Good Practices in Chemicals Management

for Manufacturers and Industrial Users of Chemicals

IAMC Toolkit

Innovative Approaches for the Sound Management of Chemicals and Chemical Waste

UNIDO
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

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Introduction

Good practices at a plant manufacturing or using chemicals can lead to significant improvements in resource efficiency and innovation over time, resulting in valuable cost savings.

This presentation provides good practices organized per major process step (e.g. synthesis & formulation, separation) to:

- Improve resource efficiency for chemicals, water and energy;
- Minimize chemical-related waste emissions, hazards and risks

Contents

Introduction to Good Practices in the Chemical Industry

Introduction to Good Practices in the Chemical Industry

This document provides an overview of good practices for chemicals management to:

- Improve resource efficiency for chemicals, water and energy
- Minimize chemical-related waste emissions, hazards and risks

Good practices are techniques that, compared to other practices, have produced superior results over time.

Note: Good practices can also vary by industry, enterprise size and geographic area.

The good practices covered here focus on the on-site manufacture and industrial use of chemicals and not the entire value chain of chemicals management.

Good Practices in a Chemical Plant

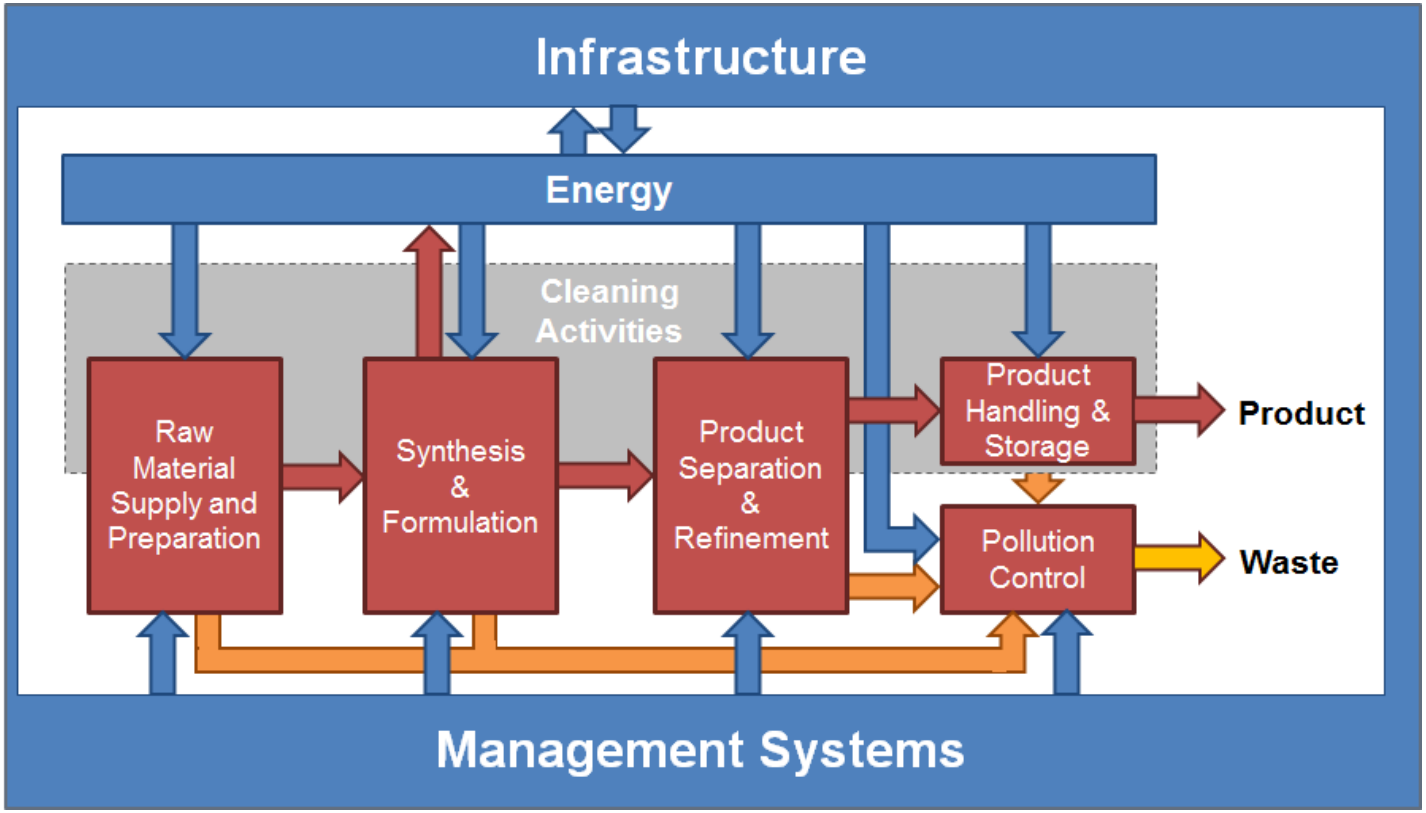
The production process can be divided into three different sections in order to categorise good practices:

Source: ISSPPRO

Infrastructure

Core processes

Management Systems



Core Processes

- Synthesis and formulation
- Separation and finishing processes
- Process equipment cleaning and maintenance
- Storage

Synthesis and Formulation: Challenges

Typical sources of chemical consumption, waste and risk include:

- Process wastewater
- Non-insulating vents
- Too high/low pressure
- Corrosion in reactor vessels
- High consumption of additives increasing the amount of waste
- Hazardous waste generation

Source: Suva

Reactors

Source : Shutterstock

Synthesis and Formulation: Good Practices

Material efficiency

- Segregate and reuse dust emissions in the production process
  - Stages: reactor feeding, production or cleaning
- Change form of input and output material
  - Example: Order raw materials or manufacture products in pellet form to reduce dust emissions.
- Substitute raw materials by less or non-toxic materials
- Find a suitable market for a by-product or upgrade a by-product to a more valuable and sustainable co-product
- Use waste streams (internal or external sources) as raw materials

Synthesis and Formulation: Good Practices

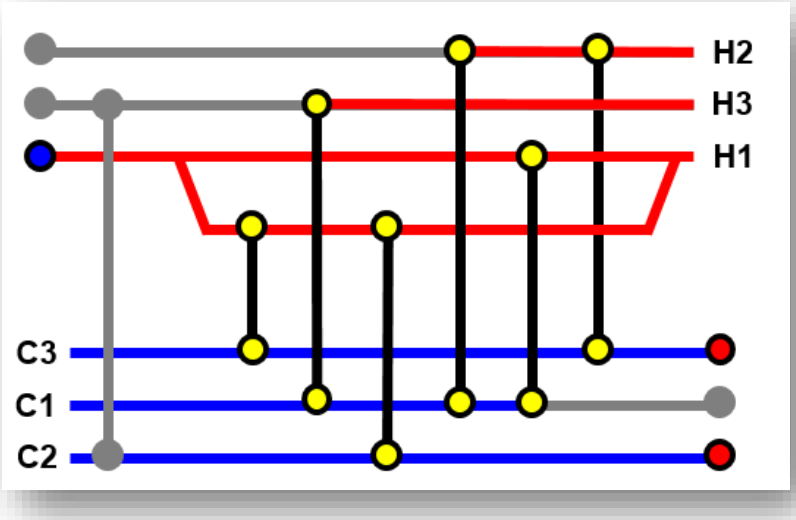
Reactor vessel

Programme for unexpected upsets and trips and minimize off-spec material (which causes waste or additional emissions)

Improve heat management efficiency

- Design heat exchange networks using pinch analysis for facilities with exothermic/endothermic processes
- Improve heat transfer in the reactor

Heat exchanger network

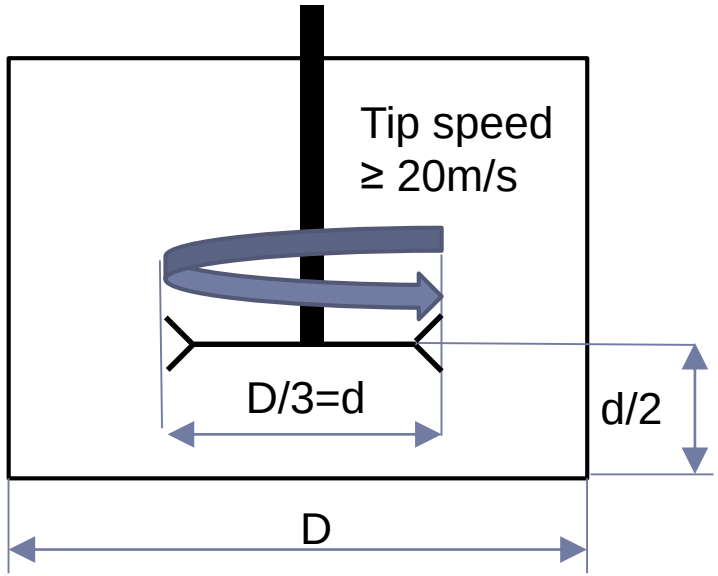


Source: ISSPPRO

Synthesis and Formulation: Good Practices

- Reactor vessel
- Improve mixing and dispersing
  - Unreacting raw materials can reduce material efficiency
  - Optimize pre-dispersing and dispersing before filtering residues
- Collect emissions
  - Collect emissions, e.g. VOCs, from reactor vents and return them to the process, redirect them to condensation or decompose them in a thermal oxidizer
- Use separation reactors
  - Remove by-products (e.g. water in polymer condensation reactions) to drive reaction to higher product yield and reduce unwanted by-products
  - Use reactive distillation to combine reaction and separation in one step

Design criteria for mixing: pre-dispersing dissolver disk



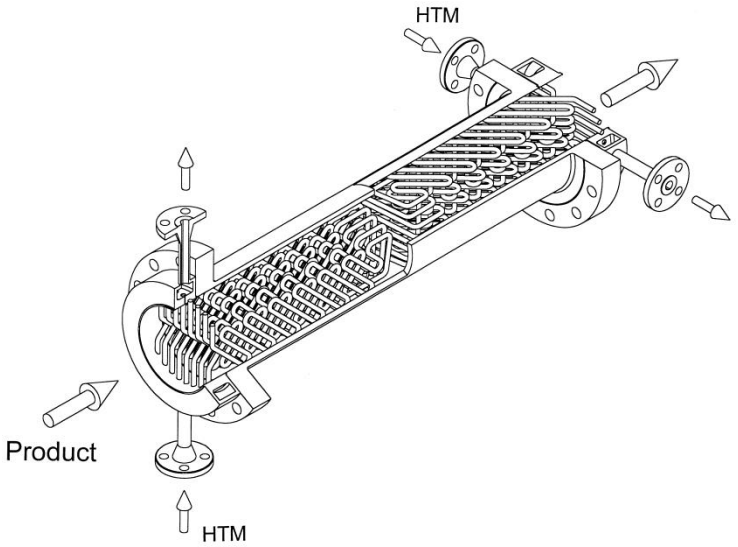
Source: based on Schott | Täubler

Synthesis and Formulation: Good Practices

Reactor vessel

- Change reactor design to increase yield (e.g. process intensification with a plug flow static mixer reaction instead of a CSTR)
- Design for system for optimum product recovery, cleaning-in-place and quick turnaround times
- Improve catalyst through collaboration with supplier
- Use Statistical Process Control (SPC) methods and other six sigma quality improvement methods
- Redesign processes
- Improve feeding process, especially for exothermic reactions

Plug flow static mixer reactor: polymerization



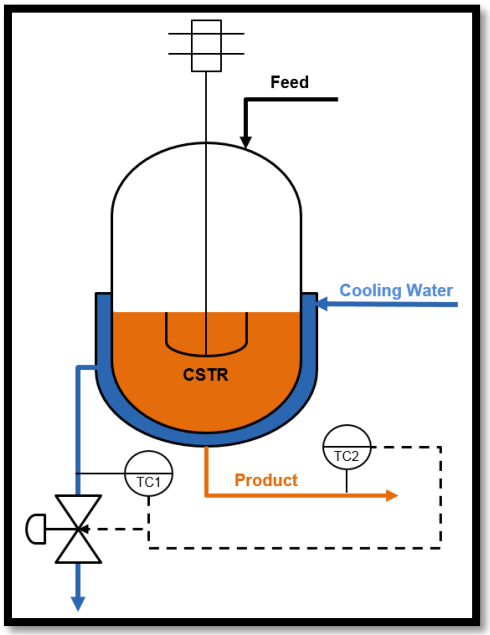
Source: ©Sulzer Chemtech Ltd

Synthesis and Formulation: Good Practices

Reactor vessel

- Improve process control and on-line monitoring of reaction
- Change controller type for better response and safety (e.g. cascade feedback for an exothermic CSTR)
- Distribute feeds to maximize mixing
- Automate start-up, shutdown, changeover

Exothermic CSTR controlled by outlet coolant temperature



Source: based on University of Michigan Chemical Engineering Process Dynamics and Controls Open Textbook

Controller type: cascade feedback: product outlet temperature outputs set point to the temperature controller which controls coolant valve

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Core Processes

- Synthesis and formulation
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- Process equipment cleaning and maintenance
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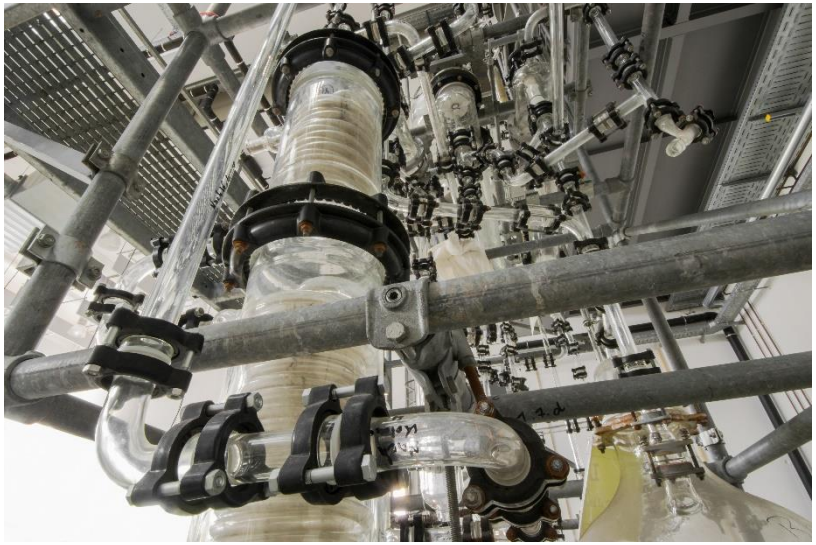
Separation Processes: Challenges

Typical sources of chemical consumption, waste and risk include:

- VOC emissions from distillation operations
- Equipment leaks of VOCs
- Equipment leaks of benzene
- Equipment leaks of volatile toxic air pollutants
- Toxic air pollutants in process vents, storage vessels, transfer operations and wastewater
- Emissions and leakage of toxic air pollutants

Separation Processes: Good Practices



Distillation column

Source : Shutterstock

For better separation:

- Retray or repack column
- Change feed tray
- Improve feed distribution for packed columns
- Remove overhead products from tray near tops of column

For better energy efficiency:

- Preheat feed e.g. using heat exchange networks

Improve overall efficiency by:

- Upgrading distillation bottoms to a value-added product

Core Processes

- Synthesis and formulation
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Equipment Cleaning and Maintenance: Challenges

Typical sources of chemical consumption, waste and risk include:

- Evaporation of hazardous solvent
- Leakage of cleaning products
- Spillage, soil contamination
- Water pollution
- Generation of wastewater
- Generation of (hazardous) waste
- Waste product from facility cleaning

Maintenance: Good Practices

General

- Develop a TPM programme
- Use compatible materials
- Minimize waste
- Drain filters
- Introduce oil management
- Check for steam, water and air leaks

Energy efficiency

- Choose energy-efficient motor drives
- Variable drive electric motors
- Eliminate electric motor voltage unbalance

Compressed air

- Conduct compressed air audits
- Maintain compressed air system
- Recover heat from compressed air
- Install air drying system in compressed air units
- Check for compressed air leaks
- Eliminate improper use of compressed air
- Use outside air for intake to air compressor

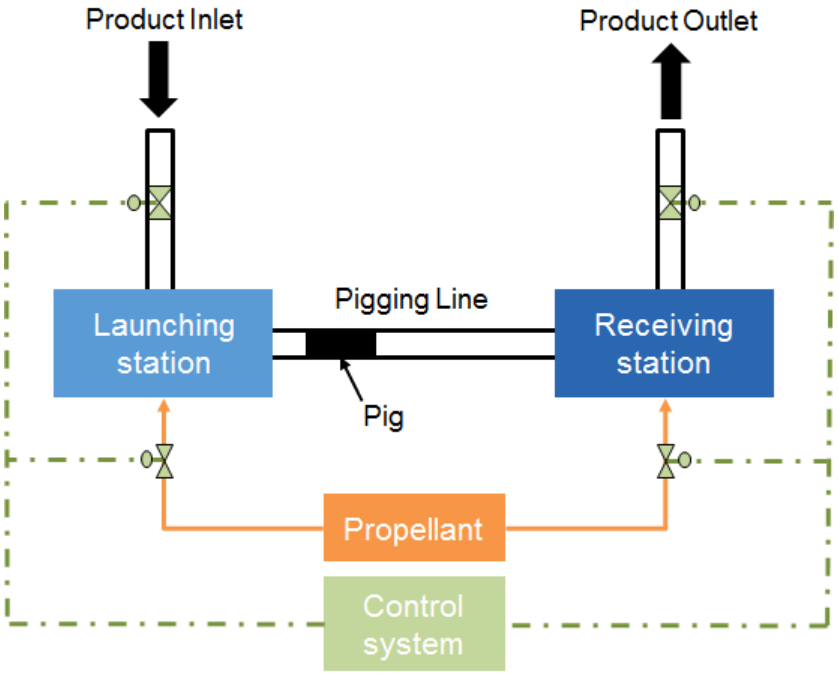
Separation Processes: Challenges

Product recovery

- "Pig" lines
- Double pig long lines

General cleaning

- Use mechanical wiping
- Reduce consumption of cleaning products
- Keep surfaces smooth
- Assign cleaning and downtime costs

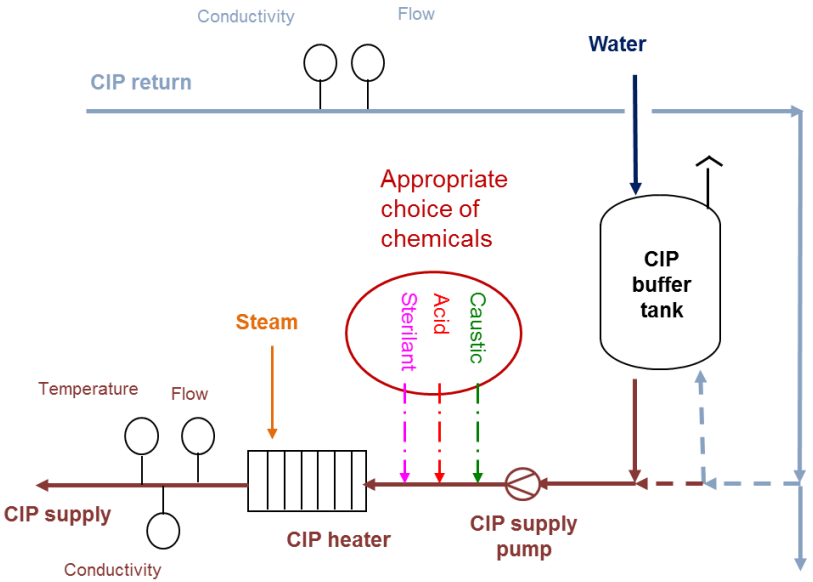


Source: based on Industrial Pigging Technology

Process Equipment Cleaning: Good Practices

- Use raw material for cleaning
- Eliminate 'dead' zones in piping
- Install spring loaded valves
- Design to clean in place

- Use enclosed cleaning systems
- Standardize & reduce number cleaning products
- Select alternative cleaning agent
- Run tests to determine optimum cleaning cycle time, temperature and concentration of cleaning product



Rotary sprayhead

Source: Industrial Trading Solutions Ltd

Fixed spray balls and rotary sprayhead

Source: Industrial Trading Solutions Ltd

Core Processes

- Synthesis and formulation
- Separation and finishing processes
- Process equipment cleaning and maintenance
- Storage

Storage Tanks: Challenges

Typical sources of chemical consumption, waste and risk include:

- Risk of leaking
- Hazardous waste and wastewater
- Fugitive air emissions

Good Practices: Storage Tanks

- Use at least two levels of protection against overfilling to prevent environmental contamination
- Internal floats to reduce volatile emissions
- Cathodic protection to inhibit corrosion
- Agitation if required to prevent build-up of contaminates
- Use ultrasonics to increase cleaning to and reduce use of hazardous cleaning agents
- Use automated high-pressure spray nozzles to increase cleaning time

Storage tank

Source : Shutterstock

Storage Areas (Raw materials, Products, Hazardous Waste): Challenges

Typical sources of chemical consumption, waste and risk include:

- Outdoor storage of raw materials and/or containers resulting in corrosion of cans, moistening of solids, overheating of liquids, etc.
- Inefficient storing organization (e.g. FINO – First In Never Out)
- Improper hazard labelling
- Stock volume too high: lifetime of raw materials could be exceeded
- Mechanical damage of drums, bags, etc. and leakage of hazardous chemicals
- Dirty conditions: final products have to be repacked before selling

Storage Areas: Good Practices

- Operations
  - Central chemical approval
  - Improve production scheduling
  - Computerized inventory
  - Isolate incompatible chemicals
  - Reduce buying, rationalize types of chemicals
  - Isolate hazardous waste from chemical storage

Packaging

- Use liners
- Use recyclable packaging
- Use returnable packages
- Use standard pallets
- Use appropriate container sizes (larger and therefore fewer containers if possible)
- Use refillable containers

Storage Areas: Good Practices Safety Measures

Primary safety measures

- Isolate non-compatible chemicals
- Use flammable cabinets
- Seal concrete floors
- Separate incompatible materials
- Limit access

Secondary safety measures

- Have spill kits available
- Protect storage space
- Raise drums
- Provide drum funnels

Infrastructure

- General good practices for infrastructure
- Boilers and furnaces
- Cooling towers
- Heat exchangers
- Pumps, valves and piping

General Good Practices for Infrastructure

General:

- Perform regular maintenance and service

Heat transfer:

- Check for unused heat and reuse it if possible

Motors (pumps, compressors):

- Adjust motors (e.g. motor efficiency class, speed regulation)

Compressors:

- Use variable-speed compressors
- Adjust dimension of compressed air system
- Avoid leakages

Boilers and Furnaces: Challenges

1. Typical sources of chemical consumption, waste and risk include:
   - Significant source of wastewater
   - Solid waste generated from boiler or furnace cleanout
   - Leakage
   - Energy loss through unused heat

Industrial boiler room

Source : Shutterstock

Boilers and Furnaces: Good Practices

Boiler and steam system

- Use waste heat for feedwater economizers and existing steam for superheating
- Use in-situ sensors for real-time control of oxygen concentration and boiler performance. Use stack-gas concentrations to tune boiler combustion controllers

Boiler and steam system

- Monitor and repair steam leaks as part of an on-going maintenance programme
- Maintain steam traps
- Return condensate
- Insulate steam lines

Furnace/Process heater

- Cogeneration from waste heat
- Replace furnace

Cooling Towers: Challenges

Typical sources of chemical consumption, waste and risk include:

- Significant source of wastewater
- Vapour discharged to the atmosphere
- Leakage
- Emissions of (toxic) air pollutants

Cooling towers

Source : Shutterstock

Cooling Towers: Good Practices

- Use less toxic biocides instead of chlorine gas and chromium compounds
- Reuse cooling and blowdown water
- Use other wastewater streams as cooling tower water source
- Continuously monitor water quality
- Use blowdown water for non-critical cleaning processes

Heat Exchangers: Challenges

Typical sources of chemical consumption, waste and risk include:

- Significant source of wastewater
- Leakage
- Failures/Malfunctions
- Causes production downtime and wasted labour

Heat exchangers

Source: Shutterstock

Good Practices: Heat Exchangers

- Non-corroding tubes
- Monitor fouling in heat exchangers
- Implement on-line cleaning
- Cathodic protection to inhibit corrosion in tubes carrying water
- Use heat exchange networks to optimize heat utilization: waste heat, low-pressure steam, high pressure steam, superheated high pressure steam)

Heat exchangers

Source: Shutterstock

Pumps, Valves and Piping: Challenges

Typical sources of chemical usage, waste and risk:

- Vapour losses from storage containers
- Losses from pumps, valves and fittings
- Losses during loading and unloading activities
- Losses from reactors, heat exchangers, separation tanks, centrifuges or other process equipment
- Evaporation from accidental liquid spills or leaks
- Energy loss through low efficiency or wrong dimension

Good Practices: Pumps, Valves and Piping

General

- Leak detection and repair programme
- Work with vendors

Piping

- Dimension pipes correctly to minimize pressure drop and energy consumption of pumps
- Use rupture disks

Pumps

- Recover seal flushes
- Turn off pump flush
- Use seal-less pumps
- Optimize or replace pumps to reduce energy consumption (e.g. variable control drives)

Key Messages

Good practices at a plant manufacturing or using chemicals can lead to significant improvements in resource efficiency and innovation over time, resulting in valuable cost savings.

Good practices in the following areas can lead to improvements in resource efficiency, waste reduction and cost savings:

- Core processes:
  - Synthesis and formulation
  - Separation and finishing processes
  - Process equipment cleaning and maintenance
  - Storage
- Infrastructure:
  - Boilers and furnaces
  - Cooling towers
  - Heat exchangers
  - Pumps, valves and piping

Sources

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Images

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