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GUIDELINES FOR CHEMICAL CONTROLLERS

Chemical controllers can offer improved precision of water balance using sensor technology with control algorithms, and are required within California for public pools built or remodeled on after September of 2012; prompting consultation and plan review approval from Environmental Health jurisdictions. These units were developed to provide continuous analysis and control of chemical constituents; primarily the pH and disinfectant levels. They help to address the problem of dispensing too little or too much, by feeding as needed depending on set values. Variation can exist between units from the relatively basic to the more advanced systems with multifunction controls and features. While essential features can dictate the feeding of chlorine and acid, additional characteristics can command filters, pumps, auto fills, heaters, lighting, valves, added chemical pumps, and other equipment for automated functions. Chemical management can be enhanced with augmented feeding of enzymes, algaecides, clarifiers, bicarb, salts, and other varieties in liquid or dry form. The components within these systems can also extend to include electronic control boards, display screens, relays, alarms, and sensors. Some systems can be interfaced for full control from a remote site via computer or mobile device. At the core is a microprocessor capable of reading and storing sensor data while sending appropriate relay signals to chemical feeders; dictating how much chemical to add. Readings can be gathered from the interface display. Units equipped with memory banks and remote monitoring features can retain data capable of retrieval anytime and anywhere. Some may require very basic programming, while others can be made to perform more advanced functions. Given the degree of variation between chemical controllers, service and maintenance can differ from one unit to another. Installation, periodic servicing, and replacement time frames of integrated components can differ between units and sites. Referring to manufacturer guidelines is essential.

Plan review of chemical controllers prior to installation is a required process whereby documents and/or renderings are reviewed for compliance. A plan review application with the local Environmental Health jurisdiction will be evaluated for conformance with pertinent laws, regulations, and national guidelines. The controller is required to retain NSF-50 certification.

Installation should be situated within secure areas and with safeguards to prevent tampering with the control interference and set point values. For instance, a control interface with lock-out features may provide some degree of security. Shield the controller against direct sunlight, dripping water, and overhead or adjacent leaks that cause damage the unit. Mount the unit with protection against vibrations. Relaying of the power supply in accordance with applicable national and current local (NEC) codes is required. Retain a licensed electrician to perform all electrical wiring. Install away from sources of electrical interference. An "earth ground" connection is necessary to avert the impact of ground loop interference that can cause erratic readings, system malfunction, and damage. Adhere to manufacture instructions and contact the local building authority when installing circuit breakers and ground fault circuit interrupters (GFCI). Adequate ventilation should be available since chemical fumes and excessive heat can damage equipment. Exposing electronics to acid fumes can cause corrosion to circuitry. Likewise, chemical feeder pumps and storage containers will require safe and secure installation. Chemical pumps and feeders are responsible for chlorine and acid delivery and can vary from relatively simple with minimal parts and components, to more elaborate mechanisms. Peristaltic pumps apply rollers that squeeze a feeding tube, grabbing the liquid chemical through the tube. Erosion feeders can be used for feeding dry chemicals by applying the water stream through the pipework to dissolve the dry chemical tablets or granules. A diaphragm or piston pump functions with a motorized cam and series of check valves. One contributing factor to failure could result from contaminants (sand or grit) lodged within a valve. Refer to the manufacturer for chemical controller relaying instructions.

For systems without heating, installing the chlorine injection line before the filter, with the acid injection line after filter – is suggested to reduce the risk of merging both chemicals. If this isn't possible, the injection points must be separated by a distance according to the manufacturer.

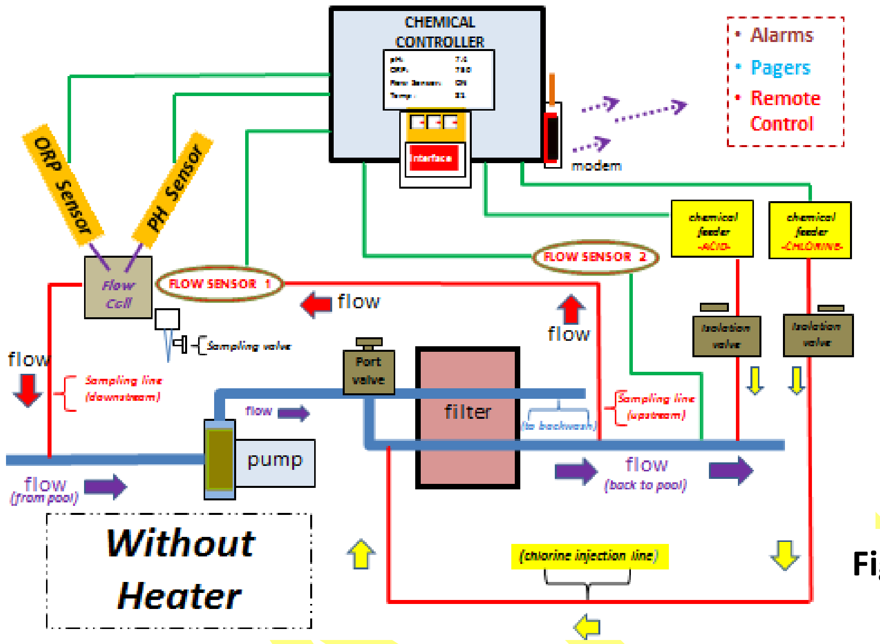


Fig. 1

For systems that include heating, installation of the injection points must be situated upstream or after the heater to prevent chemical exposure to the heating elements. The injection joints must be separated by a distance according to the manufacturer.

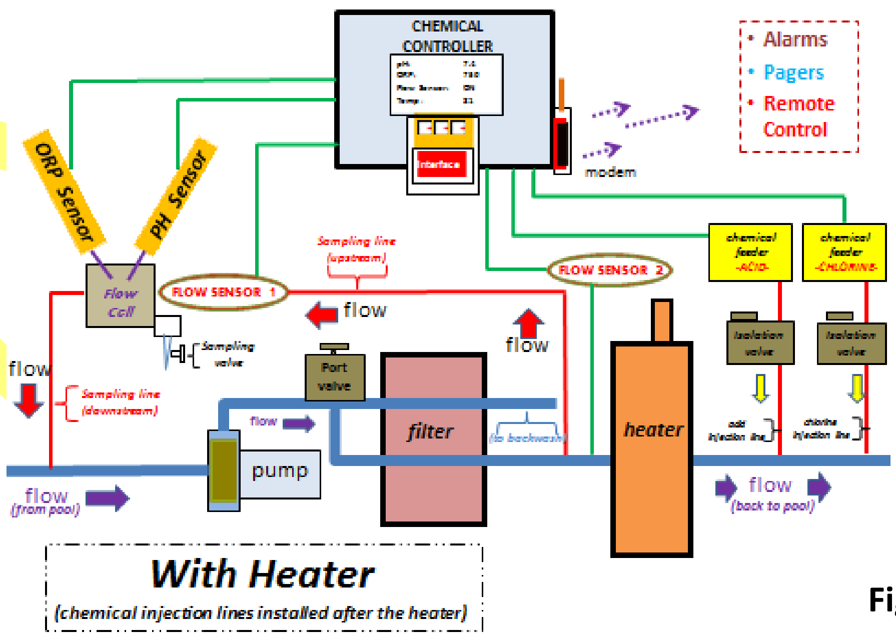


Fig. 2

Disinfection rates and values are measured using probe sensors designed to target specific chemical constituents, particularly disinfection and oxidizing values.

a) **pH** probes can measure the scale of relative acidity and alkaline conditions.

b) **Amperometric** probes can determine the disinfectant concentration or quantity, similar to a titration test kit used for measuring relative amounts of chlorine or bromine, expressed in parts per million (PPM). Constant pressure is essential for reading accuracy.
c) **Oxidation Reduction Potential (ORP)** probes – Instead of retrieving the quantity amount of residual disinfectant, the rate of oxidative disinfection is retained by measuring the combined effects of oxidants within the pool. OPR measures the disinfectant work value or effective potency; taking on a qualitative, rather than quantitative approach. These probes are capable of measuring the electron activity between oxidizers (disinfectants) and reducers (contaminants), expressed in millivolts (mV). Higher values correlate with greater oxidative disinfection.

Colorimetric testing (applying implements and technology separate from probes) can determine the disinfectant concentration and additional characteristics such as pH quantity by using light spectrometry or reagents comparable to a titration test kit; capable of rendering values expressed in parts per million (PPM). Integral magnetic coils and other components will require periodic maintenance.

The sensors may contain sensitive components including electrodes and glass material, requiring careful handling. The controller calculates how long to activate the feeder relays. A gel coating for each sensor may be necessary, requiring periodic replacement. Dropping the sensor or exposure to vibration or physical impact can cause damage. Drastic variation in pressure may affect readings or cause damage to the sensors. Improper flow and air leaks can adversely react with the sensors. Additionally, monitor for water leaks to avoid damage to other components and equipment.

The flow cell chamber containing the sensor probes will require exposure to positive pressure. The inlet supply of the sampling line should retain higher pressure than the discharge or exit line to accommodate a steady water flow supply in the appropriate direction, with the input maximum pressure retained at a PSI value in accordance with the manufacturer. The inlet sampling line should be installed after the filter and before any heater or solar valve. The return or exit line should be installed after the heater with as much distance as possible away from any equipment. The maximum pressure across the sensors should be maintained in accordance with the manufacturer. Do not expose the sensors to negative pressure or vacuum. Situate the flow cell exit line to the suction side of the pump to prevent vacuum from drawing the gel coating from the sensors.

Install the chemical injection lines in accordance with the manufacturer. It's essential for injection lines to be installed after the heater. *Figure 1* displays a system without a heater unit. In this scenario, using the filter as a barrier between the chlorine and acid injection lines can prevent unintended mixing of the two chemicals. The chlorine line should be installed before the filter, with the acid line after. *Figure 2* displays a system that includes a heater. In this scenario, all chemical injection lines require installation after the heater with distance separation recommended by the manufacturer.

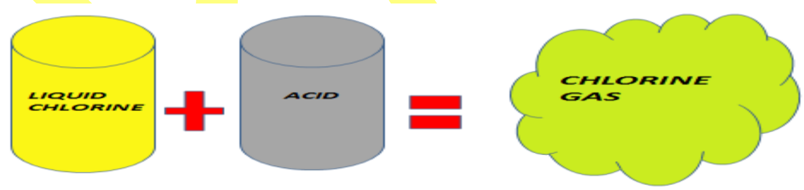
Balancing the water is the first step and entails achieving desirable pH levels, appropriate total alkalinity, and calcium hardness. Balanced water is neither corrosive nor scaling. Although the controller is an automatic system, the initial and periodic monitoring of the chemical constituents by manual means are required for maintaining disinfection and water quality. Measure the pH, alkalinity, and calcium hardness of the pool water using a DPD test kit. The pH value is required between 7.2 to 7.8. A disinfectant or free available chlorine level of 1.0 to 10.0 ppm is required for swimming pools without cyanuric acid, or 3.0 to 10.0 PPM with cyanuric acid. Spas, wading pools, and spray grounds will require a level between 3.0 and 10.0 PPM. Desirable ORP values can range from 640 mV to 750 mV. The use of cyanuric acid should be maintained at less than 50 PPM or at a level in accordance with the manufacturer since high levels can affect the ORP values. The suggested range for calcium hardness is 200 to 500 PPM. High levels of total dissolved solids (TDS) can become problematic, particularly with salt water pools. The recommended TDS (including salt) is a minimum 3000 to a maximum 6000 PPM. Salt water pools should retain gold plated sensors instead of platinum since gold appears to be less reactive to salt. The Langelier Saturation Index (LSI) calculator can be used to diagnose the water balance. Some controllers may retain an integrated LSI calculator. A value between +0.5 to -0.5 is desirable.

Fluctuations in pH, cyanuric acid levels, total dissolved solids, and supplemental or added disinfectants may influence the primary disinfectant reading relative to ORP. It's crucial to maintain the total alkalinity for securing the pH level. A total alkalinity range of 60 to 120 PPM is highly suggested. Periodic adjustments to the ORP level are likewise essential for retaining consistent disinfectant residual levels in parts per million (PPM).

With exception to pH and disinfectant values, all other chemical constituents including calcium hardness, ORP, TDS, and total alkalinity need not fall precisely within the aforementioned values, given variations in water quality from pool to pool. Achieving appropriate water balance will require consultation with professionals experienced with swimming pool chemical control operations.

Monitoring and maintenance are necessary for accuracy and reliable readings. This includes manual testing of pH and disinfectant levels, measured against the chemical controller readings to confirm the reliability of equipment. Although chemical controllers can be used to account for the measurements of various chemical constituents, written accounts of these values are still required at the facility premise. ORP values are not intended to replace parts per million (ppm) values and manual readings of disinfectant and pH levels should be checked against the automated ORP values with frequency to detect possible instrument error, miscalibration, and other system malfunctions. Routine maintenance is critical. Lack of cleaning and accumulated dirt, oils, and calcium can foul the sensors, leading to inaccuracy and unintended consequences. The sensors also require protection from freezing conditions. When winterizing the pool, store the sensors away from freezing temperatures. Hard copy or written accounts of the chemical readings must still be retained on site. Manual water sampling with record keeping need not be performed every day since these values are already contained within the chemical controller. Instead, the pool service technician may transfer these "daily" readings from the controller and into the hard copy logs during periodic service visits. Additionally, notate any service or maintenance work into the logs. These logs are essential for review by the local Environmental Health Authority.

Preventing chlorine off gassing is an absolute necessity in safeguarding against chemical exposure including poisonous fumes, caustic liquids and even explosions. Chlorine and acid are incompatible chemicals necessary for proper pool disinfection. Improper and uncontrolled mixing of the two can likely yield dangerous chlorine gas, yet pose minimal risk when dosed separately and rendered comparatively harmless when diluted by the vast amounts of pool water. Exposure to chlorine gas can result from manual or hand mixing of incompatible chemicals, typically within the chemical room, and may result in vapors traveling into the pool as well as other common areas. Exposure can also result from liquid chlorine and acid being inadvertently drawn, mixed, and then accumulated within the pipework when circulation or flow has ceased from an inactive recirculation pump. Therefore, when power to the pump is eventually restored, a release of the yellowish-green gas occurs abruptly within seconds after flow is reinstated, with the chlorine gas entering the pool through the pool return inlets. Any disruption to flow or pool circulation must likewise interrupt chemical feeding to prevent a potential chemical build up within the pipework.



Without pump operation, there can be no flow through the pipes. The unwanted blend of chlorine and acid starts with disruption to flow, both deliberate (during routine equipment maintenance) and unintended (during power outages). When power is restored, certain pumps (particularly those with integrated starting features such as a variable frequency drive) will not automatically restart to safeguard against damaging the pump. On the other hand, the chemical feed pumps and chemical control system are not always equipped with such features, causing both chlorine and acid pumps to re-start – injecting acid and chlorine into the pipework of stagnant water without flow. As such, the chemical feed pumps and the chemical control system must be equipped with safeguards against indiscriminate feeding, which at a minimum should include an electrical interlock between the chemical control system and the starting controls of the pump in addition to establishing a link between chemical dosing and pump failure. However a pump running under cavitation with loss of prime could stop or limit the circulation flow, yet fail to restrict the chemical pumps from continual feeding. To overcome this complication, supplemental flow switches or sensors relayed to the chemical dosing equipment should serve to disrupt chemical feeding upon loss of circulation flow. For instance, a chemical controller flow sensor and a secondary flow sensor on the main circulation return pipe are required. This would require routine testing of flow sensors to be performed since sensors and switches in general may not always be reliable. The installation of two or more redundant switches can further reduce the possibility of failure.

Equipment safeguards are required against chemical off gassing, but may vary and differ in features, appearance, and design. Some chemical controllers are equipped with remote control capabilities. Some may also have alarm features. But many others do not. Operation and routine testing in accordance with the manufacturer's specifications are critical to ensure adequate performance. Malfunctions must be averted to prevent incompatible chemicals from mixing.

Anti-syphon valves in the chemical feeder pumps are highly recommended and may be required by the chemical pump manufacturer. If chemical containment vessels, injection points, pipework, and filtration are located above the pool, liquid contained within the system above the pool water level may drain back into the pool and moreover syphon or draw both chlorine and acid into the system pipework.

Chemical tubing is also subject to improper fit, wear, and deterioration, causing unintentional draw of chemical material. Tubing can only be replaced with an equivalent specifically intended for the chemical feed pump. Given the variation in moving parts and components, periodic testing and maintenance is highly recommended. Chemical tubing and containers should also be color coded and labeled accordingly to prevent accidental mixing.

Interlocks and Flow Sensors function as safeguards against uncontrolled chemical feeding, requiring integration into the chemical feeding systems; primarily the chemical controllers and feeders. Uncontrolled chemical feeding can result in off gassing or spill exposure caused when overfeeding and build-up of chlorine or acid within the pipes are suddenly driven into the pool at high concentrations right after recirculation and flow reactivation. With bathers present in the pool, serious injury can occur. When pool recirculation or flow stops, all feeding mechanisms must automatically cease. Interlocks, flow sensors or switches can serve this function. To help protect against possible malfunctions, chemical controllers should at all times be operating with the pump; both continuously running 24 hours. However flow sensors can be susceptible to malfunction and have been known to fail. Rotary flow switches can spin in either direction, potentially failing to impede chemical feeding in the event of a backflow. Air pockets can disturb function of the bobbing float. And although chemical controllers may already have integrated flow sensors or switches, the installation of an added or redundant flow sensor may be necessary for added protection against chemical misfeeding and unintended consequences. Any chemical feeder augmented into a system, but relayed independent from the chemical controller, will require its own set of flow sensors.

Rotary Flow Switch

Paddle or Reed Flow Switch

Bobbing Float or Magnetic Flow Switch

In accordance with the Model Aquatic Health Code, *all chemical control and feed systems for each venue or portion of a venue shall be provided with an automatic means to be disabled in event of a low flow or no flow condition. This shall be accomplished through an electrical interlock consisting of at least two of the following:*

1) Recirculation pump power monitor
2) Flow meter/flow switch in the return line,
3) Flow meter/flow switch at the chemical controller

The electrical interlock system shall be installed per manufacturer's instructions and shall never be altered.

The installation of flow switches, sensors, and other electrical components and corresponding relays require methods approved and intended by the manufacturer. Such installations may fall outside the scope of Environmental Health and require consultation with approval from the local Building Authority for compliance with the National Electrical Code (NEC), or with applicable local codes. To extend performance, accuracy, and safeguarding against failures, chemical controllers should undergo routine maintenance and calibration with frequent and periodic intervals. Assessments should be performed only by service professionals with experience in swimming pool chemical control systems.

Chemical controllers provide the benefits of consistent disinfection under varying water conditions. Advanced systems can be complicated, relying on routine service and maintenance, essential for continued reliability. System failure, insufficient service, and negligence can lead to unintended consequences. Consult with your local Environmental Health Authority for further information and requisites.

Procedural safeguards

Strategies beyond equipment design should be implemented to further reduce any likelihood of unwanted chemical releases, and should include routine testing of the chemical control system. When performing maintenance, service repairs, or any work to the chemical feeding system, secluding the chemical feeders from the rest of the water circulation system with ***isolation valves*** is necessary. The isolation valves must be compatible with the chemical being injected. When performing service maintenance to chemical control and feed systems, be sure to follow standard procedures for ***lockout-tagout (LOTO)***. The locked unit is then tagged with an inscription identifying the worker who has installed it. This prevents accidental startup and unintended chemical feeding from the unit.

Contingency planning is strongly recommended with an emergency action plan that includes a protocol to evacuate the pool after a pump failure, with safeguards against reentry – including ***safety signs*** *displaying warning announcements not to enter the pool with an inactive pump.* The plan should have further measures against chemical off gassing disasters and be site specific and customized to meet the needs of the facility.

EMERGENCY ACTION PLAN *(recommended for commercial facilities and venues)*

An effective emergency response plan begins and ends with good management and supervision. Planning will include procedures for emergency situations, reporting requirements, restoration of facility operations, implementing practice drills, and performing self-inspections; all of which should be incorporated into a written emergency action plan, as required by SARA Title 3. The written plan should be specifically developed and tailored to characteristics unique to each facility. If your swimming pool has a permit from your local Hazardous Materials Programs due to the quantities of hazardous material(s) stored at your facility, you likely have already prepared an Emergency Action Plan.

Consult with service professionals with expertise in developing emergency action plans specific to public pools. Local hazardous material and fire personnel should be consulted for issues pertaining to chemical storage. Once complete, put the plan into action. Emergency drills should be practiced routinely.

Emergency Response

Dangerous situations can vary. Irrespective of risk level, any situation with imminent hazards jeopardizing health and safety can be considered an emergency. Applying the following countermeasures in response to emergencies is recommended:

1) Manage the emergency

- Coordinate with staff and confirm your mode of communication. Effective communication is essential.
- Develop a chain of command as part of your emergency response plan. Phones must be available and conveniently located. Emergency phone numbers must be prominently posted. A method of communication between staff using whistles and hand signals should also be established.
- Develop a contact list prescribing assignments and responsibilities.

2) Assign Responsible Staffers

Designate staff members for emergency situations. Assignments should be relegated according to skill. For instance, lifeguards are better qualified to perform emergency rescue than the facility manager. Likewise, the facility manager may be better equipped to report incidents and supervise exercise drills. Assign staffers for each of the following actions:

- Emergency rescue and first aid to injured parties (typically performed by lifeguards).
- Immediate contact of emergency personnel (local fire and rescue).
- Initiate closure of the facility. Begin evacuation and clearing procedures and install closure signs at all entrances.
- Direct traffic.
  - Crowd control: Usually a large number of people congregate at the scene of an emergency. The emergency plan must include clearing the incident area and crowd control with on-going supervision of the facility.
  - Meeting and guiding emergency personnel to the site and/or injured party. During an emergency it's extremely important to provide rescue personnel with facility layout information. Access for emergency personnel should be evaluated with routes determined in advance.

Reporting Requirements

Any drowning, chemical injury, waterborne illness, and rescue requiring resuscitation or medical facility attention will require reporting to Contra Costa Environmental Health as quickly as possible but **within 24 hours.**

1) Produce records indicating the number of pool users, all lifeguards on duty, water characteristics, equipment maintenance including failures and malfunctions.

2) These records must be available for review by the Permit Issuing Official for at least 2 years.

Restoration of Facility Operations

Depending on the state and complexity of the operations, consultation from service professionals may be necessary to evaluate all system operations prior to resuming reopening. Equipment function and water characteristics must be restored. Regulation components and automation systems must be assessed and adjusted accordingly. Keep inventory record and data of all incident situations including written assessments with corrective measures taken by you and consultant or service professional.

Practice Drills

Practice makes perfect and training is essential for emergency response situations. Staff members assigned to emergency response must be trained. Provide training with frequent practice to reinforce the principles and routinely rehearse the plan.

1) Practice emergency response drills including passage routes for directing emergency personnel.

2) Practice lifesaving skills to sustain proficiency in performing rescues.

3) Practice search procedures for lost bathers.
4) Practice flashlight distribution for staff, applicable to indoor pools or pools open at night, without the presence of natural night.
5) Practice all other response protocols; site specific and tailored for your facility.

Self-Inspections

Ensuring good facility maintenance will minimize equipment failures, disruptions, and reduce delays during emergencies. To help ease your response to emergency situations, perform compliance checks of your own accord. Develop an inspection checklist or adapt the inspection report issued by Contra Costa Environmental Health to identify the wide range of health hazards including unsafe water conditions, broken equipment, inadequate safety signs, missing rescue devices, electrical equipment malfunctions, broken/loose suction outlet covers, missing first aid kits, broken gates and fences, etc. Take action to correct any deficiencies. Close the pool, restrict public access, and post closure signs when encountering imminent health hazards that can't be corrected.

After the emergency

Preparing for an emergency is extensive and includes many responsibilities. Proficiency in record keeping, retaining reports, reassessing and replacing equipment are few of the multiple issues to deal with. Staff debriefing should be implemented following the emergency. For further information on developing an emergency response plan, consult with industry professionals and refer to the following online resources:

https://emergency.cdc.gov/ https://nspf.org/ https://apsp.org/