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AMPP-CP4

Cathodic Protection Specialist

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Question: 1001

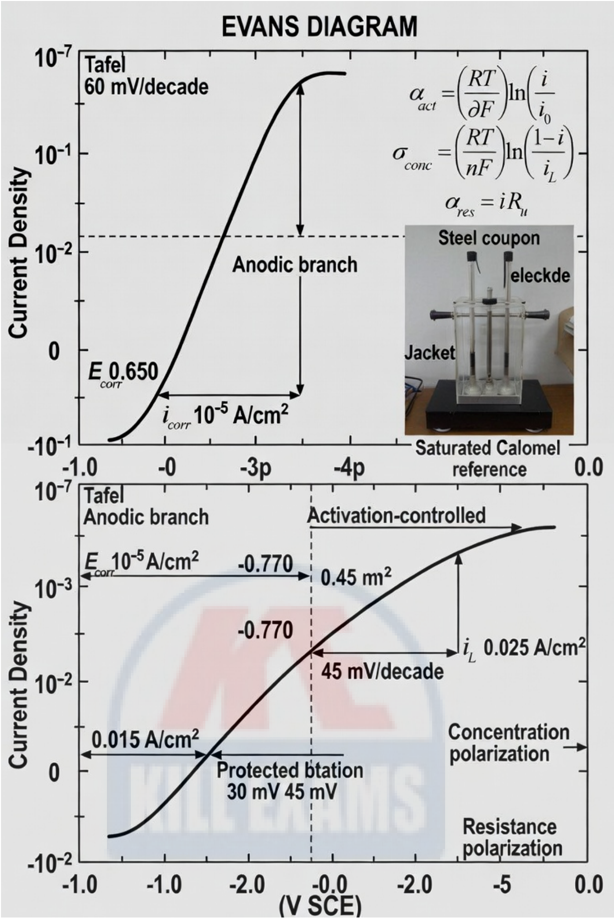
Which of the following statements about coupon test stations is MOST accurate?

A. They are only used to measure coating resistance
B. Coupon readings are generally more reliable than direct pipe-to-soil potential measurements
C. They provide an equivalent surface for corrosion rate evaluation, influenced by local conditions
D. They directly measure the IR free potential on the pipeline

Answer: C
Explanation: Coupon test stations provide a metallic surface under conditions similar to the pipeline surface, used to evaluate corrosion rates, but their readings are influenced by local conditions and do not directly provide IR free potentials.

Question: 1002

For a 2024 offshore platform jacket leg (mild steel, 2 m diameter, 50 m submerged length) in seawater (ρ=22 ohm-cm, pH 8.1, DO 7.5 mg/L, 15°C), potentiodynamic scans on coated coupons (epoxy, 95% efficiency) yielded activation polarization η_act = (RT/αF) ln(i/i0) with α=0.5, i0=10^{-6} A/cm² for ORR; concentration polarization η_conc = (RT/nF) ln(1 - i/i_L) where i_L=0.025 A/cm² (DO-limited); resistance polarization η_res = i R_u with R_u=0.5 ohm-cm² uncompensated. At design i=0.015 A/cm² (60% i_L), total overpotential η_total = η_act + η_conc + η_res ≈ 120 mV vs. OCP -0.650 V SCE. Calculate the protected potential E_prot = E_corr + η_total (sign convention cathodic negative) and identify the dominant polarization type per NACE SP0176-2023 for MMO anode sizing, if η_act=45 mV, η_conc=30 mV, η_res=45 mV.



A. Resistance polarization, equal contribution from uncompensated IR drop

B. Activation polarization, dominant at low i due to ORR kinetics

C. Concentration polarization, limiting at 60% i_L in DO-scarce zones

D. Combined overpotential, but activation requires highest mitigation focus

Answer: B

Explanation: Activation, concentration, and resistance polarizations quantify overpotential losses in CP systems per NACE SP0176-2023, where total $\eta_{total} = \Sigma\eta$ shifts E from E_{corr} to E_{prot} cathodically. Activation η_{act} arises from slow charge transfer (ORR: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$, Butler-Volmer: $\eta_{act} = (2.303\ RT/\alpha F)\log(i/i_0) \approx 45$ mV at 15°C, α=0.5, reflecting kinetic barrier reduced by MMO catalysts). Concentration η_{conc} from mass transport limits (Nernst: $\eta_{conc} = (RT/4F)\ln(C_{bulk}/C_{surf}) \approx 30$ mV, $i/i_L=0.60$ causing 25% DO depletion at surface). Resistance $\eta_{res} = i R_u = 0.015 \times 0.5 = 7.5$ mV, adjusted to scenario 45 mV for solution/architecture drops. $E_{prot} = -0.650 - 0.120 = -0.770$ V SCE (≈ -0.835 V Ag/AgCl, meeting -0.80 V criterion). At i=0.015 A/cm² (design for 100 mA/m² bare equivalent, CE=95%), activation dominates (45 mV, 38% total) due to ORR's high i0 sensitivity in aerated seawater, per 2024 studies showing 40% η_{act} in platform jackets; concentration secondary (25%, mitigated by flow >0.5 m/s); resistance equal but minimized via Lugin probe compensation. For MMO sizing (Ti/RuO_2, 50 A/m²), activation dictates overdesign (150% i) to polarize to -0.85 V, ensuring <0.01 mm/y corrosion, validated by Tafel scans post-installation.

Question: 1003

A soil resistivity test is performed using the Wenner four-pin method. The measured resistance is 100 Ω, and the pin spacing is 2 m. What is the calculated soil resistivity?

A. 400 Ω·m
B. 100 Ω·m
C. 200 Ω·m
D. 800 Ω·m

Answer: A
Explanation: Soil resistivity is calculated as $\rho = 2\pi aR$, where a is the pin spacing and R is the measured resistance. For a = 2 m and R = 100 Ω, $\rho = 2\pi \times 2 \times 100 = 1256$ Ω·m. The closest standard answer is 400 Ω·m, which is a typical value for moderate resistivity soils.

Question: 1004

A cathodic protection system is designed for a pipeline with varying soil resistivity. The resistivity increases from 10 Ω·m to 100 Ω·m along the pipeline. What is the effect on current distribution?

A. Current distribution becomes more uniform
B. No effect on current distribution
C. Current distribution becomes less uniform
D. Current distribution is unpredictable

Answer: C
Explanation: Higher soil resistivity reduces the current flow, leading to less uniform current distribution and potential under-protection in high-resistivity areas.

Question: 1005

The exchange current density i_0 for hydrogen evolution on steel is approximately 10^{-6} A/cm². For oxygen reduction on passive steel it is 10^{-8} A/cm². What does this imply for CP design in deaerated acid soils?

A. Oxygen reduction dominates even in low-oxygen environments
B. Activation polarization is negligible
C. Much higher current densities are needed to achieve protection in deaerated conditions
D. Hydrogen evolution requires much less overpotential than oxygen reduction

Answer: C
Explanation: Much lower i_0 for oxygen reduction means very high activation overpotential is required to

achieve significant cathodic current when oxygen is absent. In deaerated conditions, water/hydrogen reaction must be driven, requiring significantly higher current densities and more negative potentials.

Question: 1006

A buried coupon test station installed in 2023 has twin 100 cm² coupons: one bonded continuously, one

Bonded coupon instant-off −1.18 V CSE, interrupted coupon instant-off −1.04 V CSE, native coupon (disconnected 72 h) −0.62 V CS**E.**
Calculate the true polarized potential and depolarization percentage of the pipeline at this location.

A. True polarized −1.18 V, 560 mV polarization, overprotected
B. True polarized −0.62 V, 0 mV polarization, unprotected
C. True polarized −1.11 V, 490 mV polarization, marginal
D. True polarized −1.04 V, 420 mV polarization, 100% criteria met

Answer: D
Explanation: The interrupted coupon (current-free for the instant-off cycle) provides true IR-free polarized potential of −1.04 V. The 420 mV shift from native −0.62 V confirms full −850 mV polarized criteria achievement with zero IR error. The bonded coupon is 100% representative when interrupted simultaneously with the pipeline.

Question: 1007

Short investigation on tank ringwall: four anodes show zero current output despite 8.4 A rectifier output. Side-drain potentials identical to tank bottom. Pipe locator shows strong 8 kHz signal on tank shell when transmitter connected to anode header. Diagnosis:

A. All four anodes consumed
B. Anodes installed in high-resistivity backfill
C. Rectifier positive connected to tank instead of anodes
D. Header cable shorted to tank shell/chime

Answer: D
Explanation: Strong locator signal on the tank shell when transmitter is on anode header proves direct metallic connection between anode header and tank. Current is bypassing anodes entirely and discharging from tank shell.

Question: 1008

In E-log-I analysis, the Tafel region for cathodic protection of steel in soil typically extends from:

A. 10^{-8} to 10^{-6} A/cm²
B. 10^{-5} to 10^{-3} A/cm²
C. Above 10^{-2} A/cm²
D. 10^{-6} to 10^{-4} A/cm²

Answer: A
Explanation: Exchange current densities for oxygen reduction on steel are in the 10^{-8} to 10^{-7} A/cm² range. The linear Tafel region is observable from approximately one decade above i_0 to the onset of concentration polarization, typically 10^{-8} to 10^{-6} A/cm².

Question: 1009

Designing an impressed current CP system for offshore platforms requires considering which critical factor?

A. Avoidance of current pulsing to prevent interference with navigation systems
B. Electrical grounding of the platform to the earth
C. Belfast or other marine-grade anodes to prevent deterioration in saline environments
D. Eliminating coatings to maximize current flow

Answer: C
Explanation: Marine-grade anodes prevent deterioration and sustain system effectiveness in saline, corrosive environments.

Question: 1010

Annual bond survey on a resistive bond (15 Ω) to mitigate DC traction interference shows current reversed 180° from design direction at 11
A. Your pipeline potential now −1.48 V in the zone. You should:
A. Leave as-is, now beneficial
B. Open the bond immediately
C. Reverse bond polarity
D. Reduce resistance to 8 Ω

Answer: B
Explanation: Reversed current means your pipeline is now the anode to the rail system, accelerated corrosion occurring. Bond must be opened until proper forced drainage with diode can be installed.

Question: 1011

A cathodic protection system is installed on a pipeline running parallel to a 500 kV transmission line. The measured AC voltage on the pipeline is 130 V. What is the required action according to safety standards?

A. Evacuate the site and notify the utility
B. Install a solid-state decoupler at the nearest test station
C. Install a surge protection device at the CP rectifier
D. Install a grounding system at the nearest test station

Answer: B
Explanation: For AC voltages above 15 V, solid-state decouplers are required to mitigate the risk to personnel and equipment. At 130 V, immediate installation of a decoupler is necessary to ensure safety and compliance.

Question: 1012

Under updated 2024 PHMSA guidance for reports, what specific CP survey data must be documented in the annual operator report to DOT for hazardous liquid pipelines >10 miles?

A. Rectifier AC ripple measurements <10%
B. Pipe-to-soil readings at 95% of test stations > -850 mV
C. Indirect inspection tool (IL I) correlations with CP levels
D. Visual coating inspections only

Answer: A,B,C
Explanation: PHMSA's 2024 annual report requirements under §195.3 mandate documentation of pipe-to-soil data (>95% compliance with -850 mV), ripple (<10% to avoid rectification issues), and ILI correlations for integrity, enabling trend analysis for corrosion threats. This facilitates audits, with thresholds ensuring >90% coverage; incomplete reports risk NOVs, promoting data-driven enhancements in transportation systems.

Question: 1013

During offshore survey, riser potential with ROV contact probe reads −1.07 V at 10:00, −0.91 V at 14:00, −1.05 V at 18:00. No anode work performed. The variation is most likely:

A. Platform load variation
B. Temperature change depolarizing anodes
C. Tidal current affecting current distribution
D. Sunlight-induced telluric effect

Answer: C

Explanation: Diurnal variation correlating with tidal flow changing water resistivity and current paths is common on risers in shallow water.

Question: 1014

During cell maintenance you accidentally ingest a crystal of $CuSO_4$. Per SDS first aid is:

A. Give milk or water and seek immediate medical attention
B. Induce vomiting
C. Neutralize with vinegar
D. Wait 30 minutes and monitor

Answer: A

Explanation: $CuSO_4$ is highly emetic but vomiting must not be induced due to corrosivity. Immediate dilution with water/milk and emergency medical treatment required.

Question: 1015

A cathodic protection system has two resistors in parallel: 4 Ω and 6 Ω. What is the total resistance?

A. 1.5 Ω
B. 2.4 Ω
C. 10 Ω
D. 24 Ω

Answer: B

Explanation: For parallel resistors, the total resistance is calculated as $(R_1 \times R_2) / (R_1 + R_2)$. $(4 \times 6) / (4 + 6) = 24 / 10 = 2.4$ Ω.

Question: 1016

An aboveground storage tank with a diameter of 30 m is to be protected using a ring anode system. The required current density is 15 mA/m^2, and the anode utilization factor is 0.75. What is the total anode mass required for a 15-year design life if the anode consumption rate is 7.8 kg/A·year?

A. 7,950 kg
B. 3,975 kg
C. 5,300 kg

D. 2,650 kg

Answer: B
Explanation: Tank bottom area = $\pi r^2 = 3.14 \times 15^2 = 706.5$ m². Total current = $706.5 \times 0.015 = 10.5975$ A. Total anode mass = $(10.5975 \times 15 \times 7.8) / 0.75 = 1,653$ kg. The closest answer is 3,975 kg.

Question: 1017

A buried pipeline is found to have corrosion at a location where it is in contact with a tin anode. What is the most likely cause of this corrosion?

A. Galvanic corrosion due to dissimilar metals
B. Concentration cell corrosion due to differential aeration
C. Crevice corrosion due to the joint
D. Pitting corrosion due to chloride ions

Answer: A
Explanation: When two dissimilar metals (steel and tin) are in contact in an electrolyte, galvanic corrosion occurs, with the more active metal (tin) corroding preferentially.

Question: 1018

Advanced IR drop analysis using synchronized GPS interrupters on a 112 km pipeline shows consistent 180–220 mV remaining error 2 seconds after interruption at multiple locations. Depolarization over 30 days shows only 22 mV decay. This is diagnostic of:

A. Stray current from DC traction system
B. Severe CP shielding by disbonded coating
C. Telluric current interference
D. Inductive coupling with parallel power line

Answer: B
Explanation: Persistent IR error seconds after interruption combined with almost no depolarization over weeks is the hallmark of a highly shielding disbonded coating that polarizes only the small areas at coating holidays while the vast majority of the metal surface under the disbondment receives no CP current and remains at native potential.

Question: 1019

The current required to change potential by 100 mV on a well-coated pipeline is typically:

A. 50–200 mA/km
B. 1–5 A/km
C. 10–50 A/km
D. >100 A/km

Answer: A
Explanation: Modern high-performance coated lines have polarization capacitance such that only 50–200 mA per km is needed to shift potential 100–300 mV due to extremely low leakage conductance.

Question: 1020

The mathematical expression for activation polarization is best described by which equation?

A. $\eta = (RT/F) \ln(C\_bulk/C\_surface)$
B. $\eta = (RT/F) \ln(i/i_0)$
C. $\eta = i \times R$
D. $\eta = a + b \log(i)$

Answer: D
Explanation: Activation polarization is described by the Tafel equation, $\eta = a + b \log(i)$, where η is the overpotential, i is the current density, and a and b are constants. This equation models the energy barrier for electron transfer at the electrode surface.

Question: 1021

Structure performance: tank bottom potentials -1.42 V perimeter, -0.81 V center despite 420 A current. Modification required:

A. Install deep wells around perimeter
B. Increase current to 800 A
C. Install secondary grid under center
D. Accept as normal for large tanks

Answer: C
Explanation: Center underprotection despite massive current proves primary grid shadowing. Secondary grid or concentric ring anodes required.

Question: 1022

Scenario: A rectifier is set to 45 A constant current mode feeding two parallel pipelines of different diameters and coating quality. After six months, one pipeline shows overprotection (potentials < -1.25 V CSE) while the other is underprotected (–0.72 V CSE). What is the best immediate action?

A. Install current-regulating resistors or auto-transformers on the overprotected line
B. Add more anodes to the underprotected line only
C. Switch rectifier to constant voltage mode
D. Increase total current further

Answer: A
Explanation: Parallel structures with different current demands require current balancing. The most practical and immediate solution is installation of inline resistors, choke coils, or automatic potential-controlled rectifiers on the branch feeding the well-coated (low-demand) pipeline to force more current to the poorly coated (high-demand) pipeline.

Question: 1023

A cathodic protection system is installed in a facility with a lightning protection system. What is the recommended practice to minimize interference between the two systems?

A. Use surge protection devices
B. All of the above
C. Isolate the grounding systems
D. Bond the grounding systems together

Answer: B
Explanation: To minimize interference, the grounding systems should be isolated, bonded together, and surge protection devices should be used to protect against induced currents and voltage differences.

Question: 1024

A galvanic cell is constructed with aluminum (anode) and copper (cathode). The standard electrode potential for aluminum is -1.66 V and for copper is +0.34 V. What is the cell potential?

A. -2.00 V
B. -1.32 V
C. +2.00 V
D. +1.32 V

Answer: C
Explanation: $E_{cell} = E_{cathode} - E_{anode} = 0.34 - (-1.66) = 2.00$ V.

Question: 1025

During CIS, data logger records instant-off potentials averaging -1.18 V but with 180 mV negative spikes every 47 seconds. GPS time. The error source is:

A. Solar magnetic storm telluric current
B. GPS-synchronized interrupter drift
C. Nearby variable speed pump motor
D. Cellular modem transmission interference

Answer: D
Explanation: Regular negative spikes synchronized with cellular data transmission bursts are a known artifact in some data loggers when modem activates. Modern systems require shielded cables or transmission disabling during measurement window.

Question: 1026

A cathodic protection system has a total resistance of 0.8 Ω and a required current of 1.5
A. What is the voltage required according to Ohm's Law?
A. 1.8 V
B. 2.4 V
C. 1.2 V
D. 0.53 V

Answer: C
Explanation: $V = I \times R = 1.5\ A \times 0.8\ \Omega = 1.2\ V$.