Pollution Prevention Opportunities for Chemical Manufacturing

The keys to pollution prevention are good operating practices and production process modifications. Wastes are usually generated from the mishandling of materials and the inadvertent production of off-spec materials.

Y/N	Opportunities	Comments
	I. Material Input, Storage and Handling	
___	Inventory control	First in, first out to prevent expiration
___	Designate material storage area	Provide protection, spill containment; keep area clean and organized; give one person the responsibility to maintain the area
___	Return obsolete materials to suppliers	Suppliers are the best persons to handle them
___	Segregate wastestreams, especially nonhazardous from hazardous	Prerequisite for recovery and reuse
___	Store packages properly and shelter from weather	To prevent damage, contamination and product degradation
___	Prevent and contain spills leaks via proper equipment maintenance and increased employee training and supervision	To prevent the generation of wastes
___	Minimize traffic through material storage area	To reduce contamination and dispersal of materials
___	Improve quality of feed by working with suppliers or installing purification equipment	Impurities in feedstream can be major contributors to waste
___	Reexamine need for each raw material	Need for a raw material that ends up as waste may be reduced or eliminated by modifying the process and improving control
___	Use off-spec material	Occasionally, a process can use off-spec material because the particular quality that makes the material off-spec is not important to the process
___	Improve product quality	Product impurities may be creating wastes at customers' plants; effect should be discussed with customers
___	Use inhibitors and continuously improve	Inhibitors prevent unwanted side reactions or polymer formation

___ Reformulate products from powder to pellet	To reduce dust emissions and waste generation
___ Reuse inert ingredients when flushing solids handling equipment	To minimize need for disposal
___ Change shipping containers, both for raw materials and products	To avoid disposal, change to reusable containers, totebins or bulk shipments.
___ Recover product from tankcars and tanktrucks	To minimize product drained from tanks going to waste

II. Production Process Modifications

Reactors: The reactor is the heart of the process and can be a primary source for waste products. The quality of mixing is the key.

___ Improve physical mixing in a reactor	Install baffles, a high rpm motor for the agitator, a different mixing blade design, multiple impellers, pump recirculation or an in-line static mixer
___ Distribute feeds better for better yield and conversion, both for inlet and outlet	Add feed distributor to equalize residence time through fixed bed reactor to minimize under- and over-reactions that form by-products
___ Improve ways reactants are introduced into the reactor	Get closer to the ideal reactant concentrations before the feeds enter the reactor to avoid secondary reactions which form unwanted by-products in the premixing of reactants
___ Improve catalyst and continuously upgrade	Catalyst has a significant effect on reactor conversion and product mix; changes in the chemical makeup of a catalyst, the method by which it is prepared, or its physical characteristics can lead to substantial improvements in catalyst life and effectiveness
___ Provide separate reactor for recycle streams	The ideal reactor conditions for converting reactor streams to usable products are different from those in the primary reactor; this separation affords optimization for both streams
___ Better heating and cooling techniques for reactors	To avoid hot spots that would give unwanted by-products

___ Consider different reactor design	The classic stirred-tank back mix reactor is not necessarily the best choice. A plug flow reactor offers the advantage that it can be staged, and each stage can be run at different conditions for optimum product mix and minimum waste generation
___ Improve control to maintain optimal conditions in reactor	To increase yield and decrease by-product; at a minimum, stabilizing conditions in reactor operation frequently if advanced computer control is not available

Heat Exchangers: Heat exchangers can be a source of waste, especially with products that are temperature-sensitive. Reducing tube-wall temperature is the key.

___ Use lower pressure steam	To reduce tube-wall temperature
___ Desuperheat steam	To reduce tube-wall temperatures and increase the effective surface area of the exchanger because the heat transfer coefficient of condensing steam is ten times greater than that of superheated steam
___ Install a thermocompressor	To reduce tube-wall temperature by combining high and low pressure steam
___ Use staged heating	To minimize degradation, staged heating can be accomplished first using waste heat, then low pressure steam and finally, desuperheated high pressure steam
___ Use on-line cleaning techniques for exchangers	Recirculating sponge balls and reversing brushes can be used to reduce exchanger maintenance, and also to keep the tube surface clean so that lower temperature heat sources can be used
___ Use scraped-wall exchanger	To recover saleable products from viscous streams, e.g. monomers from polymer tar
___ Monitor exchanger fouling	Sometimes an exchanger fouls rapidly when plant operating conditions are changed too fast or when a process upset occurs; monitoring can help to reduce such fouling
___ Use noncorroding tube	Corroded tube surfaces foul more quickly than noncorroded ones

Pumps: Preventing leaks is the key.

___ Recover seal flushes and purges	Recycled to the process where possible
___ Use sealless pumps	Use can-type or magnetically driven sealless pumps

Furnaces: Avoiding the hot tube-wall temperature is the key.

___ Replace coil	Alternative designs should be investigated wherever replacement becomes necessary
___ Replace furnace with intermediate exchanger	Use a high temperature intermediate heat transfer fluid to eliminate direct heat
___ Making use of existing steam superheat	Sufficient superheat may be available to heat a process stream, avoiding exposure of the fluid to hot tube-wall temperature of a furnace

Distillation Column:

Distillation column typically produces waste in three ways:

- Allowing impurities to remain in a product from inadequate separation
- Forming waste within the column itself through polymerization from the high reboiler temperature in the column
- Losing products through venting or flaring from inadequate condensing

___ Increase reflux ratio if column capacity is adequate for better separation	Increase the ratio by raising the the pressure drop across the column and increasing the reboiler temperature using additional energy
___ Add section to column for better separation	The new section can have a different diameter and can use trays or high efficiency packing
___ Retray or repack column for better separation	Repack to lower pressure drop across a column and decrease the reboiler temperature; large diameter columns have been successfully packed
___ Change feed tray for better separation	Match the feed conditions with the right feed tray in the column through valving changes
___ Insulate	Good insulation prevents heat losses and fluctuation of column conditions with weather
___ Improve feed distribution	Especially for a packed column
___ Preheat column feed	Preheating improves column efficiency and also requires lower temperatures than supplying the same heat to the reboiler; often the feed can be preheated by cross exchange with another stream

___ Remove overhead products from tray near top of column	To obtain a higher purity product if it contains a light impurity
___ Increase size of vapor line	To reduce pressure drop and decrease the reboiler temperature
___ Modify reboiler design	A falling film reboiler, a pumped recirculation reboiler, or high-flux tubes may be preferred to the conventional thermosiphon reboiler for heat-sensitive fluids
___ Reduce reboiler temperature	General temperature reduction techniques include using lower pressure steam or desuperheated steam, installing a thermocompressor and using an intermediate transfer fluid
___ Lower column pressure	To decrease reboiler temperature; the overhead temperature, however, will also be reduced which may create a condensing problem
___ Improve overhead condensers condensers	To capture any overhead losses through retubing, condenser replacement or supplemental vent condenser addition
___ Improve column control	Similar to improving reactor control
___ Forward vapor overhead to the next column	Use a partial condenser and introduce the vapor stream to the downstream column

Piping: A simple piping change can result in a major reduction of waste.

___ Recover individual wastestream	Segregation is crucial for reuse
___ Avoid overheated lines	Review the amount and temperature of heat-sensitive materials in lines and in vessel tracing and jacketing
___ Avoid sending hot materials to storage	To prevent excessive venting and degradation of products
___ Eliminate leaks	To prevent waste generation
___ Change metallurgy or use lining	Metal may cause a color problem or act as a catalyst for the formation of by-products

___ Monitor major vents and flare system and recover vented products	Storage tanks, tankcars and tank trucks are common sources of vented products; install a condenser or vent compressor for recovery

Process control: Modern technology allows computer control system to respond more quickly and accurately than human beings. This capability can be used.

___ Improve on-line control	Good process control reduces waste by optimizing process conditions and reducing plant trips and wastes
___ Optimize daily operation	A computer can be programmed to analyze the process continually and optimize the conditions to prevent waste
___ Automate startups, shutdowns and product changeover	To bring the plant to stabilize conditions quickly to minimize the generation of off-spec wastes
___ Program plant to handle unexpected upsets and trips	To minimize downtime, spill, equipment loss and waste generation

Miscellaneous:

___ Avoid unexpected trips and shutdowns	A good preventive maintenance program, adequate sparing of equipment and adequate warning system for critical equipment
___ Use wastestreams from other plants	Internal waste exchanges are feasible, but wastestreams should be adequately characterized
___ Reduce number and quantity of samples	Review sampling frequency and procedure and recycle the samples
___ Find a market for waste product	Wastes can be converted to saleable by-products with additional processing and creative salesmanship
___ Install reusable insulation	Particularly effective on equipment where the insulation is removed regularly to perform maintenance

III. Equipment Cleaning and Changeover

___ Avoid unnecessary equipment cleaning	Explore the feasibility of eliminating cleaning step between batches

___ Maximize equipment dedication	Dedicating tanks to one product will reduce clean-out and save time and labor cost for changeover
___ Recover more products	Scraping down tanks, pigging or blowing lines can recover more product and reduce wastes
___ Use less cleaner	High pressure sprays, pressurized air, steam and heated cleaning bath can reduce the amount of cleaner used and disposed of as waste
___ Reuse cleaner	Reclaim and reuse cleaner if feasible
___ Consider alternative cleaning methods and less hazardous cleaners	Mechanical cleaning such as plastic media blasting and ultrasonic cleaning, together with more biodegradable cleaner, can reduce waste volume and toxicity
___ Standardize cleaning products used in plant	To maximize recovery potential

Acknowledgement:
Materials for production process modification were adopted from Ken Nelson, Dow Chemical USA, " Use These Ideas to Cut Wastes," Hydrocarbon Processing, March 1990.
