TANKS, REACTORS and other vessels can be cleaned in many ways. However, use of automated clean-in-place systems has increased rapidly. That’s because automated devices clean more thoroughly than other methods, dramatically reducing or eliminating risk of cross-contamination caused by product or cleaning-chemical residue.

Automated cleaning provides other benefits as well:
• faster return to service of vessels — downtime can be reduced by as much as 90%;
• decreased water and chemical use;
• lowered wastewater disposal costs;
• improved safety because workers no longer have to enter tanks; and
• better staff productivity because people can be deployed to other tasks.

The decision to automate is easy — a plant usually can recoup the cost of an automated system in the first few months of operation through reduced chemical and water costs and increased production. However, determining the best cleaning equipment can be hard. If vessels are large, have obstructions such as mixing paddles, and contain sticky, flammable or toxic residues, selection can get challenging. So, this article offers some guidelines to help you choose the most appropriate equipment for your operation.

THE STARTING POINT
Before you begin evaluating cleaning equipment, you must understand your cleaning requirements.

Residue. First, assess the residue to determine what’s required to remove it. Is the substance sticky or easily cleaned? Can a cleaning liquid dissolve it? If not, what level of impact is needed to break it up and wash it away?

(Cleaning equipment vendor can use computational fluid dynamics modeling to determine the flow rate, operating pressure, coverage and the position of the spray head for complete cleaning of the vessel and any permanently installed equipment.)

Cleaning agents. Once you understand the residue’s characteristics, you can sort out which cleaning agents to use. Chemical additives typically are employed to remove contaminants, improve tank wetability and reduce foam. Heat can boost the cleaning action of many water-based detergent chemicals.

Vessel size. Interior surface area and distance between the walls substantially affect selection. Evaluate the spray distance, usually measured in terms of the vessel diameter, but also consider vessel length and height. For example, for a 20-ft.-dia., 40-ft.-long vessel, use two vessel cleaners that each can handle up to 20 ft. or a single vessel cleaner that can handle up to 40 ft. You may need multiple nozzles if the spray can’t reach a part of the vessel due to internal obstructions such as an agitator (Figure 1).

Impact. The level of impact needed to thoroughly clean vessels depends on the residue, cleaning chemicals and water temperature. Hard-to-clean residues require greater impact. The theoretical spray impact, I, equals $K Q P^{1/2}$ where $K$ is a constant, $Q$ is flow rate and $P$ is liquid pressure.

If you’re not certain how much impact is needed, a cleaning equipment vendor should be able to provide guidance and impact data. Some manufacturers will conduct tests in their spray labs with your specific residue to optimize
cleaning performance. Another option is a short-term lease on
a pumping system and vessel cleaner, so you can evaluate the
equipment in your production environment. Some vendors also
offer no-obligation equipment trials.

**Safety.** Is the residue, cleaning solvent or environment toxic
or flammable? The answer will significantly influence the type
of equipment you choose.

Once you understand your cleaning requirements, the next
step is to evaluate the cleaning equipment. So, let’s look at
what’s available and the pros and cons of each option.

**THE TYPE OF POWER**
The first decision is whether to use a machine powered by fluid
or a motor.

- Fluid-driven cleaning machines use fluid to spin a turbine
  that powers a gear set (Figure 2). The nozzle assembly rotates
  as the hub revolves around its central axis. The higher the
  liquid pressure and flow, the faster the rotation.
- Motor-driven cleaning machines rely on an external elec-
  tric or air motor to drive the nozzle assembly (Figure 3). The
  nozzles revolve around the central axis of the nozzle assembly.

Both machines operate at high pressures, provide 360°
cleaning coverage and suit large vessels (up to 100 ft. dia.). They
often offer comparable cleaning performance. However, there are
several operational differences.

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**Clogging.** A fluid-driven machine is more prone to clogging.
As fluid passes through the device, debris can accumulate in the
internal flow passages or get caught in the gears. When this hap-
pens, the machine stops working because the gears no longer can
rotate. Verifying operation is crucial but can be challenging —
it’s difficult to visually observe the inside of a large vessel.

A motor-driven machine will continue to operate even with
debris in the nozzles. The external motor ensures continued rota-
tion and cleaning. Plus, you easily can hear the sound from the
motor and verify operation without having to inspect the vessel.

If you’re using less than pristine water and it’s difficult to see
inside your vessel, a motor-driven machine is a better choice.

**Cleaning cycle time.** If short cleaning cycles are a priority, con-
sider a motor-driven unit. Using an electric motor, cycle times
remain constant regardless of operating pressure and flow rate.
With an air motor, you can increase air pressure to make the
nozzle hub rotate more quickly.

Figure 1. The size of a vessel or internal obstructions may
require use of multiple nozzles for effective cleaning.
Fluid-driven machines can achieve comparable cycle times to motor-driven machines by raising pressure. However, operating at higher pressures increases wear of internal parts and results in more frequent maintenance. 

*Sparking or explosion risks.* Explosion-proof electric motors are available or you can use an air motor. Or you may be able to change cleaning solvents to eliminate the explosion hazard without negatively impacting cleaning. Other options include increasing humidity in the vessel to minimize the risk of static electricity, prevent complete drying of the residue and ease residue removal.

**OTHER CONSIDERATIONS**

Fluid-driven machines generally cost less than motor-driven ones, although the cost depends upon the size of the machine. However, fluid-driven machines have many internal parts and disassembly, replacement and reassembly of worn parts can be time-consuming. In some cases, maintenance requires a special tool kit. Factory refurbishing usually is recommended based on hours of use.

Motor-driven machines require minimal maintenance and are serviced easily by the user. The motors are positioned outside the tank, ensuring long life and minimal exposure to harmful solvents.

Which is a better choice? Fluid-driven machines usually cost less. Motor-driven machines are less expensive to operate and maintain. The specifics of your operation such as water quality and hours of use will determine which is more cost-effective.

If you’ve determined that a motor-driven cleaner is your best choice, you must select between two types:

1. Machines with nozzles in a fixed position. These can be permanently installed or moved from vessel to vessel but the cleaning head is in a fixed position on the unit. Maximum operating pressure is 5,000 psi. Various types of motors are available and users specify extension length, flange size and a two- or four-nozzle hub.

2. Machines with retractable nozzles. These permanently installed units offer a higher level of automation (Figure 4). A pneumatic mechanism inserts and retracts the extension and the cleaning head. A control panel allows setting multiple stopping points between full insertion and full retraction to position the nozzles where more impact is required or to clean around obstructions. The control panel can be located away from the vessel for convenience or safety. Maximum operating pressure is 4,000 psi.
The properties of the residue or the cleaning agents and your desired level of automation will determine which option is best for your operation.

**PERFORMANCE VALIDATION**

Once you’ve selected and installed a new cleaning machine, how do you know if it’s doing its job?

Visual inspection is one option. Monitor the machine to make sure it’s working and inspect the inside of the vessel when the cleaning cycle is complete. Swab or riboflavin tests are common ways to verify cleanliness. Of course, the viability of these approaches depends on the size and location of your vessel.

Another option is using an acoustic monitoring device (Figure 5). A sensor mounted to the exterior of the tank “listens” to the performance of the cleaning equipment and identifies variations from a predetermined baseline. It instantly can detect rotation failure and changes in rotation speed or spray pressure and can notify operators via audible or visual alarms. The monitoring device also transmits performance documentation for quality control and record keeping. It obviates visual monitoring and post-cleaning tests.

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