Cleaned-In-Place (CIP) Systems and Controls[1]

E. SCOTT WELCH,[2] G. and H. Products Inc., Kenosha, Wisconsin 53140

Abstract

A discussion of how C.I.P. relates to *control* of plant operation, sanitation and operating costs. Slides will show typical layout and design. There will be photos of existing installations. Some of topics covered will be: How C.I.P. Relates to Basic Elements of Cleaning; Other Methods of Cleaning; Process Equipment; Process Layout; Process Control; Labor Relations; Quality Control; Cleaning Control; Cleaning Costs; Plant Operating Costs.

Cleaning of processing systems by some form of cleaned-in-place (CIP) has been accomplished for many years in the United States and other countries. Growth of CIP has been slow. However, years ago it was anticipated that CIP would spread like a forest fire, but this has not happened. Like most things, clean-in-place has grown slowly.

The dairy industry has led in the application of clean-in-place because it was forced by the nature of the product. Not even the end-product could be sterilized without developing the undesirable cooked flavor of canned milk. Because milk is so perishable and because it could not be sterilized in the final container and be a marketable product, it was necessary to develop systems that would improve the shelf life. Most of the systems that were installed were the result of pressures such as product quality, competition, economics, and health officials. Now almost every plant has some form of CIP systems. Economics has forced the use of cleaned-in-place.

The experience of working with this perishable product and designing and building these systems is beneficial to other industries. Because CIP is not as yet widely used in the fat and oil industry, a broad outline is given. CIP refers to cleaning plant-process equipment and piping in place without disassembly. All systems employ some form of circulation that brings the cleaning agent in turbulent contact with the soiled surface so as to loosen and carry the soil away. All are essentially loop circuits. Rinse-cleaning agents and final rinse are circulated through these lines to remove the soil and leave the lines in a clean condition. This is accomplished with a minimum modification of the piping system and leaves the basic system in place.

Cleaning of tanks and vats has to be handled differently because they are larger and complete flooding is impractical. Flooding requires too much solution and too many cleaning chemicals. Also, it is practically impossible to develop sufficient agitation effectively to remove the soil.

Tanks are far more effectively cleaned by spray systems that utilize a minimum of cleaning solution. These circulate at a high rate, while keeping a minimum of solution in the vessel, so that the cleaning solution is continuously covering all the surface area of the tank, even the bottom. The spray and continuously flowing stream have been found to be an effective way of cleaning tanks. Since the stream is kept flowing, soil is not even allowed to accumulate on the bottom of the vessel.

CIP is emphasized as it relates to processing. It is not something separate, a system in itself. It is only important as it aids and improves the process. It is one of the tools for a better and more profitable process, a tool through which new types of equipment can be successfully applied to the processing operation, new equipment that is capable of enhancing the operational effectiveness of the process. Also emphasized is the control CIP gives over the operation and the operating cost.

Cleaning effectiveness is determined by the utilization of four basic elements: scrubbing actions (surface turbulence), exposure (time), cleaning agent (chemical action), and temperature (activity).

Surface Turbulence. The scrubbing action is the turbulence that brings the cleaner in contact with the soil, that carries the soil away and brings fresh cleaner to the surfaces.

Exposure. The time during which the surface is exposed to the cleaning agent is an important factor in all cleaning.

The Cleaning Agent. This is the medium used to clean the surface and hold the soil: during the rinse cycle, water; during the wash cycle, water and a cleaner (chemical agent) to attach the soil and hold the soil in the solution.

Temperature. High temperature changes many solid soils to a liquid for easier removal. Also raising the temperature increases chemical activity.

To appreciate why CIP is so effective, it may be compared with hand scrubbing, the original method of cleaning and the most familiar. Utilization of the four basic elements of cleaning is described.

Surface Turbulence. In hand scrubbing, turbulence is provided by the brush. This is an effective means of removing deep heavy soil; however, with microscopic soil on the surface of the metal, it is another story. There the only scrubbing action is the agitation of the turbulence created by the brush. This is usually moderate and brief on any given area.

Exposure (time of exposure). With hand scrubbing the brush-exposure time is of necessity very brief. Because of economics one cannot scrub long in one spot. With CIP the flowing turbulence is continuous throughout the complete cycle. Again CIP is more effective, cleaning exposure time is easily increased over hand scrubbing and at lower cost.

Cleaning Agent. Chemical cleaning agents can be used which are stronger than human hands can stand. Again cleaning effectiveness can easily be increased over hand scrubbing.

Temperature. In CIP temperatures can be higher than those which can be tolerated by human hands. For effective removal of many fats, high temperatures are necessary to melt the fat during the rinsing and the washing cycles. Temperature increases chemical activity and reduces the strength of the chemicals required.

TABLE I

Comparison

	Hand-Clean	CIP
Turbulence	By brush	By flow
Exposure	Limited by economics	Throughout cycle
Cleaning agent	Limited by hands	Limited only by material
Temperature	Limited by hands	Most effective

For a comparison of CIP and pressure-gun cleaning, the similarities and differences may be studied. Both systems can use strong cleaners; however, as hand-operated pressure guns are used on the outside of equipment, there is the risk of chemical burns with strong chemicals. Surface turbulence with both systems is high. CIP systems provide continuous exposure of the surface because the cleaning solution is retained within the system. With the pressure gun, only a small surface is covered by the spray. Cleaning time in any given area is of necessity short.

Now for a look at CIP cleaning as compared with the "cleaned-out-of-place" (COP) tanks. These are the circulating tanks utilized to clean small parts which must be removed from the system for cleaning. COP tanks have a definite place and can be effective for small parts. Again, though in a direct comparison, CIP has some distinct advantages, particularly in terms of line velocity, surface turbulence, and the ability to carry the soil away from the

[1] Presented at the AOCS Short Course, "Processing Quality Control of Fats and Oils," East Lansing, Mich., Aug. 29–Sept. 1, 1966.

[2] Present address De Laval Separator Company, Poughkeepsie, N.Y.

surface. A COP tank can loosen the soil; however, because of the large cross-sectional area, it is hard to obtain sufficient turbulence effectively to remove the soil from rather long or fairly large parts. Because of the rather low velocity frequently found in parts, particularly the inside of pipe sections, it is desirable to hand-rinse and inspect the parts at the finish of the rinse cycle.

Of course, also on parts that are washed out of place, there is always the problem of recontamination by handling while re-assembling the system. This is emphasized because usually the weakest link in any cleaned-in-place systems are the parts which, of necessity, must be taken apart and handled during re-assembly, for example, tank door gaskets, final swing door connections to fillers, and so forth. It is important that the man handling these parts use a sanitizer on his hands and sanitize these parts just prior to the assembly so that every part put back into the system is exposed to a sanitizing agent.

Next for a look at some of the things CIP does for process equipment, process layout, and process control. CIP does more than just clean existing lines and equipment. It makes practical a whole new approach to plant processing. Systems can be effectively and economically applied that formerly could not even be considered, systems that are not cleanable by hand methods or systems that are so costly to hand-clean that they could not be considered.

By employing CIP, the designer enjoys a new freedom. He can consider designs that formerly were impractical. Equipment can be designed to fit the process and, with minor modifications, be set up to be cleaned in place, for example, silo tanks, also desludging clarifiers and separators. One can imagine the time saved by cleaning desludging clarifiers and separators in place, particularly important with today's higher production rates. One can visualize the maintenance required in the plant by parts that are damaged in cleaning and think of the savings made by cleaning equipment in place and eliminating the handling of parts.

An organization in Joliet, Illinois, had a homogenizer which was essentially a high-pressure pump that utilized nickel alloy sleeves around the plungers. The damage to this machine caused by hand-cleaning, dropping of parts, improper assembly, and so forth, was so high that this customer elected to clean the equipment in place even though he knew that this would destroy the nickel alloy sleeves.

Yet under a CIP program which utilized alkali cleaners, these nickel alloy sleeves lasted approximately six months and three were replaced at a cost of approximately $110 each. In spite of the predictable $600 plus per year maintenance expense on these machines, the customer found that he saved money in parts alone over his previous operating method. In addition, he saved the cost of the daily hand-cleaning. The manufacturers have now re-designed this equipment so it is available in all stainless steel parts, and CIP is taken for granted.

A silo tank is a wonderful way to get a lot of liquid storage space in a small area, but it surely could not be cleaned without CIP.

CIP thinking also aids equipment design. A good sanitary design, as required for CIP, is also a good process for design, for example: clean, smooth surfaces, a radius in the corners, elimination of exposed threads. Thus the equipment designer is freed of the requirement that all process equipment be hand-cleanable.

Cleaned-in-place is equally valuable to the process layout. The designer is free of the requirement that product lines be removable for cleaning. In plant layout, primary consideration should be given those things which improve the process and lower over-all operating cost.

Liquid ingredients are the easiest to convey long distances. However many times other ingredients, much harder and more costly to convey, are moved considerable length so as to keep take-down liquid lines short. With CIP the length of liquid lines need not be a primary consideration because long lines are cleaned as easily as short lines with only slight increases in cleaner costs. It then becomes an economic analysis between the initial higher cost of the longer lines as opposed to the lower operating costs of a more effective product layout. The process flow should determine the plant layout, not the cost of hand-cleaning the system. CIP makes this approach practical.

On the control of the processing operation, first, the control equipment may be considered. The valves and most of the equipment required for remote control in automated processing cannot practically be hand-cleaned. If these more complex valves and components were hand-cleaned, the result in increased maintenance and cleaning costs would be so high that it would be impractical to employ such a system. CIP makes it economical to employ advanced equipment. This can be cleaned at less cost than hand-cleaning of the simple, short layout. Also, with CIP, the control lines and connections remain in place, thereby eliminating the scrambled connections that could result from improper assembly after hand-cleaning.

Control systems design is important. Good design functionally separates process and cleaning so that one system cannot interfere with the other. The systems are set up so that is is impossible to run a line-cleaning CIP circuit so long as any phase of that circuit is being utilized for process. Also, it is impossible for the switches to control when a CIP circuit is in process. Almost always a refined remote control system is more complex than the old manual system it replaces, and hand-cleaning is just too costly in terms of cleaning time, equipment repair, and product loss from improper assembly.

Years ago the author worked with a plant where all of the processing and filling took place in a small room. At night after the production operation was completed, two men totally cleaned this processing plant. They cleaned the vats, the lines, and the fillers and re-assembled the plant for processing the next day. Later they moved into a new plant with four times their previous production capacity. This new plant had a more versatile processing system which utilized more lines, valves, and longer piping systems. This new plant had better dry-ingredient and finished-product flow.

Because of this, the piping system was much more complex; however they did not think much about it because they were cleaning the system in place and utilizing less time than they had previously utilized to clean their much simpler system by hand. This difference was brought home to them suddenly however when they decided on one of their down days to completely disassemble the piping and valve system and inspect it, replace the gaskets, and re-assemble (this was in the days prior to the use of all welded piping systems). They decided to start this operation the day before and get most of it done. Two men were brought in the evening before and started disassembling and inspecting the system. They had not been working many hours when they realized that two men could not possibly handle the job. So the next day four men were brought in and a supervisor; after about 14 hours of work they finally got the system completed and back together. Then and only then did they realize what CIP was doing for them in helping them clean and maintain the plant.

Labor is another thing that should be considered in conjunction with CIP systems. At first there was concern about the reaction of the plant men to the decreased labor requirements, but fears were unfounded. Plant clean-up men were so pleased by the elimination of the unpleasant cleaning jobs that they did not fight the cleaned-in-place systems. In fact, some unions have asked for CIP systems because they do not want to clean storage tanks in which they have to wash the surface over their heads and have cleaning solutions dripping down their necks.

CIP gives management a control of the cleaning operation that is not possible with manual systems. With a properly designed system, it is impossible to miss part of the circuit. The cleaning cycle is programmed so that it cannot be short-cut. An automatic cycle is not affected by the mood of the operator. Programmed CIP cycles give consistent, predictable cleaning results day in and day out.

Quality control is the next consideration. Cleaning results and product quality are no better than the

(Continued on page 393A)

• *CIP Systems and Controls*

(Continued from page 370A)

weakest link in any system. A system that is set up to give management control over the cleaning operation also is an essential step in obtaining quality control over the finished product. With well-designed CIP systems, one can have consistently cleaned lines and equipment. For every place in which hand-cleaning can be eliminated, recontamination during re-assembly can also be eliminated.

Effective inspection can be accomplished by examining the areas that are difficult to clean. Most companies utilize visual inspection, black light inspection, and bacterial swabs incubated for plate counts. If these difficult areas are properly cleaned, it may be assumed usually that the easier-to-clean areas are also cleaned.

Controlled CIP systems also provide management with a tool for controlling cleaning costs. CIP makes better use of cleaners because they are retained within the system and not dumped on the floor as they would be with hand-cleaning. Also, the concentrations are controlled, and it is possible to utilize more effectively chemical cleaners than would be possible with hand cleaning.

A CIP program gives management a predictable control over the cleaning cost and an efficiency not achieved by hand-cleaning. CIP affects cleaning costs in many ways, not always expected. The obvious is the reduction of clean-up time and clean-up labor. More time is made available for processing, thereby reducing overhead per unit of production. Because equipment is not taken down and hand-cleaned, dropping and other hand-cleaning damage are eliminated, thereby reducing maintenance and repair cost.

The floors remain dry and clean. This reduces accidents and greatly improves plant working conditions. As working conditions improve, so does plant morale, and this has some very desirable and tangible benefits. Turn-over of plant personnel is reduced. Output per manhours usually goes up. Dry floors not only lead to better morale but also to fewer accidents and lower insurance premiums.

Some pitfalls must be considered however. Almost everything develops by stages. In planning a process system, it is usually impossible to build a practical system with low operating cost in small easy steps. A given phase or operation must function as a whole to be practical. And that operation must be planned as a part of an overall processing system if it is to be practical.

Every plant expansion or modification or improvement in process should require a hard evaluation of economics. Plants that survive and grow are the plants that have low production costs. Future production needs must be anticipated five to 10 years in the future and plants planned to meet these production requirements.

The product standards, the sanitary requirements, and economics will dictate that CIP be a part of these plans. CIP is just beginning to grow in the oil industry. It is conceivable that in the next 10 to 20 years, manual cleaning will cease to exist and there will be the first truly automatic plants, largely possible because of the new method called CIP.

Harshaw Acquires Belle Chemical

Purchase of Belle Chemical Company, Inc., Lowell, North Carolina, was announced today by The Harshaw Chemical Company, Division of Kewanee Oil Company. Robert A. Lucht, President of Harshaw, stated, "The addition of Belle Chemical will significantly broaden the line of textile dyes now available from Harshaw, and it will enable us to give better service by reason of their location in the heart of the textile industry."

Belle Chemical Company is a manufacturer of high quality dyestuffs for the dyer and printer of both natural and man-made fibers. The Harshaw Chemical Company produces a complementary line of dyestuffs at their Louisville, Kentucky plant. In addition, Harshaw manufactures a wide variety of organic and inorganic pigment colors for many applications, including coatings, plastics, inks and textile.