Chemical Manufacturing

Process Description

There are two kinds of chemical manufacturing, inorganic and organic. Inorganic chemicals are often manufactured with mineral origin and do not contain basic carbon molecular structure. The organic chemical manufacturing industry is divided into three main categories, gum and wood chemicals, cyclic organic crudes and intermediates, and industrial organic chemicals not classified elsewhere.

Many inorganic compounds are made through oxidation-reduction reactions or electrolysis of aqueous solutions. Common inorganic finished products are alkalis, chlorine, industrial gases (helium, oxygen, nitrogen, and hydrogen), pigments, fertilizers and construction materials.

Gum and wood chemicals are materials that are distilled or otherwise separated from wood and include charcoal, tall oil, rosin, turpentine, pine tar, acetic acid, and methanol. Cyclic organic crudes and intermediates are materials produced from petroleum, natural gas, and coal and include benzene, toluene, xylene, and naphthalene. Industrial organic chemicals not classified elsewhere include a wide range of items and the products may be either intermediates or end product. Organic chemical manufacturing's two main processes are chemical reaction and purification. The chemical reaction process occurs in a reaction vessel and often involves agitation, heat, catalysts or a combination. The purification process eliminates contaminates and other undesirable features for the final product; solvents, centrifugation or distillation are often used in the purification process.

Waste Streams

Waste streams of concern from chemical manufacturing, either inorganic or organic, include spent solvents, volatile organic compound (VOC) releases, laboratory chemical wastes, waste oils, and process wastewater. These waste streams originate from both the reaction stage (reaction vessels) and the purification step (reactors, centrifuges, filters and others). The waste stream's constituents vary greatly from a large array of solvents to heavy metals with each waste stream distinctive to its manufacturing process. Non-point source releases result from fugitive emissions, leaks and spills.

Pollution Prevention Opportunities

Inorganic and organic chemical manufacturing presents many opportunities for pollution prevention. Opportunities lie in process conditions, product formulation, catalyst use, and raw materials.

Process conditions are pollution prevention opportunities available during the production process of inorganic and organic chemicals. Examples include selecting operating temperatures near ambient temperature; optimizing product manufacturing sequences to minimize washing operations and cross contamination; adding vent condensers to recover vapors in storage tanks; regenerating catalyst in-situ; improving mixing in the reactor to increase effectiveness of the reaction and lowering steam pressure to reduce reactor temperatures for higher reactor temperatures often result in more releases.

Substituting or eliminating hazardous components in chemical manufacturing include implementing technologies (i.e. separation, filtration, centrifugation) that do not require the use of solvents; replacing hazardous substances with less hazardous and more biodegradable materials, utilizing higher purity chemicals; purifying chemicals before use or reuse and using less soluble materials.

Many pollutants in chemical manufacturing result from the use of catalysts and the intermediate production stage. Releases may be reduced by selecting catalysts that reduce the yield of undesirable chemicals; eliminating catalysts containing heavy metals; utilizing "robust" catalysts; modifying reaction sequences to reduce the amount or composition of intermediates; increasing product yield to reduce by-products; and developing a sales outlet for by-products.

Raw materials can be better managed by recovering and reusing input materials resulting in less generation of wastes. Incorporating materials with low vapor pressure reduces fugitive emissions in material handling and storage. Receiving materials in bulk containers and hard-piping materials into process vessels will reduce fugitive emissions and spill potential.

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Pollution Prevention Checklist

- ☐ Substitute hazardous substances with less hazardous and more biodegradable materials; use less soluble materials and higher purity raw materials.
- ☐ Increase or optimize production runs to reduce changeover and cleanup.
- ☐ Optimize mixing and agitation to reduce the use of heat and the generation of undesirable by-products.
- ☐ Keep lids closed and thoroughly seal reaction vessels; utilize seal-less design pumps and valves.
- ☐ Recover and reuse spent solvents and catalysts.
- ☐ Utilize alternative separation technologies such as distillers, membranes…etc. rather than solvents for the purification process.
- ☐ Sequence the addition of reactants and reagents to optimize yields and lower emissions.
- ☐ Select reactor operating temperature at or near ambient temperature, when possible.
- ☐ Use hot process steam to heat feed (if required); utilize waste heat to preheat materials
- ☐ Improve reactor mixing to increase the effectiveness of catalysts; use more select catalysts to reduce generation of undesired chemicals; eliminate catalysts containing heavy metals.
- ☐ Find an outlet market for by-products.
- ☐ Implement a training program for employees on proper handling and disposal techniques of raw materials, by-products and wastes. Implement a documented preventive maintenance program on all reaction vessels, pipes, control valves, pumps, centrifuges, distillation columns and filter presses.
- ☐ Receive materials in bulk or ship by pipeline (if possible).
- ☐ Dike or secondary contain process vessels and storage tanks.
- ☐ Eliminate storm water intrusion into process operations and sanitary waste streams.