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SUMMARY

Process control applied to disinfection
An explanation is given of the functioning of "closed loop control" chlorination, which system controls the quantity of chlorine gas added to the water by 1) flow rate and 2) the residual chlorine in the water main. By this system a safe water disinfection can be reached without expensive over-chlorination. The control system must, however, be integrated with the plant hydraulics to assure a perfect mixing of the chlorine with all of the process water.

Process control applied to disinfection

Instrument companies, especially those concerned with chlorination control, are marshalling their research and development resources to provide the elements of automation neccessary for improvement of the disinfection processes.

As an example, witness the recent developments in chlorine feeding and control equipment. Starting in the early fifties, leading manufacturers abandoned the use of metal as a basis of chlorinator design and turned to newly developed plastics to provide the answers to the basic corrosion problems associated with handling of chlorine gas.

This changeover from metal to plastic immediately produced savings in initial and maintenance costs and provided greater safety to operating personnel.

The use of corrosion-resistant flexible plastic materials also permitted manufacturers to adapt standard diaphragm regulator control practices, successfully used in industry for decades, to the control of highly corrosive chlorine gas. From the engineering point of view, the time was ripe for automation of the disinfection process through the marriage of instrumentation and chlorination.

This instrument control flexibility, combined with the fact that Chlorinators, as designed, could conveniently receive two signals, led instrument companies to the concept of closed loop chlorination control.

How was the concept of closed loop control implemented? First, research years were invested in the development of residual analysis equipment that could dependably analyze and control chlorine residual on a continuous basis. Then, the closed loop system was made effective. The schematic of a closed loop chlorination control system is shown in Figure no. 1. One Chlorinator input signal controls quantity aspects of disinfection, proportioning chlorine feed to water flow rate. The other signal, induced by analysis of the chlorine residual, was then assigned to adjust this quantity signal to control the chlorine feed consistent with the quality and chlorine demand variations in the water. Its essential components are:

A water ejector which:

a. creates a vacuum for withdrawal of chlorine gas from its pressurized container,
b. mixes chlorine gas and water into a solution,
c. provides transport of this solution to the point of application, and
d. provides operational safety by virtue of the fact that it creates a vacuum.

A differential pressure regulator which, on receipt of the proportional flow signal from the flow sensing device, automatically adjusts the pressure drop acros the automatic control valve to proportion chlorine feed to water flow.
A residual chlorine analyzer which continuously analyzes the chlorinated water in the water main.
A controller, operating in conjunction with the analyzer, which forwards a control signal to the automatic control valve in the Chlorinator.
This control signal is superimposed on the proportional signal from the flow sensing device. This maintains the desired residual by adjustment of the chlorine feed to compensate for quality or chlorine demand variations of the water in the analyzed sample.

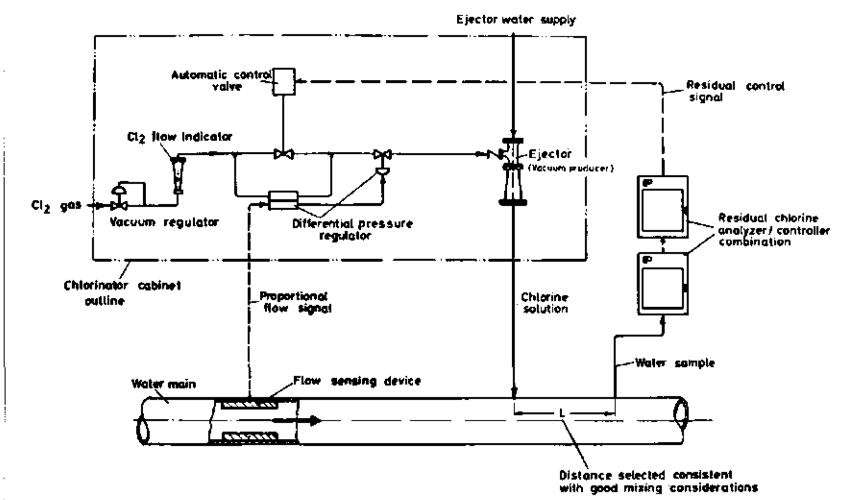
The basic aim in the design of a water treatment plant must be that disinfection be actually accomplished. A well-engineered closed loop residual chlorine control system can assure disinfection automatically without involving excessive laboratory analysis and without the danger of under-chlorination or the excessive cost of over-chlorination.

Figure 2a displays a residual reading associated with manual Chlorinator control. Over-chlorination is difficult to avoid since conscientious operators sometimes carry their levels of chlorine residual in excess of actual demand. Their attention is most probably directed toward disinfection safety — rather than toward chemical cost savings.

Figure 2b illustrates the benefit of closed loop chlorine control in a well-engineered system. Precise residual control is evidenced despite variations in water flow rate and chlorine demand. The absence of over-chlorination emphasizes the potential for chemical cost saving.

There is always the possibility that manual operation of the Chlorinator system may lean on the side of under-chlorination at the sacrifice of disinfection. In such a case, closed loop control

Fig. 1 - Closed-loop chlorination system.



will sense and correct the chlorine feed for proper disinfection.

Equipment costs are relatively modest and would seem to be insignificant compared to the benefit of assured disinfection.

Field test work in the development of closed loop chlorination control has led inescapably to the conclusion that good, sound, operable equipment per se cannot alone assure adequate disinfection. The control system must be integrated with the plant hydraulics to develop chlorine, contact facilities there will assure perfect mixing of the chlorine with all of the process water.

This is true whether we are concerned with closed pipe line, open channel, clearwell, contact tank or pump suction chlorination.

An integration of the plant hydraulics and its dosing equipment is therefore of prime consideration. Following are a number of points that, in my opinion, can be of help in designing a residual controlled chlorination system and its proper integration into the plant.

The higher the water flow rate through the Chlorinator ejector, the better the chlorine gas is mixed, and put into solution. Engineers should specify rates through ejectors to provide 1000 ppm instead of concentrations as high as 2500 ppm in the chlorine water distribution system. The tendency is to do otherwise today, by minimizing flow through the ejector to hold down pumping or water costs.

Some engineers are careless about providing adequate distribution of chlorine solution. They should endeavor to take advantage of natural points of turbulence in the system, a complex set of fittings or pumps — all of which aid the mixing process. See Figure no. 3a through e for various possibilities of chlorine distribution. I believe, common sense guides one's ideas on how to achieve good mixing.

The water flow sensing device should be closely related to the point of chlorine injection. It should not be expected that the influent plant flowmeter can furnish the proportional flow signal for the Chlorinator on the plant effluent — the flow rates at the two points can be completely out-of-phase with one another.

The sampling point for the residual chlorine analyzer should be located as close to the point of chlorine injection, being sure, however that adequate mixing has taken place before sampling. See Figure no. 1 again. If distance „L" is too short, good mixing is in question. If it is too long, the contact time may be too long resulting in control loop time lag. Control loop lag time is the time elapsed between a change in output signal from the residual controller and the observation of a change in residual on the recorder as a result of the signal change. The total time lag is composed primarily of the Chlorinator to respond to the signal change, transport time of the chlorine solution, contact time between the chlorine and the water in the water main before sampling, the sampling transport time between the sampling point and the reaction time within the analyzer itself.

Another factor associated with process control that continually presents serious problems is the oversizing of a Chlorinator to meet capacity requirements that may not develop for 10 to 15 years. In early plant operation, when the flow is perhaps only one tenth of maximum design, controls are often asked to do the impossible. This problem can be easily resolved at low cost by specification of interchangeable Chlorinator parts for both the low initial capacity and the future maximum capacity.

Improved engineering techniques and the application of instrument controls have refined the chlorination process to the point where disinfection can easily be put under automatic control. Disinfection, however, depends as much on the hydraulic process as it does on controls. The control system must be integrated with plant hydraulics to develop chlorine contact that will assure perfect mixing of the chlorine with all of the process water.

Most water treatment plants and pollution control plants are constructed for the primary purpose of disinfection and safety. Capital costs of chlorination control equipment normally amount to less than 1 percent of total construction costs. These costs are insignificant, I'm sure, if they are compared with the benefits of assured disinfection.

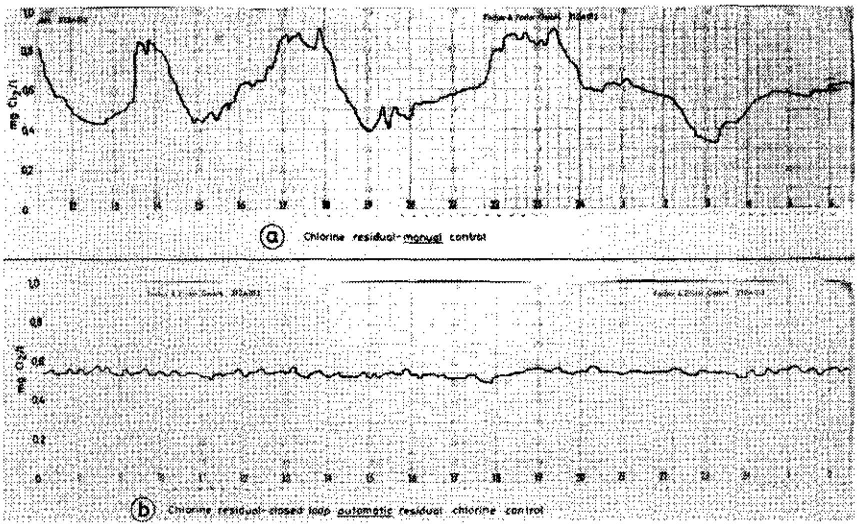


Fig. 2 - Residual chlorine values.

Fig. 3 - Suggested good mixing methods.