POLLUTION PREVENTION: STRATEGIES FOR CHEMICAL PRODUCTION

What is pollution prevention?
Pollution prevention is the reduction or elimination of discharges or emissions to the environment. This includes all pollution: hazardous and non-hazardous, regulated and unregulated, across all media, and from all sources. Pollution prevention can be accomplished by reducing the generation of wastes at their source (source reduction) or by using, reusing or reclaiming wastes once they are generated (environmentally sound recycling).

Why practice pollution prevention?
Pollution prevention is good business. While most pollution control strategies cost money, pollution prevention has saved many firms thousands of dollars in treatment and disposal costs alone.

Many companies have already discovered the tremendous benefits of pollution prevention. The 3M Co.'s "Pollution Prevention Pays" Program has eliminated the annual generation of more than 500,000 tons of pollutants. Cumulative savings since the program began in 1975 are estimated at $426 million.

Smaller companies can also benefit. One firm reduced its hazardous waste disposal costs by 74% and decreased raw material costs by 16%.

By reducing or eliminating wastes a firm can:
- solve the waste disposal problems created by land bans
- reduce waste disposal costs
- reduce costs for energy, water and raw materials
- reduce operating costs
- protect workers, the public and the environment
- reduce risk of spills, accidents and emergencies
- reduce vulnerability to lawsuits and improve its public image
- generate income from wastes that can be sold

Each of the pollution prevention practices described in this fact sheet is an extension of the simple but powerful idea that it makes far more sense to eliminate the generation of waste than to develop complex and costly treatment schemes once it has been generated.

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How do we get started?

A systematic approach will produce better results than piecemeal efforts. An essential first step is a comprehensive waste audit. The waste audit should systematically evaluate opportunities for improved operating procedures, process modifications, process redesign and recycling.

To conduct a waste audit, follow these steps:

- List all generated waste
- Identify the composition of the waste and the source of each substance
- Identify options to reduce the generation of these substances in the production or manufacturing process
- Focus on wastes that are most hazardous and techniques that are most easily implemented
- Compare the technical and economic feasibility of the options identified
- Evaluate the results and schedule periodic reviews of the program so it can be adapted to reflect changes in regulations, technology, and economic feasibility

Will pollution prevention work in chemical production?

A 1987 Chemical Manufacturer’s Association (CMA) survey indicates that the chemical industry has made strides in waste reduction. In 1987, 77% of hazardous solid waste was recycled. The generation of solid waste, excluding material that was recycled, was reduced by about 40% between 1981 and 1987.

Despite these reductions, according to Department of Commerce figures, in 1988 the chemical industry spent approximately $3.1 billion on pollution control. So the industry still has tremendous incentive to reduce waste.

Setting up a pollution prevention program does not require expensive technologies. Some of the most effective techniques are simple and inexpensive. Others require significant capital expenditures, however many provide a return on that investment.

Improved Operating Procedures

Good operating procedures rely not on changes in technology or materials, but on human adaptability. Small changes in personnel practices, housekeeping, inventory control, waste stream segregation, material handling and scheduling improvements, spill and leak prevention and preventive maintenance can mean big waste reductions. To reduce waste in chemical production:

- Reduce inventory of raw materials. Test materials first to determine whether or not they can be used in current manufacturing processes.
- Reduce excess and off-specification production. Produce only the amount requested or needed.
- Segregate waste to recover useful materials and cut disposal costs.
- Conserve water. Reuse rinse waters. If possible, clean process equipment with process fluids.
- Prevent contamination of stormwater runoff, thereby eliminating treatment of contaminated rainwater. Replace leaking valves, pumps and seals.
Process Redesign

Chemical engineers are uniquely qualified to solve problems in the chemical industry because of their background in disciplines including chemistry, reaction kinetics, physics, thermodynamics, engineering, fluid mechanics, economics, and fine particle technology.

In the past, chemical engineers have done a good job of designing and modifying chemical production processes and technologies to recover product and unconverted raw materials. They pursued this strategy to the point that the cost of further recovery could not be justified.

Now the costs of end-of-pipe treatment and disposal have made source reduction an equally good investment. Greater reductions are possible when process engineers trained in pollution prevention incorporate waste reduction into process redesign projects. Designs that reduce the amount of waste generated can also reduce energy consumption and maintenance costs. For example:

A company which manufactures intermediates used in the production of a powerful antibiotic purified one intermediate via caustic hydrolysis, to assure the intermediate did not degrade while being held for subsequent processing. The purification generated 2,300 gallons of toluene-contaminated wastewater per batch. Three process vessels used for purification could emit as much as 1,600 pounds of toluene per year to the air.

The company determined that by modifying the mole ratios of reagents used to manufacture the intermediate, the one reagent causing the degradation could be significantly reduced. The caustic purification step was eliminated. Product stability and throughput dramatically increased. Manufacturing costs were reduced by $280,000 per year without any capital expenditures for new equipment.

Recycling

Recycling is the use, reuse, or reclamation of a waste after it is generated. The chemical firm should check with federal, state and local environmental authorities for applicability of recycling programs. Examples of recycling opportunities include:

- Recycle and reuse excess, off-specification materials and samples taken for quality control testing.
- Reuse inert ingredients when flushing solids handling equipment.
- Segregate & reuse dust emissions in the production process.
- Distill waste solvents, and regenerate catalysts.

Process Modifications

Rethinking an entire production or manufacturing process can be a very effective way of preventing pollution. Often the new process is more efficient and costs less to operate. Upgrading the system not only reduces waste but can improve product quality, save money by reducing the need for maintenance, and increase control of raw materials used in production. Consider the following process modifications:

- Improve scheduling. Scheduling the production of chemicals that use the same production line can reduce cleaning requirements.
- Shift from batch manufacturing to continuous manufacturing. This can reduce evaporation loss.
- Maximize dedication of process equipment. This can reduce equipment cleaning frequency and waste generated.
- Relocate process equipment and change piping configuration to prevent possible contamination from other sources.
- Clean equipment with small amounts of cleaning solution. If water is the cleaning agent, use sprays or jets of water to clean tanks or equipment. Where possible, the small amount of concentrated waste collected should be recycled as a raw material. Rinse machinery and tanks less often.
- Use pumps and piping systems to transfer liquid materials. This can reduce spillage.
- Reformulate products. For example, prepare chemicals in pellet form instead of powder, to reduce dust emissions.
- Substitute less toxic or non-toxic materials as raw products.
Who's going to do it?

Pollution prevention requires a new attitude about pollution control. Traditional thinking places all the responsibility on a few environmental experts in charge of treatment. The new focus makes pollution prevention everyone's responsibility. Preventing pollution may be a new role for production-oriented managers and workers, but their cooperation is crucial. It will be the workers themselves who must make pollution prevention succeed in the workplace.

Management commitment and employee participation are vital to a successful pollution prevention program. Management can demonstrate its commitment to pollution prevention and encourage employee participation by:

- Training employees in pollution prevention techniques
- Encouraging employee suggestions
- Providing incentives for employee participation
- Providing resources necessary to get the job done


FURTHER POLLUTION PREVENTION INFORMATION

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The Center for Hazardous Materials Research (CHMR) is a non-profit subsidiary of the University of Pittsburgh Trust, and is a non-regulatory organization. Its mission is to assist in developing and implementing practical solutions to the technical, environmental, economic, and health problems associated with hazardous and solid waste. For more information on this and other CHMR publications call (800) 334-CHMR.
FACT SHEET

- Are your coolants becoming rancid quickly?
- Do your employees complain about skin irritation or odors in the shop?
- Are you having a difficult time disposing of your spent coolants?
- Are your coolant replacement costs high?

If you answered yes to any of these questions, coolant maintenance may be a means of controlling these problems and reducing your coolant costs. Please note that sources for the types of equipment identified in this fact sheet are available on separate lists from MnTAP.

Cause and prevention of rancid coolant

Most coolants are typically disposed of due to bacterial growth, not the loss of a coolant's cutting fluid properties. Tramp oil can coat the surface of the coolant and allow anaerobic (oxygen deficient) conditions to form. The anaerobic bacteria can act as a skin irritant and can produce hydrogen sulfide gas which smells like rotten eggs.

Proper coolant maintenance can prevent this bacterial growth. Coolant maintenance incorporates the following:

- Routine removal of tramp oil and metal chips/fines in the machine's sump.
- Control of bacterial growth.
- Maintenance of the proper coolant-to-water mix and additive concentrations.

If numerous brands of coolant are being used in your shop, coolant maintenance will be hard to do. Generally, maintenance works best in shops using only one or two types of coolants. Some employee time also must be allotted for the maintenance procedure to be performed, and it must be regularly scheduled for a maintenance program to succeed.

Removal of tramp oil

A number of devices that skim tramp oil off the surface of coolants are available. Machine sumps may need to be modified to allow access for this equipment. Ideally, skimming equipment should be placed near the sump's coolant return pump since the...
pumping action will tend to draw the tramp oil toward it. If skimming equipment cannot be placed near the pump, a simple baffle or weir system to contain the tramp oil in an area of the sump may allow the skimmers to remove the oil in the most effective manner. Skimming devices should run only when a sufficient volume of tramp oil has accumulated. If they are run continuously, excessive coolant loss could occur. Timers on the skimming devices can help assure that this does not occur and eliminate the need to manually turn the skimmers on and off. Two types of skimmers are shown below.

Removal of metal chips/fines

Metal chips and fines must be removed routinely. They not only interfere with the coolant return pumps but also serve as sites for bacterial growth. Chips can be prevented from entering sumps with the use of screens on coolant entrances to the sump or over exits from the holding trays. Chips and fines also can be removed from the sump using rakes or vacuuming equipment. For machines running steel or cast iron stock, a magnetic separator may be the most efficient way to remove chips and fines. For grinders, a filtration system prior to returning the coolant to the machine’s sump may be the route to pursue.

Control of bacterial growth

Bacterial growth can be controlled in a variety of ways including cleaning the coolant sump with steam or chemicals when the coolant is replaced, use of a biocide, adjustment of the coolant’s pH, or adequate circulation of the coolant.

**Sump cleaning** - When a coolant is replaced, the machine sump should be chemically or steam cleaned to remove any residual bacteria that may be in the sump. If this is not done new coolant may be immediately contaminated with the same bacteria that caused the last batch of coolant to become rancid. Unfortunately, it may be difficult to access the machine sumps; therefore, you may need to modify existing sumps to allow access for cleaning tools. You also may want to keep this accessibility in mind when purchasing new machines. Studies have shown that sumps constructed out of sheet metal with rounded corners are easier to clean.

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Use of biocides - Many different biocide products are on the market. You should work with your coolant supplier to determine which biocide is required for the coolants being used and the relative risks of the chemicals. The disposal facility must be kept in mind when choosing a biocide. You may want to check with the disposal facility prior to purchasing and using any biocide product to ensure that the biocides you are considering will not limit your disposal options. Inexpensive bacteria testing kits are available that will help you determine when a biocide is necessary and ensure that excessive amounts will not be added to the coolants.

pH adjustment - A drop in the pH of the coolants can be an indicator of anaerobic bacterial growth. By controlling the pH of the coolant with a caustic soda or sodium hydroxide solution, the need for a biocide can be greatly reduced. Portable pH meters or pH paper can be purchased to help determine when adjustment is necessary. Again, you should contact the supplier of your coolant to be sure that the solution used is compatible with your coolant. You also should note the necessary safety precautions that must be followed when working with concentrated chemicals.

Coolant aeration - The concept behind aeration is to ensure that an oxygen enriched environment is maintained, thereby preventing anaerobic conditions. This may be something as simple as running the coolant through the machine's system when parts are not being machined or adding a stirring or air line to the sump to aerate the coolant.

Maintaining coolant and additive concentrations

Maintaining the proper coolant-to-water ratio is critical since coolants are designed for optimum performance at specified concentrations. Coolant that is overly dilute or concentrated may reduce tool life and result in using more coolant than necessary. The same is true for additives. Your coolant supplier should be able to assist you in determining the necessary concentrations for the type of machining done in your shop.

Refractometers are fairly inexpensive and simple devices that can provide accurate measurements of coolant concentrations. Coolant proportioning devices are also available which would enable more accurate mixing of solutions.

Other considerations

In cases where the sump is inaccessible and cannot be modified (making oil/chip removal and sump cleaning difficult) a different coolant may still provide a longer life in the same environment.

A centralized sump for several machining operations also may ease maintenance procedures and reduce the overall capital costs for maintenance-related equipment such as oil skimmers.

For further information, contact MnTAP at 612-627-4646 or 1-800-247-0015.

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