

# CIP Pumping Systems: Mixing the Old and New

By John H. Horwath

**Klenzation® Tank Washing Systems Can Readily Be Adapted To Any Type of Plant Layout Without Special Engineering**



**WASHING COLD MILK LINES**

The Klenzation Tank Washing System is designed and built to accept existing equipment enabling the user to easily convert the system for washing cold milk lines. This can be done at a modest cost.

**KLENZATION® DETERGENTS AND SANITIZERS**

Klenzation Liquid Alkaline Detergents are the result of years of Klenzade research and development work under field conditions. Specially formulated for Klenzation Washing Systems, these products are highly concentrated compounds, exhibiting extra efficient detergency with water conditioning properties and excellent rinsability. No waste, no dirt, no manual washing. Concentration of 30 gal.

Klenzade Liquid Sodium Hypochlorite, long acknowledged as the leading sanitizer in the dairy industry, is used for sanitizing Klenzation Alkaline Detergents to increase detergent action.

Klenzade Liquid Sodium Hypochlorite may also be used under controlled conditions for a sanitizing rinse if desired.

Klenzade Star-Bac quaternary ammonium compound can also be used as a sanitizer by adding an additional metering pump.

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Pumps designed for today's clean-in-place systems are a far cry from the general purpose industrial units first introduced during the 1940s in dairies to replace what was previously a totally manual process. The then new procedure employed tanks, piping, valves, spray balls and pumps. CIP systems also used more effective acid and chlorine detergent blends developed by the chemical industry. These blends improved cleaning capability immeasurably. In addition to provid-

ing a cleaner system, there was a huge cost savings since manual labor constituted as much as 50% of the total milk cost from farm pick-up to distribution of the product.

In 1953 the first 3-A<sup>1</sup> Standard for CIP cleaning was published. Minimal requirements established for satisfactory application included a suggested cleaning procedure. Since its conception in the dairy industry, the basic procedure has been modified and accepted in other industries:

1960s Food and beverage  
1970s Pharmaceutical and chemical  
1980s Cosmetics and biotechnology

Designing a CIP process involves consideration of materials and methods of construction, specialized cleaning equipment, and processing equipment design that is conducive to CIP cleaning. A first generation permanently in-stalled storage tank and tanker washing system is shown in Photo 1.

The first CIP recirculating units were portable and generally consisted of a small tank, pump, regulator and a return line recorder mounted on a dolly. Hoses connected the recirculating unit to the piping circuit or to a spray line. This permitted effective cleaning, but

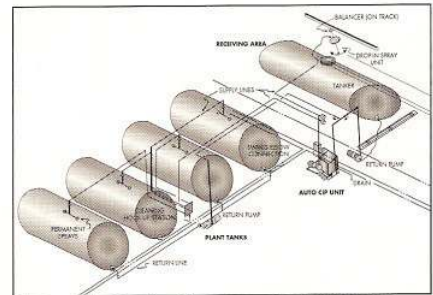


Figure 1. Basic diagram of a latter-day CIP system

the labor cost saving was insignificant because the portable arrangement could not be automated.

Permanently installed CIP supply return piping was an integral part of the first single automatically controlled recirculating unit. Introduced in the 1960s, this arrangement featured several important improvements:

- elimination of human error
- improved safety of personnel
- greater productivity
- less maintenance
- reduced costs

Figure 1 depicts a basic diagram of a latter-day CIP system incorporating supply/return piping for cleaning four in-plant tanks and an individual mobile tanker in a receiving area. Check valves in the system provide continuous movement of flush, wash and rinse solutions from the return pumps back to the recirculating unit. Solution supply to the sprays is controlled by one air-operated valve and a u-bend position on a cleaning hook-up station. Return flow from the tank is accomplished by installing a removable elbow between the tank outlet valve and a permanently in-stalled return header to the pump. Note that

<sup>1</sup> 3-A Standards refer to those Standards for the design, installation, operation and cleaning of dairy processing equipment as developed jointly by 1) the International Association of Milk, Food and Environmental Sanitarians, 2) the U.S. Public Health Service (FDA), and 3) the Dairy Industry Committee.



tankers are cleaned with a drop-in spray nozzle supplied by a hose, and the tanker return flow is through a hose to a permanently mounted return pump.

## The CIP Pump

As clean-in-place operations grew more sophisticated, so did the specifications governing the pumps. Interestingly, however, neither the flow requirement nor the specified head have changed significantly in the last 40 years for the majority of services. Typically, flow rates for individual spray heads range from 5 to 200 gpm, with operating spray nozzle pressures as low as 5 psig and as high as 60 psig. A minimum flow rate of 5ft/sec is considered desirable through most pipe lines. Cleaning agents commonly used include alkaline compounds, acidic compounds, water (hot and cold rinses), water conditioners and wetting agents (surfactants).

Most dairy, food and pharmaceutical equipment can be effectively cleaned with a solution that is 99.5 to 99.75% water. Chemicals (liquid or dry form) make up the remainder. While lines are pressure washed, processing and storage vessels are sprayed with the solution generally on only the upper surfaces, with the liquid then cascading down the sides of the vessel chamber. Recirculation is essential to maintain economic operation for high volumes of solution that must be brought into contact with the soiled surfaces for periods of time ranging from 5 minutes to 1 hour or more.

Because of pressure requirements, 3500 rpm centrifugal pumps are used to deliver the cleaning and sanitizing solutions to the spray balls. Low head units running at 1750 rpm can be employed as return pumps. However, there are occasions where the higher head 3500 rpm units may also be used in return circuits. Some CIP installations utilize a gravity or eductor arrangement to return the solution back to the tank. When air-bound problems occur in return lines, modifications can usually be made in the system or pump to alleviate the condition.

The Net Positive Suction Head (NPSH) available for the supply pump is a critical design consideration in a CIP suction system - particularly when CIP fluids are heated (raising their vapor pressure perceptibly) to the point that temperature can become the predominant factor in the NPSH available. To avoid suction cavitation, the system NPSH available at the highest liquid

pumping temperature and lowest suction level must be equal to, or greater than, the pump's NPSH requirement at the intended point of flow.

The solution contact surfaces are usually stainless steel (300 series) with surface finish dependent on how the part is manufactured. Wrought product resulting in a fabricated or stamped component has more stringent finish specifications than that of a component manufactured from an investment casting process per the 3-A standard.

Today pump manufacturers offer a variety of designs and surface finishes for CIP pump applications, ranging from an all-cast surface finish to an all-polished surface. In between this range, pumps are available with inside polished and an outside cast surface, or the opposite - a cast inside and a polished outside to maintain uniformity of appearance in the exposed areas (Photo 2). Non-polished interior units can be furnished with cast enclosed impellers while polished interiors require a semi-open impellers arrangement (Photo 3).

A vast difference in pump performance exists dependent on which manufacturing process is followed. Initially, CIP pump designs developed from

wrought sheet and plate were utilized for handling both product (milk) and cleaning solutions (cleaning compounds). These fabricated units, while quite economical, delivered relatively poor overall performance - primarily because of the hydraulic design. On the other hand, cast pumps intended for handling only the cleaning solution performed well and generally lasted longer. Fabricated units were developed primarily for the dairy industry. Cast units evolved from industrial pump design and combined empirical and theoretical approaches that utilized the advantage of smooth conversion of velocity energy to pressure energy through transitional streamline conversion.

## Why Industrial Pump Design?

Redesigned industrial style centrifugal pumps have been utilized for CIP throughout the world for more than 40 years. Why have these units been so highly accepted even as systems become more complex? Because they have the proper hydraulic design and, if operated and maintained correctly, are reliable, efficient, quiet running and long-lasting. Modern manufacturing processes have increased the performance range of CIP pumps and reduced their costs.

## Hydraulic Design

As manufacturing processes improved in the 1960s and 1970s, Ampco and other manufacturers began adapting to investment casting foundries and NC machining practices. Today the basic difference is not in manufacturing, but in the pump's hydraulic design. Fabricated design units cannot provide the generated transitional flow paths required for an efficient conversion of velocity energy to pressure energy.

Established design concepts carried over from 50 years of the fabrication process mind set have slowed total acceptance of the intricate investment casting capability by basic fabricators. Individual component or segmented portions of their positive improvements have been made, but not one has made a total approach providing what a CIP pump should have:

- streamline entry
- gradual flow redirection
- double curvature vanes
- spiral volute - increasing cross section
- continuing energy transition (velocity to pressure)

Pumps without these hydraulic fea-



Photo 2. A polished pump exterior maintains uniformity of appearance in the exposed areas.

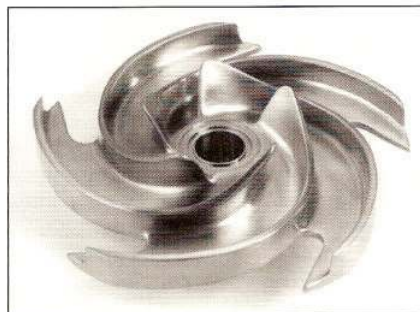


Photo 3. A polished pump interior requires a semi-open impeller arrangement.

(Photo courtesy of Ampco Pumps)

(Photo courtesy of Ampco Pumps)



## CIP Pumping Systems

tures will not only be significantly less efficient for their intended range, more noisy and more costly to operate. Be aware that wasted power contributes to wear and tear on a pump, thereby reducing its life. In a typical closed-coupled centrifugal pump more than 90% of the motor shaft output is directly utilized for converting mechanical energy into hydraulic energy.

Obviously, mechanical design, basic operation, and accurate and complete performance data are also of prime concern. However, these factors do not have as much impact as the hydraulic design.

Also to be included under hydraulic design is the pump's suction design and capability. Design factors to be taken in account here include the number of impeller blades, blade inlet angle and profile, radius of gyration of the blade profile, curvature of the blade and the blade's leading edge.

A proper design also features non-overloading performance as the primary components - casing volute, impeller and suction entry - have together been designed for the same basic flow range, thus preventing operation beyond the range of the selected motor horsepower.

The typical industrial pump manufacturer will conduct calibration performance tests in conformance with the Hydraulic Institute standards, using a closed loop set-up for a horizontal pump to establish the stable hydraulic flow range based on the available NPSH of the system provided by the user.

### Pump Maintenance

Pump maintenance begins with purchasing a pump unit capable of withstanding the environment in which it is to be placed, as well as the hydraulic conditions to be imposed on it.

As with most other centrifugal applications, the biggest trouble areas for CIP pumps are shaft sealing and bearing failure. Initial mechanical sealing selection can be difficult if no previous experience for the media being pumped is available. Once this is resolved, periodic inspection should be made. This shouldn't present any problems because CIP and sanitary pumps are disassembled frequently for sanitary inspection. Users should pay particular attention when checking the sealing surfaces on the mating parts (stationary and rotating) relative to wear and surface irregularities. Check also the secondary elastomer seals with regard to any change in their physical condition (swelling, surface change, brittleness, compression or

resilience).

Bearings require protection from the humid environments in which CIP pumps commonly operate, in addition to possible shaft leakage. Initial pump protection should include a slinger and splash plate. The motor itself should provide further protection as described earlier in this article. Another commonly encountered problem in CIP service is excessive greasing of bearings. Check your motor manual and adhere to the instructions provided.

### The Future

Tomorrow's process needs will continue to call for ever higher standards for CIP and sanitary pumps. Currently, a tentative 3-A sanitary standard is being developed for mechanical seals. Included in the discussions are the pump manufacturers, some of which make their own seals, and several major mechanical

seal manufacturers to provide their expertise relative to today's limitations.

It is the goal of the progressive pump manufacturer to meet new challenges without compromising the basic hydraulic design (industrial type) which remains critical to excellence in overall performance. Properly applied, a pump with good hydraulics will utilize the vast majority of energy to develop water horsepower and a minor amount to develop wasted hydraulic horsepower (turbulence, eddy currents, entrance and exits losses). An improperly applied and/or a poorly designed unit can result in unwanted high radial loads (affecting shaft and bearing), internal cavitation in high pressure areas, internal erosion due to minimal flow and motor overload (due to poor pump design only).■

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# One Manufacturer's CIP Pump Evolution

**A**mpco Pumps' first venture into CIP service occurred in 1957 when a standard industrial frame mounted 2-1/2" x 2" unit was purchased by a Wisconsin dairy to pump 150 gpm at a head of 90 feet (Photo 1). This pump replaced a cast iron unit that was leaking badly through the stuffing box area and had a severely corroded housing. The wetted end of the replacement pump was 316 stainless steel (CF-8M), with a mechanical seal

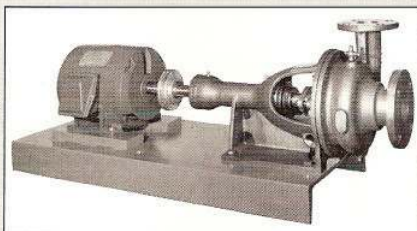


Photo 1. Industrial frame mounted unit used for early CIP service - circa 1957.

like those used in the chemical processing industries.

Because the service is relatively mild compared to the standards required for equipment in the chemical processing industry, pumps intended for CIP applications were usually economical, compact, close-coupled designs (Photo 2). In such a configuration the pump is mounted integrally on the



Photo 2. Typical compact close-coupled centrifugal design used for CIP applications in the late 1950s and early 1960s.



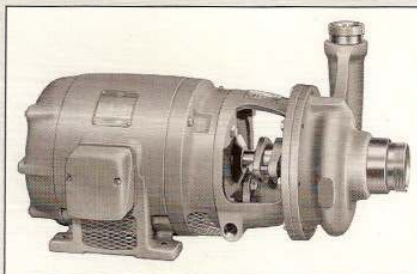
motor rather than using a frame-mounted base design in which the pedestal relieves the motor of bearing loads, pump shaft leakage and heat - all important considerations in chemical processing.

The close coupled pump motor became popular almost immediately because it was more compact and economical. Shaft sealing (both packed stuffing boxes and bellow style mechanical seals) were utilized in early designs, but leakage often resulted in premature failure of the motor's inboard bearing. Furthermore, attempts to reduce leakage by installing mechanical seals were hampered primarily by the lack of a satisfactory seat material. Standard ceramic, ni-resist and tungsten-carbide had all been corrosively attacked on the seal mating surfaces by various cleaning agents. Work with a major seal manufacturer and experience with several Midwest field installations resulted in the development of a new seat material (High Purity Ceramic by Coors), which remains a standard today. In cases where thermal shock may occur (due to an abrupt liquid temperature differential of 100°F or more), hard faced stainless steel seats now provide a reasonable alternative.

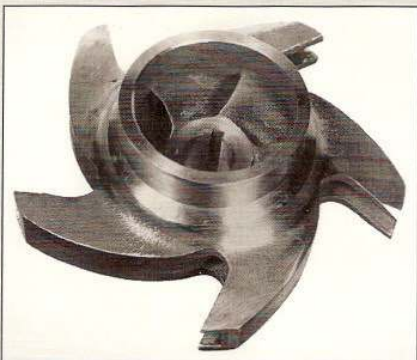
In the early years of clean-in-place systems, totally enclosed fan cooled (TEFC) motors were inadequate for dairy service because they developed condensation in humid environments, and the one-way condensation drain holes found in today's designs weren't available in the 1960s. The popular motor that emerged was the open drip proof enclosure type with encapsulated windings and an oil seal arrangement in the motor housing that protected the inboard bearing.

Current close-coupled pump motor selection provides several options relative to enclosures, including TEFC in both rolled steel and cast iron construction, epoxy finished rolled steel TEFC with "double sealed" bearings, and an all stainless rolled steel TEFC motor with a contact lip seal on shaft extensions and special processed cast end plates.

A major 1960 modification eliminated the pump's suction and discharge flanges from the casing (Photo 3). This reduced the component weight by 25%. Replacing the flanges were ferrules with sanitary connections for both inlet and outlet. Since there were at least 18 different designs of sanitary connections available at the time, customers could select the desired connections and have them brazed into the pump's housing.



**Photo 3.** A major 1960 modification eliminated the pump's suction and discharge flanges from the casing.



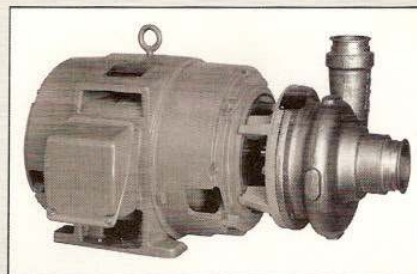
**Photo 4.** The Hydro-Dyne impeller introduced in 1966 altered the traditional configuration of fully shrouded impellers.

To effect further cost reduction goals, Ampco introduced a patented "Hydro-Dyne" impeller (Photo 4) in 1966. This altered the traditional configuration of fully shrouded impellers and eliminated the need for hydraulic balancing chambers. It also enabled entrapment areas to be removed, vane and casing reduced and flow guidance improved.

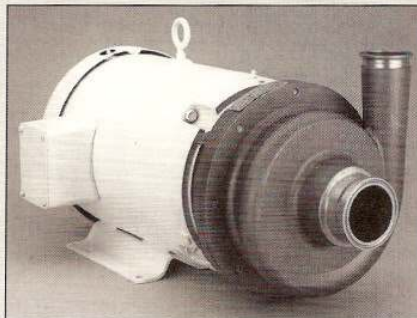
In 1969 a Type JM closed-coupled pump motor ("T" Series), developed jointly by the Hydraulic Institute and NEMA (National Electrical Manufacturers Association), featured a more compact and economical design that reduced shaft overhang (Photo 5). This modification resulted in longer motor bearing life because of reduced bearing loads, a decrease in motor shaft deflection, and higher life expectancy for the mechanical seal due to reduced opening between the seal faces on each revolution - making it harder for sediment, dirt or other particles to enter.

During the same era the 3-A CIP accepted practices for permanently installed sanitary product lines and cleaning systems (Specification 605-O2) called for an SIS #3 cast finish (green sand molding - 500 RMS) as the minimum requirement.

Throughout the 1980s seven draft proposals were submitted relative to 3-



**Photo 5.** The 1970 Type JM closed-coupled pump motor reduced shaft overhang.



**Photo 6.** Ampco introduced a pump line manufactured exclusively for CIP operation in 1988.

A CIP practices, primarily concerning pumps. Major changes included a new cast surface finish requirement (200 RMS), elimination of exposed threaded connections (NPT or UNS standards) and counter-bore depth limitations.

To remain abreast of proposed 3-A practices, Ampco proceeded to retool and eventually introduced a new pump line manufactured exclusively for CIP operation (Photo 6). The current version of this pump is in conformance with 3-A Standard number 47-00 which became effective in November 1996 and established a standard specifically for CIP dairy applications complete with a sanitary seal. ■

*All photos courtesy of Ampco Pumps.*

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