

G Value chart at 20 degrees C



Graph based on interpolation of data reported by Lai et al, Journal American Water Works Association, October 1975, Cornwall and Bishop, Journal American Water Works Association, September 1983, and McConnachie, Journal of the Environmental Engineering Division of the American Society of Civil Engineers, December 1991. Relationship is based on Boltac standard 60mm x 16mm paddle in 100mm x 100mm x 100mm deep, standard Boltac 1 Litre jar. Graph produced by New Zealand Environmental Technologies, 81 Gillespies Road Upper Hutt, phone NZ 04 5264109. © New Zealand Environmental Technologies 1997.

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