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AMPP

CUI

Corrosion Under Insulation Inspection Specialty

Question: 631

Which parameter best approximates the driving force for corrosion potential in an electrochemical cell?

A. Electrical resistivity of the metal alone
B. Potential difference between anodic and cathodic half-reactions
C. Thickness of insulation only
D. Temperature of the surrounding air alone

Answer: B

Explanation: Driving force for corrosion is the potential difference between anodic oxidation and cathodic reduction half reactions.

Question: 632

Which ASTM standard is best suited for evaluating the adhesion strength of protective coatings applied on hot substrates for CUI mitigation?

A. ASTM D4541
B. ASTM D3359
C. ASTM G8
D. ASTM D522

Answer: A

Explanation: ASTM D4541 covers pull-off adhesion strength measurement suitable for critical coatings systems. D3359 is for tape adhesion rating, G8 evaluates cathodic disbondment, D522 for flexibility by bending.

Question: 633

Which parameters must be incorporated in CUI risk modeling formulas to predict corrosion rates accurately in carbon steel insulated systems?

A. Water film thickness inside insulation layers
B. Operating temperature and duration above dew point
C. Yield strength of the base metal
D. pH levels of condensate accumulated under insulation

Answer: A,B,D

Explanation: Water film thickness affects oxygen availability for corrosion, temperature influences reaction kinetics, and condensate pH governs corrosion aggressiveness. Yield strength is a mechanical property unrelated to corrosion rate prediction.

Question: 634

A CUI inspection reveals that a carbon steel pipe's aluminum jacketing has developed pinholes after 5 years in a coastal environment. What is the primary cause of this jacketing failure?

A. Improper installation of the vapor barrier
B. Mechanical damage from external impacts
C. Pitting corrosion due to chloride exposure
D. Thermal expansion mismatch with insulation

Answer: C

Explanation: In a coastal environment, aluminum jacketing is susceptible to pitting corrosion due to chloride exposure from saltwater, leading to pinholes that compromise the jacket's integrity. Improper vapor barrier installation could exacerbate moisture ingress but is not the primary cause of pinholes. Mechanical damage may cause dents or tears but not typically pinholes. Thermal expansion mismatch could stress the jacketing but is less likely to cause localized pitting compared to chloride-induced corrosion.

Question: 635

In a marine environment, a carbon steel pipe insulated with mineral wool at 125°C shows severe CUI. Which factors contribute to the formation of an electrochemical cell?

A. Chloride-rich moisture ingress
B. High thermal conductivity of insulation
C. Potential difference between metal grains
D. Presence of a metallic conductor

Answer: A,C,D

Explanation: Chloride-rich moisture acts as an electrolyte, enabling ion transport. A potential difference between metal grains creates anodic and cathodic sites, and the steel pipe itself serves as the metallic conductor for electron flow. High thermal conductivity of insulation is not directly related to forming an electrochemical cell.

Question: 636

Scenario: A fiberglass reinforced plastic (FRP) jacketing is selected for a high-temperature insulated pipe at 180°C. What key precaution must be taken regarding jacketing properties and installation?

A. Verify FRP resin system withstands operating temperature without degradation
B. Ensure jacketing is ventilated to avoid heat build-up
C. Use external paint coating to improve jacketing durability
D. Limit FRP thickness to reduce thermal diffusion

Answer: A

Explanation: FRP resin must be compatible with service temperature to avoid cracking and degradation. Ventilation is not standard as jacketing should be sealed. Paint may improve UV resistance but is secondary. Limiting thickness reduces durability.

Question: 637

In system design to mitigate adverse features, what is the recommended practice for insulation on piping risers exposed to frequent rainfall?

A. Use vented drip edges at riser base and specify sloped insulation jackets to promote water runoff
B. Use uniform thickness cylindrical insulation and no venting to avoid vapor ingress
C. Select open-cell insulation to absorb rainwater and reduce immediate runoff
D. Apply vapor barriers only on horizontal pipe sections

Answer: A

Explanation: Vented drip edges and sloping avoid water accumulation at riser bases, critical in rainfall exposure. Uniform thickness without venting encourages pooling. Open-cell insulation absorbs water, increasing CUI risk. Vapor barriers need to be continuous, not limited by orientation.

Question: 638

A carbon steel vessel insulated with fiberglass at 140°C shows CUI. The electrochemical cell is analyzed. What is the role of the metallic conductor?

A. Facilitates ion transport
B. Provides a pathway for electron flow
C. Reduces oxygen to hydroxide
D. Undergoes oxidation

Answer: B

Explanation: The metallic conductor (the steel vessel) provides a pathway for electron flow from the anodic site (where oxidation occurs) to the cathodic site (where reduction occurs). Ion transport occurs in the electrolyte, oxygen reduction happens at the cathode, and oxidation occurs at the anode.

Question: 639

In a petrochemical plant, a carbon steel pipe operating at 120°C is insulated with mineral wool and covered with aluminum jacketing. After a year, inspection reveals localized corrosion under the insulation due to moisture ingress. Which sequence best represents the steps in the CUI cycle for this scenario?

A. Coating degradation, moisture ingress, corrosion initiation, corrosion propagation
B. Corrosion initiation, coating degradation, moisture ingress, corrosion propagation
C. Moisture ingress, corrosion initiation, coating degradation, corrosion propagation
D. Moisture ingress, coating degradation, corrosion initiation, corrosion propagation

Answer: C

Explanation: The CUI cycle begins with moisture ingress, which occurs when water penetrates the insulation due to damaged or poorly sealed jacketing. This is followed by corrosion initiation, where the presence of water and contaminants (e.g., chlorides) on the metal surface triggers corrosion. Coating degradation may occur subsequently as corrosion products or environmental factors compromise the protective coating. Finally, corrosion propagation continues as the corrosive environment persists, leading to material loss. In this scenario, moisture ingress due to the aluminum jacketing's failure is the initial step, followed by corrosion initiation on the carbon steel, then potential coating degradation, and finally corrosion propagation.

Question: 640

A design engineer is selecting a coating for a piping system operating at 170°C. According to NACE SP0198, which coating is most suitable?

A. Epoxy coating with a maximum temperature rating of 120°C
B. Novolac epoxy coating with a maximum temperature rating of 200°C
C. Organic zinc primer with a maximum temperature rating of 100°C
D. Silicone alkyd coating with a maximum temperature rating of 80°C

Answer: B

Explanation: NACE SP0198 recommends coatings with a temperature rating exceeding the operating temperature. Novolac epoxy with a 200°C rating is suitable for 170°C operations. The other coatings have lower temperature ratings, making them prone to degradation and ineffective for CUI protection.

Question: 641

A spray-on insulative coating with a polysiloxane matrix is applied to a pipe at 250°C. Compared to traditional insulation, what is a key advantage in terms of CUI mitigation?

A. Ability to act as a sacrificial anode
B. Elimination of seams that allow moisture ingress
C. Higher thermal conductivity for heat dissipation
D. Lower cost of materials

Answer: B

Explanation: Spray-on insulative coatings eliminate seams and gaps, reducing moisture ingress compared to traditional insulation systems, which rely on jacketing that can fail. They do not act as sacrificial anodes, have lower thermal conductivity, and are not necessarily cheaper.

Question: 642

Calculate the time to first corrosion attack if the wet/dry cycle frequency is 2 cycles per week, and the corrosion initiation requires at least 5 continuous wet days per cycle with no drying phase. Assume continuous exposure at 95°C and insulation retaining moisture. Choose the closest estimate.

A. 1 week
B. 2.5 weeks
C. 10 weeks
D. 20 weeks

Answer: C

Explanation: Each cycle requires 5 continuous wet days (~1 week), with 2 cycles per week implies wet/dry sequences that may not meet continuous wet days. Since drying reduces attack likelihood, continuous wet exposure must accumulate over about 10 weeks to initiate corrosion due to incubation period at 95°C.

Question: 643

A refinery is installing a new jacketing system over a carbon steel pipeline operating at 175°C. Which design feature of the jacketing system is critical to minimizing CUI risk?

A. Overlapping seams with watertight seals
B. Use of a high-emissivity coating to radiate heat
C. Incorporation of a robust vapor barrier
D. Ventilation holes to allow moisture escape

Answer: A,C

Explanation: Overlapping seams with watertight seals prevent water ingress, a primary cause of CUI, by ensuring the jacketing system is impermeable. A robust vapor barrier further enhances protection by blocking moisture from reaching the insulation and pipe surface. A high-emissivity coating is irrelevant to CUI prevention, as it focuses on heat radiation rather than moisture control. Ventilation holes are counterproductive, as they allow moisture entry, increasing CUI risk.

Question: 644

According to NACE SP0198, which design mechanic minimizes CUI in a system operating at 175°C?

A. Incorporate a thermal spray aluminum coating with a minimum thickness of 200 μm
B. Use a single-layer insulation system to reduce installation time
C. Use galvanized steel banding to secure insulation
D. Weld insulation to the piping to ensure stability

Answer: A

Explanation: NACE SP0198 recommends thermal spray aluminum coatings for sacrificial protection against CUI. A single-layer insulation system may not prevent moisture ingress effectively. Galvanized steel banding is prone to corrosion. Welding insulation to piping prevents inspection, increasing CUI risk.

Question: 645

Which of the following increases the likelihood of CUI in a stainless steel piping system?

A. Exposure to coastal environments with high chloride levels
B. Operating temperatures between 50°C and 175°C
C. Use of non-absorptive insulation like cellular glass
D. Poorly maintained jacketing with gaps

Answer: A,B,D

Explanation: Coastal environments with high chloride levels accelerate stress corrosion cracking. Operating temperatures between 50°C and 175°C are within the CUI risk range for stainless steel. Poorly maintained jacketing allows moisture ingress. Non-absorptive insulation like cellular glass reduces CUI risk.

Question: 646

Which formula correctly relates char expansion factor (EF), dry film thickness (DFT), and char thickness (CT) required to achieve a certain fire resistance level?

A. EF = CT × DFT
B. CT = DFT / EF
C. CT = EF × DFT
D. DFT = CT + EF

Answer: C

Explanation: Char thickness is the product of expansion factor and dry film thickness: CT = EF × DFT.

Question: 647

For a low-temperature service piping system insulated with mineral wool, which coating characteristic is vital to prevent CUI?

A. Excellent adhesion at subzero temperatures
B. High UV resistance to sunlight
C. Ability to withstand repeated freeze-thaw cycles
D. High gloss finish for moisture repellence

Answer: A,C

Explanation: Adhesion at subzero ensures coating doesn't crack or delaminate in cold service. Freeze-thaw resistance prevents cracking from ice formation on insulation or substrate. UV resistance and gloss are less critical under insulation.

Question: 648

A CUI inspection report shows that insulated pipe surfaces closest to weld joints have significantly higher corrosion rates. What insulation-related reason justifies this trend?

A. Welds cause thermal bridging that reduces insulation effectiveness
B. Weld areas are always insulated with lesser thickness by design
C. Jacketing material does not adhere properly over welds
D. Welded joints generate heat that dries the insulation causing cracks

Answer: A

Explanation: Thermal bridging at welds can cause localized temperature drops on pipe surfaces encouraging condensation beneath insulation leading to CUI hot spots.

Question: 649

Select all the key influencing parameters when designing an anti-CUI protective coating to withstand CUI cycles.

A. Coating adhesion loss due to wet/dry cycling
B. Coating permeability to water vapor and O2
C. Ability to withstand thermal expansion matching steel substrate
D. Electrical resistivity of coating under wet conditions

Answer: A,B,C

Explanation: Adhesion loss, permeability, and thermal mismatch dictate coating performance. Electrical resistivity is important but secondary compared to mechanical and diffusion properties for CUI.

Question: 650

A chemical plant uses calcium silicate insulation on a stainless steel vessel operating at 120°C. Which property of calcium silicate directly contributes to CUI risk if not properly managed?

A. High compressive strength
B. High water retention capacity
C. Low thermal conductivity
D. Resistance to thermal shock

Answer: B

Explanation: Calcium silicate's high water retention capacity can trap moisture against the metal surface, promoting CUI if the insulation becomes wet due to poor sealing or environmental exposure. High compressive strength, low thermal conductivity, and resistance to thermal shock are beneficial for structural and thermal performance but do not directly contribute to CUI risk.

Question: 651

An inspector is evaluating a fireproofed vessel with a cementitious coating operating at 250°F (121°C). The vessel shows signs of CUF. Which non-destructive testing (NDT) method is most effective for quantifying wall loss?

A. Infrared thermography
B. Pulsed eddy current (PECT) testing
C. Radiographic testing (RT)
D. Ultrasonic testing (UT)

Answer: B

Explanation: Pulsed eddy current (PECT) testing quantifies wall loss through insulation and non-ferrous cladding without removal, making it ideal for detecting CUF. Infrared thermography identifies wet insulation but not wall loss. Radiographic testing detects metal loss but is less precise. Ultrasonic testing requires coating removal.

Question: 652

In a chemical plant, a carbon steel pipe insulated with mineral wool operates at 160°C. After a storm, water infiltrates the insulation, leading to CUI. Which sequence of actions best mitigates the progression of the CUI cycle?

A. Apply a cathodic protection system
B. Inspect and repair the insulation jacketing
C. Remove and replace the wet insulation
D. Use infrared thermography to detect wet spots

Answer: B,C,D

Explanation: Mitigating CUI requires addressing moisture ingress and its consequences. Inspecting and repairing the insulation jacketing prevents further water infiltration. Removing and replacing wet insulation eliminates the corrosive environment. Using infrared thermography helps identify wet spots for targeted repairs. Cathodic protection is not typically effective for CUI, as it is designed for buried or submerged structures, not insulated systems where moisture is trapped locally.

Question: 653

During fireproofing inspection, the thickness gauge readings varied significantly across the surface of an intumescent coating. Which is the most probable corrosion risk stemming from this thickness variation?

A. Thinner areas may not provide adequate fire resistance and allow moisture ingress
B. Thicker areas increase corrosion risk by trapping more moisture under coating
C. Uniform thickness is less important than adhesion properties
D. Thickness variation does not impact corrosion but only fire resistance

Answer: A

Explanation: Thinner areas reduce fire protection and barrier properties, increasing corrosion risk from moisture ingress. Thicker areas generally reduce moisture penetration; adhesion is important but insufficient alone.

Question: 654

A coating is applied on a hot substrate at 145°C. Which parameter must be monitored to ensure proper film formation?

A. Coating viscosity
B. Relative humidity
C. Surface temperature
D. UV exposure

Answer: C

Explanation: Surface temperature must be monitored during hot substrate application at 145°C to ensure proper curing and film formation, as excessive heat can cause defects like pinholes. Coating viscosity and relative humidity are secondary, and UV exposure is irrelevant under insulation.

Question: 655

How do the thermal expansion coefficients of spray-on insulative coatings affect CUI protection when applied on carbon steel structures?

A. Coefficients closer to steel's reduce stress and cracking from temperature changes
B. Larger divergence in coefficients causes beneficial micro-fracturing aiding vapor escape
C. Low thermal expansion promotes adhesion loss under cyclic loading

D. Thermal expansion is irrelevant for insulation coatings

Answer: A

Explanation: Matching thermal expansion minimizes mechanical stresses that cause cracking or delamination, preserving coating integrity and CUI resistance.

Question: 656

In a scenario where insulation has been damaged exposing carbon steel at 120°C while the ambient environment is humid and rainy, which combination of actions is most critical to interrupt the CUI cycle?

A. Immediate removal of damaged insulation section
B. Application of corrosion-resistant coating before re-insulation
C. Increasing insulation thickness to prevent moisture ingress
D. Heating the pipe above 200°C to dry the metal surface

Answer: A,B

Explanation: Removing damaged insulation stops moisture trapping, and applying corrosion-resistant coatings protects the bare metal. Increasing insulation thickness alone may trap moisture; heating above 200°C is impractical and may not prevent CUI once initiated.

Question: 657

A refinery's insulated piping system, fireproofed with a high-density concrete coating, shows signs of moisture ingress. The system operates at 200°F (93°C). Which design flaw likely contributed to corrosion under fireproofing (CUF)?

A. Absence of a cathodic protection system
B. Inadequate sealing of jacket seams
C. Use of a non-breathable vapor barrier
D. Use of organic-based primer

Answer: B

Explanation: Inadequate sealing of jacket seams allows moisture ingress, a primary cause of CUF, as water becomes trapped against the steel surface. Cathodic protection is less relevant for insulated systems. A non-breathable vapor barrier may trap moisture but is secondary to poor sealing. Organic-based primers are less critical than moisture ingress in this context.

Question: 658

A chemical plant experiences CUI due to water ingress at insulation terminations. Which design modification addresses this issue?

A. Apply a weatherproof silicone sealant at terminations
B. Increase insulation thickness to 150 mm
C. Replace terminations with welded caps
D. Use a vapor-permeable coating at terminations

Answer: A

Explanation: Applying a weatherproof silicone sealant at terminations prevents water ingress, addressing the root cause of CUI. Increasing insulation thickness does not address termination vulnerabilities. Welded caps are not practical for insulation terminations. A vapor-permeable coating allows moisture to enter, increasing CUI risk.

Question: 659

What is the primary reason for the formation of differential aeration cells in corrosion under insulation conditions?

A. Variations in metal microstructure
B. Differences in moisture content leading to oxygen concentration gradients
C. Temperature fluctuations under insulation
D. Presence of inhibitors unevenly applied

Answer: B

Explanation: Differential aeration cells form due to local differences in oxygen availability, often caused by uneven moisture retention under insulation, causing anodic and cathodic regions.