

Chapter IV

EXPERIMENTAL TESTS AND APPARATUS

These in water works consist of routine and jar tests. These routine tests normally include pH, alkalinity, hardness, turbidity and residual iron.

4.1 Jar Tests

4.1.1 Purpose of Test

One of the objectives of a water treatment plant is to produce a finished water which is clear and colorless, and, therefore, of an appearance and taste acceptable to the consumer.

Surface waters generally contain suspended matter called turbidity which varies in size and amount. When an untreated turbid water is applied alone to a rapid sand filter, only a portion of the dirt will be removed. Turbidity removal is improved by adding a coagulant to the water, mixing rapidly for a brief interval, stirring slowly for a longer period, and then settling for an even longer time.

The jar tests are designed to show the nature and extent of the chemical treatment which will prove effective in the plant. Many of the chemicals added to a water supply can be evaluated on a laboratory scale by means of jar tests. Among the most important of these chemicals are coagulants, coagulant aids, softening chemicals, and activated carbon for taste and odor removal.

4.1.2 Apparatus

4.1.2.1. A stirring machine with six paddles, capable of operation at variable speeds (from 0 to 100 revolutions per minute). Multiple stirring units like that illustrated in Fig.4.1.

4.1.2.2. Beakers, 1,000-ml, can be used with stirring machines.

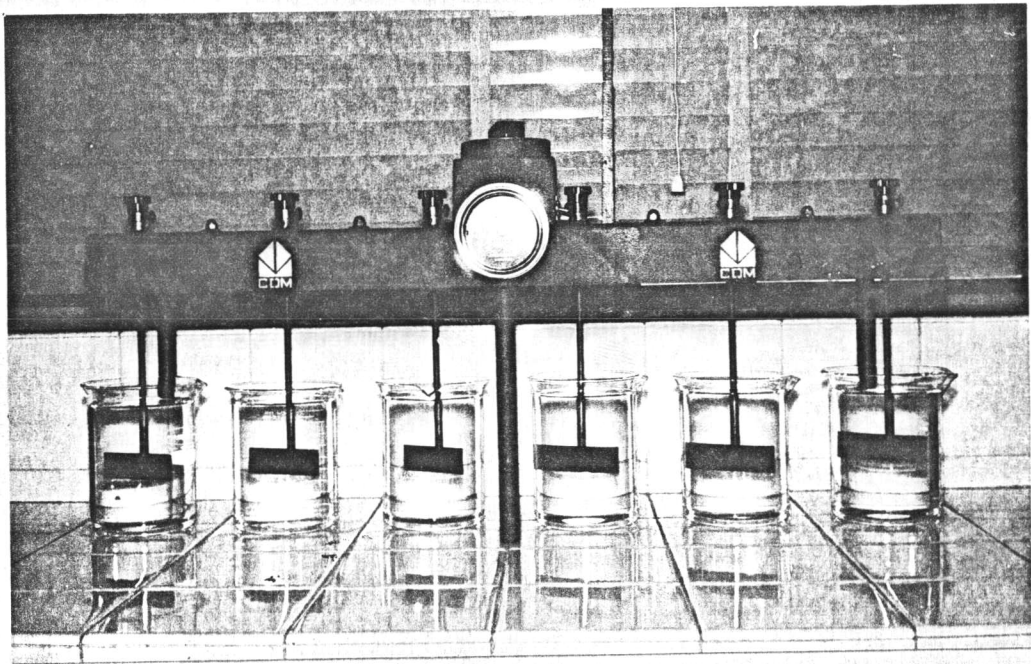


FIGURE 4.1 STIRRER FOR JAR TEST

- 4.1.2.3 A plastic pail, with a capacity in excess of 2 gallons, for collecting the sample.
- 4.1.2.4 A 1,000-ml graduated cylinder, to be used for measuring samples.
- 4.1.2.5 Measuring pipets, 1, 5 and 10 ml, all graduated in 0.1 ml steps, for dosing samples rapidly with coagulant, and other necessary solutions. Rinse these pipets thoroughly with tap water or distilled water to prevent caking with coagulant, or other solutions being used.
- 4.1.2.6 Apparatus for determining turbidity, pH, alkalinity, hardness, and iron residual.

4.2 pH Value

4.2.1 Purpose of Test

The pH scale denotes the intensity of acidity and alkalinity. The pH scale runs from 0 to 14. A water having a pH of 7.0 is at the midpoint of the scale and is considered neutral. Such a water is neither alkaline nor acidic. A water containing an acid will yield a pH reading below 7.0. The stronger the intensity of the acidity, the lower the pH will be. A pH of 0 means that the sample is very acid. The opposite holds true with alkalis. Alkalis raise the pH values above 7.0. A pH of 14 means that the sample is intensely alkaline.

pH plays an important role in such treatment processes as coagulation, softening, and corrosion control. The pH test enables the plant operator to detect changes in the raw and finished-water quality, and accordingly to add the proper chemical doses for the best coagulation and softening reactions. The finished water of some plants is adjusted with lime or soda ash to the slightly alkaline pH of 8 or more for the purpose of minimizing corrosion in the distribution system.

4.2.2 pH Determination

There are two methods for determining the hydrogenion

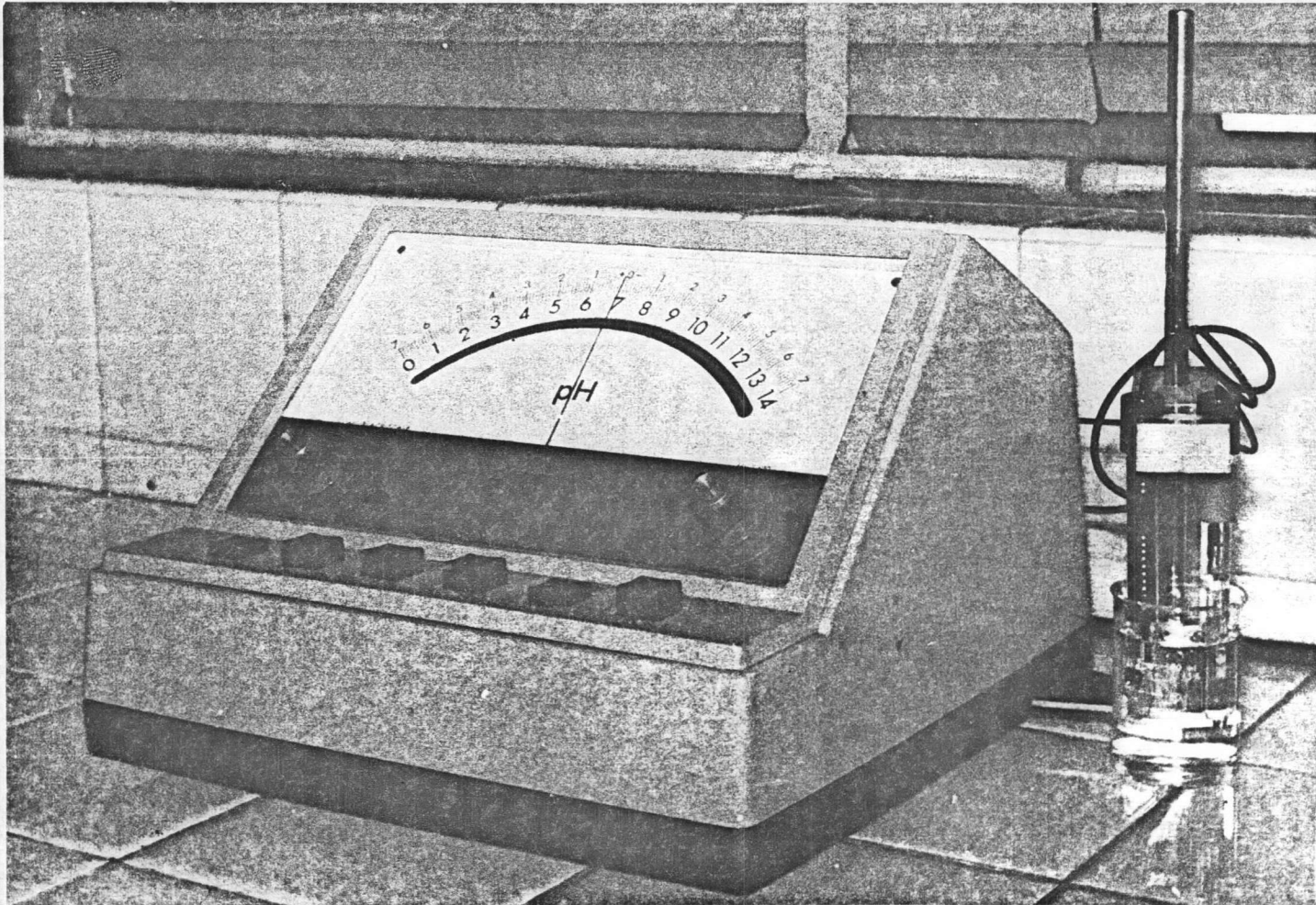


FIGURE 4.2 ELECTROMETRIC DETERMINATION OF pH VALUE

concentration or the pH value :

- (1) The electrometric method.
- (2) The colorimetric method.

As far as the experiment in this thesis is concerned, the electrometric method, which is more convenient than the colorimetric method, was used. Fig.4.2 shows the pH meter used in this study.

The electrodes when placed in a water solution develop an electrical potential that is proportional to the hydrogen ion concentration. The potential is amplified and balanced against a standard potential through a complicated system of electron tubes and a sensitive potentiometer. The balancing voltage is read directly in terms of pH value.

4.3 Turbidity

4.3.1 Purpose of Test

Water supplies obtained from rivers usually require chemical flocculation because of high turbidity. Turbidity measurements are used to determine the effectiveness of the treatment produced with different chemicals and the dosages needed. Thus they aid in selection of the most effective and economical chemical to use. Such information is necessary to design facilities for feeding the chemicals and for their storage.

Turbidity measurements help to gauge the amount of chemicals needed from day to day in the operation of treatment works. Measurement of turbidity in settled water prior to filtration is useful in controlling chemical dosages so as to prevent excessive loading of rapid sand filters. Finally, turbidity measurement of the filtered water are needed to check on faulty filter operation.

4.3.2 Turbidity Determination

Turbidity values may range from essentially zero in pure water to several thousand in highly turbid rivers; consequently no one method of measurement is applicable to all samples. Determination of turbidity

should generally be performed in the laboratory and in the field.

Three types of turbidimeters are frequently used.

- (1) Jackson Turbidimeter.
- (2) Baylis Turbidimeter.
- (3) Hellige Turbidimeter.



The Jackson turbidimeter is the standard instrument for measuring turbidity. It consists of three essential parts: a calibrated glass tube, a holder, and a candle. Details of its construction and operation are given in "Standard Methods". With the tube in place over the lighted candle, portions of the sample are added until the **outline** of the candle flame is no longer discernible. Readings in terms of turbidity are then made directly from the calibrated tube. A series of readings should be taken on each sample to obtain reliable results until the operator becomes highly proficient in its use.

The Jackson turbidimeter is considered a rather crude instrument in this day of modern instrumentation. Attempts are being made to replace it by a standard instrument with greater ease of operation and less dependence on the human eye (SAWYER and McCARTY).

The Baylis turbidimeter of St. Louis type of turbidimeter is designed to measure extremely low turbidity such as occur in the effluents of rapid sand filters.

The Baylis turbidimeter is enclosed in a galvanized iron box. There are two glass tubes at one end of the box, one tube contains a standard solution of known turbidity and the other is filled with the water to be tested. The contents of the tubes are viewed from above. Light inside the box is furnished by a 250 watt bulb. Different tubes contain standard solution and are tried until the standard solution that is nearest to the sample is found.

The Hellige turbidimeter is the accurate instrument for measuring the turbidity of water.

The instrument is particularly efficient in measuring low turbidity ranges, even to fractions of 1 part per million silica, for which no other method of measurement is available. Turbidities as low as 0.05 p p m. can readily be detected. By utilizing the various tubes

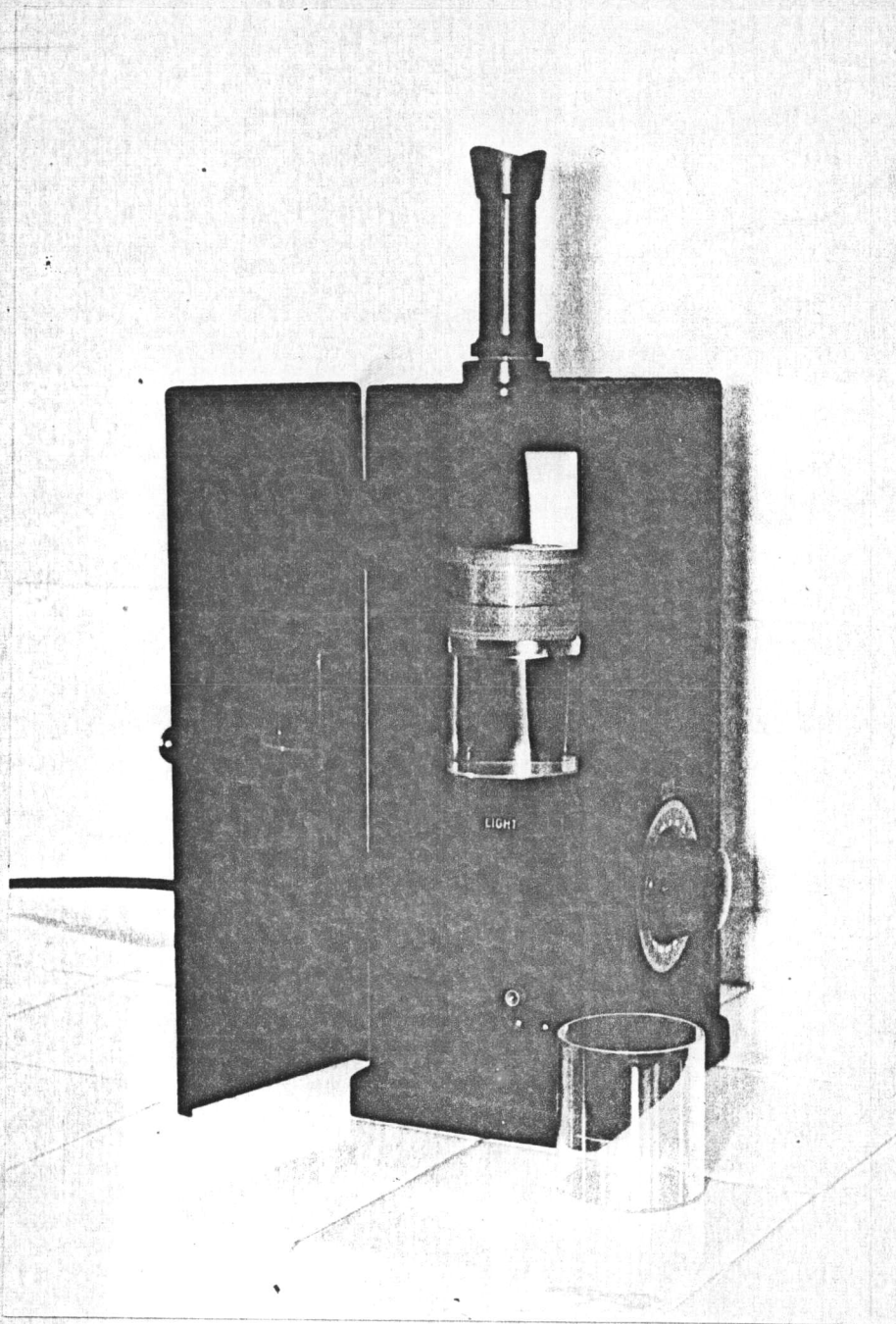


FIGURE 4.3 HELLIGE TURBIDIMETER

and light filters furnished with the instrument, the complete turbidity scale from 0 to 150 p.p.m. SiO_2 can be accurately measured. Higher values are determined by diluting the sample with turbidity-free water.

The easy, 3-step operating procedure enables completely untrained personnel to make accurate and rapid tests with confidence. First, the tube is filled with sample to be tested, covered with the glass plunger, and placed in the instrument. Second, the dial at the side of the instrument is turned until the field seen in the eyepiece becomes uniform. Third, the value indicated on the dial is read and the turbidity content of the sample being tested is determined directly from one of the charts furnished with the instrument.

The sturdy construction of the Hellige Turbidimeter assures long and dependable service. The metal housing with heavy cast iron base measures 6 x 7 x 16 inches and is finished in crystal black. Mounted in the housing are an opal glass bulb, vitreous enameled reflector, and a precision slit which is regulated by a large, graduated dial. A platform in the front compartment supports a special apertured-mirror and the specimen tube. A frame with two glass light filters is held under the platform, and an opal glass reflector is located below. The sensitivity and range of the turbidimeter are greatly increased by the light filters, and long, cumbersome tubes are not needed. An ocular with lens and diaphragm is mounted at the top of the apparatus. In order to facilitate comparisons in the presence of extraneous light, the ocular is furnished with a shield designed to fit the curvature of the eye. A dark room or shaded area is never required.

The glass plunger furnished with the instrument automatically adjusts the liquid in the tubes to the exact height so that careful filling is unnecessary. In addition, perfectly uniform observation field, free from distortion and shadow, are assured by the polished plane surfaces of the plunger and the plano-parallel bottom plates of the tubes (HELLIGE CATALOG No.62 a).

4.4 Alkalinity

4.4.1 Purpose of Test

Many of the chemicals used in treating water can cause a change in its alkalinity, but the most pronounced changes are caused by coagulants and by the softening chemicals, lime and soda ash (sodium carbonate). This alkalinity test is intended to provide results for use in calculating the chemical dosages needed in the coagulation and softening processes.

4.4.2 Alkalinity Determination

In order to distinguish between the kinds of alkalinity present in a sample and to determine the quantities of each, a titration is made with 0.02 N H_2SO_4 using phenolphthalein and methyl-orange as indicators. Phenolphthalein gives a pink color only in the presence of hydroxide or normal carbonate. Methyl-orange is yellow in the presence of all types of alkalinity. The quantities of alkalinity may be determined from the results of acid titrations. If the results of titration of a 100-ml. sample with 0.02 N H_2SO_4 are substituted in the correct condition and the results multiplied by 10, the values obtained will be in parts per million (ppm.) of the specific alkalinity in terms of $CaCO_3$ (alkalinity is usually expressed in terms of $CaCO_3$). The factor 10 is used because 1 ml. of 0.02 N sulfuric acid is equal to 1 mg. of $CaCO_3$. If a 100 ml. sample is used, 1 ml. of acid would present 1 mg. of $CaCO_3$ per 100 ml., or 10 mg. per liter (10 ppm.), (STANDARD METHODS 1965).

4.5 Hardness

4.5.1 Purpose of Test

Hardness of a water is an important consideration in determining the suitability of a water for domestic and industrial uses. The engineer uses it as a basis for recommending the need for softening processes. The relative amounts of calcium and magnesium hardness and of carbonate and noncarbonate hardness present in a water are factors in determining

the most economical type of softening process to use, and become important considerations in design. Determinations of hardness serve as a basis for routine control of softening processes.

4.5.2 Hardness Determination

To determine the values of hardness, a titration is made with standard EDTA using Buffer solution and Eriochrome Black T as an indicator. Using 100-ml. of sample and after EDTA has been added, the solution will turn from wine red to blue. This is the endpoint of the titration. The quantities of the hardness may be determined from the results of standard EDTA titrations are multiplied by 10, the values obtained will be in parts per million (ppm.) in terms of CaCO_3 (STANDARD METHODS 1965).

4.6 Iron

4.6.1 Purpose of Test

Removal treatment is undertaken on those water supplies where iron causes color, staining, bacterial, and taste and odor problems in the distribution system. Iron coagulants may be added in water treatment for the removal of turbidity. In such cases, significant amounts of iron in the finished water indicate that an incorrect coagulant dosage is being applied. A knowledge of the total iron content of a water is adequate for most purposes.

This method is designed to measure the total iron that is normally present in water or that may be introduced as a result of treatment with iron coagulants.

4.6.2 Iron Determination

There are many methods of determining iron that have been developed. Some of them is Hellige Color Disc Method. By color disc No. 611-35. The procedure as follows :

1. Place 100 ml of the water to be tested in an Erlenmeyer flask.

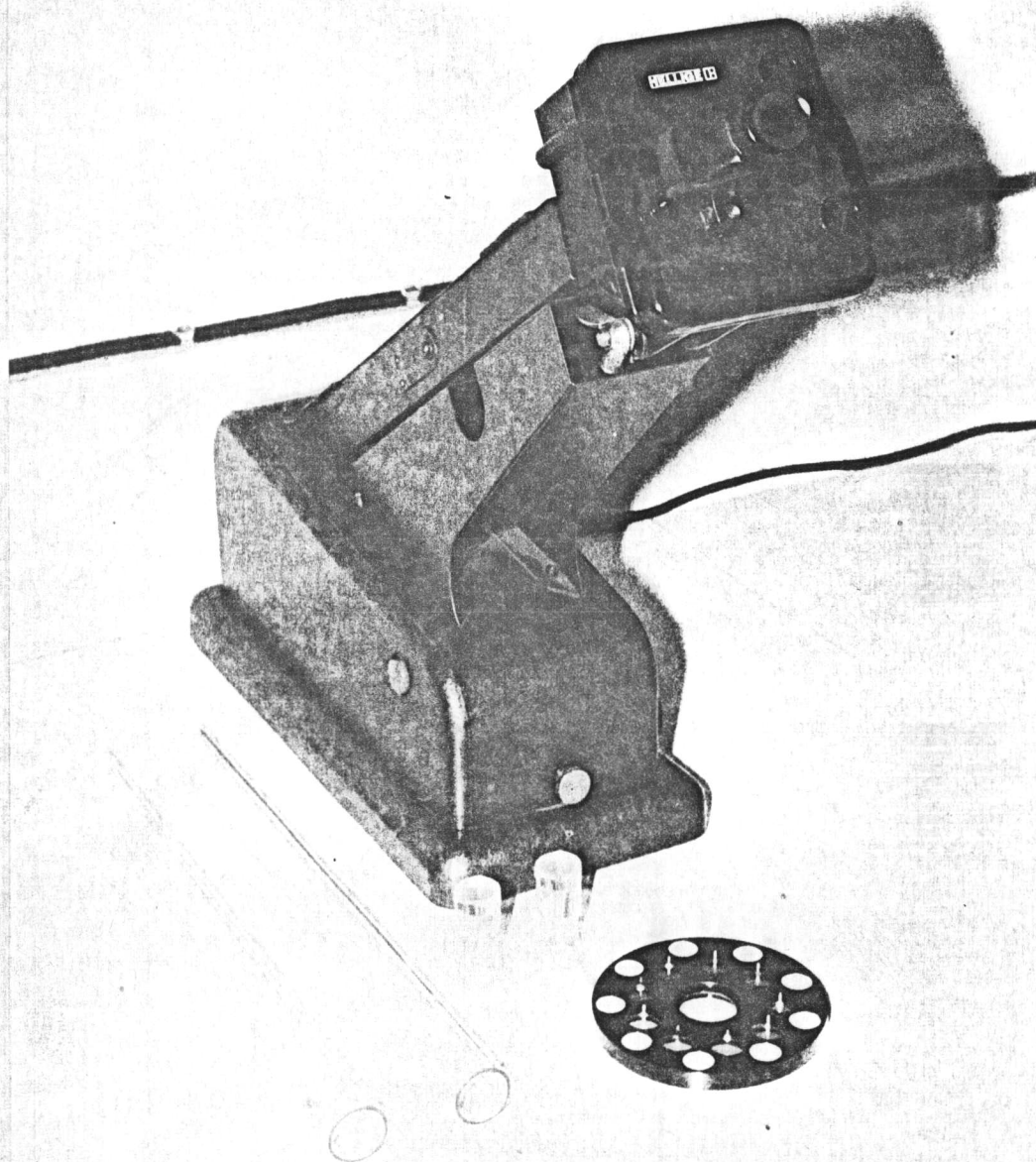


FIGURE 4.4 HELLIGE COLOR DISC FOR DETERMINATION OF IRON

2. Add 10 ml of 6N hydrochloric acid.
3. Add 0.2N potassium permanganate, dropwise until a faint pink color persists for a few minutes.
4. Boil until the volume is slightly less than 100 ml.
5. Cool to room temperature and add another drop of potassium permanganate solution.
6. Dilute to exactly 100 ml with distilled water. Add exactly 10 ml of potassium thiocyanate reagent, and mix.
7. Make the color comparison within 10 minutes, as follows:
 - 7.1 Fill a 200 mm Nessler tube to the mark with the treated sample, insert a glass plunger, and place the tube on the right-hand opening of the stage.
 - 7.2 Fill another Nessler tube to the mark with distilled water, insert a glass plunger, and place on the left-hand opening of the stage. Close the cover. The second tube is used for optical compensation.
 - 7.3 Remove the color disc until a color match is obtained or until the unknown value can be estimated by the interpolation between two of the glass standards.
 - 7.4 The color disc directly in parts per million of iron in the range from 0-3.0 ppm. Fe, but other ranges are easily obtained by altering the quantity or dilution of the sample and multiplying the reading accordingly (HELIGE).

4.7 Test Procedure

Samples of river water were treated at a given dose of ferrous sulphate in liter beakers, rapidly mixed by stirring with a rod and then agitated with mechanical stirrer as noted. pH value was determined upon completion of agitation and sample allowed to settle for 15 minutes. Determination were usually made for every 0.5 pH value.

4.7.1 Test Procedure for Coagulation Treatment

The procedure used in the Jar tests is as follows :

1. Fill a series of beakers with 1-liter of raw water into each.
2. Place all the beakers containing the measured 1-liter samples on the stirring machine.
3. With a measuring pipet, add increasing doses of coagulant solution as rapidly as possible. Select a series of doses so that the first beaker will represent undertreatment and the last beaker will represent overtreatment. Then a proper series is set up, the succession of beakers will show poor, medium, fair, good and excellent coagulation at the end of the run.
4. Lower the stirring paddles into the beakers, start the stirring machine, and operate it for 5 minutes at a speed of 60 to 80 revolutions per minute.
5. Note the appearance of first floc.
6. After 5 minutes reduce the stirring speed to 30 revolutions per minute, and continue stirring at that speed for 25 minutes.
7. Observe each beaker for the appearance of floc and record.
8. Lift the stirring paddles and leave to stand.
9. Using a glass tube immediately siphon off 2.5 cm. (1 in.) of water (A).
10. After 5 minutes siphon off a further 1 in. of water (B).
11. After 15 minutes siphon off a further 1 in. of water (C).
12. Compare the turbidity of A, B, and C.

$$12.1 \text{ Turbidity reduct ratio after 5 minutes} = \frac{A-B}{A}$$

$$12.2 \text{ Turbidity reduction ratio after 15 minutes} = \frac{A-C}{A}$$

13. The pH value, alkalinity, hardness and also residual iron with influenced coagulation were noted in order to check the condition of water.

4.8 Preparation of The Jar Tests.

4.8.1 Coagulant Coagulants were prepared as follows :

Weight 10.0 grams of ferrous sulphate dissolved in 1 liter of distilled water. This preparations gave a solution of such concentration that 1 cc. was equivalent to 10 ppm. or 10 ml./liter (AWWA M.12 1964).

4.8.2 Lime Solution

Weight 10.0 grams of lime were added to 1 liter of distilled water and the mixture boiled for about 15 minutes to expel the carbon dioxide and then cooled to room temperature and filtered. The clear saturated lime water contained about 1.6 grams per 1,000 cc. The solution was kept in a well stopped bottle to prevent precipitation upon standing (AWWA M.12 1964).

4.9 Procedure in Determination of Amount of Ferrous Sulphate for Various Turbidity

The procedure for these tests was the same as in the previous teste. There was only one difference in these latter tests. Very fine clay were added to the raw water samples before being treated by ferrous sulphate.

Test No 12 to 22 was made to determine the amount of ferrous sulphate needed to remove the turbidity for various ranges caused by clay from Pathum Thanee which added.

The procedure was as follows :

- 4.9.1 Collect about 15 liters of raw water and added the fine clay sample. After mixed sample leave it for $1\frac{1}{2}$ hours.
- 4.9.2 The turbidity of the mixture should be read by the use of a Hellige Turbidimeter.
- 4.9.3 Using lime solution in raising pH to about 11.
- 4.9.4 Run coagulation tests with ferrous sulphate as a coagulant.