

PHA and What-If Checklist Questions

A compilation of typical What-If questions used in process facility has been made to facilitate a What-If checklist for typical petroleum, petrochemical, or chemical facilities. This listing is by no means exhaustive and should be supplemented and tailored to suit the particular facility under review.

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PART 1 PIPING

What-If checklist

- What if piping leaks?
- What if high pressure flammable, corrosive, or toxic gases leak into a liquid pipeline?
- What if piping is fractured?
- What if piping plugs?
- What if piping becomes fouled?
- What if moisture remains in piping?

- What if piping is corroded internally?
- What if piping is corroded externally?
- What if piping is eroded?
- What if piping becomes embrittled?
- What if piping loses its heat tracing?
- What if piping supports fail?
- What if piping is subject to external impact?
- What if piping is subject to internal impact?
- What if piping is subject to backflow?
- What if piping is subject to flow or pressure surges?
- What if piping is subject to liquid hammer?
- What if piping is subject to vibration?
- What if piping welds are insufficient?
- What if gaskets, seals, or flanges leak?
- What if pressure relief is not provided?
- What if pressure relief fails (open or closed)?
- What if sight glass breaks?
- What if flame arrestor fails?

PART 2 VALVES

What-If checklist

- What if valve fails mechanically?
- What if valve actuator fails?
- What if valve is inadvertently or mis-operated?
- What if valve is locked opened or closed?
- What if valve leaks?
- What if seals fail?
- What if valve becomes fouled or corroded?
- What if valve electric or pneumatic controls fail?
- What if valve is subjected to flow or pressure surges?
- What if valve is subject to liquid hammer?
- What if valve is impacted externally?
- What if valve is impacted internally?
- What if valve is subjected to abrasive or particulate matter?
- What if valve is subjected to backflow?
- What if valve handles multiphase substances?
- What if valve is not fire rated?

PART 3 PROCESSING VESSELS

What-If checklist

Feed

- What if vessel feed is increased?
- What if vessel feed is decreased?
- What if vessel feed is stopped?
- What if vessel feed temperature increases?
- What if vessel feed temperature decreases?
- What if vessel feed composition changes (e.g., more or less oil, gas, or water)?
- What if excessive solids are entrained in feed?

Vessel

- What if vessel pressure increases?
- What if vessel pressure decreases?
- What if vessel level increases?
- What if vessel level decreases?
- What if vessel LAH fails?
- What if vessel LAL fails?
- What if vessel PAH fails?
- What if vessel PAL fails?
- What if vessel TAH fails?
- What if vessel TAL fails?
- What if vessel solid/sand removal system fails?
- What if vessel interface transmitter fails?
- What if vessel high-interface alarm fails?
- What if vessel low-interface alarm fails?
- What if vessel internals plug?
- What if vessel internals collapse?
- What if vessel relief valve lifts or leaks by?
- What if vessel ruptures due to internal corrosion, defective materials, or poor workmanship?

Vessel piping

- What if vessel oil outlet block valve is closed?
- What if vessel water outlet block valve is closed?
- What if vessel gas outlet block valve is closed?
- What if vessel oil outlet control loop fails open or closed?

- What if vessel water outlet control loop fails open or closed?
- What if vessel gas outlet control loop fails open or closed?
- What if oil outlet plugs?
- What if water outlet plugs?
- What if solids form (possible hydrates) in gas outlet line?
- What if vessel drain valve is open or leaking by?
- What if pipe ruptures due to internal corrosion, defective materials, or poor workmanship?

Fired vessels

- What if vessel temperature control loop fails open or closed?
- What if fuel supply is cut off?
- What if flame fails?
- What if air damper fails open or closed?
- What if blower or motor fails?
- What if fuel supply pressure decreases?
- What if fuel supply pressure increases?
- What if water is entrained in fuel supply?
- What if fuel supply regulator fails open or closed?
- What if fuel main/pilot shut-off valves fail to open or close as required?
- What if fuel supply PAH fails?
- What if fuel supply PAL fails?
- What if vessel TAH fails?
- What if vessel TAL fails?
- What if fuel oil heater fails?
- What if fuel oil pump fails?
- What if fuel oil contains excessive solids?
- What if atomizing steam flow rate increases?
- What if atomizing steam flow is cut off?
- What if burner tube skin temperature increases?
- What if burner tube skin temperature decreases?
- What if stack temperature decreases?
- What if stack temperature increases?
- What if burner tube ruptures?
- What if burner tube supports fail?
- What if solids or coke build up on tube external surface?
- What if solids build up on tube internal surface?

Vessel external factors

- What if the instrument air supply is cut off?
- What if there is an electrical power failure?
- What if vessel or piping is damaged by a motor vehicle collision?
- What if the ambient temperature is low?
- What if the ambient temperature is high?
- What if there is a severe earthquake?
- What if there is a wind or sand storm?
- What if the instrument or electrical component has an electrical fault?
- What if the vessel is struck by lightning?
- What if there is excessive rainfall?

PART 4 TANKS**What-If checklist*****Feed***

- What if tank feed is increased?
- What if tank feed is decreased?
- What if tank feed is stopped?
- What if tank feed temperature increases?
- What if tank feed temperature decreases?
- What if tank feed composition changes (e.g., more or less oil, gas, vapor pressure, chemical proportions, and water)?
- What if excessive solids are entrained in feed?

Tank

- What if the tank pressure increases?
- What if the tank pressure decreases?
- What if the tank level increases?
- What if the tank level decreases?
- What if the tank LAH fails?
- What if the tank LAL fails?
- What if the tank TAH fails?
- What if the tank TAL fails?
- What if the tank solid or sand removal system fails?
- What if the tank interface transmitter fails?
- What if the tank high-interface alarm fails?
- What if the tank low-interface alarm fails?
- What if the tank internals plug?

- What if the tank internals collapse?
- What if the tank relief valve lifts or leaks by?
- What if the tank ruptures due to internal corrosion, defective materials, or poor workmanship?

Tank piping

- What if the tank gross outlet block valve is closed?
- What if the tank oil outlet block valve is closed?
- What if the tank water outlet block valve is closed?
- What if the tank gas outlet block valve is closed?
- What if the tank gross outlet control loop fails open or closed?
- What if the tank oil outlet control loop fails open or closed?
- What if the tank water outlet control loop fails open or closed?
- What if the tank gas outlet control loop fails open or closed?
- What if the tank oil outlet plugs?
- What if the tank gross outlet plugs?
- What if the tank water outlet plugs?
- What if tank solids form (possible hydrates) in gas outlet line?
- What if the tank drain valve is open or leaking by?
- What if a pipe ruptures due to internal corrosion, defective materials, or poor workmanship?

Tank external factors

- What if instrument air supply is cut off?
- What if there is an electrical power failure?
- What if the tank or piping is damaged by a motor vehicle collision?
- What if the ambient temperature is low?
- What if the ambient temperature is high?
- What if there is a severe earthquake?
- What if there is a wind or sand storm?
- What if the instrument or electrical component has electrical fault?
- What if the tank is struck by lightning?
- What if there is excessive rainfall?

PART 5 PUMPS

What-If checklist

- What if the pump fails to start or stop on demand?
- What if the pump is started with the discharge valve closed?

- What if the pump is started with the suction side valve closed?
- What if the pump inlet piping is blocked?
- What if the pump relief valve fails open or closed?
- What if the pump loses suction or has too low an NPSH?
- What if the pump becomes vapor locked or cavitates?
- What if the pump packing gland or seal leaks?
- What if the pump is subjected to fire?
- What if the pump is subjected to freezing?
- What if the pump is submerged underwater?
- What if the pump overspeeds?
- What if the pump underspeeds?
- What if the pump is not maintained?
- What if the pump breaks a shaft?
- What if the pump loses lubrication?
- What if the pump is out of balance?
- What if the pump handles substances containing abrasive or particulate matter?
- What if the pump's power supply fails?

PART 6 COMPRESSORS

What-If checklist

- What if a compressor is started with the suction valve closed?
- What if a compressor is started with the discharge valve closed?
- What if a compressor overheats?
- What if a compressor is subjected to freezing conditions?
- What if a compressor underspeeds?
- What if a compressor overspeeds?
- What if a compressor's power fails?
- What if a compressor's coupling to driver fails?
- What if a compressor's suction liquid knockout drum overflows?
- What if air enters the compressor?
- What if a compressor's feed line fails or has too low a pressure?
- What if a compressor's feed pressure increases?
- What if a compressor's relief valve fails closed?
- What if a compressor's relief valve opens inadvertently?
- What if a compressor's seals, valves, or piston rings leak?
- What if a compressor's tail rod breaks?
- What if a compressor is subjected to excessive vibration?

- What if a compressor instrumentation fails?
- What if a compressor is not cleaned or maintained?
- What if a compressor handles substances containing contaminants or particulate matter?
- What if toxic or corrosive gases are introduced to the compressor inlet stream?
- What if a compressor is submerged underwater?
- What if a compressor is exposed to a fire?

PART 7 HEAT EXCHANGERS

What-If checklist

Exchanger feed

- What if an exchanger tube or shell flow rate is increased?
- What if an exchanger tube or shell flow rate is decreased?
- What if an exchanger tube or shell flow is stopped?
- What if the tube or shell feed temperature increases?
- What if the tube or shell feed temperature decreases?
- What if the tube or shell feed composition changes (e.g., more or less oil, gas, or water)?
- What if excessive solids are entrained in a tube/shell feed?

Exchanger

- What if an exchanger pressure increases?
- What if an exchanger pressure decreases?
- What if an exchanger tube ruptures?
- What if an exchanger experiences excessive fouling?
- What if an exchanger handles abrasive/erosive substances?
- What if an exchanger loses insulation?
- What if an exchanger internals plug?
- What if an exchanger internals collapse?
- What if an exchanger relief valve lifts or leaks by?
- What if an exchanger shell ruptures due to internal corrosion, defective materials, or poor workmanship?

Exchanger piping

- What if an exchanger tube or shell outlet block valve is closed?
- What if an exchanger drain or vent valve is open or leaking?
- What if a pipe ruptures due to internal corrosion, defective materials, or poor workmanship?

Exchanger external factors

- What if an exchanger or piping is damaged by a motor vehicle collision?
- What if the ambient temperature is low?
- What if the ambient temperature is high?
- What if there is a severe earthquake?
- What if there is a wind or sand storm?
- What if an instrument or electrical component has an electrical fault?
- What if an exchanger is struck by lightning?
- What if there is excessive rainfall?

PART 8 REACTORS**What-If checklist**

- What if a reactor leaks?
- What if a reactor ruptures?
- What if a reactor experiences corrosion internally or externally?
- What if a reactor experiences erosion?
- What if a reactor loses agitation or agitates too little?
- What if a reactor agitates too much?
- What if a reactor loses cooling?
- What if a reactor cools too much?
- What if a reactor loses heating?
- What if a reactor's heating rate is increased or decreased?
- What if a reactor is charged too fast?
- What if a reactor is charged too slowly?
- What if a reactor is overfilled?
- What if a reactor is underfilled?
- What if a reactor is charged with an improper reactant ratio?
- What if a reactor loses a reactant feed?
- What if a reactor is charged with a wrong material?
- What if a reactor is charged in the wrong sequence of reactants?
- What if a reactor is charged with no or too little catalyst?
- What if a reactor vent line plugs?
- What if a reactor's pressure is too high?
- What if a reactor's pressure is too low?
- What if a reactor's relief valve opens inadvertently?
- What if a reactor's relief valve fails closed?
- What if a reactor's controls fail?

- What if a reactor's instrumentation fails?
- What if a reactor's discharge line plugs?
- What if a reactor's discharge valve opens too soon?
- What if a reactor loses inerting?
- What if a reactor's lining fails?
- What if a reactor's coolant leaks into reactants?
- What if a reactor contents spontaneously ignite?
- What if a reactor produces hazardous byproducts?
- What if a reactor's side reactions predominate?
- What if a reactor becomes contaminated?
- What if a reactor is not cleaned or maintained?

PART 9 COLUMNS (TOWERS)

What-If checklist

- What if a column leaks?
- What if a column ruptures?
- What if a column experiences corrosion internally or externally?
- What if a column loses reflux or cooling?
- What if a column loses heating?
- What if a column loses feed?
- What if a column's feed is increased?
- What if a column's feed is too hot?
- What if a column's feed is too cold?
- What if a column's feed composition changes?
- What if a column loses liquid level?
- What if a column's discharge valve opens too wide?
- What if a column's discharge valve is blocked?
- What if a column's pressure is too high?
- What if a column's pressure is too low?
- What if a column is blocked in but heat remains on?
- What if a column under vacuum leaks air in?
- What if a column is subjected to fire conditions?
- What if a column's relief valve fails to open?
- What if a column's relief valve opens inadvertently?
- What if a column's instrumentation fails?
- What if a column experiences internal blockages to inlet diffusers or trays?
- What if a column experiences gas or liquid entrainment?

- What if a column loses packing?
- What if a column has tray damage?

PART 10 FLARES

What-If checklist

- What if the flare flow rate is greater than design flow rate?
- What if the flare experiences a flameout?
- What if the flare is fed an inadequate amount of combustion air?
- What if the flare is fed excessive combustion air?
- What if the flare is fouled with solids?
- What if liquids carry over from upstream knockout vessel to flare?
- What if the flare creates excessive radiant heat levels?
- What if the flare cannot be lighted?
- What if the flare blower or motor fails?
- What if there is an electrical power failure?
- What if the instrument air supply is lost?
- What if the fuel gas supply is lost?
- What if the flare control panel malfunctions?
- What if the fuel supply pressure decreases?
- What if the fuel supply pressure increases?
- What if water is entrained in fuel supply?
- What if solids or coke build up on stack or nozzles?

Flare piping

- What if the flare inlet block valve is closed?
- What if the fuel gas supply block valve is closed?
- What if the fuel gas regulator fails open or closed?
- What if the fuel shut-off valve fails to open or close as required?
- What if solids form (possible hydrates) in relief outlet line?
- What if a pipe ruptures due to internal corrosion, defective materials, or poor workmanship?

External factors

- What if stack or piping is damaged by a motor vehicle collision?
- What if the ambient temperature is low?
- What if the ambient temperature is high?
- What if there is a severe earthquake?
- What if there is a wind or sand storm?

- What if the instrument or electrical component has an electrical fault?
- What if the relief stack is struck by lightning?
- What if there is excessive rainfall?
- What if excessive vegetation is allowed to grow at base of flare?

PART 11 ELECTRICAL EQUIPMENT

What-If checklist

Generators

- What if the LEAD generator fails?
- What if the STANDBY generator fails?
- What if the EMERGENCY generator fails?
- What if the generator alarms or shutdowns fail?
- What if the generator space heaters fail to operate?
- What if the generator becomes overloaded?
- What if the fuel supply becomes contaminated?
- What if the engine cooling equipment becomes fouled?
- What if the voltage regulator fails high or low?
- What if an exciter fails open?

Motors

- What if a motor overheats?
- What if a motor fault occurs?
- What if a motor bearing fails?
- What if a motor turns in the reverse direction?
- What if the motor grounding cable is not connected?

Motor control center

- What if a main breaker trips?
- What if voltage is high or low?
- What if an internal fault occurs?
- What if a starter fails open or closed?
- What if a motor overload fails to operate?
- What if a motor circuit protector opens?
- What if a control transformer fuses open?
- What if the motor control center is not grounded?

Switchgear

- What if an incoming voltage is too high or low?
- What if an incoming voltage frequency is too high or low?

- What if a main breaker trips?
- What if an internal fault occurs?
- What if a breaker control voltage fails?
- What if the breaker interlocks are bypassed?
- What if a grounding resistor is disconnected?

PART 12 COOLING TOWERS

What-If checklist

- What if a cooling tower has excessive fouling of internals?
- What if a cooling tower has power loss to pumps or fans?
- What if a cooling tower has containments in water?
- What if a cooling tower has excessive fan vibration?
- What if a cooling tower has flammable mixtures in the water?
- What if the cooling tower motor overheats?
- What if a cooling tower catches on fire?
- What if the cooling tower structure is deteriorated?
- What if the cooling tower motor is not grounded?

PART 13 UTILITY SYSTEMS

What-If checklist

- What if the facility air system fails?
- What if the instrument or utility air system fails?
- What if the breathing air system fails?
- What if the cooling water system fails?
- What if the cooling ammonia system fails?
- What if the cooling Freon system fails?
- What if the cooling steam system fails?
- What if the cooling nitrogen system fails?
- What if the electrical system fails?
- What if the fuel gas system fails?
- What if the natural gas system fails?
- What if the propane fuel system fails?
- What if the bunker C fuel system fails?
- What if the heating oil fuel system fails?
- What if the kerosene fuel system fails?
- What if the helicopter refueling system fails?
- What if the diesel fuel system fails?

- What if the steam heating system fails?
- What if the electric heating system fails?
- What if the transfer oil heating system fails?
- What if the inert gas blanketing system fails?
- What if the flush oil system fails?
- What if the seal oil system fails?
- What if the mineral oil system fails?
- What if the heat transfer oil system fails?
- What if the purge gas system fails?
- What if the NDT radioactivity system fails?
- What if the sanitary sewer system fails?
- What if the storm sewer system fails?
- What if the oil water drains system fails (open or closed system)?
- What if the steam system fails?
- What if the facility water system fails?
- What if the city water system fails?
- What if the well water system fails?
- What if the fire water system fails?
- What if the water storage system is empty?
- What if the chilled water system fails?
- What if the zeolite water system fails?
- What if the demineralized water system fails?
- What if the communications network fails?
- What if the plant alarm system fails?
- What if the security system fails?
- What if the backup utility system fails?

PART 14 HUMAN FACTORS

What-If checklist

General

- What if an improper or unfinished design is issued?
- What if unqualified personnel prepared the engineering design?
- What if an error in engineering calculations was performed?
- What if incorrect materials are ordered or used?
- What if construction is performed improperly?
- What if quality assurance procedures are not available or followed?
- What if improper or inadequate start-up procedures are written?
- What if improper or inadequate start-up procedures are used?

- What if improper or inadequate operating procedures are written?
- What if improper or inadequate operating procedures are used?
- What if instructions for modifications are not provided?
- What if improper maintenance is performed?
- What if improper inspection is performed?
- What if improper decommissioning procedures are used?
- What if improper demolition procedures are used?
- What if management is inadequate or unsatisfactory?
- What if regulations have not been complied with?

Operators

- What if an operator does not perform an action?
- What if an operator performs the wrong action(s)?
- What if an operator performs an action at the wrong place?
- What if an operator performs an action in the wrong sequence?
- What if an operator performs an action at the wrong time?
- What if an operator makes an incorrect reading?
- What if operators work long hours?
- What if operators are not provided with supervision?
- What if operators are not trained?
- What if operators do not understand or know the hazards of the process?
- What if an operator is inundated with instrumentation readings or alarms?

Equipment

- What if access to equipment is not possible?
- What if a valve is too “frozen” to operate?
- What if a valve is not marked for identification?
- What if an electrical switch does not indicate its function?
- What if an emergency egress route is not marked?
- What if an emergency egress route is blocked?
- What if equipment operation is opposite to normal convention?
- What if color coding is not used (e.g., wiring, piping, signs, and safety tools)?
- What if adequate lighting is not available?
- What if instructions are not provided in indigenous languages?
- What if indicator lights are not working?
- What if indicator light lenses are of the wrong color?

- What if air breathing masks do not fit personnel?
- What if oil spill boom is too heavy to move?
- What if an emergency alarm does not operate?
- What if an emergency alarm cannot be heard?
- What if an emergency alarm is confused with other instructional tones?
- What if no communication devices are available?

PART 15 GLOBAL EVENTS

What-If checklist

Maintenance

- What if maintenance is not performed regularly?
- What if maintenance is not performed accurately?
- What if maintenance is performed at the wrong time?
- What if maintenance is performed with the wrong materials or parts?
- What if maintenance does not restore the component to working conditions?
- What if maintenance inadvertently initiates a future hazardous condition?

Sampling

- What if sampling is performed irregularly?
- What if sampling is performed improperly or with improper containers?
- What if sampling is performed from the wrong system?
- What if sampling contaminates samples?
- What if sampling is not properly coordinated with others or with prudent controls?

Testing

- What if testing is performed improperly?
- What if testing is not performed thoroughly or realistically?
- What if testing is performed irregularly?

Weather

- What if a rapid change in barometric pressure occurs, such as hurricanes or severe storms?
- What if a drought occurs that impacts the availability of cooling water?
- What if a dust storm occurs?
- What if a sand storm occurs?

- What if ambient temperature is extreme (low or high)?
- What if unexpectedly low temperatures occur (i.e., $< -50^{\circ}$)?
- What if a brush or forest fire occurs?
- What if flooding occurs?
- What if fog occurs?
- What if frost occurs?
- What if hail occurs?
- What if ice forms on structures during cold weather or from condensation on insulated lines?
- What if lightning occurs?
- What if a mud slide occurs?
- What if a heavy and prolonged rainstorm occurs?
- What if it snows?
- What if there is static electricity buildup?
- What if there is a tornado?
- What if there are high winds?

Geological events

- What if subsidence occurs?
- What if there is an avalanche?
- What if there is coastal erosion?
- What if there is an earthquake?
- What if there is a landslide?
- What if there is a tsunami or tidal wave?
- What if there is volcanic activity?

Transportation

- What if there is an airplane accident?
- What if there is a helicopter accident?
- What if there is a marine accident?
- What if there is a railroad accident?
- What if there is a vehicle accident?
- What if there is a crane accident?
- What if there is a lifting device accident?
- What if there is a fork lift accident?

Human induced

- What if there is an incident in an adjacent unit or facility?
- What if there is construction in the vicinity?

- What if there are dropped objects?
- What if there is a fire in an adjacent unit?
- What if there is leakage of hazardous or toxic chemicals in the area?
- What if there is a missile projection from compressed gas cylinders, rotating equipment, and so on?
- What if there is a problem from a nearby plant?
- What if there is a problem from a pipeline incident?

Human civil

- What if someone sabotages the plant?
- What if someone vandalizes the plant?
- What if there is a terrorist act?
- What if there is civil or political unrest?