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Question: 1

A field operator contacted the control room about a leaking connection on a heat exchanger. The control room operator instructed the field operator to bypass the heat exchanger. However, unknown to the control room operator, additional piping had recently been installed upstream of the heat exchanger, and had not been recorded on the P&ID. When the field operator incorrectly opened a valve in the new piping, the process stream was routed to an unintended location.
Which of the following groups of Risk Based Process Safety elements, if properly implemented, could have prevented this incident?

A. Process Knowledge Management – Safe Work Practices – Management of Change
B. Management of Change – Conduct of Operations – Emergency Management
C. Process Knowledge Management – Management of Change – Training and Performance Assurance
D. Asset Integrity – Training and Performance Assurance – Management of Change

Answer: C

Explanation:
The best answer is C because the scenario shows three clear failures that align directly with these RBPS elements. First, the new upstream piping was not recorded on the P&ID, which is a failure of Process Knowledge Management (PKM). CCPS identifies PKM as the element for developing, documenting, and maintaining accurate process safety information such as drawings and system knowledge. Second, the piping had been recently installed, so the change should have been formally reviewed, approved, documented, and communicated through Management of Change (MOC). CCPS describes MOC as the system for recognizing changes, evaluating their hazards, authorizing them, and ensuring follow-up actions are completed. Third, the field operator incorrectly opened a valve, which points to inadequate Training and Performance Assurance —operators must be trained and shown capable of performing tasks correctly, especially when systems have changed.
The other options are weaker because Emergency Management is mainly for response, not prevention; Asset Integrity concerns equipment fitness and reliability, not undocumented configuration changes; and Safe Work Practices, while important, do not address the central failure as directly as PKM, MOC, and Training.

Question: 2

Austenitic stainless steels are typically susceptible to which of the following corrosion mechanisms specifically attributed to chloride exposure? (Select all that apply)

A. Stress corrosion cracking
B. Galvanic corrosion
C. Pitting corrosion
D. Uniform corrosion

Answer: A,C

Explanation:
The correct answers are A (Stress Corrosion Cracking) and C (Pitting Corrosion) because both are well-known chloride-induced damage mechanisms affecting austenitic stainless steels, as emphasized in CCPS Mechanical Integrity guidance. Chloride ions are particularly aggressive toward the passive oxide layer that protects stainless steel. When this protective film is locally broken down, pitting corrosion occurs, leading to highly localized attack that can penetrate deeply while leaving most of the surface intact. This makes detection difficult and increases the likelihood of sudden failure.
Additionally, chloride stress corrosion cracking (SCC) occurs when tensile stress (residual or applied), a susceptible material (such as austenitic stainless steel), and a corrosive chloride environment are present simultaneously. This mechanism can lead to brittle, catastrophic cracking with little prior warning, which is why CCPS highlights it as a critical degradation mechanism in process equipment.
Galvanic corrosion (B) requires two dissimilar metals electrically connected in an electrolyte and is not specifically caused by chloride exposure alone. Uniform corrosion (D) is a general material loss across the surface and is not the primary concern for stainless steels in chloride environments, where localized attack dominates.
Proper Mechanical Integrity programs per CCPS require identification of such damage mechanisms, material selection, inspection strategies, and monitoring to prevent unexpected failures.

Question: 3

A facility's process safety staff does consequence modeling for releases of various toxic substances that the facility handles. Which elements of Risk Based Process Safety would be most likely to use the results of this modeling? (Select all that apply)

A. Operational Readiness
B. Measurement and Metrics
C. Stakeholder Outreach
D. Hazard Identification and Risk Analysis
E. Emergency Management

Answer: C,D,E

Explanation:
The correct answers are C (Stakeholder Outreach), D (Hazard Identification and Risk Analysis), and E (Emergency Management) because consequence modeling is fundamentally used to understand the potential impact of hazardous material releases and to support risk-informed decision-making across these RBPS elements. Within Hazard Identification and Risk Analysis (HIRA), consequence modeling is a core analytical tool used in studies such as HAZOP, LOPA, and quantitative risk assessments (QRA). It helps estimate the severity of potential release scenarios, including toxic dispersion, which directly supports risk evaluation and safeguards selection.
For Emergency Management, modeling results are essential to plan effective response strategies. They define hazard zones, evacuation distances, shelter-in-place decisions, and emergency resource

allocation. CCPS emphasizes that credible worst-case and alternative release scenarios should guide emergency preparedness planning.
In Stakeholder Outreach, consequence modeling provides critical information for communicating risks to external parties such as local communities, regulators, and emergency responders. This aligns with CCPS guidance on transparency and community awareness, ensuring stakeholders understand potential offsite consequences.
Operational Readiness (A) focuses on startup and system preparedness, not consequence modeling outputs. Measurement and Metrics (B) deals with performance indicators rather than predictive hazard analysis. Therefore, they are less directly connected to the use of consequence modeling results.

Question: 4

Which of the following can be considered applicable inspection methods as part of an Inspection/Testing/Preventive Maintenance program under the Asset Integrity and Reliability Element? (Select all that apply)

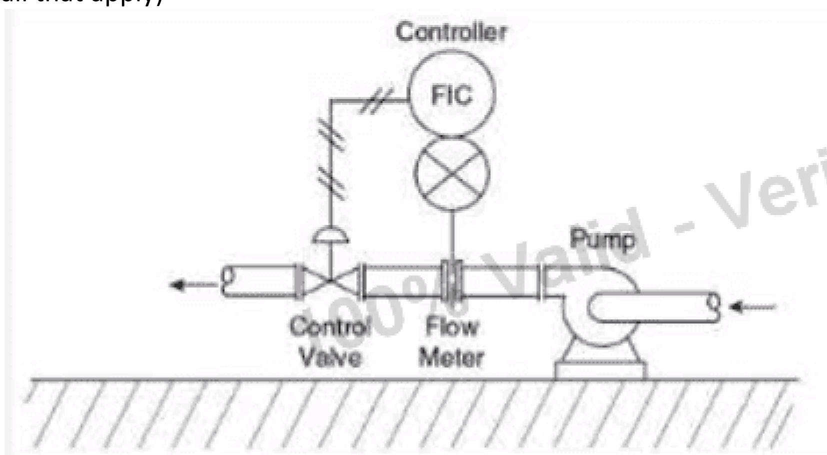
A. Ultrasonic Thickness Measurements
B. Work Orders
C. Ultrasonic Leak Detection
D. Positive Material Identification

Answer: A,C,D

Explanation:
The correct answers are A (Ultrasonic Thickness Measurements), C (Ultrasonic Leak Detection), and D (Positive Material Identification) because these are recognized inspection and testing techniques within CCPS's Asset Integrity and Reliability element of RBPS. This element ensures that critical equipment is designed, fabricated, installed, and maintained to perform reliably throughout its lifecycle.
Ultrasonic Thickness Measurement (UT) is a widely used non-destructive examination (NDE) method to monitor wall loss due to corrosion or erosion. It provides quantitative data that supports fitness-for-service evaluations and remaining life assessments.
Ultrasonic Leak Detection is another diagnostic tool used to identify leaks in pressurized systems, valves, and fittings. It supports early detection of loss of containment, which is critical for preventing process safety incidents.
Positive Material Identification (PMI) verifies that the correct alloy materials are installed, helping prevent failures due to incorrect material selection—especially important in environments prone to corrosion, high temperature, or hydrogen damage.
Work Orders (B), while essential for maintenance management, are administrative controls rather than inspection or testing methods. CCPS distinguishes between execution systems (like work orders) and actual inspection techniques used to assess equipment condition.
These inspection methods collectively support proactive identification of degradation mechanisms and ensure equipment integrity is maintained.

Question: 5

Which of the following statements are correct regarding the flow control loop in the illustration? (Select all that apply)



A. The component failure probabilities are multiplied together to determine the overall failure probability for the control loop.
B. The component reliabilities are multiplied together to determine the overall reliability for the control loop.
C. The overall failure of the control loop requires failure of all of the components.
D. The overall failure of the control loop requires failure of only one of the components.

Answer: B,D

Explanation:
The correct answers are B and D because a typical flow control loop (including flow meter, controller, control valve, and associated instrumentation) behaves as a series system from a reliability perspective, as described in CCPS risk analysis and Layer of Protection Analysis (LOPA) principles.
In a series system, the system fails if any single component fails, which supports answer D. For example, if the flow transmitter gives incorrect readings, or the control valve fails to actuate, the loop can no longer maintain proper control. This aligns with CCPS guidance that basic process control systems (BPCS) are generally not highly reliable independent protection layers due to multiple potential failure points.
For such systems, the overall reliability is calculated by multiplying the reliabilities of individual components, which supports answer B. Each component must function correctly for the system to succeed.
Option A is incorrect because failure probabilities are not simply multiplied in this context; instead, reliability (success probability) is multiplied, and failure probability is derived from the complement.
Option C is incorrect because it describes a parallel system, where all components must fail for system failure—this is not applicable to a standard control loop.
This concept is critical in CCPS hazard analysis and LOPA when evaluating safeguard effectiveness and independence.

Question: 6

Which of the following is generally a disadvantage of a rupture disc vs a relief valve?

A. Reduced fugitive emissions – no simmering or leakage prior to bursting
B. Protect against rapid pressure rise caused by heat exchanger tube ruptures or internal deflagrations
C. Is relatively more susceptible to damage during installation
D. Less expensive way to achieve corrosion resistance

Answer: C

Explanation:
The correct answer is C because rupture discs are generally more fragile and susceptible to damage during installation and handling compared to relief valves, which is a recognized disadvantage in CCPS guidance on pressure relief systems within Mechanical Integrity.
Rupture discs are thin membranes designed to burst at a specific pressure. Because of their delicate construction, improper installation (e.g., incorrect torque, misalignment, or physical handling damage) can alter their burst pressure or cause premature failure. This sensitivity requires strict installation procedures, trained personnel, and careful inspection practices.
Option A is actually an advantage of rupture discs. They provide tight sealing with zero leakage, preventing fugitive emissions and eliminating simmering that can occur in relief valves.
Option B is also an advantage. Rupture discs respond very rapidly to sudden pressure spikes, making them suitable for scenarios like deflagrations or tube ruptures.
Option D is generally considered an advantage as well, since rupture discs can be made from corrosion-resistant materials or coated, often at lower cost than equivalent corrosion-resistant relief valves.
CCPS emphasizes selecting pressure relief devices based on service conditions, reliability, response characteristics, and maintenance considerations, including installation sensitivity.

Question: 7

Which of the following are Hazard Identification and Risk Analysis methods? (Select all that apply)

A. Root Cause Analysis
B. Layer of Protection Analysis
C. Bow-Tie Analysis
D. What-If
E. Fish Bone Analysis
F. FMEA

Answer: B,C,D,F

Explanation:
The correct answers are B (Layer of Protection Analysis), C (Bow-Tie Analysis), D (What-If), and F (FMEA) because these are recognized Hazard Identification and Risk Analysis (HIRA) methodologies within CCPS Risk-Based Process Safety.
What-If analysis is a qualitative method used to systematically evaluate deviations from intended operation by asking structured “what if” questions. FMEA (Failure Modes and Effects Analysis) is a structured technique that identifies potential failure modes, their causes, and consequences, often used during design and early lifecycle stages.

Layer of Protection Analysis (LOPA) is a semi-quantitative method that evaluates risk by analyzing initiating events and independent protection layers, determining whether risk reduction is sufficient. Bow-Tie analysis visually integrates fault trees (causes) and event trees (consequences), helping to identify preventive and mitigative barriers.
Root Cause Analysis (A) and Fishbone Analysis (E) are not HIRA methods; instead, they are incident investigation tools used after an event to determine underlying causes. CCPS clearly distinguishes between proactive hazard analysis (HIRA) and reactive learning methods (incident investigation and root cause analysis).
These HIRA tools are essential for identifying hazards, evaluating risks, and ensuring appropriate safeguards are in place to prevent major process safety incidents.

Question: 8

A strong Management of Change system should ensure that: (select all that apply)

A. Emergency changes do not require Management of Change controls
B. Root causes are identified
C. Adequate evaluations of the potential safety and health impacts are performed
D. Appropriate updates have been made to the preventive maintenance requirements
E. Temporary changes are returned to normal by the required date

Answer: B,C,D,E

Explanation:
The correct answers are B, C, D, and E because these align directly with CCPS expectations for a robust Management of Change (MOC) system under Risk-Based Process Safety.
C (adequate safety and health evaluations) is fundamental to MOC. CCPS requires that all changes—whether in equipment, procedures, chemicals, or organization—be reviewed for potential process safety impacts before implementation.
D (updates to preventive maintenance requirements) is also essential. Changes can affect equipment reliability and degradation mechanisms, so inspection, testing, and maintenance programs must be updated accordingly to maintain asset integrity.
E (management of temporary changes) is a key CCPS requirement. Temporary changes must be tracked, reviewed, and either made permanent through full MOC or reverted by a defined expiration date to prevent them from becoming uncontrolled permanent conditions.
B (root causes identified) is indirectly relevant, as changes often arise from incident learnings, and MOC should incorporate lessons learned to prevent recurrence.
Option A is incorrect because emergency changes still require MOC controls, though they may follow an expedited process. CCPS clearly states that all changes must be managed to ensure risks are properly evaluated and controlled.

Question: 9

Which of the following statements apply to the purpose of an incident investigation? (Select all that apply)

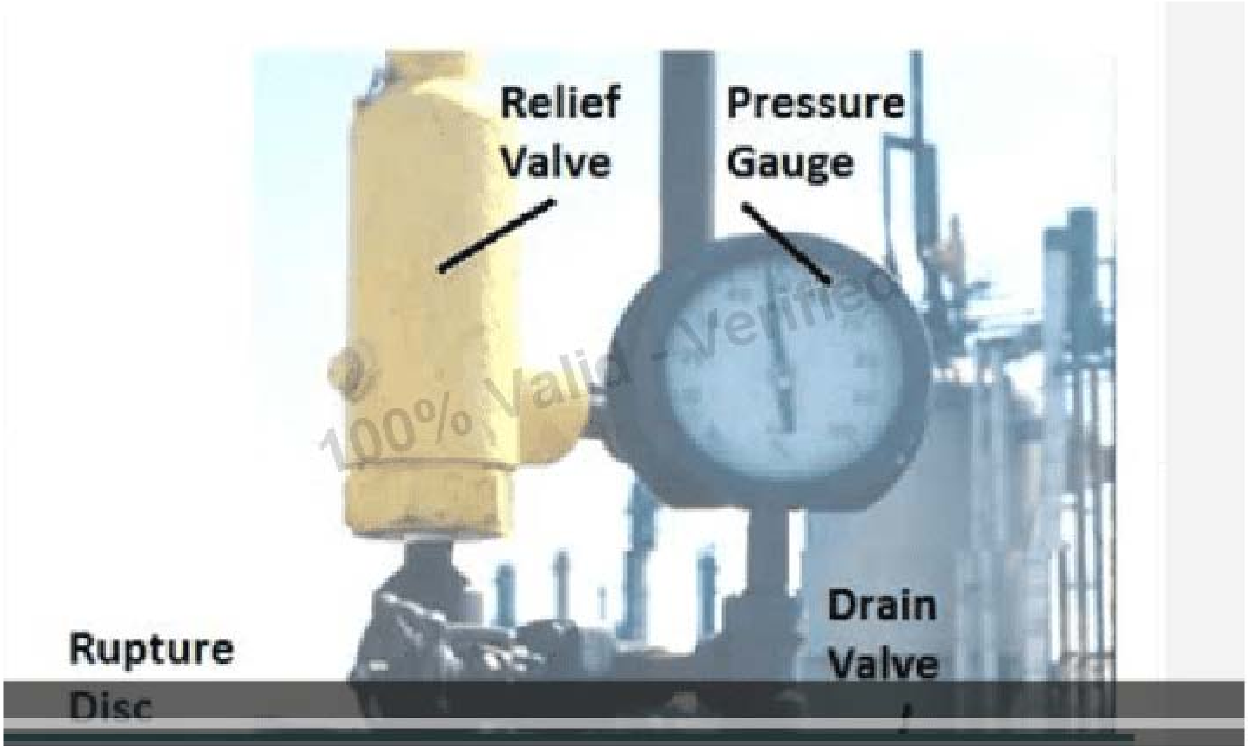
A. To help continually improve the process safety management efforts
B. To determine who should be disciplined for causing the event
C. To prevent reoccurrence of the same or similar process safety incidents
D. To document all injuries as process safety incidents

Answer: A,C

Explanation:
The correct answers are A and C because CCPS defines the primary purpose of incident investigation as learning and prevention, not blame or administrative classification. A (continuous improvement) is a core objective. CCPS emphasizes that incident investigations should identify system weaknesses, gaps in safeguards, and management system deficiencies.
The findings are used to strengthen process safety programs, improve procedures, enhance training, and refine risk controls.
C (prevent recurrence) is the fundamental goal. Investigations focus on identifying root causes and contributing factors to ensure that similar incidents do not happen again. This includes both immediate causes and deeper organizational or systemic issues.
Option B is incorrect because CCPS promotes a no-blame or just culture approach. The focus is not on assigning fault or discipline but on understanding why defenses failed. Blame-oriented investigations discourage reporting and hinder learning.
Option D is also incorrect because not all injuries are classified as process safety incidents. CCPS distinguishes between occupational safety (e.g., slips, trips) and process safety events (loss of containment of hazardous materials). The purpose of investigation is not merely documentation but learning and prevention.
Overall, incident investigation is a critical feedback loop in RBPS for continuous risk reduction and organizational learning.

Question: 10

The photo below represents part of the overhead piping for a reactor with a 90 psig maximum allowable working pressure (MAWP). Which of the following statements are correct? (select all that apply)



A. A rupture disc installed upstream of a relief valve can protect the valve from corrosion and fouling
B. The pressure gauge shown can be used to verify that the relief device is set correctly
C. A drain valve between the rupture disc and relief valve can compromise overpressure protection
D. The combination of rupture disc and relief valve is an acceptable overpressure protection configuration

Answer: B,D

Explanation:
The correct answers are B and D because they highlight subtle but critical deficiencies in the pressure relief system configuration, consistent with CCPS guidance.
Option B is correct because the presence of additional components (such as a pressure gauge connection or trapped pressure between the rupture disc and relief valve) can lead to pressure buildup on the downstream side of the rupture disc. This backpressure increases the effective burst pressure, meaning the disc may not rupture at its intended set point, thereby compromising overpressure protection.
Option D is also correct because if the rupture disc is intended to protect the relief valve from corrosion, any leakage, improper installation, or pressure buildup in the space between the disc and valve can negate that protection. For example, corrosive process fluid could still reach the relief valve if the disc is not perfectly leak-tight or if the system is not properly maintained.
Option A is incorrect because current operating pressure does not guarantee safety—relief systems must function correctly during upset conditions. Option C is incorrect because placing a rupture disc upstream of a relief valve is an accepted practice when properly designed. CCPS emphasizes that improper installation details can significantly degrade relief system performance, even when components appear correct.

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