CLEANING METHODS AND PRACTICES – M9

Eco-efficiency opportunities for Queensland manufacturers

Clean away your costs

Cleaning is an important part of most manufacturing processes whether it is to ensure a sanitised product, eliminate contamination or generally just good housekeeping. Cleaning plant and equipment can account for a large proportion of a manufacturer's costs when labour, water, chemicals and waste disposal are taken into consideration.

Improving cleaning methods and practices can go a long way to improving a company's performance and productivity. There are many opportunities within a factory to reduce cleaning requirements from equipment design through to improved work processes and alternative cleaning options, to reduce the need for and cost of cleaning.

Equipment design

Cleaning requirements should be considered when new equipment is designed and old equipment is retrofitted. Easy-to-clean equipment reduces water and chemical consumption as well as labour. Giving preference to equipment with fewer moving, and more easily accessible parts will reduce overall cleaning time.

Pipework designed with minimal bends and dead ends will reduce the possibility of the build up of contamination. Ensuring the pipes 'fall' to a drain point will help minimise cleaning. Durable and easy-to-clean floor and wall surfaces will help reduce water use during cleaning especially for those factories with high hygiene requirements.

Similarly, choosing equipment that is self cleaning can reduce the need to disassemble equipment and significantly reduce labour and down time.

Any increased capital costs for easy-to-clean equipment should be offset against the long-term reduction in labour, water and chemical costs.

Minimising pipework with fewer bends and dead ends will reduce cleaning requirements.

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SELF-CLEANING SYSTEM SAVES TIME AND MONEY[1]

Bundall Powder Coating and Sandblasting on the Gold Coast upgraded its dust handling system to install a largely self-cleaning extraction system. They replaced two old style cyclone extraction units with one new dust extraction system.

Previously, what was not extracted using the cyclone units ended up in the air and spread around the factory. The new system reduced clean up time and improved air quality and safety for workers by using the correct velocity and air movement through a redesign. Downtime is also reduced as the system cleans off-line at the end of the shifts and the staff do not need to physically clean the cartridges. The only cleaning is the removal of a plastic bag of excess powder twice a week.

Other benefits of the system, apart from reduced labour time, include:

- reduced noise as the filters are only cleaned at the end of the shift
- improved air quality and better working environment for staff
- reduced filter replacement costs as the units last longer than traditional filters
- reduced footprint as two cyclone filters have been replaced with one unit
- helped Bundall achieve accreditation with their major clients increasing work prospects.

Good Housekeeping

Good housekeeping refers to simple, practical and common sense measures to increase the productivity of a business. These measures are often quick to implement and relatively low in cost. The benefits of improved housekeeping include cost savings as well as improved management of environmental impacts.

Production plants that neglect good housekeeping are often visibly unclean, unsafe and disorganised. A walk through the site may find evidence of some or all of these symptoms - air and water leaks, spills, water running unnecessarily, wasted raw materials, evidence of unnecessary rework, blocked drains and sometimes unmotivated staff.

Improved housekeeping will generally reduce cleaning requirements through a more organised factory. The following are some concepts to improve housekeeping and reduce cleaning:

- effective cleaning through good design and layout, such as:
  - smooth, light colour internal walls with an impervious coating which will also reduce lighting requirements
  - easy-to-clean and correctly-sized drains
  - intact, impervious and slip resistant floors constructed of appropriate strength material, floor should be smooth and sloped to drains
  - segregation of dry areas and stores from wet areas
  - easy-to-clean, self-draining equipment design with no dead legs
- encouraging dry cleaning by having cleaning tools in easily accessible designated areas and specific tools for specific tasks or routines
- scheduling production to reduce cleaning requirements, e.g. reduce the chance of materials hardening on surfaces, by minimising the number of product changes and limiting disruptions such as poor scheduling of raw materials or staff breaks, scheduling product throughput from light to dark to reduce cleaning in between product lines
- maintaining and calibrating process controls to avoid spills and overflows on filling lines.

1 FEN, 2007, New extraction system makes powder coating facility self-cleaning, Reed Business Information, www.myfen.com.au/Article/New-extraction-system-makes-powder-coating-facility-self-cleaning/134318.aspx

Dry cleaning is one of the easiest methods to reduce cleaning costs.

Dry cleaning

Dry cleaning is one of the easiest methods to reduce cleaning requirements. It will also have flow-on improvements to wastewater quality and quantity, waste disposal and reduce chemical demand.

Although dry cleaning may be practised widely, there is often room for improvement. Operator training and commitment are key factors in achieving good dry cleaning outcomes:

- when using dry cleaning techniques, remove as much product from plant and equipment as possible. In some cases product can also be recovered and returned for processing or sold as a by-product, for example, sawdust for compost
- use drip/catch trays or lips on equipment and benches to help reduce the amount of material landing on the floor or into drains
- use scrapers, brushes and vacuum devices to pre-clean containers, equipment and conveyors prior to washing. Scrubber and vacuum cleaners can wet or dry clean floors and remove gross soiling before washing with water. These cleaners are fast and efficient and reduce chemical use, but may be unsuitable for small areas, or areas with restricted access.

High-pressure cleaning systems

High-pressure cleaners are a water efficient option for floor and equipment washdown. Cleaning with high-pressure water can use up to 60 per cent less water, compared with using mains hoses.[2] Mobile high-pressure cleaners have flow rates ranging from 4 L/min to 20 L/min with pressures of up to 500 kPa. To reduce the time required to set up mobile pressure washers, it is worth considering installing a ring main system.

It is important that high-pressure cleaners complement cleaning procedures and should not replace dry cleaning. The use of high-pressure cleaning systems may not be suitable for some areas of the plant as aerosols from spray and splash can cause the deposition of microorganisms from the floor to settle back onto equipment and product.

Trigger-operated controls for hoses

The installation of a trigger gun can provide significant savings for companies. A hose left on unnecessarily for one hour a day can waste between 470 kL and 940 kL of water a year. That represents $1391 -$2782[3] a year per hose. In contrast, the cost of a trigger gun can range from just $20 to $100 for a heavy-duty item.

- Ensure trigger guns are ergonomic, particularly where staff are required to operate the trigger for long periods of time.
- Automatic reel-up hoses can help to protect the hose and the trigger gun.

Clean in Place

A clean-in-place (CIP) system automatically delivers a standard number of wash and rinse cycles to the internal surfaces of a closed system. CIP systems can allow equipment, tanks and pipes to be cleaned without being disassembled, saving labour and eliminating human contact with chemicals.

A CIP system usually consists of several chemical and rinse water-holding tanks, associated pumps and piping to allow the recirculation of rinse water and cleaning chemicals. Full recovery systems can recover up to 99 per cent of the cleaning solution.[4] CIP systems are usually custom designed for specific applications and incorporated into the full process design. Often they are run by microprocessors and computers providing traceability and security for the processor.[5]

Portable CIP systems are also being developed that are usually cheaper and can, in some cases, offer greater flexibility than fixed centralised CIP.

2 Envirowise 1998, Reducing the cost of cleaning in the food and drink industry, ETBPP GG154 **www.envirowise.gov.uk**.
3 Water charge =$2.10/kL BCC water supply costs for between 201-300kL for February 2009 and Trade waste charge = $0.86/kL BCC tradewaste charge category C for average low impact manufacturing wastewater composition February 2009.
4 Daufin G., Escudier, J.P., Carrere, H., Bérot, S., Fillaudeau, L. and Decloux, M., 2001, 'Recent and emerging applications of membrane processes in the food and dairy industry'. Trans IChemE, vol. 79(C2), 89–102.
5 Higgins, K, T., April 11, 2003, Tech update: Clean-in-place continues to evolve, Food Engineering Magazine, **www.foodengineeringmag.com/CDA/Archives/23f45103942f8010VgnVCM100000f932a8c0____**.

Regular review of CIP systems is essential. As numerous factors interact during the cleaning process it is important to trial all modifications as even small changes can affect cleaning effectiveness and product quality. The effectiveness of CIP systems can be improved by:[6]

- maintaining and calibrating in-line monitoring instrumentation
- reviewing cleaning cycle lengths to ensure they have not become excessive
- assessing chemicals, blends and concentrations to ensure that they achieve effective cleaning, but are safe for the operator, and environment
- checking for excessively high or low temperatures
- checking for opportunities to recover more rinse water and spent solution
- training operators and adequately supervising to improve efficiency and safety
- regularly monitoring equipment and repairing promptly.

Once any changes have been made, the system must be validated to ensure safety of the product.

Cleaning Methods

There are many different cleaning options available to manufacturers depending on the contaminant to be removed and the level of cleanliness required. Cleaning method choice should consider both ability to remove the contaminant and the cost effectiveness of the method. The following table provides a comparison of different cleaning methods.

Cleaning method	Description and Application	Advantages	Disadvantages
Caustic cleaners	Traditional cleaner containing sodium. Used as a general cleaner and removes organic components such as proteins and fats.	Cheap, widespread.	Contributes to high total dissolved solids (TDS) (e.g. sodium) levels in wastewater stream. Difficult to remove from wastewater streams without energy intensive membrane treatment. Future tradewaste charges may include TDS levels.
Potassium cleaners	Replaces sodium of the caustic cleaners with potassium, Same applications as caustic cleaners.	Irrigation with wastewater streams containing low levels of potassium can provide nutrient benefits to plants.	High levels in wastewater streams can have detrimental impact on soil structure and function if used for irrigation. Costs more than sodium based cleaning products.
Ozone	Ozone is generated and oxidises when it comes into contact with the object to be cleaned. Effective on a broad spectrum of microorganisms including bacteria, fungi, viruses, protozoa, bacterial and fungal spores.[7]	Oxidation gives antimicrobial properties. Degrades to oxygen at room temperature in both air and water. Can be used in wastewater treatment system to reduce Biochemical oxygen demand (BOD) and Chemical oxygen demand (COD). Can neutralise some odours.	Needs to be generated on site immediately prior to use. Can degrade rubber in high concentrations.[8] Higher capital and maintenance costs compared with chemical methods but operating costs are only electricity. [9] Can be expensive operating costs due to the amount of energy required. Does not provide residual sanitisation.
Steam	Water is turned into steam at high pressure and temperature. Applications include removal of fats, oils and microorganisms and dislodging soiling.[10]	High pressure steam dissolves fats and oils, and kills microbes.[11] Dry steam cleaning can clean sensitive areas in processing plants. Dry steam is very water efficient with only 5-6% moisture.	High pressure can spread airborne bacteria if not properly controlled.
Sonication	Application of sound waves directly at objects. Removes fats.	Sound waves loosen material off hard surfaces. If used in conjunction with anaerobic digestion can potentially increase biogas yields.	Needs to be used in conjunction with other treatment measures.

6 UNEP Working Group for Cleaner Production, 2004, Eco-efficiency for Australian dairy processors: Fact sheet 8: Optimisation of CIP systems **www.ecoefficiency.com.au**
7 Pascual, A., Llorca, I. and Canut, A., 2007, "Use of ozone in food industries for reducing the environmental impact of cleaning and disinfection activities." Trends in Food Science and Technology 18, S29-S35.
8 Pascual et al, 2007.
9 Safe and hygienic water treatment in food factories, 2007, Trends in Food Science & Technology 18 S93-S100.
10 Pehanich, M., 2006, Cleaning without chemicals **www.foodprocessing.com/articles/2006/052.html**
11 Pehanich, M., 2006, Cleaning without chemicals (as per 10).

Cleaning method	Description and Application	Advantages	Disadvantages
Vibratory cleaning	Objects to be cleaned placed in a trough containing a solid media and fluid. An eccentrically loaded drive shaft imparts motion on the tank. The object is cleaned from contact with the solid media and the fluid flushes away the contaminants.[12] Removes light rust, oxidation, dirt and some greases and oils.	No hazardous chemicals. Removes heavy layers of caked dirt. Can clean sensitive parts and get into corners if the right media is used. No manual cleaning required.	Batch process. High noise levels. Potential media lodging within the part. Cannot remove heavy grease layers. Difficult to unload small objects. Long cycle times for heavily dirty loads.[13]
Enzymes	Natural enzymes are applied to the surface to mimic the way nature cleans. Removes grease and oils.	Speeds up chemical reactions in mild conditions of temperature and pH. Produces fewer contaminates in wastewater stream. Often requires less energy input in the form of heat.[14] Reduction in staff exposure to chemicals.	Extreme pH and temperature will destroy enzymes. Initial cleaning with low doses of chemicals often required. Sometimes longer residence time of enzyme cleaners is required to ensure effectiveness.
Electrolysed water	Generated from brine solution using electrolysis. Produces an alkaline solution – pH 11-13; and acidic solution – oxidising agent. Applications include killing bacteria, viruses, protozoa, algae, fungi and spores.	More effective than sodium hypochlorite at similar concentrations.[15] Does not require rinsing. No hazardous chemicals required.	Increases total dissolved solids levels in wastewater stream compared with cleaning system such as ozone. System requires backwashing to remove calcium build up on membranes.
Thermal cleaning	Heating the object to temperatures which remove organic material through oxidation. Removal of organic material.	Can clean large quantities of parts simultaneously. Cleaning results are consistent. Cost of cleaning relatively low Removed multiple contaminants – e.g. oil, grease, paint, gaskets and rubber. Reduction in amount of waste to be disposed of. Not labour intensive.[16]	Flash rusting may occur on cleaned parts from moisture present in the air. Subsequent treatment is required to remove ash and/or rust from part surfaces. Unacceptable softening of substrates may occur, particularly aluminium.[17]
Aqueous cleaners	Water is primary solvent with detergents, surfactants, pH buffers, emulsifiers etc as required. Acidic aqueous solutions remove: scale, rust and oxides from metals. Alkaline aqueous solutions remove: salts, organic soils, oxides, metal chips, grease	Alkaline aqueous cleaners used at a broad range of temperatures. Can be used in pressure spray washing, ultrasonic and immersion.[18]	Acidic aqueous cleaners can attack metal objects. Wastewater and sludge generated.
Semi-aqueous cleaners	Made of natural or synthetic organic solvents, surfactants or corrosion inhibitors and other additives. Removes waxes, heavy greases, tar and baked-on organic materials. Reduced volatile organic compounds (VOCs) emissions.	Often used with immersion or ultrasonic systems.[19] Water soluble or insoluble.	Can contain VOCs. Concerns of aquatic toxicity, human health effects and flammability.[20] May alter wastewater discharge requirements.

12 National Center for Remanufacturing and Resource Recovery (NC3R), 2001, Vibratory Cleaning. **www.cims.rit.edu/ne/pubs/NC3R_5vibratory_web.pdf**
13 NC3R, 2001, Vibratory Cleaning (as per 12).
14 Palmowski, L., Baskaran, K., Wilson, H. and Watson, B., October 2005, Deaken University, *Clean in Place – A Review of Current Technology and its Use in the Food and Beverage Industry.*
15 Envirolyte Industries International Ltd, 2005, Electrochemical Activation (ECA) Technology, Water Purification System of the Future, Tallinn, Estonia.
16 National Center for Remanufacturing and Resource Recovery (NC3R), 2001, Thermal Cleaning. **www.cims.rit.edu/ne/pubs/NC3R_4thermal_web.pdf**
17 NC3R, 2001, Thermal Cleaning (as per 16).
18 State of Oregon, Department of Environmental Quality, 2001, Alternative Cleaning Solvents and Processes. **www.deq.state.or.us/pubs/general/AlternativeCleaning.pdf**
19 State of Oregon, 2001, Alternative Cleaning Solvents and Processes (as per 18).
20 State of Oregon, 2001, Alternative Cleaning Solvents and Processes (as per 18).

Cleaning method	Description and Application	Advantages	Disadvantages
Dry ice blasting	Dry ice (carbon dioxide at a low temperature) at a very high velocity is an alternative to abrasive blasting. The pressure loosens the contaminant from the surface. It produces only carbon dioxide which becomes a gas when released. Can replace some solvent cleaners. Removes impurities from surfaces such as rust, grease and oils. The supercool temperature of -79 °C of the dry ice stream also kills bacteria, mould and fungus on contact reducing the need to use chemicals to sanitise.	Reduced waste disposal as no residual wastes produced from blast media. Clean in place reduces labour and time as the equipment does not need to be disassembled[21] and can be cleaned while equipment is still hot. Can be used in areas which are inaccessible by hand or where blast media may accumulate or be difficult to remove. Safe to use around electrical components and other sensitive equipment. Reduced potential to damage equipment as dry ice turns into a gas when it hits the surface. Health and safety of staff improves as there is less exposure to chemicals such as solvents.	It can contribute to increased levels of carbon dioxide in the atmosphere through generation, capture, pressurising, storage and application of carbon dioxide. Preference should be given to companies who source carbon dioxide from the byproducts of other processes to reduce their contribution to greenhouse gases. Care must be taken to ensure good ventilation during the use of dry ice blasting as oxygen levels can be depleted.[22] The system can generate noise and particles can be distributed.
Sponge blasting	Sponge blasting is an alternative method to sand blasting. Small pieces of sponge containing abrasive materials, are blasted at the surface to be cleaned. The sponge flattens against the surface exposing the abrasives to the surface and then capturing the contaminants within the sponge. The sponge is then regenerated for reuse. Removes surface contaminants such as rust, paint and soot.	Approximately 90% reduced rebound of materials and dust improving worker health and safety. [23] Less pollution and waste generation than sand blasting. Improved community relations due to reduction in dust generation. Fewer defects and rework and increased first pass visibility tests.	Whilst the blast media can be recycled the initial costs to purchase the material can be quite high.
Ultrasound	An electrical current is passed through a container holding piezo ceramic crystals. The crystals vibrate at approximately 30,000 times a second causing waves which form thousands of microscopic bubbles which cavitate due to the sound waves. Cavitation results in a similar action to scrubbing on a microscopic scale on objects close to the bubbles. Can replace some solvent cleaners.	Some benefits include:[24] A more thorough clean as the water particles can reach areas which are difficult to clean when the object is immersed in the tank. A faster cleaning process especially when detergents are added to the water. The detergents are generally biodegradable and have a longer lifespan than solvents. Retrofitting is possible especially when tanks are already available and can be custom made to suit the user's requirements. The system can be fully automated and simple to operate, this reduces operator training and improved health and safety of the operators. Reduces the impact on the object being cleaned and so reduces damage from cleaning. Reduction in labour and waste disposal costs compared with solvent use.	Some of the disadvantages include:[25] A batch process which may result in longer waiting periods. Large loads take considerably more energy and time than smaller loads. Heavily soiled objects can take long periods to clean. Poor cleaning can result if the tank is crowded. Increase energy and cleaning chemistry compared with solvent use. Ultrasound is more applicable to intricate objects with lower levels of soiling to be most cost effective but can be used for other types of cleaning.

21 Wickens Dry Ice Blasting, 10 benefits of dry ice blasting, **www.wickensdryiceblasting.com/wickens_benefits.htm**
22 ColdJet Australia, Dry Ice FAQ, **www.coldjet.com.au/dry_ice_faqs.html**
23 Sponge-Jet, 2009, Features and benefits, **www.spongejet.com/features.php**
24 Centaur Media Plc, Tuesday 17th January, 2006, *Industrial cleaning – a new perspective,* **www.mwponline.co.uk/ProductionCaseBook/industrial_cleaning_a_new_perspective**
25 National Center for Remanufacturing & Resource Recovery (NC3R) 2005, Ultrasonic Cleaning **www.cims.rit.edu/ne/pubs/NC3R_2ultrasonic_web.pdf**

MELBOURNE GRAVITY USE DRY ICE BLASTING TECHNOLOGY TO MINIMIZES CLEANING AND MAINTENANCE TIME[26]

Melbourne Gravity, an aluminium diecasting company, purchased a dry ice cleaning system and reduced their total cleaning and maintenance time on their tooling. Dry ice blasting can be operated while the equipment is still hot and online reducing cleaning time from more than an hour to just 5-10 minutes. That's a reduction of up to 90%.

The blast media disappears on impact ensuring no risk of entrapment of the media, and does not damage equipment which is traditionally an expensive cost of other cleaning techniques.

The plant now runs at full production for the whole shift with cleaning completed by one operator in 90 minutes at the end of the shift significantly reducing down time. The total output of the plant has increased by 15% for the cost of just 90 minutes of overtime for one operator. The system paid for itself in just a couple of months.

GLADSTONE FISH MARKETS CLEAN REFRIGERATION UNITS WITH DRY ICE SAVING TIME[27]

Traditionally, Gladstone Fish Markets would clean their three refrigeration systems using chemicals and scrubbing by hand, taking approximately 24 hours to complete. Whilst the result was good, they were unable to use the equipment for three days, reducing their productivity. They brought in a third party to dry ice blast the system which took three and a half hours leaving a much cleaner result. This not only saved them $5,000 in lost revenue, as they were able to use the equipment immediately after cleaning, but it also reduced labour costs and the need to dismantle equipment. The also had no post-cleanup requirements or waste disposal costs.

Chemical management

Sometimes chemicals are unavoidable. The types and amounts of chemicals used to clean have a large impact on costs and also the wastewater system. Exposure of staff to toxic chemicals can also have health and safety implications. Prevention of overuse of chemicals through better control of the types and amounts of chemicals used can provide a more effective cleaning system and reduce costs.

Waste can be reduced by purchasing chemicals in bulk or in higher concentrations, whilst keeping operator heath and safety in mind. Chemicals must be correctly labelled and stored in bunded, dry, well ventilated areas to reduce the risk of environmental harm and improve health and safety of staff.

Optimising chemical use can save money.

Review chemical use

Regular review of chemicals used on site will allow operators to optimise the types, quantities and conditions of use leading to:

- optimised exposure times, temperatures and concentrations of chemicals
- reduced toxicity and impact on operator health and safety
- reduced impact of chemicals on the environment, and wastewater pollutant loads through reduction of chemicals and use of less toxic chemicals
- reduced maintenance, by reducing use of corrosive chemicals.

26 Case study courtesy of ColdJet Australia, Dry Ice Blasting, **www.coldjet.com.au**
27 CQ Dry Ice Solutions, Portfolio of Industrial Cleaning Jobs, **www.cqdis.com.au/pdfs/CQ_Dry_Ice_Solutions_Portfolio_191107.pdf**

Chemical control

Chemicals may be unnecessarily overused to ensure cleanliness. Most equipment will have instructions of the optimal amount of cleaning required. Savings can be made through automatic dosing machines which can be programmed to provide an accurate amount of chemical depending on the cleaning activity. This reduces human error, saving money as well as improving health and safety.

Service-based agreements and performance contracting can be used to help reduce chemical and water usage by including environmental objectives and targets in agreements.

BETTER CHEMICAL MANAGEMENT

Priestley's Gourmet Delights, a bakery product manufacturer, worked with their chemical supplier to consolidate cleaning chemicals and improve the dispensing system, reducing costs from $4000 to $2000, a saving of 50 per cent in the first year. (Priestley's Gourmet Delights is an ecoBiz participant.)

This series of fact sheets provides examples and suggestions to the modern manufacturer on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website **www.ecoefficiency.com.au** for more ideas and case studies.

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