Appendix

A Sample Inherently Safer Process Checklist

The following checklist contains a number of questions which can aid in identifying inherently safer process options. The list is adapted from CCPS (1993a). Other checklists, particularly the extensive checklist in Appendix B of the Guidelines for Hazard Evaluation Procedures, 2nd Edition with Worked Examples (CCPS, 1992) contain many questions which are related to inherent safety.

1. Minimize

- Have all in-process inventories of hazardous materials in storage tanks been minimized?
- Are all of the proposed in-process storage tanks really needed?
- Has all processing equipment handling hazardous materials been designed to minimize inventory?
- Is process equipment located to minimize length of hazardous material piping?
- Can piping sizes be reduced to minimize inventory?
Can other types of unit operations or equipment reduce material inventories? For example:
- Wiped film stills in place of continuous still pots
- Centrifugal extractors in place of extraction columns
- Flash dryers in place of tray dryers
- Continuous reactors in place of batch
- Plug flow reactors in place of CFSTRs
- Continuous in-line mixers in place of mixing vessels

Is it possible to feed hazardous materials (for example, chlorine) as a gas instead of liquid, to reduce pipeline inventories?

Is it possible to generate hazardous reactants "in-situ" from less hazardous raw materials?

Is it possible to generate hazardous reactants on site from less hazardous materials, minimizing the need to store or transport large quantities of hazardous materials?

2. Substitution/Elimination

Is it possible to completely eliminate hazardous raw materials, process intermediates, or by-products by using an alternative process or chemistry?

Is it possible to completely eliminate in-process solvents by changing chemistry or processing conditions?

Is it possible to substitute less hazardous raw materials?
- Noncombustible rather than flammable solvents
- Less volatile raw materials
- Less toxic raw materials
- Less reactive raw materials
- More stable raw materials

Is it possible to substitute less hazardous final product solvents?

For equipment containing materials which become unstable at elevated temperature or freeze at low temperature, is it possible to use heating and cooling media which limit the maximum and minimum temperatures attainable?
3. Moderate

- Can the supply pressure of raw materials be limited to less than the working pressure of the vessels they are delivered to?
- Can reaction conditions (temperature, pressure) be made less severe by using a catalyst, or by using a better catalyst?
- Can the process be operated at less severe conditions? If this results in lower yield or conversion, can raw material recycle compensate for this loss?
- Is it possible to dilute hazardous raw materials to reduce the hazard potential? For example:
  - Aqueous ammonia instead of anhydrous
  - Aqueous HCl instead of anhydrous
  - Sulfuric acid instead of oleum
  - Dilute nitric acid instead of concentrated fuming nitric acid
  - Wet benzoyl peroxide instead of dry

4. Simplify

- Can equipment be designed sufficiently strong to totally contain the maximum pressure generated, even if the “worst credible event” occurs?
- Is all equipment designed to totally contain the materials which might be present inside at ambient temperature or the maximum attainable process temperature (i.e., don’t rely on the proper functioning of external systems such as refrigeration systems to control temperature such that vapor pressure is less than equipment design pressure)?
- Can several process steps be carried out in separate processing vessels rather than a single multipurpose vessel? This reduces complexity and the number of raw materials, utilities, and auxiliary equipment connected to a specific vessel, thereby reducing the potential for hazardous interactions.
- Can equipment be designed such that it is difficult or impossible to create a potential hazardous situation due to an operating error (for example, by opening an improper combination of valves)?
5. **Location/Siting/Transportation**

- Can process units be located to reduce or eliminate adverse impacts from other adjacent hazardous installations?
- Can process units be located to eliminate or minimize:
  - Off-site impacts?
  - Impacts to employees on-site?
  - Impacts on other process or plant facilities?
- Can the plant site be chosen to minimize the need for transportation of hazardous materials and to use safer transport methods and routes?
- Can a multistep process, where the steps are done at separate sites, be divided up differently to eliminate the need to transport hazardous materials?