

# PHA Pro V6 CHECKLIST INDEX

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*Comments on study Worksheet are made by exception.*

# Worksheet

## Subsystems: 1. Process-plant Buildings

What If	Remarks
1. Is the structural design sufficient to withstand blast overpressures resulting from credible events (vapor cloud explosions, dust explosions, PV-ruptures, BLEVEs, etc.) in near-by processing facilities without serious personnel injury or damage to safety critical equipment?	
2. If the building could be subjected to blast overpressures, have windows been eliminated or designed to prevent breakage and injury to building occupants?	
3. Does the building site meet current company, industry or insurance spacing criteria relative to the hazards of near-by processing or storage facilities?	
4. Has the building been designed for credible external events [e.g., earthquake, hurricane, flood, etc.]? Have building impacts from adjacent equipment failures during external events been evaluated [e.g., power loss, falling structures, etc.]?	
5. For occupied buildings, does the structure include multiple egress routes for personnel in case a fire occurs adjacent to the structure?	
6. Are building sewer systems segregated from process sewer systems to prevent ingress of flammable or toxic vapors?	
7. Are large pieces of furniture, equipment, instrument racks, battery racks, and ceiling fixtures adequately anchored in the event of blast or seismic events?	
8. For multi-story buildings, is heavy equipment located on the ground floor?	
9. Is equipment located in the building appropriate for the electrical classification of the building and adjacent facilities?	
10. For occupied buildings, does the building contain adequate numbers and types of personnel protective equipment to handle emergency that could reasonably be expected to occur?	
11. For occupied buildings, are evacuation plans clearly posted and reviewed with personnel?	
12. Is the building equipped with a fire suppression system appropriate the building function and the material/equipment located in the building?	
13. Has the reliability of critical equipment following a blast, fire, or other external event been evaluated?	
14. For occupied buildings, has the potential for impacts to occupants from a near-by release of toxic material been evaluated?	
15. For normally unoccupied buildings where a hazardous atmosphere could develop (such as analyzer buildings), is the building equipped with gas analyzers, detectors, or some other means to alert personnel entering the building that a hazard exists?	
16. For occupied buildings that could be subjected to toxic materials, does the HVAC design prevent toxic material ingress to the building interior? Do personnel receive an alarm if the HVAC system is not functioning as designed?	
17. Is Utility gas for the building odorized?	

## Subsystems: 2. Compressors

What If	Remarks
1. Is the compressor casing design pressure greater than the maximum compressor suction pressure plus the compressor shutoff pressure [consider largest impeller(s) when determining maximum compressor differential]? Is this true for each compressor stage?	
2. Is the downstream piping or equipment design pressure greater than the maximum compressor discharge pressure [consider largest impeller(s) when determining maximum compressor differential], or is the downstream piping or equipment protected from overpressure in the event that the compressor is blocked in?	

Subsystems: 2. Compressors

What If	Remarks
3. If a downstream blockage would raise the compressor suction pressure, is the downstream piping and equipment rated for the maximum suction pressure plus the compressor shutoff pressure?	
4. If a downstream blockage would not raise compressor suction pressure, is the downstream piping and equipment rated for the greater of (1) normal suction pressure plus the compressor shutoff pressure or (2) maximum suction pressure plus normal compressor differential pressure?	
5. Has a discharge relief valve been provided for positive displacement compressors?	
6. Is the compressor adequately protected from damage when operating at low flow rates [determine if minimum flow or anti-surge protection is required]?	
7. Is the compressor design temperature greater than the maximum upstream operating temperature? Is the compressor design temperature greater than the maximum interstage temperature?	
8. Is the compressor material selection appropriate for the expected vapor properties, including maximum contaminant concentration?	
9. For vibrating services, are pulsation dampeners included in the design? Is discharge piping adequately supported? Are branch connections adequately supported?	
10. Is the selected mechanical seal appropriate for the intended service, including maximum contaminant concentration?	
11. Has mechanical seal failure been evaluated?	
12. Has bearing failure been evaluated?	
13. Has failure of compressor heat removal equipment (e.g., lube oil coolers, seal oil coolers, and seal flush) been evaluated [consider loss of circulation and plugging of coolers]?	
14. Are compressor "run" indicators (running lights or other process indicators) provided at a continuously staffed location for critical service compressors?	
15. Has the compressor stopping been evaluated?	
16. Has closing the compressor discharge valve been evaluated? Has closing the compressor interstage discharge valve been evaluated?	
17. Has liquid carryover to the suction of the compressor been evaluated?	
18. Has reverse flow through the compressor when it shuts down been evaluated [assume the discharge check valve sticks open]? Has reverse flow for each compressor stage been evaluated?	
19. Has compressor over-speed been evaluated?	
20. If the compressor is provided with minimum flow or anti-surge protection, have failures of the compressor anti-surge control system been evaluated?	
21. Has a cooler (e.g., interstage cooler, lube oil cooler, and seal oil cooler) tube leak been evaluated?	
22. Has operation with higher specific gravity vapor, due to process upset or startup/shutdown, been evaluated [consider whether or not the compressor is adequately sized for other fluids, such as nitrogen or fuel gas, if the compressor will be required to transfer the other fluids during startup or shutdown]?	
23. Is adequate firewater coverage available for the compressor area?	
24. Is there adequate emergency access to the compressor?	
25. Can the compressor be safely isolated in an emergency?	

Subsystems: 2. Compressors

What If	Remarks
26. If emergency isolation valves (either manual, automatic, or remotely operated) are provided to isolate the compressor, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
27. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
28. For installations where critical service equipment (e.g., air-cooled heat exchangers or power/instrument cables) is located above a compressor handling flammable material, is the critical equipment adequately protected in the event of fire at the compressor [review requirements for fireproofing and installation of fixed water or fixed steam deluge]?	
29. If fixed water or fixed steam deluge is provided, can the valve or station that actuates the system be operated safely in the event of fire at or near the compressor [consider location of valve/station or the ability to operate valve/station remotely]?	
30. Have flexible piping components (e.g., hoses, expansion joints, and tubing) been reduced or eliminated where possible? If flexible piping components are installed, are they designed for maximum operating pressure and temperature? Are flexible connections adequately protected against possible rupture due to mechanical impact and fire?	
31. Have leaks (at mechanical seal, flanges, etc.) to the atmosphere been evaluated for compressors located in buildings or shelters [concern is for buildup of explosive atmosphere with possible fire or explosion]?	
32. For compressor installations where minor leaks are known to occur (e.g., mechanical seal, packing, or distance piece leaks), are the leaks vented to a safe location?	
33. For compressor installations using an engine driver (gas or diesel driven), are the air intake and exhaust lines vented to a safe location?	
34. Can critical service compressors be quickly shut down from a safe location?	
35. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are procedures in place for the routine testing of these valves?	
36. For critical service compressors, are preventative maintenance procedures in place to reduce the likelihood of equipment failures that could result in hydrocarbon or toxic material releases?	
37. For compressor installations with auxiliary systems (e.g., lube oil, seal oil, vibration, etc.), are alarms and shutdowns routinely tested?	

Subsystems: 3. Safety / Emergency Response

What If	Remarks
1. Is there a written emergency response plan for this unit that addresses credible emergency scenarios (e.g., toxic material releases, fire, explosions, sabotage, bomb threat, etc.)? Are copies of the written plan readily available to all affected personnel?	
2. Does the emergency response plan include an incident command structure (or other authority and communication structure) that outlines personnel responsibilities during emergency situations?	
3. Does the emergency response plan specify evacuation routes and personnel assembly or refuge areas?	
4. Does the emergency response plan contain emergency notification requirements, including a list of contact names and phone numbers, for both company and outside responders? Is this list up-to-date?	
5. Does the emergency response plan identify essential personnel who must remain on-site during an emergency [confirm that a sufficient number of trained people who are knowledgeable in the hazards of the process and emergency response are available at all times, either on-site or via rapid call-out]?	

Subsystems: 3. Safety / Emergency Response

What If	Remarks
6. Does the emergency response plan identify the resources (personnel and equipment) available from outside sources (i.e., community fire departments, mutual-aid partners, etc.)?	
7. Does the emergency response plan include procedures to account for all personnel following an incident, including employees, contractors, and visitors?	
8. Do procedures specify proper response to warning sirens, whistles, or horns? Are these warning devices routinely tested?	
9. Does the emergency response plan specify which communication channels are restricted for use by emergency responders during an incident?	
10. Does the emergency response plan include provisions for off-site traffic control and access for off-site responders?	
11. Does the emergency response plan specify the reporting requirements for the various incidents that may occur at the facility, including reporting to facility and company management as well as to outside agencies?	
12. Has an incident command center, stocked with necessary reference information (e.g., emergency response plan, site and community maps, call-out lists, etc.) and communication systems been established? For large facilities, is this information available at multiple locations?	
13. Are hypothetical emergency drills routinely conducted? Do outside sources (i.e., community fire departments, mutual-aid partners, etc.) participate in the hypothetical drills? Are procedures in place to critique the response to hypothetical drills and resolve the recommendations from these reviews?	
14. Is a program in place to verify all affected personnel receive initial and refresher training in the emergency response plan? Is the refresher training provided on an annual basis and whenever updates to the plan are made?	
15. Has the adequacy of the outside agency response program been evaluated [consider familiarity with the hazards of the process, knowledge on how to respond to emergency situations, physical condition of outside agency members, etc.]? Has the adequacy of the outside agency equipment been evaluated [consider availability and adequacy of fire-fighting equipment, including foam, adequacy and integrity of personnel protective equipment, and amount of equipment available]?	
16. Do procedures specify the method and frequency for inspection, maintenance, service, and testing of emergency response equipment (i.e., fire suppression and extinguishing systems, personnel protective equipment, etc.)?	
17. Is detection/alarming equipment for fire or flammable gas tested regularly and maintained in functional condition?	
18. Are open safety recommendations valid?	
19. Are open safety recommendations being addressed in a timely manner?	
20. Are open Incident Investigations being completed in a timely manner?	
21. Are recommendations being addressed promptly?	
22. Is lighting adequate?	
23. Is emergency lighting adequate?	
24. Are safety showers and eyewashes adequate in location and performance?	
25. Are safety shower lights adequate?	
26. Does the building ventilation system function properly?	
27. Do the steel structures for buildings, tanks, vessels and pumps have electrical grounding straps that are intact and connected?	
28. Are process alarms audible in the areas being reviewed?	

Subsystems: 4. Exchangers

What If	Remarks
1. Is the design pressure of the heat exchanger greater than the maximum upstream pressure [consider both shell- and tube-sides]?	
2. Is the design temperature of the heat exchanger greater than the maximum upstream temperature?	
3. Is the heat exchanger material appropriate for the expected fluid properties, including maximum contaminant concentration?	
4. For heat exchangers with high-pressure process fluid on the tube-side, is the shell-side adequately protected in the event of tube failure? [For shell-and-tube heat exchangers with substantial pressure differential between the shell and tubes and normally liquid-filled on lower pressure shell side, sudden tube rupture may result in overpressure and damage to exchanger shell or downstream piping and equipment.]	
5. Is the heat exchanger adequately designed for vacuum conditions [determine if vacuum conditions can be created if a hot fluid (e.g., steam) is blocked in and cooled]?	
6. Is adequate overpressure relief protection for the heat exchanger provided (consider both shell- and tube-sides)?	
7. For heat exchangers where the cold-side can be blocked in, is adequate thermal overpressure protection provided?	
8. Has heat exchanger tube leak or rupture been evaluated [for cooling water, steam, and condensate exchangers, determine if flammable or toxic process fluids may leak into the utility systems]?	
9. For heat exchanger relief valves that vent to the atmosphere (relief valves on the cooling water or steam/condensate side of heat exchangers may vent to atmosphere), has tube rupture been evaluated [determine if flammable or toxic process fluids may vent to atmosphere]?	
10. Has loss of cooling water (either cooling water supply blocked in or loss of cooling water supply) been evaluated?	
11. Has loss of steam (or other heating medium) been evaluated?	
12. Has bypassing the heat exchanger been evaluated? Have the effects of increased temperature on downstream equipment or tankage been evaluated?	
13. Has heat exchanger tube- or shell-side fouling been evaluated [may be similar to, but less severe than, loss of cooling water or steam supply]?	
14. Has heat exchanger tube plugging been evaluated?	
15. Has increased temperature of heating medium (e.g., super-heated steam or hot oil) been evaluated?	
16. For air-cooled heat exchangers, has loss of air cooler fans (loss of power, fans shut off, louvers closed, variable pitch fans at minimum, etc.) been evaluated?	
17. Has blocking in the heat exchanger been evaluated?	
18. Has the buildup of non-condensables (may occur during startup or process upset) in the heat exchanger been evaluated?	
19. Is adequate firewater coverage available at or near the heat exchanger?	
20. Is there adequate emergency access to the heat exchanger?	
21. For installations where critical service equipment (e.g., air-cooled heat exchangers or power/instrument cables) is located above rotating equipment (pumps or compressors) handling flammable material, is the critical equipment adequately protected in the event of fire at the pump or compressor [review requirements for fireproofing and installation of fixed water or fixed steam deluge]?	
22. Is there adequate clearance around the heat exchanger to allow maintenance access (for cleaning of the exchanger and/or removal of the tube bundle)?	

Subsystems: 4. Exchangers

What If	Remarks
23. Are the exchanger inlet, outlet, and bypass lines or valves clearly labeled, including flow direction?	
24. Are air cooler fan "run" indicators (fan running lights or other process indicators) provided at a continuously staffed location for critical service air-cooled heat exchangers (e.g., reactor effluent coolers and overhead condensers)?	
25. For equipment that must be maintained while the process unit is "on-line," is safe access and egress provided for maintenance personnel (e.g., access platforms, heat shielding for elevated air coolers, etc.)?	
26. Is the heat exchanger's minimum pressurizing temperature (MPT) documented and available to operations and maintenance personnel?	

Subsystems: 5. Fired Heaters

What If	Remarks
1. Is the design pressure of the fired heater tubes greater than the maximum upstream pressure?	
2. Is the fired heater tube material appropriate for the fluid properties, including maximum contaminant concentration?	
3. Are the fired heater tubes provided with sufficient tube skin temperature indicators? Are the temperature indicators considered reliable?	
4. If snuffing steam is provided at the fired heater box, are the snuffing steam lines adequately drained and trapped?	
5. Is the fired heater provided with an appropriate safety shutdown system?	
6. Is adequate overpressure relief protection for the fired heater tubes provided?	
7. If relief valves are installed at the outlet of a fired heater, are the installations designed to prevent plugging or coking of the relief valve inlet?	
8. Has loss of flow to one or more fired heater tube passes been evaluated [may be due to pass valve closed, tube coking, two-phase slug flow, etc.]?	
9. Has total loss of flow to the fired heater been evaluated?	
10. Has a fired heater tube leak or tube rupture been evaluated [determine if back flow from downstream equipment may contribute to the severity of the possible consequences, and therefore if back-flow prevention (i.e., check or isolation valve) is required]?	
11. Has loss of fuel gas to the fired heater been evaluated?	
12. Has a momentary dip in the pressure of the fuel gas supply to the fired heater been evaluated [determine if loss of burner(s) flame may occur, followed by buildup of flammable mixture and possible explosion]?	
13. Has high fuel gas pressure been evaluated [may be caused by fuel gas pressure regulator failure]?	
14. Has contaminants (e.g., H <sub>2</sub> S, amine, caustic, or solids) or the wrong concentration (e.g., low or high BTU-content components) in the fuel gas or fuel oil supply to the fired heater been evaluated?	
15. Has liquid hydrocarbon carryover into the fuel gas supply to the fired heater been evaluated?	
16. Has after-burning in the radiant section of the fired heater box been evaluated?	
17. Has bypassing the fired heater been evaluated? Have the effects of increased temperature on downstream equipment been evaluated?	
18. Has fired heater tube fouling been evaluated?	
19. Has fired heater tube plugging been evaluated?	

Subsystems: 5. Fired Heaters

What If	Remarks
20. Has forced or induced draft fan failure (fan off or fan over-speed) been evaluated?	
21. Has louver or damper failure (wide open or closed) been evaluated?	
22. Has over firing the fired heater burners (too much fuel gas or high BTU-content fuel gas) been evaluated?	
23. Has blocking in the fired heater been evaluated?	
24. Is adequate firewater coverage available at or near the fired heater?	
25. Is there adequate emergency access to the fired heater?	
26. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
27. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
28. If snuffing or purging steam is provided, can the valve or station that actuates the snuffing steam be operated safely in the event of a fire [consider location of valve/station or the ability to operate valve/station remotely]?	
29. Is there adequate clearance around the fired heater to allow maintenance access (for cleaning of the fired heater tubes and/or inspection and repair of the heater box)?	
30. Are sufficient fired heater box testing ports available to allow verification that the heater box is purged, and therefore safe to light? Is access to the testing ports adequate?	
31. Are the fuel gas and/or fuel oil supply valves clearly labeled? Is the snuffing steam valve/station clearly labeled?	
32. Are the fired heater inlet, outlet, and bypass lines or valves clearly labeled, including flow direction?	
33. Is access adequate at all valve manifolds for both routine and emergency operation and for maintenance?	
34. For equipment that must be maintained while the process unit is "on-line," is safe access and egress provided for maintenance personnel (e.g., access platforms, furnace draft fans and soot blowers, furnace stack sampling systems and analyzers, etc.)?	
35. Are procedures in place for safe lighting (including firebox purging)?	
36. For fired heater tube material that is susceptible to stress-corrosion cracking (if exposed to air or water), are procedures in place to maintain the tubes under an inert atmosphere during shutdowns or passivate the tubes prior to exposure to the air?	
37. Do procedures require monitoring the burner flame pattern and possible flame impingement on the fired heater tubes routinely? Do the procedures require monitoring the tubes for hot spots and the condition of tube supports?	
38. Are fired heater emergency response procedures in place [consider loss of flow, loss of flow to one pass, tube rupture, loss of fuel gas or fuel oil supply, loss of combustion air, etc.]? Are hypothetical drills periodically performed?	
39. Do procedures require routine testing of critical alarms and safety shutdown systems, including primary elements or sensors, shutdown system control and logic, and final elements such as emergency isolation valves or equipment shutdown interlocks [determine the need for on-line testing of safety shutdown systems]?	
40. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are procedures in place for the routine testing of these valves?	
41. Is the maximum design temperature of the fired heater tubes and furnace stack documented and communicated to operations personnel?	

Subsystems: 5. Fired Heaters

What If	Remarks
42. Is the minimum pressurizing temperature (MPT) of the fired heater tubes documented and communicated to operations and maintenance personnel?	

Subsystems: 6. Human Factors

What If	Remarks
1. Are the field instruments that are routinely monitored by operations personnel easily accessible to ensure information is read in accordance with recommended frequency [consider instruments or areas that are difficult to reach, such as climbing 40 feet of ladder or squeezing into close quarters]?	
2. Are all operating valves accessible during normal or emergency operation?	
3. Are manually operated valves positioned to allow proper operation without muscle strain?	
4. Is access adequate at all valve manifolds (including battery or plot limit) for both routine and emergency operation and for maintenance? [Review requirements for changing battery or plot limit blinds.]	
5. Are elevated valves accessible during normal or emergency operation (i.e., access provided by ladders/platform or chain operator)?	
6. Are valve chain operators properly maintained?	
7. Can critical valves or equipment be closed or shut off from a safe location in a timely manner?	
8. Have valve manifolds been arranged to reduce the likelihood of mis-manifolding? Has valve mis-manifolding been evaluated?	
9. Do alarm indicators (e.g., lights, horns, or whistles) adequately alert field personnel to upset or emergency conditions? Does the alarm indication alert all potentially affected employees?	
10. Are emergency shutdown switches guarded against inadvertent operation [consider location, switch operation, and guards or covers]?	
11. Are remote startup/shutdown switches clearly labeled and protected from inadvertent operation?	
12. Are remote switches for different systems separated by sufficient distance to prevent operation of the wrong system during stressful situations?	
13. Is the lighting adequate in the unit [consider local instrument panels, battery or plot limit valve manifold locations, equipment and valves requiring operation during emergency conditions, etc.]? Is the emergency lighting (light fixtures on the emergency power circuit) adequate in the unit?	
14. Are drain valves located to allow personnel to monitor levels while draining?	
15. Are the engineering units of similar instruments consistent [e.g., do the pump seal flush rotameters all display flow in either gpm or gph]?	
16. Are field instrument indicators routinely checked for accuracy?	
17. Are field instrument ranges appropriate for the service [e.g., avoid using a 0-2500 psig pressure gage on a 100 psig system]?	
18. Are control valves and associated instrumentation accessible for maintenance?	
19. Are operating ranges for process variables specified in the same engineering units as the instrument read-out or indicator (i.e., mental conversion of units is avoided)?	
20. Does the process control system console layout allow for rapid response to upset situations? If required, does the process control system console layout allow for response by multiple personnel?	

Subsystems: 6. Human Factors

What If	Remarks
21. Do the process control system displays adequately present the process information [consider the logical layout of process or equipment configuration information, consistent presentation of information, visibility of information from various work positions, and the logical linking of information between displays]?	
22. Do the process control system displays for similar equipment (e.g., parallel trains or similar equipment in series) present the information in a unique manner to avoid confusion?	
23. Do the process control system displays provide feedback to operations personnel to confirm operator actions? Does the feedback provide operators with logical information (e.g., is 100% valve output equivalent to valve wide open)?	
24. Does the control board layout minimize the possibility of operator error during stressful situations?	
25. Are board-mounted shutdown switches or buttons sufficiently distinguishable/separated from alarm acknowledgment buttons to minimize inadvertent operation?	
26. Are emergency shutdown switches guarded against inadvertent operation [consider location, switch operation, and guards or covers]?	
27. Are control system display targets (touch screens) spaced adequately to prevent accidental operation?	
28. Are the control system display symbols consistent and meaningful? Are the control system display symbols standardized (i.e., consistent representation and common use of acronyms, abbreviations, and equipment tags)?	
29. Are critical alarms prioritized to alert operations personnel to upset situations that require immediate response?	
30. Is the cause of "nuisance" alarms (repetitive alarms that operations personnel ignore or acknowledge without investigating) determined and repaired in a timely manner?	
31. Are equipment "run" indicators (running lights or other process indicators) and valve position indicators provided at a continuously staffed location for critical equipment, valves, and instruments?	
32. Are calculations performed by operations personnel documented in a consistent manner and periodically checked for correctness?	
33. Is the control room lighting adequate [review direct and indirect lighting]? Is the control room emergency lighting (light fixtures on the emergency power circuit) adequate?	
34. Are the communications facilities between process units adequate for clear and uninterrupted communications during both normal and emergency situations [e.g., telephone land lines, radio, computer network, and E-mail, and are systems redundant and/or secure]?	
35. Are the control building air conditioning and pressurization adequate to protect the electronic instrumentation? Are they adequate to prevent intrusion of toxics, flammables, or corrosive contaminants (if applicable)?	
36. Are all equipment labels (e.g., vessels, piping, valves, instrumentation, etc.) easy to read (clear and in good condition)?	
37. Are all equipment labels correct and unambiguous?	
38. Are all equipment labels located close to the items that they identify?	
39. Do all equipment labels use standard terminology (e.g., acronyms, abbreviations, equipment tags, etc.)? Are the equipment labels consistent with nomenclature used in procedures?	
40. Are all components that are mentioned in procedures (e.g., valves) labeled or otherwise identified?	
41. Do switch labels identify discrete positions (e.g., ON or OFF, OPEN or CLOSE)?	
42. Are signs (e.g., emergency exit, restricted entry, etc.) clearly visible [consider location and condition]? Are the signs easy to read [consider letter size and color]?	

Subsystems: 6. Human Factors

What If	Remarks
43. Are pipelines and electrical conduit clearly labeled at points where they become invisible (e.g., routed underground)?	
44. Do procedures prevent changing alarm set points without proper review and authorization? Are alarm changes (set point or priority) communicated to all affected employees?	
45. Do procedures prevent changing process control system or safety shutdown system control or logic (software) without proper review and authorization? Are process control system or safety shutdown system changes communicated to all affected employees?	
46. Do operating procedures document the alarm set points? Do the procedures specify the expected operator response to the alarm? Do the procedures specify the potential consequences if the alarm set points are exceeded (i.e., consequences of deviation)?	
47. Do procedures require routine testing of critical alarms and safety shutdown systems, including primary elements or sensors, shutdown system control and logic, and final elements such as emergency isolation valves or equipment shutdown interlocks [determine the need for on-line testing of safety shutdown systems]?	
48. Do operating crews communicate unusual equipment or instrument status (bypassed or out of service) in writing? Are operating crews provided with written temporary operating procedures when equipment or instruments are bypassed or out of service?	
49. Do procedures require verification that instruments that are deliberately disabled during operation (e.g., shutdown interlocks bypassed to allow testing) are placed back in service?	
50. Do procedures require control valve bypasses to remain closed during normal operation [possible concern for loss of level during upset conditions if the bypass around an LCV is open]?	
51. Do procedures specify proper response to alarm indicators (e.g., lights, horns, or whistles) during emergency situations? Are hypothetical emergency situation drills periodically performed? Are the alarm indicators routinely tested?	
52. Are staff levels (both size and experience) sufficient to handle routine and non-routine duties that can be reasonably expected to occur during a shift?	
53. Is the length of a normal shift appropriate given the degree of alertness required and potential for operator fatigue [consider number of manual adjustments required in a single shift, effect of rotating shifts]?	
54. Are shift turnover periods sufficient to adequately communicate plant operating conditions from off-shift to on-shift personnel?	
55. Are emergency procedures presented in a clear, step-by-step format to reduce the "panic" factor during upset situations? Are hypothetical drills of emergency situations periodically performed?	
56. Can tasks requiring the operator to perform nearly simultaneous actions be accomplished without traveling large distances (e.g., switching unit rundown into an alternate rundown line, lighting furnace burners, etc.)?	
57. Are sufficient tasks assigned during low activity operation to minimize the effects of boredom (e.g., possible loss of alertness)?	
58. Does the location of emergency equipment (e.g., fire gear, SCBA, acid suits, etc.) allow for rapid access and use? Does the location of first aid supplies allow for rapid access and use?	

Subsystems: 7. Instrumentation

What If	Remarks
1. Is the instrument specification suitable for the expected fluid properties, including maximum contaminant concentration?	
2. List troublesome and unreliable instruments.	
3. Is the instrument design pressure greater than the maximum operating pressure of the process system to which it is connected?	

Subsystems: 7. Instrumentation

What If	Remarks
4. Is the instrument design temperature greater than the maximum operating temperature of the process system to which it is connected?	
5. Is the instrument installation designed to allow on-line testing and calibration of the instrument?	
6. Are critical safety shutdown systems designed and installed to ensure reliability of the shutdown system [consider requirements for redundancy of components, independence from process control system, and ability to test system to ensure reliability]?	
7. Are critical safety shutdown systems designed to fail-safe? Does the design require operator action to reset the shutdown system (e.g., manual reset of isolation valves) after the shutdown system is actuated to prevent unsafe conditions due to system response when the shutdown trip condition clears?	
8. Are instrument installations that result in moment arm arrangements (multiple or heavy valves branching from the pipe) adequately designed (e.g., supported or reinforced, such as bridge welding) to prevent failure of welded connections due to vibration or mechanical impact?	
9. Are emergency shutdown switches guarded against inadvertent operation [consider location, switch operation, and guards or covers]?	
10. Are all critical service alarms routed to a continuously staffed location?	
11. Are redundant instrument or power cables physically separated [i.e., separated to prevent a single incident, such as fire or mechanical impact, from resulting in failure of both cables]?	
12. Are instrument-sensing lines adequately purged or heat traced to prevent plugging? For plugging services, does the design allow for safely unplugging the instrument on-line?	
13. Are utility instruments adequately heat traced and insulated or designed to prevent cold weather freezing and plugging?	
14. Are control valves or emergency isolation valves designed to close under maximum differential pressure process conditions?	
15. For services where the piping specification changes to a lower design rating after the control valve, is the downstream piping specification suitable for upset situations with the control valve wide open?	
16. Are the instruments suitable for the electrical area classification?	
17. Has the control valve failing wide open been evaluated?	
18. Has the control valve failing closed been evaluated?	
19. Has the control valve leaking been evaluated?	
20. Has the control valve bypass left open or leaking been evaluated?	
21. For plugging or fouling services, has plugging of the flow orifice or other primary flow element been evaluated?	
22. Has operation with higher or lower specific gravity fluid (may be due to process upset or startup/shutdown) been evaluated?	
23. Has loss of power to the process unit been evaluated [determine if the process unit is designed fail-safe]?	
24. Has loss of power, including partial loss of power and total loss of power, to the process control system been evaluated?	
25. Has loss of instrument air to the process unit been evaluated [determine if the process unit is designed fail-safe]?	
26. Has inadvertent operation of the safety shutdown system been evaluated?	
27. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	

Subsystems: 7. Instrumentation

What If	Remarks
28. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
29. Are critical safety shutdown systems adequately protected in the event of fire? [Determine if the safety shutdown system's primary elements or sensors, the power and instrument cables, and the final elements such as emergency isolation block valves or equipment shutdown interlocks are adequately fireproofed, fail-safe, and/or located in a non-hazardous area.]	
30. Are the control building air conditioning and pressurization adequate to protect the electronic instrumentation? Are they adequate to prevent intrusion of toxics, flammables, or corrosive contaminants (if applicable)?	
31. Are control valves and associated instrumentation accessible for maintenance?	
32. Can critical valves or equipment be closed or shut off from a safe location?	
33. Is the lighting adequate in the unit [consider local instrument panels, battery or plot limit valve manifold locations, equipment and valves requiring operation during emergency conditions, etc.]? Is the emergency lighting (light fixtures on the emergency power circuit) adequate in the unit?	
34. Are all instrument labels easy to read (clear and in good condition)?	
35. Are all instrument labels correct and unambiguous?	
36. Are all instrument labels located close to the items that they identify?	
37. Do all instrument labels use standard terminology (e.g., acronyms, abbreviations, equipment tags, etc.)? Are the instrument labels consistent with nomenclature used in procedures?	
38. Are all components that are mentioned in procedures (e.g., valves) labeled or otherwise identified?	
39. Do switch labels identify discrete positions (e.g., ON or OFF, OPEN or CLOSE)?	
40. Are the field instruments that are routinely monitored by operations personnel easily accessible to ensure information is read in accordance with recommended frequency [consider instruments or areas that are difficult to reach, such as climbing 40 feet of ladder or squeezing into close quarters]?	
41. Are the engineering units of similar instruments consistent [e.g., do the pump seal flush rotameters all display flow in either gpm or gph]?	
42. Are field instrument indicators routinely checked for accuracy?	
43. Are field instrument ranges appropriate for the service [e.g., avoid using a 0-2500 psig pressure gage on a 100 psig system]?	
44. Are operating ranges for process variables specified in the same engineering units as the instrument read-out or indicator (i.e., mental conversion of units is avoided)?	
45. Are calculations performed by operations personnel documented in a consistent manner and periodically checked for correctness?	
46. Does the process control system console layout allow for rapid response to upset situations? If required, does the process control system console layout allow for response by multiple personnel?	
47. Do the process control system displays adequately present the process information [consider the logical layout of process or equipment configuration information, consistent presentation of information, visibility of information from various work positions, and the logical linking of information between displays]?	
48. Do the process control system displays for similar equipment (e.g., parallel trains or similar equipment in series) present the information in a unique manner to avoid confusion?	
49. Do the process control system displays provide feedback to operations personnel to confirm operator actions? Does the feedback provide	

Subsystems: 7. Instrumentation

What If	Remarks
operators with logical information (e.g., is 100% valve output equivalent to valve wide open)?	
50. Are critical alarms prioritized to alert operations personnel to upset situations that require immediate response?	
51. Is the cause of "nuisance" alarms (repetitive alarms that operations personnel ignore or acknowledge without investigating) investigated and repaired in a timely manner?	
52. Are equipment "run" indicators (running lights or other process indicators) and valve position indicators provided at a continuously staffed location for critical equipment, valves, and instruments?	
53. Are the communications facilities between process units adequate for clear and uninterrupted communications during both normal and emergency situations [e.g., telephone land lines, radio, computer network, and E-mail, and are systems redundant and/or secure]?	
54. Is the control room lighting adequate [review direct and indirect lighting]? Is the control room emergency lighting (light fixtures on the emergency power circuit) adequate?	
55. Do procedures prevent changing alarm set points without proper review and authorization? Are alarm changes (set point or priority) communicated to all affected employees?	
56. Do procedures prevent changing process control system or safety shutdown system control or logic (software) without proper review and authorization? Are process control system or safety shutdown system changes communicated to all affected employees?	
57. Do operating procedures document the alarm set points? Do the procedures specify the expected operator response to the alarm? Do the procedures specify the potential consequences if the alarm set points are exceeded (i.e., consequences of deviation)?	
58. Do operating crews communicate unusual instrument status (bypassed or out of service) in writing? Are operating crews provided with written temporary operating procedures when instruments are bypassed or out of service?	
59. Do procedures require verification that instruments that are deliberately disabled during operation (e.g., shutdown interlocks bypassed to allow testing) are placed back in service?	
60. Do procedures require control valve bypasses to remain closed during normal operation [possible concern for loss of level during upset conditions if the bypass around an LCV is open]?	
61. Do procedures specify proper response to alarm indicators (e.g., lights, horns, or whistles) during emergency situations? Are hypothetical emergency situation drills periodically performed? Are the alarm indicators routinely tested?	
62. Do procedures require routine testing of critical alarms and safety shutdown systems, including primary elements or sensors, shutdown system control and logic, and final elements such as emergency isolation valves or equipment shutdown interlocks [determine the need for on-line testing of safety shutdown systems]?	
63. Do procedures specify response to potential process control system failures [consider loss of input or output signal(s), loss of display screens (loss of view), loss of memory devices, loss of equipment or system interfaces (gateways), loss of power, loss of backup power, loss of control program, etc.]?	
64. Do procedures require physical isolation of power source(s) prior to release of equipment for maintenance work (i.e., lockout/tag out)?	
65. Can instrument loop drawings be found by equipment number or system number?	
66. Is master instrument data kept and managed at one location?	
67. Do bypassed trips get properly documented with a start date, work order number, stop date, and list of interim safeguards; and are they reconciled promptly?	
68. Are Temporary instructions, addressing any need for interim safeguards, provided for instruments or instrument loops that are out of service while the plant is operational?	

Subsystems: 8. Maintenance

What If	Remarks
1. Has piping and equipment been designed and installed to allow depressurization, draining, and isolation prior to maintenance work?	
2. Has access to equipment for maintenance been evaluated [review crane position and lifts; removal of heat exchanger tube bundles, vessel internals, and rotating equipment elements; location of monitoring equipment; lay down of tools and materials; etc.]?	
3. If required, are connections for in-place chemical cleaning or neutralization of equipment or piping provided?	
4. Does the piping design prevent connection of air tools to other process gas systems (e.g., nitrogen or natural gas), such as special connections to the utility air header?	
5. Are equipment and piping that are not designed for field hydro testing clearly identified (e.g., relief headers, large overhead vapor lines, refractory lined equipment and piping, expansion bellows, etc.)?	
6. Are analyzer buildings or enclosures properly ventilated to prevent buildup of flammable or toxic materials? Alternatively, are flammable or toxic material detectors provided inside the building to alert personnel of possible danger prior to entering? Do the detectors alarm to a continuously staffed location as well as locally, outside the building?	
7. Are there written maintenance procedures for all routine or contemplated maintenance activities? Are the procedures appropriate for the complexity of the job task [i.e., are generic procedures used for routine or simple tasks and job specific procedures used for non-routine or complex tasks]?	
8. Are written maintenance procedures developed for non-routine maintenance activities prior to commencing the work?	
9. Have all personnel involved in maintaining the integrity of process equipment (including contract personnel) received appropriate training? Does the training include an overview of the process, the hazards associated with the process, and review of all generic or specific procedures applicable to the employee's job tasks?	
10. Is the work permit system understood by all affected employees, maintenance (including contractors), operations, and engineering? Does the work permit clearly explain the approvals and communication required prior to commencing a maintenance activity? Does the work permit system require physical inspection of the job site by maintenance and operations personnel prior to commencing work [concern is for working on the wrong line or equipment, opening equipment that is still under pressure or contains toxic material, verification of the correct personnel protective equipment (PPE) required for the job task, etc.]?	
11. Do procedures require physical isolation of power source(s) prior to release of equipment for maintenance work (i.e., lockout/tag out)?	
12. Do the repairs to the piping or equipment (materials and methods) comply with the applicable industry codes and company guidelines?	
13. Do field hydro test procedures include guidance regarding special requirements [e.g., minimum pressurizing temperature for heavy-wall vessels and piping, low-chloride test water for 18-8 stainless steel, adequate vents for large-diameter or thin-wall equipment to prevent collapse from external pressure, etc.]?	
14. For maintenance activities where pressure relief devices are isolated or removed, is backup relief protection provided?	
15. Do procedures require physical inspection of completed maintenance work by operations personnel before "sign-off" of the work or job order?	
16. Do procedures require new gaskets (and bolts if needed) to be installed when a flange closure is opened or broken? Do the procedures provide guidance on the proper gasket material for the process service?	
17. Do procedures require tightness testing of all flange bolts prior to startup [concern is for flanges that were opened during shutdown or flange bolts that may have loosened due to thermal expansion and contraction]? Do the procedures provide guidance to prevent over- or under-tightening flange bolts?	
18. Do procedures specify the proper settings for pipe spring hanger supports? Do the procedures require checking the pipe spring hanger	

Subsystems: 8. Maintenance

What If	Remarks
settings prior to each startup and during normal operation?	
19. Are maintenance personnel trained in the use of piping specifications? Is a process in place to verify the latest piping specification is used?	
20. For piping modifications and repairs, do procedures require verification that the repair material to be installed meets the requirements of the piping specification?	
21. Is the piping system's minimum pressurizing temperature (MPT) documented?	
22. Do procedures require that 18-8 stainless steel equipment and piping in sour or H2S services (i.e., exposed to sulfides) be blanketed with dry inert gas when shut down, or flushed with soda ash, KOH, or ammonia neutralizing solution, before opening for inspection and maintenance? [Concern is for ambient moisture contacting sulfide scale on the surface of 18-8 stainless steel, with the potential for polythionic acid stress corrosion cracking of the stainless.]	
23. Do procedures for loading and unloading catalyst (i.e., reactors, driers, columns, etc.) include information regarding the hazards of the catalyst and identify the PPE required when handling either fresh or spent catalyst?	
24. Have all maintenance personnel been trained in the purpose and use of the facility management of change (MOC) procedure? Do all maintenance personnel understand the MOC definition of "replacement-in-kind"?	
25. Do procedures require appropriate approval and supervision of crane use [concern is for lifts over equipment that contain toxic or hazardous materials, over power lines, over critical equipment, etc.]? Are lifts reviewed by crane operator before they are performed?	
26. Do procedures require appropriate inspections and approvals prior to performing hot taps?	
27. Do procedures specify appropriate methods for temporary leak repair (e.g., type of clamp, material, etc.)? Do the procedures include administrative controls that require a permanent repair be made at the earliest opportunity (i.e., next shutdown)?	
28. Do procedures prevent changing alarm set points without proper review and authorization? Are alarm changes (set point or priority) communicated to all affected employees?	
29. Do procedures prevent changing process control system or safety shutdown system control or logic (software) without proper review and authorization? Are process control system or safety shutdown system changes communicated to all affected employees?	
30. Do procedures require routine testing of critical alarms and safety shutdown systems, including primary elements or sensors, shutdown system control and logic, and final elements such as emergency isolation valves or equipment shutdown interlocks [determine the need for on-line testing of safety shutdown systems]?	
31. Do procedures require verification that instruments that are deliberately disabled during operation (e.g., shutdown interlocks bypassed to allow testing) are placed back in service?	
32. Do procedures prohibit the use of pipe wrench extensions ("persuaders") on small or special valves in hazardous service [e.g., small piping valves, screwed bonnet valves, orbit valves, twin-seal valves, etc.]?	
33. Do warehouse procedures include verification that materials received are in accordance with the purchase specification?	
34. Are special materials of construction identified on process flow diagrams (PFD), piping and instrument diagrams (P&IDs), operating procedures, or other PSI documentation? Is this information kept current via the MOC process?	
35. Do procedures require testing of alloy materials for proper alloy content when received at the facility site (i.e., positive materials identification [PMI] program)? Are received materials accompanied by proper documentation (i.e., mill certificates, chemical test reports, ANSI or ASME specification, etc.)?	
36. Are materials segregated and clearly identified when stored, to reduce the possibility of incorrect material installation?	
37. Are alloy materials stored such that they are protected from ambient conditions as necessary [i.e., 18-8 stainless steel materials protected	

Subsystems: 8. Maintenance

What If	Remarks
from chloride salts at seacoast locations, etc.]?	
38. Are there procedures to order, receive, document, and issue materials for ASME Code vessel or piping repairs or modifications? Do procedures specify ASME Code welder qualifications and testing?	
39. Are a representative number of new and refurbished valves inspected for the proper valve packing material upon receipt from the vendor or contract shop?	
40. Is a program in place for routine monitoring of critical rotating equipment for excessive vibration?	
41. Is a program in place for routine monitoring of lube or seal oil quality at critical rotating equipment [e.g., monitor for metal fragments, oil degradation, contaminants, etc.]?	
42. Is a program in place for routine testing of critical turbine over-speed trip devices?	
43. Is a program in place for routine testing and inspection of pressure relief devices? Is documentation maintained regarding the test plan and results for each relief device [i.e., last test date, results from last test, next test date, etc.]?	
44. Is a program in place for routine testing of flexible piping components (e.g., hoses, expansion joints, and tubing)?	
45. Is sufficient PPE available at all times [review the needs for normal operating, shutdown operation, and emergency response situations]?	
46. Is a cleaning and testing program in place to ensure PPE is fit for use? Are locations where clean and used PPE properly segregated and labeled?	
47. Is a program in place to periodically inspect and test cranes and equipment (i.e., lifting slings) used for lifts?	
48. Is a program in place to ensure routine testing and maintenance of critical steam traps?	
49. Is all equipment labeled and clearly identified (e.g., tag number, unit number, module number, etc.)?	
50. For equipment that must be maintained while the process unit is "on-line," is safe access and egress provided for maintenance personnel (e.g., access platforms, heat shielding for elevated air coolers, furnace draft fans and soot blowers, furnace stack sampling systems and analyzers, etc.)?	
51. For maintenance activities where bulky PPE is required, has emergency access and egress been evaluated?	
52. Have piping temporary repairs been removed as promptly as possible per AP-19.7?	
53. Is any team member aware of any temporary repairs to piping which do not show up on the SAP "XXTR" list?	
54. Do all bleed and drain valves in the potable water system (including safety showers and eyewashes) have approved backflow preventers installed?	

Subsystems: 9. Materials

What If	Remarks
1. Have carbon and alloy steel materials in sour water service been reviewed for hardness and their susceptibility to wet H2S cracking? [Note: NACE Standard MR-01-75 provides guidelines on material selection for sour services, including maximum hardness limits to prevent sour water cracking.]	
2. Have materials for piping and equipment in hydrogen service been selected or reviewed for adequate resistance to hydrogen attack in accordance with American Petroleum Institute (API) Publication 941 (i.e., reviewed using API Publication 941 "Nelson Curves")? [Note: Low molybdenum content carbon-moly alloy materials are susceptible to hydrogen attack.]	

Subsystems: 9. Materials

What If	Remarks
3. Have all carbon steel vessels, other major equipment, and piping, in amine or caustic service operating above ambient temperature, been stress-relieved? [Note: Typical operating temperatures where stress-relieving is required are: 100 °F for amine equipment, 120 °F for caustic equipment, and 140 °F for steel piping in amine or caustic service.] Have these equipment and piping services been inspected for amine or caustic stress-corrosion cracking?	
4. Is the heat tracing for carbon steel piping in amine or caustic service designed to prevent overheating and stress-corrosion cracking?	
5. Have equipment and piping in locations subject to cold weather (i.e., 20 °F or less) been reviewed per API RP-920 for resistance to cold temperature brittle fracture? Have storage tanks been similarly reviewed per API RP-650? Have critical equipment items (e.g., thick-walled vessels and piping) been assigned a Minimum Pressurization Temperature (MPT) or Minimum Design Metal Temperature (MDMT), and have these limits been incorporated into the operating and maintenance procedures?	
6. Has the possibility of auto-refrigeration been evaluated for LPG and other low boiling point liquid services [concern is for cold temperature brittle fracture], and the material selection of piping and relief devices specified accordingly?	
7. Are carbon steel air coolers and air cooler outlet piping in hydrotreater reactor effluent service designed for fluid velocities of 20 feet/second or less to prevent erosion/corrosion from ammonium sulfides?	
8. Has increased metal temperature in heat exchangers and downstream piping, due to heat exchanger fouling, been considered in material selection of the exchanger and piping? Has increased temperature of downstream piping and equipment, due to bypassing heat exchangers, been considered in material selection? Has increased temperature of downstream piping and equipment, due to loss of cooling in heat exchangers (e.g., loss of cooling water, loss of air cooler fans, etc.), been considered in material selection?	
9. Is the maximum fluid velocity of rich and lean MEA or DEA, and concentrated sulfuric acid, limited in carbon steel service? [Concern is for excessive corrosion/erosion due to high fluid velocities; MEA/DEA is typically limited to 6 feet/second, and concentrated sulfuric acid is typically limited to 3 feet/second.]	
10. Has all carbon steel or monel piping and equipment in HF acid service been stress-relieved after welding?	
11. Have high-pressure hydrotreater reactors and other heavy-wall vessels and piping constructed of 2-1/4 chrome material and operating between 700 °F and 1050 °F been reviewed for potential temper embrittlement failure? If such failure is possible, do the operating and maintenance procedures explain the design limitation of the material [e.g., do not fully pressure the system when the metal temperature is below the alloy's maximum possible ductile-to-brittle transition temperature range, such as 300 °F]?	
12. Has the material selection for auxiliary lube oil and seal oil systems considered the effects of ambient moisture intrusion, during normal and shutdown operation? [Concern is for corrosion due to water, with possible damage to mechanical seals, etc. due to corrosion products.]	
13. For heaters, furnaces or boilers, designed to burn fuel containing sulfur compounds, has the possibility of acid condensation during low temperature flue gas operation been evaluated? [Concern is for corrosion of heater ducts, stacks, fans, and waste heat recovery heat exchangers due to condensed combustion products.]	
14. Has chloride stress-corrosion cracking of austenitic stainless steel piping and equipment been evaluated? [Concern is for exposure to high chloride content water, e.g., brackish fire water, water-soaked insulation containing chlorides, coastal hurricane tides, etc.]	
15. Has ammonia stress-corrosion cracking of copper-based alloys been evaluated?	
16. Are special materials of construction identified on process flow diagrams (PFD), piping and instrument diagrams (P&IDs), operating procedures, or other PSI documentation? Is this information kept current via the MOC process?	
17. Do procedures specify hydro testing austenitic stainless steel equipment and piping systems with water containing less than 50 ppm chloride? [Concern is for chloride stress corrosion cracking.]	
18. Do procedures require that austenitic stainless steel equipment and piping in sour or H <sub>2</sub> S services (i.e., exposed to sulfides) be blanketed with dry inert gas when shut down, or flushed with soda ash, KOH, or ammonia neutralizing solution, before opening for inspection and maintenance? [Concern is for ambient moisture contacting sulfide scale on the surface of austenitic stainless steel, with the potential for	

Subsystems: 9. Materials

What If	Remarks
polythionic acid stress corrosion cracking of the stainless materials.]	
19. Do procedures specify thorough water flushing of carbon steel equipment and piping in amine or caustic service before steaming out to prevent amine or caustic stress-corrosion cracking?	
20. Do inspection procedures for 1 chrome and 1-1/4 chrome equipment and piping operating above 800 *F include monitoring for creep embrittlement cracking (i.e., hydrogen service, high-pressure steam, etc.)?	
21. Do warehouse procedures require testing of alloy materials for proper alloy content when received at the facility site (i.e., positive materials identification [PMI] program)? Are received materials accompanied by proper documentation (i.e., mill certificates, chemical test reports, ANSI or ASME specification, etc.)?	
22. Are materials segregated and clearly identified when stored, to reduce the possibility of incorrect material installation?	
23. Are materials stored such that they are protected from ambient conditions as necessary [i.e., austenitic stainless steel materials protected from chloride salts at seacoast locations, etc.]?	
24. Are there procedures to order, receive, document, and issue materials for ASME Code vessel or piping repairs or modifications? Do procedures specify ASME Code welder qualifications and testing?	
25. Do construction procedures specify that all equipment, piping, instruments, and structural steel are painted (or otherwise protected) to prevent external corrosion? Are the painted surfaces inspected and maintained [especially under insulation when process temperatures are below 180 - 200 °F]?	
26. Are a representative number of new and refurbished valves inspected for the proper valve packing material upon receipt from the vendor or contract shop?	

Subsystems: 10. Piping and Valves

What If	Remarks
1. Is the piping specification suitable for the fluid properties, including maximum contaminant concentration? Is the piping specification suitable for potential stress-corrosion cracking, hydrogen blistering, or other metallurgical concerns, as applicable?	
2. Are the piping system fabrication requirements [e.g., post weld heat treatment (PWHT), stress relieving, and nondestructive examination (NDE)] appropriate for the intended service [consider process upsets including contaminant carryover]?	
3. Is the piping design pressure greater than the maximum operating pressure [consider maximum pump or compressor discharge pressure]?	
4. Is the piping design temperature greater than the maximum operating temperature [consider loss of cooling, cooler bypassed, exothermic reaction, etc.]?	
5. Is the piping system adequately designed for thermal growth at maximum temperature [consider superheated steam, loss of cooling, cooler bypassed, steam-out, etc.]?	
6. For flashing liquids, is the piping specification suitable to prevent brittle fracture [consider large pressure drop situations such as venting or draining, etc.]?	
7. Is the piping system adequately guided and supported?	
8. Is the piping system adequately designed for cyclical conditions (e.g., pressure, temperature, and vibration)?	
9. Are valve installations that result in moment arm arrangements (multiple or heavy valves branching from the pipe) adequately designed (e.g., supported or reinforced, such as bridge welding) to prevent failure of welded connections due to vibration or mechanical impact?	

Subsystems: 10. Piping and Valves

What If	Remarks
10. Are piping dead legs eliminated?	
11. Is the piping system adequately designed to minimize the effects of internal corrosion or erosion [consider carryover or increased concentration of corrosive material due to process upset, accumulation of corrosive material in valve seats or drains, increased erosion or corrosion due to velocity, injection of chemicals such as anti-foulants]?	
12. Is the piping system adequately designed to minimize the effects of external corrosion [consider underground installations, insulation on cold piping, exposure to corrosive atmosphere such as salt water or cooling tower drift, upsets resulting in release of corrosive materials, etc.]?	
13. Is the piping system adequately designed for cold weather conditions? Where applicable, are freeze protection and/or heat tracing design adequate?	
14. Is the piping system adequately designed for hot weather conditions?	
15. Does the piping system allow for flushing and/or purging of lines and equipment for startup or shutdown?	
16. Are process piping connections to utility systems adequately designed and installed to prevent contamination of the utility system [review requirements for check valves, double block and bleeds, removable spools, flexible connections, and blinds]?	
17. Is the piping system adequately designed for thermal expansion of trapped process material? Is the discharge of the thermal relief device routed to a safe location?	
18. Do the repairs to the piping (materials and methods) comply with the applicable industry codes and company guidelines?	
19. Have cold weather conditions been evaluated [consider water freezing in low points or in dead-end lines, materials that increase in density, etc.]?	
20. Have hot weather conditions been evaluated [thermal overpressure of blocked-in lines or equipment, etc.]?	
21. Have plugged lines or valves been evaluated?	
22. Has rapid closing of automatic valves or check valves been evaluated [determine whether or not hydraulic hammer may occur if a valve closes suddenly; for example, check valve on the discharge of cooling water supply pump when pump shuts off]?	
23. Has a valve not opening [may be due to plugging, stem failure, or valve seizing] when demanded been evaluated?	
24. Has a bypass valve (either equipment or control valves) left open or leaking been evaluated?	
25. Is adequate firewater coverage available near the piping system (e.g., battery or plot limit manifolds and other valve manifolds)?	
26. Is there adequate access to the piping system in the event of fire or other emergency [consider battery or plot limit manifolds and other valve manifolds that contain hazardous materials]?	
27. If the piping system contains a large inventory of hazardous material (e.g., off-plot transfer or feed lines), can the piping system be isolated in an emergency?	
28. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
29. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
30. Has flange leak been evaluated [consider leaks that may result in flame impingement on nearby piping or equipment, hydrocarbon release resulting in fire, and chemical exposure to operators]?	

Subsystems: 10. Piping and Valves

What If	Remarks
31. Are the drains and vents located to minimize the potential for damage due to mechanical impact?	
32. Have flexible piping components (e.g., hoses, expansion joints, and tubing) been reduced or eliminated where possible? If flexible piping components are installed, are they designed for maximum operating pressure and temperature? Are flexible connections adequately protected against possible rupture due to mechanical impact and fire?	
33. Are battery or plot limit lines/valve labels easy to read (clear and in good condition)?	
34. Is the lighting adequate in the unit [consider local instrument panels, battery or plot limit valve manifold locations, equipment and valves requiring operation during emergency conditions, etc.]? Is the emergency lighting (light fixtures on the emergency power circuit) adequate in the unit?	
35. Are all operating valves accessible during normal or emergency operation?	
36. Are manually operated valves positioned to allow proper operation without muscle strain?	
37. Is access adequate at all valve manifolds (including battery or plot limit) for both routine and emergency operation and for maintenance? [Review requirements for changing battery or plot limit blinds.]	
38. Are elevated valves accessible during normal or emergency operation (i.e., access provided by ladders/platform or chain operator)?	
39. Are valve chain operators properly maintained?	
40. Can critical valves or equipment be closed or shut off from a safe location in a timely manner?	
41. Has equipment that must be operated in short time sequence (such as valve switching) been located to facilitate operator actions [i.e., minimum separation]?	
42. Have valve manifolds been arranged to reduce the likelihood of mis-manifolding? Has valve mis-manifolding been evaluated?	
43. Do procedures require that all drain and vent valves are either plugged, capped, or blinded?	
44. Do procedures specify which blinds are to be removed and which spectacle blinds are to be turned prior to or during startup?	
45. Do procedures require routine testing of emergency isolation valves [determine the need for on-line testing of safety shutdown systems]?	
46. Do procedures control the position of critical valves (e.g., locked or car sealed open valves beneath relief valves, equipment bypasses or isolation, and area containment drains)?	
47. Are piping systems inspected at an appropriate interval (depending upon service and history) to confirm fitness for continued service?	
48. Do procedures require new gaskets (and bolts if needed) to be installed when a flange closure is opened or broken? Do the procedures provide guidance on the proper gasket material for the process service?	
49. Do procedures require tightness testing of all flange bolts prior to startup [concern is for flanges that were opened during shutdown or flange bolts that may have loosened due to thermal expansion and contraction]? Do the procedures provide guidance to prevent over- or under-tightening flange bolts?	
50. Do procedures specify the proper settings for pipe spring hanger supports? Do the procedures require checking the pipe spring hanger settings prior to each startup and during normal operation?	
51. Are maintenance personnel trained in the use of piping specifications? Is a process in place to verify the latest piping specification is used?	
52. For piping modifications and repairs, do procedures require verification that the repair material to be installed meets the requirements of the piping specification?	

Subsystems: 10. Piping and Valves

What If	Remarks
53. Is a program in place for routine testing and inspection of pressure relief devices?	
54. Is the minimum pressurizing temperature (MPT) of the piping systems documented and available to operations and maintenance personnel?	
55. Are the critical check valves for this study identified as Priority "A" in SAP?	
56. Are there PM work orders and spare parts available for all critical check valves?	
57. Are the historical "problem" lines identified in the Corrosion Monitoring Program?	
58. Are the "problem" lines managed appropriately to avoid loss of containment?	
59. Is there any piping that is due or will be overdue for inspection, or past calculated retirement date, before the next inspection?	
60. Is there adequate data to justify continued operation of any piping that is past due on inspection or calculated retirement date?	
61. Is the CMP inspection plan appropriate for the fluid symbols/service in this study?	
62. Does the CMP address how to change the percent of inspection, frequency and method as equipment ages?	

Subsystems: 11. Pumps and Drives

What If	Remarks
1. Is the pump casing design pressure greater than the maximum pump suction pressure plus the pump shutoff pressure [consider largest impeller when determining maximum pump differential]?	
2. Is the downstream piping or equipment design pressure greater than the maximum pump discharge pressure [consider largest impeller when determining maximum pump differential], or is the downstream piping or equipment protected from overpressure in the event that the pump is blocked in?	
3. If a downstream blockage would raise the pump suction pressure, is the downstream piping and equipment rated for the maximum suction pressure plus the pump shutoff pressure?	
4. If a downstream blockage would not raise pump suction pressure, is the downstream piping and equipment rated for the greater of (1) normal suction pressure plus the pump shutoff pressure or (2) maximum suction pressure plus normal pump differential pressure?	
5. Has a discharge relief valve been provided for positive displacement pumps?	
6. Is the pump adequately protected from damage when operating at low flow rates [determine if minimum flow protection is required]?	
7. Is the pump design temperature greater than the maximum operating temperature?	
8. Is the pump material selection appropriate for the expected fluid properties, including maximum contaminant concentration?	
9. Is the selected mechanical seal or packing appropriate for the intended service, including maximum contaminant concentration?	
10. Has mechanical seal or packing failure been evaluated?	
11. Has failure of pump heat removal equipment (e.g., lube oil coolers, gland oil coolers, stuffing box coolers, seal flush coolers, and seal flush) been evaluated [consider loss of circulation or supply and plugging of coolers]?	
12. Are pump "run" indicators (running lights or other process indicators) provided at a continuously staffed location for critical service pumps?	
13. Has the pump stopping been evaluated?	

Subsystems: 11. Pumps and Drives

What If	Remarks
14. Has blocking in the pump been evaluated?	
15. Has loss of suction to the pump been evaluated?	
16. Has reverse flow through the pump, when it shuts down, been evaluated [assume the discharge check valve sticks open]?	
17. If the pump is provided with minimum flow protection, have failures of the minimum flow system been evaluated [consider minimum flow valve (control or manual) closed and wide open]?	
18. Has the pump stopping and the minimum flow recycle control valve open (trying to maintain minimum flow) been evaluated?	
19. For manual minimum flow recycle systems (manual valve or restriction orifice), has the pump stopping been evaluated?	
20. For parallel pump arrangements (one pump operating and an idle spare pump on standby), has leakage through the spare pump's discharge check valve been evaluated [concern is for over pressuring the spare pump suction valve and piping]?	
21. Has operation with higher specific gravity fluid, due to process upset or startup/shutdown, been evaluated [consider whether or not the pump driver is adequately sized for water if the pump will be required to transfer or circulate water during startup or shutdown]?	
22. Is adequate firewater coverage available for the pump area?	
23. Is there adequate emergency access to the pump?	
24. Can the pump be safely isolated in an emergency?	
25. If emergency isolation valves (either manual, automatic, or remotely operated) are provided to isolate the pump, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
26. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
27. For installations where critical service equipment (e.g., air-cooled heat exchangers or power/instrument cables) is located above a pump handling flammable material, is the critical equipment adequately protected in the event of fire at the pump [review requirements for fireproofing and installation of fixed water or fixed steam deluge]?	
28. If fixed water or fixed steam deluge is provided, can the valve or station that actuates the system be operated safely in the event of fire at or near the pump [consider location of valve/station or the ability to operate valve/station remotely]?	
29. Have flexible piping components (e.g., hoses, expansion joints, and tubing) been reduced or eliminated where possible? If flexible piping components are installed, are they designed for maximum operating pressure and temperature? Are flexible connections adequately protected against possible rupture due to mechanical impact and fire?	
30. Have leaks (at mechanical seal, flanges, etc.) to the atmosphere been evaluated for pumps located in buildings or shelters [concern is for buildup of explosive atmosphere with possible fire or explosion]?	
31. For pump installations using an engine driver (gas or diesel driven) are the air intake and exhaust lines vented to a safe location?	
32. Can critical service pumps be quickly shut down from a safe location?	
33. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are procedures in place for the routine testing of these valves?	
34. For critical service pumps, are preventative maintenance procedures in place to reduce the likelihood of equipment failures that could result in hydrocarbon or toxic material releases?	
35. For pump installations with auxiliary systems (e.g., lube oil, seal oil, vibration, etc.), are alarms and shutdowns routinely tested?	

Subsystems: 11. Pumps and Drives

What If	Remarks
36. Is impeller diameter, horsepower and speed listed for each pump in this study on the P&ID's?	
37. Is the horsepower and speed listed for each turbine?	

Subsystems: 12. Reactors

What If	Remarks
1. Is the reactor material selection appropriate for the fluid properties, including maximum contaminant concentration?	
2. Is the reactor designed to the appropriate industry, company, or local jurisdiction codes?	
3. Is the reactor material selection appropriate to minimize the potential for brittle fracture?	
4. Are the reactor fabrication requirements [e.g., post weld heat treatment (PWHT) and nondestructive examination (NDE)] appropriate for the intended service?	
5. Do repairs to the reactor (materials and methods) comply with the applicable vessel code?	
6. Is the reactor adequately protected from overpressure?	
7. Is the pressure relief valve that protects the reactor from overpressure sized for the most severe upset condition (e.g., loss of cooling, external fire, blocked-in condition, and blow-down or high-pressure surge from an upstream vessel, etc.)?	
8. If applicable, is the pressure relief valve sized for two-phase flow conditions?	
9. Is the reactor protected from vacuum conditions that may develop (e.g., cool down after steam out or liquid withdrawal)?	
10. Has blocking in the reactor been evaluated?	
11. Has loss of flow to the reactor been evaluated? Has loss of one or more reactants to the reactor been evaluated?	
12. Has adding reactants to the reactor in the wrong order been evaluated?	
13. Has delayed addition of one or more reactants been evaluated?	
14. Has adding too much of one or more reactants to the reactor been evaluated?	
15. Has increased feed temperature to the reactor been evaluated [consider increased feed or reactant preheat or loss of feed or reactant cooling]?	
16. For jacketed reactors, has jacket leak or failure been evaluated?	
17. For reactors with mixer or agitators, has failure of the mixer been evaluated [consider mixer off, mixer started late or early, mixer run too long or not long enough, mixer running too fast or too slow, mixer running in reverse]?	
18. Has contaminated (e.g., pipe scale, air, water, H2S, and other process materials) reactor feed been evaluated?	
19. Has loss of external cooling (including jacket water) or loss of quench to the reactor been evaluated?	
20. Has reactor catalyst bed plugging or channeling been evaluated?	
21. Has liquid carryover (e.g., hydrocarbon, water, and caustic) to the reactor been evaluated?	
22. If the reactor is blanketed or purged, has loss of purge or blanket gas been evaluated [consider loss of supply or purge valve closed]? Has too much purge or blanket gas been evaluated [consider increased supply pressure or purge valve wide open]? Has contaminated purge or blanket gas been evaluated?	

Subsystems: 12. Reactors

What If	Remarks
23. Has catalyst carryover to downstream equipment been evaluated?	
24. Is adequate firewater coverage available for the reactor area?	
25. Is there adequate emergency access to the reactor?	
26. Is the reactor support structure adequately fireproofed?	
27. Can the reactor be safely isolated and depressured in an emergency?	
28. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
29. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
30. If fixed water or fixed steam deluge is provided, can the valve or station that actuates the fixed deluge be operated safely in the event of a fire [consider location of valve/station or the ability to operate valve/station remotely]?	
31. Is the reactor tag number clearly labeled [also consider requirements for labeling equipment description]?	
32. Are reactor inlet and outlet lines and valves clearly labeled, including flow direction?	
33. Is the lighting adequate in the unit [consider valve manifold locations and valves requiring operation during emergency conditions, etc.]? Is the emergency lighting (light fixtures on the emergency power circuit) adequate in the unit?	
34. Are the field instruments that are monitored by operations personnel on a routine basis easily accessible to ensure information is read in accordance with recommended frequency [consider instruments or areas that are difficult to reach, such as climbing 40 feet of ladder or squeezing into close quarters]?	
35. Do reactor catalyst loading and unloading procedures address the hazards associated with catalyst handling [consider loading hose failure, wrong material loaded, contaminated material loaded, spills and leaks, exposure of personnel to fresh or spent catalyst, pyrophoric catalyst, disposal of spent catalyst]?	
36. Do procedures address the hazards associated with catalyst regeneration [concern for high temperatures, burning, uncontrolled or runaway reaction, isolation from parallel reactors]?	
37. Do reactor filling and draining procedures address the hazards associated with batch operation [concern for wrong material added, material added in wrong sequence, too much heat added, reacting or mixing too long, etc.]?	
38. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves routinely tested?	
39. Do procedures control the position of critical valves (e.g., locked or car sealed open valves beneath relief valves, equipment bypasses or isolation, and area containment drains)?	
40. Are reactors inspected at an appropriate interval (depending upon service and history) to confirm fitness for continued service?	
41. Is the reactor's minimum pressurizing temperature (MPT) documented and communicated to operations and maintenance personnel?	
42. Are reactor catalyst bed differential pressure limitations communicated to and monitored by operations personnel?	

Subsystems: 13. Relief Systems

What If	Remarks
1. If applicable, are relief systems, relieving devices, and flares designed in accordance with the latest versions of American Petroleum Institute (API) Recommended Practices (RP) 520 and 521? [Note: API RP-520 was revised in 1990, changing the relief valve sizing equations.]	
2. Has the relief system design capacity been verified, if necessary, for all unit modifications, expansions, and debottlenecking projects? Are relief system calculations current and available for review?	
3. If rupture disks are installed under relief valves, does the relief valve sizing consider flow restriction (i.e., derate) caused by the rupture disk?	
4. Have the relief valve inlet and outlet branch connections been properly reinforced to prevent vibration failure due to the relief valve opening [severe vibration may occur when relieving from a high pressure system, or in high- capacity relief valves]?	
5. Are the inlets and outlets of all relief valves free-draining to prevent trapping liquid? Are all relief headers free-draining to the relief collection or knock out (KO) drum?	
6. Are relief header block valves installed to prevent blockage in case of an internal valve component failure [e.g., are gate valves in relief headers installed with the stem in the horizontal plane to prevent dropping the gate if the valve stem fails by cracking or corrosion]?	
7. Are drains from flare stack molecular or other vapor-phase gas seals left open and designed to be free draining to prevent accumulation of liquids that could plug the seal and flare stack? Are the drain lines from vapor or liquid seals winterized to prevent freezing? Does the sizing of the drain line consider the possibility of plugging due to corrosion products?	
8. Is each ASME Pressure Vessel or Boiler Code vessel protected by a Code-approved relief device?	
9. Are the relief headers designed to accommodate the maximum piping expansion anticipated for the highest temperature relief condition?	
10. Are the relief headers provided with continuous fuel gas or natural gas purge to ensure that oxygen cannot accumulate or be drawn into the system? [Concern is for an explosive mixture forming in the relief system.]	
11. Is the relief system adequately designed to minimize the effects of internal corrosion or erosion [consider venting or relief of sulfur compounds, chloride or fluoride compounds, caustic, amine, etc., with the potential for corrosion, stress-corrosion cracking, and other materials problems]?	
12. If the relief system handles heavy oils (residuum, vacuum bottoms, etc.), are branches and headers designed to prevent plugging [e.g., heat tracing, heated "gut" line, flush oil, heating coils at the KO drum, etc.]?	
13. Have flexible piping components (e.g., expansion joints and bellows) been reduced or eliminated where possible? If flexible piping components are installed, are they designed for maximum relief pressure and temperature? Are flexible connections located to minimize damage and possible rupture due to mechanical impact or fire? Are flexible connections designed to minimize collection of liquids and corrosion products in the bellows or piping run?	
14. Is relief header sizing based on the maximum relieving capacity of each relief valve? [Selecting the next largest orifice size may significantly increase the relief valve capacity over the minimum required by the process, possibly impacting the relief system design capacity.]	
15. Has the possibility of auto-refrigeration been evaluated for LPG and other low boiling point liquid services [concern is for cold temperature brittle fracture], and the material selection of piping and relief devices specified accordingly?	
16. Have cold weather conditions been evaluated [consider water freezing in relief header low points or in dead-end lines, materials that increase in density, etc.]?	
17. Are flare combustion controls, including pilot burner flame front generators, provided with a reliable, uninterruptible source of electric power? [In a general power failure, the flare may be required to remain in operation to safely dispose of flammable materials.]	
18. Has rapid closing of relief valves been evaluated [determine whether or not hydraulic hammer may occur if a relief valve closes suddenly,	

Subsystems: 13. Relief Systems

What If	Remarks
for example, if a high-pressure liquid relief valve on the discharge of a pump slams shut after opening]?	
19. Has rapid closing of automatic valves or check valves been evaluated [determine whether or not hydraulic hammer may occur if a valve closes suddenly; for example, check valve on the discharge of cooling water supply pump when pump shuts off]?	
20. Has the need for redundant relief valves been evaluated [e.g., dirty or fouling services requiring frequent testing and inspection of relief valves, critical services where failure of relief valves to reseat may result in significant production loss, etc.]?	
21. Have credible worst-case releases of hazardous materials from extinguished flares, atmospheric process or tank vents, or from relief valves that exhaust to the atmosphere been evaluated [concern is for ground-level concentrations of toxic or flammable materials]?	
22. Has the maximum heat release from the flare during credible worst-case relief scenarios been evaluated with respect to ground-level personnel, nearby tankage and equipment, and traffic on adjacent roads? [Depending upon the location and height of the flare stack, concern is for significant flare tip heat releases that may endanger operating or maintenance personnel in the area, or that may cause overheating of flammable materials stored nearby. When maximum relief cases are redefined during the lifetime of the facility, the potential risk to nearby personnel and equipment should be evaluated based on the maximum heat that may be released from the flare stack.]	
23. Is there adequate emergency access to the flare stack and adjacent equipment in the event of fire [consider burning liquids from flare tip, igniting grass around base of stack]?	
24. Are relief system and flare alarms and instrument readings displayed at a continuously staffed location?	
25. Is lighting at the relief drum and flare stack control stations adequate?	
26. Are all flare and relief system operating valves and controls accessible during normal or emergency operation?	
27. Are relief system controls and instruments identified with permanent signs or tags?	
28. Are flare seal drain valves located to allow monitoring the filling and draining of the flare seal and ensure the safety of personnel [consider potential exposure to sour gas, sour water, LPG, benzene, etc.]?	
29. Is a program in place for routine testing and inspection of pressure relief devices? Is documentation maintained regarding the test plan and results for each relief device [i.e., last test date, results from last test, next test date, etc.]?	
30. Is a program in place for the routine replacement of rupture disks at the end of their useful lives, as recommended by the rupture disk manufacturer? Is documentation maintained regarding the replacement plan?	
31. Are procedures in place to document critical process safety information for each relief valve and rupture disk: sizing criteria (vapor, liquid, and mixed phase); maximum relieving material flow rate; fluid properties (molecular weight, density, viscosity, temperature, etc.); set pressure; equipment protected; design relief case (blocked discharge, fire, utility failure, etc.); flange size and rating (inlet and outlet); orifice size; and relief valve or rupture disk manufacturer and model number?	
32. Do procedures require that changes to relief valve set pressures are reviewed through the Management of Change process?	
33. Do procedures prevent unintentional closure of block valves upstream or downstream of relief valves [e.g., chain-locked or car-sealed open valves, operator checklists, three-way/non-closing valves, etc.]?	
34. Do procedures require all relief valve bypasses to be closed during startup?	
35. Do maintenance procedures specify proper rupture disk installation, including bolt tightening and disk orientation with respect to flow [flare buckle pin]?	
36. Do procedures prevent the accidental filling of relief headers with liquid if they are not designed to support the weight of a liquid-filled line?	
37. Do operating crews communicate unusual equipment status (bypassed or out of service) in writing (e.g., relief bypass valves that are open during normal operation)? Are operating crews provided with written temporary operating procedures when equipment is bypassed or out of service?	

Subsystems: 13. Relief Systems

What If	Remarks
38. Are the hazards associated with atmospheric relief valve, tank, or process vents documented and communicated to personnel whose duties take them into the vicinity of these vents [e.g., high noise levels from high-pressure boiler safety valves, toxic or flammable vapors from tank or process vents, etc.]?	
39. Does the PSV database include the system number, inlet and outlet sizes, whether inlet or outlet block valves exist, and whether there is a common discharge header?	
40. Is the PSV data on the P&ID's consistent with the master database?	
41. Have various relieving scenarios been considered, and is the design scenario appropriately documented in the individual PSV files?	
42. Are there known operational or maintenance problems with any of these PSV's?	
43. Are Nonconformance Reports being promptly initiated and completed?	
44. Are there reoccurring problems or NCR's with any PSV's?	
45. Did the NCR "action" address the problem?	
46. Does the PSV Isolation Log Sheet provide adequate documentation?	

Subsystems: 14. Utilities

What If	Remarks
1. Is there a design standard for safe connection (both permanent and temporary) of utilities to process streams, including safeguards to prevent backflow into the utility system, and proper isolation of the utility from the process when it is not in use?	
2. Are lower-pressure steam systems, which are supplied with steam by let-down stations from higher-pressure systems, provided with suitable over-pressure protection [i.e., is the pressure safety valve (PSV) on the lower pressure line sized for the let-down control valve in the full open position]?	
3. Have steam traps been designed for all credible operating scenarios [e.g., startup, extreme cold weather, upset conditions, etc.]? Have existing steam traps that frequently fail been evaluated for proper sizing or application?	
4. If utility system PSVs relieve to the atmosphere, is it possible for heat exchanger tube leaks (or other process leaks into the utility system) to create a hazard at the utility relief valve vent outlet (concern is for hydrocarbon or toxic material release to atmosphere, may want to consider routing PSV discharge to closed relief system or safe location)?	
5. Are all steam-generating heat exchangers designed and/or operated with routine manual or continuous blow-down to prevent sludge from accumulating in the shell [concern is for sludge buildup resulting in tube or tube sheet failure]?	
6. Have high-pressure steam system PSV installations been designed to adequately resist the thrust moment imposed on the piping when the PSV opens? Is the PSV vent pipe located to exhaust steam away from platforms and other occupied areas? Is the PSV vent pipe drained to remove accumulated rainwater, which could be heated by the exhaust and expose personnel when it falls? Has personnel exposure to the noise of an atmospheric relief been evaluated?	
7. Are all critical utility service indicators and alarms routed to a continuously staffed location?	
8. Are redundant main power lines or cables physically separated [i.e., separated to prevent a single incident, such as fire or mechanical impact, from causing the failure of redundant lines or cables]?	
9. Are utility instruments adequately heat traced and insulated or designed to prevent cold weather freezing and plugging?	
10. Is the utility piping system adequately designed for thermal growth considering the maximum possible temperature [e.g., superheated	

Subsystems: 14. Utilities

What If	Remarks
steam with maximum possible superheat, or steam made up from desuperheated high-pressure steam through a let-down station and the desuperheater fails closed]?	
11. For services where the utility piping specification changes to a lower design rating after a control valve, is the downstream piping specification suitable for upset situations with the control valve wide open?	
12. Are safety showers and eye wash stations and their water supplies protected from freezing in cold weather or from overheating the water due to sun radiation?	
13. Are data sheets and other process safety information (PSI) for critical utility equipment and piping current, complete, and accurate? Are they readily available to the operators? [Note: Include PSI for vendor-supplied equipment, such as chemical injection pumps, PSVs, etc.]	
14. Has loss of each pressure level of steam (e.g., low, medium, and high pressure) to the process or utility unit(s) been evaluated?	
15. Has loss of boiler feed-water to the process or utility unit(s) been evaluated?	
16. Has loss of cooling water to the process unit(s) been evaluated [determine whether or not the process unit(s) are designed fail-safe]?	
17. Has loss of the main fire water supply to the process or utility unit(s) been evaluated [determine whether or not there are alternative sources of water to fight fires--cooling tower basins, nearby waterways or ponds, etc.]?	
18. Has loss of normal plant power, including partial loss of power and total loss of power, to the process or utility unit(s) been evaluated? [Note: Include evaluation of power to emergency communications, emergency lighting, control room HVAC, flare pilot flame front generation panel, field solenoid trip valves, electronic governors for machinery, security gates, emergency block valve MOVs, etc.]	
19. Has loss of emergency power [from an emergency generator and/or uninterruptible power supply (UPS)] to the process or utility unit(s) been evaluated [determine whether or not the process or utility unit(s) are designed to be fail-safe; e.g., has the distributed control system (DCS) software been configured to open/close control valves or to leave them in their last positions if total power is lost to the DCS]?	
20. Has loss of instrument air to the process or utility unit(s) been evaluated [determine whether or not the process or utility unit(s) are designed to be fail-safe]?	
21. Has loss of plant or utility air to the process or utility unit(s) been evaluated?	
22. Has loss of natural gas or fuel gas to the process or utility unit(s) been evaluated?	
23. Has a momentary dip in the pressure of the fuel gas supply to fired heaters or boilers been evaluated [determine if loss of burner(s) flame may occur, followed by buildup of flammable mixture and possible explosion]?	
24. Has high fuel gas pressure been evaluated [may be caused by fuel gas pressure regulator failure]?	
25. Has contaminants (e.g., H2S, amine, caustic or solids) or the wrong concentration (e.g., low or high BTU-content components) in the fuel gas or fuel oil supply to the fired heaters or boilers been evaluated?	
26. Has liquid hydrocarbon carryover into the fuel gas supply to fired heaters or boilers been evaluated?	
27. Has loss of nitrogen to the process or utility unit(s) been evaluated?	
28. Has a leak in a process unit to a utility stream that returns to the Utilities Area been evaluated [e.g., cooling water exchanger tube leak to returned water, steam heater tube leak to condensate, etc.]?	
29. Has excess or loss of chemicals in the utility stream been evaluated, including evaluation to downstream process units [consider excess or loss of: chlorine or other biocide, water treating chemicals for boiler feed-water (BFW) and cooling water, oxygen scavengers and filming amines for steam, etc.]?	
30. If emergency isolation valves (either manual, automatic, or remotely operated) are provided to isolate utility supply headers, are these valves appropriate for the service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation	

Subsystems: 14. Utilities

What If	Remarks
valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
31. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
32. Has an accidental release of hazardous materials that could result in a hazardous airborne cloud been evaluated [e.g., chlorine, ammonia, hydrogen sulfide, etc.]?	
33. Are chemical injection facilities that could be hazardous to personnel or the environment identified (by signs, color coding, pavement striping, etc.)? Are chemical spills prevented from entering the storm water or oily water drain systems? Has the need for safety showers and eyewash stations to be situated nearby been evaluated?	
34. Has the need for alarming the activation of safety showers and eye wash stations been considered [i.e., are facilities remote from frequented areas, potentially preventing awareness of an incident and delaying assistance to personnel who activate emergency stations]?	
35. For process units handling flammable materials, are critical utilities (such as power and instrument cables, cooling water, instrument air, etc.) adequately protected in the event of fire? Are they routed away from likely sources of leaks and fires (such as fired heaters and pump rows), adequately fireproofed, or located in a non-hazardous area?	
36. Are utility header valves and associated instrumentation accessible for maintenance?	
37. Are the Utilities Area control building air conditioning and pressurization adequate to protect the electronic instrumentation? Are they adequate to prevent intrusion of toxics, flammables, or corrosive contaminants (if applicable)?	
38. Has control building utility supply failure (including HVAC failure), coincidental with a release of hazardous materials in the process unit or from a nearby process unit, been evaluated?	
39. Can critical utility valves or equipment be closed or shut off from a safe location?	
40. Is the lighting adequate in the unit [consider local instrument panels, battery or plot limit valve manifold locations, equipment and valves requiring operation during emergency conditions, etc.]? Is the emergency lighting (light fixtures on the emergency power circuit) adequate in the unit?	
41. Are utility lines and valves clearly labeled, including flow direction?	
42. Are the utility field instruments that are routinely monitored by operations personnel easily accessible to ensure information is read in accordance with recommended frequency [consider instruments or areas that are difficult to reach, such as climbing 40 feet of ladder or squeezing into close quarters]?	
43. Are the engineering units of similar instruments consistent [e.g., do the steam and boiler feed-water meters all display flow in gpm or lbs/hr, and the fuel gas and nitrogen meters in SCFH or SCFD]?	
44. Are field instrument indicators routinely checked for accuracy?	
45. Are field instrument ranges appropriate for the service [e.g., avoid using a 0-500 psig pressure gage on a 50 psig steam system]?	
46. Are the communications facilities between the Utilities Area and other process units adequate for clear and uninterrupted communications during both normal and emergency situations [e.g., telephone land lines, radio, computer network, and E-mail, and are systems redundant and/or secure]?	
47. Is the control room lighting adequate [review direct and indirect lighting]? Is the control room emergency lighting (light fixtures on the emergency power circuit) adequate?	
48. Do procedures prohibit connection of drinking or potable water supply lines to any process or other utility system, even temporary connections during shutdowns and maintenance work? [Note: Drinking water should only connect to sinks, drinking fountains, sanitary facilities, safety showers, and eye wash stations.]	

Subsystems: 14. Utilities

What If	Remarks
49. Do procedures control connection of firewater to process systems or to other utility systems [e.g., to provide water for hydro testing piping and equipment systems]?	
50. Do procedures prohibit connecting air tools to any other utility except to a compressed air system? [Note: Use of nitrogen for air tools in a confined space, for example, may expose personnel to nitrogen asphyxiation.]	
51. Do procedures prohibit use of hose connections on process systems [e.g., air hose connection on fuel gas system]?	
52. Do procedures specify that all blinds and drop-out spools in utility connections to process equipment are turned to their "safe" position before introduction of hazardous materials at startup of a process or utility unit [e.g., pre-startup checklist, etc.]?	
53. Do emergency procedures include loss of steam?	
54. Do emergency procedures include loss of normal electric power?	
55. Do emergency procedures include loss of cooling water?	
56. Do emergency procedures include loss of instrument air?	
57. Do emergency procedures include loss of natural gas or fuel gas?	
58. Do emergency procedures include loss of boiler feed-water?	
59. Do procedures specify response to potential process control system failures [consider loss of input or output signal(s), loss of display screens (loss of view), loss of memory devices, loss of equipment or system interfaces (gateways), loss of power, loss of backup power, loss of control program, etc.]?	
60. Is there a procedure or program to place winterization measures in service before cold weather arrives [e.g., steam traps and tracing, electric tracing, insulation, etc.]?	
61. Are steam traps routinely inspected and repaired or replaced? [Note: Concern is for flooding equipment or tracers, leading to loss of heating, with potential for freezing, rupture, and loss of containment.]	
62. Do procedures prevent the use of utility hoses for temporary process piping?	
63. Is there a procedure for routine inspection of utility hoses?	

Subsystems: 15. Pressure Vessels

What If	Remarks
1. Is the pressure vessel material appropriate for the fluid properties, including maximum contaminant concentration [determine predicted corrosion rate]? Does the pressure vessel material selection consider the potential for brittle fracture?	
2. Is the pressure vessel designed to the applicable industry, company, and local jurisdiction codes, regulations, and practices?	
3. Are the pressure vessel fabrication requirements [e.g., post weld heat treatment (PWHT) and nondestructive examination (NDE)] appropriate for the intended service?	
4. Do the repairs or modifications (materials and methods) comply with the applicable vessel code or practice?	
5. Is the pressure vessel adequately protected from overpressure?	
6. Is the pressure relief valve that protects the pressure vessel from overpressure sized for the most severe upset condition [e.g., loss of cooling, external fire, blocked-in condition and blow-down or high-pressure surge from upstream vessel]?	

Subsystems: 15. Pressure Vessels

What If	Remarks
7. Is the pressure vessel protected from vacuum conditions that may develop [e.g., cool down after steam out or liquid withdrawal]?	
8. Has the vessel been designed and installed to allow depressurization, draining, and isolation prior to maintenance work?	
9. Is the pressure vessel support structure adequately fireproofed?	
10. Has blocking in the pressure vessel been evaluated?	
11. Has loss of level in the pressure vessel been evaluated [may be due to loss of feed into the vessel or bottom outlet valve wide open]?	
12. Has liquid carryover (e.g., hydrocarbon, water, and caustic) to the pressure vessel been evaluated? Has liquid carryover from the pressure vessel been evaluated?	
13. If the pressure vessel is routinely (either continuously or periodically) drained (e.g., hydrocarbon, water, and caustic), has the drain valve closed been evaluated? Has the drain valve left open or leaking been evaluated? Has process material to the drain system been evaluated (e.g., hydrocarbon to the sour water system)?	
14. If the pressure vessel is provided with a vent valve, have the consequences of the vent valve closed been evaluated? Has the vent valve wide open or leaking been evaluated?	
15. If the pressure vessel is blanketed or purged, has loss of purge or blanket gas been evaluated [consider loss of supply or purge valve closed]? Has too much purge or blanket gas been evaluated [consider increased supply pressure or purge valve wide open]? Has contaminated purge or blanket gas been evaluated?	
16. For pressure vessels and associated piping that are subject to cold weather conditions, has freezing process materials, including water, been evaluated?	
17. Is adequate firewater coverage available for the pressure vessel area?	
18. Is there adequate emergency access to the pressure vessel?	
19. Can the pressure vessel be safely isolated in an emergency?	
20. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves appropriate for the process service and valve location [review requirements for fire-rating of isolation valves; fail-safe position of isolation valves; and fireproofing of valve actuator, power cables, and instrument cables of the isolation valves]?	
21. If emergency isolation valves are provided, has failure of the isolation valves been evaluated [consider valves closing and valves failing to close when demanded]?	
22. If fixed water or fixed steam deluge is provided, can the valve or station that actuates the fixed deluge be operated safely in the event of a fire [consider location of valve/station or the ability to operate valve/station remotely]?	
23. Is the vessel tag number clearly labeled [also consider requirements for labeling equipment description]?	
24. Are vessel inlet and outlet lines and valves clearly labeled, including flow direction?	
25. Is the lighting adequate in the unit [consider valve manifold locations and valves requiring operation during emergency conditions, etc.]? Is the emergency lighting (light fixtures on the emergency power circuit) adequate in the unit?	
26. Are the field instruments that are monitored by operations personnel on a routine basis easily accessible to ensure information is read in accordance with recommended frequency [consider instruments or areas that are difficult to reach, such as climbing 40 feet of ladder or squeezing into close quarters]?	
27. Are all operating valves accessible during normal or emergency operation?	
28. Are manually operated valves positioned to allow proper operation without muscle strain?	

Subsystems: 15. Pressure Vessels

What If	Remarks
29. Are drain valves located to allow personnel to monitor levels while draining?	
30. Do pressure vessel loading and unloading procedures address the hazards associated with loading and unloading [consider loading hose failure, wrong material loaded, contaminated material loaded, spills and leaks, overpressure supply truck or rail car if using pressurizing gas to unload, movement of supply truck or rail car, static electricity, grounding, etc.]?	
31. Do procedures require that all drain and vent valves are either plugged, capped, or blinded?	
32. If emergency isolation valves (either manual, automatic, or remotely operated) are provided, are these valves routinely tested?	
33. Do procedures require routine testing of critical alarms and safety shutdown systems (e.g., vessel level alarms and level shutdown interlocks), including primary elements or sensors, shutdown system control and logic, and final elements such as emergency isolation valves or equipment shutdown interlocks [determine the need for on-line testing of safety shutdown systems]?	
34. Do procedures control the position of critical valves (e.g., locked or car sealed open valves beneath relief valves, equipment bypasses or isolation, and area containment drains)?	
35. Are pressure vessels inspected at an appropriate interval (depending upon service and history) to confirm fitness for continued service?	
36. For vessels that contain liquids that when flashed could result in low temperatures (e.g., LPG such as propane), do procedures specify the proper method to drain water from the vessel [two drain valves should be provided; throttle with the downstream drain valve to allow use of the upstream drain valve for isolation]? Do procedures specify water removal (water draw) frequency?	
37. Is the pressure vessel's minimum pressurizing temperature (MPT) documented and available to operations and maintenance personnel?	
38. Have pressure vessel nonconformance Reports been promptly filed, addressed, and closed?	
39. Do the NCR's address root causes satisfactorily?	
40. Are the historical "problem" vessels identified in the Corrosion Monitoring Program?	
41. Are the "problem" vessels managed appropriately to avoid loss of containment?	
42. Are there any vessels that are due, or will be overdue inspections, or past calculated retirement date, before the next inspection?	
43. Is there adequate data to justify continued operation of any equipment that is past due on inspection or calculated retirement date?	

Subsystems: 16. Plant Layout/Siting

What If	Remarks
1. Do plant setbacks and equipment spacing comply with company, industry, or insurance requirements?	
2. Can equipment be accessed for maintenance without the need for conducting heavy crane lifts over pipe ways or other in-service equipment?	
3. Is the secondary containment or drainage for storage vessels containing incompatible materials segregated to prevent adverse reactions if spills occur?	
4. Is the unit sufficiently isolated from adjacent unit(s) (e.g., by berms, drainage channels, etc.) to minimize impact if a loss of containment occurs in the adjacent unit?	
5. Have site-specific hazards such as earthquake, hurricane, lightning, and flood been evaluated?	
6. Are horizontal LPG storage vessels oriented with their ends directed away from occupied buildings and critical equipment?	

Subsystems: 16. Plant Layout/Siting

What If	Remarks
7. Is rotating machinery (i.e., pumps and compressors) located such that a seal fire will have minimal impact on adjacent or overhead equipment?	
8. Is equipment that is located adjacent to roads or other access ways adequately protected from damage due to vehicle impact?	
9. Are the egress routes (number and path) adequate to safely evacuate the unit in the event of emergency? Has the potential for simultaneously blocking all egress routes been evaluated (e.g., train crossing, main access road closed due to maintenance, etc.)?	
10. Is emergency vehicle access to the unit adequate?	
11. Is motor vehicle access to the unit adequately controlled [review installation of signs and road barriers]?	
12. Is site security sufficient to prevent unauthorized access to the unit?	
13. If applicable, are tall structures equipped with aircraft warning lights?	
14. Are electrical power supply lines for the unit routed to minimize the potential for power loss to the unit due to a fire at other units?	
15. Are redundant instrument or power cables adequately separated to prevent a single incident (e.g., fire, supporting pole failure, etc.) from resulting in failure of both cables (i.e., common cause failures)?	
16. Has all buried equipment (e.g., process lines, fire water lines, electrical conduit, and sewers) been identified on drawings and by aboveground markers as appropriate?	
17. Are atmospheric vents for flammable or toxic material routed to a safe location (i.e., away from personnel and ignition sources)?	
18. Does all equipment and instrumentation comply with the electrical area classification?	
19. Has equipment that is routinely operated been placed for ready access by the average size operator?	
20. Has equipment that must be operated in short time sequence (such as valve switching) been located to facilitate operator actions [i.e., minimum separation]?	
21. Is plant surface drainage sufficient to handle maximum expected runoff, including fire water runoff?	
22. Have the possible explosion, fire, and toxic material impacts to nearby occupied or critical buildings been evaluated?	

Subsystems: 17. Insulation

What If	Remarks
1. Is damaged insulation on piping, vessels, and tanks promptly written up for repairs?	
2. Are repairs to damaged insulation promptly completed to avoid external chloride cracking or internal condensation corrosion?	
3. Has asbestos insulation been removed without use of proper controls since the last revalidation?	

Subsystems: 18. IH/Environmental/Environmental/Secondary Containment

What If	Remarks
1. Are there any exposure issues with asbestos, lead, arsenic, or other chemicals?	
2. Are there any recurring spills or releases that should be addressed with additional controls?	

Subsystems: 18. IH/Environmental/Environmental/Secondary Containment

What If	Remarks
3. For the main air, water, and waste emission sources, are procedures in place to assure that continuous emissions are within acceptable limits?	
4. Are there any continuous emissions sources that should be addressed with additional controls?	
5. Were the environmental incidents since the last revalidation properly addressed?	
6. Are open environmental recommendations being addressed in a timely manner?	
7. Is the secondary containment program adequate for equipment included in the study?	
8. Is the secondary containment program being used appropriately with problems being addressed promptly?	
9. Are there any other concerns?	

Subsystems: 19. Operations Documents

What If	Remarks
1. Are listed limits, from the SOCL's for pressure and temperature, consistent with equipment design conditions?	
2. For the pressure and temperature SOCL's, is the team aware of any consequences or corrective actions listed inappropriately?	
3. Were the blind drawings reviewed and updated, if necessary, before their use at the last outage?	
4. Are shut-off locations for fuel gas accessible during an emergency, and documented in SOP's?	
5. Are there any low-rate issues?	

Subsystems: 20. Management of Change

What If	Remarks
1. Are team members aware of any changes that are not shown on the P&ID's?	
2. Are changes from closed MOCs shown on the P&ID's?	
3. Are there instances of start-up before the PSSR is approved for start-up and signed off?	
4. Are there open M1 and MOC's (from SAP) that are no longer needed or desired?	
5. From a cursory look at the task list, are there open PSSR assignments that should be complete and signed off?	
6. Have P&ID changes that do not reference an MOC number been evaluated for adequacy?	
7. Is PSSR closeout being completed within 6 months of startup per AP-14?	
8. Have environmental issues, such as permitting, been adequately addressed?	
9. Are there any open PHA recommendations from closed MOCs?	

Subsystems: 21. PHA Recommendations

What If	Remarks
1. Are open recommendations this PHA or revalidation still valid?	
2. Are there adequate interim safeguards for open recommendations?	
3. Are open recommendations being addressed promptly?	
4. Are there any known problems with closed recommendations?	
5. Have recommendations from previous studies been reconciled against Incidenter to avoid missing any?	