

Guidewords to consider during HAZOP

Guide Word	Deviation	Example
Flow	More	Increased pumping capacity - increased suction pressure - reduced delivery head - greater fluid density - exchanger tube leaks - restriction orifice plates deleted - cross connection of systems - control faults - control valve trim changed - running two pumps - etc.
	No	Wrong routing - blockage - incorrect slip plate - incorrectly fitted check valve - burst pipe - large leak - equipment failure (isolation valve, pump vessel , etc.) - incorrect pressure differential - isolation in error - etc
	Less	Line restrictions - filter blockage - defective pumps - fouling of vessels, valves, orifice plates - density or viscosity changes - etc.
	Reverse	Defective check valve - siphon effect - incorrect pressure differential - two way flow -emergency venting - incorrect operation - in line spare equipment - etc.
	Other	
Pressure	More	Surge problems - connection to high pressure system - gas breakthrough (inadequate venting) - defective isothermal overpressure - positive displacement pumps - failed open PCV's design pressures, specifications of pipes, vessels, fittings, instruments - etc.
	No	See Less
	Less	Generation of vacuum condition - condensation - gas dissolving in liquid - restricted pump / compressor suction line - undetected leakage - vessel drainage - blockage of blanket gas reducing valve etc.
	Other	

Guide Word	Deviation	Example
Level	More	Outlet isolated or blocked - inflow greater than outflow - control failure - faulty level measurement - gravity liquid balancing - etc.
	Less	Inlet flow stops - leak - outflow greater than inflow - control failure - faulty level measurement - draining of vessel - etc.
	Other	
Temperature	More	Ambient conditions - fouled or failed exchanger tubes - fire situation - cooling water failure - defective control - heater control failure - internal fires - reaction control failures - heating medium leak into process - escalation procedures for relief valves
	Less	Ambient conditions - reducing pressure - fouled or failed exchanger tubes - loss of heating - depressurization of liquefied gas - Joule / Thompson effect - etc.
	Other	
Viscosity	More	Incorrect material or composition - incorrect temperature - high solids' concentration - setting of slurries - etc.
	Less	Incorrect material or composition - incorrect temperature - solvent flushing -etc.
	Other	
Relief	Other	Relief philosophy (process / fire etc) - type of relief device and reliability - relief valve discharge location - pollution implications - two phase flow - effect of de-bottlenecking on relief capacity - inlet and outlet piping - etc.
Samples	Other	Sampling procedure and operator safety -time for analysis result - calibration of automatic samplers - reliability / accuracy of representative sample - diagnosis of result - loss of sample flow - etc.
Instruments - Control philosophy	Other	Location of instruments -response time - set points of alarms and trips and ability to change - time available for operator intervention - alarm and trip testing - fire protection - trip / control amplifiers - panel arrangement and location - auto / manual facility and human error - fail safe philosophy - etc.

Guide Word	Deviation	Example
Corrosion / Erosion	Other	Cathodic protection arrangements - internal / external corrosion protection - engineering specifications - zinc embrittlement - stress corrosion cracking - fluid velocities - etc.
Service	Other	Failure of instrument air / steam / nitrogen / cooling water / hydraulic power / water or other - contamination of instrument air, nitrogen etc. - telecommunication - heating and ventilating systems - computers etc.
Composition change		Leaking isolation valves - leaking exchanger tubes - phase change - incorrect feedstock / specification - inadequate quality control - process control upset - reaction intermediates / by-products - settling of slurries - etc.
Contamination		Leaking exchanger tubes - leaking isolation valves - incorrect operation of system - interconnected systems (especially services, blanket systems) - effect of corrosion - wrong additives - ingress of air - shutdown and start up conditions - grade change - etc.
Abnormal operation		Purging - flushing - start-up - normal shutdown - emergency shutdown - emergency operations - inspection of operating machines - guarding of machinery - etc.
Maintenance		Isolation philosophy - drainage - purging - cleaning - drying - slip plates - access - rescue plan - training - pressure testing - work permit
Ignition		Grounding arrangements - insulated vessels / equipment - low conductance fluids - splash filling of vessels - insulated strainers and valve components - dust generation - powder handling equipment - electrical classification - flame arrestors - hot work - hot surfaces - auto ignition - pyrophoric materials - etc.
Spare equipment		Installed / non-installed spare equipment - availability of spares - modified specifications - storage of spares - catalogue of spares - test running of spare equipment - etc.
Safety		Toxic properties of process materials - fire and gas detection system - alarms - emergency shutdown arrangements - fire fighting response time - emergency and major emergency training - contingency plans - T.L.V.'s of process materials - first aid / medical resources - effluent disposal - hazards created by others (adjacent storage areas / process plant etc.) - testing of emergency equipment - compliance with local / national regulations - etc.

PRIORITIZATION OF SAFETY, HEALTH AND ENVIRONMENT ISSUES ASSESSMENT KEY (ALARP)

CONSEQUENCE CATEGORY	PROPOSAL FOR EXPENDITURE - SAFETY, HEALTH OR ENVIRONMENT IMPROVEMENT				
CATEGORY 5 EXTREMELY SERIOUS CONSEQUENCE	TOLERABLE BAND				
CATEGORY 4 MAJOR CONSEQUENCES		TOLERABLE BAND		UNACCEPTABLE	
CATEGORY 3 SEVERE CONSEQUENCES			TOLERABLE BAND		
CATEGORY 2 SERIOUS CONSEQUENCES		TOLERABLE		TOLERABLE BAND	
CATEGORY 1 SIGNIFICANT CONSEQUENCES					TOLERABLE BAND
EVENT FREQUENCY PER YEAR	10-7 EXTREMELY	10-6 10-5 VERY UNLIKELY	10-4 10-3 UNLIKELY UNLIKELY	10-2 0.1 POSSIBLE	1 PROBABLE 10
FREQUENCY CATEGORY	1	2	3	4	5
Example	Consequence Category 3 and Frequency Category 4				3-4

PRIORITIZATION OF SAFETY, HEALTH AND ENVIRONMENT ISSUES GUIDANCE FOR CONSEQUENCES CATEGORIES

	CATEGORY 1 EVENT SIGNIFICANT CONSEQUENCES	CATEGORY 2 EVENT SERIOUS CONSEQUENCES	CATEGORY 3 EVENT SEVERE CONSEQUENCES	CATEGORY 4 EVENT CONSEQUENCES	CATEGORY 5 EVENT CONSEQUENCES
TYPICAL MEDIA ATTENTION	Noted in Local Press, TV & Radio Few telephone calls	Significant local attention, interviews Adverse local comment	Considerable local, some national attention Local outcry	Headline national, continuing local attention	International news, outcry threatens to close operation
TYPICAL ACTION BY AUTHORITIES	Notifiable	Warning	Prosecution	Severe Fine	Prohibition
ACUTE INJURY INCIDENT - on-site effects	Minor/classified injury Low probability of Lost Time Accident	Lost Time Accident Low probability of major injury	Major injury Multiple injuries Low probability of fatality	Fatalities or few employee fatalities Low probability of many fatalities	Many fatalities (ie 5 or more)
ACUTE INJURY ACCIDENT - off-site effects	Nuisance off-site-see Environmental	People affected-short term minor	Few people require hospital treatment	Serious injuries 10s in hospital	Fatality or fatalities off site; many injuries
CHRONIC HEALTH OR PHYSICAL CONDITION - on-site effects	Occasional releases above Occupational Limits - OEL or STEL - low hazard materials Unpleasant conditions	Persistent releases above limits - 2 to 6 times Occupational Limits - non-carcinogen Harmful conditions	Distressing <i>exposure</i> Significant health effects Harmful, irreversible, unacceptable effects Sensitization effects	Employee <i>exposure</i> to high levels of carcinogens, e.g. asbestos, benzene, vinyl chloride, or life-threatening conditions	Many cases of ill health and resultant fatalities Health risk unacceptable due to continuous or discrete large releases