Pumps, the Heart of Municipal Water Treatment Facilities
Different applications call for different types of pumps, depending on the system requirements, desired discharge pressure, desired flow capacity, and available space. A typical wastewater treatment plant uses three types of pumps:

- Centrifugal pumps
- Submersible pumps
- Positive displacement pumps

Centrifugal pump

This type of pump uses centrifugal force to create sufficient velocity to move liquids. In a municipal water facility, centrifugal pumps move raw wastewater, influent wastewater, primary and secondary sludge, and effluent wastewater.

The wastewater or sludge enters the pump via the suction nozzle and encounters the impeller, a fan-like rotor fitted in a casing and mounted on a horizontal shaft; an electric or diesel motor rotates the shaft. The liquid enters through the impeller’s eye (central hole). As the impeller spins, it whips the liquid out radially, gaining kinetic energy as it centrifuges outward. The spiral-shaped casing slows down the water, converting the velocity head to a pressure head as fluid moves out through the discharge nozzle. A seal or packing rings prevent leakage.

Impellers come in three types: enclosed, semi-open, and open. The more occlusive the medium, the more open the impeller’s vanes should be.

Components of Centrifugal Pumps

Pumps are essential equipment in any system that moves fluids from point A to point B. In an organism, the heart sends wanted materials (oxygen, nutrients) to various parts of the body and carries away unwanted materials (carbon dioxide, waste). Pumps in wastewater facilities do something similar:

- Add the correct amounts of various chemicals to:
- Remove nutrients and other unwanted components
- Disinfect by killing parasites, bacteria, and viruses
- Adjust the pH to improve the taste and minimize pipe corrosion
- Fluoridate drinking water for stronger teeth
- Remove sludge from sedimentation tanks for further treatment and disposal

In distribution systems, pumps discharge water under pressure to the pipe network and lift it to a higher elevation, such as water towers.

When properly operated and maintained, pumps provide reliable, efficient service for many years.

Types of Pumps in Municipal Water Treatment Plants

Different applications call for different types of pumps, depending on the system requirements, desired discharge pressure, desired flow capacity, and available space. A typical wastewater treatment plant uses three types of pumps:
Centrifugal pumps can generate a variety of flow rates and outlet pressures, both of which are dependent on the pump’s size, the space between the impeller and the casing, and the rotational speed. Some pumps are standalone units, while others are connected in a series to generate more output pressure. In such multistage pumps, the desired pressure determines the number of stages required; each stage can achieve an output pressure of up to 250 feet.

Centrifugal pumps are popular in water treatment plants for several reasons:

- The ability to move large volumes of water at a constant output pressure
- Versatility, handling capacities from a few gallons per minute (gpm) to 50,000 gpm
- Uniform flow and output speed with pressure heads of 5 feet to 700 feet
- Functions reliably even when suspended matter are present in the water
- Simple technology and low to moderate initial costs

**Submersible pump**

As the name implies, a submersible pump is used below water level, and its primary purpose in a treatment plant is to bring in fresh water from a lake, river, reservoir, or well. It is essentially a multistage centrifugal pump in one piece of equipment. Multiple impellers, mounted on a single shaft and installed vertically, pass water up the pump. Diffusers placed above each impeller ensure that water flows vertically to the next stage. The desired output pressure determines the number of impeller–diffuser stages in a submersible pump; more stages equal greater pressure.

Driving the pump is a waterproof submersible motor powered by either the electrical grid or solar panels. The wiring is similarly waterproof.
**Positive displacement pump**
Unlike a centrifugal pump, which converts rotational energy to kinetic energy, a positive displacement (PD) pump uses the mechanical energy of a constantly moving element to transfer fluid from the pump’s cavity to its next destination. There are two basic types of positive displacement pumps: reciprocating and rotary.

**Reciprocating pumps** have a piston that moves back and forth or up and down within an enclosed cylinder. If liquid is displaced during the forward stroke only, the pump is single action; if displacement occurs at both the forward and return stroke, the pump is double acting.

The liquid enters the cylinder via the suction pipe and through a check valve. The assembly of piston, piston rod, joint, and connecting rod pushes the volume to the delivery pipe via another check valve. Since the motion is reciprocating, the positive displacement of liquid is uneven; a damper can smooth out the flow.

Most PD pumps are **rotary pumps**, where liquid is displaced out of the cavity by means of an impeller. This impeller can be in the form of a gear, lobes, screw, or blade, and moves in a smooth circular motion. The result is steady fluid displacement with each revolution of the shaft.

PD pumps are not suitable for moving large volumes of liquid, but they do excel at low-flow service, and each type has its place in water supply operations.

- Reciprocating pumps are found in applications where very high pressures are required. They are also good for pumping corrosive, abrasive, or viscous liquids, including all types of sludge and slurries.
- Rotary pumps are better suited for lower pressures due to slippage at higher pressures. Though they tend to jam if solids enter the small clearance spaces between the impeller and its casing, fluids of varying viscosities are not an issue. Rotary pumps are used for chemical dosing during various stages of the treatment process.
Monitoring Pumps for Safety, Performance, and Savings

A variety of pressure gauges and temperature sensors help plant operators monitor the health and efficiency of pumps and their motors. The instruments must be robust, as pumps work nonstop and create significant vibrations and shocks that can damage standard gauges. Pumps also operate in challenging conditions:

- High humidity
- Corrosive, abrasive, viscous, and clogging media
- Wide pressure variations
- Wide temperature variations

An easy and cost-effective way to monitor pumps is to install sensors and transmitters at critical points. By spending a few hundred dollars on measuring instruments, municipal water treatment facilities can protect an expensive pump from serious harm caused by cavitation, dry running, and other incidents.

Pressure instruments for pumps

Pressure gauges and sensors at suction and discharge nozzles, delivery pipes, release valves, control circuits, and other locations on a pump help monitor the equipment’s condition and ensure that it’s operating properly.

Pressure at the suction side, to prevent cavitation

Cavitation is the generation of vapor bubbles, which occur in high-velocity liquids. When these bubbles collapse, the result is pressure spikes. Cavitation can also occur if the local pressure drops below the vapor pressure of the liquid and then rises above it. To avoid this condition, the net possible suction head available (NPSHa) has to be greater than the net possible suction head required (NPSHr).

Monitoring the suction head (pressure in terms of water column) can help identify problems that damage pumps. The A-10 pressure transmitter features a piezoelectric sensor or thin-film technology, making it highly resistant to pressure spikes and vibration. It has an all-welded stainless steel measuring cell and does not need any soft sealing. A variety of available electrical process connections meets the requirements of almost any application.
Pressure at the discharge side, to ensure proper operations
Both underpressure and overpressure on the outlet side reduce a power plant's efficiency. All XSEL® models – 21X.34, 23X.34, and 26X.34 – feature a Bourdon tube design and movement with hardened components that reduce stress and wear. The innovative XSEL® process pressure gauge exceeds pressure gauge performance testing standards ASME B40.100 and EN 837-1. And it's safer, too: The XSEL® has a fire-resistant case according to flammability rating UL 94, V-0 test procedures. All XSEL® process pressure gauge movements are Swiss made, producing the most precise and reliable movements available today. WIKA’s industry-best warranty on all XSEL® process pressure gauges include a standard five-year warranty on the pressure gauge and a 10-year warranty on the pressure system. The XSEL® process gauge sets a standard of value as well: It is an economical solution for most processing applications since it reduces downtime from having to regularly replace worn-out instruments.

Designed for Safety
Even the highest-quality pressure gauges can fail. That's why processing plants require gauges with a safety case design. In order to protect workers, a gauge must have a solid front with a blowout back. In the event of a failure, the gauge’s internal components and media would be safely ejected out the back of the case – away from anyone reading the gauge pressure.
Eight main reasons for pressure gauges failure

Mechanical pressure gauges are often exposed to challenging operating conditions. These conditions can shorten the service life and, in extreme cases, cause early failure of the pressure gauge. The following are the most common reasons why pressure gauges fail:

1. **Vibration.** Extreme vibrations affect the gauge internals and can cause Bourdon tube fracture and media release. Signs of gauges affected by vibrations are severe, erratic pointer flutter; metal shavings collected inside the case; and a detached pointer.

   Solution: Cases with glycerin case fill will dampen and lubricate all delicate internal parts, and also prevents environmental ingress.

2. **Pulsation.** Severe pulsations/pressure cycles increase the wear of internal components and also causes pointer flutter, making it difficult to read the pressure.

   Solution: A restrictor or snubber will reduce and/or dampen the impact of pressure cycles and pressure spikes. Case filling in combination with a restrictor is also recommended.

3. **Pressure spikes.** In a treatment plant, common sources of pressure spikes are the rapid opening and closing of valves, and turning pumps on and off. A broken or bent pointer, caused by the pointer repeatedly hitting the stop pin, is a sign that the pressure gauge has been exposed to pressure spikes.

   Solution: Accessorize the gauge with a restrictor, snubber, or – even better – an external overpressure protector, which will prevent any pressure from entering the gauge internal past the set point.

4. **Overpressure.** This is when pressure gauges operate past their full scale. Extreme overpressure can cause the gauge’s Bourdon tube to rupture and release media. Two signs that a gauge has been exposed to overpressure: a severe pointer shift and a pointer pegged against the stop pin.

   Solution: Be sure to choose a gauge with the correct pressure range based on the operating conditions. An overpressure protector also shields the gauge from unsuspected overpressure conditions.

5. **High media temperature.** Discoloration of the case fill, window, or dial face is a common sign that hot media has entered the pressure system and heated the gauge above its operating limits. Extreme temperatures can cause the pressure system to fatigue and rupture.

   Solution: For steam applications, accessorize the gauge with a steam siphon. For other high media temperature applications, we recommend the use of a **diaphragm seal** with a capillary or cooling tower.
6. **Corrosion.** When the wetted parts of a pressure gauge are made of materials not compatible with the process media, the result is internal corrosion. Corrosion creates pin holes inside the pressure system, resulting in media release.

Solution: Make sure the gauge’s wetted parts are made of materials that resist the process media. For very aggressive media, we recommend the use of a diaphragm seal to separate the instrument from the process media. Of course, this protective barrier should also be made of special materials that are compatible with the process media, such as Hastelloy or tantalum.

7. **Clogging.** The socket inlet bore (orifice) can be obstructed by either highly viscous, crystalizing media or by particles or solids. Clogs prevent the gauge from reading pressure.

Solution: To prevent clogs from occurring, use a pressure gauge or diaphragm seal with a large process port (e.g., open flange or female threads).

8. **Lack of general maintenance.** Gauges become damaged due to abuse, neglect, or length of service. Always repair or replace gauges with any of these following conditions: loss of case filling, broken window, missing plug, water collected inside the case.

Solution: Implement a service schedule for your mechanical gauges. The interval between servicing depends on the critical nature of the application.
Differential temperature and pressure between the suction and the discharge fluid, to assess pump efficiency

To make sure a pump is working at optimal capacity, technicians can place highly accurate temperature sensors and pressure transmitters at both the suction and discharge sides. If the pump isn’t operating as efficiently as it can be, there will be a drop in pressure and temperature. This is thermodynamic monitoring, which does not require measuring the actual flow rate to determine efficiency.

The A-10 pressure transmitter is precision engineered for excellent performance. The standard model has a non-linearity (BFSL) of $\leq 0.5\%$ of span, and there’s an option for $\leq 0.25\%$ of span. This versatile and rugged transmitter can withstand a wide range of temperature and pressure conditions, as well as the extreme shock and vibrations found in power plants.

The TR10 series of RTD sensors can be mounted into a thermowell, or directly into the process with a spring-loaded compression fitting for easy installation and replacement. The TR10 has the option of a transmitter to convert the resistance signal into an analog or a digital output, which can be easily customized to a variety of conditions.

Differential pressure at filters and strainers, to assess debris accumulation

If pressure drops at the discharge side, that’s a good indication the strainer or filter needs to be cleaned or replaced. Monitoring the pressure differential between the inlet and outlet of a pump can also indicate overall efficiency and help identify conditions where cavitation is likely to occur.

The SP007 differential pressure transducer is fully configurable. Users have a choice of six pressure ports, five electrical connections, and a voltage or current output to match the needs of their applications. The SP007 has a standard accuracy of 0.25% and an optional high accuracy of 0.1%.
**Temperature instruments for pumps**  
Resistance thermometers (RTDs) on pumps and motors help detect changes in temperature that can warn operators of potentially dangerous and costly issues.

**Temperature at the bearings, to prevent overheating**  
A change in the bearing temperature of a pump and/or motor can indicate a developing failure or a change in loading. The compact TR58 bearing RTD sensor is designed for areas where space is an issue. It uses thin-film technology and responds extremely fast. With no moving parts, it is vibration resistant and perfect for measuring temperature in thrust bearing plates, shafts, and motor windings. The TR58 can be spring loaded into the bearings’ housing or held in position with a high temperature epoxy resin.

**Flow instruments for pumps**  
A pump is “dry running” – in a nearly empty pipe condition – when the suction side doesn’t receive enough fluid. When the pump operates with no flow at all, it is “dead-headed.” Both conditions can cause the pump to overheat and fail.

**Flow at the suction side, to signal low fluid levels**  
Ideal for monitoring cooling systems, the FSD-4 electronic flow sensor offers full flexibility in controlling flow based on a liquid’s velocity. The switch points are easy to configure using the 3-button instrument panel and large LED display, or with the IO-Link option. This advanced flow sensor has analog output signals and two digital switches, one of which can be programmed for temperature switching. There are no moving parts, which means the FSD-4 won’t ever suffer from wear and tear.
Wireless Sensors: Option for Efficient Predictive Monitoring and Maintenance

Wireless sensors are fast to install and do not require pulling wires or conduit to add additional sensing capabilities for predictive maintenance. Wireless motor and pump monitoring sensors typically offer a combination of vibration, temperature, pressure, and electric current draw. A change greater than 50% above the baseline readings is an effective predictor of future failure, giving the operator several weeks of advance notice.

Wireless motor and pump monitoring

Wireless sensors can support multiple sensors – vibration, temperature, electric current draw – with one transceiver node.

Wireless sensors for pressure and temperature monitoring

Wireless sensors can power and interface with standard industrial pressure transducers, thermocouples, and PRT/RTD temperature sensors.
WIKA, Smart Sensors for Municipal Water Facilities

WIKA is a leader and trusted partner for measurement solutions in wastewater treatment plants, and our product specialists understand the vital role that pumps play in municipal facilities. Contact us to help you select the right pressure and temperature instruments that will maximize the efficiency and prolong the service life of industrial pumps.

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