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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with the jar test and its application to the coagulation, floculation and sedimentation processes, and the chemical precipitation process. Included are objectives, an instructor guide, student handouts, and transparency masters. A video tape is also available from the author. This module considers the purpose and principles of the jar test, preparation of reagents, coagulation test, softening test, variation of stir speeds and application of results. (Author/RH)

JAR TEST

Training Module 5.230.2.77

Prepared for the

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by

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September, 1977

Module No.:

Module Title:
Jar Test

Submodule Title:

Approx. Time:
3 hours

Topic:
Summary

Instructional Objective:

Upon completion of this module the participant should be able to:

1. List the purposes and principles for various jar tests.
2. Perform and interpret the results of the coagulation jar test.
3. Perform and interpret the results of the jar test for water softening.

Instructional Aids:

Transparencies JA1 - JA3

Surface water analysis videotape.

Instructional Approach:

Lecture, discussion, videotape viewing, laboratory practice.

References:

AWWA, "Simplified Procedures for Water Examination." 1964. pp. 42-48

Class Assignments:

Module No:	Module Title: Jar Test
	Submodule Title:
Approx. Time: 0.5 hours	Topic: Purpose

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Describe in general how jar tests can be used in calculate the amount of chemicals needed for water treatment.
2. List five factors which can affect the coagulation process.
3. List three types of chemicals which can be evaluated by jar tests.

Instructional Aids:

Transparency JA1 - factors affecting coagulation

Instructional Approach:

Lecture/discussion

References:

Simplified Procedures, p.42.

Class Assignments:

Module No: Ja	Topic: Purpose of Jar Test

Instructor Notes:	Instructor Outline:
Transparency Ja-1 Factor affecting coagulation	1. Jar test used as a small scale plant set up to determine chemical and physical factors affecting precipitation treatment 2. Factors affecting coagulation a. alkalinity b. pH c. amount of coagulant d. stirring rate e. stirring time f. nature of coagulant g. temperature 3. Chemicals evaluated a. coagulant b. coagulant aids c. softening chemicals

Module No:	Module Title: Jar Test
	Submodule Title:
Approx. Time: 0.5 hours	Topic: Principles of Jar Tests

Instructional Objective:

Upon completion of this module the participant will be able to:

1. Describe the apparatus used in the jar test.
2. Describe in general how a jar test works.
3. Describe in general how to set up a jar test.

Instructional Aids:

Surface water analysis videotape.

Instructional Approach:

Lecture, discussion, videotape viewing.

References:

Simplified Procedures, p. 42-45.

Class Assignments:

Module No: Ja	Topic: Principles of Jar Tests

Instructor Notes:	Instructor Outline:
Surface water video tape	1. Show second to last section of video tape answer questions 2. Apparatus: a. stirrer b. beakers c. flock illuminator 3. Jar test works by approximating actual working conditions 4. In general a. fill beakers with sample b. add dosing solution c. stir d. observe settling

Module No:	Module Title: Jar Test
	Submodule Title:
Approx. Time: 0.5 hours	Topic: Preparation of Reagents

Instructional Objective:

Upon completion of this module the participant should be able to prepare the following reagents:

1. Coagulant dosing solution.
2. Activated silica dosing solution.
3. Activated carbon dosing solution.

Instructional Aids:

Transparency JA2- Reagent preparation

Instructional Approach:

Laboratory practice

References:

Simplified Procedures, p.44.

Class Assignments:

Module No:- Ja	Topic: Preparation of Reagents
Instructor Notes:	Instructor Outline:

Transparency Ja-2
Reagent Preparation

1. Student should prepare solutions as follows in the laboratory:

   Coagulant dosing solution:
   Use in stock plant coagulant mixture or:
   a. 10 g dissolved or suspended in 1 liter H_2O - shake well

      $FeSO_4$, $Fe_2(SO_4)_3$ or $Al_2(SO_4)_3$-$14H_2O$

   b. .1 ml is a dosage of 1 mg per liter

2. Silica dosing solution
   a. 348.4 g sodium silicate dissolved in 500 ml H_2O, dilute to 1 liter

   b. 66.0 g $(NH_4)_2 SO_4$ in 980 ml H_2O

   c. add 10 ml solution a., 20 ml H_2O in 100 ml graduate, mix

   d. add 10 ml b. to c., mix

   e. dilute to 100 ml, mix

   f. 0.1 ml equal 1 mg/liter

3. Activated carbon
   a. 1 g activated carbon to 1 lH_2O shake before use
   b. each ml equals 1 mg/l

Module No:	Module Title: Jar Test
	Submodule Title:
Approx. Time: 0.5 hours	Topic: Coagulation Test

Instructional Objective:

Upon completion of this module, the participant should be able to:

1. Set up samples for the coagulation jar test.
2. Dose a series of samples with coagulant.
3. Run the jar test in a standard way.
4. Identify poor, fair, good, and excellent coagulation.

Instructional Aids:

Instructional Approach:

Laboratory practice

References:

Simplified Procedures, p.44-45.

Class Assignments:

Module No: Ja	Topic: Coagulation Test

Instructor Notes:	Instructor Outline:

1. To set up for test place 1000 ml water sample in each of 6-1500 ml beakers by pouring back-and-forth between beaker and graduated cylinder. Place beakers on machine.

2. Add a series of doses depending on experience of coagulant from poor to excellent coagulation.

3. Run test.
   a. lower paddles
   b. 1 min stir at 80 rpm
   c. 15 min stir at 30 rpm
   d. record order of appearance and time of pinpoint flock

4. Stop machine
   a. allow settling for 5, 15, 30, 60 min.
   b. identify results as good, fair or excellent
   c. identify proper dosage beaker which uses least amount of dosing solution, bring down turbidity

Module No:

Module Title:
Jar Test

Submodule Title:

Approx. Time:
0.5 hours

Topic:
Softening Test

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Set up samples for the jar test for softening treatment.
2. Calculate the amount of dosing solution needed from hardness and alkalinity data.
3. Properly withdraw samples for further testing.

Instructional Aids:

Instructional Approach:
Laboratory practice

References:

Simplified Procedures, pp. 45-47.

Class Assignments:

Module No: Ja	Topic: Softening test
Instructor Notes:	Instructor Outline:

1. From results of other modules or artificial data determine chemical requirements, (lime, soda ash)
   a. set up beakers with 1000 ml water sample each
   b. stir at 30 rpm

2. Add correctly calculated amount of chemicals stir 30 min.

3. Withdraw sample for further testing to determine if hardness has been reduced.

Module No:	Module Title: Jar test
	Submodule Title:
Approx. Time: 0.5 hours	Topic: Variation of stir speeds

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Evaluate the results of the jar test and determine the optimum stir rate based on the variation of stir speeds.
2. Set up and perform the Jar Test to evaluate different stir speeds.

Instructional Aids:

Instructional Approach:

Laboratory practice

References:

Simplified procedures, p.45

Class Assignments:

Module No: Ja	Topic: Jar test variation of stir speed
Instructor Notes:	Instructor Outline:
Use chemical dosage determined in previous practice and vary speed	1. Explain how jar test can be used under uptimum conditions to evaluate stir speed. 2. as laboratory practice, set up and run Jar Test at Different Stir speeds.

Module No:

Module Title:

Jar Test

Submodule Title:

Approx. Time:

0.5 hours

Topic:

Application

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Describe other variations of the jar test which can be used to determine optimum operating conditions.
2. Calculate the amount of chemcial needed in a plant operation from the results of a jar test.

Instructional Aids:

Transparency JA3 - Determination of optimum dosage.

Instructional Approach:

Lecture/discussion

References:

Simplified Procedures, p. 47-48.

Class Assignments:

Module No: Ja	Topic: Application

Instructor Notes:	Instructor Outline:
Transparency JA3 Determination of optimum dosage.	1. Other tests: a. vary stirring rate b. optimum amount of carbon needed to remove odor c. vary stirring time d. vary settling period e. comparison of coagulants f. check the efficiency of softening reaction 2. Given dosage needed for 1 liter of solution multiply by capacity of plant in liter, divide by 1 million to determine Kg of chemical needed for efficient operation

Exam Questions

Jar Test
Purpose

1. What property of a suspension is tested in the jar test?

2. Name two factors affecting coagulation rate.

3. The following types of chemicals can be tested with the jar test: softening chemicals, coagulants, and coagulant _____.

Principles of Jar Tests

4. What is a "flock illuminator" used for?

5. True or False: The jar test simulates actual working conditions.

6. List the four general steps in a jar test.

Preparation of Reagents

7. Name one chemical which can be used as a coagulant.

8. The silica dosing solution is prepared from _____.

9. Calculate the concentration in mg/ml of an activated carbon suspension prepared by dissolving 1.0g carbon in one liter of water.

Coagulation test

10. What size beakers should be used if the sample size is 1000 ml?

11. Dosages should range in expected results from _____ to _____.

12. True or False: An initial fast stir, should be run before the standard stir-rate is utilized.

13. The proper dosage is determined from the dosage of the sample which requires the minimum/maximum(choose one) amount of chemicals.

Softening Test

14. What is the correct stir rate for the softening analysis jar test?

15. A sample to be tested for softening contains 10 mg/l non-carbonate hardness and 10 mg/l Bicarbonate hardness. The soda ash factor is 1.06 for non-carbonate hardness. The lime factor is 0.56 for bicarbonate hardness. Calculate the amount of soda ash and lime required in one liter to reduce the hardness to 1 mg/l for both non-carbonate and bicarbonate hardness.

16. Following precipitation, what tests are run on the supernatant to determine the success of softening?

Application

17. Name one other condition other than dosage which can be varied in

the determination of optimum operating conditions.

18. The jar test indicated that 100 mg of coagulant was required for proper coagulation of one liter. How much coagulant should be added for operation of a one million liter plant?

JAR TEST EQUIPMENT LIST

1. coagulant powder - mixture as commonly used in water treatment plants.
2. 5 - 1 liter volumetric flasks
3. distilled water
4. balance
5. 6 - 1500 ml beakers
6. stirring machine
7. floc illuminator
8. pure lime: CaO
9. 1, 2, 5, 10, 50 ml graduated pipets
10. hardness test kit
11. alkalinity test kit
12. pH meter
13. filter apparatus

Jar Test

Laboratory Procedure

I. Preparation of solutions
   A. Obtain all equipment needed as listed in "equipment" hand-out.
   B. Coagulant dosing solution
      Stock standard - 0.1 mg/ml. Add 10g coagulant to a 1ℓ volumetric flask. Dilute to the mark with distilled water.

II. Set up for test
   A. Put 1000 ml sample in each of six 1500 ml beakers on the stirring machine.
   B. Add a series of volumes coagulant to each beaker (your instructor will advise dosages depending on experience).
   C. Stir for 1 minute at 60 R.P.M.
   D. Stir for 15 minutes at 30 R.P.M.

III. Observation
   A. Observe the moment of appearance of "pinpoint" floc. for each beaker.
   B. Determine the optimum dosage for the minimum dosage which eliminates the turbidity.

IV. Softening analysis
   A. To 1000 ml distilled add the following number of grams of pure lime: 0.56 x bicarbonate alkalinity plus 1.27 x Free CO_2 plus 2.31 times the magnesium content. Mix well. 1 ml of this dosing solution should remove all the hardness.
   B. Test the hardness of the water sample.
   C. Add 0.5, 1.0, 1.1, 1.2, 1.5, 2.0 ml dosing solution to each of the 6 - 1000 ml samples to be tested in 1500 ml beakers.
   D. Stir for 30 minutes at 30 R.P.M.
   E. Allow to stand and remove and filter super natant.
   F. Test for hardness in each sample. Choose the dosing solution which gives the hardness desired in the finished water.

V. Calculation of dosage needed in plant
   A. Coagulant dosage
      Multiply the ml needed for clarification in jar test by 0.1. Multiply this number by 8.34 and by the million gallon capacity of the plant to determine pounds coagulant required.
   B. Softening
      Multiply grams lime needed in doing solution by ml dosing solution needed to achieve the hardness desired. Multiply by 8.34 and by the million gallon capacity of the plant to determine pounds pure lime required.

Data Sheet for Jar Test

Sample number _____

I. Coagulant

Beaker	I	II	III	IV	V	VI
ml Coagulant added						
Time for flock (min)						
turbidity eliminated						

Plant capacity (million gallons) _____
ml needed to just bring down turbidity _____
pounds needed in plant
= capacity x ml x mg x 8.34 = _____ lbs.

II. Softening

Grams lime per liter (mg/ml dosing solution)
= 1.27 x Free CO_2 + 0.56 x (bicarbalk + 2.31 x Mg^{++} = _____ (mg/ml dose)

Initial hardness _____
Desired hardness _____

Beaker	I	II	III	IV	V	VI
final hardness						
ml dose	0.5	1	1.1	1.2	1.5	2.0

Plant capacity (million gallons) _____
ml needed to achieve desired hardness _____ ml
mg 1 ml dosing solution _____ mg
pounds needed for plant
= capacity x ml x mg x 8.34 = _____ lbs.

Comments:

Analyst _____ Date _____

TRANSPARENCY JA1

Factors Affecting Coagulation

1. Alkalinity
2. pH
3. Amount of Coagulant
4. Stirring Rate
5. Stirring time
6. Nature of coagulant
7. Temperature

TRANSPARENCY JA2

Reagent Preparation

Dosing Solutions

I. Coagulant
   A. 10 g dissolved or suspended in 1 liter H_2O; shake well. $FeSO_4$, $Al_2(SO_4)_3 \cdot 14H_2O$.
   B. 0.1 ml is a dosage of 1 mg/liter.

II. Silica dosage solution
   A. 348.4g sodium silicate dissolved in 500 ml H_2O, dilute to 1 liter.
   B. 66.0g $(NH_4)_2SO_4$ in 980 ml H_2O.
   C. Add 10 ml solution A, 20ml H_2O to 100 ml graduated cylinder, mix.
   D. Add 10 ml B to C, mix.
   E. Dilute to 100 ml, mix.
   F. 0.1 ml equals 1 mg/l.

III. Activated Carbon
   A. 1g activated carbon suspended in 1 liter H_2O. Shake before use.
   B. Each ml equals 1mg/liter.

TRANSPARENCY JA3

Determination of Optimum Dosage

To calculate optimum dosage fo plant use:

A. From Jar test determine lowest number of ml dosing solution required to bring down the turbidity.

B. Multiply this number of ml by mg/l equivalent of 1 ml solution.

C. Convert gallon volume capacity of plant to liters (1 gallon=3.78l; multiply gallons by 3.78.)

D. Multiply liter capacity by mg chemical in "B"; divide by 1 million to obtain kg chemical.

E. Divide Kg chemical by 0.453 to obtain pounds.

F. Or: Multiply the number in "B" by 8.34 and the plant capacity in millions of gallons.