CHE 100 FALL 1995

ASSESSMENT OF DESIGN AND OPERATION ALTERNATIVES FOR OPERATION OF A HAZARDOUS CHEMICAL PROCESS

The objective of this project is to consider various design and operation alternatives of a simple hazardous chemical process. The impact of process operation which may cause spills and environmental pollution will be considered and its legal and ethical ramifications will be discussed.

THE CLASS WILL CONVENE IN THE CLASSROOM: Monday 204PH, Tuesday 118WH. DO NOT GO TO THE PC LAB.

Preparatory work: Please read this handout before coming to class on Monday October 23 or Tuesday October 24, 1995. Prepare a short report using MS Word that answers questions 1-7.

Classroom Activity: Part of the class period will be allocated to the discussion of design modifications and operation policies of the process. The rest of the period will be devoted to debating the legal and ethical ramifications of a plant accident. Students will be divided to small groups and assigned specific tasks and roles to play during the discussion of question 8:

Group 1: The employer and his representatives
Group 2: The new production supervisor and representatives of plant employees
Group 3: The mayor of the town and members of the town council
Group 4: A legal arbitration group

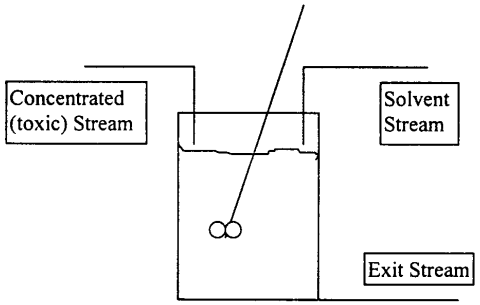
Please think ahead about your position and your input as a member of each one of the groups. You will be assigned a group at the beginning of the class period.

Final report: Revise your report addressing questions 1-7, add a new section summarizing your assessment of the case presented in question 8. Your report should be about 3 to 4 pages based on single space 12 point font.

MIXING OF TOXIC CHEMICALS IN A STIRRED TANK

A mixing tank is used in a plant where a stream that has a high concentration of a toxic chemical (such as a herbicide) is diluted by mixing it with a solvent stream. The final concentration of the product stream should match the value specified by the operator (desired value) to meet market expectations. Otherwise, a second mixing must be done to meet the desired value. Hence, equipment that could be used for some other activity would be allocated for reworking the product dilution, resulting in increased equipment time and additional labor, and consequently higher cost. Furthermore, some shipments may be delayed and result in financial penalties. The concentrated stream is coming from another processing unit, its concentration is unpredictable and it may change significantly over time. Another problem is the variation in liquid level in the mixing unit. Due to aggressive automatic control, too much material may be introduced to the mixing unit and cause a spill. The spilled material may evaporate or be absorbed by the soil. The Environmental Protection Agency (EPA) has recently set some limits on the amount of this chemical that could escape to the environment, stating that its fumes are toxic and it contaminates the soil. The plant has been in operation for several years. It is in a rural area, but over the years the nearby town has grown in population. Some town inhabitants work for the plant but many others are working for other businesses or farming. Depending on wind direction

the fumes may affect the town and the spills may contaminate the nearby ravine and drinking water.



As an engineer you are assigned to study various options to minimize spills with some low cost solutions. Installation of new process equipment, modification of plant site, improvement of the control system are among the options that can be considered.

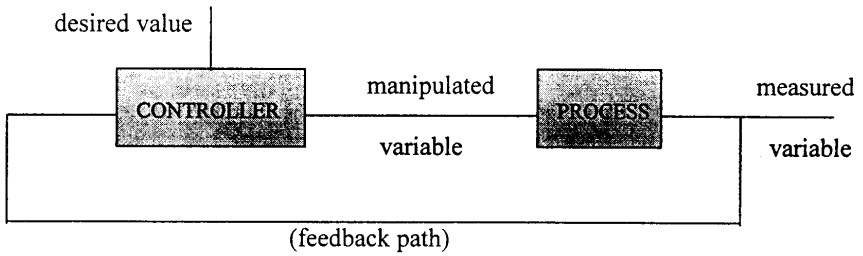
1. List some equipment and site modifications that may reduce spills and/or the pollution of the environment in case of spills. Rank the different options in equipment modification and site modification based on cost. To what extent should cost be a consideration in improving the safety of operation?

2. Automatic control systems address several needs. Rank the priority of various needs listed below:
   a) Safety of people in the plant and the surrounding community,
   b) Protection of plant equipment,
   c) Smooth operation of the plant and process equipment,
   d) Protection of the environment,
   e) Profitable operation of the plant,
   f) Manufacturing of products of high quality.

Priorities	Needs
1 (Highest priority):	
2:	
3:	
4:	
5:	
6:	

3. Various automatic control loop configurations are proposed to regulate the exit concentration (control objective 1) and the liquid level (control objective 2) in the mixing unit. First consider a the schematic diagram of a *feedback control loop*. In feedback control, an *output variable* (typically a property of the product stream) is *measured* and compared with its desired value. The difference between the measured and desired

values is used to decide how an *input variable* (typically a property of one of the inputs to the process) should be adjusted (*manipulated*) to reduce this difference. In an automatic control loop this sequence of activities is repeated continuously. A simple example where feedback control is used manually (an automated system would be somewhat wasteful for this case) is how you would adjust water temperature in the shower. Your hand that feels the water temperature generates the measurement which is compared in your brain to your preferred water temperature. You manipulate the cold or hot water flow rate by modifying the corresponding faucet opening. The feedback is the temperature sensing and its transmission to your brain which acts as a controller.



A list of control loop configurations includes the following alternatives:

a) Measure the concentration of the exit stream from the mixing unit and manipulate the flow rate of the solvent stream.
b) Measure the liquid level in the mixing tank and manipulate the flow rate of the concentrated stream.
c) Measure the liquid level in the mixing tank and manipulate the exit flow rate.
d) Measure the concentration of the exit stream from the mixing unit and manipulate the flow rate of the concentrated stream.
e) Measure the liquid level in the tank and stop all input streams if the level increases beyond a maximum level.
f) Measure the liquid level in the tank and if the level increases beyond a maximum level dump the tank contents into another storage tank.

At most **three** of the control loops can be installed in the process. Select the loops that will satisfy all the control objectives and the appropriate control needs listed in item 2.

4. What are the obligations of the plant management to plant personnel if there is a spill?

5. What are the obligations of the plant management to the inhabitants of the town if there is a spill?

6. What are the obligations of the plant management to other businesses and farms if there is a spill?

7. If there are damages due to a spill, how should the compensation limit be set? Should the limit be set according to:
   a) Total value of direct damages,
   b) Total value of direct and indirect (consequential) damages. For example, suppose that you have shot some pictures and gave it for development. If the developer loses your film, should the compensation be limited to a new roll of film or should there be additional compensation because you have lost some reminders of precious memories.
   c) Total value of the plant.
   d) Maximum limit that will not force the plant to bankruptcy.
   e) Total value of the company (the assets of the company in other business ventures).

8. You have been transferred recently to this plant and promoted to production supervisor responsible for manufacturing this toxic chemical. The demand for the product is so high that every amount of product manufactured is sold. There is a need to increase production capacity, but it necessitates relaxing the maximum level in the mixing tank slightly. The old-timers in the plant tell you that when there was such an increase in the demand in the past, the maximum liquid level allowable was adjusted. Furthermore, they also remember a few occasions where there was a spill but either the chemical dispersed quickly due to weather patterns around that time of the year or a small fine was paid. The plant manager has contacted you and told you that any increase in production will be well appreciated and hinted that superior performance is remembered when personnel evaluation reports are filed. He also said that you were the technical person who should make the decision. It looks like a challenging situation because you do not want to jeopardize the safety and cause pollution, but you do not want to look like a rookie who is scared of taking action. What are the different decisions one can make, what are the outcomes of each decision? What are the documents and guidelines available for making a decision that could be defended objectively in case there is an inquiry or legal action?