The treatment of swimming pool water with sodium hypochlorite

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1. INTRODUCTION

The method used to produce the correct chlorine residual in a swimming pool is, in many respects, immaterial although it is generally accepted that the long-established practice of gaseous chlorination is a satisfactory one. Over the year's equipment design has removed most major problems and, provided that properly designed instruments are used in conjunction with good operating disciplines, it is not difficult to maintain the pool water in the optimum condition.

However, the current trend away from the use of gaseous chlorine will undoubtedly produce operational uncertainties, even within the most experienced establishments. It has been said that the use of sodium hypochlorite as a chlorinating chemical is a safer alternative to that of chlorine gas; but, unless strict guidelines are followed, and reliable dosing plant used, the hazards can be regarded as at least significant. Indeed, it is sobering to realise that sodium hypochlorite was replaced by chlorine gas for disinfection applications more than half a century ago.

Sodium hypochlorite has been used very successfully, and for a long time, for chlorination of small swimming pools where a chlorine gas installation would be impracticable. Unfortunately, this use has led to the belief that the handling and dosing of the chemical is relatively simple; that it does not require special equipment or expertise. Notwithstanding this belief, experience has proved otherwise. The purpose of this booklet is to draw attention to the difficulties likely to be encountered, and to describe the requirements for a successful and trouble-free sodium hypochlorite installation.

2. WHAT IS SODIUM HYPOCHLORITE AND HOW DOES IT RELATE TO OTHER FORMS OF CHLORINE?

A basic understanding of the composition and nature of sodium hypochlorite is a prerequisite for its use. Although commonly used in small school pools, its use in municipal pools in the UK has been very rare and restricted mainly to emergency or standby use. This type of application is very different to the continuous addition of sodium hypochlorite to recycled pool water.

Sodium hypochlorite is a pale greenish-yellow liquid with the characteristic smell of bleach. The commercial product contains between 10 and 15% available chlorine which is considerably higher than the strength of conventional household bleach. Only swimming pool grade hypochlorite should be used and this is a reasonably clear solution. The percentage strength relates to the quantity of chlorine, as present in a chlorine gas cylinder, which is contained in the hypochlorite on a 'weight to weight' basis. The 15% liquor weighs 12.5 lb/gallon (1.25 kg per litre) so that each gallon contains approximately 1.8 lb of available chlorine. (a litre contains 180 g).

2.1 Manufacture

Hypochlorite is prepared by passing chlorine gas through sodium hydroxide (caustic soda) under very controlled conditions. Some free caustic soda is left, to improve stability, so that the resultant solution is caustic and requires the same handling precautions. The available chlorine contained in the liquor will be released as gas if it is acidified. One gallon of 15% hypochlorite could therefore, release to the atmosphere 1.8 lb of chlorine gas on acidification with disastrous consequences. It is essential that the precautions recommended in this booklet are observed to ensure that such an occurrence can be avoided.

2.2 Decomposition

Given satisfactory storage conditions, sodium hypochlorite decomposes slowly forming sodium chlorate and sodium chloride whilst liberating oxygen. Containers must be vented to release the oxygen. Pipes, pumps etc must be positioned to avoid gas pockets. The rate of decomposition is accelerated by heat, light, low pH, and the presence of dissolved metals. As a general rule, the more impurities contained in the sodium hypochlorite the less stable it is. Normal bulk delivery grades of sodium hypochlorite will average about 15% available chlorine, and will be less stable than weaker solutions. Branded solutions are available (at premium prices) which include stabilising agents to retard decomposition. These are usually weaker than that mentioned above and, although more stable, in the long run they are still subject to gradual decomposition due to heat, light etc.

High temperatures cause rapid decomposition of sodium hypochlorite and it is generally recommended that during the summer months, storage is limited to a period of one month. The ambient temperature must never be allowed to exceed 30"C.

The effect of sunlight is of particular importance when considering the storage of sodium hypochlorite. The liquor must not be stored in clear containers, and never in direct sunlight, since decomposition due to the effects of ultraviolet light is very rapid. The normal half-life of 15 % solution is reduced about four-fold. It is therefore essential when considering outdoor storage that vessel impervious to sunlight be used.

The pH of a solution is normally fixed during manufacture by the excess caustic soda but decomposition will be accelerated if the pH is below 11.

Metals may be picked up by the aggressive nature of the liquor when in contact with them. The liquor itself may contain iron as an impurity (from the caustic) and although this should be below the critical level, further pick-up of iron may accelerate decomposition. Therefore, hypochlorite should be stored and conveyed in non-metallic materials; copper and nickel, and their alloys, e.g. stainless steel, should never be used.

With so many factors influencing the decomposition of sodium hypochlorite it becomes clear that not only must materials of construction. Storage conditions etc be carefully chosen but allowance, preferably under automatic control must be made for the metering of an inconsistent material.

2.3 Dilution

Dilution of hypochlorite solution with tap water leads to the formation of a precipitate or sludge. This is caused by the excess caustic alkali raising the pH value of the water so that calcium carbonate forms and precipitates. Therefore, whenever possible, it is advisable to use the neat liquor. Obviously the harder the water the greater the quantity of sludge. This can be largely overcome by the addition of Calgon and some grades of chemical on the market do already contain a sequestering agent.

2.4 Alternative Forms of Hypochlorite

Sodium hypochlorite can be seen to have very different properties to elemental chlorine. However, it closely resembles solutions of the other hypochlorites e.g. calcium hypochlorite. This is available in granular or tablet form and can contain up to 65% available chlorine. These high strength hypochlorites are fairly stable, easy to handle and are mixed with water to produce hypochlorite solutions of up to 5% available chlorine. Little sludge is produced compared with say, bleaching powder, but rather more than diluted sodium hypochlorite.

There is some need for a settlement period after preparing solutions from such chemicals.

3. GROUND RULES FOR HANDLING SODIUM HYPOCHLORITE

From the preceding sections in this booklet it should now be obvious that Specific ground rules must be made, and adhered to, so that potential accidents arising from the use of sodium hypochlorite are prevented. personnel must be made aware of the hazards and the safety precautions to be observed in the handling and use of this chemical. A typical example of the sort of information which should be posted wherever hypochlorite is stored or handled is shown on the opposite page.

4, DELIVERY OF CHEMICALS TO THE POOL AND STORAGE

4.1 Sodium Hypochlorite

The majority of municipal size pools will need to obtain sodium hypochlorite in small bulk quantities of between 22O and 250 gallons. Smaller pools will probably use 10-gallon containers, whilst the largest establishments, such as major outdoor pools may need to use bulk supplies of 1 000 gallons or more.

SODIUM HYPOCHLORITE
HEALTH AND SAFETY, PROTECTION & FIRST AID

Sodium hypochlorite is very corrosive to the skin, eyes, clothing, most metals and painted surfaces. It must not be mixed with, or come into contact with, any chemical other than water. Personnel handling hypochlorite must wear chemical goggles and should wear protective clothing, rubber boots and gloves.

Splashes in the eyes must be dealt with immediately by prolonged irrigation with running water. Medical advice should be sought as soon as possible. Similarly, splashes to the skin or clothing should also be immediately washed in running water.

From the foregoing it will be obvious that facilities enabling these remedial actions to be easily accomplished should be readily available. An adjacent shower facility could be useful.

Obviously, the package size will depend upon the quantity used in a summer month. There is little point in storing more than is necessary and paying for chlorine that will be lost by decomposition. Existing establishments will need up to 0.75 gallons of sodium hypochlorite for every pound of chlorine gas previously used, making the sizing of the storage and dosing plant relatively simple. It must be remembered that one pound of chlorine in sodium hypochlorite occupies ten times the space of one pound of chlorine gas in a cylinder. Therefore, storage space must be plentiful and if carboys have to be used, it is necessary to store the empty as well as the full containers. The storage space should be dark and cool. It should be large enough to accept two month's stock (full and empty). When sodium hypochlorite solution is transferred from drums to solution storage tanks it is advisable to use a syphon pump or an electric barrel pump. Lifting and pouring from carboys is a hazardous procedure which should be avoided. Transfer pumps should be washed after use and preferably retained for use on only one liquid, being marked accordingly.

Polythene carboys containing sodium hypochlorite are sometimes specially vented and on no account should the liquid be transferred to sealed vessels. Some suppliers apply a partial vacuum to drums after filling, to allow for oxygen evolution and these should not be tightly resealed after having been opened. The storage area must be protected against vandalism. It is advisable to store the carboys in a secure area which can be flushed should any spillage occur. The drain from such an area must not be linked directly to that from any acid system. This practice will eliminate the possibility of forming chlorine gas. In the event of any spillage, copious quantities of water should be used for wash down purposes.

Intermediate storage tanks will normally be sized to hold about 350 gallons and will therefore accept a nominal 250-gallon delivery with safety: i.e. 220 to 250 gallons delivered, plus a residual 7-day usage safety margin and a 10% ullage. The intermediate storage tank must have a dipstick or other means to measure the level of hypochlorite content. It must be fitted with an overflow to drain and a vent to atmosphere. It must sit on a low plinth surrounded by a bund capable of receiving and containing the full store load of hypochlorite. The tank should be made of plastic material e.g. polythene and be purchased from a reputable manufacturer/supplier.

Where vehicular access to the site is close to the storage tank, filling is achieved via the filling lines as indicated in Fig.1. After filling, this filling line should be flushed out with water. It is very important to give detailed thought to the positioning of the storage tank. In some cases, chlorine gas bottles have been manhandled over fair distances and existing gas storage areas may not be suitable even if they are large enough. Alternative arrangements may be established whereby the hypochlorite supplier allows the use of the transit tank as a storage tank, removing an empty tank from site and replacing it with a full tank. The recoupling of lines and the return of the residual hypochlorite could be a problem in such instances. With bulk or intermediate bulk installations, it is advisable to use a day tank to supply the hypochlorite dosing pump. The day tank should hold one or two days requirement and should be connected to the bulk tank by a manually-valved plastic pipe. The valve should be installed near the bulk tank.

The use of a day tank adds several safety features to the installation, not least of which is the prevention of draining the contents of the bulk tank into the pool: remote but still a serious possibility. A daily operation to top up day tanks, encourages the operator to make a regular check on the plant and from this check confirm the consumption rate of chemicals. Experience has shown that the observance of these standards is essential.

4.2 Acid

Storage of any acid and the relevant handling facilities must be completely separate from hypochlorite facilities. Relatively small quantities of acid are used, so there is always some need for dilution. Hydrochloric acid fumes badly in the concentrated form and dilution is required for protection of plant and personnel against these very corrosive fumes. With dry acid, it is relatively simple to prepare the acid solution. Sodium bisulphate is very soluble, but solutions weaker than 10% would normally be employed. In preparing such solutions, it is absolutely essential that the dry solid is not accidentally fed into the hypochlorite day tank and in this connection, it is obvious that the acid tank and the hypochlorite tank should be appropriately colour-coded and have a bold means of identification.

The preparation of dilute hydrochloric acid should be as automatic as possible to avoid the lifting of concentrated acid drums. This can be best achieved by the use of a water-operated dilution device to transfer the concentrated acid from the carboy, dilute it with a fixed ratio of water and deliver it to the acid storage/day tank. Such a device can be fixed in a permanent position and the concentrated acid containers opened and connected to the device as desired. Personnel must be made aware of the dangers of handling concentrated acid and the preparation of diluted solutions. They should also be clearly informed about the disastrous effects of mixing acid with sodium hypochlorite. The precautions outlined for the handling of hypochlorite apply equally to acid, and must be strictly adhered to: a notice making these points in relation to acid should be similarly displayed.

5. THE IMPORTANCE OF AUTOMATIC RESIDUAL CONTROL WITH SODIUM HYPOCHLORITE INSTALLATIONS

Control of chlorine residuals in swimming pools has continued to make progress despite some early disappointments. Recent work has shown, and has been well reported [1], that the sensible application of modern plant techniques can maintain the pool residual within acceptable limits whatever the bathing load.

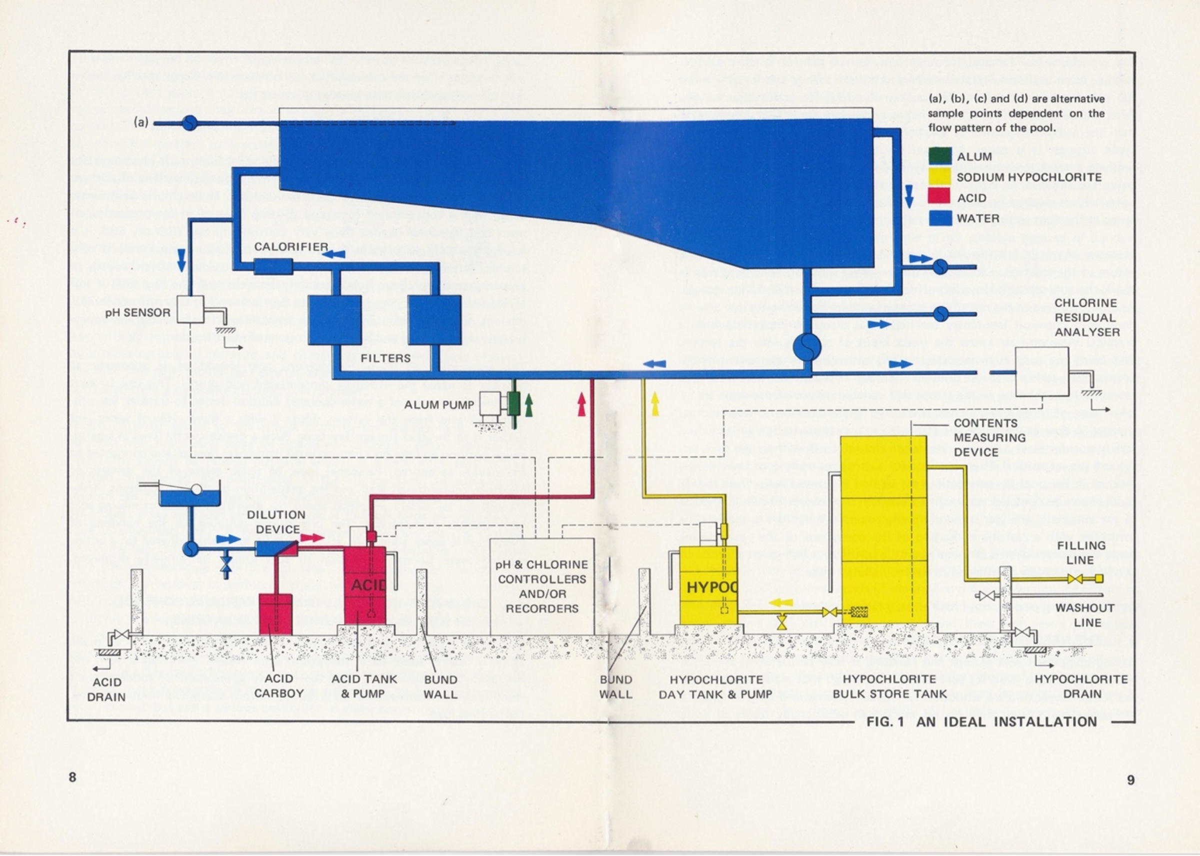

FIG. 1 AN IDEAL INSTALLATION

The arguments put forward for automatic residual control e.g. chemical cost savings, more uniformly treated water and therefore more comfortable water for swimming, are the same for sodium hypochlorite as for chlorine gas. After chlorine gas is metered, it is fed as a solution about 100 times weaker than the sodium hypochlorite solution. As the hypochlorite is relatively so much stronger it is easier, by small volumetric over or under dosing, to produce a residual which is too large or too small. Failure to recognise this point has resulted in some of the early installations overtreating the pool water with hypochlorite. Automatic residual control will maintain the dosing pump at the right setting to achieve stable residuals.

However, the main justification for automatic control rests with the variable nature of the solution - as outlined earlier. There is of course no easy way to check the strength of sodium hypochlorite either on arrival or during storage. As a rule, analysis of the chlorine content of sodium hypochlorite can only be done with chemical laboratory facilities. It is therefore impossible from a practical viewpoint to know the exact input of chlorine into the system. This being the case, it is necessary to rely on secondary assessment of the dosing plant rather than on primary metering. It is essential that these two facets of hypochlorite, i.e. the strong and variable nature of the solution, be taken care of in selecting a control scheme. There must be no large sudden changes in dose as would be the case with an on/off controller, which would add hypochlorite at a pre-set dose when the return flow from the pool fell below a pre-set residual. There is a need for a continual analysis of the chlorine residual in the pool by automatic plant so that any trend away from the set residual can be detected and rectified steadily. The choice of sampling point to the automatic analyser is therefore very important, in order to provide the controller with a realistic evaluation of the conditions of the pool. Having made the correct choice of sample point, a continuous but varied addition of hypochlorite can be maintained to the recirculated water.

Details of this type of control have already been published [2]

6. THE NEED FOR DOSING ACID

Having mentioned acid storage and handling it may be useful to know the reasons behind the need for acid dosing. It is a fact that many school pools use sodium hypochlorite without any regular systematic dosing of acid for pH correction. Often, they do no more than occasionally resort to some simple method of hand dosing a pH corrective. There are very sound reasons why these irregular and imprecise methods must be avoided in large pools. Not the least of these is the danger associated with the addition of strong acid direct to the pool and the subsequent possibility of producing local low pH conditions.

When chlorine gas is used, the acidity of the chlorine is corrected and the pH maintained by the use of soda ash, dolomitic media or sodium bicarbonate. The alkalinity of the hypochlorite must similarly be corrected when it is added to a continuously recycled system and hydrochloric acid or sodium bisulphate (dry acid) can be used. Sulphuric acid is not suitable because of handling difficulties. Sulphamic acid should not be used because of its interference with free residual chlorination. If there is a choice to be made, bearing in mind the storage difficulties, from a water treatment point-of-view it would be best to use hydrochloric acid. An increase of sulphates in the pool water may be detrimental to concrete.

Just as alum increases the quantity of soda ash required on gas chlorinated pools. it will decrease the quantity of acid required on hypochlorinated pools. It may seem at first glance that acid dosing is not really important but the symptoms caused by high pH values are not always appreciated. Conventionally, effort is made to keep the pH value up and failure to achieve this leads to the well-known symptoms of eye irritation and corrosion. However, the normal recommendation that the pH should be kept between 7.6 and 7.8 if possible and certainly between 7.4 and 8 infers both a maximum and a minimum. The maximum is designed to prevent the formation of cloudy water, scale and diminished bacterial kill.

It is well known that a pool should contain a free chlorine residual of about 1.5 mg/litre with an absolute minimum of 0.5 mg/litre. Bacteria and viruses succumb rapidly to these levels of chlorine and cross infection, to all intents and purposes, is virtually non-existent. Many pools have less than perfect water mixing and distribution patterns and these high levels of residual ensure penetration and disinfection in still areas. Furthermore. residuals of this kind assist in maintaining the filter in a clean condition. As the pH value of the water rises, the disinfecting action of the chlorine falls. If residuals are kept to the normal levels, then the pH value must be maintained below 8. It takes roughly five times the quantity of free chlorine to achieve the same rate of kill for the test organism E. coli as the pH rises from 7 to 8.5. Similarly, polio virus requires three times as much at the higher pH value. Poor bacteriological counts and therefore adverse public health reports have been received on waters seemingly adequately chlorinated but with a high pH value.

Unfortunately, it is not possible to predict the precise amount of acid that will be required for a particular pool. The amount will depend on the quantity of alum used and this will be contingent upon the bathing load and rate of filter back-washing. Less acid will be required in soft water areas than where the water is hard. More will be needed if calcium hypochlorite is used. Obviously, with sodium hypochlorite, the acid is mainly added to neutralise the free caustic but it is not possible to add the acid at a fixed ratio to the hypochlorite as with the soda/chlorine gas system. In practice, the ratio may range from about 1 : 10 to 1 : 50 by volume (concentrated acid : 15% sodium hypochlorite.) In extreme cases, with soft water and low bathing loads, even less acid may be needed. Where dry acid (sodium bisulphate) is used, a dilute solution, say, 5 to 10% is prepared and is dosed in the same way as the hydrochloric acid.

By far the most common problem with sodium hypochlorite is the formation of cloudy water and/or scale where hard or medium hard waters are treated. Operators of the large UK pools are generally well aware of the need to keep the water in chemical equilibrium and carry out regular checks on pH and alkalinity to maintain that equilibrium. As the pH rises (and the pH at which cloudiness occurs will vary) the calcium salts in the water will precipitate: either slowly to build up scale within the pipework, calorifiers, tiles etc; or quickly, to produce a milky precipitate. The first reaction will reduce plant efficiency and can lead to expensive maintenance. It can also produce a rough surface on tiles which can abrade skin and look unpleasant. Obviously cloudy water will normally clear after a turnover period, but if the pH is too high and the water hard, cloudiness could be reintroduced after a backwash if sufficient fresh make-up water has to be added.

It is obvious that some form of pH control is probably more important with hypochlorite than with chlorine gas. If this control can be automatic, then the water will retain a stable optimum pH value and the problems outlined above will not be experienced. Certainly, it is desirable to use electronic methods of pH determination. Automatic pH indication/recording or control is very desirable.

7, THE PROBLEMS RELATING TO INCORRECTLY- DESIGNED
DOSING EOUIPMENT

It has been suggested that in changing over from chlorine gas to hypochlorite 'any pump will do for the hypochlorite and the acid can be hand-dosed'. Early experiences have proved otherwise, and it is thought pertinent to point out the main potential pitfalls.

The primary problem is the sizing of the hypochlorite dosing pump: it is essential that the pump be sized correctly for the particular application. ln general, chemical dosing pumps have a limited operating range compared to the gas metering units - about 6:1 for pumps compared with 20: l for gas units - which could create problems in accurate control of feed rates. Whilst it is desirable to operate a dosing pump at the higher end of its range, from the system point of view it is necessary to retain the higher end of the range to cater for abnormal conditions. It sometimes becomes necessary to increase the chlorine dose beyond the normal level to provide for algal control and shock dosing during closed periods. It is therefore necessary to extend the basic range of the pump. One method of increasing this range is to use a Variable Duration impulse Timer wired in series with the pump. Under control of this timer the pump motor is interrupted for a percentage of a given time span. The percentage is variable and can be controlled automatically by a Chlorine Residual Controller. The device effectively extends the operating range of the pump to 50:1, or even more. ln terms of chemical dosing the intermittent addition of chemical is well suited to circulating water systems and on a short time scale, it has the same effect as continuous dosing.

Secondly, consideration must be given to the actual design of the pump. Obviously, it must have all the features necessary for continuous duty with aggressive chemicals; it should be of the positive displacement type, for control and accuracy; and it ought to include the facility for varying the applied dose while the pump is running. Diaphragm pumps are ideal for this application _ they have the accuracy and controllability required and can be produced from materials compatible with the chemicals being dosed. Diaphragm pumps are glandless and therefore avoid the problems associated with plunger type pumps used with sodium hypochlorite. peristaltic pumps and drip feed arrangements are not recommended for this type of duty.

The third criterium is the installation of the pump relative to supply source and injection point – this is of paramount importance. The following points should ensure satisfactory operation.

1. Locate the pump as close as possible to the supply container whilst allowing sufficient room for operation and maintenance work to be carried out.

2. Mount the pump and day tank assembly, securely on a firm level plinth.

3. Keep associated pipework simple and well supported it should be as short and direct as possible with the minimum of bends.

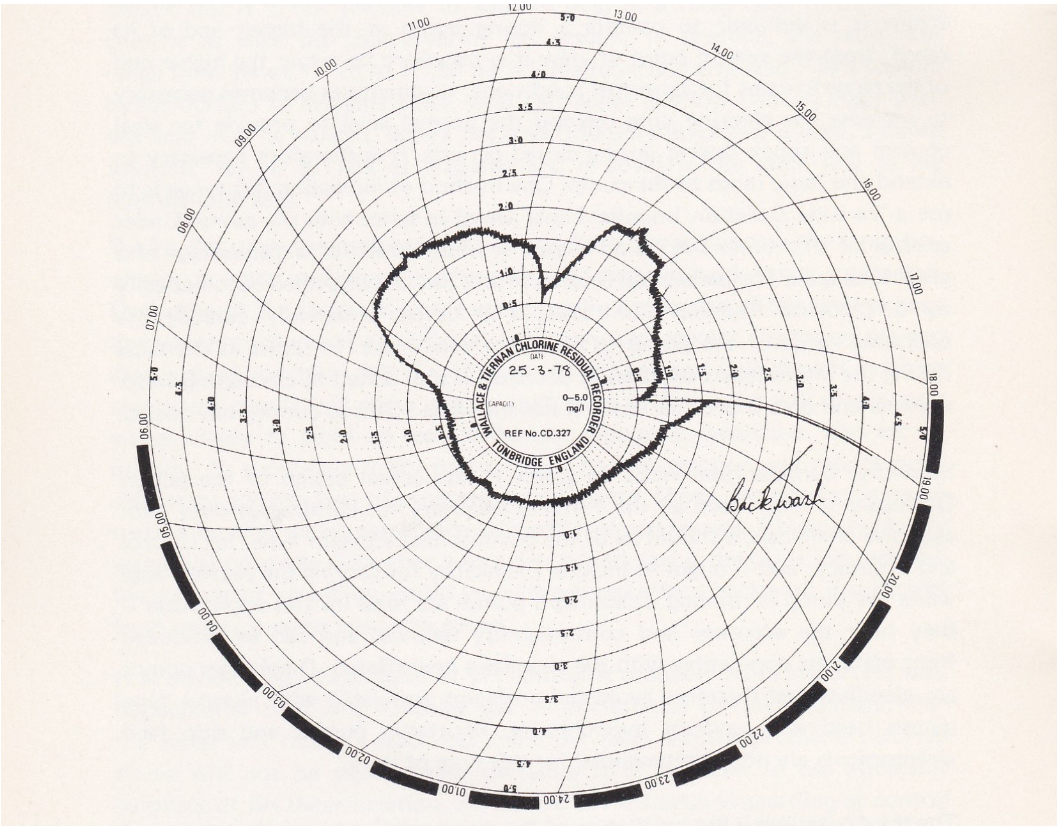

Fig.2 Typical 24-hour chart for a Municipal pool under Manual Control

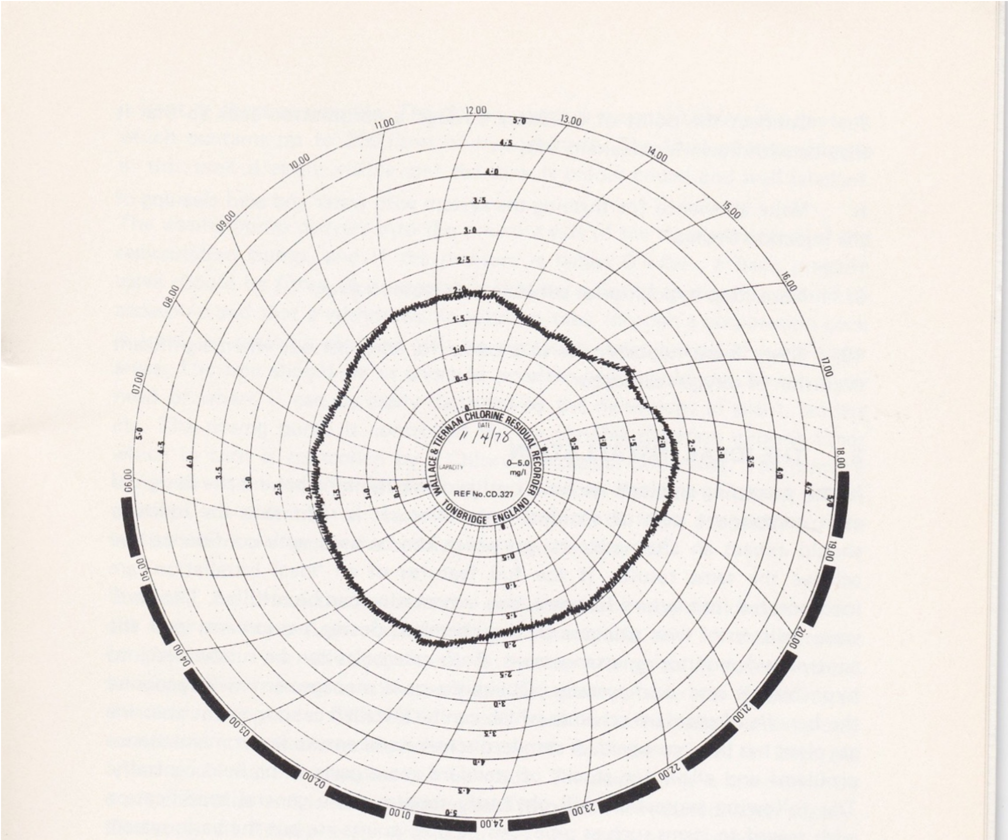

Fig.3 Typical Municipal pool under full Residual Control - 24 hour chart

4. Terminate the suction pipe about 100 mm short of the bottom of the solution container to avoid sediment pick-up.

5. Ensure that suction lift to the pump is kept to a minimum

6. Maintain a minimum pressure differential across the pump of O.4 bar, and ensure that pressure relief valves are fitted.

7. Connect the point of injection through a corporation cock so that it may be withdrawn for cleaning, etc.

8. Make allowance for flushing the system with water and acid cleaning of the injection fitting.

9. Never trap hypochlorite between two closed valves.

10. Never leave hypochlorite in a pump for long periods when significant evolution of oxygen can occur.

8 THE IDEAL INSTALLATION

ln the preceding sections we have outlined the thinking behind the design of each component part of an ideal installation. It is right that the industry should expect an alternative to gas which can be used with confidence and achieve the same results. If the full features of an 'ideal installation' are incorporated into future schemes, this expectation can be fulfilled. The hard-ware falls into two categories: the chemical dosing equipment; and the control and monitoring arrangement. Both categories can be subdivided into hypochlorite and acid systems. Obviously, pool management will recognise the benefit of standard schemes which can be installed as soon as the chlorine gas plant has been removed. A standard scheme will ensure fewer maintenance problems and allow for stocks of standard spare parts to be held centrally. The following suggestion will obviously require some general modification with regard to items such as pipe runs, sample points etc but the basic system should suit existing and new pools throughout the UK. The scheme described is typical for a normal municipal pool. For very large outdoor pools or small indoor pools, the storage facilities will differ although the overall plant will remain similar.

Fig.1 gives a schematic layout of an ideal installation. It can be seen from this layout that most of the eventualities have been taken into consideration, and that potential hazards and operating difficulties have been reduced to a minimum. The hypochlorite is shown stored in a sectionalised, site-assembled container, each section of which can be passed through normal doors obviating the need for making special openings in existing walls. Such a tank would be approximately 5 ft high and 4 ft in diameter. The pipework is run in rigid PVC with suitable chemical resistant valves. The pipe run to the day tank kept as short as possible. The dosing pump is mounted above the day tank which contains up to 200 litres of hypochlorite. The level of hypochlorite in this tank is easily visible and the tank is colour coded and well labelled.

The dosing pump delivers into the pressure side of the main, upstream of the recirculation pump, and if the pressure is below O.4 bar, a back pressure valve should be fitted. It is imperative that the point of application should be accessible and that a withdrawable solution tube through a corporation cock is used, as periodic cleaning will be necessary, particularly in hard water areas. The line should be as short as possible and should not be run over_ head or where it can be easily damaged by the movement of plant, ladders etc. The dosing pump is controlled by the variable duration impulse timer which in turn is controlled by a Chlorine Residual Controller. The primary signal to the controller is given by a Chlorine Residual Analyser which operates on a sample. of water from the pool, or from a position in the system where changes in the bathing load can be detected.

Similarly, the pH of the water in the pool should be recorded or controlled: the diagram shows such a system using hydrochloric acid for this purpose.

In particular, the dilution device is worth noting as it saves manual handling of the strong corrosive acid and also gives considerable flexibility on the acid dosing side. The 100-litre acid tank is well labelled and colour coded and it is recommended that the word, acid be written in large red lettering so that no mistakes can be made. The acid pump is controlled by a pH controller and is shown dosing acid into the recirculated water supply. Obviously, all fittings used with acid must be made of non-metallic acid resistant materials.

The emphasis in this ideal installation has been on safety and the diagram shows bund walls, separate drains etc. At first sight this ideal installation may seem to be over-complicated but there are logical and practical reasons for each item.

CAUTION

In no circumstances must the acid line be teed into the hypochlorite line.

9 CONCLUSION

If the guidelines set out in this booklet are followed and related to individual circumstances, the use of sodium hypochlorite as an alternative to chlorine gas should be satisfactorily accomplished.

It is hoped that the information given demonstrates that if optimum results are to be achieved and easily maintained. short cuts and unproven equipment should be avoided

Wallace & Tiernan Ltd hope that you will find this booklet useful as a general reference and will be pleased to offer any additional assistance that you may require

References

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2. Elphick & Fidgett - A new Look for Chlorine Residual Control at Crawley Swimming pool

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