



FIGURE 3-1

Piping and instrumentation diagram used in HAZOP example.

TABLE 4
HAZOP study results for process in Fig. 3-1

Equipment reference and operating conditions	Deviations from operating conditions	What event could cause this deviation?	Consequences of this deviation on item of equipment under consideration	Additional implications of this consequence	Process indications	Notes and questions	
Storage tank T-1	Level Less	1. Tank runs dry	Pump cavitates	Damage to pump	LIA-1, FICA-1	Can reagent react/ explode if over-heated in pump?	
		2. Rupture 4-in. discharge	Reagent released	Potential fire	LIA-1, FICA-1	Estimate release quantity. Consider second LAL shutdown on pump.	
		3. V-3 open or broken	Reagent released	Potential fire	LIA-1	Estimate release quantity.	
		4. V-1 open or broken	Reagent released	Potential fire	LIA-1	Consider V-1 protection.	
		5. Tank rupture	Reagent released	Potential fire	LIA-1	What external events can cause rupture?	
	More	6. Unload too much from tank truck	Tank overfills	Reagent released via RV-1	LIA-1	Is RV-1 designed to relieve liquid at loading rate? Consider second high level shutoff.	
		7. Reverse flow from process	Tank overfills	Reagent released via RV-1	LIA-1	Consider check valve in pump discharge line. Consider second LAH shutdown on feedlines.	
	No	Composition					
		Other than	8. Wrong reagent	Possible reaction	Possible tank rupture		Consider sampling before unloading.
	As well as	9. Impurity in reagent	If volatile, possible overpressure				Are other materials delivered in trucks?

		Possible problem in reactor			Are unloading connections different? What are possible impurities?
Pressure Less	10. Break 1-in. line to flare or 1-in. nitrogen line	Reagent released	Potential fire	PICA-1	Consider PAL to PICA-1
	11. Lose nitrogen	Tank implodes	Reagent released	PICA-1	Consider independent PAL. Consider vacuum-break valve.
More	12. PV-2 fails closed	Tank implodes	Reagent released	PICA-1	Consider PAL on PICA-1.
	13. PICA-1 fails, closing PV-2	Tank implodes	Reagent released	PICA-1	Tank not designed for vacuum.
	14. PICA-1 fails closing PV-1	Reagent released via RV-1	Tank rupture if RV-1 fails	PICA-1	What is capacity of PV-1? RV-1? Consider independent PAH.
	15. PV-1 fails closed	Reagent released via RV-1	Tank rupture if RV-1 fails	PICA-1	Consider independent PAH.
	16. V-7 closed	Reagent released via RV-1	Tank rupture if RV-1 fails	PICA-1	Is V-7 locked open? Is V-8 locked open? Consider independent PAH.
	17. Overfill tank	See Event 6	Tank rupture if RV-1 fails	PICA-1	Consider second high-level shutoff.
	18. Temperature of inlet is hotter than normal	Reagent released via RV-1	Tank rupture if RV-1 fails	PICA-1	What prevents high temperature of inlet? Consider independent PAH.
	19. High pressure in flare header	Reagent released via RV-1	Tank rupture if RV-1 fails	PICA-1	Can pressure in flare header exceed tank design? Consider alternative venting.

TABLE 4
HAZOP study results for process in Fig. 3-1 (Continued)

Equipment reference and operating conditions	Deviations from operating conditions	What event could cause this deviation?	Consequences of this deviation on item of equipment under consideration	Additional implications of this consequence	Process indications	Notes and questions
		20. Volatile impurity in feed	Reagent released via RV-1	Tank rupture if RV-1 fails	PICA-1	Consider independent PAH. Consider sampling before unloading.
	No	Same as less				
	Temperature					
	Less	21. Temperature of inlet is colder than normal	Possible vacuum (see less pressure)	Thermal stress on tank		What are temperature limits of tank?
		22. Low tank pressure	See Events 10-13	Thermal stress on tank		What are pressure limits of tank?
	More	23. Temperature of inlet is hotter than normal	See Event 18	Thermal stress on tank		What are temperature limits of tank?
		24. External fire	Tank fails	Reagent released		What could cause an external fire? What are fire-protection capabilities? Is fire protection adequate?
Feed pump P-1	Flow					
	Less	25. V-2 closed	Pump cavitates	Damage to pump	FICA-1	See Event 1.
		26. V-4 closed	Deadhead pump	Damage to pump	FICA-1	Any other problem with deadhead?
		27. Line plugs	Pump cavitates	Damage to pump	FICA-1	See Event 1.
		28. FV-1 fails closed	Deadhead pump	Damage to pump	FICA-1	See Event 26.
		29. FICA-1 fails closing FV-1	Deadhead pump	Damage to pump	None	See Event 26.
		30. V-3 open	Reagent released		FICA-1	Estimate release quantity.
	More	31. FV-1 fails open	Upset in reactor	Reagent released	FICA-1	Possible problem in reactor.
		32. FICA-1 fails, opening FV-1	Upset in reactor	Reagent released	None	See Event 31.
	Pressure					
	More	33. V-4 closed	Deadhead pump	Damage to pump	PI-1, FICA-1	See Event 26.
		34. FV-1 fails closed	Deadhead pump	Damage to pump	PI-1, FICA-1	See Event 26.
		35. FICA-1 fails, closing FV-1	Deadhead pump	Damage to pump	PI-1	See Event 26.
		36. V-2 and V-4 closed	Deadhead pump	Overpressure in pump or line	PI-1, FICA-1	Evaluate need for hydraulic relief.
	Less	37. V-2 closed	Pump cavitates	Damage to pump	PI-1, FICA-1	See Event 1.
		38. V-3 open	Reagent released		PI-1	See Event 3.
	Temperature					
	More	39. V-4 closed	Deadhead pump	Damage to pump	None	See Event 26.
		40. FV-1 fails closed	Deadhead pump	Damage to pump	None	See Event 26.
		41. FICA-1 fails, closing FV-1	Deadhead pump	Damage to pump	None	See Event 26.