9 WASTE

9.1. WASTE GENERATION

Almost any operation will generate some sort of waste. Even non-industrial type of a business will have a waste in terms of paper, cardboard, etc.. If the waste is landfilled, it is rather obvious that the space available is limited. If the waste is incinerated, a secondary waste and heat are created. Waste generators need to concentrate on the waste reduction at the source. If that is not possible, recycling is the second choice, and as the last resort, treatment of wastes that will give relatively harmless products.

9.1.1. Sources of Manufacturing Wastes

In order to be able to deal successfully with any waste issues, an auditor has to know what usually constitutes waste and where and how it is generated. Nothing can be as valuable as personal experience but even an inexperienced person doing the assessment can get a good idea from the following lists.

- Raw Materials
  - Containers, packing
  - Off-spec and expired lots
  - Spoiled batches

- Processes

Cleaning	Coating/Painting
Reactions	Plating/Anodizing/Chromating
Machining	Casting/Molding
Testing	Extracting/Refining
Printing	Packaging

Process Wastes

- Cleaning

Alkaline baths	Acidic baths
Solvents	Rags
Sludges	Oil and Grease
Grit	Rinse water

- Painting

Thinner	Paint sludge
Overspray	Filters
Containers	Unused paint
Paint stripper	Masking

- Machining

Metal chips	Trimming waste
Cutting coolants	Tapping oil
Hydraulic oil	Tramp oil
Filters	Rags

- Printing

Lithographic plates	Plate process solutions
Silver	Photo process solutions
Press washes	Rags
Paper	Inks

9.1.2. Compendium of Processes Producing Waste

Table 9.1: Waste Generated by Different Processes

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
Chemical processing (SIC: 28,29)	•Blending/mixing •Reaction to form product •Vessel cleaning	• Tank cleanout solutions • Tank cleanout solids • Reagent (liquid and powder) spills to floor • Reaction byproducts • Air emissions • Dust from powdered raw material	• Use Teflon lined tanks • Clean lines with "Pigs" instead of solvents or aqueous solutions • Use squeegees to recover clinging product prior to rinsing • Use Clean In Place (CIP) systems • Clean equipment immediately after use • Treat and reuse equipment cleaning solutions • Use cylindrical tanks with height to diameter ratios close to one to reduce wetted surface • Use tanks with a conical bottom outlet section to reduce waste associated with the interface of two liquids • Increase use of automation • Convert from batch operation to continuous processing • Use dry cleaning methods whenever possible • Use squeegees, mops and vacuums for floor cleaning • Use pumps and piping to decrease the frequency of spillage during material transfer • Install dedicated mixing equipment to optimize

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
			reuse of used rinse and to preclude the need for inter-run cleaning • Use in process recycling whenever possible • Install floating covers on tanks of volatile materials to reduce evaporation • Order paint pigments in paste form instead of dry powder to eliminate hazardous dust waste
Food processing (SIC: 20)	•Mixing/blending • Cooking/baking	• Equipment cleaning waste waters • Floor washing waste waters • Solid materials from mixer cleaning (e.g. dough) • Spent cooking oils	• Use dry cleaning methods whenever possible • Use high pressure washing equipment • Use squeegees and mops and for floor cleaning • Use continuous processing to eliminate the need for inter-run cleaning
Metal working (SIC: 33-39)	• Melting	• Air emissions • Hazardous slags • Non-hazardous slags • Metal dust • Scrubber sludge	• Recycle non ferrous dust • Alter raw materials to reduce air emissions • Use induction furnaces instead of electric arc or cupola furnaces to reduce dust and fumes • Reuse high ferrous metal dust as raw material • Use high quality scrap (low sulfur) to reduce hazardous sludge generation • Use an alternative desulfurizing agent to eliminate hazardous slag formation • Alter Product Requirements to eliminate unnecessary use of desulfurizing agent (calcium carbide) • Separate iron from slag and remelt • Treat disulfurization slag in a deep quench tank instead of spraying water onto an open pile to reduce air emissions
	• Casting	• Spent sand • Flashing • Reject castings	• Recycle casting sand • Use sand for other purposes (e.g. construction fill, cover for municipal landfills) • Avoid contamination of flashing and reject castings and reuse as feed stock • Recover metals from casting sand
	• Extrusion	• Scrap end pieces	• Avoid contamination of end pieces and reuse as feed stock
	• Coldworking (bending, pulling)	• Scrap metal	• Recycle scrap metal to foundry

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
	• Machining (cutting, lathing, drilling, tapping)	• Metal scrap • Spent hydraulic oils • Spent lubricating oils • Leaked oils • Dirty rags or towels	• Segregate metals for sale to a recycler • Reprocess spent oils on site for reuse • Install shrouding on machines to prevent splashing of metal working fluids • Utilize a central coolant system for cleaning and reuse of metal working fluid • Maintain machines with a regular maintenance program to prevent oil leaks • Implement a machine and coolant sump cleaning program to minimize coolant contamination
	• Grinding	• Metal and abrasive dust	• Separate (flotation, magnetic) and recycle scrap to foundry
	• Heat treatment	• Air emissions	• Improve furnace control
Printing (lithography, gravure, flexography, letterpress, screen) (SIC: 27)	• Image production	• Scrap film • Spent film processing solutions	• Use glass marbles to raise fluid levels of chemicals to the brim to reduce contact with atmospheric oxygen • Recycle film for silver recovery • Use electronic imaging and laser plate making • Use water-based image processing chemicals • Closely monitor chemical additions to increase bath life • Use squeegees to prevent chemical carry-over in manual processing operations • Use counter current washing in photo processors • Recycle processing baths for nickel recovery • Use silver free films • Use "washless" processing equipment
	• Plate, cylinder and screen making	• Spent plate processing solutions	• Use water-based developers and finishers • Use an automatic plate processor • Use counter-current rinsing to reduce rinse water volume (gravure) • Use drag-out reduction methods (gravure)-*see surface coating* Sell used plates to an aluminum recycler
	• Make-ready	• Scrap paper • VOC emissions	• Automate ink key setting system • Reuse scrap printed paper for make-ready • Use ink water ratio sensor • Computerized registration • Use automated plate benders

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
	• Printing	• Scrap paper • VOC emissions • Damaged rubber blankets • Waste ink • Waste printing press oils	• Install web break detectors to prevent excessive waste paper • Eliminate chemical etching and plating by using alternative printing technologies (Presensitized lithographic, plastic or photopolymer, hot metal, or flexographic) • Use a waterless plating system • Use automatic ink levelers • Schedule jobs to minimize the need for cleanup (light colors before dark) • Use dedicated presses for each color • Use less toxic solvents • Use soy or water-based inks • Automate ink mixing • Cover ink containers when not in use
	• Clean-up	• VOC emissions • Left over ink from fountains • Waste roller cleaning solution • Dirty rags • Paint skin from open ink containers • Used plates	• Use press cleanup rags as long as possible before disregarding • Recycle waste ink and cleanup solvent • Use automatic cleaning equipment • Remove rollers from the machines and clean in a closed solvent cleaner • Prevent excessive solvent usage during cleaning (operator training) • Segregate spent solvents (by color) and reuse in subsequent washings • Improve cleaning efficiency by maintaining cleaning system (rollers, cleanup blade)
Surface coating (SIC: 24, 25, 34-39)	• Painting	• Off-specification or outdated paint • Empty paint and solvent containers • Paint sludge • Spent paint filters • Booth cleanout waste (overspray) • Spent cleaning solvent • VOC emissions	• Use tight fitting lids on material containers to reduce VOC emission • Convert to higher efficiency technologies • Convert to electrostatic powder coating • Convert from water curtain spray booths to a dry system • Convert to robotic painting • Use low VOC or water based paint • Purchase high volume materials in returnable bulk containers • Train operators for maximum operating efficiency • Automate paint mixing
			• Use compressed air blowout for line cleaning prior to solvent cleaning • Shorten paint lines as much as possible to reduce line cleaning waste • Schedule production runs to minimize color changes • Recycle cleaning solvent and reuse • Use paint without metal pigments

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
	• Plating (electro, electroless) • Anodizing	• Spent alkaline cleaning solutions • Spent acid baths • Spent cyanide cleaning solutions • Spent plating solutions • Filter sludge • Waste rinse water • Waste water treatment sludge • Vent scrubber waste	• Use high purity anodes to increase solution life • Lower the concentration of plating baths • Reduce drag-in with better rinsing to increase solution life • Use deionized water for make-up and rinse water to increased solution life • Extend solution life with filtering or carbonate freezing • Use cyanide free solutions whenever possible • Replace cadmium-based solutions with zinc solutions • Replace hexavalent chromium solutions with trivalent solutions • Return spent solutions to the manufacturer • Use lower concentration plating baths • Reduce drag-out by racking parts for maximum drainage • Reduce drag-out by slowing withdrawal speed and increasing drain time • Rack parts for maximum drainage • Use drain boards between tanks for solution recovery • Reduce water use with counter current rinsing • Use fog nozzles over plating tanks and spray rinsing instead of immersion rinsing • Use reactive rinsing • Mechanically and air agitate rinse tanks for complete mixing • Use a still rise as the initial rinsing stage • Use automatic flow control • Recovery metals from rinse water (Evap., Ion exchange, R.O., Electrolysis, Electrodialysis) and reuse rinse water • Use precipitating agents in waste water treatment that produce the least quantity of waste • Use separate treatments for each type of solution and sell sludge to a recycler
	• Stripping of paint, varnish, lacquer	• Spent solvents • VOC emissions • Spent caustic solutions • Spent sand and other blasting media • Paint dust	• Use mechanical stripping methods • Use cryogenic stripping • Use non-phenolic strippers to reduce toxicity associated with phenol and acid additives • Maintain clean conditions before painting to avoid surface contamination resulting in paint defects
	• Metal plating removal	• Spent acid solution • Tank sludge	• Recover metals from spent solutions and recycle
Surface preparation/	• Chemical etching	• Spent acidic solution	• Reduce solution drag-out from process tanks • Prevent solution drag-out from upstream tanks

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
cleaning (SIC: 24, 25, 34-39)	• Solvent cleaning (vapor degreasing, solvent dip)	• Tank sludge • Waste rinse water • Spent solvents • Solvent recycle still bottoms • VOC emission • Solvent tank sludge	• Use deionized water in upstream rinse tanks • Treat and reuse rinse waters • Recover and reuse spent acid baths • Use tight-fitting lids on material containers and solvent cleaning tanks to reduce VOC emissions • Convert to aqueous cleaning system • Convert to less toxic hydrocarbon cleaners • Use peel coatings on raw materials to eliminate need for cleaning • Use water-based cutting fluids during machining to eliminate need for solvent cleaning Increase freeboard space and install chillers on vapor degreasers • Distill contaminated solvents for reuse • Remove sludge from tanks on a regular basis • Slow insertion and withdrawal of parts from vapor degreasing tank to prevent vapor drag-out • Maintain water separator and completely dry parts to avoid water contamination of solvent • Convert to aqueous cleaning • Use silhouette entry covers to reduce evaporation area • Avoid inserting oversized object to reduce piston effect • Allow drainage before withdrawing object • Eliminate the need for cleaning with improved handling practices
	• Aqueous cleaning	• Spent cleaning solutions • Waste rinse waters • Oil sludge • Tank sludge	• Remove sludge from tanks on a regular basis • Minimize part contamination before washing • Eliminate the need for cleaning with improved handling practices • Extend solution life by minimizing drag-in • Use alternatives for acid and alkaline (e.g. water, steam, abrasive) • Preinspect parts to prevent drag-in of solvents and other cleaners • Install mixers on each cleaning tanks • Closely monitor solutions and make small additions to maintains solution strength instead of lathe infrequent additions • Implement a regular maintenance program to keep racks and tanks free of rust, cracks, or corrosion • Apply a protective coating to racks and tanks • Reduce solution drag-out to prevent solution loss • Use counter current rinsing to reduce waste water • Use reactive rinsing to extend bath life
	• Abrasive cleaning	• Used buffing wheels • Spent compound	• Use water based or greaseless binders to increase wheel life • Use liquid spray (water based) adhesive instead of

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
			bar abrasives to prevent over use of material and easier part cleaning • Carefully control water level in Mass Finishing Equipment
	• Dry and wet rag cleaning	• Spent solvent wetted rugs • Oil soaked rags	• Wash and reuse rags on-site • Use an off-site rag recycling service • Minimize use of rags through worker training
Paper and pulp manufacturing (SIC: 26)	• Wood Preparation • Pulping • Screening • Washing • Thickening • Bleaching • Stock preparation • Paper machine • Finishing and Converting	• Wood waste (saw dust, bark) • Acid and Alkaline waste waters • Toxic waste waters and sludges • Wood fiber waste • Non-hazardous waste water treatment sludge	• Use diffusion pulp wash systems to maximize efficiency • Maintain spray water temperature of 60°– 70° F to maximize rinse efficiency • Employ a closed cycle mill process to minimize waste water production • Reuse rich white water in other applications • Use felt showers to minimize the amount of fresh water use • Recycle white water • Develop segregated sewer systems for low suspended solids, high suspended solids, strong wastes, and sanitary sewer • Improve process control to prevent spills of material • Minimize overflows or spills by installing level controls in process tanks and storage tanks • Install redundant key pumps and other equipment to avoid losses caused by equipment failure and routine maintenance • Provide a storage lagoon before the biological treatment system to accept long-term shock loads • Replace the chlorination stage with an oxygen or ozone stage • Recycle chlorination stage process water • Use water from the counter current washing system in the chlorination stage • Perform high consistency gas phase chlorination
Textile processing (SIC: 22)	• Fabric weaving • Milling • Sewing • Pressing • Dying	• Waste thread, yarn and material • Dye contaminated waste water	• Market waste material as clean-up rags • Recover dye from waste waters
Waste water treatment (SIC: 20, 22, 26, 28, 29, 31, 33-39)	• pH adjustment • Filtration • Mixing • Flocculating • Clarification • Polishing	• Treated effluent • Hazardous treatment sludge • Non-hazardous treatment sludge	• Use alternative flocculants to minimize sludge volume. • Use filter a filter press and drying oven to reduce sludge volume • Automatically meter treatment chemicals • Minimize contamination of water before treatment
Plastic formation (SIC: 30)	• Injection Molding	• Machine clean-out waste (pancakes) • Scrap plastic parts	• Maintain machines with a regular maintenance program to prevent oil leaks • Regrind and reuse scrap plastic parts

General industrial category	Unit operation	Common waste streams	Pollution prevention and recycle/reuse measures
		• Plastic pellet spill to floor • Spent hydraulic oil • Oil-soaked absorbent	• Filter and reuse hydraulic oil • Use and industrial vacuum for spill cleanup instead of absorbent
	• Extrusion	• Scrap end pieces	• Avoid contamination of end pieces and reuse as feed stock
	• Foaming	• Fugitive air emissions • Stack releases • Scrap foam	• Improved material handling (mixing and transfer) to avoid spills • Implement a regular maintenance program to reduce fugitive emissions from leaky valves and pipe fittings
	• Composite materials	• Empty resin and solvent containers • Spent cleaning solvents • Waste washdown water • Cleanup rags • Waste fabric • Gelcoat and resin overspray • VOC emissions • Waste resins • Resin and solvent contaminated floor sweeping	• Maximize production runs to reduce cleanings • Regenerate cleaning solvent on-site and reuse • Use less toxic and volatile solvent substitutes • Reduce transfer pipe size • Use more efficient spray method for gelcoat application • Modify material application methods to prevent material spillage • Cover solvent and resin container to minimize evaporative losses
Glass processing (SIC: 32)	• Melting • Blowing • Molding	• Scrap glass • Contaminated granular raw materials	• Avoid contamination of scrap glass and reuse as feed stock
Leather processing (SIC: 31)	• Tanning • Finishing	• Scrap leather material • Waste processing solution	• Recycle spent tanning solution
Fastening/ joining/ assembly (SIC: 24, 25, 27, 34-39)	• Gluing (adhesive) • Mechanical fastening • Welding • Part testing • Fluid filing	• Used adhesive container • Adhesive solvent air emissions • Dried adhesive • Shielding gas emissions • Metal slag • Gasoline (motor test) • Oil and grease spilled to floor • Spent clean-up rags or towels	• Purchase adhesive in bulk containers • Use water-based adhesives • Use more efficient adhesive applicators • Use a rag recycle service • Reuse rags until completely soiled • Use rags sized for each job

9.2. HAZARDOUS WASTES

It is a useful practice to divide waste into two categories, non-hazardous and hazardous. Each category groups waste according to one very important common denominator that determines to a large degree the way the waste is treated. Depending which category the waste belongs to, the proper method of disposal must be selected (sometimes the method is mandated by the law) and adequate funds made available. In most cases treatment of hazardous waste will be much more expensive than non-hazardous one. However, in many instances the process can be adapted to avoid hazardous waste generation, thus solving the problem at the source. For that reason, it is necessary that an auditor be familiar with different alternatives to common practices.

1. Non hazardous wastes
   Examples: cardboard, pallets, cooling water
   Disposal: landfill solids, sewer waste water

2. Hazardous wastes

Categories	**Examples**	
Corrosive	H_2SO_4	D002
Reactive	$NaClO_4$	D003
Ignitable	C_6H_6	F005
Toxic	Cr	D007

9.2.1. Types of Waste Generated

Everyday industry uses products containing hazardous materials:

- Rust removers, which contain concentrated acid or alkaline solutions
- Equipment cleaners, which contain flammable or combustible liquids
- Waste oil, lubricants, and fluids
- Spent solvents
- Spent caustic parts washing detergent solution
- Parts cleaning tank sludge
- Oily waste sump sludge
- Spent antifreeze
- Used rags, containing combustible or flammable solvents

- Paints with flammable or combustible thinners or reducers

9.2.2. Typical Operations Using Materials Which Generate Hazardous Wastes

Typical processes or operations that generate hazardous wastes are listed below with the type of waste produced.

1. Oil and grease removal generates:
    - ignitable waste,
    - spent solvents,
    - combustible solids, and
    - waste acid/alkaline solutions.
2. Parts and equipment cleaning generates:
    - ignitable waste,
    - spent solvents,
    - combustible solids, and
    - waste acid/alkaline solutions.
3. Rust removal generates:
    - waste acids, and
    - waste alkaline.
4. Paint preparation generates:
    - spent solvents,
    - ignitable wastes,
    - ignitable paint waste, and
    - paint wastes with heavy metals.
5. Painting generates:
    - ignitable paint wastes,
    - spent solvents,
    - paint wastes with heavy metals, and
    - ignitable wastes.
6. Spray booth, spray guns, and brush cleaning generates:
    - ignitable paint wastes,
    - heavy metal paint wastes, and
    - spent solvents.
7. Paint removal generates:
    - ignitable paint wastes,
    - heavy metal paint wastes, and
    - spent solvents

Remember, if a nonhazardous waste or material is mixed with a hazardous waste, the mixture becomes hazardous. For example, when a sawdust absorbent is used to clean up hazardous spills in a

shop, the sawdust then becomes a hazardous waste. In addition, unused hazardous materials that become too old to be used also become hazardous wastes. Good management supervision and employee training will help reduce waste in these areas.

9.2.3. Hazardous Waste Generator's Responsibilities

- Identify and quantify hazardous wastes
- Determine Status: CESQG (conditionally exempt SQG), SQG (small quantity generator), LQG (large quantity generator)
- Comply with regulations
  On-site storage
  On-site treatment
  On-site disposal
  Transport
  Offsite disposal at approved TSDF
  Plan for accidents, emergencies
  Pollution prevention plan (CA)

Table 9.2: Pollution Prevention Regulations

STATUTE	Implications	Waste Streams Affected
Clean Air Act (1970, amended 1977,1990)	Permits	VOC emissions (Solvent evaporative losses)
Resource Conservation and Recovery Act (1976, amended 1984)	Shipping and disposal records	Waste ink Spent solvents Soiled rags and paper towels
Clean Water Act (1972, amended 1977, 1987)	Publicly Owned Treatment Works (POTW) compliance	Wastewater from image production, screen making and screen reclamation
Emergency Planning and Community Right-to-Know Act (1986)	Form R reporting	Waste streams containing chemicals listed in Toxic Release Inventory (TRI) document

9.3. WASTE GENERATION AND MANAGEMENT

Management of waste related activities, like any other activities, must be conceptualized before any action is taken. All the variables have to be known, including projected amount of waste in the future. The technologies available have to be evaluated. This represents landfills, pulverization, incineration, magnetic separation, paper and plastics recovery, composting, gasification, anaerobic digestion and so on. After evaluating all options, the overall strategy in waste management has to be formulated and should be based on the most beneficial technology available. It is advisable, since the economic and political climate might change, to review the chosen strategy periodically and with respect to all existing laws (especially new which could have been enacted after a strategy was selected).

9.3.1. Waste Reduction

To be successful, waste reduction programs must be organized. It is not hard to organize waste reduction, but owners and managers will need to spend a little bit of time at first to get started. Keep in mind the following seven principles of waste reduction.

1. Management must be committed to waste reduction for it to work.
2. Businesses should know the types of hazardous waste they generate, how it is produced, and how much is produced.
3. Businesses should know how the hazardous wastes are managed and how much present waste management costs.
4. “Good housekeeping” reduces spills and other waste.
5. Store different waste types in different containers.
6. Train all employees in hazardous waste handling and waste reduction methods.
7. Be aware of the hazardous materials regulations that apply to the business. Someone should be assigned to keep track of environmental regulations.

9.3.2. Record Keeping

As specified above, a waste generator has to keep a record. That will allow everybody to track individual substances according to the needs, should they arise. The record of movement of all hazardous substances through the plant, from one manufacturing cell to another, or simply as a material flow, is a very useful tool. The example given in Table 9.3 is a hypothetical printing operation with many steps that are typical for such an operation. In the reference section at the end of the chapter there is a lot of material about hazardous waste. It is always in the company’s interest to deal with the issue of hazardous waste according to all the regulations. The penalties for noncompliance are high, and in serious cases could even cause shutdown of the operation. In the beginning of this manual it is emphasized that the industrial assessments are not compliance assessments. However, it is to the benefit of the company to be informed of the consequences of noncompliance and the auditor’s job to help in solving problems related to waste and hazardous waste in particular.

Table 9.3: Inventory of Waste Streams

Stream Number	Plant/Process Source	Waste Stream Components	Approximate Annual Production
1	Raw materials receiving	Waste paper and cardboard	
2		Damaged pallets	
3		Scrap plastic protective wrapping	
4	Inventory control	Expired ink	
5		Expired photo-processing reagents	
6	Image production	Exposed film	
7		Silver recovered from wastewater before release	
8		Wastewater containing spent reagents	
9	Screen making	Scrap nylon mesh	
10		Waste emulsion	
11		Wastewater from emulsion rinse off	
12	Ink handling	Evaporated ink thinner	
13		Excess ink from special color mixing	
14		Empty ink containers	
15	Printing	Contaminated or dried ink	
16		Scrap paper	
17		Solvent-wetted and soiled paper towels	
18		Scrap vinyl	
19		Scrap PVC	
20		Scrap Polycarbonate	
21		Contaminated solvent cleaner	
22		Evaporative loss of solvent cleaner	
23		Contaminated alcohol cleaner	

24		Evaporative loss of alcohol cleaner	
25	Special coating process	Scrap urethane film	
26		Empty urethane containers	
27	Plant and equipment cleanup	Solvent-wetted and soiled paper towels	
28		Waste mop water from floor cleaning	
29	Product shipping	Waste cardboard	
30	Screen cleaning	Ink remover	
31		Emulsion remover	
32		"Haze" remover	
33		Rinse water	
34		Solvent-wetted and soiled paper towels	
35		Damaged screens	
36	On- and Off-site materials recycling	Scrap PVC (ground onsite)	
37		Reclaimed polycarbonate sheets	
38	Office functions	Waste paper and cardboard	

9.4. MAIN WASTE STREAMS

The five main waste streams generated by industry include:

- Solvent wastes
- Water-based (aqueous) wastes
- Paint wastes
- Used oils
- Miscellaneous wastes

9.4.1. Solvent Wastes

Parts cleaning operations usually generate spent solvent waste in the form of solvent sink mineral spirits and immersion cleaner solvent. Other solvents may include other types of degreasers and

paint thinners. If generators spill these materials or use them for purposes other than parts cleaning, degreasing or removing paints, they may generate additional unnecessary waste. Solvents also evaporate easily. The use of solvent sinks for parts washing either on an owned or leased basis is being accepted as general good practice. Solvent reuse and waste containment are ideal features in this practice. The economics of the contracted service are also favorable, considering the current on-site labor costs for equipment maintenance and off-site disposal. The addition of drip trays to both solvent sinks and hot tanks would be beneficial to capture any losses. These are due to spillage as well as unauthorized uses (i.e. floor cleaning) for the solvent where the solvent is not recovered.

9.4.2. Water-Based (Aqueous) Wastes

Aqueous hazardous wastes refer to water-based detergent wastes and waste sump solids that are hazardous because they contain caustics, high levels of metals, and/or oily dirt. These wastes are typically generated by parts washing equipment.

If a business uses a jet spray washer, hot tank, or spray cleaner, it probably generates an aqueous detergent waste, aqueous caustic detergent waste, and/or waste sump solids. The majority of the heavy metal residue, oil and grease removed from hot tank operations occurs after the actual hot tank use. The heavier concentrations of waste residues are found in the waste sump. Standard practice currently is to use a high-velocity spray wand to dislodge these wastes as necessary. This can be done by use of a solids collection tray with overflow to the sump or periodic cleanout of the sump by a waste hauler for disposal at a permitted TSD facility. The bulk of the oil, grease, and heavy metal residues that are removed in jet spray parts cleaning operations. This occurs with the initial exposure to the wash solutions. In certain repair operations where there are a substantial quantity of parts to be processed, a two stage cleaning operation would provide clean parts in shorter times by using two washing devices in series. The first device would remove the heaviest residue, and the second device would provide the finish cleaning. The following are reduction practices concerning these types of wastes.

- Use a jet spray with a detergent only solution instead of a caustic-based solution. This trend is continuing with the change-over to aluminum parts in place of ferrous metals which require caustic solutions. The waste solution from the washer is hazardous if it contains metals or oily dirt. Consider pre-washing parts to reduce contamination of the washing solution. Or, try using two hot tanks, one with detergent solution only for aluminum parts, and one containing caustic detergent solution for all other types of parts.

- Place an inexpensive steel tray or pan next to the tank and drain the parts in the tray for a few minutes after cleaning them. Carefully empty any detergent remaining in the tray back into the tank.

- Designate a set of bays as primarily intended for service requiring hot tank or jet spray parts cleaning and locate the equipment near these bays. This will help reduce spills and drips within the shop, reducing floor cleaning waste.

- To extend the life of the cleaning solution and clean parts faster, consider an extra tank which would contain partially spent solution for rinsing most of the dirt and grime off the parts. Or, use a non-heated tank with partially spent solution for pre-rinsing.

- If a hot tank does not have heating elements on the bottom of the tank, the solids can easily be removed from the solution to extend the life of the cleaning solution. If the cleaning solution has become weak, the solution can be tested and more detergent or caustic material added as needed. Some equipment leasing services will provide this maintenance service for the tanks the business owns.

- Screening the solids before they reach the sump will reduce future sump cleaning costs.

- A leased system can be easier to use since new detergent compounds, tank maintenance, and waste management are included in the price of the service. A disadvantage to leasing is that it can be costly.

- Purchasing equipment is another option for parts cleaning. However, a business must make certain that its waste storage, transportation, and disposal techniques are safe and legal. Some equipment leasing services will provide raw material supply and waste removal services for tanks that the business owns.

- If a business owns parts cleaning equipment and transports the waste off-site for recycling, treatment, or disposal, the generator must have a registered hazardous waste hauler remove the aqueous caustic detergent waste.

- If the plant is large and owns a hot tank or jet spray washer equipment, an on-site aqueous waste treatment system may be cheaper than off-site disposal.

9.4.3. Paint Wastes

One of the most direct means of reducing paint waste is to use low-toxicity paints, i.e. water-based or non-metal products. Using water based paints helps to reduce the use of organic solvents, which become hazardous wastes and also a source of air pollution. Another approach the waste reduction is to use mechanical paint stripping. Substituting with bead blasting or cryogenic coating processes can help avoid caustics and solvents.

Various approaches to improve paint application:

- Segregating paint and solvent waste from other trash
- Purchasing paints only in quantities needed (to avoid discard)
- Reducing overspray

- Controlling paint quality to avoid defective batches requiring stripping and repainting
- Scheduling and sequencing paint operation more efficiently to reduce clean-up frequency

9.4.4. Used Oils

There are several oil loss reduction practices and used oil recycling technologies that may be useful for minimizing the disposal of waste oil. Oil wastes are generated primarily by the following industrial applications.

- Oil and grease removal in vehicle maintenance
- Waste oil from plant equipment maintenance
- Cleanup operations in industries

The amount of oil generated in a particular process can be decreased or sometimes eliminated by modifying or completely changing a given process. Water-based coolants and fluids often perform equally or better than similar oil-based fluids. Waste oil concentrated at the source of generation helps to segregate types of oils and oily water and reduces the risk of contamination with other hazardous materials.

Simple treatment, such as gravity settling, promotes the separation of oil/water wastes to substantially reduce the volume of waste oil. Avoid using more of the oil product than is necessary and adopt practices for using and re-using materials as much as possible.

As in many cases, adopting better housekeeping practices, which require very little cost, can have a large effect on the amount of waste oil produced. Some of these practices include:

- Avoiding contamination of used oils with other liquids, both hazardous and nonhazardous. A cleaner waste oil has more value in the marketplace.

- Preventing spills - Using properly designed storage tanks and documenting the dollar value of any spillage which does occur can lessen the probability of a spill.

- Look for creative uses; a waste oil generated in one process can sometimes be used in another.

- Installing collection/drip pans - Placing pans under machinery and lubrication operation will allow for the recovery of oils instead of their disposal with absorbents or rags.

- Examine types of oil wastes periodically; new products enter the market constantly which can offer savings as well as performance.

- Laundering oil-soaked rags - During laundering, oil can become biodegradable.

- Using rags and adsorbents to their limit - Adsorbent and rags are often thrown out before their useful life is over. Using them to capacity reduces the volume of contaminated adsorbents.

9.5. SOURCE REDUCTION AND RECYCLING

The following picture shows graphically the hierarchy of waste minimization. The way the problem is attacked is in a sequence from left to right as seen in the picture.

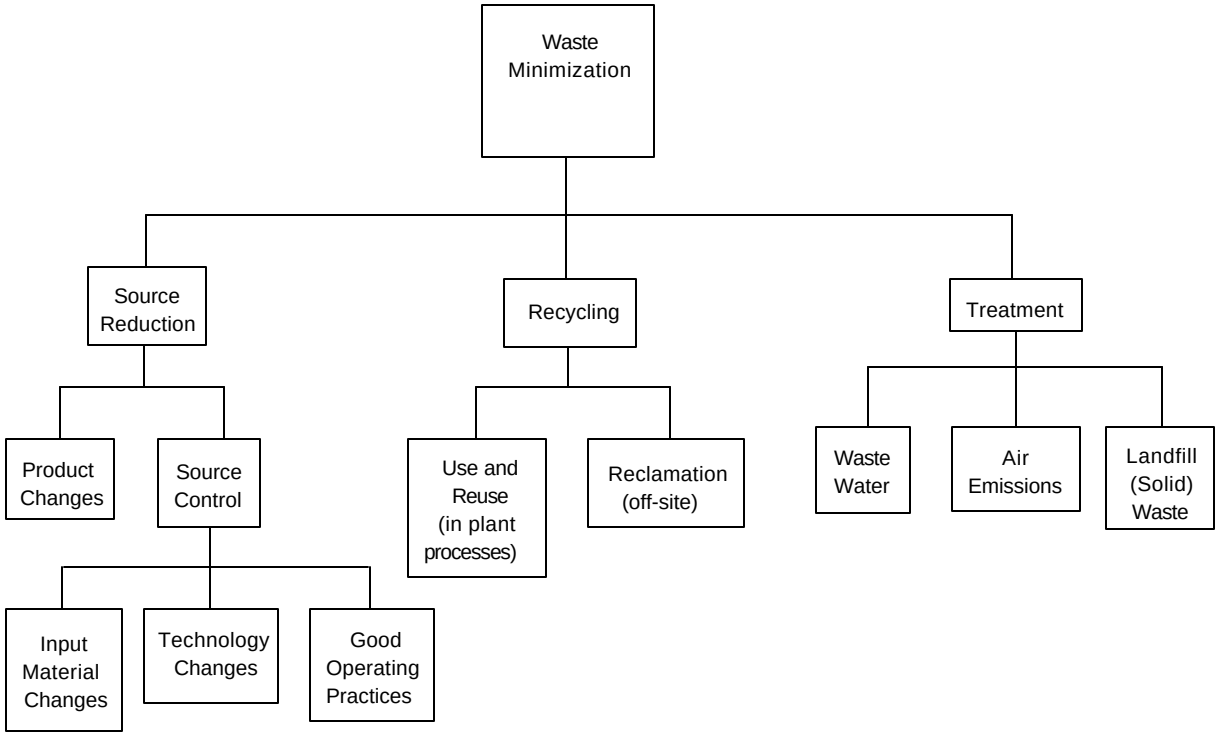

Figure 9.1: Hierarchy of Waste Minimization

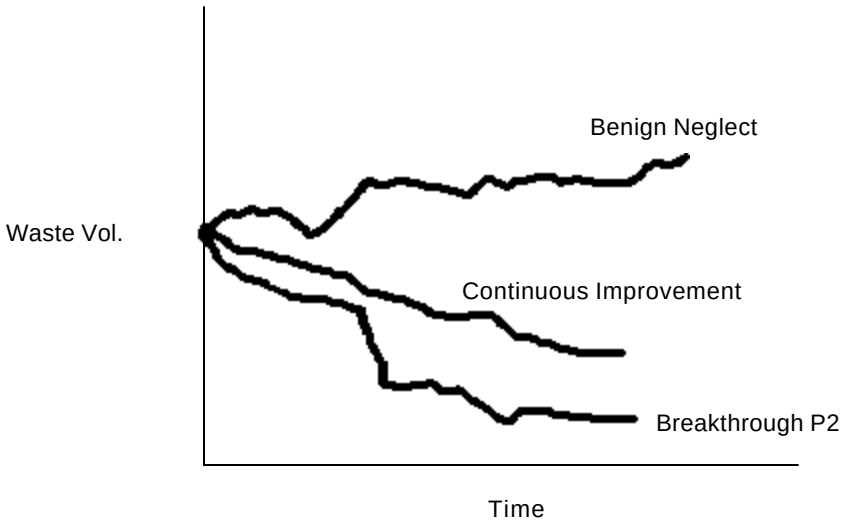

Figure 9.2: Barriers

Figure 9.2 shows how pollution prevention efforts relate to the actual volume of waste. It is much more difficult to handle the situation when the waste accumulates or nobody pays attention to the problem for a long time. Timely active response is essential.

9.5.1. Strategies in Waste Reduction

Different strategies bring different results. The following diagrams emphasize the sequence which is the easiest to take in the waste minimization efforts. The simplest step is also the cheapest to implement and gives the fastest return on investment.

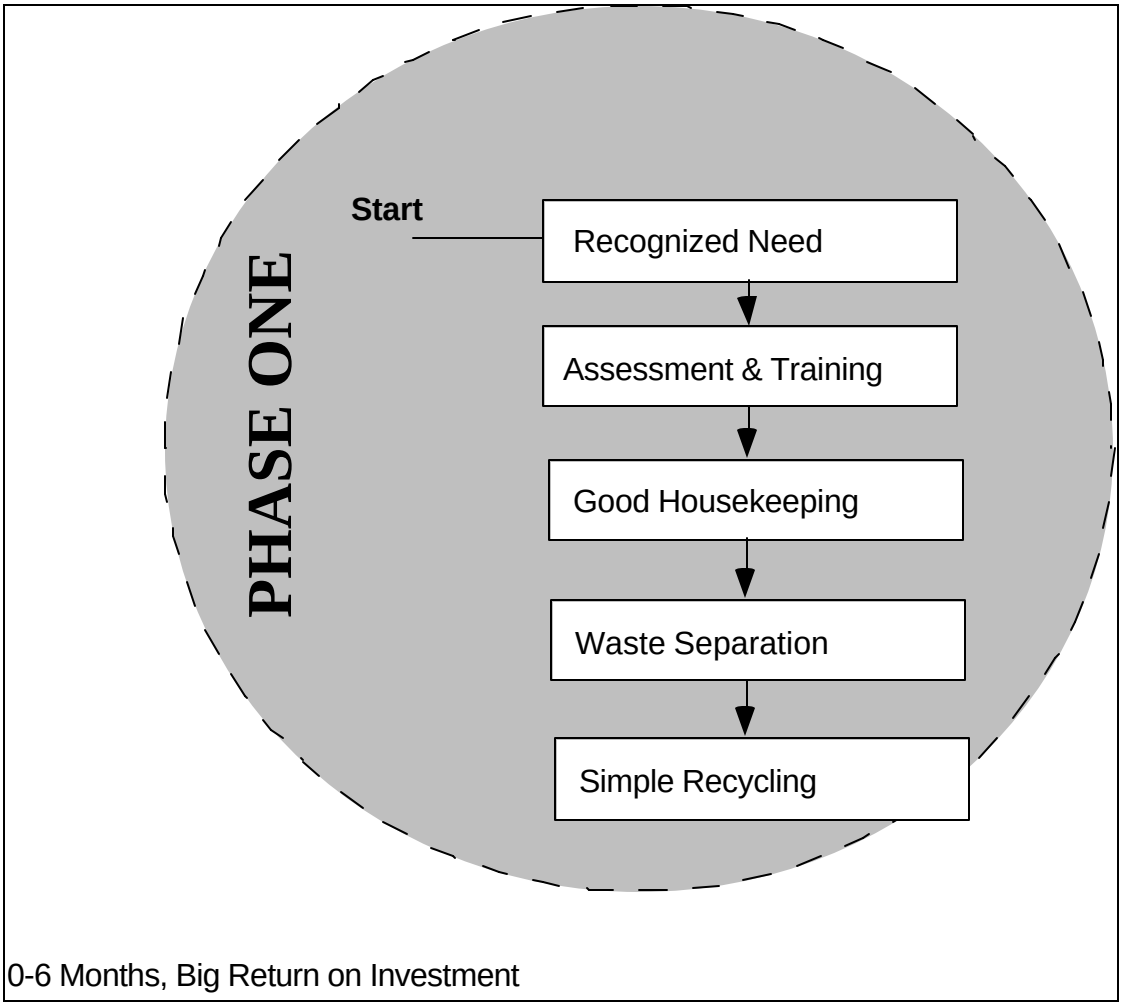

Figure 9.3: Waste Reduction - Operation Phase

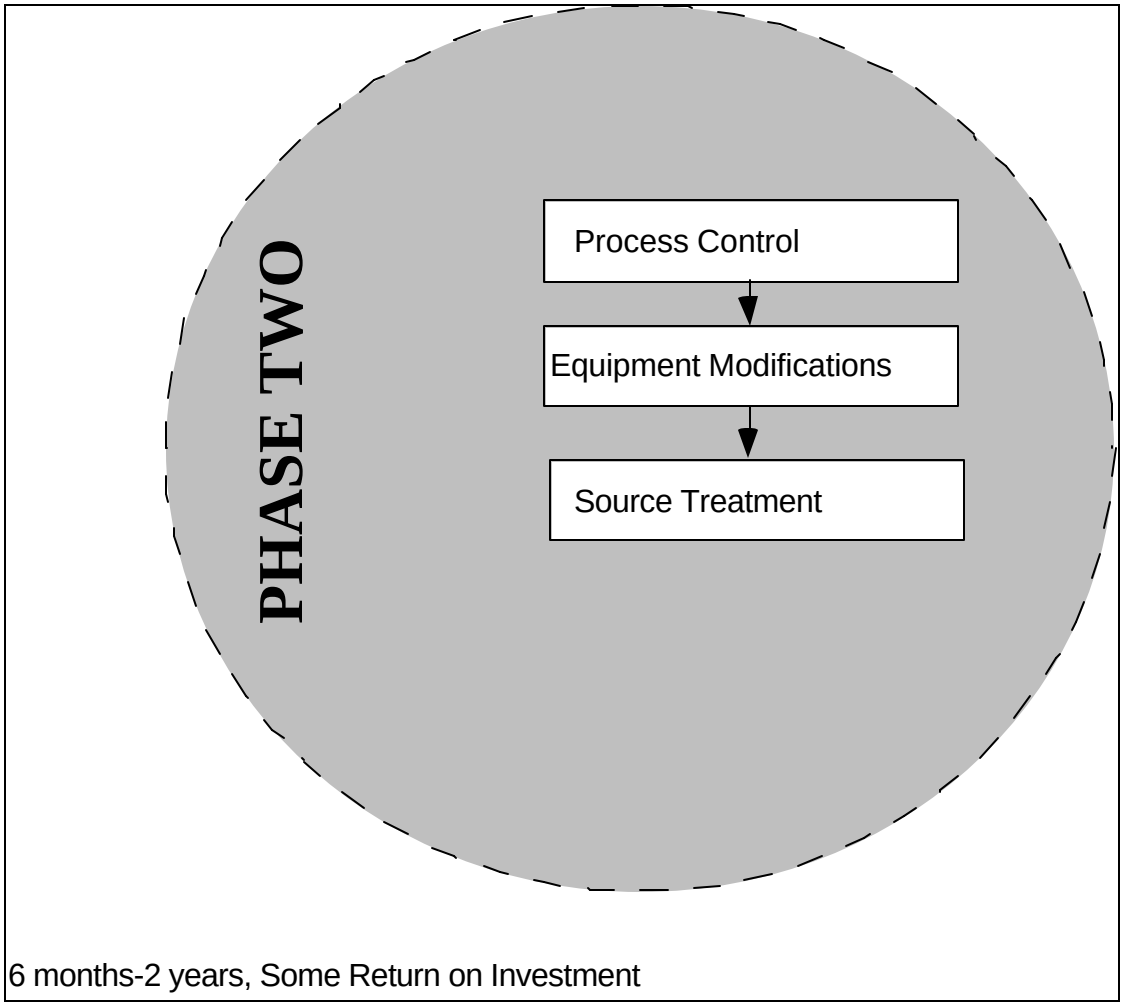

Figure 9.4: Waste Reduction - Equipment Phase

There is a parallel between Total Quality Management and Pollution Prevention. Most of the time, companies conscientious about quality are also taking care of their waste and it can be expressed even in a similar philosophy of both programs.

TQM	**P2**
Customer Satisfaction	Stakeholder Satisfaction
Continuous Improvement	Continuous Reduction
Management by Measurement	Monitor Waste
Maximize Productivity	Minimize Waste
Zero Defects	Zero Emissions

Table 9.4: Parallel Paradigms

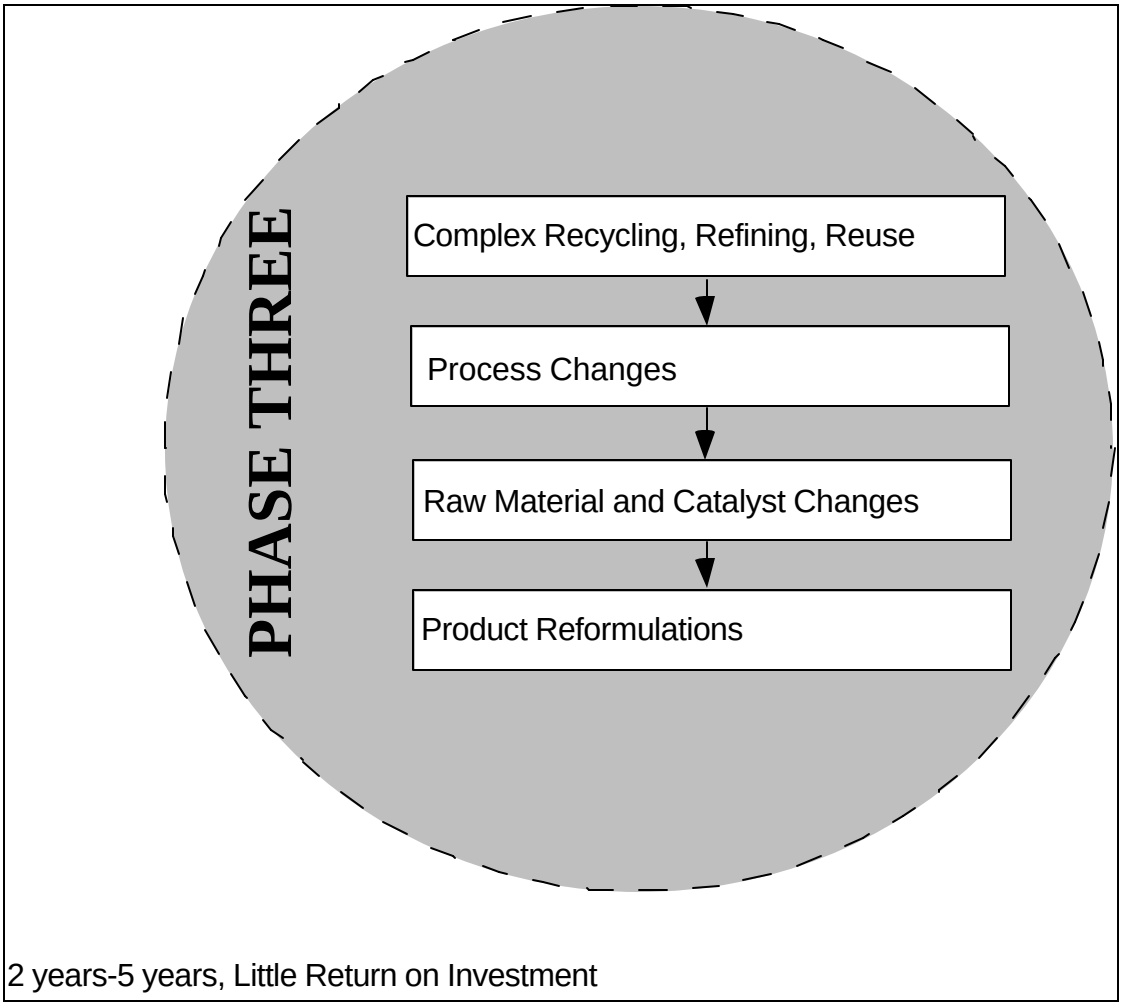

Figure 9.5: Waste Reduction - Process Phase

REFERENCES

1. *EPA, Understanding the Small Quantity Generator Hazardous Waste Rules: A Handbook for Small Business*, EPA/530-SW-86-019, 1986
2. United States Congress, *Public Law 94-580, Title III - Solid Waste Disposal*, US Government Printing Office, 1976
3. Price, R. L., *Hazardous Waste Minimization Manual for Small Quantity Generators in Pennsylvania*, Center for Hazardous Materials Research, University of Pittsburgh Applied Research Center, 1987
4. EPA, *Waste Minimization: Environmental Quality with Economic Benefits*, EPA/530-SW-87-026, 1986
5. Higgins, T.E., Hazardous Waste Minimization Handbook, Lewis Publishers, 1989