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**WASTEWATER TREATMENT METHODS**

# Why evaporation is an effective wastewater treatment alternative

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*Even though powder coating is a relatively clean process, contaminants can crop up during surface preparation when oil and other metal soils wash off parts during pretreatment stages. These contaminants then become wastewater. This article addresses various methods of wastewater disposal and explains why evaporation is one of the most effective, long-term solutions for eliminating regulatory complications. The article also discusses two primary evaporation techniques—thermal and atmospheric.*

In powder coating, as in virtually every metal coating process, pretreatment of the metal is an essential method of enhancing coating adhesion and corrosion protection. Pretreatment typically includes phosphate coating, a process that can involve anywhere from three to seven stages, depending on the end user's requirements. Each stage consists of either a chemical bath or a rinse bath. As parts pass through these baths, the solutions become contaminated and must eventually be replaced. This can be done by periodic dumping, or in the case of rinses, continuously bleeding off, a process referred to as a *running rinse*.

Although the pretreatment chemicals may be environmentally harmless, the contaminants coming off the parts—especially oils and heavy metals—may render the wastewater unsuitable for discharge to the drain. In many cases, this wastewater can be treated to remove contaminants, allowing discharge to the sewer. However, local regulations can make this difficult, especially if certain contaminants have very low allowable limits. More commonly, the company generating the wastewater may not have access to a public sewer system, or the company may prefer not to send wastewater to the drain.

Today, many companies consider wastewater a problem that can create cost and liability issues affecting the organization and its management. Consequently, as with other management concerns, companies need to carefully assess the options for wastewater management to select the best long-term solution to the problem. Such corporate focus is necessary because environmental compliance is a significant challenge to any company's future.

### Handling wastewater disposal

There are two initial steps companies can take to help reduce their wastewater disposal volumes:

**Generate less wastewater.** Companies should focus on controlling manufacturing variables that can directly reduce wastewater generation. But there is a caveat: Manufacturers should be careful that their waste-reduction efforts don't create critical and negative manufacturing issues or erode product quality. The pursuit of environmental compliance shouldn't become the disposal tail that wags the production dog.

**Recycle wastewater.** Recycling is a good approach for wastewater reduction of some very specific and extremely large streams. However, recycling is a complex, ever-changing, chemical balancing act, with many limiting factors. The potentially negative impact that recycling can have on a company's core business—manufacturing quality products—is of equal importance.

After the prudent first steps of reducing and recycling wastewater, a company inevitably has to deal with its disposal. Before evaporation became an option, the accepted disposal technologies still required additional sewer discharge, or clients hauled the entire volume off site. However, these two results increased—and today continue to increase—a company's exposure to the evertightening environmental regulations and associated costs.

In addition, companies often think that outside authorities are wielding control over their manufacturing objectives, as well as their wastewater disposal. As local laws eliminating industrial wastewater from the sewer change, oftentimes overnight, sewer discharge becomes, at best, only a short-lived disposal solution.

When sewer discharge or surface discharge isn't possible, or when companies want to avoid it, there are normally three options for handling the remaining wastewater generated by manufacturing plants:

**Off-site disposal and hauling.** Hauling off-site appears attractive because it requires no investment in capital equipment, and the costs are easily identifiable. You pay as you dispose. However, the costs are typically high, as are the liabilities associated with it. The company is forever held responsible and liable for the wastewater it generates, a situation known as cradle-to-grave. This risk is potentially staggering. Consequently, because of costs and risks, most companies today don't consider hauling a long-term solution to their wastewater disposal problem.

**Physical and chemical separation.** Available separation technologies include ultrafiltration, reverse osmosis, ion exchange, filtration, flocculation, emulsion breaking, pH adjustment, and full waste treatment. All of these processes include two steps.

***Step one.*** The first step tries to selectively remove unwanted contaminants from the wastewater. In the process, it creates two separated waste streams: the clean water, presumably sewer compliant; and the concentrated waste.

***Step two.*** The second step involves disposing of the two waste streams. The concentrated stream must be hauled off site or handled with a secondary operation—often evaporation—at the plant. The larger clean stream—presumably sewer compliant—is sent to drain and must meet local sewer regulations.

Because separation technologies don't eliminate the difficulties inherent with sewer discharge, they're often considered short-term solutions.

**Evaporation.** Evaporation disposes as it separates, in one simple step. Thus, evaporation eliminates sewer discharge accountability forever and keeps your company's wastewater disposal within your control.

Because evaporation is flexible enough to simultaneously handle multiple waste, you have an adjustable and versatile disposal method that can accommodate tomorrow's manufacturing or disposal changes with little impact on your organization. You no longer have to base your production decisions on environmental limitations.

### Choosing an evaporation technique

Once you've determined that evaporation is the most suitable technology for your wastewater disposal, you have a choice of two primary alternative evaporation techniques to reduce the water: thermal or atmospheric.

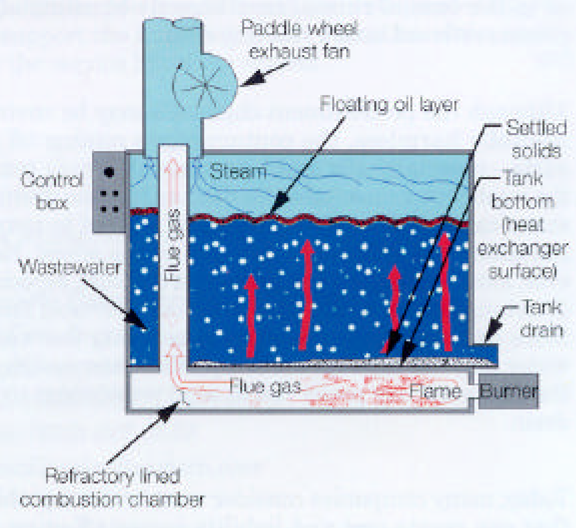
**Thermal evaporation.** Thermal evaporation relies on the boiling of wastewater at atmospheric pressure. This is a fairly simple process. However, various types of thermal evaporators have distinct and important design differences that can dramatically affect efficiency, performance, maintenance, safety requirements—and therefore, operation costs. Because the evaporative rate depends on the introduction of heat into the wastewater, thermal evaporation has the potential to be the most consistent and reliable type of evaporation. The common sources of energy are natural gas, propane, steam, or electricity. Natural gas is the most prevalent source and is found to be quite cost-effective.

Thermal evaporation can be further broken down into the following subcategories:

***Bottom heated.*** A bottom-heated design works by applying heat directly or indirectly to the bottom, and sometimes sides, of a metal tank, thereby bringing the wastewater to a boil. This is somewhat analogous to a saucepan on a stove. Usually a refractory lining directs the heat. In this design (see Figure 1), the tank bottom becomes the heat exchanger, and the solids—suspended or dissolved—fall and accumulate directly on the heat-transfer surface of the tank bottom.

**FIGURE 1**

**Bottom-heated evaporator**



***Submerged combustion.*** The use of submerged combustion has been documented as a heat source for more than 50 years, although it hasn't gained wide acceptance as a general heating method. The design (see Figure 2) requires that flame and exhaust gases be turbulently driven through a sparger tube, under the liquid's surface, into the ever-changing mixture of wastewater. The by-products of combustion then transfer their heat as the bubbles surge to the surface. Because of this design and other operational issues, the evaporation must occur in a tightly sealed vessel, which can make maintenance somewhat involved. Another inherent issue in the design is foaming, which can be controlled via expensive antifoam additives.

***Immersion heating.*** Similar in design to time-tested process tanks and boilers, a heat exchanger serpentines through the water within a tank (see Figure 3). Because the heat exchanger is tubular and elevated, solids fall harmlessly past the heat exchanger to a sloped tank bottom designed for solids accumulation. This design reduces the possibility of solids coming in contact with the heat transfer surface, thereby ensuring consistency in the efficiency and evaporative rate of the unit. This elevated, tubular design is superior to a flat, horizontal, box-type heat exchanger suspended across a tank's interior. This style allows solids to fall and accumulate directly on the heat exchanger's horizontal surface. In addition, the box impedes accessibility to the tank bottom for solids removal.

**Atmospheric evaporation.** Atmospheric evaporation relies on the capacity of the ambient air to hold moisture and the rapid removal of that moisture-laden air to the atmosphere. Atmospheric evaporators operate at room or slightly elevated temperatures, making them highly dependent on the variable relative humidity of the ambient air. Normally, an atmospheric evaporator will spray the wastewater onto a contact medium with a high surface area. A high-volume airstream then passes through this medium, allowing the airstream to be humidified and then carried away (see Figure 4). The air or the water usually must be heated to increase the capacity of the air to hold the moisture.

Because of the spraying action, the wastewater must be fairly clean to prevent the clogging of nozzles and contact medium. This may require filtration of the wastewater before it's evaporated. Oily waste streams may also become an issue.

**FIGURE 2**

**Submerged combustion evaporator**

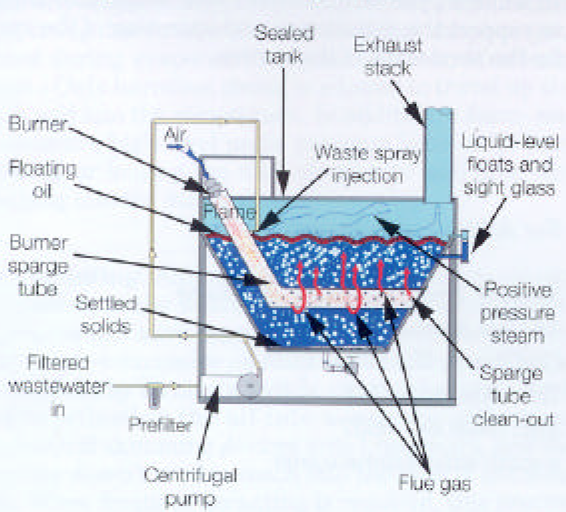



**FIGURE 3**

**Immersion-heating evaporator**

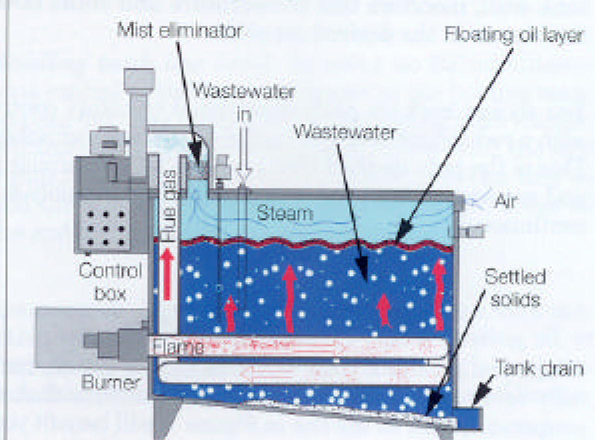
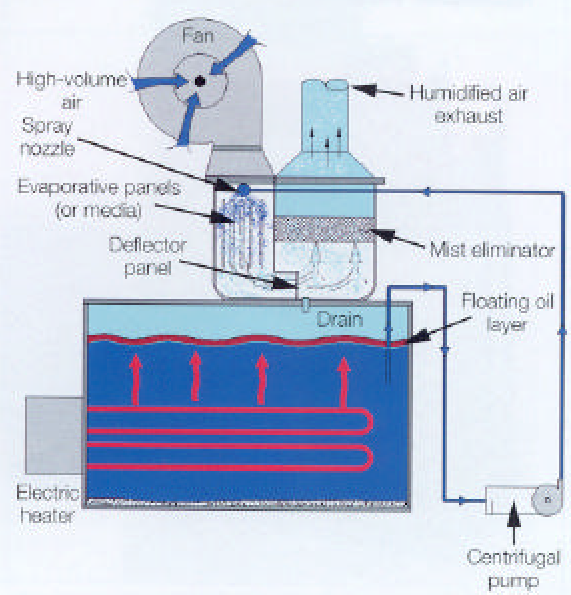



**FIGURE 4**

**Atmospheric evaporator**



Any evaporator should incorporate a mist removal system that reduces the potential discharge of mist droplets to the atmosphere. This system should provide the following:

- Containment within the evaporator of 99 percent of droplets as small as 10 microns
- Proper surface area and compression fit, regulating velocity and preventing blow-through and blow-by
- Proper operating levels, allowing fallback of mist droplets
- Foam-level probe, keeping foam from entering the mist eliminator
- A mist pad that's not designed for use as a foam breaker
- Combustion gases that don't enter the mist eliminator, protecting combustion efficiency
- Maintenance ease

## Integrating the evaporator in house

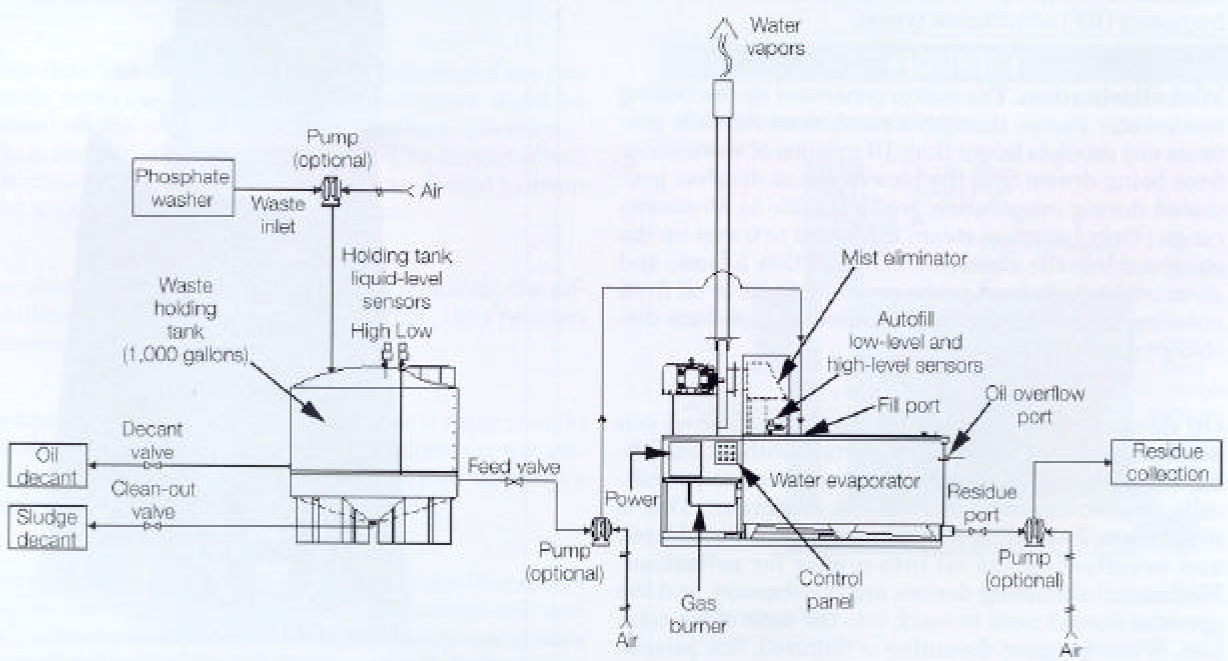
For a successful installation, clients and suppliers should consider not only evaporator specifications, but also clients' overall requirements. By doing this up front, clients and suppliers can solve many problems earlier and at a lower cost than if they waited. Critical elements to a successful installation include, among other variables, the following:

- Fluid handling of various wastewaters to a central holding tank
- Automatic feed from the holding tank to the evaporator
- Selection and sizing of process holding tanks and residue tanks (pre- and post-evaporator)
- Integration of evaporator system within available plant floor space
- Automation of various elements of evaporator system if appropriate
- Use of existing plant components—for example, tanks and pumps—for cost reduction
- Integration, if applicable, with recycling or physical separation systems (ultrafiltration, ion exchange, reverse osmosis)

**Typical evaporator system.** Although there are almost as many different configurations for wastewater evaporation systems as there are unique plant locations, most layouts are similar to that shown in Figure 5.

**FIGURE 5**

Typical water evaporator system



The wastewater from multiple waste streams is normally fed into a single large waste holding tank. This tank simplifies the removal of floating oils and settled solids from the wastewater. The waste holding tank usually has a low-liquid-level sensor that stops the feed pump when the tank is empty. When required, a high-liquid-level sensor signals when the tank is approaching highest capacity.

The evaporator operates automatically, feeding itself from the holding tank until the end of the evaporation cycle. The automatic fill control on the evaporator continually regulates the feed of wastewater to the evaporator. If the holding tank runs out of liquid, the low-level control interrupts the feed to the evaporator, and the evaporator boils down until its low-level control shuts off the burner. As more wastewater enters the holding tank, the liquid level in the holding tank rises, automatically activating the feed pump. When the level control in the evaporator senses the correct liquid level, the evaporator automatically goes back on line.

At the end of the cycle, an operator opens the evaporator drain valve, starts the drain pump, and empties the residue into either a holding tank or drums for proper disposal. This is routinely the only operator involvement required for a washer and phosphatizing operation.

## Using controls and safeties

The following controls and safeties are recommended for most evaporator systems:

**Automatic fill control.** In most evaporator wastewater systems, having the wastewater fed automatically from a holding tank to the evaporator is advantageous. This eliminates the need for operator involvement during the evaporation cycle. Use level controls that can distinguish between oily waste, floating oil, and foam (radio frequency [RF] admittance types).

**Mist elimination.** The steam generated by the boiling wastewater passes through a mesh material that prevents any droplets larger than 10 microns of wastewater from being drawn into the blower. (Most droplets generated during evaporation are in the 25- to 50-micron range.) Only harmless steam is allowed to travel up the stack and into the atmosphere. In addition, a foam- and oil-sensitive high-level probe prevents foam or oil from entering or fouling the mist eliminator and from discharging into the atmosphere.

**Oil decanting.** Although a fair amount of free oil can accumulate at the wastewater surface without inhibiting the evaporative process, you may need to periodically remove excessive oil from the evaporator. This is simply done by turning a switch, raising the liquid level, and overflowing the oil into a weir for collection. Mechanical skimming devices aren't necessary, and the operator doesn't need to reach into the tank of hot solution. When frequent decanting is required, this process can be easily automated.

**Residue removal.** Eventually, you'll want to remove the concentrate of the evaporator for disposal. The evaporator should shut down automatically when it's time for this procedure, based on boiling temperature or operation hours at boiling temperature. This simple operation, typically taking 30 minutes, involves pumping out the residue from the evaporator, inspecting and refilling the unit, and restarting a new cycle with new wastewater. Figure 6 shows the interior of an evaporator tank.

**Level controls.** RF admittance sensors should be used for level detection. Because of their unique adjustable sensitivity capabilities, sensors can either ignore or detect oil, and are also able to detect foam, which other sensors can't do. Although these sensors may cost more than other types, they do the job necessary for the evaporator to operate safely and with minimal operator attention. Following are examples of the different uses of RF admittance sensors in an evaporator system:

***Holding tank low level.*** By using an RF admittance level control as the low-level sensor in the holding tank, you can hold any floating oil in the holding tank without it transferring into the evaporator. At low level, the feed pump is disabled when the interface between this oil and the wastewater, or emulsified oily water, drops off the end of the sensor.

***Evaporator high level.*** When adjusted to a very sensitive setting, this sensor detects water, floating oil, or foam. If the unit is taken off-line by this high-level control, the operator decants oil or handles foam following

**FIGURE 6**

Evaporator tank interior

instructions provided by a technical service engineer. A float-type device or tuning fork can't reliably detect foam or distinguish between water and oil.

***Evaporator low level.*** This sensor protects against straight floating oil coming in contact with the heat exchanger. By sensing the oil and emulsion interface, the control shuts the evaporator off when the water or emulsified oily water drops off the end of the low-level sensor. If there's a floating oil layer, it's prevented from coming in contact with the heat exchanger. Tuning forks, conductivity, or float-type level sensors can't detect an oil layer.

**Temperature controls.** The temperature of many types of boiling wastewater in an evaporator rises as the concentration increases. This is permissible, up to a point. A thermostat, mounted externally against the tank wall, monitors this temperature and shuts down the burner at the desired set point.

You should back up each operational or safety control with a redundant safety device of a different technology. This is the only method that provides true redundancy and assurance that your system will operate safely and continuously.

## Evaluating your needs

When you evaluate your waste reduction needs, carefully review your alternatives. If you conclude that an evaporator, such as the one in Figure 7, will benefit your situation, look for a system supplier you think you can partner with and an evaporator designed and manufactured for these strengths:

**FIGURE 7**

Wastewater evaporator

- High efficiency at fixed energy rate, with consistent evaporative throughput
- An evaporative rate independent of humidity, temperature, or the presence of solids or oils
- High-quality components designed for reliability in a harsh boiling environment
- Redundancy, with different methodologies, in operational and safety sensors
- A control system with a complete diagnostic easily understood by the operator
- Low maintenance, with convenient removal of solids and oil
- Little, if any, pretreatment required before evaporation
- Foam detection, prevention, and control
- Integral mist eliminator for containment of mist droplets in the evaporator
- Isolation of combustion products from the tank interior and operator exposure
- Installation flexibility, from basic stand-alone design to an integrated, automatic system

As you begin the process of selecting an evaporator expert, it's critical that you learn about the equipment *and* the manufacturer. Multiple resources can help you with this: clients and users, visits to the manufacturer, environmental and engineering consultants, technical articles, magazines, and advertisements. During your review, make sure each potential supplier offers, and can supply, at minimum, a high-quality thorough pilot test, process analysis and design recommendations, regulatory assistance, technical service, and aftermarket support.

In addition, you should expect your evaporator supplier to support the installation and operation of the system for the service life of the system. **PC**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