

SOME ASPECTS OF CHLORINATION CONTROL IN CHICAGO.

ARTHUR E. GORMAN, CHIEF SANITARY ENGINEER, DEPARTMENT OF PUBLIC WORKS, CITY OF CHICAGO.

Read before the Medicine and Public Health Section of the Illinois State Academy of Science, Joliet, Ill., April 30, 1927.

In Chicago as chlorination is the first and only line of defense against a more or less dangerously contaminated public water supply, unusually rigid supervision is maintained over this and other measures directed toward safeguarding the water. Chicago conditions are not only different from those in other cities, because of the limited time available for treatment, but also the magnitude of the chlorination program is quite beyond that of most public water supplies on account of the quantity of water which is pumped. Because of these conditions much has been done, particularly during the last three years, towards improving and standardizing chlorination control work.

The water supply of the City of Chicago is obtained from Lake Michigan through six intake cribs located along the lake front from two to four miles from shore. The water taken in through the intakes passes down through a shaft to a tunnel, which conducts it to a suction well under each of the ten pumping stations, from which it is pumped directly into the distribution system. The chlorine used for disinfection is applied to the water in the suction well at the pumping station. The average daily pumpage for the entire city during 1926 was 878 million gallons. The average quantity of chlorine used for disinfection was 3.56 pounds per million gallons.

There are three fundamentals in connection with the chlorination of Chicago's water supply which are given careful attention:

1. The chlorine must be applied uniformly and continuously to the water pumped.
2. There must be good diffusion of the chlorine solution in the water being treated.
3. The quantity of chlorine applied must be adequate for positive disinfection.

To assure uniform and continuous application of chlorine to the water the City of Chicago employs a corps of 35 chlorine attendants whose duty is to attend to the operation of the chlorinating equipment and to make the necessary control tests. During each of the three eight-hour shifts at the ten pumping stations a chlorine attendant is on service. It is his duty to operate the chlorinators so as to apply the prescribed quantity of chlorine in proportion to the rate of pumpage, making an hourly check on the quantity delivered by the chlorinators by determining the loss of chlorine from the batteries which are mounted on weighing scales.

The chlorinators used at the pumping stations now in operation are of the manual type, it being necessary for the attendant to make adjustments to compensate for normal variations in the rate of pumpage and those resulting from the stopping and starting of the different units. The plans for the new Western avenue pumping station, which will be put into operation this summer, call for automatic chlorinators. This type of apparatus delivers the prescribed quantity of chlorine it is set for in direct proportion to the rate of pumpage, by means of control mechanism connected to the venturi meters.

While it is highly important that there be uniformity in the rate of application of chlorine to the water from minute to minute and hour to hour, to avoid tastes due to periodic over-dosing, it is imperative that the application of chlorine be continuous. To assure uninterrupted chlorinating service Chicago has taken unusual precautions. In each pumping station there is sufficient chlorinating equipment to deliver the maximum quantity of chlorine considered necessary at the maximum rate of pumpage for that station. In addition, there is in reserve a complete duplicate set of equipment. Each group of chlorinating units is set up in a special booth with all chlorine lead lines in duplicate and inter-connected. Duplication of booths was decided upon as chlorine is a dangerous gas and in order that operation from one booth might be carried on in case of an accident in the other, making it impossible for the operator to enter. Each booth is connected with a special exhaust system for discharging chlorine gas out of doors

when necessary and any employe whose duties require him to handle chlorine has a special gas mask for emergency service. Under normal operation the City has nearly 200 per cent stand-by chlorinating equipment available for service. Although a considerable initial outlay was necessary to provide Chicago pumping stations with this chlorinating equipment, the expense was amply justified. The average cost per capita for safeguarding Chicago's water supply by chlorine is approximately five cents per year, an exceedingly low charge for health insurance.

Under Chicago conditions it is very important that the chlorine be thoroughly diffused in the water before the latter is delivered to the distribution system. This is necessary not only for effective disinfection, but to prevent excess chlorine in the water drawn into one pump with a corresponding under-dosage in the other. The depth of the suction wells in the Chicago system varies from 30 feet to over 100 feet, with usually from two to four pumps supplied by a common well. To avoid short circuiting of chlorine to one or more pumps of a group drawing on a single well it is necessary to apply this sterilizing solution at a sufficient depth in the well to assure complete diffusion before the water reaches the pump suction. Studies made in 1924 indicated quite clearly that in many instances complaints of excess chlorine in the water were due to short circuiting of this nature. Our experiments indicate that to assure complete diffusion the chlorine should be applied to a depth of at least 30 feet below the pump suction and preferably 50 feet. It is our policy to apply the chlorine at the eye of the incoming tunnel if possible, using rubber hose encased in pipe conduits attached to the shaft wall. To avoid collapsing of the solution hose due to the long down draft of the chlorine solution, they are vented near the top of the wall.

Having perfected arrangements for a uniform and continuous application of chlorine with complete diffusion in the treated water, it is, of course, necessary that the quantity of chlorine used must be adequate for efficient disinfection. Investigators differ widely in their claims for the amount of chlorine required to kill pathogenic organisms. This is partially due to the lack of definite informa-

tion concerning the action of chlorine on these organisms as well as the concentration and time necessary for sterilization. Pending more definite information on this subject those of us who are charged with the responsibility of safeguarding a public water supply must be guided by our own experiences and the results of bacteriologic examinations of samples of the chlorinated water. In Chicago at certain seasons of the year, especially late winter and early spring, the bacteriologic control is frequently interfered with by the presence in Lake Michigan of non-confirming gas formers which seriously affect the reliability of the presumptive tests for *B. coli*.

Where the bacterial contamination of the sources of supply varies widely and frequently abruptly, a correspondingly wide margin of safety must be maintained, with the result that often greater quantities of chlorine are used for disinfection than would be necessary if the bacterial load was more uniform. It is fundamental that sufficient chlorine be present in the water to satisfy the demands of organic matter that may be present lest that available for disinfection be inadequate. Since the time interval for killing pathogens by chlorine has not been established it is common practice amongst water purification engineers to carry slight quantity of chlorine in the treated water for a period of at least five minutes after application of the sterilizing agent. In Chicago we make a practice of carrying at least one pound per million gallons residual chlorine in the water as discharged from the pumping stations. Each hour throughout the day and night the chlorine attendant makes a test for free chlorine, using orthotolidin, and comparing the intensity of the color with that of known standards. In case there is excessive absorption of chlorine, as occurs not infrequently at the South Side stations following southerly winds, the operators are authorized to increase the quantity of chlorine until the specified amount of residual can be carried. This frequently requires the application of chlorine in amounts double and even triple the average. The fact that "slugs" of grossly polluted water may be received suddenly at a station makes even the hourly residual chlorine test subject to an element of uncertainty, but it is not considered practical to make these tests

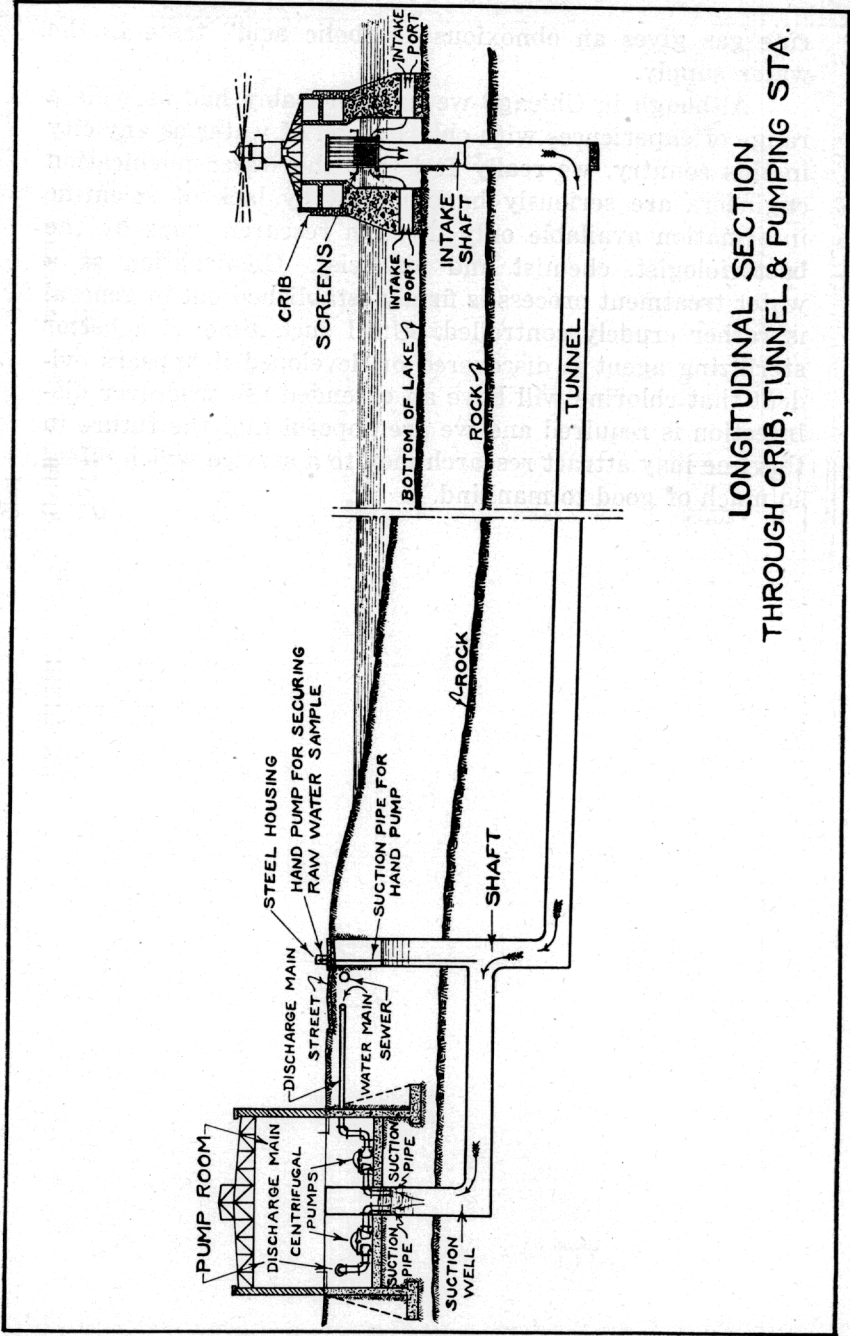
routinely at more frequent intervals. Under our present program approximately 220,000 residual chlorine tests are made at the Chicago pumping stations each year. During periods of high absorption, tests are made every 15 minutes, the operator receiving assistance at the time from other employes at the station.

The City is now arranging, through representatives of a large instrument manufacturing company, to conduct studies on apparatus which will automatically record the residual chlorine in the water at pumping stations. Equipment of this kind should supply the "missing link" in the chlorinating control of public water supplies. It does not seem beyond the realm of possibilities that this type of apparatus may even be developed to regulate the quantity of chlorine used so that a definite residual may at all times be maintained in the water supply. The successful development of such an apparatus will be a tremendous advance in the art of chlorination and should make it possible to reduce the safety margin now considered necessary where chlorination is the only treatment given a public water supply for disinfection.

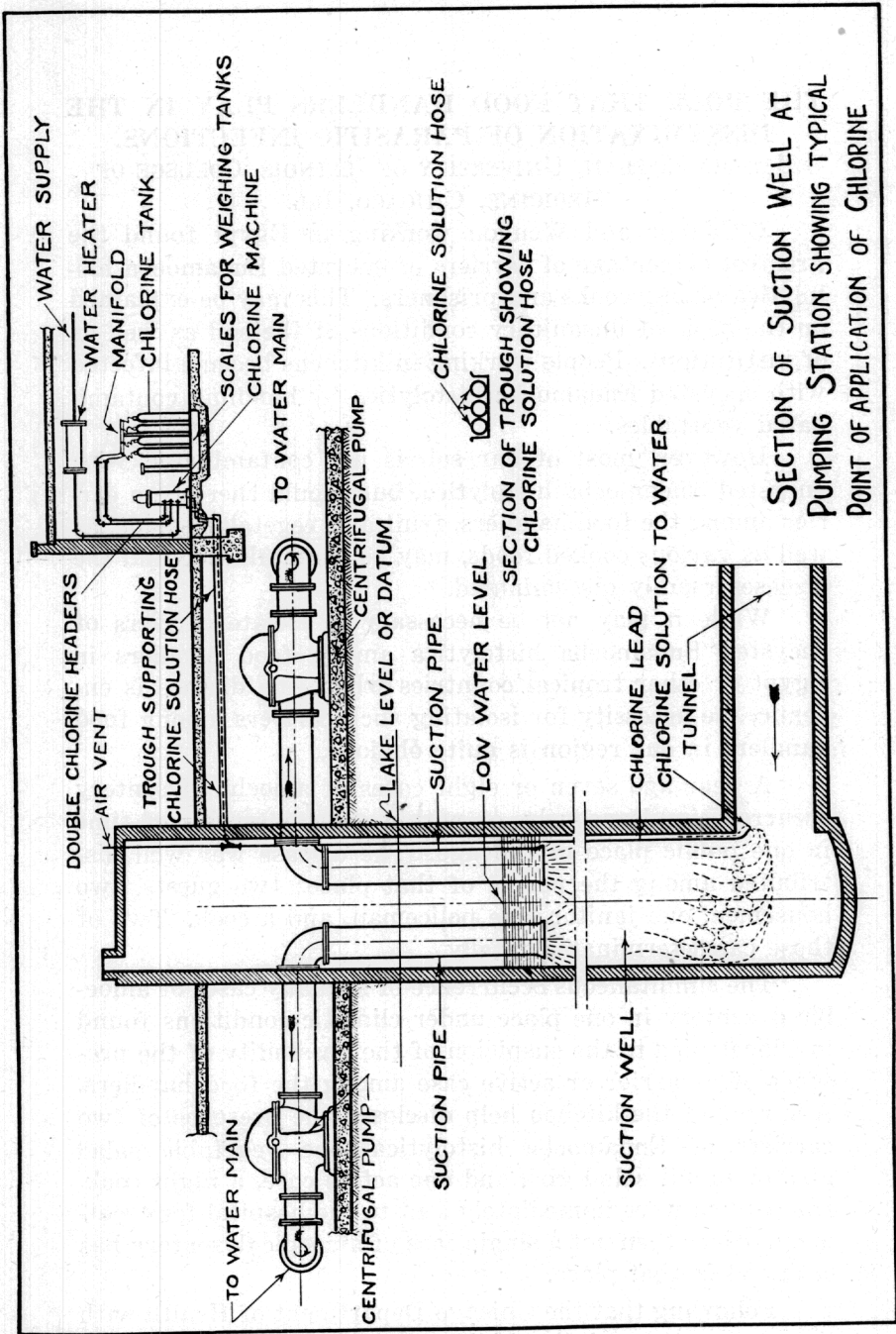
The importance of the time of contact between chlorine and water for the sterilization of pathogens is an outstanding problem under Chicago conditions where the time interval between the point of application of chlorine in the suction well and the discharge to the distribution system may vary from 16 to 90 seconds. In order to protect the first consumers supplied by mains near the pumping station it is necessary to apply larger amounts of chlorine than would be used if a short storage period were available. Our studies indicate that there is a relatively rapid absorption of chlorine in the water circulated through the distribution system. Each day tests are made at various points in the system for residual chlorine, which indicate that with few exceptions, as in the case of service mains in the vicinity of pumping stations, the quantity of free chlorine in the water is relatively small. In general, there is no serious complaint of chlorine in the Chicago water at periods when Lake Michigan is not contaminated by industrial wastes such as phenols and cresols, which combining with the chlo-

rine gas gives an obnoxious "carbolic acid" taste in the water supply.

Although in Chicago we have probably had as wide a range of experiences with chlorination of water as any city in this country, we really feel that the water purification engineers are seriously handicapped by lack of scientific information available only through research work by the bacteriologist, chemist and physicist. Chlorination as a water treatment process is firmly established but in general is rather crudely controlled. Until such time as a better sterilizing agent is discovered or developed it appears evident that chlorine will have an extended use wherever disinfection is required and we are hopeful that the future in this line may attract research men to a service which offers so much of good to mankind.



LONGITUDINAL SECTION
 THROUGH CRIB, TUNNEL & PUMPING STA.



SECTION OF SUCTION WELL AT PUMPING STATION SHOWING TYPICAL POINT OF APPLICATION OF CHLORINE