BA-CIPMC

CLEANING IN PLACE
MONITORING AND CONTROL SYSTEMS

BA-CIPMC is part of the **BAGGI BASE® Instruments Series**.
They are the result of combining the latest state-of-the-art-technology with over 60 years of industry experience.
This real time analyzer is ideal for the monitoring, verification and validation of Cleaning In Place (CIP) processes. It uses ultraviolet/visible spectrophotometry for assessment of the cleaning results. Due to its modularity, it can accommodate additional sensors when required by the application (temperature, flow, level…) and actuators for fully automated closed loop operation. Each system is tailored to the Customer's needs.

BAGGI BASE® offer solutions for measurement and analysis in gases, solids, liquids, steam and multiphase:
Temperature
Humidity
Velocity – Flow
Pressure
Level – Interface
Components Analysis
Sampling and Filtration
Data Acquisition
Vision systems

B.A.G.G.I . SrL – V.le Campania,29 20133 Milano Italy – Tel. +39 02715547 – Fax +39 027490571 – baggi@baggi.com

1 Introduction

Clean-in-Place (**CIP**) is a method of cleaning the interior surfaces of pipes, vessels, process equipment, filters and associated fittings, without disassembly.
Up to the 1950s, closed systems were disassembled and cleaned manually. The advent of CIP was a boon to industries that needed frequent internal cleaning of their processes. Industries that rely heavily on CIP are those requiring high levels of hygiene and include: pharmaceutical, cosmetics, biotechnology, beverage, brewing, dairy, processed foods.
The definition of CIP is as follows:
"*The cleaning of complete items of plant or pipeline circuits without dismantling or opening of the equipment, and with little or no manual involvement on the part of the operator. The process involves the jetting or spraying of surfaces or circulation of cleaning solutions through the plant under conditions of increased turbulence and flow velocity.*"

The benefit to industries that use CIP is that the cleaning is faster, less labor intensive and more repeatable, and poses less of a chemical exposure risk to people. CIP started as a manual practice involving a balance tank, centrifugal pump and connection to the system being cleaned. Since the 1950s, CIP has evolved to include fully automated systems with programmable logic controllers, multiple balance tanks, sensors, valves, heat exchangers, data acquisition and specially designed spray nozzle systems. Elevated temperature and chemical detergents are often employed to enhance cleaning effectiveness.
Simple, manually operated CIP systems can still be found in use today.
A modern CIP system will not only save money in terms of higher plant utilization but also in terms of significant savings in CIP detergent (by recycling cleaning solutions), water (the system is designed to use the optimum quantity of water) and man-hours.

Other benefits of a well designed CIP plant includes: operator safety (operators are not required to enter tanks and vessels to clean them and potent cleaning materials do not need to be handled by operators), and downtime (if any) between product runs / product changeover is minimized.
According to the existing automation infrastructure and/or the customer preference, a central or a decentralized system is installed and integrated into plant-wide operation.
Cleaning In Place generally comprises also a sanitisation or sterilisation process using either chemical sanitisers or the application of heat to destroy micro-organisms.

A standard CIP sequence is as follows:

1. Alkaline cleaning: to eliminate organic trace elements
2. Rinsing: to push out caustic
3. Acid cleaning: to eliminate mineral deposits
4. Rinsing: to push out acid
5. Sanitisation: to kill/inactivate micro-organisms
6. Rinsing: to eliminate CIP chemicals and prepare the line for production

The steps above can be fully-automated or semi-automated. A good design of the CIP process is able to save:

- Water: preparation of chemical / hot water solutions, rinsing steps
- Time: preparation of CIP solutions, cleaning & disinfection steps, rinsing steps
- Chemicals: alkaline, acid, disinfectant
- Energy: heating and cooling

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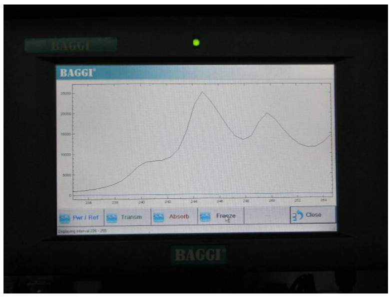
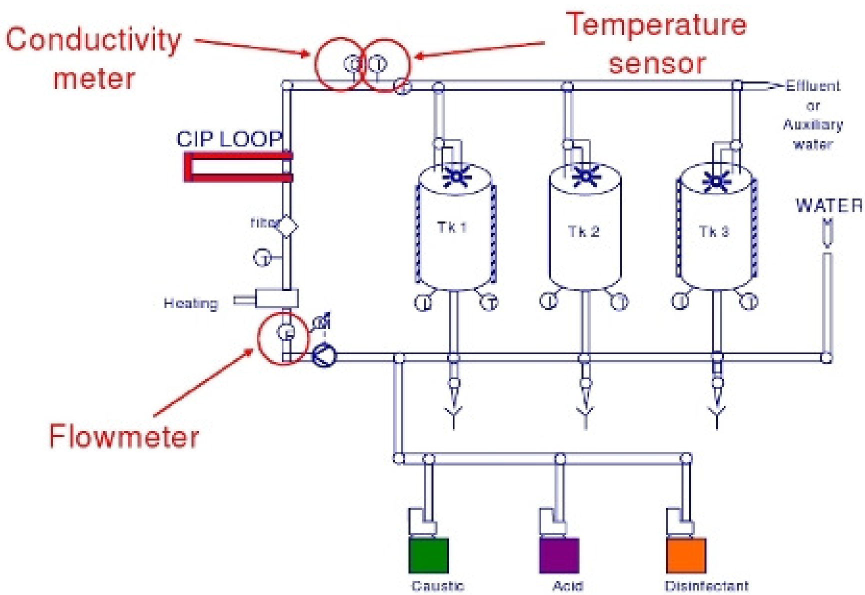
2 The BA-CIPMC Solution

The BA-CIPMC is a threefold device. It acts as:

1. **Programmable Logic Device (PLC).**
   An embedded microcomputer runs the application software for monitoring the system status and applying the closed control loop algorithms.
   The software is designed by BAGGI closely with the Customer. The programs are written in a high level object oriented language. An easy-to-use graphical interface is available for man-machine communication. The system parameters acted upon by the control algorithms are:
   - the flow velocity of the cleaning liquids
   - the time duration of each step in the procedure
   - the temperature of the cleaning solutions and water at the beginning and end of the circuit
   - the titration of the chemicals



2. **Control loop sensor/actuator devices.**
   A complete set of sensors and actuators is delivered as a component of the solution and is controlled by the PLC.
   A typical configuration is depicted in the example figure below. The tanks allow for the recover and reuse of the cleaning fluids.



Since the various cleaning solutions are more conductive than the water used for flushing, conductivity measurement is a logical way to monitor the cleaning steps and the final rinse.

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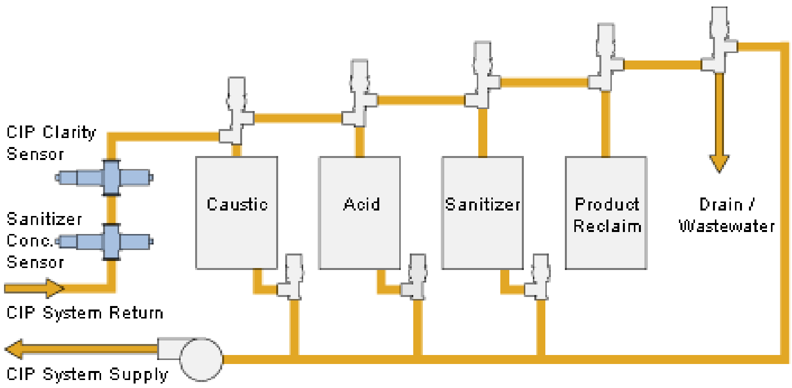
3. **Spectrophotometry for cleaning solutions titration and return water clarity monitoring.**
   Changes in pH and temperature, or the presence of unexpected compounds can all have an effect on conductivity-based sensors. Therefore the BA-CIPMC makes available concentration sensors based upon spectrophotometry analysis techniques.
   An Ultraviolet/Visible (UV/V) or Near Infrared (NIR) absorption or scattered light sensor is typically installed at the CIP return points where it is beneficial to measure the clarity/quality of the final rinse water. The choice is made according to the nature of the process residues. The inline sensor can monitor in real time the concentration of constituents in the water and detect acceptable/unacceptable contamination levels, while minimizing cycle time. Inline photometers can also be used to monitor the sanitizer concentration, to control the CIP process, for validation routines and in some cases, to monitor the residual after cleaning. Validation of cleaning procedures is of utmost importance to the pharmaceutical, food and specialty chemicals industry, while optimization of sanitizer usage offers significant cost savings.
   The following schema shows the placement of the optical cells for spectroscopy analysis:



NOTE: according to the Customer's requirements, the PLC (embedded computer) can either control the whole CIP process or only the spectrophotometer.

3 Architecture

Embedded computer

The implementation of the BA-CIPMC monitor/controller follows the general philosophy of the BASE Instruments Series.
The raw input data from the sensors (temperature, flow, spectrophotometer…) are processed by algorithms provided by BAGGI, running in an embedded computer that is the heart of the system.
When required, an ATEX version is available. In this case the computer, together with some sensors and the power converters, is within an enclosure provided with a protective purge system and an optional Vortex cooler (connected to the plant instrument air system).
The figure shows the computer's display with the functional keys, within the stainless steel ATEX certified cabinet.

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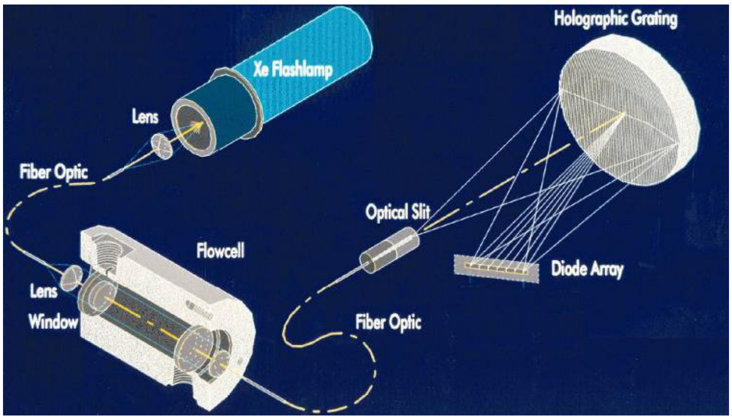
The computer is in charge of:

- Actuating the light source of the spectrophotometer
- Reading the electrical signals from the CCD array (related to the intensity of the absorbed light)
- Calculating the concentration of the compounds
- Actuating the pumps and controlling the flow values
- Controlling the temperature of the fluids
- Calculating the time duration of the cleaning/rinsing cycles and actuating the valves
- Interfacing the sensors/actuators either over 4…20 mA loops or over digital bus (e.g. Modbus)
- Actuating the output relays for handling possible alarms
- Displaying the system status and the measurement data in a Graphical User Interface (GUI)
- Storing the status and the measurement archives into non volatile memory (CSV format)
- Interfacing the human operator for system configuration and alarm reporting
- transmitting remotely the information/alarms via serial lines, Ethernet and WiFi;

Spectrophotomer

The UV/Visible band spectrophotomer schema is shown below:



The instrument is composed of an UV lamp and a diode array. The UV beam, after passing through the measurement cell, reaches a holographic grating disk. This one diverts each wavelength composing the beam onto a specific diode of the array. The voltage emitted by the individual diodes is measured and this information is acquired by the embedded computer through a serial line.
There are no moving parts.
The computer knows the amount of UV energy that has been transmitted by the lamp and is able to draw the absorption spectrum. Finally it calculates the concentration of the components.
The spectrophotometer is controlled by the computer by means of an internal USB line and is housed in the same enclosure.

The picture shows a system built to work in a potentially explosive atmosphere:

- the control computer, the spectrophotometer and the power converters are in the right side cabinet (an optional Vortex cooler is visible);
- the optical cell, the flow-meter and the pneumatically operated pump and valves are in the left side cabinet;
- the signal and the power cables are connected to the various junction boxes.

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4 Technical Specifications

Each BA-CIPMC solution is tailored according to the Customer's needs.
Here follow the standard specifications of the BASE Instrument Series.
For specific requirements, please contact the e-mail address below:
info@baggi.com

Central Controller Specification (ATEX version)

Power:
- Standard: 90-264 VAC, 47-63 Hz; 6A max

Environment:
- 0° to 40°C (32° to 104°F)
- 0° to 55°C (32° to 131°F) with vortex cooler

Dimensions:
- Skid-mount 500mm H x 400mm W x 250mm D
  (19,68" H x 15,74" W x 9,84 D)

Approximate Weight:
- 15 Kg

Analogue Inputs:
- Four inputs filtered with transient protection

Analogue Outputs:
- Six isolated outputs, 4 – 20 mA

Digital Inputs:
- Six digital inputs

Digital Outputs:
- Eight isolated relay signals

Serial Communications:
- RS-232/RS-422/RS-485 with Modbus/Profibus/FieldbusFoundationProtocol
- Ethernet card: two 10/100 mbps with RJ-45 port
- One integrated WiFi card 11 Mbit/s

Enclosure Protection:
- IP66

Compliances:
- EN61326, EN61010-1
- ATEX (optional)
  II 2 G Ex px II T6
  II 3 G Ex pz II T6

Spectrophotometer

Instrument Accuracy:
±1% F.S.

Overall Accuracy:
Function of instrument calibration; optimized by BAGGI by in-field survey .

Response time:
90% of final value in 10 sec. (typical)

All the specification data are subject to changes without notice

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