Chemical Metering and Process Control Strategies

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Chemical Metering and Process Control Strategies

- Industrial Uses of Chemical Dosing
- Typical Equipment
- Principles of Operation
- Process Control Strategies

Industrial Uses of Chemical Metering

- Water Treatment
  - Coagulation
  - Iron Sequestration
  - Disinfection
- Wastewater Treatment
  - Odor Control
  - Enhanced Primary Clarification
  - Phosphorous Control
  - Solids Conditioning
  - Disinfection

Industrial Uses of Chemical Metering

- Boiler chemical feed
- Clean-in-place (CIP) for food processors
- Adding fruit slurries to ice cream, etc.
- Car washing
- Golf courses – fertilizers and weed killers
- Greenhouses – fertilizers and insecticides
- Hotels – pools and cooling towers
- Pilot plants
- Paint manufacturing

Typical Chemical Metering System Components

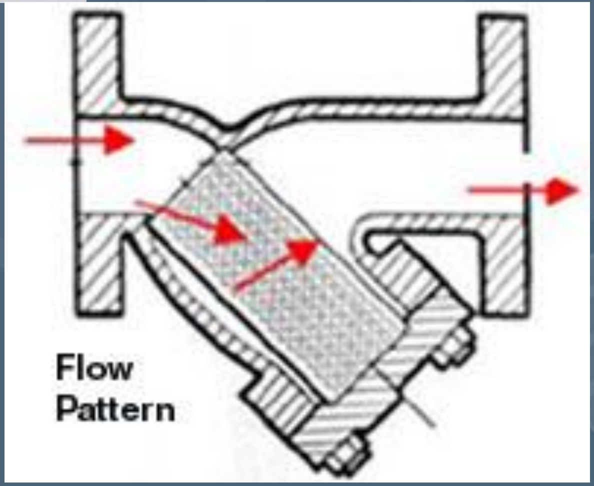
- Chemical Storage Tank
- Strainer
- Calibration Column / Cylinder
- Metering Pump
- Pressure Relief Valve
- Backpressure/Anti-siphon Valve
- Injector

Chemical Storage Tanks

- Inert (FRP or polypropylene are typical materials)
- Bulk tank/day tank combinations are common for some chemicals
- Usually vented
- Electronic or mechanical method of level sensing is normal

Strainer

- Used where feed chemical is not pure or which can become contaminated or degrade over time
- “Y” strainers are the most common
- Located between the chemical storage tank and calibration column



Calibration Column / Cylinder

- "Industrial-strength" graduated cylinders
- Not installed on all metering systems
- Used to verify pump output and to adjust operating parameters
- Located "between" the strainer and the metering pump

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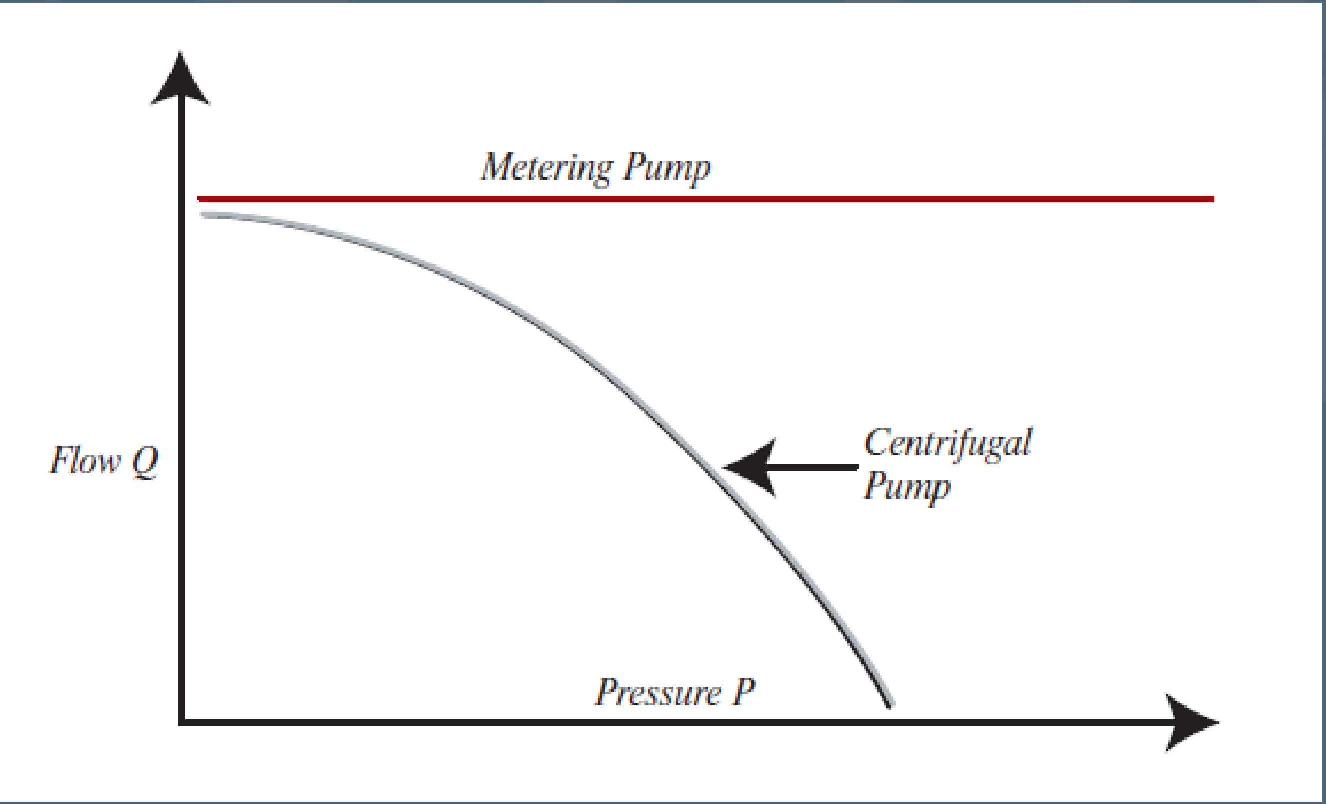
Metering Pump

The metering pump is a *positive displacement* chemical dosing device with the ability to vary capacity manually or automatically as process conditions require. It features a high level of repetitive accuracy and is capable of pumping a wide range of chemicals including acids, bases, corrosive or viscous liquids and slurries.

Typical Metering Pump Application Conditions

1. Low flow rates in mL/hr or GPH are required
2. High system pressure exists
3. High accuracy feed rate is required
4. Dosing is controlled by computer, microprocessor, DCS, PLC, or flow proportioning
5. Corrosive, hazardous, or high temperature fluids are handled
6. Viscous fluids or slurries need to be pumped
7. The metered chemical is relatively expensive

Metering vs. Centrifugal Pumps: Flow vs. Pressure



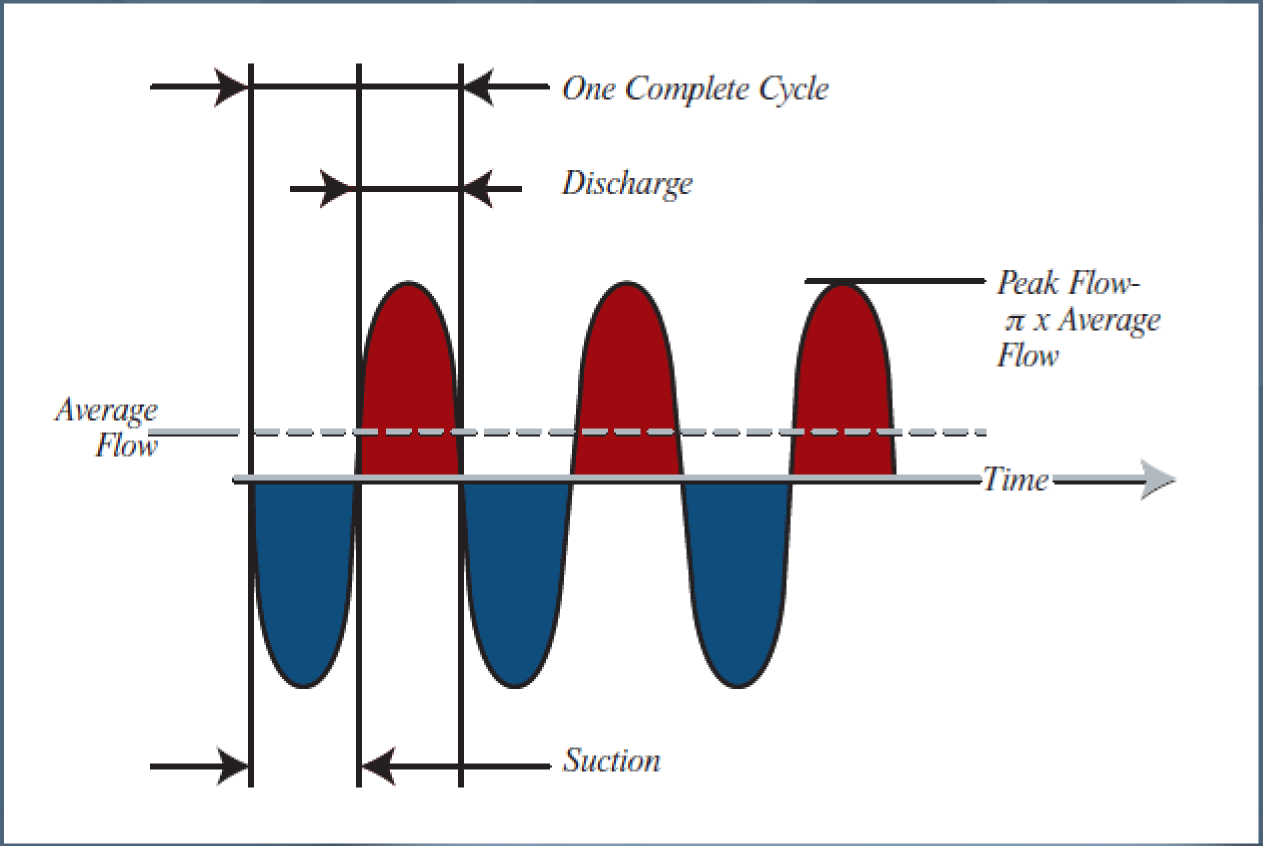
Metering Pump

- Many different manufacturers
- Different Principles/Actions/Components
  - Gear Pump
  - Diaphragm Pump
  - Piston Pump
  - Peristaltic Pump
- *Almost* all metering pumps are of the positive displacement type

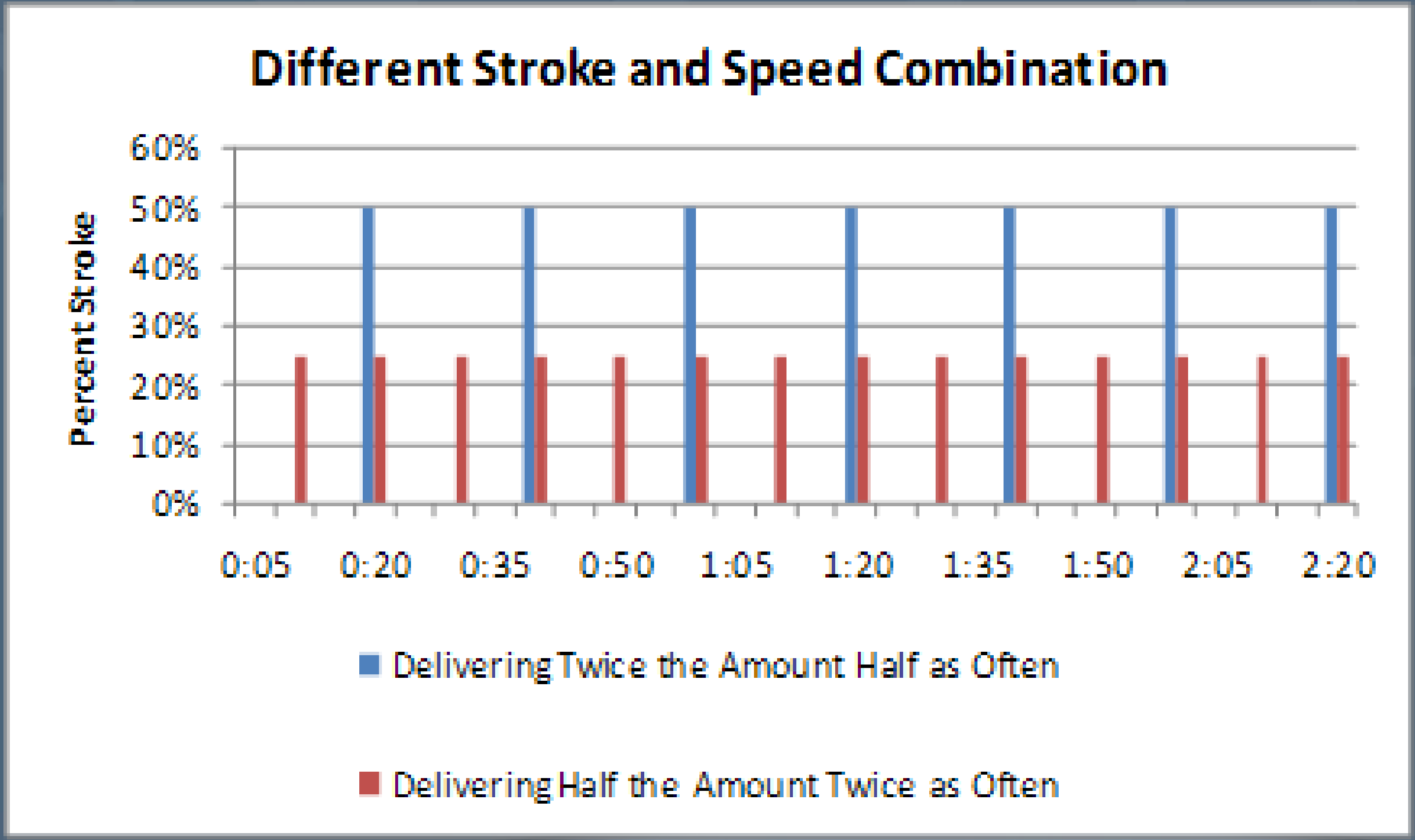
Metering Pump

- Many metering pumps demonstrate a pulsation due to the action/mechanism involved
- Pumps with pulsation effects:
  - Piston Pumps
  - Peristaltic Pumps
  - Diaphragm Pumps
  - Gear pumps (to a lesser degree)
- Pumps without (or minimal) pulsation:
  - Rotary lobe Pumps
  - Progressing Cavity Pumps

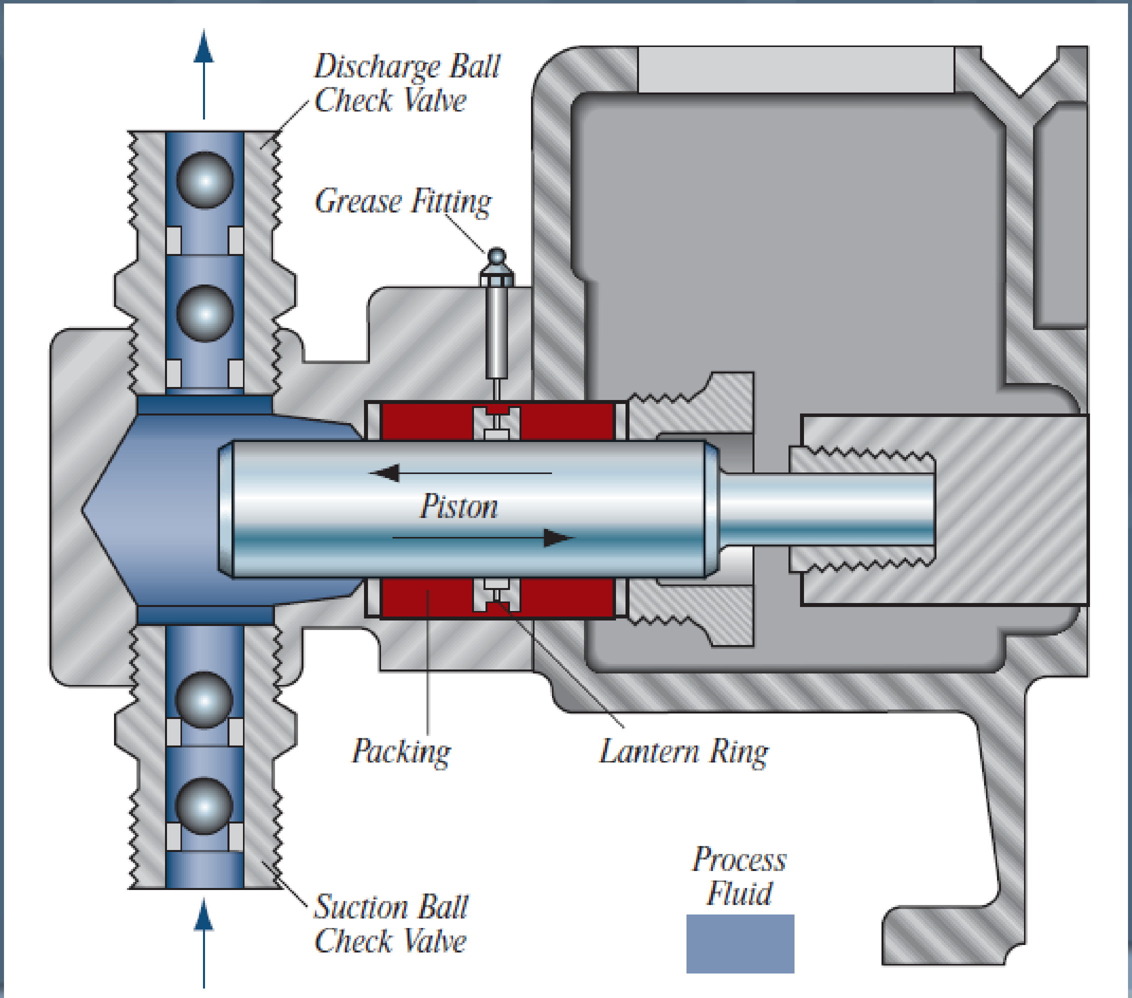
Discontinuous Flow: Pulsation Effect



Speed and Stroke Settings: Jolts of Chemical

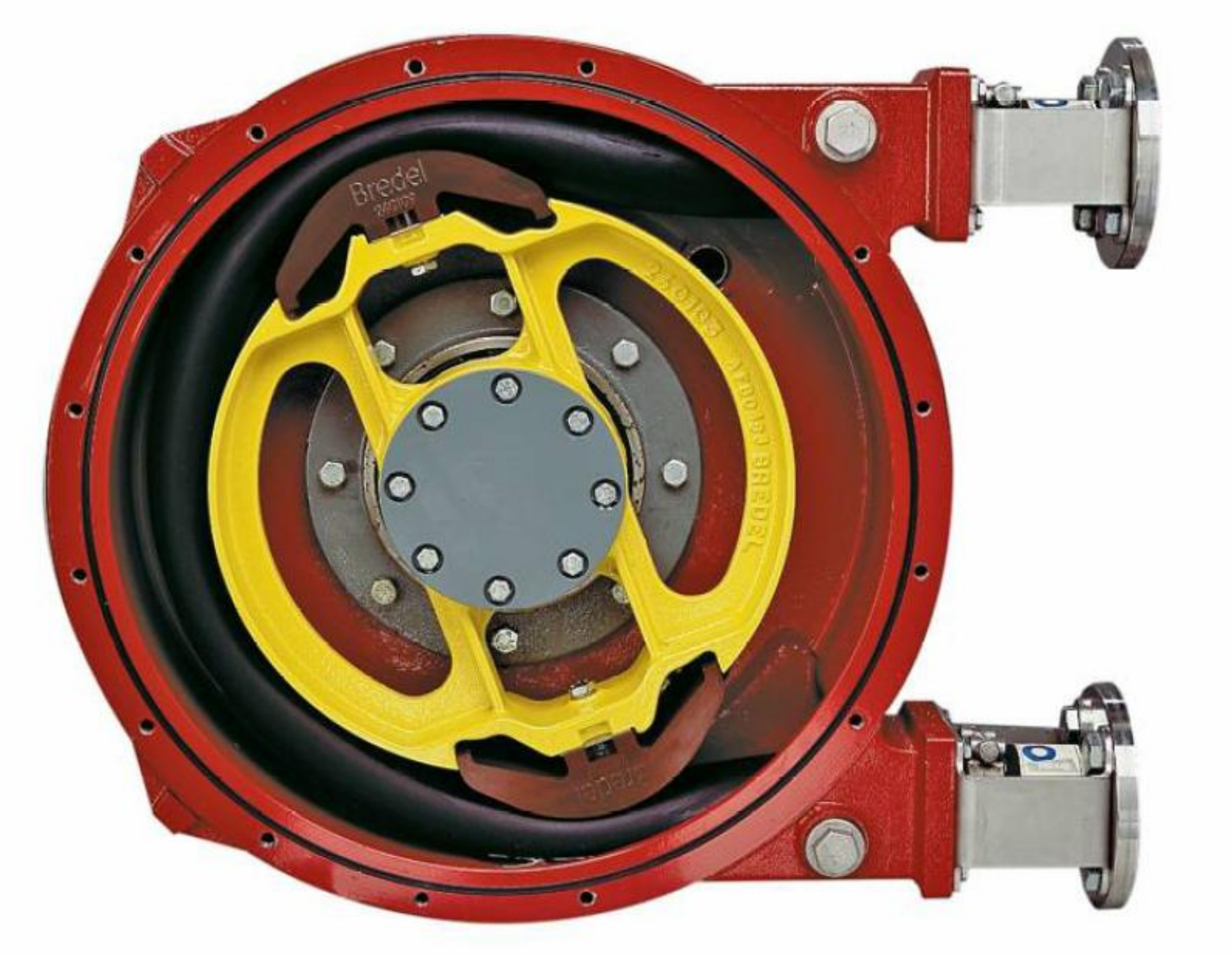


Piston Pump Internal Components

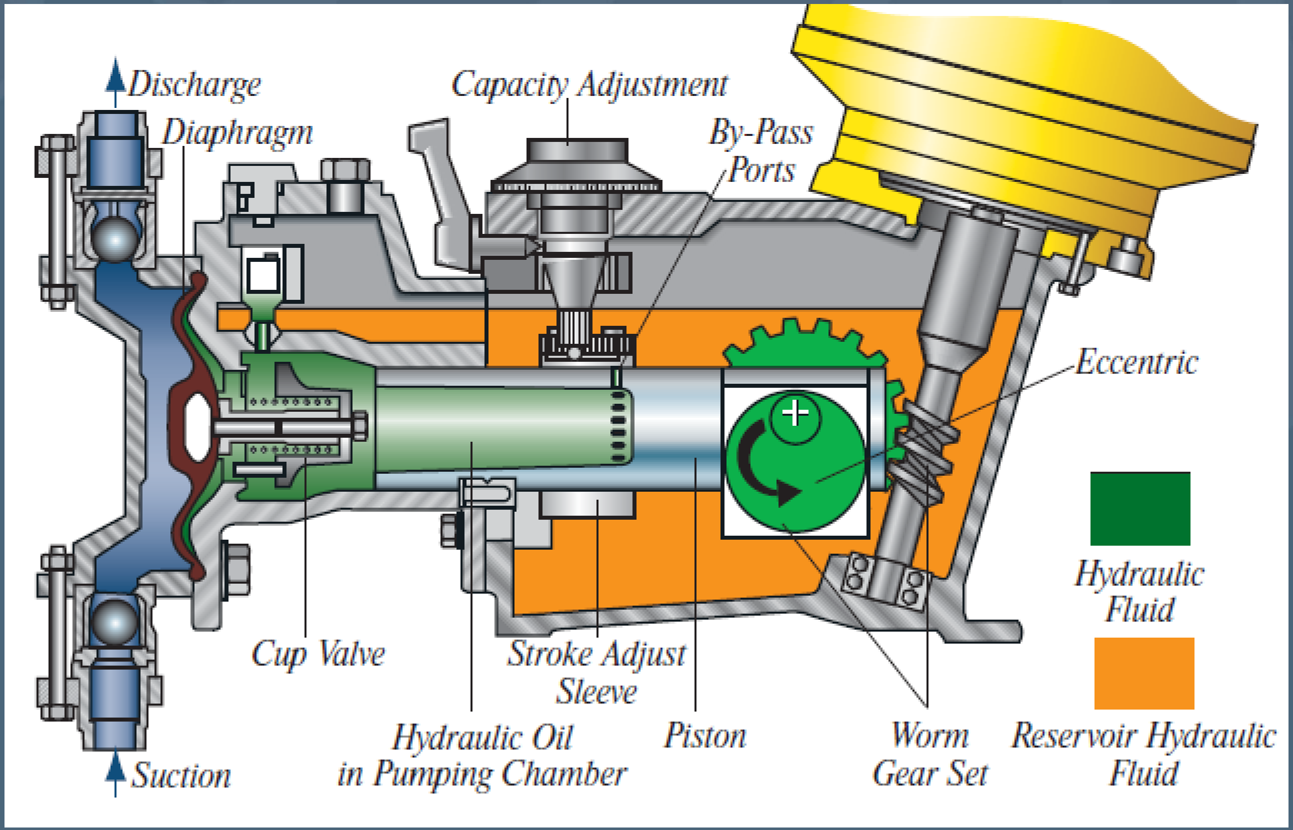


http://www.miltonroy.com/Files/Milton_Roy/Global/US-en/product_files/Bulletin210-B_2005.pdf

Peristaltic Pump Internal Components



Diaphragm Pump Internal Componets



- Courtesy Milton Roy

Solenoid-actuated Diaphragm Metering Pump

E Class metering pump. Property of WALCHEM, an Iwaki America Company

Degassing Valve Operation (e.g., hypochlorite)

E Class metering pump. Property of WALCHEM, an Iwaki America Company

Pressure Relief Valve

- Prevents damage to piping and equipment if a discharge valve is closed
- Chemical relief port is almost always plumbed back to the chemical storage tank
- These are located *before* the backpressure/anti-siphon valve

Backpressure/Anti-siphon Valve

- Prevents siphoning when the dosing point is lower than the pump
- Provides a consistent pressure against which the pump operates; this improves accuracy of the metering operation
- Typically installed just downstream of the pressure relief valve

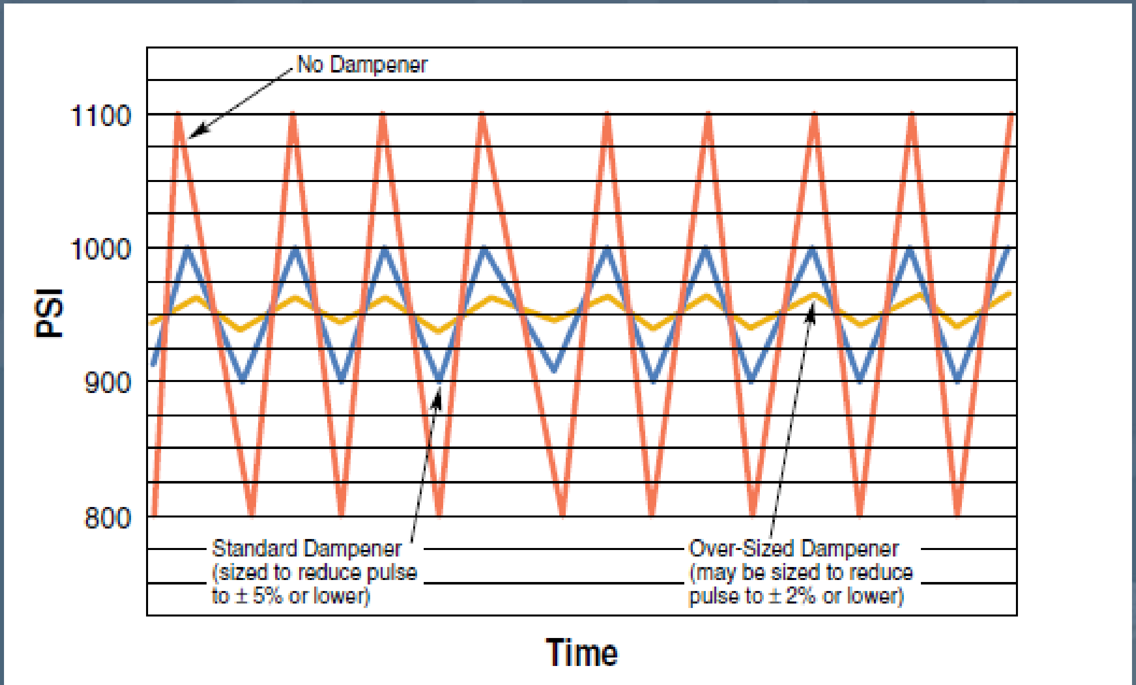
Pulsation Dampener

- Dampens the pressure <u>and the flow</u> from pumps that exhibit pulsing
- Internally, there is an elastomeric bladder or diaphragm.
- Above the diaphragm, the space is filled with compressed gas
- Below the diaphragm, the fluid being pumped fills the chamber, further compressing the gas

In-line (static) mixer

- Another way to minimize the pulsation effect
- Typically used in polymer applications, but not corrosive chemical situations, e.g., ferric chloride or alum
- Can significantly lower chemical costs when the mixture is more uniform (reduced dosages)

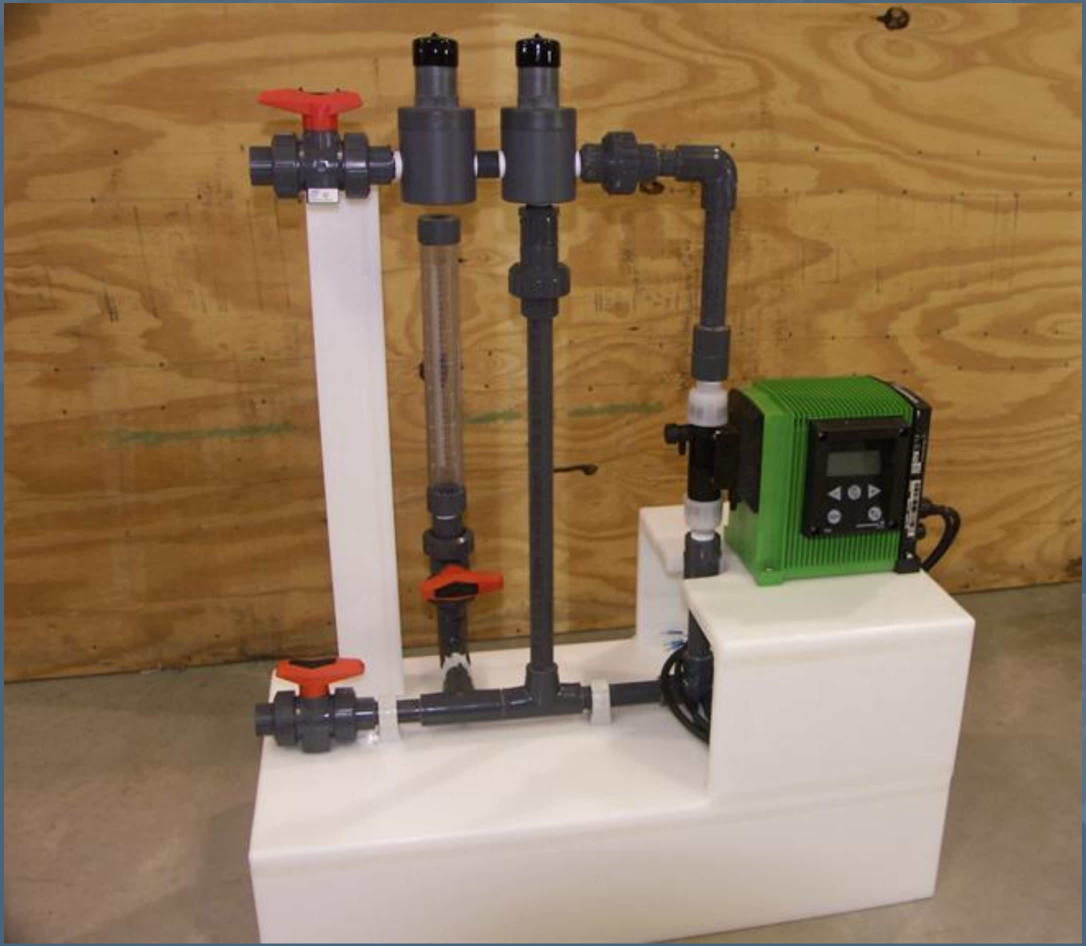
Pulsation Dampener



- This graph shows the system pressure with and without a dampeners
- Note that the system pressure w/o dampening is 800 psi, but that with dampening, the system pressure rises (915 psi and 980 psi)

Very Simple System

- Shows
  - Inlet valve
  - Calibration column
  - Overpressure return
  - Metering Pump
  - Pressure Relief Valve
  - Backpressure/Anti-siphon valve
  - Outlet valve
- Doesn't Include
  - Chemical Storage Tank
  - Pulsation Dampener



Skid-mounted diaphragm pumps

- •Isolation ball valves before and after the basket strainer
- •Double-action diaphragm pumps
- •Prominent pulsation dampeners

Chemical Metering and Process Control Strategies

PROCESS CONTROL STRATEGIES

Process Control Strategies

- Document a technically-based operational strategy
- Similar to, but different from, a plant’s O&M manual
- Lists the equipment and tankage used to accomplish a specific treatment objective, e.g., disinfection
- Instructional and reference guides for operators
- Useful for training new operators
- Addresses the interrelationship between two or more processes

Elements of a Process Control Strategy

- Summary
- Process Overview
- Unit Physical Information
- Theory and Operational Parameters
- Common Problems
- Relationship to Other Processes

Summary

"Chlorine is added to the wastewater flow prior to discharge. With sufficient contact time and chlorine concentration the number of pathogens in the wastewater is significantly reduced."

Process Overview

"Chlorination occurs after effluent filtration and prior to dechlorination. Before the flow enters the chlorine contact basin, a strong chlorine solution is added. The volume of the contact basin is large enough to ensure a chlorination time of at least 30 minutes even at high flow. During this period pathogens in the water absorb chlorine and are destroyed. Dechlorination, the removal of left over chlorine, occurs at the discharge of the chlorine contact basin. The overall goal of chlorination is to maintain coliform counts below the permit limits."

Unit Physical Information

- Lists the number of pumps, tanks, etc.
- Identifies the capacity of each, in gpm, gallons, or whatever units are used
- Gives typical detention times for tanks with
  1. Design Average Flow
  2. Maximum Flows
  3. Current Flow rates
- Location and type of valves in/out of a process
- May reference manufacturer’s O&M manuals

Theory and Operational Parameters

- Describes the physical, biological and chemical actions involved in the process
- Operating Parameters
  - Controllable example: dissolved oxygen
  - Uncontrollable example: wastewater temperature
- Monitoring Parameters and Targets
- Control Parameters

Monitoring Parameters

- What raw data will we use to evaluate the process?
- What are the expected values/ranges of the parameters?
- What are the target values?
- How often will we monitor the process?

Table of Performance and Monitoring Parameters

Parameter	Units	Range	Target	Frequency
Free Chlorine Residual [1]	mg/L	0.3 – 0.7 mg/L	0.5 mg/L	3 per week
Total Chlorine Residual [1]	mg/L	0.6 – 0.8 mg/L	0.7 mg/L	3 per week
Free Chlorine Residual [2]	mg/L	0.3 – 0.6 mg/L	0.5 mg/L	1 per month
Total Chlorine Residual [2]	mg/L	0.4 – 0.7 mg/L	0.6 mg/L	1 per month
Free Chlorine Residual [3]	mg/L	0.3 – 0.7 mg/L	0.5 mg/L	1 per month
Total Chlorine Residual [3]	mg/L	0.5 – 0.8 mg/L	0.7 mg/L	1 per month
Chlorine Demand	mg/L	0.2 – 0.4 mg/L	0.2 mg/L	Calculated
Total Coliform Bacteria	Colonies per 100 milliliters		**0**	3 per month

[1] When measured at the DPW Building.
[2] When measured at the Business Centre Water Tower
[3] When measured at the other "bacti" sampling locations (ISD, High School)

Control Parameters

- Things the operator can directly adjust or control
- Adjustments made based on monitoring parameters and deviations from "target" values

Table of Control Parameters

Parameter	Units	Range	Target
Stroke [1]	%	10% – 100%	80%
Speed [1]	%	40% – 80%	70%
Stroke [2]	%	10% – 100%	80%
Speed [2]	%	40% – 80%	70%
Stroke [4]	%	10% – 100%	55%
Speed [4]	%	25% – 70%	60%
Water Main Flushing	Days Between	90 – 180	180
Dead End Main Flushing	Days Between	60 – 90	90

[1] Well #1 sodium hypochlorite pump
[2] Well #2 sodium hypochlorite pump
[4] Well #4 sodium hypochlorite pump

Performance Parameters

- These are a subset of the monitoring parameters
- In some cases, the performance criteria are dictated by the NPDES or groundwater permit
- In other cases, the performance is related to cost, efficiency, or some other internally-determined criteria

Common Problems section

- This section addresses the common problems that the operators have observed
- The interrelationship of Control Parameters and Common Problems needs to be addressed here
  - e.g., higher ferrous chloride feed rates may depress dissolved oxygen concentrations in the aeration tank
- “Typical” problems should be included, but not complex or infrequently occurring problems
  - e.g., a filamentous bacteria problem would not be addressed by a PCS. You would want an SOP!

Relationship to Other Processes

- This section discusses the flows into and out of a process, and the effects of/to those other processes
- Impacts to related processes during upset or overload conditions should be discussed
- This section should guide the operator about which process takes precedence when strategies are in conflict, e.g., anaerobic digester process control would override a primary clarifier control strategy (usually)

Questions and (hopefully) Answers

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