Selecting the right chemical dosing system

The accurate, controlled delivery of chemicals is a fundamental part of many industrial processes and almost all municipal water or wastewater treatment regimes. In the majority of cases, chemical dosing is carried out using automated equipment.

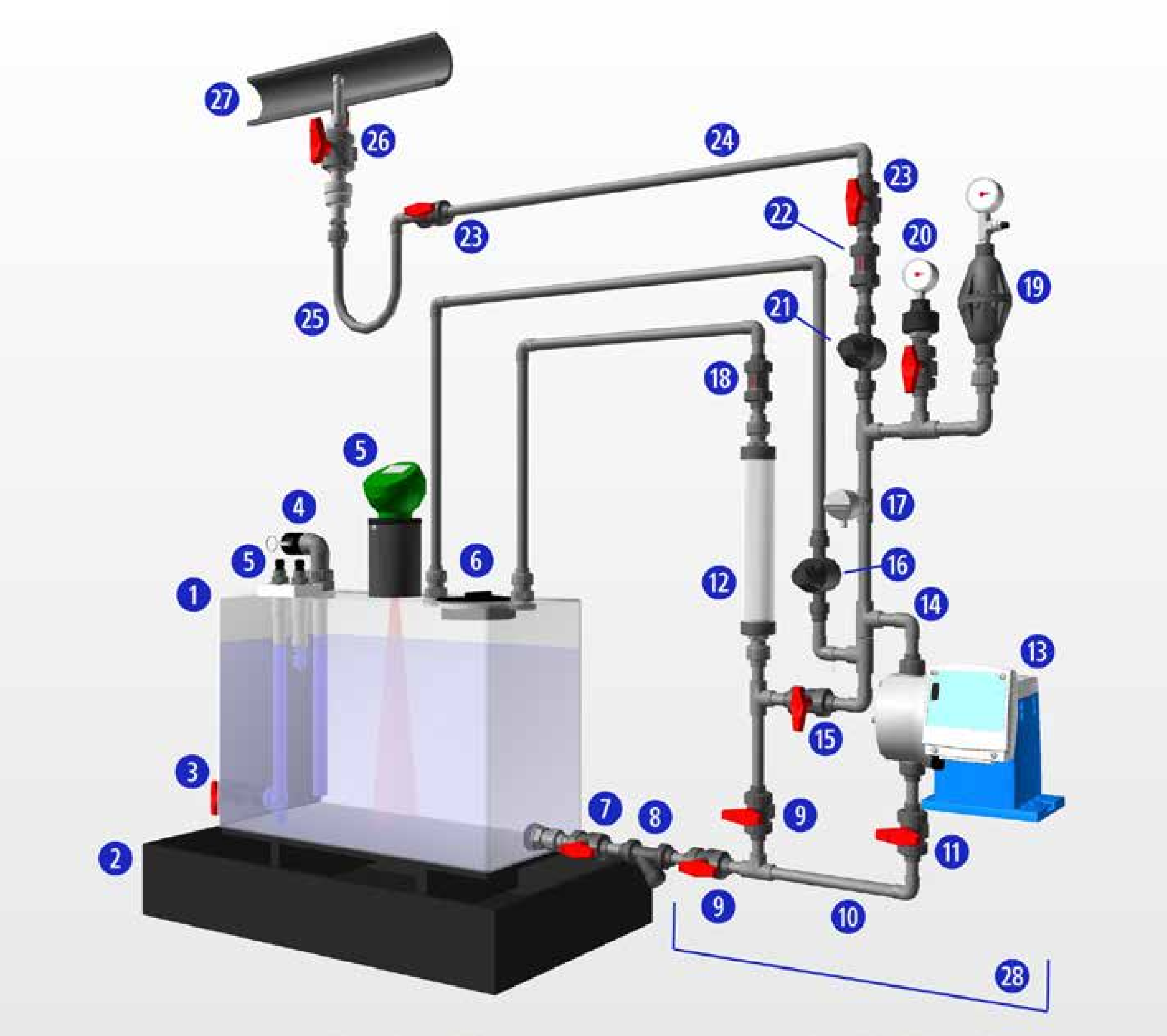
Properly specified, installed and maintained dosing systems are accurate, reliable, inexpensive to run and will provide many years of satisfactory service. They may be set to operate at a fixed rate, or be controllable to maintain process performance as the quality and volume of process water changes over time.

A key challenge for system owners, however, lies in ensuring that the dosing system they select is the right one for their application, site and process conditions. With several alternative technologies, dozens of equipment manufacturers and hundreds of product variants available on the market, that choice can seem extremely challenging. This guide has been created to explain the key components of a chemical dosing system, and to highlight some of the main factors that companies should consider as they compare different approaches or manufacturer offerings.

System overview

A dosing system comprises a chemical storage tank, a metering pump, control system, and associated valves, pipework and accessories. Let's look in detail at the pumps and associated elements:

A typical installation



1. Chemical storage tank
2. Tank safety bund with alarm
3. Tank drain valve
4. Chemical fill point connection
5. Tank level instruments
6. Tank inspection lid
7. Tank outlet valve
8. Outlet strainer
9. Calibration valves
10. Suction piping
11. Pump isolation valve
12. Calibration vessel
13. Dosing pump
14. Pipework connections to pump
15. Calibration vessel fill valve
16. Pressure relief valve (PRV)
17. Flow verification instrument
18. Calibration vessel air release valve
19. Pulsation damper
20. Pressure gauge
21. Pressure loading valve (PLV)
22. Non-return valve (NRV)
23. Isolation valve(s)
24. Dual contained delivery line
25. Dosing lines
26. Injection fittings
27. Process system
28. Dosing cabinet/drip tray

Chemical storage tank

Typically made from chemically resistant plastics or stainless steel, the selection of storage tanks must be based on the chemicals you intend to store and the chemical concentration. Tank considerations must include:

- Internal or external location (effects of weather and UV)
- Tank sizing dependant on fill cycle frequency
- Requirements for fill connection and level instruments
- Requirements for access to the tank top or manways for tank inspection
- Chemical compatibility and life expectancy
- Requirement for bunding as secondary spill containment
- Outlet valve and pipework configuration.

Chemical metering pumps

Metering, or dosing pumps are designed to deliver precisely measured quantities of chemical, provide suction if required to extract the chemical from the storage tank, and pressure to transport it through the distribution pipework to its point or points of use.

Dosing pumps use three main pumping approaches: Diaphragm pumps, Peristaltic pumps and Progressive Cavity pumps.

Diaphragm pumps use a reciprocating action to move a flexible diaphragm, adjusting the volume of an internal tube or cavity. A known volume of chemical is alternately drawn into the cavity through an inlet valve, then pushed out into the chemical delivery pipework through an outlet valve. Chemical flow is not continuous, but rather a series of pulses. The motion of the diaphragm may be provided in a number of ways: by a solenoid, a stepper motor, or by a mechanical linkage driven by a conventional motor.

A derivative of the basic mechanical diaphragm (MD) pump is the Piston-Diaphragm (PD) or hydraulic diaphragm arrangement for more arduous, high accuracy or higher pressure applications. In these pumps, the diaphragm is displaced by a secondary hydraulic fluid driven by a reciprocating piston.

Of these different diaphragm technologies, **solenoid driven, basic mechanical diaphragm pumps** typically offer the lowest initial purchase cost and simplest control and installation. While solenoid pumps can offer high discharge pressures they usually offer low maximum flows and their rapid oscillation can lead to noise and spikes in discharge pressure. Solenoid pumps may also be less rugged in operation and have a shorter life expectancy than higher cost alternatives.

Top end options are hydraulic diaphragm pumps. They are very accurate, have a long operating life, since the diaphragm is evenly supported by hydraulic fluid rather than a mechanical linkage, and can cope with hard-to-handle materials such as slurries. Beyond high capital cost and limited suction lift capability, these systems also require additional attention to maintenance, due to the need to manage and maintain the hydraulic components and fluid.

Between these two extremes are **motor driven mechanically actuated diaphragm pumps**, offering reasonable capital cost, simple maintenance and good life expectancy, at the expense of somewhat lower accuracy and pressure capability compared to hydraulic diaphragm systems. Conventional motor driven units are ideal for straightforward metering applications requiring a limited range of capacity adjustment and limited degree of automation, the more recently introduced stepper motor driven units offer a far wider range of capacity adjustment, extensive automation options and the ability to meter viscous liquids or troublesome chemicals such as sodium hypochlorite.

Peristaltic pumps use a rotary motor drive to move a series of rollers over a flexible tube inside a rigid housing. The rollers squeeze the tube, forcing chemical out into the distribution pipework. As peristaltic pumps do not reciprocate, the chemical flow is continuous, the absence of internal valves makes the pump more tolerant of liquids containing solids and an excellent choice for sodium hypochlorite and similar gas liberating chemicals. Peristatic pump designs offer good levels of suction lift – useful if the pump must be mounted above the storage tank or a long distance from it. Since the chemical is only in contact with the pump tube, peristaltic designs also simplify the task of ensuring compatibility between the pump and the chemicals it carries. Their disadvantages include limited discharge pressure capability and the need for periodic replacement of the pump tube, which can wear out over time. Advanced peristaltic pumps employ stepper motor drives for a broad range of capacity adjustment and automation options, plus have built-in tube failure detection systems to avoid any possibility of leaks arising from such an event.

Progressive cavity pumps use a helical rotor turning inside a specially shaped stator. The motion of the rotor against the stator results in the creation of a series of fixed shape cavities that transport chemical through the pump to the distribution pipework. Progressive cavity pumps work well with slurries, viscous materials and chemical products that are sensitive to shear, but have a limited range of capacity adjustment and the complex shapes and tight manufacturing tolerances required for their operation leads to high capital and maintenance costs.

Control systems and sizing

Diaphragm pumps traditionally allowed the volume delivered per stroke to be adjusted by changing the stroke length, often with a manual or automatic adjustment option. Furthermore, the output can be adjusted by altering the stroke rate or rotational frequency by adjusting the motor speed. More recently, stepper motor drives have been used providing a greater degree of motor speed control and negating the need for stroke length adjustment.

Chemical dosing pumps can be controlled manually, or via digital or analogue signals from one or more flowmeters and sensors in the process system, or via a signal from a networked SCADA system, to give flow proportional metering or set point dosing control. Modern stepper motor pumps also have various internal timers and control functions operated via a touch screen or bluetooth interface.

The 'turn-down ratio' (the ratio between the maximum and minimum output of the pump) varies considerably across different models and manufacturers of pump. The pump must be selected carefully to ensure accuracy can be maintained across the minimum and maximum dose rate requirements of the process.

Metering, or dosing pumps are designed to deliver precisely measured quantities of chemical, provide suction if required to extract the chemical from the storage tank, and pressure to transport it through the distribution pipework to its point or points of use.

System components

A dosing system requires a number of additional components to facilitate safe, reliable operation and simple maintenance. These items include control valves, switches, gauges, indicators and transmitters to indicate the presence or absence of flow, flow rates and operating pressures. Data may be relayed to on-site operators and/or a central SCADA system.

Components may include:

- Pressure relief valves (PRV) – to protect pumps and other components from overpressure due to blockage or closed valves. These are usually considered critical components
- Pressure loading valves (PLV) – to maintain a small positive pressure immediately downstream of the metering pump. A PLV is desirable for most diaphragm pumps to ensure a constant pressure is applied to the flexible diaphrgam ensuring accuracy. They also assist as an anti-syphon device
- Flow instruments – to verify or measure the volume of chemical being discharged by the dosing pump
- Pulsation dampers - contains pressurised gas behind a diaphragm and act as shock absorbers to suppress flow and pressure spikes inherent with reciprocating chemical pumps
- Calibration columns – to allow manual calibration or verification of system output
- Flushing and drain connections allow water to be flushed into the system to remove residiual chemicals before maintenance
- Dosing lines – to convey the chemical from the dosing system to the point of application, often flexible hoses, dual-contained and routed through underground ducts or trenches
- Filters or strainers – to prevent debris entering pumps or distribution pipework
- Static mixers – to ensure rapid, thorough mixing of the chemical into the process fluid flow
- Injection lances / quills – to deliver the chemical to the correct point of application into the process flow stream
- Enclosures, shields and dual contained pipework ensure the safety of personnel & operators in the event of a line breakage or pump failure.

Component selection criteria

When specifying chemical dosing system components, a number of key criteria need to be considered. These include:

- **The chemical being handled and the concentration used**. This question determines the selection of the materials used for storage tanks, pumps, pipework and all other components. Material choices must be taken with great care. Some materials perform poorly when exposed to highly concentrated chemicals but safely at lower concentrations. Even small components using inappropriate materials, for example internal valve components or the diaphragms used in pressure gauges, may introduce a potential failure point in a system. Some chemicals may produce heat or vapours during handling, and these characteristics must be accommodated in the system design. High specific gravity, viscous or lumpy materials will require appropriate pumps and fittings. Note that special precautions are needed at both low and high temperatures.
- **The range of output volumes and system pressures required**. These parameters will determine the required size, specification and capabilities of the components used across the system.
- **The location and operating environment of all components**. Real world installations often require compromises in the location and working conditions of system components. Dosing pumps may have to be installed above storage tanks, for example, requiring a pump design capable of generating sufficient suction pressure. Parts may be exposed to wind, rain, extreme temperatures or intense sunlight, which can degrade some materials. The availability of suitably skilled operators and maintenance personnel may be limited. Wherever possible these factors should be considered and accommodated at the system design stage.
- **Process tolerance**. Many chemical addition processes, particulary those related to potable water supply, require continuous uninterrupted operation. This may require parallel chemical metering streams to be installed to provide a duty-standby functionality, pre-assembled packages may be desirable to minimise installation times and process interruption.

How WES can help

WES is an independent company dedicated to the design, engineering and supply of chemical dosing systems and services. Because we aren't linked to any single equipment manufacturer, we can provide our clients with unbiased advice about the technologies, approaches and solutions that best meet their needs. Our services can be as simple as the supply of an individual component, or as complex as the design, build and installation of large scale bulk chemical dosing systems. We pride ourselves in our ability to solve problems and keep our customers' process running, whether that involves the rapid delivery or temporary equipment on a hire basis or the development of innovative solutions to the toughest chemical dosing challenges.

WES Limited
Precision House
Rankine Road
Basingstoke
RG24 8PP

Telephone: **01256 819777**
Email: **info@wes.ltd.uk**

www.wes.ltd.uk

Follow us on LinkedIn and Twitter