

# PRACTICE EXAM 9: RED SEAL WELDER SIMULATION (125 QUESTIONS)

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1. Under WHMIS 2015, a welding flux SDS lists two separate health hazard classifications: "Acute Toxicity Category 4" and "Specific Target Organ Toxicity — Single Exposure (STOT-SE), Category 1." What specifically distinguishes the Acute Toxicity classification from the STOT-SE classification for this product?

A. Acute Toxicity applies to products causing harm only through skin contact or ingestion, while STOT-SE applies exclusively to respiratory harm from inhalation over extended periods

B. Acute Toxicity applies only to products lethal in small quantities, while STOT-SE applies exclusively to products causing allergic reactions after repeated trace-amount exposures

C. Acute Toxicity communicates the hazard from a single brief exposure capable of causing death or serious injury (quantified by LD50 or LC50 values), while STOT-SE identifies specific organs or systems — such as the nervous system, respiratory system, or blood — that are targeted by a single exposure without the product necessarily meeting acute lethality thresholds

D. Acute Toxicity and STOT-SE describe identical health outcomes and differ only in regulatory threshold values — both require the same GHS pictogram and the same SDS emergency response sections regardless of the specific classification

2. A welding contractor sets up a GMAW station in a new fabrication facility. The electrical engineer specifies that the welding power source must be both "grounded" and "bonded" to the workpiece and facility structure. What is the specific distinction between grounding and bonding in this welding electrical context?

A. Grounding connects the power source frame and electrical components to earth ground through the building's grounding system, protecting against electrical shock if a fault energizes the equipment frame; bonding connects the work return cable firmly from the work clamp to the workpiece and back to the power source return terminal, providing the low-impedance current return path for the welding circuit and minimizing stray current through unintended paths

B. Grounding connects the work return cable to the workpiece to complete the welding circuit, while bonding connects the power source to the building structure to prevent voltage buildup on the equipment chassis during the welding operation

C. Grounding and bonding are interchangeable terms in welding electrical installations — both describe the practice of connecting the work return cable directly to the workpiece closest to the weld joint, and the terms are used without distinction in Canadian electrical codes

D. Grounding applies only to AC power sources and connects the neutral conductor to earth to prevent shock; bonding applies only to DC welding equipment and connects the negative terminal to the workpiece to ensure the correct polarity for the GMAW welding circuit

3. A welding supervisor assigns a new worker to an SMAW workstation where a half-face air-purifying respirator (APF 10) with P100 and organic vapor cartridges is required for manganese fume exposure control. Before assigning the work, the supervisor must confirm the worker's respirator fit. Which statement correctly describes the fit test requirements?

A. Fit testing is only required for powered air-purifying respirators and supplied-air respirators — half-face APF 10 respirators are one-size-fits-all devices that do not create a facial seal and therefore do not require fit testing before use

B. Fit testing is required only when the worker's previously used respirator brand is unavailable — once fit-tested to any respirator model, the result transfers to all respirators in the same APF category without additional testing

C. Fit testing is required before first use and annually, but only when the respirator is worn for more than 4 continuous hours per shift — part-time respirator users with shorter exposure periods are exempt from the fit test requirement

D. Fit testing is required for all workers before using any tight-fitting respirator, including a half-face APF 10 — the test must be conducted for the specific make, model, and size of respirator that will be used; a qualitative or quantitative fit test must be documented and must be repeated if the worker's facial characteristics change, they change respirator models, or annually per OHS requirements

4. A welder sustains a laceration requiring stitches while grinding a structural weld, receives medical attention, and returns on modified duties the following day. Which parties have mandatory reporting obligations for this workplace injury?

A. Only the worker has a mandatory reporting obligation — the worker must report to the Workers' Compensation Board within 72 hours; the employer's reporting obligation is optional and triggered only if the worker applies for wage-loss benefits

B. Both the employer and the worker have mandatory reporting obligations — the employer must file an Employer's Incident Report and the worker must file a Worker's Report of Injury; the treating healthcare provider also has a reporting obligation to the WCB; failure by any party to report within the legislated timeframe can result in fines and penalties

C. Only the treating physician has a mandatory reporting obligation — the physician's report registers the claim in the workers' compensation system, relieving both the employer and the worker of any independent reporting requirement

D. No mandatory reporting is required for injuries resulting in modified duties rather than full time-loss — the WCB reporting obligation is only triggered when the worker misses complete shifts, and modified-duty injuries are classified as first-aid incidents

5. A structural steel fabrication shop generates waste including SMAW electrode stubs, empty electrode containers, spent SAW granular flux, carbon steel grinding dust, and empty argon/CO<sub>2</sub> cylinders. Which waste component most likely requires disposal as regulated hazardous waste rather than ordinary industrial solid waste?

A. Used electrode stubs from carbon steel SMAW, because the electrical energy applied during welding changes the steel's metallurgical composition and creates a hazardous alloy exceeding the TCLP regulatory threshold for metals

B. Empty shielding gas cylinders, because residual compressed gas in supposedly empty cylinders meets the definition of a hazardous compressed gas under CEPA and the Transport of Dangerous Goods regulations, requiring specialized cylinder return through registered gas distributors

C. Grinding dust from carbon steel areas where stainless steel welding was also performed, because the dust may contain hexavalent chromium (Cr<sup>6+</sup>) or other leachable metals at concentrations exceeding TCLP regulatory thresholds, qualifying it as hazardous waste requiring registered disposal

D. Spent SAW flux, because the slag from submerged arc welding always contains radioactive thorium from the tungsten electrodes used to initiate the arc, placing all spent SAW flux in the radioactive waste category under the Nuclear Safety and Control Act

6. A plant safety manager is explaining to new supervisors the difference between a workplace safety inspection and a safety audit. Which statement correctly distinguishes these two activities?

A. A safety inspection is conducted annually by an external third-party auditor against a documented standard, while a safety audit is an informal daily walk-through conducted by the supervisor — the audit requires no documentation while the inspection requires a full written report

B. A safety inspection focuses exclusively on physical hazards visible during a walk-through, while a safety audit focuses exclusively on administrative controls such as training records and documented procedures — the two activities are always conducted separately and never combined

C. A safety inspection is a formal regulatory process conducted only by provincial OHS inspectors resulting in legally binding orders, while a safety audit is an internal assessment that produces only recommendations with no enforcement authority

D. A safety inspection identifies specific physical hazards and conditions at a point in time and is typically focused on what currently exists; a safety audit is a systematic, documented examination of the entire safety management system — policies, procedures, training, records, physical conditions, and compliance — evaluating whether the system as a whole effectively prevents incidents; an audit produces findings about system effectiveness rather than only listing individual hazards

7. An industrial fabrication plant where oxy-fuel cutting, GMAW, and SMAW are performed simultaneously must have an Emergency Response Plan (ERP). Which elements are required to be included in the ERP under applicable Canadian regulations?

A. The ERP must include emergency procedures for all foreseeable emergencies including fire, explosion, hazardous material release, medical emergency, and power failure; emergency equipment locations; escape routes and muster points; worker and emergency coordinator responsibilities; personnel accounting procedures; emergency service notification procedures; and a schedule for conducting emergency drills to verify the plan's effectiveness

B. The ERP only needs to address fire emergencies in welding environments — the presence of oxy-fuel cutting equipment automatically restricts the required ERP to fire-related incidents only, and other emergencies are handled under separate organizational response protocols

C. The ERP is only required when more than 50 workers are on site simultaneously — smaller facilities are exempt from the formal Emergency Response Plan requirement and may use informal verbal emergency procedures documented only in the supervisor's daily log

D. The ERP must be submitted to and approved by the provincial OHS authority before any welding or cutting work can begin — without written confirmation of provincial approval, welding operations cannot proceed regardless of safety measures in place

8. A fabricator uses three processes in one work area: SMAW at 150 A, angle grinding of weld reinforcement, and visual inspection of completed welds. What is the minimum eye and face protection required for each of these three tasks?

A. The same shade 5 lens is appropriate for all three tasks — SMAW at 150 A, grinding, and visual inspection all produce similar levels of UV/visible radiation requiring the same shade for complete eye and face protection

B. SMAW at 150 A requires a welding helmet with a minimum shade 10 lens; grinding requires a full-face shield or safety glasses with side shields to protect against flying abrasive particles and metal fragments; visual inspection requires safety glasses with side shields at minimum — each task presents a distinct hazard type and level requiring matched protection

C. Eye protection is only mandatory during active welding — grinding and visual inspection are non-hazardous secondary tasks where eye protection is recommended but not legally required under OHS regulations for certified welders

D. A single shade 5 welding lens provides adequate protection for all three tasks because shade 5 provides both UV/IR protection for SMAW and sufficient impact resistance for grinding operations — wearing multiple eye protection types for different tasks creates confusion and is discouraged by OHS best practice guidelines

9. A health and safety officer is conducting exposure assessments for welders performing SMAW on carbon steel all day. The officer focuses on two fume components: manganese and iron oxide. Which statement most accurately describes the specific health significance of each component?

A. Manganese and iron oxide cause identical health effects — both are respiratory irritants regulated at the same occupational exposure limit because they have equivalent toxicological profiles for welders

B. Iron oxide is the more toxic component and the primary target of welding fume health surveillance — high iron oxide fume concentrations cause progressive pulmonary fibrosis that permanently impairs lung function and is the leading occupational disease in SMAW welders

C. Manganese is of greater toxicological concern because chronic low-level manganese inhalation causes manganism — a neurological disorder with symptoms resembling Parkinson's disease including tremors, rigidity, and cognitive impairment; iron oxide causes mild reversible lung discoloration (siderosis) that is generally benign; both require monitoring but manganese is the priority target for exposure control in carbon steel welding

D. Iron oxide and manganese fumes are both harmless below the ACGIH TLV for total welding fume — individual component limits do not apply and only the total particulate concentration needs to be measured and controlled

10. A permit-required confined space entry is planned for a welder to perform SMAW repairs inside a large storage tank. What minimum rescue equipment must the standby attendant have, and under what condition may the attendant enter the space to attempt a rescue?

A. The standby must be equipped with a personal alarm button and two-way radio — the standby attendant may enter the space whenever they believe the entrant is in distress, provided they take a deep breath and check the atmospheric conditions themselves before entering

B. The standby attendant requires no specialized rescue equipment beyond a flashlight and first aid kit — the standby's role is only to maintain communication with the entrant and call emergency services; all physical rescue is performed exclusively by the fire department

C. The standby must be equipped with the same PPE as the entrant so they are ready to enter immediately in an emergency — the standby should enter the space immediately upon losing communication to assess the situation before calling for additional help

D. The standby must be equipped with communications equipment, a harness retrieval system for non-entry rescue where possible, emergency signaling to summon help, and appropriate atmospheric monitoring equipment — the standby must NOT enter the confined space unless trained as an authorized entrant, the space is confirmed safe, and a second standby is positioned outside; non-entry retrieval must always be attempted first before any rescue entry is considered

11. A project electrical safety plan requires all temporary power distribution for portable welding equipment at a construction site to use ground fault circuit interrupter (GFCI) protection. Why is GFCI protection specifically required for welding equipment on construction sites, and what does a GFCI device detect?

A. GFCI devices monitor the difference between current flowing out through the hot conductor and current returning through the neutral conductor — if this difference exceeds approximately 5 milliamps, indicating current is leaking through an unintended path such as a person or wet surface, the GFCI trips the circuit within milliseconds, preventing fatal electrocution; GFCI protection is required on construction sites because temporary wiring, outdoor conditions, damaged cords, and welding-environment moisture increase the probability of ground fault conditions that would not trip conventional overcurrent devices

B. GFCI devices detect excess current draw above the breaker's rated amperage — on construction sites, temporary wiring is often undersized for welding loads, and the GFCI provides backup overcurrent protection that trips faster than conventional circuit breakers when welding loads exceed the conductor's rated capacity

C. GFCI protection is not required for welding equipment because welding power sources operate at voltages below the 50 V threshold that triggers GFCI requirements in the Canadian Electrical Code — welding voltages of 20–38 V OCV are considered inherently safe and exempt from ground fault protection requirements

D. GFCI devices detect arc flash events in the welding circuit and disconnect power within 0.008 seconds to prevent arc flash burns — this is required on construction sites because welding arcs operate at higher voltages than in shop environments, increasing arc flash incident energy above the threshold for third-degree burns

12. A welder needs to access a work platform 4 metres above the floor to perform welding repairs, and a portable extension ladder is available. Which statement describes the correct setup and work practices for this application?

A. The welder should set up the ladder at any convenient angle and use it as a working platform, resting the electrode holder, cables, and welding machine on the ladder rungs to keep them organized and off the floor during the repair work

B. No specific ladder angle requirements apply to welders because the additional weight of welding equipment makes the 4:1 angle rule unsafe — a steeper angle is required to keep the welder's center of gravity over the ladder base during active welding

C. The extension ladder must be set at the correct angle (1 metre out for every 4 metres of height), extend a minimum 1 metre above the landing, be secured at the top and/or bottom, be on stable level ground, and the welder must face the ladder when ascending and descending — welding equipment must not be draped over or hung from the ladder in a way that creates tripping or electrical hazards

D. Extension ladders may only be used as access equipment, never as a work platform — the welder is required to use a scissor lift, aerial work platform, or fixed scaffolding for elevated welding; using an extension ladder for welding access is prohibited under all Canadian OHS regulations

13. A welding crew performs SMAW production work in a non-air-conditioned fabrication shop during a summer heat wave at 38°C and 65% relative humidity. Which combination of controls most effectively reduces heat stress risk for the welders?

A. Providing each welder with a personal cooling vest filled with ice packs is the only required heat stress control — the cooling vest reduces the core body temperature burden and is the single most effective control for all industrial welding heat stress conditions

B. A combination of controls is required: scheduling the heaviest welding tasks during cooler morning hours; providing hydration stations with cool water at each workstation; installing spot coolers or fans directed at the weld areas; implementing buddy observation to detect early heat illness symptoms; and conducting physiological monitoring such as pulse rate checks during work periods; a single control is rarely sufficient in severe heat conditions

C. Workers acclimatized to heat do not require any additional heat stress controls regardless of temperature and humidity — acclimatization provides complete protection against heat-related illness in all workplace heat stress conditions encountered in Canada

D. Welding cannot be performed when ambient temperature exceeds 35°C under OHS regulation — work must be stopped entirely and cannot resume until temperature drops below 35°C regardless of any engineering or administrative controls implemented

14. A welder reviews the Safety Data Sheet for a FCAW wire containing chromium and nickel and turns directly to Section 8 for workplace exposure information. What information must Section 8 of a WHMIS 2015-compliant SDS contain?

A. Section 8 provides physical and chemical properties including melting point, boiling point, specific gravity, and vapor pressure — this section confirms whether the product will vaporize at welding temperatures and contribute to fume generation

B. Section 8 describes safe storage requirements including required temperature range, incompatible materials, required container types, and maximum quantity limits per storage area

C. Section 8 describes first aid measures for each exposure route including specific antidotes or treatments and recommendations for medical attention

D. Section 8 describes exposure controls and personal protection — it includes occupational exposure limits for each hazardous component, required engineering controls such as LEV specifications, appropriate respiratory protection type and protection factor, and required PPE for skin, eyes, and hands during normal use

15. A maintenance team must perform SMAW welding on a piping system that recently carried natural gas. The maintenance manager initiates a Permit to Work (PTW) process before any welding begins.

What is the primary purpose of the PTW system, and which work control function does it provide that a WPS cannot?

A. The PTW system verifies that all required preparation steps are completed before high-hazard work begins — confirming the piping has been properly purged, isolated, atmosphere-tested, and signed off by authorized personnel; the PTW communicates who authorized the work, what hazard controls are in place, the permit time limit, and required steps if conditions change; the WPS covers only the welding procedure and has no mechanism for confirming the safety of the work environment before welding starts

B. The PTW ensures the WPS has been reviewed and approved by the engineering authority before hot work on gas piping begins — the PTW is a WPS approval form specific to utilities and process industries that substitutes for the standard CWB procedure qualification requirements

C. The PTW replaces the confined space entry permit for welding inside gas piping — once a PTW is issued for hot work on a gas system, no separate confined space entry permit is required because the PTW covers all associated hazards

D. The PTW system verifies that the welding crew has reviewed all applicable SDSs — the PTW functions primarily as a WHMIS compliance verification tool with no role in controlling physical isolation or atmospheric conditions of the work area

16. During a pre-job safety walkthrough of a structural steel welding area, a safety-conscious welder identifies four conditions. Which represents the MOST SIGNIFICANT slip, trip, and fall hazard specific to welding environments?

A. A single electrode wrapper lying on the concrete walkway floor — paper wrappers create a minor slip hazard in dry conditions and should be picked up, but do not represent the most significant hazard category in welding environments

B. A 25-metre welding cable running along the floor from the power source to the work area, taped down at floor transitions with duct tape — cables taped down with high-visibility tape present minimal hazard when the tape is maintained and the path is marked

C. Hot slag and spatter accumulation on the floor grating at the base of a metal staircase, combined with grinding debris and worn non-skid tape on the grating — hot spatter burns through non-skid tape, and the combination of metallic debris, worn slip protection, and heat damage on a sloped stair surface creates a severe slip-and-fall hazard in a location where falls cause serious injury

D. A slight bow in a floor drain cover near the weld area caused by a previous piece of heavy material being dragged over it — a bowed drain cover creates a subtle trip hazard but is in a clearly visible low-traffic area that can be stepped around

17. A welder spills approximately 50 mL of SAW granular flux containing calcium fluoride and manganese silicate on both forearms. Within minutes the welder reports a burning sensation. What is the correct first aid response, and what must the first-aider be aware of?

A. The correct first aid is to brush off the dry flux with a dry cloth and then apply burn gel — water should not be used because flux compounds are highly reactive with water, and the reaction with skin moisture is what is causing the burning; adding water worsens the reaction

B. The correct immediate first aid is to flush the affected skin with large volumes of cool running water for at least 15–20 minutes to dilute and remove the flux — the first-aider must wear gloves to avoid secondary contamination; the SDS for the specific flux must be checked for additional steps such as calcium gluconate gel for fluoride compounds, and medical attention should be sought if burning persists

C. Dry flux on skin does not require first aid — flux compounds are biologically inert and the burning sensation is caused by friction from the granular particles; brushing the particles off is sufficient and no further action is needed

D. The correct first aid requires a specialized pH-buffering neutralizer applied before flushing with water — flushing with plain water before neutralizing the flux drives the chemical deeper into the skin tissue and must not be done first

18. In the context of occupational health and safety law, a welding supervisor is found responsible after an incident where a welder was injured using equipment the supervisor knew was defective. The supervisor's defense is that they were not present at the time. Which legal concept most directly applies, and what must a supervisor demonstrate to establish a due diligence defense?

A. Due diligence does not apply to supervisors — under Canadian OHS law, criminal and civil liability for workplace incidents is borne exclusively by the employer, and supervisors cannot be held personally liable regardless of their prior knowledge

B. Under the principle of strict liability, supervisors are automatically liable whenever an injury occurs in their area of responsibility — no defense is available and due diligence cannot reduce or eliminate liability for any supervisor-level OHS violation

C. Due diligence requires only that the supervisor had no direct physical involvement in the incident — a supervisor who was not physically present when the defective equipment was used has established due diligence by default

D. Due diligence requires the supervisor to demonstrate all reasonable precautions were taken to prevent the incident — in this case, knowing the equipment was defective and allowing it to remain in service represents a failure of due diligence regardless of physical presence; supervisors have a positive duty under OHS law to identify and remove hazards, and prior knowledge of a defect without corrective action is direct evidence this duty was not fulfilled

19. Under WHMIS 2015, supplier labels use the signal words "DANGER" and "WARNING" as required label elements. Which statement correctly describes how these two signal words are differentiated?

A. "DANGER" is used on supplier labels for products in the more severe hazard categories within a given hazard class, while "WARNING" is used for less severe categories of the same hazard type; only one signal word appears on a label even when a product has multiple hazards, and "DANGER" takes precedence over "WARNING" when both would apply

B. "DANGER" applies only to products that are immediately dangerous to life and health, while "WARNING" applies to products with chronic health effects that develop after repeated exposures — the signal word indicates whether the health risk is acute or chronic in nature

C. "DANGER" is used exclusively on products classified as physical hazards such as flammable and explosive products, while "WARNING" is used exclusively on products classified as health hazards — the signal word identifies the hazard category type rather than the severity level

D. "DANGER" and "WARNING" are used interchangeably on WHMIS 2015 supplier labels — the choice of signal word is determined by the manufacturer's preference and marketing conventions rather than by a standardized regulatory classification criterion

20. A welder works on a structural steel connection 5 metres above the floor using a personal fall arrest system with a 1.8-metre energy-absorbing lanyard and full-body harness. The anchor point is at the welder's foot level. Considering a typical deceleration distance of 1.0 metre for a fully deployed energy absorber, what is the minimum clearance below the welder's feet needed to prevent contact with a lower level?

A. The minimum fall clearance required is 1.8 metres (lanyard length only) — the energy absorber and harness elongation do not add to the total fall distance because they activate only during impact and do not extend the total fall height

B. The minimum fall clearance is approximately 4.3 metres, calculated as: lanyard length (1.8 m) + energy absorber deceleration distance (1.0 m) + harness elongation and dorsal D-ring height above feet (approximately 1.5 m) = 4.3 m below the anchor; since the anchor is at foot level, at least 4.3 m of clearance below the welder's feet is required — with only 5 m to the floor, this is a marginal situation requiring engineering review

C. The minimum fall clearance is 2.8 metres, calculated as lanyard length (1.8 m) plus half the energy absorber distance (0.5 m) plus a 0.5 m safety factor — the full deceleration distance only applies when the lanyard is attached above the welder's head, not at foot level

D. No fall clearance calculation is needed when the anchor is at foot level because foot-level anchor points are prohibited by all Canadian OHS fall protection standards — the calculation is irrelevant because the described configuration violates the requirement for anchoring above the dorsal D-ring

21. A structural connection drawing shows a weld symbol with a circle below the reference line containing the number "18" and the notation "4 spaces @ 50" to the right of the symbol. What type of weld does this symbol specify and what do the numerical values mean?

A. The symbol specifies a circular groove weld for a pipe-to-plate connection — "18" is the groove weld root opening in mm and "4 spaces @ 50" indicates the spacing between four groove weld segments around the pipe circumference

B. The symbol specifies a spot weld for resistance welding — the circle on the reference line is the spot weld designation, "18" is the nugget diameter in mm, and "4 spaces @ 50" specifies the number of spot welds and their center-to-center pitch in mm

C. The symbol specifies a plug weld — the circle below the reference line is the plug weld symbol, "18" is the hole diameter in mm, and "4 spaces @ 50" indicates that 4 plug welds are required with 50 mm center-to-center spacing; the hole is on the arrow-side member and is filled with weld metal

D. The symbol specifies a seam weld — the circle represents a resistance seam weld, "18" is the seam width in mm, and "4 spaces @ 50" specifies the required overlap distance between adjacent seam weld segments

22. Under AWS D1.1 Structural Welding Code, a fabricator assembles a prequalified double-V groove butt joint. The inspector measures a root face of 2 mm and a root opening of 5 mm. The specified

prequalified joint calls for a root face of  $3 \text{ mm} \pm 1.5 \text{ mm}$  and a root opening of  $3 \text{ mm} \pm 1.5 \text{ mm}$ . What is the disposition?

A. Both dimensions are acceptable — root face of 2 mm is within the  $3 \pm 1.5 \text{ mm}$  tolerance range of 1.5–4.5 mm, and root opening of 5 mm is also within the same tolerance range

B. The root face of 2 mm is within tolerance and acceptable, but the root opening of 5 mm exceeds the 4.5 mm maximum and the joint must be re-fitted or receive a formal engineering disposition before welding proceeds

C. Both dimensions are rejectable — the root face specification governs a double-V groove and any deviation from the nominal 3 mm value requires complete joint re-preparation regardless of the stated tolerance

D. The root face of 2 mm is within the tolerance range of 1.5 to 4.5 mm and is acceptable; the root opening of 5 mm exceeds the maximum of 4.5 mm — under AWS D1.1, the inspector must reject the joint as-fit; the fabricator must either close the gap to within tolerance or, if the gap cannot be closed without stress, may insert and tack-weld a backup strip with the engineer of record's approval

23. Under CWB Standard W47.1, a purchasing agent asks why a structural steel fabricator holds a W47.1 Division 2 certification rather than Division 1. What is the technical difference between W47.1 Division 1 and Division 2 certifications?

A. A W47.1 Division 1 certification requires a Welding Engineer (P.Eng. with welding specialization) to be responsible for the company's welding activities and to prepare, approve, and control all welding procedure specifications — required for high-consequence structural applications; W47.1 Division 2 requires only a Welding Supervisor with demonstrated welding knowledge and experience rather than a registered Welding Engineer, making it appropriate for manufacturers of less-critical structural components

B. W47.1 Division 1 allows the company to weld materials with carbon equivalents up to 0.65, while Division 2 is limited to materials with carbon equivalents below 0.45 — the division designation is based exclusively on the chemical composition range of materials the company is authorized to weld

C. W47.1 Division 1 certification is required for welding on dynamic structures while Division 2 is for static structures — the division designation reflects the service load type rather than the level of engineering oversight required

D. W47.1 Division 1 and Division 2 differ only in the number of welders employed — companies with more than 25 welders must hold Division 1, while smaller companies may operate under Division 2; the technical requirements for procedures and qualifications are identical between divisions

24. A welder picks up a plate from the steel storage rack labeled "CSA G40.21 350W." Before welding, the welder reviews the applicable WPS. What does the "W" suffix in "350W" indicate, and why is it significant for the welding procedure?

A. The "W" indicates "weldable" — the steel has been certified by the manufacturer as pre-qualified for welding without any preheat requirement regardless of thickness, carbon equivalent, or restraint level; the WPS preheat requirements can be waived for any 350W steel in any application

B. The "W" indicates "weathering" steel — 350W contains small additions of copper, chromium, and nickel that enable it to form a tightly adherent protective patina when exposed to the atmosphere; this designation is significant for welding because standard carbon steel filler metals may not match the weathering steel's corrosion performance at the weld joint, and the WPS should specify a matching weathering-grade filler metal when the joint will be exposed to weather in service

C. The "W" indicates "wide flange" — the material was produced from wide-flange beam sections subsequently flame-cut to plate dimensions; the flame-cutting process requires the WPS to specify enhanced preheat because edge hardening from flame cutting affects heat input requirements

D. The "W" designates "welded" construction — the steel was manufactured by the electric resistance welded process rather than by rolling, and this manufacturing history does not affect the WPS for structural welding

25. A piping inspector reviews a weld map for an ASME B31.3 process piping installation. Weld No. P-107 lists the line designation "200-CS-3"-1500#." What does this notation communicate to the inspector?

A. The notation means the piping line is 200 metres long, the material is cold-reduced seamless pipe, the nominal pipe size is 3 inches, and the pressure rating is 1,500 bar — both the physical attributes and service pressure in metric units are specified

B. The line designation communicates the process fluid number (200), the pipe schedule is CS (carbon steel class schedule), the nominal pipe size is 3-inch diameter, and the flange and valve pressure class is 1,500 psi — the full designation tells the inspector the process line identity, material, size, and pressure class

C. The line designation communicates the process line number (200), the material code (CS = carbon steel), the nominal pipe size (3 inches), and the ASME pressure class (1500# = Class 1500 rating) of the flanges and fittings — this information allows the inspector to confirm the WPS is appropriate for the material, size, and service pressure class

D. The notation is a contractor-specific internal reference code with no standardized meaning — each contractor's piping numbering convention varies and the inspector must request the contractor's legend document before interpreting any line designation

26. Following hydrostatic testing and draining of a completed ASME VIII Div 1 pressure vessel, the inspector needs to verify the integrity of the closure welds before shipment but the vessel cannot sustain a second hydrostatic test. What alternative leak testing method is recognized by ASME Section V Article 10, and what is its principal limitation compared to a pressure test?

A. Vacuum box testing using a soap solution is the ASME Section V Article 10 alternative — this method is superior to pressure testing because it detects leaks from the outside and can be applied to the entire vessel surface in one continuous sweep without any pressure risk

B. Pneumatic leak testing using dry air or nitrogen to pressurize the vessel, with external soap bubble solution or acoustic emission monitoring to detect leaks, is one ASME-recognized alternative — pneumatic testing's principal limitation is the higher stored energy in a compressed gas system; if the vessel were to fail, the energy release would be significantly more violent than during hydrostatic testing, requiring greater safety exclusion zones and additional risk management

C. Helium mass spectrometer leak testing is the only ASME-recognized alternative to hydrostatic testing — all other leak testing methods are exclusively NDE methods under ASME Section V and do not qualify as pressure integrity tests under Section VIII Division 1

D. Ultrasonic examination of all closure welds to 100% coverage is the only acceptable substitute for a second hydrostatic test — the UT must be performed by a Level III examiner and results documented on Form UG-84 before the vessel can be released for shipment

27. A CWB-qualified welder must submit a macro examination specimen as part of a qualification test on a T-joint fillet weld. The specimen is prepared by cross-cutting the test weld, grinding, and etching the cross-section. Which defects and dimensional attributes is the macro examination specifically designed to reveal?

A. The macro examination reveals only surface defects visible on the weld bead profile — internal defects such as subsurface porosity, root lack of fusion, and deep cracks cannot be detected and require RT or UT to identify

B. The macro examination reveals only the weld metal grain structure and heat-affected zone size — dimensional measurements of weld throat and leg cannot be made on a macro specimen because the etching process distorts the dimensions

C. The macro examination reveals the weld profile from the outside surface but cannot evaluate the root area of a T-joint fillet weld because the root is the furthest point from the etched cross-section surface

D. The macro examination reveals the complete cross-sectional geometry including actual weld throat and leg dimensions, degree of root fusion, the presence of discontinuities throughout the cross-section (porosity, cracks, LOF, inclusions), the heat-affected zone width, and the weld profile — this is why macro examination is used for fillet weld qualification testing where the critical root fusion and actual throat cannot be assessed from the surface

28. A GTAW procedure qualification was conducted using 100% argon shielding gas at 15 L/min. The welding engineer now wants to use the same PQR to support a new WPS specifying helium-25% argon at 18 L/min. Under ASME Section IX QW-408 essential variables for GTAW, does this change require requalification?

A. Under ASME Section IX QW-408.2, a change in shielding gas type or mixture is an essential variable for GTAW — changing from 100% argon to a helium-argon mixture requires either a new qualification test or an existing PQR that specifically qualifies the helium-argon mixture; the argon-qualified PQR cannot support the new WPS without requalification

B. Shielding gas type is a supplementary essential variable in ASME Section IX, not an essential variable — supplementary essential variables only apply when notch toughness testing is required, and for a standard structural GTAW procedure the change from argon to helium-argon does not require requalification

C. A change in shielding gas flow rate from 15 L/min to 18 L/min is the only variable being changed — the gas type change from pure argon to a helium blend is classified as the same "inert" category under ASME IX and does not trigger requalification; only changes between inert and active shielding gases require requalification

D. No requalification is required for any shielding gas change in GTAW procedure qualification under ASME Section IX — shielding gas composition and flow rate are non-essential variables in all editions and may be changed without requalification as long as the base metal, filler metal, and welding position remain unchanged

29. A structural connection requires a single-lap fillet welded joint between two 8 mm thick plates, with the minimum overlap length specified as 5T. What is the reason for this minimum overlap requirement, and what is the required minimum overlap dimension?

A. The 5T minimum overlap specifies that the plate edge must extend a minimum of 5T beyond the toes of the fillet welds — for 8 mm plate, the plate edge beyond the fillet welds must be 40 mm minimum; this prevents distortion of the plate edge from the heat of the fillet weld

B. The 5T minimum overlap is a preheat requirement — 5T defines the minimum plate surface that must be preheated before welding to prevent heat sink effects causing insufficient fusion at the plate edge fillet weld

C. The 5T minimum overlap ( $= 5 \times 8 \text{ mm} = 40 \text{ mm}$ ) ensures the load transfer path through the two longitudinal fillet welds is long enough for the shear flow to develop the required joint strength — insufficient overlap creates an eccentrically loaded joint where the short weld length cannot transfer the design load through shear without excessive peel forces on the fillet weld root

D. The 5T minimum overlap ensures both plates have equal thermal mass at the weld zone — the 5T requirement is waived when both plates have identical thickness and the same preheat is applied to both sides of the joint

30. A welder completes a long continuous fillet weld on a stiffener plate to a base plate in a single pass and discovers the base plate has bowed longitudinally, now concave on the weld side. What specifically causes longitudinal distortion in fillet welded connections, and what welding technique directly counters it?

A. Longitudinal distortion is caused by the fillet weld size being too large for the plate thickness — reducing the weld size to the minimum required eliminates longitudinal bowing; over-welding is the exclusive cause

B. Longitudinal distortion results from the longitudinal shrinkage of the weld along its length — the weld metal is shorter after cooling than the parent material along the same axis, pulling the plate into a bow with the concave face toward the weld; backstep welding, skip welding, or welding alternate short segments from the center outward distributes the longitudinal shrinkage and reduces the net bow

C. Longitudinal distortion is caused by the plate being improperly clamped during welding — if not held flat in a jig, the weld heat causes free thermal expansion that permanently bows the plate; adequate clamping is the only prevention regardless of welding technique

D. Longitudinal distortion only occurs in groove welds, not fillet welds — fillet welds produce only angular distortion and transverse shrinkage; a longitudinal bow observed after fillet welding is caused by pre-existing plate camber rather than the welding process

31. A fabrication shop producing large numbers of identical structural T-joints currently welds double-sided fillet welds in the horizontal fillet position (2F). The foreman proposes mounting assemblies on a rotary positioner to weld in the flat "boat" position (45° tilt). What quality and productivity benefits justify this investment?

A. Welding in the flat "boat" position allows higher welding currents and larger electrode diameters than the horizontal fillet position, enabling single-pass deposition of larger fillet welds that would require multiple passes horizontally; the improved pool support reduces undercut at the upper toe, improves root fusion, produces more uniform leg dimensions, increases travel speed, and reduces welder fatigue

B. The boat position provides quality benefits only for fillet welds larger than 12 mm — for welds below 12 mm, the horizontal and boat positions produce identical quality and the positioner investment provides no technical justification

C. Positioners are only permitted for GMAW and SAW processes — SMAW in the boat position is not recognized by any structural welding standard as equivalent to flat or horizontal position welding and does not qualify under the same WPS

D. The boat position reduces weld quality compared to horizontal position because the 45° tilt creates a gravity component along the weld axis that causes the pool to run forward, producing inconsistent fusion that is specifically prohibited in quality-critical structural fabrication standards

32. A welder completes a structural weld repair and the quality plan requires liquid penetrant testing (PT) before acceptance. In what specific order must the PT process steps be performed, and why is the sequence important?

A. The correct PT sequence is: apply developer, wait dwell time, apply penetrant, remove excess penetrant, inspect — developer is applied first to prepare the surface and the penetrant is then attracted into the developer for maximum indication visibility

B. The correct sequence is: apply penetrant, apply developer simultaneously, wait combined dwell time, remove both simultaneously, inspect under UV light — both can be applied simultaneously to save time in time-critical repair applications

C. The correct sequence is: clean and dry the surface, apply penetrant, wait penetrant dwell time, remove excess penetrant, apply developer, wait developer dwell time, inspect — however, the sequence may be reversed for subsurface discontinuities where developer is applied first to draw penetrant upward

D. The correct sequence is: pre-clean and dry the surface thoroughly, apply penetrant and allow adequate dwell time for it to enter any discontinuities, remove excess surface penetrant without removing penetrant from discontinuities, apply developer and allow developer dwell time for trapped penetrant to bleed back and be adsorbed into the developer coating, then inspect under appropriate lighting — reversing any step destroys indication visibility and produces false results

33. A radiographic testing technician reviews a radiograph of a welded joint and observes the film is very light (low density) in the center of the weld area, making the weld metal difficult to see clearly. The sensitivity indicators (IQI/penetrameters) are not visible. What does this condition indicate, and what change must the radiographer make?

A. Low film density in the center of the weld indicates excessive exposure that has overexposed the film in the denser weld metal area — the radiographer must reduce the exposure time or increase source-to-film distance to reduce the dose

B. Low film density at the weld center is expected because the weld metal is denser than the base plate — radiation absorption by the denser weld metal reduces film exposure, producing a lighter image in the weld; this is the normal appearance of a correctly exposed radiograph

C. Low film density indicates underexposure — insufficient radiation has reached the film to produce adequate photochemical effect; the radiographer must increase the exposure by increasing source activity, increasing exposure time, or decreasing source-to-film distance until film density in the weld area meets the code-required minimum (typically 2.0–4.0 H&D density per ASME Section V), and the IQI must be visible at the required sensitivity

D. Low film density in the weld area indicates the radiation source energy is too low to penetrate the weld cross-section — the technician must switch to a higher-energy radiation source; film density cannot be corrected by adjusting exposure time or source-to-film distance

34. A structural engineer specifies a CJP groove weld at a critical tension connection. The welder asks why a CJP is required rather than a PJP groove weld. Which explanation most accurately describes the design distinction?

A. A CJP groove weld is specified exclusively to eliminate backing bar requirements — the complete penetration means no backing bar is needed; the structural strength of CJP and PJP groove welds of the same size are identical, and the choice is purely based on fabrication preference

B. A CJP groove weld provides full-thickness weld metal across the entire joint cross-section, developing the full strength of the base metal in tension, shear, compression, and bending — a PJP has an unwelded root portion that reduces the effective throat and joint load capacity; where full base metal strength must be developed across the joint or where the un-welded PJP root would be subject to tensile forces that initiate fatigue cracking, the engineer specifies CJP to ensure the connection has no effective notch at the root

C. CJP groove welds are required by code only when the base metal exceeds 19 mm — for plate up to 19 mm, PJP groove welds are structurally equivalent to CJP welds and may be substituted without engineering approval in all structural applications

D. A CJP groove weld is visually distinguishable from a PJP groove weld by the presence of a backing bar — any weld with a backing bar is by definition a CJP weld, while any weld without a backing bar is a PJP weld regardless of actual penetration depth achieved

35. A welder notices a single-V groove joint has been prepared with an included groove angle of  $40^\circ$  instead of the specified  $60^\circ$ . The root face and root opening are within tolerance. What quality risk does the reduced groove angle create, and how should the welder proceed?

A. A  $40^\circ$  included groove angle has no quality implications because the depth of groove preparation is unchanged — the welder should proceed with the specified WPS without modification

B. A  $40^\circ$  groove angle actually improves weld quality compared to  $60^\circ$  because the narrower groove produces less weld metal volume, reducing distortion and heat input — the welder should proceed immediately because the tighter angle is the better choice

C. A  $40^\circ$  included angle reduces electrode access in the lower passes — the welder cannot adequately direct the electrode into the narrow groove to achieve sidewall fusion on early fill passes; this restricted access is the primary source of incomplete sidewall fusion (LOF) defects in tight-angle groove welds; for SMAW, a minimum included angle of  $60^\circ$  is typically required for prequalified single-V joints, and the out-of-specification preparation must be reported to the inspector or supervisor for disposition before welding proceeds

D. A reduced groove angle from  $60^\circ$  to  $40^\circ$  requires increasing the root face to a minimum of 8 mm — without this increase, the reduced angle causes complete burn-through on the root pass; the welder may proceed only after re-preparing the root face to at least 8 mm

36. A maintenance welder orders replacement pipe to repair a section of process piping stamped "4-inch NPS SCH 80." The material is carbon steel ASTM A106 Grade B. What does "SCH 80" mean and how does it relate to the pipe wall thickness?

A. "SCH 80" is the pipe schedule number — a standardized designation specifying the wall thickness relative to the nominal pipe size; for 4-inch NPS Schedule 80, the wall thickness is approximately 0.337 inches (8.56 mm); as the schedule number increases (10, 20, 40, 80, 120, 160), the wall thickness increases for the same nominal pipe size; the welder must specify the same schedule number when ordering replacement pipe to ensure the same wall thickness and pressure rating

B. "SCH 80" indicates the pipe was manufactured to API Schedule 80 — a petroleum industry specification requiring specific chemical composition and mechanical testing beyond the ASTM A106 Grade B standard; pipes marked SCH 80 have had 80% of their total required production tests completed at the mill

C. "SCH 80" means the pipe nominal bore ID is 80% of the nominal pipe size — for 4-inch NPS, the actual bore ID is  $4 \times 0.80 = 3.2$  inches; the schedule number represents the percentage relationship between the nominal pipe size and the actual bore diameter

D. "SCH 80" designates a weld seam classification — Schedule 80 pipes have an 80% joint efficiency factor assigned to the longitudinal seam and must be welded with a WPS qualified at 80% of the base metal tensile strength minimum

37. An engineer asks why the minimum Charpy V-notch energy requirement for the weld metal of a liquefied natural gas (LNG) storage tank is specified at  $-162^{\circ}\text{C}$  rather than the  $-30^{\circ}\text{C}$  commonly used for general structural work. Which explanation is technically correct?

A. The  $-162^{\circ}\text{C}$  testing temperature is specified only as a contractual requirement from the LNG facility operator — there is no technical basis for low-temperature Charpy testing for carbon steel weld metal because carbon steel does not undergo ductile-to-brittle transition below  $-40^{\circ}\text{C}$

B. The  $-162^{\circ}\text{C}$  testing requirement applies only to the base metal, not the weld metal — weld metal toughness is inherently superior to base metal toughness due to fine grain structure from rapid solidification, and weld metal impact testing at LNG temperatures is waived in all applicable codes

C. The  $-162^{\circ}\text{C}$  testing temperature is required because LNG storage tanks are made exclusively from titanium alloy — titanium's BCC crystal structure has a ductile-to-brittle transition that only appears below  $-100^{\circ}\text{C}$ , while austenitic stainless steel and nickel alloys used in other LNG applications do not require low-temperature testing

D. The Charpy test temperature for LNG service must match or be lower than the minimum design metal temperature of the tank — LNG is stored at  $-162^{\circ}\text{C}$ , and at this temperature a weld metal with a high ductile-to-brittle transition temperature could fracture in a brittle mode under hydraulic head or thermal stresses; the  $-162^{\circ}\text{C}$  test temperature confirms the weld metal DBTT is below the minimum service temperature, ensuring the weld metal remains on the upper shelf throughout service

38. A fabrication shop must perform post-weld heat treatment on an ASME VIII Div 1 pressure vessel requiring a soak temperature of  $620^{\circ}\text{C} \pm 15^{\circ}\text{C}$  using either electric resistance heating blankets or an enclosed furnace. Which statement correctly describes the minimum equipment requirements for compliant PWHT?

A. Either heating method is acceptable with no additional equipment requirements — the welder performing the PWHT must visually observe the heating blanket color to estimate the temperature, and official temperature documentation is only required when the customer specifically requests it

B. An enclosed furnace is the only ASME-permitted method for PWHT of pressure vessels — electric resistance heating blankets are classified as field repair methods and are not acceptable for original vessel fabrication

C. Regardless of the heating method, PWHT must be performed with calibrated thermocouples attached directly to the vessel wall and connected to a calibrated recording instrument that produces a time-temperature chart — the chart is required QA documentation; heating and cooling rates must be controlled within specified limits, and thermocouples must be located to verify the entire required volume of material reaches the minimum soak temperature

D. The only temperature documentation requirement for ASME PWHT is that the operator records the soak start and end times in the fabrication traveler — an actual thermocouple-generated time-temperature chart is optional documentation that is not required by ASME VIII Division 1 for field PWHT operations

39. A structural welder holds a CWB qualification for SMAW on structural steel plate in the 3G and 4G positions. The welder has been on medical leave for 8 months and is returning to welding work. Under CWB standards, what recertification or requalification is required before the welder can return to production welding on certified work?

A. No recertification is required — CWB welding qualifications are lifetime credentials that remain valid regardless of any period of inactivity; once a welder passes their qualification test, the certification remains valid permanently unless voluntarily surrendered

B. Under CWB standards, a welder who has not been engaged in welding in the qualified process within the previous 6 months must demonstrate continued proficiency before returning to production work on certified structures — the company's responsible welding supervisor must verify and document the welder's ability to produce acceptable welds in the qualified process and position; a requalification test may be required at the CWB's discretion; re-employment after extended medical leave triggers this activity requirement review

C. The welder must repeat the full original qualification test because any break in employment resets the qualification to "inactive" status — only welders in continuous employment with the same CWB-certified company maintain active qualification status

D. CWB qualifications require annual renewal through written examination only — the welder must pass a written theory test covering SMAW processes every 12 months regardless of production welding activity; no practical requalification is ever required after the initial test

40. On a fabrication drawing, a weld symbol shows a wavy line (surfacing weld symbol) below the reference line. Adjacent to the symbol are the numbers "6" and "150 × 200." What does this symbol specify?

A. The wavy line below the reference line is the surfacing weld symbol — it specifies that a weld layer (surfacing, hardfacing, or buildup deposit) is to be deposited on the arrow-side surface; "6" specifies the minimum finished deposit thickness in mm after machining; "150 × 200" specifies the area to be surfaced in mm; surfacing weld symbols never appear on both sides of the reference line because surfacing is applied to a surface rather than joining two members

B. The wavy line below the reference line indicates a back weld — "6" specifies the back weld throat in mm and "150 × 200" indicates the spacing between two back weld passes; back welds always use the wavy line symbol to distinguish them from the bevel symbols used for groove welds

C. The wavy line symbol is used exclusively for flexible or dynamic connections where controlled weld flexibility is designed into the joint — "6" specifies the minimum weld root width and "150 × 200" specifies the minimum flexibility zone dimensions

D. The wavy line symbol below the reference line indicates the weld must be performed with a mechanized oscillating (weaving) motion — "6" specifies the minimum weave amplitude and "150 × 200" specifies the weld length and width

41. A maintenance welder finds that pipe in a newly completed process area is banded in orange with a white secondary band. According to CAN/CGSB 24.3 pipe identification conventions, what additional precaution must the welder take before any hot work on orange-banded piping?

A. Orange banding with a white secondary band indicates drinking water service — the only required precaution is to notify the facilities manager of the planned outage; no chemical hazard precautions are needed for potable water piping

B. Orange banding with a white secondary band indicates a cryogenic service such as liquid nitrogen — the welder must verify the pipe is fully warmed to ambient temperature before hot work because cutting or welding cold piping creates condensation and potential for brittle fracture

C. Orange and white banding indicates a steam service piping system — the welder must confirm the system is fully depressurized and cooled before any cutting begins, and additional preheat requirements for steam system carbon steel piping apply

D. Orange banding in the CAN/CGSB piping identification system indicates flammable or combustible liquids — the welder must confirm the piping is fully isolated, drained, purged, and atmosphere-tested before any hot work begins; orange-coded piping contains petroleum or other flammable liquids that present explosion and fire hazards if hot work is performed without complete isolation and purging

42. A process plant piping inspector applies ASME B31.3 to evaluate a new small-bore piping installation for a chemical process. The inspector identifies some pipe welds in what B31.3 classifies as "Category D" fluid service. What specific provisions of B31.3 apply to Category D fluid service piping, and how do they differ from Normal Fluid Service requirements?

A. Category D fluid service requires the most rigorous inspection — it is defined as hazardous flammable or explosive service and mandates 100% radiographic or ultrasonic testing, mandatory PWHT, and third-party verification of all weld procedure qualifications

B. Category D fluid service is defined as non-toxic, non-flammable service at temperatures between  $-20^{\circ}\text{C}$  and  $186^{\circ}\text{C}$  and pressures below 1030 kPa gauge — Category D has the same examination and testing requirements as Normal Fluid Service, and the distinction serves only documentation purposes

C. Category D fluid service is defined as non-flammable, non-toxic service where failure of any component would not endanger persons and where the fluid is non-damaging to human tissue — the relaxed provisions for Category D allow random rather than 100% examination of welds, permit use of certain unlisted components, and may allow exemption from hydrostatic testing in some cases; these reduced requirements reflect the lower consequence of a Category D piping failure

D. Category D fluid service applies exclusively to utilities such as instrument air, nitrogen, and cooling water — the examination and pressure test requirements are identical to Normal Fluid Service because B31.3 does not distinguish between service types for examination requirements, only for the design factor applied to allowable stress

43. During inspection of a structural steel beam, the inspector discovers two arc strikes on the base metal surface approximately 80 mm from the nearest weld toe. The arc strikes are approximately 5 mm in diameter with a slightly hardened appearance. Under CSA W59 and structural welding inspection requirements, how must these arc strikes be dispositioned?

A. Arc strikes outside the weld zone are reportable and rejectable under CSA W59 — arc strikes must be ground smooth to remove the hardened surface material and the ground area must be MT or PT inspected to confirm no cracks remain; the hardened surface from rapid heating and quenching can serve as a fatigue crack initiation site under cyclic loading and must be removed; a repair weld may also be required if grinding removes more than the permitted amount of base metal

B. Arc strikes outside the weld zone are a cosmetic issue only — they must be documented in the inspection record but require no corrective action because they are not within the weld metal or HAZ and cannot affect structural performance

C. Arc strikes anywhere on the structure must be repaired by depositing a repair weld using E7018 SMAW — grinding without subsequent repair welding is not a permitted corrective action for arc strikes on structural steel under any applicable standard

D. Arc strikes are only a concern on fatigue-sensitive structures — on statically loaded members, arc strikes are acceptable without corrective action regardless of size, depth, or hardness because static loading does not create the cyclic stress that initiates cracking at surface discontinuities

44. An UT technician performing phased-array UT (PAUT) on a structural weld reports an indication at 45 mm depth in a 50 mm thick groove weld with a dB response 8 dB above the reference level. The applicable code specifies rejection at 6 dB above reference for indications in this zone. What action is required?

A. The 8 dB response is only 2 dB above the rejection threshold — this marginal exceedance requires additional RT to verify the UT finding before any weld rejection or repair can proceed; UT indications within 5 dB of the rejection threshold are always considered "conditional accepts" under all structural welding codes

B. An indication 8 dB above reference exceeds the code rejection threshold of 6 dB — the weld contains a rejectable indication at this location; the technician must document the indication's position, depth, length, and dB amplitude in the inspection report, report the indication as rejectable, and recommend repair; the welder and engineering team must be notified and a repair procedure established

C. A UT indication amplitude 8 dB above reference is below the minimum recordable threshold — only indications 10 dB or more above reference are required to be recorded or evaluated; the technician does not need to include it in the official inspection report

D. An indication 8 dB above reference is automatically classified as a planar defect — any UT indication above the reference level in structural welds is always a planar crack by definition under all structural welding codes, and no further characterization is required before recommending immediate weld removal and replacement

45. During production inspection of structural fillet welds, the inspector uses a fillet weld gauge and measures the effective throat of a 6 mm specified fillet weld as 5.2 mm. The fusion line is clean with no visible discontinuities, and the workpiece is statically loaded carbon steel. What is the correct disposition of this measurement?

A. The 5.2 mm effective throat is acceptable for a 6 mm fillet weld — CSA W59 permits effective throat values up to 25% less than the nominal leg size, so any effective throat above 4.5 mm is acceptable regardless of weld profile

B. A 5.2 mm effective throat on a 6 mm fillet is unacceptable because the effective throat must equal exactly 6 mm divided by  $\sqrt{2}$  ( $= 4.24$  mm) — measuring the effective throat against the nominal leg size is incorrect; the 5.2 mm reading is irrelevant without knowing the theoretical throat

C. The 5.2 mm effective throat is acceptable for any fillet weld regardless of specified leg size — CSA W59 does not set a minimum effective throat for statically loaded connections; effective throat is inspected only on dynamically loaded structures

D. For a 6 mm specified fillet weld, the theoretical throat is approximately 4.24 mm ( $6 \times 0.707$ ) — a measured effective throat of 5.2 mm exceeds the theoretical throat and confirms the actual throat is meeting the required value; however, visual inspection must also confirm the actual fillet leg dimensions meet the minimum specified leg size, and the inspector should use the leg gauge to verify actual leg dimensions rather than relying on the throat measurement alone

46. A welding contractor is awarded a contract to fabricate structural steel bridge components to CSA S6. When the CWB auditor arrives to certify the company, what is the auditor specifically evaluating beyond individual welder qualification records?

A. The CWB company audit only reviews welder qualification records — company certification is simply a registry of all individually qualified welders employed at the company; the audit confirms the company employs enough qualified welders to complete the contract

B. The CWB auditor evaluates only the welding equipment to confirm it is in serviceable condition — calibration records for power sources, meters, and gauges are the sole focus of company certification

C. The CWB company audit evaluates the complete welding quality management system — this includes: the presence and currency of all required WPSs with supporting PQRs; documentation and control systems for WPSs, welder qualification records, and material traceability; the qualifications and responsibilities of the welding supervisor; calibration status of welding equipment; storage and handling conditions for consumables; and evidence the company actually implements its quality system in production rather than only on paper

D. The CWB company audit is a documentation review only — the auditor reviews paper records but does not visit the production floor, observe any welding, evaluate equipment, or interview production workers; certification is based exclusively on the completeness of the submitted document package

47. A fabricator is assembling a large rectangular structural steel frame (3 m × 5 m) from four heavy section members connected at the corners with full-penetration groove welds. Which welding sequence most effectively minimizes angular distortion and out-of-square condition after welding?

A. The most effective sequence is to weld all four corners in a balanced, symmetric pattern — beginning with root passes at diagonally opposite corners simultaneously or sequentially in short passes, then rotating to fill passes at all four corners in sequence, always maintaining symmetry; this balances the transverse shrinkage forces from opposite corners against each other so the frame remains square rather than pulling out-of-square from sequential shrinkage on one side

B. The most effective sequence is to complete one corner fully (all passes from root to cap) before moving to the next — fully completing each corner locks the joint geometry in place before the next corner is started, preventing the cumulative distortion that occurs when all four corners are partially welded simultaneously

C. Welding sequence has no effect on frame squareness for full-penetration groove welds — the frame dimensions are controlled entirely by the fit-up jig and tack welds; once the frame is tack-welded square in the jig, the final weld sequence cannot cause any measurable distortion

D. The most effective distortion control is to fully weld the two long sides of the frame before welding the two short sides — welding the longer members first establishes a rigid spine that resists distortion from subsequent short-side welds; this sequential approach is the recommended method in all structural welding distortion control guidelines

48. A maintenance welder finds an unmarked bar of metal in the scrap bin and suspects it might be low-alloy steel. The welder uses a bench grinder spark test as a quick field identification method. How is a spark test performed and what characteristics distinguish low-alloy or medium-carbon steel from pure iron or stainless steel?

A. A spark test is performed by holding the material against a grinding stone and observing the spark color — low-alloy and carbon steel always produces orange sparks, stainless steel produces green sparks due to chromium content, and pure iron produces white sparks; spark color alone is sufficient for definitive material identification

B. A spark test is performed by briefly pressing the material against a rotating grinding wheel and observing the spark stream — low-alloy and medium-carbon steel produces a bright yellow-white spark stream with numerous short bushy star-shaped bursts caused by carbon reacting with oxygen; higher carbon content produces more and brighter burst explosions; austenitic stainless produces long thin red-orange streaks with few or no bursts; pure iron produces long continuous pale yellow streams with minimal bursting; spark testing provides a rough indication of carbon content but should be confirmed by chemical analysis before welding

C. A spark test is performed by immersing the material in hydrochloric acid for 60 seconds and observing the color of the resulting sparks when the acid-cleaned surface is subsequently ground — the acid etching removes surface oxides that interfere with the spark pattern; without this pre-treatment, the test cannot distinguish carbon steel from low-alloy steel

D. A spark test can only distinguish ferrous from non-ferrous metals — within the ferrous category, all metals produce identical spark patterns and the test cannot identify specific alloy content or carbon level; a chemical spot test must be used to distinguish between ferrous alloys

49. A welder is setting up a new oxy-acetylene cutting station and notices the acetylene working pressure gauge reads 200 kPa (approximately 29 psi). The welding instructor immediately reduces the working pressure to below 103 kPa (15 psi). Why is this pressure reduction critical for safety?

A. The 200 kPa working pressure exceeds the cylinder delivery pressure limit — at pressures above 150 kPa, acetylene regulators automatically vaporize the acetone solvent in the cylinder, contaminating the cutting gas with acetone vapor that degrades flame quality and fouls cutting tip orifices

B. The 200 kPa working pressure exceeds the rated pressure of standard single-stage acetylene regulators — standard regulators are rated for a maximum of 150 kPa outlet pressure, and at 200 kPa the regulator relief valve opens continuously, venting acetylene into the atmosphere and creating a fire hazard

C. At pressures above 150 kPa, acetylene becomes chemically unstable because the free acetylene molecules begin ionizing, converting acetylene to acetaldehyde and creating a toxic vapor that cannot be detected by smell

D. Acetylene in its free (undissolved) state becomes chemically unstable and can decompose explosively at pressures above approximately 103 kPa (15 psi) — at this pressure, acetylene can detonate through self-decomposition without any mixture with oxygen; this is why acetylene working pressures must never exceed 103 kPa regardless of application, and why acetylene cylinders must never be used on their side, which would allow liquid acetone rather than dissolved acetylene to enter the lines

50. A fabricator must plasma arc cut 316L stainless steel components to tight dimensional tolerances. The PAC machine offers air plasma, nitrogen plasma, and argon-hydrogen plasma options. Which plasma gas selection produces the best cut quality on 316L stainless steel in terms of cut face oxidation and dimensional accuracy?

A. Air plasma is the best choice for 316L stainless because the oxygen component reacts with chromium in the stainless surface to form a hard smooth chromium oxide layer that seals the cut face against further oxidation and provides superior dimensional stability

B. Argon plasma without any hydrogen addition produces the best results on 316L stainless because pure argon's complete inertness prevents all oxidation of the chromium and nickel, and argon's high ionization potential produces the highest arc temperatures for the cleanest cut

C. Nitrogen plasma with nitrogen or argon-nitrogen shielding produces better cut quality on 316L stainless than air plasma — nitrogen is inert relative to stainless steel and does not oxidize the cut face the way the oxygen in air plasma does, producing a brighter, more corrosion-resistant cut face with tighter dimensional accuracy; argon-hydrogen plasma provides the highest cut quality on stainless (particularly for thicker sections) but at higher consumable cost

D. The plasma gas has no effect on cut quality for 316L stainless — the passivation layer on stainless steel protects the cut face from all plasma gases equally, and only the travel speed and amperage settings affect dimensional accuracy of plasma cuts on any stainless grade

51. An OFC operator notices that cut quality is acceptable for the first two cylinders of the day but progressively deteriorates for the third cylinder — heavier dross forms, cut faces become rougher, and an orange tinge appears in the cutting flame. What does the orange tinge specifically indicate, and what is the most likely cause of the deterioration?

A. An orange tinge in the cutting oxygen flame indicates the oxygen supply is contaminated with a combustible gas — most likely acetylene or propane that has back-flowed from a leaking manifold check valve into the oxygen manifold; when combustible gas mixes with the oxygen supply, the contaminated stream ignites and burns with the orange coloration typical of hydrocarbon combustion; this condition is dangerous and the operator must immediately shut down the system, evacuate the area, and have the manifold and check valves inspected before any further use

B. An orange tinge indicates the fuel gas running pressure is too high — excess fuel gas from an over-pressured regulator produces an orange carburizing flame that degrades cut quality; reducing the fuel gas pressure to the manufacturer's recommended setting corrects the condition

C. An orange tinge indicates the cutting nozzle is worn and the orifice has enlarged beyond specification — the enlarged orifice causes turbulence that mixes the flame gases, producing orange coloration; the tip must be replaced

D. An orange tinge in the OFC cutting flame is caused by iron oxide vapors from the recently cut steel recirculating in the flame — this is a normal characteristic of OFC on structural steel and indicates the cutting is proceeding correctly; the orange coloration has no diagnostic significance

52. A maintenance welder asks why CAC-A uses copper-coated carbon-graphite electrodes rather than bare carbon electrodes or metal electrodes. Which explanation correctly describes the function of the copper coating and the carbon-graphite composition?

A. The copper coating is a safety feature providing electrical insulation between the electrode and the electrode holder until the arc is struck — once the arc is struck, the copper coating vaporizes and the bare carbon conducts the arc for the remainder of the electrode's life

B. CAC-A electrodes must contain graphite rather than pure carbon because graphite has a melting point below 3,000°C, matching the arc temperature — pure carbon has a melting point above 3,500°C and would not melt to form the arc; the lower-melting graphite is required for the arc to form and operate correctly

C. The carbon-graphite composition provides the high-temperature stability needed to sustain the arc without melting the electrode, since carbon sublimates rather than melts at arc temperatures, maintaining arc geometry; the copper coating improves the electrical conductivity of the electrode, reduces contact resistance in the electrode holder, and increases the current-carrying capacity — allowing higher operating currents than bare carbon electrodes of the same diameter

D. CAC-A electrodes must be copper-coated to prevent the carbon from absorbing moisture from the atmosphere — bare carbon electrodes would absorb humidity over time, causing hydrogen porosity in the base metal similar to undried SMAW electrodes; the copper forms a hermetic seal around the carbon core

53. An OFC operator adjusts the preheat flame by increasing the fuel gas flow without changing the oxygen. The operator observes a bright white feather extending from the inner cone. What flame type does this indicate, what is its effect on the OFC cut, and how should the flame be corrected?

A. A white feather extending from the inner cone indicates an oxidizing flame caused by excess oxygen relative to fuel gas — the white feather results from complete combustion of residual hydrocarbons; an oxidizing preheat flame improves OFC cut quality by providing additional oxygen, and no correction is needed

B. A white feather extending from the inner cone indicates a carburizing (reducing) flame — excess fuel gas creates the bright white feather of unburned carbon in the outer flame envelope; a carburizing preheat flame causes the steel surface to carburize and harden before cutting, reducing the efficiency of the oxidation reaction; the correction is to slowly increase the oxygen flow until the white feather just disappears, producing a neutral flame with a clean, well-defined inner cone

C. A white feather from the inner cone is normal for all cutting tips — it indicates the fuel gas to oxygen ratio is correctly balanced for OFC cutting at the current tip size; attempting to adjust the flame to eliminate the white feather creates an oxygen-deficient mixture that prevents the cutting reaction from initiating

D. A white feather from the inner cone indicates excessive tip pressure from an over-pressured oxygen regulator — the high oxygen pressure forces unburned oxygen through the preheat orifice and creates the feather; the correction is to reduce the oxygen regulator pressure to the manufacturer's specified setting for the tip size

54. A plasma arc cutting operator wants to run the plasma torch at the maximum rated cutting amperage continuously throughout a full 8-hour shift. The plasma power source is rated at 120 A at 60% duty cycle. Why is it not possible to run at 120 A for a full 8-hour shift at 100% duty cycle?

A. A 60% duty cycle rating means the power source can operate at full rated amperage for a maximum of 60 hours total before its annual maintenance service — the 60% refers to 60% of an annual service interval, not a time-within-hour limitation

B. A 60% duty cycle at 120 A means the power source can operate at full rated amperage for 60% of a 5-minute or 10-minute cycle period (depending on manufacturer rating) followed by cool-down time — operating beyond the rated duty cycle allows the power source transformer and internal components to overheat above their thermal ratings, degrading insulation, shortening service life, and causing thermal shutdown or permanent damage to the power source

C. Duty cycle refers to the maximum number of cutting starts per hour — at 120 A and 60% duty cycle, the operator may initiate the plasma arc no more than 36 times per hour; continuous cutting from a single arc start is not restricted by duty cycle

D. The duty cycle rating specifies the percentage of every 10-minute period (or as specified by the manufacturer) during which the power source can sustain its rated output — at 60% duty cycle, 120 A is sustainable for 6 minutes out of every 10; continuously exceeding the duty cycle causes the power source to thermally trip or damages the transformer windings by allowing temperatures to exceed the insulation class rating; for continuous production, the operator must either reduce cutting amperage (which allows a higher duty cycle) or use a power source with a higher duty cycle rating

55. During a production OFC session, the operator notices the preheat flame holes are partially blocked with metal oxides and spatter, causing uneven preheat across the tip face. What is the correct tip cleaning procedure?

A. The correct procedure is to use a proper tip cleaner — a set of calibrated round files or reamers matched to the orifice sizes — to clean each orifice by inserting the correct-sized cleaner and moving it gently in a straight in-and-out motion; never ream in a circular motion, which would enlarge and distort the orifice; the cutting oxygen orifice and preheat orifices must be cleaned with matching-sized cleaners to avoid enlarging any orifice beyond specification; do not use drill bits, nails, or improper objects that damage the orifice geometry

B. The correct procedure is to use a wire brush to vigorously scrub the tip face, then use a metal punch to clear each blocked orifice by tapping sharply through each hole — the punch clears the oxide plug and the wire brush removes surface contamination

C. The correct procedure is to heat the tip to bright red using a separate torch and then quench it in water — the thermal shock causes oxide deposits to crack and fall free from the orifices; repeat the heat-quench cycle until all orifices are clear and the tip face is clean

D. The correct procedure is to soak the tip overnight in a 50% hydrochloric acid solution — the acid dissolves iron oxide deposits from the orifices; the tip is then rinsed in water and dried with compressed air before reinstallation; this is the only method approved by all cutting tip manufacturers

56. An operator using CAC-A must produce a groove of 12 mm depth for a repair cavity. The first pass produces only 6 mm depth. Which technique adjustment most directly increases the groove depth in a subsequent pass?

A. Increasing the compressed air pressure above the recommended level is the most direct way to increase groove depth — higher air pressure removes more metal per pass by increasing the jet force that ejects the molten metal; doubling the air pressure to 1,400 kPa from the standard 700 kPa doubles the groove depth per pass

B. Increasing the welding current within the electrode's rated amperage range is the most direct way to increase groove depth — higher amperage melts a larger volume of metal per unit length of electrode travel; this increases the depth of the molten pool and allows the air jet to eject more metal per pass; the operator can also slow the travel speed to allow deeper penetration per pass, combining both effects to achieve the required 12 mm depth

C. Reducing the electrode diameter is the most direct way to increase groove depth — a smaller diameter electrode concentrates the arc energy on a smaller area, producing a deeper narrower groove; switching from a 10 mm to a 6.4 mm electrode while maintaining the same amperage doubles the current density and doubles the groove depth per pass

D. Increasing the electrode travel speed is the most direct way to increase groove depth — faster travel produces more concentrated heating per unit length because the electrode moves forward faster than the metal can dissipate the arc heat; this concentrated thermal energy creates deeper melting without requiring any change in amperage or electrode diameter

57. When lighting an oxy-acetylene cutting torch, the torch acetylene valve must be opened before the torch oxygen valve. Which explanation is most accurate for why this sequence is critical for safety?

A. The torch acetylene valve is opened first because acetylene is the primary fuel and it takes several seconds to purge the oxygen from the torch body before the acetylene arrives; opening acetylene first ensures the torch is filled with pure acetylene before lighting

B. The torch acetylene must be opened first because the cutting oxygen valve is mechanically linked to the acetylene valve — opening oxygen before acetylene defeats the valve interlock mechanism built into cutting torches

C. Opening the acetylene valve first at the torch purges the mixed gas from the torch body and mixing chamber; lighting a pure acetylene stream avoids the risk of lighting a pre-mixed oxygen-acetylene mixture inside the torch that could flash back into the mixing chamber; once the acetylene flame is lit and stable, the oxygen is slowly introduced to develop the correct flame type — this sequence prevents internal ignition of pre-mixed gas and is the standard safe lighting procedure for all oxy-fuel torches

D. Opening the acetylene valve first is preferred by some welders but is not required by any safety standard — either gas can be opened first without any safety difference; the critical safety step is the order in which the cylinder valves are opened, not the torch valves

58. A fabrication shop uses OFC to cut carbon steel and wants to add stainless steel plate cutting. The production manager asks why OFC cannot be used on stainless steel and what PAC advantages apply specifically to stainless steel. Which explanation is most complete and accurate?

A. OFC can be used on stainless steel — the technique requires using a stainless steel flux injection to overcome the surface oxide, and this OFC variant is used routinely in all stainless steel fabrication shops; PAC is used only when the tightest dimensional tolerances are required

B. OFC fails on stainless steel because stainless steel has lower thermal conductivity than carbon steel — the heat from the preheat flame cannot penetrate through the stainless steel to reach the cutting zone; PAC uses a plasma jet that can penetrate any thermal conductivity

C. OFC fails on stainless steel because stainless steel has a higher melting point than carbon steel — the OFC preheat flame cannot raise the stainless steel surface to the cutting oxygen ignition temperature; PAC uses a plasma jet that operates at temperatures far above the melting point of any metal

D. OFC fails on stainless steel because the chromium in the alloy forms a dense, refractory chromium oxide ( $\text{Cr}_2\text{O}_3$ ) on the cut surface that melts at approximately  $2300^\circ\text{C}$  — this oxide shields the underlying metal from the cutting oxygen, preventing the continuous oxidation reaction OFC depends on; PAC does not rely on oxidation chemistry — it melts and ejects material by the thermal energy and kinetic force of the plasma jet, cutting stainless cleanly regardless of the oxide layer

59. A fabricator produces both manual hand-cut and machine-cut parts from the same 20 mm structural steel plate using OFC with the same tip size and gas pressures. Machine-cut parts consistently show tighter dimensional tolerances, straighter cut lines, and smoother cut faces. What is the primary technical reason for this quality difference?

A. Machine-mounted torches maintain perfectly constant travel speed, height, and angle throughout the entire cut — human hands cannot replicate the steady, vibration-free, constant-velocity motion of a machine at any cut length beyond approximately 300 mm; variations in hand speed, minor torch height fluctuations, and arm movement all introduce drag line irregularity, kerf width variation, and dimensional deviation that machine motion eliminates; this is the primary technical advantage of mechanized OFC for quality applications

B. Machine torches use higher cutting oxygen pressure than is safe for hand operation — the higher pressure produces faster oxidation and cleaner cut faces; hand torches are pressure-limited for operator safety below the optimal cutting pressure, resulting in lower cut quality

C. Machine cutting consumes less fuel gas than manual cutting for the same length of cut because the machine never pauses, reverses, or hesitates; the reduced total fuel consumption produces a cooler overall heat input that reduces the HAZ width and improves dimensional accuracy

D. Machine torches are always equipped with a flux injection system not available on hand torches — the flux injection produces a smoother oxidation reaction that improves cut face quality and dimensional accuracy regardless of the plate material

60. A CAC-A operator is gouging a longitudinal groove along a steel plate in the flat position. The operator holds the electrode at a very shallow angle (approximately  $20^\circ$  from horizontal) and finds the groove is wide and shallow. When the operator increases the angle to approximately  $45^\circ$ , the groove becomes narrower and deeper. What is the correct technical explanation for this effect?

A. A shallow electrode angle in CAC-A produces a deep narrow groove because the shallow angle directs the air blast more efficiently in the longitudinal direction, concentrating the jet force and increasing the metal removal rate; a steeper angle redirects the air blast upward and reduces jet efficiency

B. A shallow electrode angle directs the arc heat over a wider, shallower area because the arc plays across the work surface at a low angle rather than concentrating directly below the electrode tip — this produces a wide, shallow groove; increasing the angle toward  $45^\circ$  concentrates the arc force and heat more directly into the work surface, creating a narrower, deeper groove; electrode angle is therefore a direct control variable for the groove cross-section geometry in CAC-A gouging

C. Electrode angle has no effect on CAC-A groove depth or width — the groove dimensions are determined exclusively by the electrode diameter and the welding current; the electrode angle affects only the direction of the expelled metal stream, not the groove cross-section produced

D. A shallow electrode angle ( $20^\circ$ ) produces a deep narrow groove because the current path through the molten metal is longest at shallow angles, providing maximum joule heating of the deepest metal layers; increasing to  $45^\circ$  reduces the current path length and reduces the groove depth proportionally

61. A maintenance welder needs to make an OFC cut in a gray cast iron machine housing. After several attempts, the welder cannot establish a continuous cut — the cutting reaction keeps stopping and requires constant restarting. What is the fundamental reason OFC cannot produce a continuous cut in gray cast iron, and what alternative thermal cutting process could be used?

A. OFC cannot cut gray cast iron because the iron is too dense — the high density of cast iron requires cutting oxygen pressure to be increased to three times the structural steel setting, which standard regulators cannot supply; plasma arc cutting with a high-pressure power source is the only alternative

B. OFC cannot cut gray cast iron because the casting process creates internal voids, cracks, and inclusions that interrupt the oxygen stream and prevent the continuous oxidation reaction; if the cast iron is free of internal defects, OFC works normally

C. OFC cannot cut gray cast iron because the carbon content is too low — gray cast iron with less than 1% carbon does not generate enough exothermic energy from the oxidation reaction to maintain the cutting temperature; the cut stops because the iron-oxygen reaction is endothermic in low-carbon cast iron

D. OFC cannot produce a continuous cut in gray cast iron because the silicon content (1–3%) creates refractory silicon dioxide that solidifies over the cut front faster than the cutting oxygen can penetrate — the slag bridges the cut gap and the reaction extinguishes; simultaneously, the graphite phase burns rather than oxidizing cleanly, overheating the cut zone; plasma arc cutting is a practical alternative because it removes material through melting and kinetic ejection without requiring a continuous chemical oxidation reaction

62. A production supervisor is establishing a preventive maintenance program for a high-definition plasma arc cutting system. The supervisor asks the lead operator how to determine when plasma consumables should be replaced before quality problems develop. Which consumable wear monitoring approach is most accurate?

A. Plasma consumables should be replaced only when cut quality visibly deteriorates — replacing consumables based on a maintenance schedule results in discarding serviceable consumables unnecessarily and increasing operating costs

B. The electrode should be replaced whenever the nozzle is replaced — since both consumables wear at the same rate in a high-definition plasma system, they must always be replaced together as a matched set; replacing them individually at different intervals causes asymmetric wear that permanently damages the torch body

C. The electrode should be checked regularly by measuring the depth of the pit (hafnium insert erosion) on the electrode tip — most manufacturers specify a maximum pit depth (commonly 1–1.5 mm) beyond which the electrode produces an unstable arc; the nozzle orifice bore should be checked for enlargement or out-of-round wear; replacing both consumables at the manufacturer-specified interval before reaching the wear limit prevents the degraded cut quality that worn consumables produce

D. Plasma consumables are lifetime-rated components — they do not wear measurably during normal production and never require replacement unless the torch is physically damaged; the only maintenance required is cleaning the torch body and gas distribution ring with compressed air

63. An OFC operator has experienced two backfires during the cutting shift. The operator has eliminated contaminated gases as the cause. Which tip and technique condition most commonly causes repeated backfires, and how should the operator address it?

A. Repeated backfires during OFC are most commonly caused by overheated cutting tips — the tip temperature rises above the fuel gas autoignition point in the tip orifices when the tip is held too close to the work, when pauses in travel cause the preheat flame to overheat a stationary area, or when the tip surface becomes contaminated with spatter; the operator should maintain proper tip-to-work distance, keep the torch moving, occasionally cool the tip by briefly directing the preheat flame away from the work, and clean the tip with proper tip cleaners regularly to prevent recurrence

B. Repeated backfires are exclusively caused by moisture contamination of the gas supply — the operator should immediately replace all gas hoses and both gas cylinders; backfires caused by anything other than moisture contamination cannot occur more than once per shift

C. Repeated backfires are caused by using an undersized tip for the plate thickness — the pressure drop through the undersized tip orifices creates reverse flow in the torch mixing chamber; switching to a correctly sized tip eliminates all backfires regardless of operating technique

D. Repeated backfires during OFC cannot be addressed by the operator — they indicate a defective torch check valve that must be replaced by a qualified gas equipment technician; the torch must be taken out of service immediately and sent for factory repair

64. A project engineer reviews the method statement for a repair welding job on a mining shovel bucket made from abrasion-resistant (AR) steel (Brinell hardness 400). The method statement specifies CAC-A for removal of cracked weld metal before repair welding. What specific precautions apply to CAC-A on high-hardness AR steels?

A. CAC-A is not permitted on any AR steel with hardness above 300 HB — the carbon deposition from the CAC-A electrode into the high-hardness steel base metal forms iron carbides that make the metal brittle and impossible to weld; mechanical grinding or chipping must be used for all AR steel defect removal

B. CAC-A can be used on high-hardness AR steel for defect removal, but the CAC-A heat input creates a zone of local re-hardening and potential reheat cracking in the already hard base metal — the groove surface and adjacent base metal must be carefully ground to remove all carbon deposits, and the entire excavated zone must be MT or PT inspected for cracks before repair welding proceeds; preheat per the applicable WPS for the AR steel grade must be applied both before CAC-A gouging and before any repair welding

C. CAC-A on AR steel requires DCEN polarity exclusively — standard DCEP causes unacceptable carbon migration into high-hardness AR steel; switching to DCEN prevents carbon deposition and eliminates all preheat requirements for AR steel repair preparation

D. CAC-A on high-hardness AR steel requires reducing the electrode diameter to 6.4 mm maximum — larger electrodes produce too much localized heat input and cause the AR steel to transform to austenite, permanently removing the hardness from the base metal; only 6.4 mm electrodes at 150 A maximum maintain AR steel hardness during gouging

65. During pre-shift inspection of the oxy-fuel cutting equipment, the welder notes that the torch tip threads are cross-threaded and cannot be fully tightened by hand — the tip can be moved when finger-tightened, indicating potential gas leakage. What is the correct action?

A. The operator should use a spanner wrench to forcefully tighten the cross-threaded tip until gas leakage stops — cross-threaded connections can be used safely if tightened enough to prevent detectable gas leakage; the cross-threading only creates a cosmetic problem with the thread condition

B. The operator can continue using the torch if the tip is tightened with a wrench and a soap bubble test confirms no leakage — a successful soap bubble leak test before each light-up session is sufficient to confirm safety for cross-threaded connections

C. The operator should apply PTFE thread sealing tape to the tip threads before tightening — the sealer fills the cross-threaded gaps and creates a gas-tight seal; this is the recommended repair procedure for cross-threaded torch tip connections in all oxy-fuel equipment

D. The operator must remove the torch from service and report the damage to the maintenance department — cross-threaded tip connections cannot be safely used even if tightened, because the damaged threads cannot provide reliable gas sealing; a loose or improperly sealed tip connection can allow gas to leak into the torch body, creating conditions for an internal fire or flashback; the torch must be repaired by qualified personnel and leak-tested before being returned to service

66. A fabrication shop must cut 12 mm copper bus bars for an electrical switchgear project using plasma arc cutting. What plasma gas characteristics are necessary for cutting copper effectively, and why does standard air plasma perform poorly on copper?

A. Air plasma is the optimal plasma gas for cutting copper — copper is one of the few metals where the oxygen in the compressed air plasma reacts exothermically with the copper to produce copper oxide, providing additional heat that speeds the cutting process and produces cleaner cut faces than inert gas plasma

B. Any plasma gas works equally well on copper because copper's low melting point (1085°C) means the plasma arc easily exceeds the temperature needed to melt and eject it; gas selection for copper PAC is based on cost and availability rather than technical performance

C. Standard air plasma performs poorly on copper because copper is highly thermally conductive — the high thermal conductivity dissipates heat away from the cut zone rapidly, and copper's high electrical conductivity can cause arc instability; a high-energy plasma gas such as argon-hydrogen (typically 65–35% or 50–50% ratio) providing significantly higher arc enthalpy than air or nitrogen, or nitrogen plasma at higher amperage, are preferred for copper cutting to overcome the rapid heat dissipation

D. Copper cannot be cut by plasma arc cutting under any conditions because copper's high electrical conductivity prevents formation of a stable plasma arc — current bypasses through the copper workpiece rather than maintaining the required plasma column; only waterjet cutting or mechanical sawing can be used on copper bus bars

67. A shop currently uses acetylene for all OFC operations. The shop manager is considering switching to propane or natural gas to reduce fuel costs. Which comparison of acetylene, propane, and natural gas for OFC applications is most technically accurate?

A. Acetylene burns at a higher flame temperature (approximately 3,160°C with oxygen) than propane (~2,820°C) or natural gas (~2,770°C), providing faster preheat times and better performance for cutting thick sections — however, acetylene is more expensive per unit of heat output; propane and natural gas are suitable for OFC of carbon steel but require different tip designs with higher preheat oxygen ratios and longer preheat times; none of the alternative fuel gases achieves acetylene's combination of preheat speed and cutting performance at all plate thicknesses

B. Propane produces an identical flame temperature to acetylene at the same fuel gas volume flow rate — the only difference between acetylene and propane for OFC is cost per cylinder; tip selection is identical for both gases and no technique adjustments are needed when switching from acetylene to propane

C. Natural gas produces the highest flame temperature of the three common fuel gases because methane has a higher heating value per cubic metre than both acetylene and propane; natural gas is not only the cheapest fuel but also the highest performing fuel for OFC at all plate thicknesses

D. All three fuel gases are interchangeable for OFC without any equipment or technique modifications — the cutting oxygen flow does all the actual cutting work regardless of the preheat fuel type; fuel gas selection affects only cost and does not affect preheat time, cut quality, or tip selection

68. A maintenance welder must use CAC-A to remove a defective weld in an extremely tight corner where available access limits the electrode angle to approximately  $60\text{--}70^\circ$  from the work surface (very steep). What effect does this steep electrode angle have on the gouge, and what technique adaptation minimizes quality problems?

A. A steep electrode angle ( $60\text{--}70^\circ$  from horizontal) produces the best groove quality in tight spaces because the steep angle concentrates the arc directly below the electrode in a confined beam, producing the most consistent and deepest groove; no technique adaptation is needed when access forces a steeper angle

B. A steep electrode angle in CAC-A produces a wide, shallow groove because the steep angle directs the arc force upward and away from the work — the electrode holder must be held flat at  $10\text{--}15^\circ$  from the work surface to produce a deep groove in tight spaces where standard access is limited

C. Access restrictions that prevent achieving the correct CAC-A electrode angle automatically render the CAC-A process unusable for that location — if the correct  $35\text{--}45^\circ$  angle cannot be achieved, CAC-A cannot be used and mechanical grinding or chipping must be substituted regardless of the time penalty

D. A steep electrode angle ( $60\text{--}70^\circ$  from the surface) in CAC-A produces a narrower, deeper groove than the standard  $35\text{--}45^\circ$  angle because the arc concentrates its energy more directly below the tip — the operator should reduce travel speed and reduce the amperage slightly to prevent excessive depth from the more concentrated arc; pausing every 50–75 mm of electrode travel to clear expelled metal and inspect the groove depth prevents inadvertent over-excavation in restricted access locations

69. A new apprentice is setting up an OFC station and notices the facility has both single-stage and two-stage gas regulators in the shop. The apprentice asks when each type is appropriate for OFC work. Which explanation is most accurate?

A. Single-stage regulators are only for very low-pressure applications below 100 kPa and must always be used for acetylene cylinders — two-stage regulators are required for all oxygen applications because oxygen system pressures are higher than acetylene system pressures

B. Two-stage regulators provide more stable outlet pressure as the cylinder empties compared to single-stage regulators — as a single-stage regulator's inlet pressure decreases with cylinder emptying, the outlet pressure tends to drift and requires periodic readjustment; a two-stage regulator reduces pressure in two steps, making the final outlet pressure more stable and consistent throughout the cylinder life; two-stage regulators are preferred for precision cutting applications where consistent gas pressure is critical to cut quality

C. Single-stage and two-stage regulators are interchangeable in all OFC applications — the choice is based only on the available inlet pressure range; there is no difference in outlet pressure stability or performance between the two regulator types when properly set for the same application

D. Two-stage regulators must be used on all fuel gas cylinders because the high inlet pressures of acetylene and propane cylinders will damage the diaphragm of a single-stage regulator; single-stage regulators are only approved for inert gas applications where the cylinder pressure cannot exceed 2,000 kPa

70. A plasma arc cutting operator progressively increases the torch standoff distance (height above the plate surface) above the optimal setting during a test cut. Which specific cut quality changes occur as the standoff becomes too large, and why do these changes occur?

A. Increasing standoff distance above optimal in PAC improves cut quality — the additional distance reduces thermal damage to the nozzle and electrode while allowing the plasma jet to cool slightly; this cooled plasma produces a narrower kerf with less HAZ

B. Increasing standoff distance has no effect on cut quality as long as the arc does not lose contact with the workpiece — quality effects only become apparent when the arc extinguishes; until arc extinction, cut quality is independent of standoff distance

C. As standoff increases above the optimal setting, the plasma jet expands and diverges before reaching the work surface, reducing its energy density and velocity at the kerf — this produces an increased bevel angle on the cut faces, wider kerf, more dross on the underside, increased HAZ width, and reduced penetration consistency; the expanded jet also becomes more susceptible to cross-draft interference; the optimal standoff maintains the highest energy density and most focused plasma column at the point of material contact

D. Excessive standoff distance in PAC causes the arc to transfer from the workpiece to the nozzle (double arcing) — double arcing causes immediate catastrophic nozzle failure; this is the only quality

effect of excessive standoff and it always occurs immediately when the standoff exceeds the optimal value by more than 1 mm

71. A production facility uses mechanized OFC to cut complex structural parts from 19 mm plate in a nested layout to maximize material utilization. After cutting, parts from the center of the plate are correct but parts from the plate edges show dimensional errors. The cutting machine has been verified as mechanically accurate. What causes the edge-part dimensional errors in nested cutting layouts?

A. Parts cut near the plate edge receive asymmetric heat input — the plate edge lacks the thermal mass of a full-width plate on one side, causing heat to dissipate more rapidly in one direction; this asymmetric cooling creates residual stress imbalance that causes partially cut edge parts to distort or move during cutting, changing the actual dimensions relative to the programmed path; the solution is to program a sequential cutting strategy that completes interior parts first (providing surrounding plate for thermal support) and cuts edge parts last, or to use tabs and bridges to maintain part position during cutting

B. Edge-part dimensional errors are caused by lower oxygen pressure available at the torch when it is at the extreme travel limits of the CNC machine — edge positions correspond to maximum travel range and hydraulic pressure in the drive system drops at extremes, reducing cut accuracy; the solution is recalibration of the machine's drive system hydraulic pressure

C. Parts near the plate edge always have more mill scale than interior areas because mill scale at the plate edge is thicker due to the higher cooling rate during steel rolling — the thicker edge-area mill scale requires a longer preheat dwell and causes the cutting oxygen to be partially consumed oxidizing the scale instead of the underlying metal, reducing dimensional accuracy

D. Dimensional errors in edge parts from nested OFC layouts are caused by operator fatigue — manual correction of the programmed path at plate edges is required for all CNC OFC machines, and operators who have worked for more than 4 hours make increasingly large manual correction errors; the solution is to have a fresh operator complete the edge-part cuts

72. A pipeline welder uses E6010 cellulosic electrodes almost exclusively for field girth weld root passes and hot passes on natural gas transmission pipeline. Why is E6010 preferred for this application over low-hydrogen alternatives like E7018?

A. E6010 is preferred for pipeline root passes because it is the only electrode that produces complete root penetration on pipeline joints — all other electrode types including E7018 are incapable of producing an acceptable internal root bead in pipeline girth welds; this is an absolute requirement for API 1104 pipeline work

B. E6010 is preferred because it is less expensive per kilogram than E7018 and pipeline welding consumes large quantities of electrodes — the cost savings over the length of a major pipeline project makes E6010 the economically mandated choice regardless of technical factors

C. E6010 is preferred because it works on both AC and DC power sources — pipeline welding uses engine-driven welders that are typically AC generators, and AC compatibility is the only factor governing electrode selection for field pipeline applications

D. E6010 cellulosic electrodes produce a deeply penetrating, forceful arc with a fast-freezing slag that allows the keyhole technique required for full-penetration root passes in a single downhill pass on pipeline — the cellulosic coating generates shielding gases (primarily CO and CO<sub>2</sub>) that provide vigorous arc force to push through the root gap; the fast-freezing slag supports the pool in any position including downhill; the relatively thin slag is easily cleared before the hot pass; these characteristics — keyhole capability, positional slag control, and fast slag removal — have made E6010 the standard for field pipeline root passes for decades

73. A pipeline repair job has only AC generator power available. The job requires SMAW root passes in the 5G position on API 5L pipe. Which electrode is most appropriate as a substitute for E6010 on AC power, and what differences in welding behavior should the welder expect?

A. E7018 is the appropriate AC-compatible substitute for E6010 because E7018 is specifically formulated for AC welding and produces deeper penetration than E6010 when used on AC power; E6010 and E7018 have identical arc behavior except for hydrogen content

B. E6013 is the most appropriate AC substitute for E6010 because E6013 produces a smoother, more stable arc on AC than E6011 and has equal penetration characteristics to E6010; E6011 is never used in pipeline applications regardless of power source type

C. E6011 is the most appropriate substitute when only AC power is available — E6011 shares most of E6010's characteristics (cellulosic coating, forceful penetrating arc, all-position capability, fast-freezing slag) but contains additional potassium compounds in the coating that stabilize the AC arc; the welder should expect slightly less arc force than E6010 on DC, somewhat more spatter on AC, and a slightly less fluid pool — technique adjustment may be needed but E6011 produces acceptable root passes in all positions on AC

D. No electrode substitute for E6010 exists for AC power sources — if DC power is unavailable, all root pass welding on API pipelines must be postponed until DC engine-driven welders can be mobilized; using any other electrode type for pipeline root passes is prohibited by API 1104 under all circumstances

74. A welder is completing root passes in a full-penetration groove weld on 19 mm structural plate in the 2G (horizontal) position. The root bead shows complete external profile, but the radiograph reveals a linear indication along the bottom of the root bead characterized as "root cold lap" or "root LOF." Which technique correction most directly addresses this specific root defect?

A. Root cold lap at the bottom of the root bead in 2G position is caused by a root opening that is too large — reducing the root gap below 2 mm increases the preheat concentration and eliminates the cold lap by providing more metal support at the root

B. Root cold lap along the bottom of a 2G root bead typically occurs when the arc is directed too far toward the upper plate, causing the molten pool to flow away from the lower groove face before achieving fusion — the correction is to adjust the work angle to direct slightly more heat toward the lower groove face, ensuring the arc establishes fusion on the lower side of the groove before the pool freezes; maintaining a consistent arc length to avoid reducing the arc penetration force is also critical

C. Root cold lap along the bottom of a 2G root bead is caused by using too high an amperage — excess heat input causes the pool to flow excessively, overwhelming the groove face before fusion bonds; reducing the amperage by 20% while maintaining the same travel speed eliminates root cold lap in horizontal position groove welds

D. Root cold lap along the bottom of a 2G root bead is caused by the electrode depositing too slowly — insufficient electrode melt rate at the recommended amperage means the pool solidifies before the root gap is completely filled; increasing the electrode size provides more metal feed rate and eliminates the cold lap

75. A high-production structural fabrication shop is considering using the "gravity welding" (automatic gravity feed) technique for depositing fillet welds on T-joint assemblies. A supervisor asks what gravity welding involves and what production advantages it provides. Which description is most accurate?

A. Gravity welding uses a holder device that clamps the electrode at a fixed angle and allows gravity to feed the electrode into the weld as it burns down — the welder places the electrode in the holder, initiates the arc, and the electrode self-feeds at the natural melt-off rate without the welder needing to manually maintain arc length or feed the electrode; this technique allows one welder to tend multiple simultaneous arcs on adjacent joints and is particularly effective for flat and horizontal fillet welds on large repetitive structural assemblies; the main limitation is that the technique only works in gravity-favorable positions and requires specific electrode types that run well with gravity feed

B. Gravity welding is a technique where the entire welding power source is positioned above the workpiece and the electrode is fed downward by a motorized wire drive — the downward gravity-assisted wire feed increases the deposition rate by 40% compared to horizontal wire feed

C. Gravity welding requires no power source — it uses only a specially insulated electrode connected to the structural steel ground; as the electrode makes contact with the previously welded area, thermoelectric current from the temperature differential between the electrode and the base metal generates the arc; no external power source is needed

D. Gravity welding is a technique used only for overhead welding where the electrode holder is mounted below the weld joint and gravity keeps the electrode from pulling away from the joint — it is used exclusively for overhead (4G) position welding because gravity assistance is only available in the downward direction from the welder's perspective

76. A pipeline welder consistently finds crater cracks in the weld termination zone when stopping the arc on E6010 root passes. The crater cracks are visible as radial cracks emanating from the center of the weld stop. What technique change directly prevents crater cracking at SMAW weld terminations?

A. Crater cracking at SMAW terminations is prevented by increasing the welding current by 20–30% at the termination zone — the higher current creates a larger final pool that has sufficient volume to accommodate the shrinkage stresses without cracking; immediately breaking the arc once the higher current has created the enlarged termination pool

B. Crater cracking at the weld termination is prevented by gradually reducing the heat input and backstepping at the termination — the welder pauses at the end of the weld, makes a short reverse motion of approximately 10–20 mm back along the completed weld, then breaks the arc; this backfills the crater with additional weld metal before the arc is broken, reducing the volume of the shrinkage cavity and the tensile stress concentration at the termination; the filled crater has sufficient metal volume and reduced depth-to-width ratio to resist the solidification cracking that occurs in deep, unfilled craters

C. Crater cracking at SMAW terminations cannot be prevented by technique adjustment — it is a material property issue caused by high sulfur content in E6010 electrodes; switching to E7018 low-sulfur electrodes is the only way to prevent crater cracking regardless of any technique change

D. Crater cracking is prevented by maintaining maximum arc travel speed at the termination — fast travel speed at the end of the weld produces a smaller crater with less volume; the reduced crater size means less solidification shrinkage and therefore no cracking at the termination point

77. A pipeline construction crew is performing SMAW on high-strength line pipe (API 5L X70) in an area near a long-operated transmission pipeline. The welders report severe arc blow — the arc deflects violently and cannot be controlled for the root pass. The DC power source is set to DCEP. Which combination of corrective actions is most likely to reduce the magnetic arc blow?

A. Switching from DCEP to DCEN is the only effective corrective action for magnetic arc blow — DC electrode negative reversal changes the magnetic field polarity around the electrode and neutralizes the external magnetic field from the adjacent pipeline; no other corrective action has any effect on magnetic arc blow severity

B. Increasing the welding current to the maximum electrode rating is the most effective corrective action — higher current produces a stronger magnetic field around the arc that overwhelms the external magnetic interference; this is the standard response for all magnetic arc blow conditions regardless of severity

C. Using a longer arc length reduces arc blow severity because the longer arc gap allows the deflected arc stream to travel farther from the work before making contact; the longer arc path reduces the angular deflection visible at the work surface; increasing arc length should be the first corrective action attempted

D. Switching to AC power is the most direct and effective corrective action for magnetic arc blow because the continuously reversing AC polarity means the arc deflection alternates direction too rapidly to produce a net directional deflection; additional corrective actions that may help include changing the electrode angle into the direction of arc blow, wrapping the work return cable around the pipe to provide a counter-magnetizing field, positioning the ground connection on both sides of the joint, and reducing the welding current

78. After completing a root pass on a large-diameter pipe in the 5G position using E6010 electrodes, the welder begins the hot pass — a second pass deposited at higher current while the root is still warm. What is the specific purpose of the hot pass in pipeline welding, and what parameters distinguish it from subsequent fill passes?

A. The hot pass in pipeline welding has identical parameters to the root pass — the same amperage, electrode size, and travel speed are used; "hot pass" only refers to the ambient temperature of the pipe, not any difference in technique; it is called the "hot pass" because pipeline work takes place outdoors in summer heat

B. The hot pass serves the same function as a PWHT preheat — it is used to maintain the interpass temperature at the minimum required level specified by the WPS; the welder must pause between the root and hot passes until the root bead cools to the minimum interpass temperature before the hot pass is deposited

C. The hot pass is deposited at higher amperage than the root pass to create enough heat to melt out any thin areas, undercut, or incomplete fusion in the root bead surface — the aggressive heat input of the hot pass also burns off cellulosic inclusions from E6010's cellulosic slag and smooths the convex root bead profile to provide an adequate substrate for the fill passes; hot pass amperage is typically 10–20% higher than the root pass amperage for the same electrode size

D. The hot pass is deposited at lower amperage than the root pass to avoid melting through the root bead — the hot pass must protect the root bead from burn-through by gently flowing over it with minimal penetration; the primary purpose is cosmetic: to provide a smooth starting surface for the fill passes without disturbing the root bead geometry

79. A welding supervisor discovers a new box of E7016 electrodes was left outside on a construction site in light rain overnight. The cardboard boxes appear damp on the outside. The supervisor must decide whether the electrodes can be used for structural welding on a critical bridge component. Which action is correct?

A. E7016 basic low-hydrogen electrodes have calcium carbonate and calcium fluoride coatings that are highly hygroscopic — once exposed to moisture, the coating absorbs water into the coating matrix that cannot be reliably removed by simply drying the electrode exterior; damp electrodes must not be used for critical structural welding because the absorbed moisture will decompose in the arc to produce hydrogen, causing distributed porosity and increasing the risk of hydrogen-induced delayed cracking in the high-strength base metal; the supervisor must either recondition the electrodes per manufacturer specifications (typically 260–430°C for 1 hour minimum in a certified electrode oven with temperature recording) or reject and replace them

B. E7016 electrodes are waterproof — the copper-colored coating on basic electrodes prevents any moisture absorption regardless of ambient conditions or exposure duration; wet cardboard packaging does not affect electrode performance and the electrodes can be used directly from the damp boxes without any additional drying

C. E7016 electrodes exposed to rain can be dried by placing them on the hood of a warm vehicle for 30 minutes — the engine heat through the metal hood is sufficient to restore the electrodes to acceptable condition without requiring a certified electrode oven

D. Damp E7016 electrodes can be identified and accepted or rejected by bending three electrodes from the box — if no electrode coating cracks when bent at 90°, all electrodes in the box are acceptable for use without reconditioning; only electrodes with cracked coatings after the bend test are discarded

80. A maintenance welder must repair a cracked weld in a 316L stainless steel piping system. The local supplier can provide E308L-16 or E316L-16 SMAW electrodes. Which electrode selection is most technically defensible and why?

A. E308L-16 is the correct choice for 316L repairs because the molybdenum in 316L base metal adds sufficient Mo to the deposited weld metal through dilution — the E308L-16 electrode provides the

chromium and nickel needed, and the base metal dilution supplies the molybdenum; no Mo addition in the electrode is required for 316L repair welding

B. E316L-16 is the correct electrode for 316L stainless steel repair because it matches the base metal composition including the molybdenum addition that gives 316L its superior pitting corrosion resistance — using E308L-16 without molybdenum could produce a weld deposit with inadequate Mo content to resist pitting corrosion in the same service environment as the surrounding 316L base metal; matching composition is the fundamental principle of stainless steel repair electrode selection

C. Either E308L-16 or E316L-16 produces identical results for 316L repair because the post-weld passivation treatment required for all stainless steel repairs restores the corrosion resistance of the weld area regardless of electrode Mo content — passivation compensates for any differences in electrode composition

D. Neither E308L-16 nor E316L-16 can be used for 316L pipe repairs — stainless steel SMAW electrodes may not be used for pressure piping repairs under any circumstance; GTAW must be used exclusively for all stainless steel pressure piping repairs under ASME B31.3

81. A maintenance welder must repair a cracked gray cast iron pump housing using SMAW with ENiFe-CI (55% nickel) electrodes. The welder has limited cast iron repair experience and asks about the critical technique differences compared to structural steel SMAW. Which combination of techniques is most critical for preventing cracking?

A. Cast iron welding with ENiFe-CI electrodes requires welding at the highest possible amperage to complete the repair as quickly as possible — high heat input in cast iron reduces the risk of cold cracking because the high temperature prevents the tensile stresses that initiate cracks; the welder should not stop or pause until the entire repair is complete

B. Cast iron welding with ENiFe-CI electrodes requires DCEN polarity exclusively — DCEP causes the nickel in the electrode to migrate into the base metal rather than staying in the deposit, reducing the repair's crack resistance; the polarity specification overrides all other technique considerations for cast iron repair

C. Cast iron repair welding must be performed without any preheat — preheating cast iron before SMAW with ENiFe-CI electrodes causes thermal expansion cracking; these electrodes are specifically designed for cold welding of cast iron and any preheat is detrimental

D. Cast iron repair with ENiFe-CI electrodes requires: preheating the entire casting evenly to 200–300°C to reduce thermal gradient and stress; using very short beads (20–30 mm maximum) deposited one at a time with peening immediately after each bead while it is still above approximately 400°C to relieve tensile solidification stresses; allowing each short bead to cool slightly before depositing the

next; and slow controlled cooling after welding (insulated blankets or buried in dry sand) to prevent the rapid cooling that creates brittle microstructures in the cast iron HAZ

82. A newly certified welder is assigned to a structural steel fabrication project and encounters a WPS specifying vertical-up (3G, upward progression) for all groove welds in 12 mm structural plate. The welder asks why the WPS does not allow vertical-down instead, since downward welding is faster. Which explanation correctly describes why the WPS specifies vertical-up?

A. Vertical-up welding produces greater penetration and better fusion than vertical-down welding for a given electrode and amperage — in vertical-up progression, the welder works against gravity and the pool tends to flow away from the arc, helping maintain the arc at the fusion boundary and producing complete sidewall and root fusion; vertical-down is faster but produces shallower penetration and is more susceptible to slag inclusions and incomplete fusion because the slag tends to flow ahead of the arc in the downward direction, contaminating the fusion boundary; AWS D1.1 and CSA W59 limit vertical-down SMAW to fillet welds and do not permit it for groove welds in structural members unless specifically qualified

B. Vertical-up is required because structural steel codes prohibit vertical-down welding entirely — no application of vertical-down SMAW is permitted in any structural steel code; the WPS can only specify vertical-up because vertical-down does not exist as a qualified position for any structural application

C. Vertical-up produces a wider bead than vertical-down, which is required by the structural code to achieve the minimum throat for structural groove welds — vertical-down narrow beads are acceptable for fillet welds but not for groove welds where the wider bead is the primary code requirement

D. Vertical-down welding is used exclusively for pipeline applications and cannot be certified for structural steel work — pipeline welding codes use vertical-down, while structural codes use vertical-up; the process is physically identical but the two codes use incompatible position designations that prevent certification under both simultaneously

83. A welder-in-training is asked to decode the electrode designation "E7018-H4R." Which decoding is complete and accurate?

A. E = electrode; 70 = minimum tensile strength of 70,000 psi; 1 = suitable for flat position only; 8 = low-hydrogen sodium coating type; H4 = maximum of 4 layers of coating; R = rutile coating supplement

B. E = electrode; 70 = minimum tensile strength of 700 MPa; 1 = all-position capability; 8 = type of electrode coating and current; H4 = maximum diffusible hydrogen of 4 mL/100 g of deposited weld metal tested per AWS A4.3; R = moisture-resistant coating that allows electrodes to be exposed to the atmosphere for an extended period before requiring reconditioning

C. E = electrode; 70 = minimum tensile strength of 70 ksi (approximately 480 MPa); 1 = all-position designation (flat, horizontal, vertical, and overhead); 8 = electrode covering type and current compatibility (basic covering, usable on AC and DCEP, iron powder addition); H4 = maximum diffusible hydrogen of 4 mL/100 g of deposited weld metal per AWS A4.3; R = moisture-resistant designation indicating the electrode has an enhanced low-moisture coating that allows extended atmospheric exposure while maintaining H4 hydrogen levels

D. E = electrode; 7 = minimum tensile strength in units of 10,000 psi; 0 = root pass only application; 18 = iron powder percentage in the coating by weight; H4 = minimum hardness of 4 HRC in the deposited weld metal; R = reclassified electrode that meets an updated specification superseding the original E7018 designation

84. A welder who normally works only with structural steel SMAW is told that SMAW electrodes exist for welding aluminum. The welder asks a senior welder about the characteristics and limitations of SMAW on aluminum. Which statement most accurately describes SMAW of aluminum?

A. SMAW aluminum electrodes work identically to steel SMAW electrodes — the technique, parameters, and post-weld slag removal are the same; the only difference is that aluminum electrodes use a sodium-based coating instead of the iron powder coating used in steel electrodes

B. SMAW aluminum electrodes (such as E4043 covered electrodes) can be used for aluminum repair in limited applications, but the process has significant limitations: the flux coating is highly hygroscopic and the flux slag is extremely corrosive to aluminum if not completely removed after welding (flux residue causes accelerated corrosion of the base metal); the aluminum arc is difficult to control and the process is not suitable for thin sections; the slag must be removed by thorough rinsing with hot water and wire brushing; SMAW aluminum is rarely used in modern fabrication where GMAW or GTAW are available

C. SMAW cannot be used on aluminum under any conditions — the covered electrode arc creates a reducing atmosphere that immediately solidifies the aluminum oxide layer on the electrode tip, preventing the arc from initiating or sustaining on any aluminum alloy

D. SMAW aluminum electrodes require DCEN polarity exclusively — on DCEP the aluminum electrode decomposes rapidly, contaminating the arc; the arc stability and aluminum oxide removal in aluminum SMAW occur through the DCEN-specific cathodic cleaning mechanism

85. A training instructor explains the effect of DC polarity on SMAW weld penetration using E6010 electrodes. How would switching the same electrode from DCEP to DCEN change the penetration profile, and why?

A. On DCEP (electrode positive), approximately two-thirds of arc heat concentrates at the electrode (anode) and one-third at the work — the electron bombardment of the workpiece at the cathode spot provides concentrated heating at the weld pool, producing defined penetration; on DCEN (electrode negative), the electrode is the cathode and the work is the anode, reversing the concentration so more arc heat goes to the work; in the abstract this increases workpiece heating on DCEN, but for most coated electrodes including E6010, DCEP is specified because the electrode coating chemistry requires the cathode drop at the workpiece for stable arc operation — switching to DCEN with E6010 produces unstable arc behavior rather than simply deeper penetration

B. DC polarity has no effect on SMAW penetration profile — penetration depth and width are determined exclusively by the welding current level; polarity only affects the electrode melt rate, not the heat distribution between electrode and workpiece

C. DCEN always produces shallower penetration than DCEP for any SMAW electrode — DCEN is specifically used when shallow penetration is required to avoid burn-through, and DCEP is used in all other applications; this relationship is universal and applies to all SMAW electrode types

D. DC polarity in SMAW affects only the mechanical properties of the deposited weld metal — switching from DCEP to DCEN increases the tensile strength and hardness of the deposit by changing the dilution ratio; penetration profile and pool shape are identical regardless of polarity

86. An inspector examining a structural SMAW weld made with E7018 in the 1G (flat) position finds a linear indication in the radiograph running parallel to the weld axis approximately 2 mm below the cap surface, extending the full length of the joint. The indication has a double-line character described as "wagon tracks." What specifically causes this defect and which technique change prevents it?

A. Wagon tracks are caused by using too high a welding current — excess current melts the electrode coating in large drops that fall into the pool and solidify as parallel lines of flux inclusions below the weld cap; reducing the current by 25% eliminates the wagon tracks

B. Wagon tracks result from the weld pool solidifying too quickly — the fast solidification rate traps slag from previous passes at the fusion boundaries on both sides of the pass; slowing solidification by increasing preheat and interpass temperature prevents wagon track formation

C. Wagon tracks are caused by the electrode holder cable creating a magnetic field parallel to the weld axis — the field aligns iron particles in the pool into two parallel lines that appear as the double-track radiographic indication; relocating the cable perpendicular to the weld axis eliminates this defect

D. Wagon tracks are a specific form of slag inclusion formed when slag from a previous pass is incompletely removed at the edges (toes) of the bead — the two parallel lines correspond to the slag remaining at each toe of the underlying pass; this occurs when the welder begins depositing a new pass before all slag at the bead toes has been removed; using a chipping hammer and wire brush to completely remove all slag from both weld bead toes before depositing each subsequent pass eliminates wagon tracks

87. A pressure piping contractor must perform SMAW welding on P22 (2.25Cr-1Mo) chrome-moly steam piping in a power plant. The material specification requires weld metal that matches the base metal's elevated-temperature creep strength. The electrode selection comes down to E8018-B2 or standard E7018. Which statement correctly identifies the required electrode and the critical consequence of using the wrong electrode?

A. E7018 is the correct electrode for all chrome-moly piping because the iron powder in E7018's coating adds sufficient chromium and molybdenum to the deposit through the flux chemistry — the "B" designation in E8018-B2 is a manufacturer's marketing designation, not a compositional specification

B. Either E7018 or E8018-B2 is acceptable for P22 pipe welding because base metal dilution during SMAW provides enough Cr and Mo to compensate for any compositional difference between the two electrodes — compositional matching of filler metal to base metal is only required for the root pass, not for fill passes

C. E8018-B2 is the required electrode — it deposits nominal 2.25% Cr and 1% Mo to match the P22 base metal composition and provide the creep rupture strength required for elevated-temperature service; substituting E7018 (a plain carbon-manganese deposit without Cr or Mo) creates a compositionally mismatched weld zone incapable of sustaining the required creep strength at service temperature and subject to premature failure under sustained high-temperature stress

D. E9018-B3 (3Cr-1Mo deposit) is the required electrode for all chrome-moly SMAW regardless of whether the base metal is P11, P22, or P91 — over-alloying with excess chromium and molybdenum is always preferred over strict compositional matching to ensure adequate elevated-temperature strength throughout the full weld joint

88. A welder used 4.8 mm E7018 electrodes in root and first fill passes of a groove weld where the WPS specified 3.2 mm maximum. The 4.8 mm electrode was operated at 180 A; the 3.2 mm electrode would have used 100 A. Using the same arc voltage of 24 V and travel speed of 4 mm/s, what is the heat input difference between the two options, and why did the WPS limit the electrode diameter?

A. The heat input difference is negligible — electrode diameter has no effect on heat input calculation since heat input is determined exclusively by travel speed; since both electrode sizes were used at the same travel speed, the heat input is identical regardless of the amperage or electrode diameter

B. Heat input at 180 A =  $(24 \text{ V} \times 180 \text{ A}) / (4 \text{ mm/s} \times 1000) = 1.08 \text{ kJ/mm}$ ; heat input at 100 A =  $(24 \text{ V} \times 100 \text{ A}) / (4 \text{ mm/s} \times 1000) = 0.60 \text{ kJ/mm}$ ; the 4.8 mm electrode produces 80% more heat input per unit length than the specified 3.2 mm electrode; the WPS likely specified the smaller electrode for the root and early fill passes to limit heat input for metallurgical reasons such as maintaining HAZ toughness, controlling distortion, or preventing excessive dilution with the base metal in the first passes

C. The 4.8 mm electrode produces the same heat input as the 3.2 mm electrode because larger electrodes always operate at higher efficiency — the efficiency factor exactly compensates for the higher amperage, producing equivalent joules per millimetre regardless of electrode diameter

D. The WPS limitation on electrode diameter to 3.2 mm for root passes is purely an ergonomic requirement — larger electrodes are heavier and harder to manipulate in a narrow groove; there is no heat input or metallurgical significance to the electrode size limit for root passes in structural groove welding

89. A structural welder certified for 4G (overhead) SMAW is assigned to deposit fillet welds on overhead structural connections. The welder asks a senior welder for specific technique tips for overhead welding. Which guidance most directly addresses the unique challenges of the overhead position?

A. Overhead SMAW requires reducing the amperage compared to flat position welding (typically 10–15% reduction for the same electrode size) to maintain a smaller pool that is easier to support against gravity; keeping the arc as short as possible increases arc force to help support the pool; pointing the electrode upward toward the joint at a slight drag angle and keeping the electrode as nearly vertical as the joint geometry permits helps maintain pool control; using a slightly weaving motion with brief pauses at the toes helps achieve full fusion without excessive pool volume that would drip; smaller electrode diameters than the flat position maximum allow finer pool control

B. Overhead SMAW requires increasing the amperage by 25% compared to flat position welding — the extra amperage is needed to overcome gravity's effect on the pool; without the additional heat, the weld metal freezes too quickly and produces lack of fusion at the weld toes

C. Overhead SMAW technique is identical to flat position SMAW because the electrode is pointing downward (toward the ground) in both positions and the arc force direction relative to the electrode is the same; no parameter or technique modification is needed for certified welders transitioning between flat and overhead positions

D. Overhead welding requires switching to DCEN polarity because DCEN concentrates arc heat at the workpiece rather than the electrode, providing more focused heating that prevents the molten pool from becoming too large and dripping; DCEP is too hot for overhead welding with any electrode type

90. A welding instructor is teaching the four metal transfer modes in GMAW. A student is confused about the difference between spray transfer and globular transfer since both occur at currents above a certain threshold but are described differently. Which explanation most accurately distinguishes these two modes?

A. Spray transfer and globular transfer are two names for the same metal transfer mode — both terms describe the continuous droplet transfer that occurs above the spray transition current; manufacturers use the terms interchangeably depending on their product documentation conventions

B. Globular transfer occurs at currents above the spray transition threshold while spray transfer occurs at currents below it — the terms describe the transfer modes in reverse order of current level; globular transfer is the high-current mode producing the finest droplets

C. Spray transfer occurs in all GMAW shielding gas mixtures containing carbon dioxide as the primary component (above 25% CO<sub>2</sub>), while globular transfer only occurs with inert shielding gases (pure argon or argon-helium) — the gas composition is the determining factor between these two transfer modes

D. Globular transfer occurs at intermediate currents below the spray transition threshold where the arc is continuous but the droplet diameter exceeds the electrode wire diameter — large irregular drops transfer intermittently with significant spatter; at the spray transition current and above (in argon-rich shielding gas), the electromagnetic pinch force exceeds the surface tension holding the droplet, producing very fine droplets smaller than the electrode diameter that transfer continuously and axially as spray transfer with dramatically reduced spatter; these are distinct modes separated by the spray transition current

91. A structural inspector asks a welding supervisor to explain the difference between "dual-shield" FCAW and self-shielded FCAW (FCAW-S), since both use flux-cored wire but are used in different field situations. Which description is most accurate?

A. Dual-shield FCAW uses two layers of shielding — an inner layer of argon from the torch nozzle and an outer layer of CO<sub>2</sub> from a secondary nozzle at the same torch; the two concentric shielding layers provide superior atmospheric protection; self-shielded FCAW uses only a single CO<sub>2</sub> layer

B. Dual-shield FCAW is used exclusively indoors where electricity and shielding gas are available, while self-shielded FCAW is exclusively an outdoor process; there are no applications where both types could be used in the same work area

C. Dual-shield FCAW uses both a flux core inside the wire AND an external shielding gas supply — the flux core provides deoxidation and metallurgical improvements while the external gas provides primary atmospheric shielding; self-shielded FCAW generates all required atmospheric protection exclusively from the vaporization of the core compounds, requiring no external shielding gas; dual-shield is not wind-resistant and must be protected from winds above ~8 km/h, while self-shielded FCAW can tolerate significant wind without quality loss — this makes self-shielded the preferred choice for outdoor construction work in windy conditions

D. Dual-shield FCAW is a term for SAW — the "dual shield" refers to the submerged flux layer and the internal flux core providing dual protection; self-shielded FCAW and dual-shield SAW are the only two flux-cored processes recognized by AWS A5.20

92. A production facility welds 304L austenitic stainless steel brackets using GMAW with 98% argon/2% oxygen shielding gas mix. A new engineer wants to switch to a less expensive 75/25 Ar/CO<sub>2</sub> mixture to reduce gas costs. Which technical concern makes this substitution inadvisable for 304L stainless steel?

A. The 75/25 Ar/CO<sub>2</sub> mixture has a lower ionization potential than 98/2 Ar/O<sub>2</sub> and cannot sustain spray transfer mode — without spray transfer, the 304L welds will always be in short-circuit transfer regardless of current setting, and short-circuit transfer is prohibited by code for stainless steel

B. CO<sub>2</sub> in the shielding gas reacts with chromium and nickel in the 304L stainless weld pool, reducing these elements from the deposit and creating a carbon-enriched, chromium-depleted weld composition — the carbon pickup from CO<sub>2</sub> decomposition promotes chromium carbide precipitation (sensitization) at the grain boundaries of the weld HAZ, degrading the corrosion resistance of the completed joint; the small oxygen addition in 98/2 Ar/O<sub>2</sub> provides arc stability without significant carbon pickup

C. The 75/25 Ar/CO<sub>2</sub> mixture produces higher spatter than 98/2 Ar/O<sub>2</sub> on stainless steel — the higher spatter rate is the primary technical concern because it increases cleanup time and reduces productivity, making the cost savings from the cheaper gas negligible

D. The 75/25 Ar/CO<sub>2</sub> mixture is incompatible with ER308L wire — the AWS A5.9 specification for ER308L specifically prohibits its use with any shielding gas containing more than 5% CO<sub>2</sub>; using ER308L with 25% CO<sub>2</sub> violates the wire classification requirements and voids the electrode manufacturer's warranty

93. A production manager implements new consumable control procedures requiring all opened FCAW wire spools to be stored in sealed containers with desiccant when not in use, and that spools left open for more than 48 hours in humid environments be tested or rejected before use. A production welder challenges this as overly cautious. Which technical justification supports the manager's procedure?

A. FCAW wire is not susceptible to moisture absorption — the all-metal wire construction makes it immune to moisture pickup regardless of storage conditions; the desiccant requirement has no technical basis

B. The 48-hour limit applies only to self-shielded FCAW wire — gas-shielded FCAW wires contain no hygroscopic flux compounds and are not affected by humidity at any practical atmospheric moisture level

C. FCAW wire storage requirements apply only when ambient relative humidity exceeds 90% — at humidity below 90%, all FCAW wire types are impervious to moisture absorption for up to 30 days; the procedure's 48-hour limit is unnecessarily conservative for normal shop conditions

D. FCAW wire (particularly self-shielded and some gas-shielded wires) contains hygroscopic flux compounds in the core — moisture absorbed from humid storage conditions can produce elevated diffusible hydrogen levels in the deposited weld metal, increasing the risk of porosity and hydrogen-assisted cracking in susceptible base metals; sealed storage with desiccant prevents moisture pickup; the 48-hour limit in humid environments reflects the period beyond which moisture absorption may reach levels that affect weld quality; this is a legitimate quality assurance measure supported by welding engineering best practice

94. A GMAW operator welding 4 mm mild steel sheet with ER70S-6 wire, 75/25 Ar/CO<sub>2</sub>, and short-circuit transfer finds that the welds produce excessive spatter and an irregular "sputtering" sound rather than the smooth, consistent "frying bacon" sound of well-tuned short-circuit transfer. The wire feed speed and voltage are within the standard parameter range. What is the most likely cause?

A. The most likely cause of excessive spatter and irregular arc sound in GMAW short-circuit transfer is incorrect inductance setting on the power source — inductance controls the rate of current rise during the short circuit re-ignition phase; too low an inductance setting allows current to rise too rapidly during the re-ignition burst, causing violent droplet detachment that produces large spatter; increasing the inductance smooths the current rise and produces the clean frying-bacon sound; most GMAW power sources for short-circuit transfer have an inductance or "arc control" adjustment specifically for this purpose

B. The sputtering sound and excessive spatter indicate the shielding gas cylinder is nearly empty — low cylinder pressure causes flow rate reduction, partial atmospheric contamination, and arc instability; the

characteristic sputtering and spatter of a nearly empty gas cylinder exactly matches this description; the welder should replace the cylinder immediately

C. Excessive spatter in GMAW short-circuit transfer is always caused by a worn contact tip — as the contact tip bore wears oval, the wire exits at a varying angle, changing the arc-to-pool relationship on each short circuit cycle and producing irregular, high-spatter transfer; replacing the contact tip with a new one always eliminates spatter problems in short-circuit GMAW

D. The sputtering sound and excessive spatter are caused by the wire speed being too low for the set voltage — low WFS relative to voltage creates a "stubbing" arc that repeatedly contacts the base metal rather than achieving smooth transfer; increasing the WFS (or reducing the voltage) brings the arc into the stable short-circuit transfer range and produces the frying bacon sound

95. A mining equipment maintenance shop is evaluating FCAW wires for hardfacing wear-resistant deposits on bucket teeth, dipper lips, and dragline components. The maintenance supervisor asks the welding engineer to explain what FCAW wire classifications are designed for hardfacing and what deposit properties they provide. Which explanation is most accurate?

A. Standard structural FCAW wires (E71T-1 class) can be used for hardfacing applications by increasing the amperage by 50% above the structural recommendation — the higher amperage changes the microstructure of the deposit from ductile to wear-resistant by rapid quenching; no special hardfacing wires are needed for most mining equipment applications

B. FCAW hardfacing wires are classified under the AWS A5.20 standard for stainless steel FCAW wires — all hardfacing deposits are classified as stainless steel deposits regardless of the chromium content because the hardening mechanism is the same as in stainless steel weld metal

C. FCAW hardfacing and surfacing wires are classified under AWS A5.21 (Composite Surfacing Welding Rods and Electrodes) — these include classifications producing deposits ranging from moderate work-hardening austenitic manganese (for impact-dominated wear) to high-chromium carbide (for severe abrasion) to complex carbide alloys; the classification system identifies the deposit type and its intended wear mode; selecting the correct hardfacing type requires matching the deposit microstructure to the predominant wear mechanism (abrasion vs. impact vs. metal-to-metal wear)

D. There are no FCAW wires specifically designed for hardfacing — hardfacing must always be performed using SMAW covered electrodes because only the covered electrode process can deposit the high-alloy, high-carbon chemistry required for wear-resistant surfaces; FCAW wire chemistry is limited to structural-grade weld metals with insufficient hardness for hardfacing applications

96. A GMAW production welder has been running high-deposition welding continuously for several hours. The welder notices the arc becoming increasingly erratic and weld appearance deteriorating. Inspection of the contact tip reveals the bore is significantly enlarged and out-of-round. What specific effects does a worn, enlarged contact tip bore have on GMAW weld quality?

A. A worn contact tip bore has no effect on GMAW weld quality as long as the wire can physically pass through the tip — the contact between wire and tip is maintained by the wire's inherent stiffness pressing against the bore wall, and this mechanical contact remains adequate for current transfer until the bore becomes so large that the wire passes through without touching the walls at all

B. An enlarged, out-of-round contact tip bore causes poor and inconsistent electrical contact between the wire and the tip — inconsistent contact produces variable and unreliable current pick-up, which results in the wire arriving at the arc at varying temperatures, producing unstable arc characteristics, inconsistent penetration, arc wandering, increased spatter, and erratic wire extension; the enlarged bore also causes the wire to exit at a variable angle rather than a consistent direction, contributing to arc wander; contact tips must be replaced when bore wear exceeds manufacturer specifications

C. A worn contact tip bore improves GMAW arc stability by providing less constraint on the wire — the looser bore allows the wire to self-adjust its exit angle to the optimal position for arc stability; production GMAW systems are specifically designed to operate with worn, larger-bore tips

D. Contact tip bore enlargement only affects wire feed speed — the larger bore creates less friction on the wire, allowing it to travel faster than the set WFS; the higher effective wire speed increases the deposition rate but has no effect on arc stability, penetration, or bead quality

97. A welding engineer is comparing FCAW-G and SAW for a production application involving long, straight fillet welds on structural steel plates in flat and horizontal positions. Which comparison is most technically accurate?

A. SAW generally achieves higher deposition rates and lower fume exposure than FCAW-G because SAW submerges the arc under a blanket of granular flux that confines heat and captures fumes — SAW can operate at very high currents (400–1200 A) far beyond the FCAW-G range (typically 150–400 A), producing deposition rates several times higher; however, SAW requires a fixed horizontal setup and cannot be used out-of-position, and requires flux handling, recovery, and storage infrastructure; FCAW-G is more flexible, portable, and applicable to multiple positions but at lower deposition rates and with fume generation that requires ventilation; the choice depends on whether the production volume and joint geometry justify SAW's infrastructure requirements

B. FCAW-G and SAW achieve identical deposition rates for flat position fillet welds because both processes are optimized for this exact application — the choice should be made exclusively on the basis of equipment capital cost

C. FCAW-G always produces higher heat input than SAW for the same deposition rate because the open-arc nature of FCAW-G dissipates more energy as radiant heat loss; SAW's submerged flux reflects all radiated heat back into the weld pool, making SAW inherently more energy-efficient per unit of deposited weld metal

D. SAW cannot be used for structural fillet welds because the process requires a flat-bottom groove to contain the molten flux pool — the inclined surfaces of a fillet weld at a T-joint cause the SAW flux to slide off before the arc can establish; only FCAW-G, SMAW, and GMAW are applicable for fillet welding

98. After GMAW welding of carbon steel using ER70S-6 wire and 75/25 Ar/CO<sub>2</sub> shielding, the quality inspector identifies numerous small, glassy, brownish islands on the weld surface. An inexperienced inspector asks what these islands are and whether they represent a weld quality defect. Which explanation is most accurate?

A. The brownish glassy islands are evidence of hydrogen porosity that broke the surface during solidification — the smooth glassy appearance is caused by hydrogen gas oxidizing at the surface as it escapes; each island represents a surface-breaking pore and all must be ground out and re-welded

B. The islands are oxidized base metal that was not completely melted by the arc — surface oxide contamination in GMAW always produces brownish glassy residue; the presence of islands confirms that the base metal surface was inadequately cleaned and the joint must be ground and re-welded

C. The islands are caused by CO<sub>2</sub> in the shielding gas decomposing to carbon monoxide and carbon inside the weld pool — the carbon deposits as graphite islands on the weld surface during solidification; graphite islands are a serious carbon contamination defect that requires immediate process shutdown and investigation

D. The brownish glassy islands are silica (SiO<sub>2</sub>) residues — ER70S-6 wire contains elevated silicon and manganese as deoxidizers; these deoxidizers react with dissolved oxygen in the pool to form silicon and manganese oxides that float to the surface and solidify as the characteristic glassy silica islands; they are a normal product of the deoxidation reaction in GMAW of carbon steel, not a weld defect; however, they must be removed by wire brushing or grinding before any additional weld passes are deposited over them, as they would become entrapped slag inclusions if buried under subsequent passes

99. A welding purchasing agent encounters the term "metal-cored arc welding" (MCAW) in a supplier's consumable catalog. The agent asks the welding engineer to explain what MCAW is, how it differs from FCAW-G, and when it is advantageous. Which explanation is most accurate?

A. MCAW is another name for submerged arc welding — the "metal core" refers to the solid metal wire electrode used in SAW, which is always a metal core wire; the term was introduced to distinguish SAW consumables from covered SMAW electrodes in supplier product catalogs

B. MCAW uses a metal-cored wire with a hollow center containing compressed shielding gas — the gas is stored inside the wire and released as the wire melts, eliminating the need for any external shielding gas supply; this makes MCAW the most field-portable of all GMAW-type processes

C. Metal-cored arc welding uses a tubular wire electrode (similar in construction to FCAW) but the core contains metal powders — iron powder, deoxidizers, and alloy additions — rather than flux; like GMAW solid wire, it requires external shielding gas; compared to solid wire GMAW, MCAW produces higher deposition rates from the metal powder additions, wider arc coverage for improved fusion on out-of-flat joints, and lower silica island formation on the weld surface; compared to FCAW-G, it produces no slag and therefore no slag removal between passes, but its deposit toughness may be lower than FCAW-G for some applications

D. MCAW uses a metal core and requires no shielding gas or flux of any kind — all atmospheric protection and metallurgical control come from alloying elements vaporized from the metal core; it is used only in enclosed vacuum chambers where external shielding gases would be diluted by the vacuum environment

100. A GMAW operator is experiencing a problem where the arc periodically "birdnests" — the wire bunches up and jams at the drive rolls rather than feeding to the torch. The operator has already verified that the contact tip, liner, and drive roll groove size are correctly matched to the wire diameter. What is the most common remaining cause of birdnesting in a correctly set-up GMAW system?

A. Birdnesting in a correctly set-up GMAW system is caused by the wire spool being wound in the wrong direction — if the wire unwinds in the incorrect direction, the wire twist causes it to spring back at the drive rolls and bunch up; the operator must rotate the spool 180° to correct the winding direction

B. Birdnesting after ruling out tip, liner, and drive roll match is most commonly caused by excessive drive roll pressure (over-tightened rolls that distort the wire cross-section), or a blockage or sharp bend in the conduit liner (which creates back-pressure that forces the wire to pile up at the drive rolls), or a wire spool brake (hub tension) set too tight, which resists unwinding and creates back-tension on the wire feed; the operator should check each of these systematically — release drive roll pressure, inspect and replace the liner if blocked, and adjust the spool hub brake tension

C. Birdnesting in GMAW always indicates the wrong wire type — FCAW wires are commonly mistakenly loaded into GMAW systems, and the extra stiffness of the flux-cored wire causes birdnesting in drives designed for solid wire; the operator must verify the wire type matches the drive roll and liner specifications

D. Birdnesting is exclusively caused by an electrical fault in the wire feed motor — the motor shaft speed fluctuates due to commutator wear, alternating between over-feeding and under-feeding the wire; the motor must be replaced before any further production welding can proceed

101. A production engineer monitoring a FCAW-G operation notices that after initial arc establishment, the wire feed speed gradually decreases over 30–60 seconds until the arc becomes unstable and eventually extinguishes. The drive rolls are turning at constant speed and the machine settings have not been changed. Which cause is most consistent with this description?

A. Gradual arc extinction after a stable start in FCAW-G indicates that the welding current is falling below the minimum spray transfer threshold — the wire feed speed gradual decrease is a protective feature of constant-voltage FCAW machines that reduces WFS as arc energy decreases; the operator must increase the voltage setting to maintain spray transfer throughout the weld

B. The gradual WFS decrease and eventual arc extinction is caused by the flux in the FCAW core absorbing arc energy over time — the core flux is a thermal insulator that becomes progressively less conductive as it heats up, increasing the electrical resistance of the wire, which the constant-voltage machine compensates for by reducing the wire feed speed

C. Gradual wire feed decrease and arc extinction in FCAW-G after a stable initial arc is caused by the shielding gas cylinder pressure dropping below the regulator's minimum operating pressure — the low pressure causes increasing gas flow interruption that destabilizes the arc; the arc extinction corresponds to complete cylinder depletion

D. Gradual wire feed speed reduction and eventual arc extinction in FCAW-G most likely indicates a progressive restriction developing in the wire feed path — typically a partial blockage in the liner from accumulated metallic or flux debris, increasing friction from a slight kink in the conduit, or the wire spool hub brake becoming progressively tighter as the spool warms; the initial constant drive roll rotation cannot overcome the increasing back-resistance, so the wire stretches and slips at the drive rolls rather than advancing, producing the observed gradual WFS decrease; inspecting and cleaning the liner and checking the spool tension are the diagnostic steps

102. A GMAW operator is asked to order replacement wire for a machine currently using wire marked "ER70S-6." What does each element of the classification mean?

A. E = electrode; R = rod (applies to both wire electrodes and filler rods); 70 = minimum tensile strength of the deposited weld metal of 70 ksi (approximately 480 MPa); S = solid wire; 6 = the chemical composition designator indicating specific silicon (approximately 1.4–1.85%) and manganese (1.65–2.15%) content that provides good deoxidation performance and wetting even on mill-scaled or lightly contaminated surfaces; higher S-numbers indicate increasing silicon/manganese deoxidizer levels

B. E = electrode; R = rutile flux coating; 70 = minimum yield strength of 70,000 psi; S = submerged arc capability designation; 6 = recommended operating voltage range of  $60 \text{ V} \pm 10\%$ ; this classification decoding applies to solid GMAW wire only

C. E = electrode; R = right-hand twist of the wire helix; 70 = minimum elongation of 70% in the deposited weld metal; S = silicon-killed steel composition; 6 = maximum carbon content of 0.06% in the wire composition

D. E = electrode; R = round cross-section wire; 70 = operating temperature range in degrees Fahrenheit; S = structural grade classification per AWS D1.1; 6 = number of required qualification tests that must be passed before this wire is approved for structural use

103. A FCAW-G operator is producing fillet welds on a horizontal T-joint and finds that the weld bead has a humped, irregular cross-section — the bead has high peaks and valleys along its length rather than a smooth, uniform profile. The wire feed speed, voltage, and travel speed appear within normal range. What is the most likely cause?

A. The irregular humped bead profile in FCAW-G is caused by the flux-cored wire being too stiff — the wire's cast and helix cause the electrode to oscillate back and forth as it exits the contact tip, producing the alternating high and low areas visible in the completed bead profile; switching to a more flexible wire brand eliminates the irregular profile

B. The irregular bead profile is caused by the  $\text{CO}_2$  content in the shielding gas being too high —  $\text{CO}_2$  above 20% creates an unstable short-circuit transfer condition even in FCAW-G wires rated for  $\text{CO}_2$  shielding; the arc instability produces the humped profile; switching to a higher-argon mixture corrects the profile

C. The humped, irregular bead profile in FCAW-G is most commonly caused by excessive travel speed — when travel speed is too high for the deposition rate, the weld metal deposits as separated, humped-up masses rather than a continuous, smooth bead; the pool does not have time to flow out and wet into the base metal between deposits; reducing travel speed allows the pool to flatten and wet the joint surfaces continuously, producing a smooth, uniform bead profile

D. The irregular bead profile is caused by intermittent electric ground connection failures — loose work clamp connections produce periodic current interruptions that result in the arc extinguishing and restarting, creating the humped appearance at each arc restart location; securing the work clamp to a clean, direct contact point corrects the irregular profile

104. A Canadian welder trained using ISO terminology is working at a US facility that uses AWS terminology. The supervisor asks for the wire feed speed to be set to "350 inches per minute." The

Canadian welder is accustomed to specifying WFS in metres per minute. What is the correct conversion to metres per minute, and why might parameter documentation present this type of confusion?

A. 350 inches per minute converts to  $350 \times 0.0254 = 8.89$  m/min  $\approx 9$  m/min; this conversion is straightforward and no documentation confusion exists between Canadian and US facilities because both countries have standardized on metres per minute for all GMAW parameter documentation since the adoption of SI units

B. 350 inches per minute =  $350 \times 0.0254$  m = 8.89 m/min, typically rounded to approximately 8.9 m/min; parameter documentation between US and Canadian facilities can create confusion because the US welding industry still commonly uses imperial units (inches per minute for WFS) while Canadian facilities may use SI units (m/min for WFS); this discrepancy is significant because WPS parameters documented in different unit systems must be carefully converted rather than simply transposed, as the numerical values differ substantially (350 ipm vs. 8.89 m/min describe the same WFS but appear very different

C. 350 inches per minute =  $350 \div 39.37 = 8.89$  feet per minute — this conversion applies because US facilities use feet per minute while Canadian facilities use metres per minute; the WPS must specify WFS in feet per minute for US facilities and metres per minute for Canadian facilities per ASME IX requirements

D. No conversion is needed — 350 inches per minute is equivalent to 350 centimetres per minute which rounds to 3.5 m/min; the "inches" designation in US WFS specifications is a legacy label that actually denotes centimetres; this legacy naming causes confusion but the numerical values are equivalent between US and Canadian WFS specifications without any conversion factor

105. A welding supervisor specifies E71T-1M FCAW-G wire for structural column splices in a high-rise building project where welds will be performed in various orientations including vertical-up groove welds in the field. A junior inspector asks what the "1" and "M" designators specifically mean in E71T-1M and how they confirm the wire is appropriate for vertical-up field welding. Which decoding is most accurate?

A. The "1" in E71T-1M indicates the wire is single-pass only — it may not be used for multi-pass groove welds in thick structural members; the "M" indicates the wire is rated for manual (hand-held) operation only, not for mechanized or automated FCAW systems

B. The "1" indicates the wire can be used only in the 1G (flat) position — despite the general perception that E71T-1M is an all-position wire, the AWS A5.20 standard specifies that the "1" in the fourth position of the designation refers to flat position only for structural applications; out-of-position use requires a separate qualification test

C. The "1" indicates a minimum tensile strength of 1,000 MPa; the "M" indicates the wire requires a magnesium shielding gas; this classification is specified for structural applications where base metal tensile strength exceeds 700 MPa

D. In E71T-1M, the digit before the T (which here is "1") is the position designator — "1" indicates the wire is suitable for all positions including vertical-up and overhead; "M" indicates the wire is qualified for use with a mixed (argon-CO<sub>2</sub> or Ar/CO<sub>2</sub>) shielding gas rather than CO<sub>2</sub>-only (C suffix); the combination of all-position capability ("1") and mixed-gas compatibility ("M") confirms the wire is appropriate for vertical-up field welding with the 75/25 or 80/20 Ar/CO<sub>2</sub> shielding gas typically used for field FCAW-G

106. A piping contractor is planning to use GMAW with ER316L wire to weld root passes on 316L stainless steel pressure piping. The quality engineer specifies that back-purging with argon is required for all root passes. Why is back-purging necessary for GMAW root passes on stainless steel, and what specific defect does it prevent?

A. Back-purging is required because the GMAW process generates significantly more heat than GTAW and the extra heat increases oxidation rate on the back of the root pass — the back purge provides cooling by flowing cool argon across the root face, reducing the peak temperature and preventing the root from melting through

B. Back-purging is required for GMAW stainless root passes to provide electrical grounding for the GMAW circuit — stainless steel piping is non-conductive at the pipe inner surface due to the chromium oxide passivation layer, and argon back purge gas ionizes and provides the return current path through the pipe interior

C. Back-purging displaces oxygen from the interior of the pipe at the root weld zone — without back-purge, the root pass back-bead surface oxidizes (sugars) at elevated welding temperatures; this oxidation consumes chromium from the root surface, creating a chromium-depleted, sensitized zone and a rough, porous root bead surface; the oxidized root bead is structurally weaker, more corrosion-prone, and may trap oxidation scale that can contaminate the process fluid; argon back-purging maintains an inert atmosphere on the back side and prevents oxidation

D. Back-purging is required only when the GMAW process uses CO<sub>2</sub> shielding gas — pure CO<sub>2</sub> decomposes to carbon monoxide and oxygen in the arc, and the oxygen can migrate through the molten root to the back side of the pipe; with argon-rich shielding mixtures, no CO<sub>2</sub>-derived oxygen is present and back-purging is unnecessary

107. A FCAW-G operator starts the arc but immediately observes the wire "cold feeding" — the wire advances toward the plate but the arc does not establish, and the wire piles up on the plate surface

without melting. After releasing the trigger the wire has formed a piled-up ball of unmelted wire on the work surface. What is the most likely cause and correction?

A. Cold wire feeding (wire advancing without an arc) in FCAW-G is most commonly caused by a failed arc-start condition — the wire made physical contact with the work but the arc current did not flow; the most common causes are: a work return clamp that is not making proper electrical contact with the workpiece (corroded contact surface, clamped to a painted or coated area, or connected to a non-conductive surface), an open circuit in the work return cable, or a power source fault that prevents arc initiation; the operator should check that the work clamp is securely connected to clean, bare metal and verify the work cable continuity before attempting another arc start

B. Cold feeding indicates the voltage is set too high — at excessively high voltage, the arc energy immediately ionizes all the shielding gas in the cup rather than concentrating at the wire tip; without concentrated arc energy at the wire tip, the wire advances but melts only from radiant heat, producing the piled-up cold-feed condition; reducing the voltage to the normal range corrects cold feeding

C. Cold feeding in FCAW-G indicates the wire feed motor is running at twice its set speed — a control board failure causes the motor to alternate between over-feeding and under-feeding the wire; the motor must be replaced before any further production welding can proceed

D. Cold wire feeding occurs when the flux core inside the FCAW wire has been compressed during storage — compressed flux reduces the electrical conductivity of the wire core, preventing arc current from flowing through the full wire cross-section; the operator can restore conductivity by straightening a 500 mm length of wire and passing a test current through it before installation

108. Two GTAW welders are setting up for carbon steel root pass welding on structural pipe. One welder uses a high-frequency (HF) arc starting unit, while the other uses the scratch-start technique. A QC inspector asks about the quality implications of each arc starting method. Which comparison is most accurate?

A. Scratch starting is the preferred method for carbon steel GTAW because the physical contact between the tungsten and the base metal preheats both components simultaneously, providing a stronger initial bond and better root fusion than the cold-contact HF start

B. HF arc starting initiates the arc without the tungsten contacting the base metal — the high-frequency, high-voltage spark ionizes the shielding gas between the tungsten and the work, allowing the arc to transfer without contact; this prevents tungsten contamination of the weld at the arc start, preserves the tungsten tip geometry, and avoids tungsten inclusions in the root bead; scratch starting requires tungsten contact with the base metal, which can deposit tungsten particles in the initiation zone, contaminate the

tungsten tip, and require grinding before continuing; HF starting is preferred for quality-critical applications

C. HF arc starting and scratch starting produce identical weld quality because the arc characteristics after initiation are the same regardless of the starting method; the only difference is that HF starting requires additional equipment; scratch starting is economically equivalent in quality for all GTAW applications

D. HF arc starting is only available on AC GTAW machines — DC GTAW power sources used for carbon steel and stainless steel cannot produce the high-frequency needed for non-contact arc starting; all DC GTAW operations must use the scratch start method

109. A GTAW training class discusses tungsten electrode preparation for different welding applications. The instructor explains that the tungsten tip preparation differs depending on the polarity and base metal being welded. Which statement correctly describes the appropriate tungsten tip geometry for DCEN GTAW of carbon steel versus AC GTAW of aluminum?

A. Both DCEN carbon steel GTAW and AC aluminum GTAW require the tungsten to be prepared with a pointed tip — the pointed tip is the universal GTAW tungsten preparation for all applications; the only difference is the tungsten alloy type

B. Both DCEN carbon steel and AC aluminum GTAW require the tungsten to be prepared with a balled tip — the ball provides the widest possible arc coverage for both applications; balling is achieved by touching the tungsten to a copper plate for 2–3 seconds before the weld

C. For AC aluminum GTAW, the tungsten must be prepared with a sharp point that self-balls during the first few seconds of AC welding — the EP half-cycles during AC welding cause the point to melt and ball automatically; attempting to start with a balled tip on AC aluminum GTAW causes the ball to fall off into the weld pool

D. For DCEN GTAW of carbon steel, the tungsten should be prepared with a ground pointed tip (taper length approximately 2–3× electrode diameter) — the pointed tip on DCEN concentrates the arc into a narrow, well-defined plasma column providing precise control and deep penetration; for AC aluminum GTAW, a balled (hemispherical) tip is required — the EP half-cycles during AC welding heat the electrode tip enough to melt the pointed geometry into a ball; attempting to weld AC aluminum with a sharply pointed tungsten causes unstable arc behavior; the ball is formed by striking the AC arc on a copper block before moving to the work

110. A GTAW welder switches from a standard collet body to a gas lens assembly when welding thin-wall stainless steel tubing. The arc becomes more stable and less sensitive to air movement at a slightly

longer arc length than was possible with the standard collet body. What does the gas lens assembly specifically do to produce these improvements?

A. The gas lens assembly increases the shielding gas flow rate by a factor of 5 — the lens restricts the gas exit area, creating back-pressure that forces more gas through the nozzle per minute; the higher gas flow rate provides better shielding coverage less sensitive to air movement and longer arc lengths

B. The gas lens assembly contains a chemical oxygen getter material (a zeolite compound) that removes residual oxygen from the argon supply before it reaches the nozzle — the purified argon from the gas lens provides better shielding than standard argon from a collet body

C. The gas lens contains a series of fine mesh stainless steel screens that straighten the turbulent gas flow from the supply line into a uniform, laminar flow across the entire nozzle cross-section — the laminar flow blanket provides more effective atmospheric shielding at a given gas flow rate and maintains the shielding envelope at longer arc lengths and with some ambient air movement; the improved laminar shielding allows a slightly longer arc length, larger nozzle standoff, and better visibility of the weld pool

D. The gas lens creates an electrostatic field around the shielding gas column that aligns the argon atoms parallel to the electrode axis — the aligned gas atoms flow more directly toward the weld pool than unaligned gas, providing better shielding coverage; the electrostatic alignment is powered by the GTAW arc itself and requires no external power source

111. A GTAW welder is assigned to weld a copper bus bar connection (99.9% pure copper, deoxidized) in a switchgear assembly and asks for guidance on the key differences compared to welding stainless steel and carbon steel with GTAW. Which guidance is most accurate?

A. Copper's thermal conductivity is approximately 7 times greater than carbon steel — heat dissipates from the weld zone so rapidly that with the same parameters used for stainless steel, fusion is impossible; the welder must significantly increase the heat input (using higher amperage, helium-argon shielding gas to increase arc enthalpy, preheat of 200–400°C for heavier sections, and slower travel speed) to overcome the heat sink effect and achieve fusion; deoxidized copper also requires careful filler metal selection (such as ERcCu) to prevent porosity from oxygen pickup; DCEN is standard for copper GTAW

B. Copper GTAW requires DCEP polarity exclusively — on DCEN, copper reflects the arc back toward the tungsten, preventing arc initiation; DCEP provides the cathodic cleaning necessary to break the copper surface oxide and establish the arc

C. Copper GTAW requires the same parameters as stainless steel GTAW for the same plate thickness — copper and stainless steel have similar thermal properties, and the same WPS can be used for both materials without modification; only the filler metal needs to change

D. Copper GTAW cannot be performed with argon shielding gas — the high thermal conductivity of copper requires helium shielding exclusively; argon is insufficient to maintain the required arc stability when welding any copper alloy thicker than 1.5 mm regardless of preheat temperature

112. A welding engineer is evaluating "hot wire GTAW" for increasing deposition rate on a stainless steel cladding application. A purchasing agent asks how it differs from conventional cold wire GTAW and what advantage it provides. Which description is most accurate?

A. Hot wire GTAW uses a specially alloy-coated electrode wire that generates its own heat through a pyrotechnic reaction when it contacts the arc — the self-heating wire melts faster than conventional cold wire, increasing deposition rate by 200%

B. In hot wire GTAW, the filler wire is independently pre-heated by passing a separate AC resistance heating current through the wire (between the contact tube and the weld pool) just before it enters the weld pool — the pre-heating reduces the energy the arc must supply to melt the wire, allowing significantly higher wire feed speeds and deposition rates (typically 2–5× higher than cold wire GTAW) without a corresponding increase in total heat input to the base metal; this makes hot wire GTAW particularly valuable for stainless steel cladding where high deposition rate and controlled dilution are both required

C. Hot wire GTAW is a trade name for the process in which the GTAW power source is preheated to operating temperature before the arc is struck — heating the power source above 40°C before initiating the arc improves arc starting reliability on all materials

D. Hot wire GTAW uses a wire electrode heated to 800°C by an external furnace before loading into the wire feeder — the pre-heated wire is softer and more ductile than room-temperature wire, reducing the cast and helix that cause feeding problems; the softened wire also produces a smoother bead profile

113. A GTAW welder is certified to weld titanium pressure vessels. The weld procedure requires "trailing shielding" in addition to the standard torch cup shielding and back purge. Why is trailing shielding specifically necessary for titanium, and what does it accomplish?

A. Trailing shielding is only required for titanium wall thicknesses above 25 mm — thin titanium below 25 mm cools quickly enough that the weld metal temperature drops below the oxidation threshold before the standard torch cup shielding ends

B. Trailing shielding is required for titanium to prevent the formation of titanium hydrides — the trailing shield displaces the hydrogen in ambient air from contacting the recently deposited weld metal; titanium hydrides form when titanium above 300°C contacts any hydrogen source

C. Trailing shielding is required for titanium because titanium has an extremely high melting point — the trailing shield provides additional heat to keep the weld metal above the fusion temperature for a longer period, improving weld pool flow and reducing the porosity that forms when titanium cools too quickly

D. Titanium is highly reactive with oxygen, nitrogen, and hydrogen at temperatures above approximately 300–400°C — contamination by any of these gases at this temperature range causes the weld and HAZ surface to become brittle, discolored, and potentially cracked; the standard torch cup shields only the molten pool and immediate solidification zone; the hot weld and HAZ remain above the contamination threshold for several seconds after the arc passes and are exposed to the atmosphere after the torch moves forward; the trailing shield extends the inert gas coverage over the recently solidified hot metal until it cools below the critical contamination temperature

114. A GTAW technician is set up to weld an inside-corner T-joint in thin stainless steel with a #4 (1/2-inch) gas cup, then switches to a #8 (1-inch) ceramic cup for welding the exterior of a stainless pressure vessel nozzle. The technician maintains the same gas flow rate of 8 L/min for both cup sizes. A QC inspector questions whether the same flow rate is appropriate for both cup sizes. Which explanation correctly addresses this question?

A. The same 8 L/min flow rate is equally appropriate for all GTAW cup sizes — shielding effectiveness in GTAW is determined exclusively by the total flow rate in L/min, and the cup diameter has no effect on the minimum adequate flow rate

B. A larger cup always requires a lower flow rate than a smaller cup — the larger cross-sectional area of the #8 cup means the same volume of gas exits more slowly, providing better laminar flow and superior shielding; reducing the flow rate from 8 L/min to 4 L/min for the #8 cup improves shielding effectiveness

C. Shielding gas flow rate in GTAW must be matched to the cup size — a larger cup such as the #8 requires a higher flow rate to fill the larger nozzle cross-section and maintain adequate gas velocity at the nozzle exit to protect the weld zone; using 8 L/min in a #8 cup that was adequate for the #4 cup may produce insufficient coverage velocity in the larger cup; a general guideline is to use a flow rate in L/min approximately 8–10 times the cup size number (in US numbering), suggesting approximately 12–15 L/min for a #8 cup

D. Cup size has no relationship to gas flow rate requirements in GTAW — the standard flow rate of 8 L/min applies universally regardless of the cup size, tungsten diameter, or base metal being welded; any flow rate deviation from 8 L/min requires special engineering approval

115. A welding engineer is implementing automated GTAW for welding long seams on stainless steel pressure vessel shells and specifies a seam tracking system that uses through-the-arc sensing to detect joint position during welding. How does through-the-arc seam tracking work?

A. Through-the-arc seam tracking uses a laser beam reflected off the groove surface to measure the distance from the torch to the groove walls — changes in reflected laser intensity indicate when the torch has drifted off the joint center, and a servo motor corrects the position; the GTAW arc itself plays no role in the sensing mechanism

B. Through-the-arc seam tracking monitors changes in welding current (in CV mode) or voltage (in CC mode) that occur as the arc interacts with the groove geometry — when the torch is centered in the groove, the arc-to-work distance and electrical characteristics are symmetrical; when the torch drifts, the difference in arc length to each groove wall creates detectable changes in the electrical signal; the controller interprets these changes and drives the torch back to center; this method requires no separate sensor and uses the arc itself as the sensing element

C. Through-the-arc seam tracking measures the temperature of both sides of the joint using infrared sensors mounted 50 mm ahead of the torch — temperature asymmetry between the two sides indicates that the arc has drifted toward the warmer side; the controller corrects the torch position by moving away from the warmer side

D. Through-the-arc seam tracking uses the magnetic field generated by the welding arc to create a 3D map of the joint profile ahead of the torch — the mapping data is used to program the exact torch path before welding begins; real-time corrections during welding are not made because the entire weld path is pre-programmed from the pre-weld magnetic scan

116. A GTAW technician is welding a critical stainless steel instrument manifold. The WPS requires a 15-second pre-purge before arc initiation and a 30-second post-purge after arc extinguishment. A time-pressured production scheduler asks if these purge times can be eliminated to improve cycle time. Which explanation most clearly justifies the purge time requirements?

A. Pre-purge establishes a full envelope of shielding gas throughout the torch cup, gas lens, and the space between the tungsten and work before the arc is struck — without pre-purge, residual air in the torch and cup contaminates the initiation zone; this is particularly critical for stainless steel and reactive

metals where even momentary air exposure during arc start causes surface oxidation and potential tungsten contamination; post-purge maintains the shielding gas flow for the specified time after the arc is extinguished while the tungsten, nozzle, and recently deposited weld metal are still at temperatures where oxidation can occur; eliminating either purge creates a risk of contamination at the weld start or finish zones that would require repair

B. Pre-purge and post-purge are optional on GTAW machines equipped with gas lenses — the gas lens turbulence suppression eliminates the need for pre-purge because the laminar gas flow from the lens reaches the cup exit immediately; post-purge can also be eliminated for stainless steel because stainless does not oxidize at GTAW torch body temperatures

C. The purge times specified in the WPS are minimum legal requirements under the Transportation of Dangerous Goods Act — argon shielding gas is classified as a dangerous compressed gas and the purge time specifies the minimum atmospheric displacement period required before the gas can be used in contact with a heat source

D. Pre-purge and post-purge are required only when the GTAW system operates above 200 A — at currents below 200 A, the tungsten and weld zone cool quickly enough that no post-purge is needed; the pre-purge requirement only applies when the torch has been idle for more than 30 minutes

117. A manufacturing engineer is selecting between GTAW and GMAW for welding 2 mm 304L stainless steel sheet metal components for a food processing equipment application. Both processes are technically capable. Which comparison is most technically accurate for this specific application?

A. GMAW is always preferred over GTAW for any material thickness below 3 mm — GMAW produces less heat input per unit length than GTAW at equivalent travel speeds because the lower arc voltage of GMAW short-circuit transfer reduces the joule heating, producing less distortion on thin sheet metal

B. GTAW and GMAW produce identical results on 2 mm 304L stainless steel sheet — the choice should be made exclusively on the basis of equipment availability and operator preference

C. GMAW is preferred for food processing equipment stainless steel because GMAW deposits a thicker, more continuous oxide layer on the weld surface that provides better corrosion protection than the thinner GTAW oxide layer

D. GTAW produces superior surface appearance (smooth, shiny weld face), lower heat input for the same joint penetration (reducing distortion on 2 mm sheet), no silica island formation, and no spatter — all of which are advantages for food processing equipment where surface finish, cleanliness, and dimensional accuracy are paramount; GMAW on thin stainless produces silica islands requiring brushing, risk of spatter even with short-circuit transfer, and a slightly rougher weld surface; for 2 mm

304L food processing equipment, GTAW is the technically superior process despite its lower deposition rate

118. A GTAW apprentice is learning to control arc length. The instructor asks what happens to the weld pool and bead shape as the arc length is progressively increased from the optimal 1–2 mm to 6–8 mm while keeping all other parameters constant. Which prediction is most accurate?

A. Increasing the arc length in GTAW increases the depth of penetration — the longer arc column has more time to preheat the base metal surface before the molten arc column contacts it, producing a wider and deeper fusion zone

B. Increasing the arc length in GTAW has no effect on weld bead shape or penetration depth because the power source operates in constant-current mode — the current remains at the set value regardless of arc length; since heat input depends only on current and travel speed, and these are unchanged, the bead dimensions are unchanged

C. Increasing the arc length in GTAW increases the arc voltage, which increases arc power and bead width; however, the arc energy distributes over a wider area at the longer arc length, actually decreasing the current density and penetration depth; the pool becomes wider and shallower; at extreme arc lengths, shielding gas effectiveness degrades because the laminar shielding envelope cannot extend uniformly over the larger arc gap, risking atmospheric contamination; maintaining a short, controlled arc length (1–3× electrode diameter) is fundamental GTAW technique

D. A longer arc length in GTAW immediately causes the constant-current power source to shut down through its arc-voltage protection circuit — all GTAW power sources have a maximum operating voltage of 15 V, and arc lengths above approximately 3 mm produce voltages above this limit; arc extinction by protective shutdown is the only result of any arc length increase beyond 3 mm

119. A GTAW welder is instructed to keep the tungsten electrode extension (stickout beyond the end of the gas cup) to a maximum of 6 mm for stainless steel welding. The welder asks why a longer tungsten extension is technically undesirable even though it provides better visibility of the pool. Which explanation is most accurate?

A. A longer tungsten extension removes the tip of the tungsten from the effective shielding gas coverage provided by the ceramic cup — as the tungsten extends further from the cup exit, the turbulent boundary of the shielding gas envelope reaches the tungsten tip sooner, reducing atmospheric protection at the electrode tip and the immediately adjacent weld zone; longer extensions also increase the arc length required to reach the work when the cup is positioned at normal standoff, making arc length control

more difficult; the recommended extension is the shortest length that allows adequate pool visibility for the specific joint configuration

B. Tungsten extension beyond 6 mm causes the tungsten to overheat because the cup no longer provides thermal support to the electrode body — without the ceramic cup's thermal insulation, the unsupported tungsten extension absorbs heat from the arc faster than the shielding gas can cool it, causing the extension to melt into a ball regardless of the current setting

C. Tungsten extension length has no effect on shielding effectiveness or arc control — the 6 mm maximum is purely an ergonomic guideline to prevent accidentally touching the tungsten to the weld pool when visibility is limited; there is no metallurgical or quality justification for the extension limit

D. A longer tungsten extension increases the contact resistance between the tungsten and the collet, reducing the current delivered to the arc — longer extensions allow the tungsten to deflect in the collet bore, reducing the electrical contact area and the effective welding current; short extensions are specified to maximize current delivery to the arc

120. A GTAW welder discovers they accidentally contaminated a section of a 316L stainless steel weld by allowing the filler wire to contact the tungsten electrode. The affected 80 mm length of weld shows a dull gray surface color and radiography reveals dense inclusions consistent with tungsten contamination. How must the contaminated zone be handled before welding continues?

A. The contaminated zone can be cleaned by wire brushing with a stainless steel brush followed by argon torch purging at maximum gas flow to re-oxidize the contamination zone — wire brushing removes the surface contamination and purging removes any residual contaminants; no weld metal removal is required for tungsten contamination discovered on visual inspection

B. The contaminated 80 mm section must be completely removed by grinding, machining, or careful mechanical removal until all contaminated weld metal is excavated — the removal must extend beyond the visible discoloration to ensure all tungsten particles are removed; after excavation, MT or PT should be performed to confirm the removal is complete; a replacement tungsten electrode must be prepared with the correct tip geometry before re-welding; the excavated cavity must be re-welded with correct technique and re-inspected by RT after completion

C. Tungsten contamination in GTAW stainless steel does not require any corrective action — the tungsten inclusions are inert and chemically stable in stainless steel service environments; the cosmetic discoloration and RT indications are acceptable under all stainless steel welding standards for food and chemical processing applications

D. The contaminated zone should be preheated to 800°C for 30 minutes to dissolve the tungsten particles into the surrounding stainless steel weld metal — tungsten is soluble in stainless steel at

temperatures above 800°C, and the extended soak ensures complete dissolution; after cooling, the zone may be used without any additional NDE

121. A welding engineer is reviewing the flux specification for a SAW procedure on a pressure vessel and discovers the procedure calls for an "active" flux (Mn-Si active flux) rather than a "neutral" flux. The engineer asks for an explanation of the metallurgical significance of active versus neutral flux selection. Which explanation is most accurate?

A. Active flux and neutral flux are interchangeable designations used by different flux manufacturers to describe the same chemical composition — they differ only in the country of origin of the manufacturer; North American manufacturers use the term "active" while European manufacturers use "neutral" for the same composition type

B. Active fluxes reduce the required preheat temperature by 50°C compared to neutral fluxes for the same base metal — the active compounds react exothermically with the base metal surface and provide supplemental heat that compensates for lower preheat temperatures; neutral fluxes have no supplemental heat contribution

C. Active fluxes require higher current density than neutral fluxes for the same bead width — the active compounds require more electrical energy to decompose in the arc and therefore consume more of the total arc energy; to compensate, active flux SAW must be operated at 20% higher amperage than neutral flux SAW for the same wire and plate combination

D. Active (or alloying) fluxes contain Mn, Si, and other elements that are intentionally transferred to the weld deposit during the SAW process — the flux chemistry modifies the weld metal composition, and the transfer efficiency of these elements changes with heat input (more element transfer at higher heat input, less at lower); this heat-input sensitivity means any change in SAW heat input changes the weld metal composition and therefore changes the mechanical properties, requiring requalification; neutral fluxes transfer minimal elements to the deposit and produce more consistent weld metal properties across a wider range of heat inputs, making neutral fluxes preferred for pressure vessel applications requiring tightly controlled and reproducible mechanical properties

122. A SAW operator is changing from a wire/flux combination qualified for carbon steel (EM12K wire with neutral flux) to a new combination for a chrome-moly pressure vessel (EB3 wire with a basic neutral flux). The operator notices the PQR for the chrome-moly combination required separate qualification even though the same SAW equipment was used. Why does ASME Section IX require a new procedure qualification when the wire/flux combination changes?

A. Under ASME Section IX, a change in the flux classification or the wire classification is an essential variable for SAW procedure qualification — the wire and flux interact chemically in the SAW arc to

produce the deposited weld metal composition; each specific wire/flux combination produces a unique deposit chemistry and microstructure; the EB3/basic neutral flux combination produces a Cr-Mo alloy deposit with specific mechanical properties that can only be established by a qualification test using that specific combination; the EM12K/neutral flux PQR does not qualify any Cr-Mo wire/flux combination regardless of equipment similarities

B. A new PQR is required only because the base metal P-Number changes from carbon steel to chrome-moly alloy — the wire and flux change itself is not an essential variable under ASME IX; the same EM12K wire/flux PQR would qualify the EB3/basic flux combination if the P-Number were kept the same

C. ASME Section IX requires a new PQR for any SAW operation at a different facility than where the original PQR was performed — the company-specific qualification requirement means that transferring PQRs between sites requires requalification even when the wire, flux, and base metal are identical

D. ASME Section IX does not require new qualification for SAW wire and flux changes — SAW wire/flux combinations are covered by a universal SAW qualification that applies to all wire and flux types as long as the tensile strength of the deposited weld metal from the new combination meets the minimum required value; no physical qualification testing is required for wire/flux changes that maintain the required minimum tensile strength

123. A pipeline fabrication shop is considering SAW for welding the longitudinal seams of large-diameter (36-inch, 914 mm) line pipe from API 5L X70 steel plate. What modifications to a standard flat-plate SAW setup are required for effective inside longitudinal seam welding of pipe?

A. SAW cannot be used for inside longitudinal seam welding of large-diameter pipe — the weld pool would be suspended upside-down on the inside of the pipe, and the flux blanket would fall off before the arc could be established; mechanized GMAW or FCAW is required for all inside pipe longitudinal seam applications

B. SAW for inside longitudinal pipe seam welding requires inverting the power source and flux delivery system to operate the arc from below the pipe — the inverted flux delivery system uses compressed air to force the flux up against the inside pipe surface; this specialized system is required for any pipe inside diameter below 2,000 mm

C. Inside longitudinal seam SAW of large-diameter pipe is performed with the pipe positioned with the seam at the bottom (6 o'clock position) — the pipe is placed on turning rolls with the seam at the lowest point so the SAW torch travels along the inside bottom of the pipe where gravity holds the flux in contact with the plate; the flux hopper, delivery nozzle, and recovery system are adapted for inside-diameter use; the pipe diameter must be large enough to accommodate the SAW torch and flux handling equipment inside; this is standard practice for large-diameter line pipe fabrication

D. SAW for longitudinal seam welding of pipe requires preheating the entire pipe to 400°C before any SAW welding begins — the high thermal mass of large-diameter pipe absorbs heat from the SAW arc so rapidly that fusion is impossible without pre-established preheat above 400°C, regardless of the X70 carbon equivalent

124. A fabrication specification for a SAW vessel shell longitudinal seam allows two options: (1) weld from both sides with back-gouging and re-welding, or (2) use a permanent backing strip on the root side with welding from one side only. What are the code implications of using a permanent backing strip on a pressure vessel weld?

A. A permanent backing strip is always preferred over back-gouging for all SAW pressure vessel applications because it eliminates the cost and time of back-gouging and re-welding; there are no code implications or restrictions associated with the use of permanent backing strips in ASME pressure vessel fabrication

B. A permanent backing strip remaining in the completed joint creates a crevice at the junction between the backing strip and the vessel shell — this crevice can trap corrosive process fluids and may create a fatigue crack initiation site under cyclic loading; ASME Section VIII Division 1 restricts or prohibits the use of permanent backing in certain service categories (cyclic service per Appendix 5 and some lethal service requirements under UW-2); the joint efficiency assigned to backing strip joints may also differ from joints welded from both sides; the engineer must confirm the applicability of permanent backing under the specific code edition, design conditions, and service environment

C. A permanent backing strip changes the SAW joint from a CJP to a PJP weld — under ASME Section VIII, all backing strip joints are automatically classified as PJP and receive a reduced joint efficiency regardless of the weld penetration depth achieved; the PJP classification requires a 25% increase in calculated shell wall thickness

D. Permanent backing strips are prohibited on all ASME Section VIII Div 1 vessels regardless of service conditions — the backing strip creates a notch at the root that violates the smooth bore requirement under UG-93; all vessel seams must be welded from both sides with back-gouging, and this requirement cannot be waived for any combination of service conditions or vessel class

125. A welding engineer is evaluating options for maximizing productivity on thick-wall (50 mm) pressure vessel shell longitudinal seam SAW. After implementing a two-wire tandem SAW setup, metallurgical testing shows adequate tensile strength but Charpy impact values are lower than those achieved with the single-wire procedure at the same test temperature. Why did the impact values decrease, and what corrective action is available?

A. The decreased Charpy impact values from tandem SAW compared to single-wire SAW are caused by the second electrode's current interfering with the first electrode's flux recovery system — incomplete flux recovery causes flux dilution of the weld metal, reducing the impact toughness by adding unmelted flux particles to the deposit; cleaning and recalibrating the flux recovery system restores the impact values

B. The decreased impact values from tandem SAW are caused by the higher speed of the tandem process — faster travel speed in tandem SAW produces a more rapidly solidified weld deposit that has insufficient time to develop the crystallographic texture needed for good impact toughness; reducing the tandem travel speed to match the single-wire speed restores the impact values

C. The decreased Charpy values from tandem SAW result from the second wire's AC interference with the primary DC wire's arc — the electromagnetic crosstalk between the two electrodes changes the arc plasma composition, reducing the inert gas coverage of the pool and causing nitrogen pickup that degrades impact toughness; switching both electrodes to DC eliminates the electromagnetic interference and restores impact values

D. The decreased Charpy impact values from tandem SAW compared to single-wire SAW result from the higher heat input per pass in the tandem system — the increased thermal energy from the two simultaneous arcs produces a coarser-grained HAZ and weld metal microstructure with larger prior austenite grains; coarser grain structure has lower impact toughness; corrective actions include optimizing the tandem parameters to reduce the total heat input per pass (reducing amperage or increasing travel speed), selecting a higher basicity flux that produces better HAZ grain refinement through the inoculation effect, or using impact-tested supplemental filler metal additions; if the impact values remain insufficient after optimization, tandem SAW may not be appropriate for this vessel's impact testing requirements

## Practice Exam 9: Answer Key and Explanations

1. C — Acute Toxicity is quantified by LD50 or LC50 values for single-exposure lethality outcomes, while STOT-SE identifies specific organs or systems — nervous, respiratory, blood — that are damaged by a single exposure at concentrations that may not meet lethality thresholds. A product can cause serious, irreversible organ-specific harm well below the dose that triggers acute toxicity classification. This distinction determines which first aid measures, medical surveillance requirements, and engineering controls are most critical for the specific product.

2. A — Grounding connects the power source frame to the earth ground system, providing shock protection if an electrical fault energizes the equipment chassis. Bonding creates the dedicated low-impedance return path for welding current from the workpiece clamp back to the power source return terminal, preventing stray current from finding unintended paths through building structures, gas piping, or instrumentation. Both are independently necessary: grounding protects the operator, bonding protects the welding circuit integrity.

3. D — Fit testing must be performed for the specific make, model, and size of tight-fitting respirator that the worker will actually use — fit test results do not transfer between different models or APF categories. Qualitative or quantitative test results must be documented and repeated annually or whenever facial characteristics change, as these factors affect the seal quality that the test verified. Without this verification, the specific seal between that respirator and that worker's face is assumed rather than confirmed.

4. B — Under workers' compensation legislation, the employer, the worker (or their representative), and the treating healthcare provider each have independent mandatory reporting obligations — all must file regardless of whether the injury resulted in time loss or modified duties. Failure to report within the legislated timeframe can result in fines and claim complications for each responsible party independently. Modified duty does not reduce or eliminate any party's reporting requirement.

5. C — Grinding dust from areas where stainless steel welding or stainless steel components were present can contain hexavalent chromium ( $\text{Cr}^{6+}$ ) — a regulated toxic metal — at concentrations that may exceed TCLP leachate thresholds and qualify the dust as hazardous waste requiring registered disposal. Standard carbon steel electrode stubs and empty gas cylinders are governed by different specific regulations and do not automatically fall into the TCLP-based hazardous waste category. The key regulatory trigger is whether leachable toxic constituents are present above threshold concentrations.

6. D — A safety inspection identifies specific physical hazards at a point in time and is fundamentally a snapshot of current conditions. A safety audit is a systematic, documented examination of the entire safety management system — policies, procedures, training, records, and physical conditions — to evaluate whether the overall system effectively prevents incidents. The audit's broader and more evaluative scope produces findings about systemic effectiveness rather than simply listing individual hazards found on the day of the visit.

7. A — Canadian OHS regulations require ERPs to address all foreseeable emergencies (fire, explosion, chemical release, medical emergency, power failure), not fire alone. Required elements include emergency equipment locations, escape routes and muster points, worker and emergency coordinator responsibilities, personnel accounting procedures, notification procedures for emergency services, and a drill schedule. The drill schedule is critical because a plan that has never been practiced provides far less protection than one that has been repeatedly rehearsed.

8. B — SMAW at 150 A produces intense UV, visible, and IR radiation requiring a minimum shade 10 lens. Angle grinding produces flying metal particles and abrasive fragments requiring a face shield or

safety glasses with side shields for kinetic impact protection. Visual inspection requires minimum side-shield safety glasses to protect against ambient metallic debris, chips, and grinding particles in the area. Each task presents a fundamentally different hazard type, and using the same eye protection for all three fails to meet the hazard-specific requirements for at least two of the three tasks.

9. C — Manganese is the toxicologically more significant fume component because chronic low-level inhalation causes manganism — a progressive neurological disorder with symptoms resembling Parkinson's disease (tremors, rigidity, cognitive impairment) that may be partially irreversible. Iron oxide causes siderosis, a generally benign lung discoloration from iron oxide deposition that does not produce progressive fibrosis or measurable functional impairment in most exposures. This asymmetry in health consequence severity makes manganese the primary target for exposure measurement and engineering control in carbon steel SMAW operations.

10. D — The standby attendant must have communications equipment, a non-entry retrieval system (tripod and winch), emergency signaling to summon additional help, and atmospheric monitoring equipment. The standby must NOT enter the confined space unless trained as an authorized entrant, the space is confirmed safe for entry, and a second standby is positioned outside — non-entry retrieval must always be attempted first. The history of multiple-fatality confined space incidents resulting from untrained attendants entering to rescue incapacitated workers makes this restriction one of the most critical safety rules in confined space management.

11. A — A GFCI monitors the difference between current flowing out through the hot conductor and current returning through the neutral — a difference of approximately 5 milliamps indicates leakage through an unintended path (such as a human body or a wet surface) and trips the circuit within milliseconds. Construction sites require GFCI because temporary wiring, outdoor conditions, damaged cords, and welding-environment moisture create ground fault conditions that conventional overcurrent breakers cannot detect at the milliamp-level currents that cause ventricular fibrillation. The millisecond response time is what makes GFCI life-saving where conventional breakers are not.

12. C — The correct extension ladder angle is 1 unit out for every 4 units of height (4:1 ratio), the ladder must extend a minimum 1 metre above the landing, be secured at the top or bottom, be on stable level ground, and the user must face the ladder when ascending and descending. Welding equipment must not be draped over or hung from the ladder because it creates both tripping hazards during descent and electrical shock hazards if the welder contacts energized cables while on the ladder. These requirements apply regardless of the duration of the elevated work or the trade performing it.

13. B — Effective heat stress management requires multiple simultaneous controls because no single measure is adequate at 38°C and 65% relative humidity. Scheduling heavy tasks in cooler morning

hours reduces peak metabolic heat load; hydration stations maintain fluid balance; spot coolers reduce the heat gain from the environment; buddy observation detects early heat illness symptoms before they progress; and physiological monitoring provides objective data for intervention decisions. The multi-barrier approach reflects the OHS principle that hazards of this severity require redundant controls at multiple points in the causal chain.

14. D — Section 8 of a WHMIS 2015-compliant SDS is Exposure Controls and Personal Protection — it contains the occupational exposure limits for each hazardous component, required engineering controls including LEV specifications, appropriate respiratory protection type and assigned protection factor, and required PPE for the skin, eyes, and hands. Physical and chemical properties are in Section 9; first aid measures are in Section 4; storage requirements are in Section 7. This section is the one workers use most directly to determine which controls to apply during the actual welding operation.

15. A — The PTW verifies that all preparatory steps (purging, isolation, atmosphere testing, engineering authorization) have been completed and signed off before high-hazard work begins — a function entirely outside the scope of a WPS, which covers only the welding procedure itself. The PTW also communicates who authorized the work, what specific hazard controls are in place, the permit time limits, and required actions if conditions change. This pre-work environmental safety verification is the critical safety layer that distinguishes hot work on hazardous systems from routine shop welding.

16. C — Hot slag and spatter accumulating on metal stair grating represents a compounded multi-factor hazard at the highest-consequence location — spatter burns through non-skid tape over time, metallic grinding debris is particularly slippery, and the sloped grating surface is the most unforgiving fall surface in the described area. A fall on a metal staircase typically causes more severe injury (head trauma, fractures from height change) than a fall on flat floor. The convergence of degraded slip protection, metallic debris, and a height-transition zone makes this the worst combination of probability and consequence in the four scenarios.

17. B — The correct immediate first aid for chemical skin contact — including calcium fluoride-containing flux — is immediate flushing with large volumes of cool running water for 15–20 minutes to dilute and remove the chemical. The first-aider must wear gloves to prevent secondary contamination; the SDS must be checked for product-specific additions (such as calcium gluconate gel for fluoride burns); and medical attention should be sought if burning persists. Time to flush is the primary determinant of tissue damage extent — delaying flush to neutralize the chemical first or using only a dry cloth significantly worsens the outcome.

18. D — Due diligence requires affirmative demonstration that all reasonable precautions were taken to prevent the incident. Prior knowledge of the defective equipment without corrective action is direct

evidence of a failed due diligence duty — the supervisor had the knowledge, the authority, and the obligation to remove the equipment from service and did not. Physical absence at the time of the injury does not constitute due diligence because the critical failure (allowing the known hazard to remain) occurred before the incident. Supervisors have a positive, proactive duty to eliminate identified hazards, not merely to avoid proximity to the consequences.

19. A — "DANGER" is the signal word for the more severe hazard categories within a hazard class — for example, Flammable Gas Category 1 (extremely flammable) uses DANGER while Category 2 (flammable) uses WARNING. Only one signal word appears on any given product label regardless of how many hazard classes apply, and DANGER always takes precedence over WARNING when both would otherwise be required. This tiered system communicates relative severity within the same type of hazard, allowing workers to prioritize their precautionary response proportionally.

20. B — With the anchor at foot level, the total fall distance before arrest is: lanyard length (1.8 m) + energy absorber deceleration distance (1.0 m) + dorsal D-ring height above feet (approximately 1.5 m for an average worker) = approximately 4.3 m required clearance below the anchor point. Since the anchor is at foot level, 4.3 m of clearance must exist below the welder's feet — with only 5 m to the floor, this is marginal and requires engineering review before work proceeds. Ignoring the harness elongation component is the most common underestimate in fall clearance calculations.

21. C — The circle below the reference line is the plug weld symbol, indicating a weld deposited through a hole in the arrow-side member to fuse both members together. The number adjacent to the symbol (18) specifies the plug hole diameter in millimetres, and "4 spaces @ 50" specifies that 4 plug welds are required at 50 mm center-to-center spacing. Plug welds are used when fillet weld access is unavailable and the circle distinguishes them visually from all other weld types in the AWS A2.4 symbol system.

22. D — The root face of 2 mm is within the  $3 \pm 1.5$  mm tolerance range (1.5–4.5 mm) and is acceptable. The root opening of 5 mm exceeds the 4.5 mm maximum by 0.5 mm and constitutes a rejectable fit-up — the inspector must reject the joint as-fit. Under AWS D1.1, the fabricator may either close the gap to within tolerance, or if the gap cannot be physically closed without inducing stress, may insert a backing strip with the engineer of record's approval — both paths require resolution before welding proceeds.

23. A — W47.1 Division 1 requires a registered Welding Engineer (P.Eng. with welding specialization) to prepare, approve, and control all WPSs and to take responsibility for the company's welding activities — required for high-consequence structural applications where engineering-level oversight is mandated. Division 2 requires only a Welding Supervisor with demonstrated knowledge and experience rather than

P.Eng. registration, making it appropriate for fabricators of less-critical structural components. The distinction is a personnel qualification requirement, not a material or process restriction.

24. B — The "W" suffix designates weathering steel — a structural steel grade containing copper, chromium, and nickel additions that enable it to form a tightly adherent protective rust patina when cyclically wetted and dried in the atmosphere. This is welding-significant because standard carbon steel filler metals (such as E7018) lack these alloying additions and may produce a weld zone with inferior atmospheric corrosion resistance compared to the surrounding 350W base metal in exposed uncoated applications. A matching weathering-grade filler metal should be specified in the WPS when the joint will be in weather-exposed service.

25. C — The standard ASME B31.3 line designation communicates the process line number (200), material code (CS = carbon steel), nominal pipe size (3 inches), and ASME pressure class (1500# = Class 1500 flanges and valves). The Class 1500 designation tells the inspector the maximum pressure-temperature rating of the flanges and fittings on this line, which the inspector must confirm is compatible with the specified WPS, material, and service conditions. This four-part designation provides the complete context needed for WPS-to-line compatibility verification.

26. B — Pneumatic testing (using air or nitrogen at a lower test pressure than hydrostatic) is one ASME-recognized leak test alternative, with the critical limitation being the dramatically higher stored energy in a compressed gas system — a vessel failure during pneumatic testing releases energy far more violently than a water-filled vessel failure, creating a blast and fragment hazard. This requires larger safety exclusion zones, written risk assessments, and tighter procedural controls than hydrostatic testing. The physical energy difference between a pneumatic and hydrostatic failure is the fundamental reason pneumatic testing requires more risk management.

27. D — The macro examination of a cross-sectioned, ground, and etched fillet weld specimen reveals the complete internal geometry: actual measured throat and leg dimensions, the degree of fusion at the weld root and sidewalls, the presence of any discontinuities (porosity, cracks, LOF, inclusions) throughout the entire weld cross-section, the HAZ width, and the weld profile. The root of a T-joint fillet weld is completely inaccessible to surface inspection — only the macro cross-section reveals whether the weld achieved complete fusion at the most critical location.

28. A — Under ASME Section IX QW-408.2, a change in shielding gas type or mixture is an essential variable for GTAW procedure qualification because the gas composition directly affects arc voltage, heat transfer, and the thermal distribution in the weld, all of which influence the mechanical properties of the qualified deposit. Changing from pure argon to helium-argon changes all of these parameters

simultaneously — the existing argon-only PQR cannot support the new WPS without a separate qualification test conducted specifically with the helium-argon mixture.

29. C — The 5T ( $= 5 \times 8 \text{ mm} = 40 \text{ mm}$ ) minimum overlap ensures that the load transfer path through the longitudinal fillet welds is long enough for the full design shear force to develop before the load reaches the end of the weld. Insufficient overlap creates an eccentrically loaded joint where peel forces (tensile forces perpendicular to the fillet toe) dominate over shear forces, causing premature failure through plate separation and weld root cracking. The minimum overlap requirement is a structural design criterion, not a thermal or fabrication specification.

30. B — Longitudinal distortion occurs because the weld metal is shorter after cooling than the parent material along the same axis — longitudinal weld shrinkage pulls the plate into a concave bow with the weld face on the concave side. Backstep welding, skip welding, or depositing alternate short segments from the center outward distributes the cumulative longitudinal shrinkage forces in both directions rather than allowing them to accumulate progressively toward one end. This technique does not eliminate shrinkage but prevents the unidirectional accumulation that produces the bow.

31. A — The flat "boat" position ( $45^\circ$  tilt) allows higher welding currents and larger electrode diameters than horizontal fillet position because gravity supports the pool in the flat orientation rather than requiring arc force and surface tension to hold it against gravity. This enables single-pass deposition of fillet welds that would require multiple passes in the horizontal position, reduces undercut at the upper toe (a persistent horizontal fillet problem), improves root fusion, increases travel speed, and reduces welder fatigue. The positioner investment is justified whenever production volume of repetitive T-joint assemblies is sufficient to amortize the capital cost through productivity and quality gains.

32. D — The PT sequence must be: pre-clean and dry the surface, apply penetrant (dwell time), remove excess surface penetrant without disturbing penetrant in discontinuities, apply developer (dwell time for bleed-back), then inspect. The sequence is critical because developing before removing excess penetrant creates a false background of red that masks real indications, and cleaning after developing removes the bleed-back that makes discontinuities visible. Each step has a specific function that is destroyed if the sequence is altered.

33. C — Low (light) film density indicates underexposure — insufficient radiation reached the film to produce the required photochemical darkening of the silver halide emulsion. The radiographer must increase the exposure by increasing source activity, increasing exposure time, or decreasing source-to-film distance until the film density in the weld area meets the code-required minimum (typically 2.0–4.0 H&D density per ASME Section V). Without both the minimum density requirement and IQI visibility

being satisfied, the film lacks the sensitivity needed to reliably detect the minimum-size discontinuity the code requires.

34. B — A CJP groove weld develops the full cross-sectional area of the base metal in the joint, providing full tensile, shear, compression, and bending strength through the connection without any root-notch stress concentration. A PJP groove weld leaves an unwelded root portion that both reduces the effective throat (limiting joint strength) and creates an inherent notch at the root — the primary initiation site for fatigue cracking under cyclic tensile loading. Where full base metal strength must be developed or where the un-welded root would be exposed to tensile stress, the engineer must specify CJP.

35. C — A 40° included angle (narrower than the required 60°) restricts electrode access in the lower passes of the groove, preventing the welder from directing the electrode toward the groove sidewalls at the correct angle to achieve complete sidewall fusion — making incomplete sidewall fusion (LOF) the primary defect risk. For prequalified single-V SMAW joints per AWS D1.1 and CSA W59, a minimum 60° included angle is specified precisely to maintain this electrode access. The welder must stop and report the non-conforming groove preparation to the inspector or supervisor for disposition before any welding proceeds.

36. A — Schedule 80 is a standardized pipe schedule designation that specifies the wall thickness for a given nominal pipe size — for 4-inch NPS Schedule 80, the wall thickness is 0.337 inches (8.56 mm) per ASME B36.10. Higher schedule numbers indicate greater wall thickness for the same nominal pipe size, providing higher pressure capability. The welder must specify the identical schedule number when ordering replacement pipe to ensure the same wall thickness, pressure rating, and weld joint geometry dimensions are maintained.

37. D — The Charpy V-notch test temperature for any pressure-retaining component must match or be lower than the minimum design metal temperature (MDMT) to confirm the material remains on the ductile upper shelf throughout the service temperature range. LNG is stored at  $-162^{\circ}\text{C}$ , and a weld metal with a ductile-to-brittle transition temperature above  $-162^{\circ}\text{C}$  could undergo brittle fracture under hydraulic head or thermal stresses during filling, operation, or upset events. The  $-162^{\circ}\text{C}$  qualification temperature provides direct evidence that the weld metal toughness is adequate for the actual worst-case service condition.

38. C — ASME Section VIII Division 1 requires that PWHT be performed with calibrated thermocouples attached directly to the vessel wall (or within the code-required proximity to the weld) and connected to a calibrated recording instrument that produces a time-temperature chart. This chart is required QA documentation — regardless of whether electric blankets or a furnace is used —

confirming that the entire required volume of material reached the minimum soak temperature for the minimum required duration and that heating and cooling rates remained within specified limits. Without the thermocouple chart, no code-compliant evidence of successful PWHT exists.

39. B — CWB standards require a welder who has not been engaged in welding in the qualified process within the previous 6 months to demonstrate continued proficiency before returning to production work on certified structures. After 8 months of medical leave, the welder exceeds this threshold, triggering a proficiency verification requirement by the company's responsible welding supervisor — and potentially a formal requalification test at the CWB's discretion. This provision exists because welding skill is a perishable ability that degrades without regular practice, and weld quality on certified structures depends on consistently maintained skills.

40. A — The wavy line below the reference line is the surfacing weld symbol, indicating a deposited layer (surfacing, buildup, or hardfacing) on the arrow-side surface of the member rather than a joint weld. The number "6" specifies the minimum finished deposit thickness in millimetres after any required machining to final dimension, and "150 × 200" specifies the rectangular surface area to be surfaced. The surfacing symbol always appears on only one side of the reference line because surfacing is applied to a surface, not to a joint between two members.

41. D — In the CAN/CGSB 24.3 piping identification standard and industrial plant color-coding conventions, orange designates flammable or combustible liquids — petroleum products and hydrocarbon-based fluids. Before any hot work on orange-coded piping, the welder must confirm the piping is fully isolated, drained, purged of all flammable vapor, and atmosphere-tested to confirm the safe work condition. Performing hot work on incompletely purged flammable liquid piping is the scenario that has produced numerous fatal flash fire and explosion incidents in the process industry.

42. C — ASME B31.3 Category D fluid service is defined as non-flammable, non-toxic service at temperatures between  $-20^{\circ}\text{C}$  and  $186^{\circ}\text{C}$  and pressures below 1030 kPa gauge where failure would not endanger persons. The relaxed provisions (random rather than 100% examination, unlisted components permitted, possible hydrostatic test exemption) reflect the lower consequence of a Category D failure compared to Normal Fluid Service. These reduced requirements are not a shortcut — they are a proportionate response to the reduced hazard level of the specific service conditions.

43. A — Arc strikes are rejectable under CSA W59 because the rapid heating and quenching of the arc strike creates a hardened, potentially cracked surface zone that serves as a preferential fatigue crack initiation site under cyclic service loading. The affected zone must be ground smooth, MT or PT inspected to confirm no remaining cracks, and potentially repair-welded if grinding removes more than the permitted base metal allowance. Arc strikes have initiated fatigue fractures in structural members

that ultimately led to structural failures, making their mandatory remediation both code-required and safety-critical.

44. B — An indication measuring 8 dB above the reference level exceeds the code rejection threshold of 6 dB above reference — this is a rejectable indication by the applicable code, regardless of how small the margin of exceedance is. The technician must document the indication's location, depth, length, and amplitude; report it as rejectable; and notify the welder and engineer to establish a repair procedure. No margin for "borderline" acceptance exists above the rejection threshold — the threshold is a bright line.

45. D — For a 6 mm specified fillet weld, the theoretical throat is approximately 4.24 mm ( $6 \times 0.707$ ). A measured effective throat of 5.2 mm exceeds the theoretical throat, confirming the actual throat is meeting the required minimum. However, the inspector should also verify the actual fillet leg dimensions with the leg gauge because the effective throat measurement alone cannot confirm whether both fillet legs individually meet the specified 6 mm minimum — a weld with deep penetrating profile could have an adequate effective throat with undersized legs. Both dimensional checks are required for a complete visual inspection.

46. C — The CWB company audit evaluates the complete welding quality management system: the presence and currency of all WPSs with supporting PQRs, documentation and control systems, the qualifications and responsibilities of the welding supervisor, calibration status of welding equipment, consumable storage and handling conditions, and evidence that the documented quality system is actually implemented in production and not merely maintained on paper. A CWB company certificate attests to the existence and effectiveness of this entire system — not merely the employment of individually qualified welders.

47. A — Welding diagonally opposite corners in a balanced, symmetric pattern creates opposing transverse shrinkage forces that tend to cancel each other — each corner's weld pulls the frame slightly inward, but corners on opposite diagonals pull in opposing directions, maintaining squareness better than any sequential approach. Completing one corner fully before moving to the next concentrates shrinkage on one side of the frame before any counteracting force from the opposite corner is applied. Checking and adjusting squareness after each pass sequence allows early corrective action before joint stiffness increases.

48. B — A spark test is performed by pressing the material briefly against a rotating grinding wheel and observing the spark stream characteristics. Medium-carbon and low-alloy steel produces abundant bushy, star-shaped burst explosions in the spark stream — caused by the rapid exothermic oxidation of carbon-bearing droplets as they cool through the air. Austenitic stainless steel produces long, thin, relatively featureless red-orange streaks with few or no bursts; pure iron produces long, continuous pale

yellow streams with minimal bursting. The spark test provides quick relative carbon content indication but requires chemical analysis confirmation before welding an unidentified material.

49. D — Acetylene can self-decompose explosively at pressures above approximately 103 kPa (15 psi) without any mixture with oxygen, triggered by heat, shock, or pressure alone — this self-decomposition reaction is thermodynamically favorable and, once initiated, propagates without any external fuel source or oxidant. This chemical instability is why acetylene is dissolved in acetone within a porous matrix in the cylinder and why all acetylene equipment specifies a 103 kPa (15 psi) maximum working pressure — a limit that applies regardless of tip size, plate thickness, or flow rate requirements.

50. C — Nitrogen plasma provides sufficient arc energy to cut 316L stainless steel without contributing oxygen to the cut zone — nitrogen is chemically unreactive with stainless steel at plasma arc temperatures, producing brighter, smoother cut faces with better dimensional accuracy than air plasma, which oxidizes the chromium and nickel in the cut face. Argon-hydrogen plasma provides even higher arc enthalpy for thicker sections but at higher consumable cost. For dimensional accuracy and cut face quality on stainless steel, any nitrogen or argon-based plasma gas is superior to air plasma.

51. A — An orange tinge in the OFC cutting oxygen flame is a diagnostic sign of combustible gas contamination in the oxygen supply — most likely fuel gas that has back-flowed through a leaking check valve in a manifold system into the oxygen supply line. The contaminated oxygen-fuel mixture ignites and burns with the characteristic orange coloration of hydrocarbon combustion. This condition is immediately dangerous because a reverse-flow fire inside the oxygen manifold, regulator, or hose can cause catastrophic equipment failure — requiring immediate system shutdown and evacuation before inspection.

52. C — The carbon-graphite composition of CAC-A electrodes provides high-temperature stability because carbon sublimates (transitions directly to vapor) rather than melting at arc temperatures, maintaining the electrode's geometric integrity during arc operation. The copper coating improves electrical conductivity at the contact surface, reduces contact resistance in the electrode holder jaw grip, and increases the current-carrying capacity of the electrode — enabling operation at higher amperages than bare carbon electrodes of the same diameter could sustain. Together, these properties make the electrode simultaneously an effective arc conductor and a thermally stable tool.

53. B — A bright white feather extending from the inner cone of the preheat flame indicates a carburizing (excess fuel) flame — the unburned carbon-bearing gas creates a luminescent white secondary flame envelope around the inner cone. A carburizing preheat flame causes carbon to be absorbed into the steel surface before the cutting oxygen is applied, hardening the surface and inhibiting the iron-oxygen cutting reaction efficiency. The correction is to slowly increase the oxygen flow until

the white feather disappears completely, producing a neutral flame with a clean, sharply defined inner cone.

54. D — The duty cycle rating defines the percentage of each 10-minute period (in most manufacturer standards) during which the power source can sustain its rated output before thermal damage occurs. At 60% duty cycle and 120 A, the unit requires 4 minutes of cooling for every 6 minutes of operation at full rated amperage. Continuous operation at 100% duty cycle heats the transformer windings and internal components above their insulation class temperature rating, progressively degrading the insulation, shortening equipment service life, and risking unplanned thermal shutdown during production.

55. A — Calibrated tip cleaners — round reamers precisely matched to each orifice size — must be inserted with a straight in-and-out motion (never circular reaming) to clear oxide deposits without enlarging or distorting the precision-machined orifice geometry. Using drill bits, nails, or any oversized tools enlarges the orifice beyond specification, changing the gas flow velocity and flame characteristics in ways that degrade cut quality and may prevent proper oxygen concentration at the cutting front. Each orifice requires its own matching-sized cleaner to preserve the dimensional integrity that determines tip performance.

56. B — Higher amperage within the electrode's rated range is the most direct control for increasing CAC-A groove depth because amperage determines the total arc energy available to melt metal — higher current melts a larger volume of metal per unit of travel, creating a deeper molten pool that the compressed air jet ejects. Reducing travel speed simultaneously gives the arc more time to penetrate at each electrode position, and both adjustments can be combined for the maximum depth-per-pass increase. Increasing air pressure primarily affects slag ejection efficiency and groove profile cleanliness, not the fundamental depth of melting.

57. C — Opening the acetylene torch valve first purges any oxygen-acetylene mixture from the torch body and mixing chamber before lighting — the torch flame ignites on pure acetylene at the tip rather than on a pre-mixed combustible charge inside the torch. A pre-mixed charge in the mixing chamber could flash back into the torch body at the moment of ignition, creating an internal fire condition before the gases have had time to flow through and clear the mixing space. Once the pure acetylene flame is stable at the tip, oxygen is slowly introduced to develop the correct preheat flame type.

58. D — OFC fails on stainless steel because chromium in the alloy forms chromium oxide ( $\text{Cr}_2\text{O}_3$ ) on the cut surface with a melting point of approximately  $2300^\circ\text{C}$  — far above both the steel's own melting temperature and the ability of the cutting oxygen stream to displace or dissolve it. This refractory oxide solidifies over the cut front faster than the cutting oxygen can reach fresh iron beneath it, extinguishing

the cutting reaction. Plasma arc cutting bypasses this mechanism entirely by removing material through thermal melting and high-velocity plasma jet ejection, not through an iron-oxygen oxidation reaction.

59. A — Mechanized OFC maintains perfectly constant travel speed, height, and torch angle throughout the entire cut — the three variables most responsible for drag line angle, kerf width consistency, and dimensional accuracy. Human hands cannot sustain constant speed, vibration-free motion, or constant torch height and angle over cut lengths beyond approximately 300 mm due to fatigue, physiological tremor, and natural arm movement geometry. This motion consistency difference is the primary technical explanation for superior machine cut quality, entirely independent of any differences in gas pressure or tip selection.

60. B — At a shallow electrode angle ( $20^\circ$  from horizontal), the arc plays across a wide, shallow area of the work surface as the electrode approaches at a low incidence angle — producing a wide, shallow groove that reflects this broad energy distribution. Increasing the electrode angle toward  $45^\circ$  concentrates the arc force and heat more directly downward beneath the electrode tip, producing a narrower and deeper groove that reflects the more concentrated energy delivery. The operator uses electrode angle as a deliberate control variable for achieving the groove cross-section dimensions specified in the repair procedure.

61. D — The silicon content of gray cast iron (1–3%) creates refractory silicon dioxide ( $\text{SiO}_2$ ) at the cut surface with a melting point above  $1700^\circ\text{C}$  — this slag solidifies over the cut front faster than the cutting oxygen can penetrate, bridging the cut gap and extinguishing the cutting reaction. Simultaneously, the graphite phase in cast iron burns exothermically rather than oxidizing cleanly, causing the cut zone to overheat and melt instead of cutting. Plasma arc cutting is a practical field alternative because it removes material by thermal melting and plasma jet ejection without any dependence on a continuous iron-oxygen oxidation reaction.

62. C — The electrode's hafnium insert forms a progressively deepening erosion pit as arc starts accumulate — most manufacturers specify a maximum allowable pit depth (typically 1.0–1.5 mm) beyond which the electrode produces an asymmetric, wandering arc with degraded cut quality and accelerated nozzle wear. The nozzle orifice should be checked for bore enlargement or out-of-roundness that widens the kerf and increases bevel angle. Proactive replacement at the manufacturer-specified interval before wear limits are reached is more cost-effective than waiting for visible quality deterioration, since by that point additional scrap, rework, and nozzle damage costs typically exceed the consumable savings.

63. A — Overheated cutting tips are the most common cause of repeated backfires because the tip orifice temperature rises above the fuel gas autoignition point when the tip is held too close to the work,

when the torch pauses over a stationary area, or when spatter accumulates and conducts additional heat into the orifice passages. Preventive measures — maintaining correct tip-to-work distance, keeping the torch moving, periodically cooling the tip away from the work, and cleaning orifices with proper tip cleaners — all address this root cause: preventing the tip temperature from reaching the autoignition point for the fuel gas in use.

64. B — CAC-A can be used on high-hardness AR steel for defect removal, but the localized heating creates re-hardened zones and may cause hydrogen-assisted cracking in the already-hard base material. All carbon electrode deposits must be removed from the groove surface by grinding (carbon contamination causes porosity and fusion defects in the subsequent repair weld), and MT or PT inspection must confirm the excavated zone is crack-free before repair welding proceeds. Preheat per the AR steel WPS must be applied both before the CAC-A gouging and before repair welding to reduce the risk of cracking in the hard, high-CE base metal at both stages.

65. D — Cross-threaded tip connections cannot be reliably sealed even with forced tightening — the damaged threads create microscopic leak paths that are not sealed by torque. A leaking tip connection allows gas to accumulate inside the torch body, where it can ignite from residual heat and create an internal fire or flashback condition. Applying PTFE tape or forced-tightening on oxygen equipment cross-thread damage is prohibited because these workarounds create false confidence about a seal that is not actually present — the torch must be repaired by qualified personnel and leak-tested before return to service.

66. C — Copper's thermal conductivity is approximately 10 times greater than steel, causing the plasma arc energy to dissipate away from the cut zone far faster than for steel applications, making it difficult to maintain sufficient cut-front temperature with standard air or nitrogen plasma at normal amperages. Argon-hydrogen plasma (typically 65/35 or 50/50 Ar/H<sub>2</sub> ratio) provides significantly higher arc enthalpy than air or nitrogen plasma, overcoming the rapid thermal dissipation and maintaining sufficient temperature at the cut front for clean, productive copper cutting. Nitrogen plasma at elevated amperage is also used, but Ar-H<sub>2</sub> is the standard recommendation for copper when cut quality is the priority.

67. A — Acetylene achieves the highest oxy-fuel flame temperature (approximately 3,160°C with oxygen) and the fastest initial heating of the steel surface to the cutting ignition temperature — this preheat speed advantage grows as plate thickness increases, making acetylene the best-performing fuel for all thicknesses. Propane and natural gas burn at lower temperatures (approximately 2,820°C and 2,770°C respectively) and require multi-flame tip designs with higher preheat oxygen ratios to compensate for their slower steel surface heating. The performance gap is a real technical distinction, not merely a cost consideration.

68. D — A steep electrode angle (60–70° from the surface) concentrates the arc more directly below the electrode tip than the standard 35–45° angle, creating a narrower and deeper groove. The operator should reduce amperage slightly to prevent unintended over-excavation from the more focused arc and reduce travel speed to maintain better depth control in the restricted access location. Pausing every 50–75 mm to clear expelled metal and visually inspect the groove depth prevents inadvertent over-excavation that would be difficult or impossible to correct in a tight-access situation.

69. B — Two-stage regulators maintain more stable outlet pressure throughout the cylinder's service life because the pressure reduction is achieved in two sequential steps — the first stage reduces the high cylinder pressure to an intermediate level, and the second stage reduces to the working pressure with far less sensitivity to changes in inlet pressure as the cylinder empties. Single-stage regulators show outlet pressure drift as the cylinder inlet pressure decreases, requiring periodic manual readjustment. For precision cutting applications where consistent gas pressure is critical to repeatable cut quality throughout the cylinder, two-stage regulators are the preferred choice.

70. C — When the standoff distance increases above the optimal setting, the plasma jet expands and diverges over the greater travel distance before reaching the work surface, reducing both the energy density and gas velocity at the kerf. The reduced energy density produces an increased bevel angle on the cut faces, wider kerf, more dross on the underside (from incomplete ejection by the lower-velocity jet), increased HAZ width, and greater susceptibility to cross-draft disruption of the plasma column. The optimal standoff is specifically the distance at which the plasma column is most focused and energetically dense at the point of material contact.

71. A — Parts near the plate edge receive asymmetric heat input during cutting because the plate lacks the thermal mass of full-width plate on the edge side, causing heat to dissipate more rapidly toward the plate edge than toward the interior. This asymmetric cooling creates an imbalanced residual stress field that causes the still-attached, partially cut edge parts to distort slightly during cutting, moving them relative to the programmed cut path. Completing interior parts first (which leaves surrounding plate for thermal support of edge cuts) or using tabs and bridges to hold edge parts stationary until all cutting is complete are the standard corrective strategies.

72. D — E6010's cellulosic coating generates vigorous shielding gases (primarily CO, CO<sub>2</sub>, and H<sub>2</sub>) that create a highly forceful, penetrating arc capable of pushing through the root gap to establish the keyhole required for a complete single-pass root bead in downhill pipeline welding. The fast-freezing cellulosic slag maintains pool control in any position including vertical-down, and the thin, easily chipped slag can be quickly cleared before the hot pass — a critical productivity factor in pipeline construction. No other electrode combines keyhole capability, downhill positional control, and fast slag removal in a single package suited for field pipeline work.

73. C — E6011 shares the same cellulosic coating chemistry as E6010 — providing the same forceful penetrating arc, fast-freezing slag, and all-position capability — but includes additional potassium compounds that stabilize the AC arc through the polarity reversals that would otherwise cause arc instability or extinction. The welder should expect slightly less arc force and somewhat more spatter on AC compared to E6010 on DC, and minor technique adjustments may be needed — but E6011 is the established industry substitute for E6010 when only AC power is available for pipeline and all-position work.

74. B — Root cold lap (lack of fusion) at the bottom of a 2G root bead occurs when the arc is directed predominantly toward the upper plate, causing the pool to flow away from the lower groove face before adequate fusion is achieved at the lower fusion boundary. The work angle adjustment — directing slightly more arc energy toward the lower groove face — is the most direct single correction for this specific geometric defect pattern, ensuring the arc force establishes fusion on the lower side before the pool solidifies. Consistent arc length control prevents further reduction of the arc penetration force that exacerbates the lower-side fusion problem.

75. A — Gravity welding clamps the electrode at a fixed angle in a specialized holder and relies on gravity to continuously feed the electrode into the weld zone at the natural melt-off rate — the welder starts the arc and the electrode self-advances without any manual rod-feeding required. This enables one welder to manage multiple simultaneous gravity holders on adjacent joints, achieving a higher number of simultaneous welds per operator than conventional SMAW allows. The technique is limited to flat and horizontal fillet positions where gravity provides the correct electrode feed direction, and requires electrode types with appropriate melt characteristics for self-feed operation.

76. B — Crater cracks form because the final weld pool is under high tensile stress from surrounding solidified metal pulling inward, and the deep, narrow crater geometry is the most crack-susceptible solidification shape. The backstep-and-fill technique deposits additional weld metal into the crater just before the arc is broken — increasing the crater volume, raising the crater floor, and changing the depth-to-width ratio to a less crack-susceptible geometry. A filled crater distributes the solidification stresses over a larger metal volume, reducing the concentrated tensile stress at the centreline below the cracking threshold.

77. D — Switching to AC power is the most direct and fundamental solution to magnetic arc blow because the continuously reversing AC current polarity causes the arc to deflect in opposite directions during each half-cycle — the alternating deflections cancel each other too rapidly to produce a net sustained directional deflection. Additional corrective actions (adjusting electrode angle into the blow direction, wrapping the return cable around the pipe to create a counter-field, dual ground connections,

reducing current) address symptoms rather than the root cause, making the polarity change the single most effective action available.

78. C — The hot pass is deposited at higher amperage (10–20% above root pass current for the same electrode size) specifically to burn out surface irregularities, undercut, and incomplete fusion in the root bead's top surface. The higher heat input simultaneously burns off cellulosic slag residue that remains on the root bead from E6010's aggressive slag system and smooths the convex root bead profile typical of keyhole technique root welding — preparing a flat, clean substrate for the fill passes. Without the hot pass, any surface defects and irregular profile would be buried under fill passes where they cannot be accessed or corrected.

79. A — E7016's basic coating (calcium carbonate, calcium fluoride) is highly hygroscopic — once exposed to rain or humidity, moisture absorbs into the coating matrix rather than merely sitting on the surface, and surface drying alone cannot remove it. Moisture in the coating decomposes in the arc to release hydrogen, which causes distributed porosity and increases the risk of hydrogen-induced delayed cracking in the HAZ of high-strength structural steel. Reconditioning at 260–430°C for a minimum of 1 hour in a certified electrode oven (with temperature chart documentation) is required to drive absorbed moisture from the coating matrix — using undried electrodes on critical structural work is not acceptable.

80. B — 316L stainless steel derives its superior pitting corrosion resistance compared to 304L from a 2–3% molybdenum addition that increases resistance to chloride-induced pitting. Relying on base metal dilution to supply adequate Mo to E308L-16 weld deposits is unreliable — typical repair dilution ratios are insufficient to bring the Mo content up to the level needed for matching corrosion resistance. E316L-16 contains the matching Mo addition, ensuring the repair deposit has equivalent chemical composition and corrosion resistance to the 316L base metal that it must equal in the same service environment.

81. D — Cast iron's low ductility, high carbon content (making the HAZ extremely hard and brittle), and high casting rigidity all create cracking risk during welding. Preheating to 200–300°C reduces the thermal gradient and peak stress during welding; short 20–30 mm beads limit the volume of stressed weld metal per pass; immediate peening above approximately 400°C plastically deforms the hot, soft weld metal to relieve tensile solidification stresses before they can crack the already-brittle HAZ; and slow post-weld cooling prevents the rapid quench that would produce brittle martensite in the cast iron HAZ. All four measures are required simultaneously — any single technique used in isolation is insufficient for high-restraint cast iron repair.

82. A — Vertical-up welding produces superior fusion and penetration because the welder's upward progression keeps the arc at the fusion boundary as gravity pulls the pool downward away from the

advancing arc. In vertical-down welding, the slag (being less dense than the weld metal) tends to flow ahead of the arc in the direction of travel, contaminating the fusion boundary and creating both slag inclusion and incomplete fusion risks. AWS D1.1 and CSA W59 explicitly limit vertical-down SMAW to fillet welds and do not allow it for groove welds in structural applications without specific procedure qualification precisely because of this fusion quality difference.

83. C — E = electrode; 70 = 70 ksi (approximately 480 MPa) minimum tensile strength of the deposited weld metal; 1 = all-position designation enabling welding in flat, horizontal, vertical, and overhead positions; 8 = basic iron-powder coating, usable on AC and DCEP; H4 = maximum 4 mL per 100 g diffusible hydrogen tested per AWS A4.3 — the H4 designation is the most commonly specified low-hydrogen level for structural applications requiring cold cracking control; R = moisture-resistant designation indicating the coating has enhanced resistance to atmospheric moisture pickup, allowing the electrode to remain exposed for up to 4 hours while maintaining H4 hydrogen levels.

84. B — SMAW aluminum electrodes (E4043 type) are available for limited repair applications, but the highly hygroscopic coating absorbs moisture readily and the resulting flux slag is aggressively corrosive to aluminum if not completely removed — flux residue causes intergranular corrosion that can exceed the severity of the original damage being repaired. Thorough slag removal requires hot water rinsing followed by stainless steel wire brushing, and the process is limited to heavier section thicknesses where difficult arc control is more manageable. In any facility with GMAW or GTAW available, SMAW aluminum welding is rarely justified.

85. A — On DCEP, electron flow from the cathode at the work surface to the electrode anode provides concentrated heating at the workpiece cathode spot that contributes to penetration. In principle, DCEN would make the work the anode with more direct workpiece heating. However, for coated SMAW electrodes including E6010, the coating chemistry depends on the cathode drop at the workpiece for stable arc ionization — switching to DCEN disrupts the specific ionization mechanism of the coating and produces an unstable, difficult-to-control arc rather than simply producing a different penetration profile. The chemistry of the coating determines the required polarity, not just the heat distribution theory.

86. D — Wagon tracks are specifically caused by slag remaining at the toes (edges) of a previously deposited bead being buried by the next pass — the un-removed slag at each toe is encapsulated, appearing in the radiograph as two parallel linear indications (one from each toe) that run the full length of the weld. The "two-rail" appearance is pathognomonic for this defect, distinguishing it from other linear indications. Complete chipping and wire brushing of both bead toes — not just the bead crown — before every inter-pass cleaning cycle is the only effective prevention because it is at the bead toes where slag is most adherent and most often incompletely removed.

87. C — E8018-B2 deposits nominal 2.25% chromium and 1% molybdenum into the weld metal, matching the P22 base metal composition and providing the solid-solution and precipitation strengthening from these alloying additions that enables the joint to carry its design creep load at elevated service temperatures. Substituting E7018 creates a plain carbon-manganese weld deposit that lacks these alloying additions entirely — the resulting compositional mismatch means the weld zone cannot develop the creep rupture strength the design depends on, and the joint will fail under sustained high-temperature stress. Segregated electrode storage with clear alloy identification markings is essential on chrome-moly piping work precisely to prevent this critical substitution error.

88. B — Heat input at 180 A =  $(24 \times 180) \div (4 \times 1000) = 4320 \div 4000 = 1.08$  kJ/mm. Heat input at 100 A =  $(24 \times 100) \div (4 \times 1000) = 2400 \div 4000 = 0.60$  kJ/mm. The 4.8 mm electrode at 180 A produced 80% more heat input per unit length than the specified 3.2 mm electrode at 100 A — a significant deviation from the qualified procedure's heat input range. The WPS electrode size restriction for root and early fill passes was most likely established to limit heat input for metallurgical reasons (HAZ toughness control, distortion management, or first-pass dilution control), and using the larger electrode is a non-conformance requiring formal engineering disposition.

89. A — Overhead welding requires reducing amperage by approximately 10–15% from the flat position setting for the same electrode size because a smaller pool is easier to support against gravity — pool volume management is the central technique challenge in overhead position. The shortest controllable arc length (without shorting) maximizes arc force, which helps support the pool against gravity at the weld surface. Brief pauses at the weld toes during a slight weave motion ensure complete toe fusion without accumulating a pool volume large enough for gravity to overcome surface tension and cause dripping.

90. D — Globular transfer occurs at current levels below the spray transition threshold where the droplet diameter exceeds the electrode wire diameter — large, irregular drops transfer intermittently with high spatter. At the spray transition current in argon-rich shielding gas, the electromagnetic pinch force exceeds the surface tension holding each droplet to the wire tip, creating very fine droplets (smaller than the electrode diameter) that transfer continuously at a high rate with minimal spatter — spray transfer. These two modes are fundamentally different in droplet size, transfer frequency, and spatter level, separated by a distinct current threshold that is specific to each wire diameter and shielding gas composition.

91. C — Dual-shield FCAW uses the internal flux core for metallurgical benefits (deoxidation, alloying) plus an external gas supply ( $\text{CO}_2$  or  $\text{Ar}/\text{CO}_2$ ) for the primary atmospheric shielding, making it dependent on the external gas supply and therefore wind-sensitive. Self-shielded FCAW generates all atmospheric protection from vaporization of core compounds (aluminum, barium fluoride, and other elements) without any external gas supply, making it wind-resistant for outdoor construction applications. This

fundamental difference in shielding mechanism is what dictates the appropriate application environment for each process.

92. B — CO<sub>2</sub> decomposes at arc temperatures to release carbon monoxide and atomic carbon — the carbon dissolves into the molten stainless steel weld pool, and when the weld cools through the sensitization temperature range (425–870°C), it combines preferentially with chromium to form chromium carbides at grain boundaries. This chromium carbide precipitation creates chromium-depleted zones adjacent to grain boundaries — the classic intergranular sensitization that significantly reduces corrosion resistance. The 2% oxygen addition in 98/2 Ar/O<sub>2</sub> provides arc stability without carbon pickup, making it safe for stainless steel GMAW where corrosion resistance must be maintained.

93. D — FCAW wire (particularly self-shielded and some gas-shielded wires) contains hygroscopic flux compounds in the tubular core that absorb atmospheric moisture during prolonged open storage in humid conditions. Moisture absorbed into the flux core raises the diffusible hydrogen content of the deposited weld metal, increasing the risk of hydrogen-assisted cracking in high-strength or restrained joints. Sealed storage with silica gel desiccant prevents progressive moisture uptake, and the 48-hour exposure limit in humid conditions reflects the rate at which moisture absorption reaches quality-affecting levels — making this a legitimate, technically defensible quality assurance procedure.

94. A — Inductance in a GMAW short-circuit transfer power source controls the rate of current rise during each re-ignition event — how quickly current ramps from the short-circuit pinch minimum back to the full arc current after each droplet detachment. Too low an inductance setting causes current to rise too rapidly during the re-ignition, generating a violent droplet detachment that expels large spatter particles. The correct inductance setting produces the smooth, rapid, low-energy re-ignitions that create the characteristic "frying bacon" sound of well-tuned short-circuit transfer — this auditory feedback is a reliable on-the-floor indicator of proper inductance setting.

95. C — Hardfacing and surfacing FCAW wires are classified under AWS A5.21 (Composite Surfacing Welding Rods and Electrodes), which provides classifications from austenitic manganese (for impact-dominated wear applications) to high-chromium carbide (for severe abrasion service) to complex multi-carbide alloys. The critical selection principle is matching the deposit microstructure to the predominant wear mechanism in the application — carbide-based deposits provide excellent abrasion resistance but can fracture under high-impact loading, while austenitic manganese deposits work-harden progressively under impact but provide less abrasion resistance. Standard structural FCAW-G wires (E71T-1 class) lack the hardness and wear-specific microstructure for any hardfacing application.

96. B — The contact tip's bore provides both electrical current transfer to the wire (through metal-to-metal contact) and geometric guidance for the wire exit angle. An enlarged, out-of-round bore creates

intermittent and variable contact — the wire touches the bore wall unpredictably at different positions as it advances, causing variable current pickup, erratic arc characteristics, inconsistent penetration, arc wander, and increased spatter as the arc position shifts with each bore contact change. Consistent, stable current transfer through a correctly sized and undamaged bore is a prerequisite for stable GMAW arc behavior.

97. A — SAW's primary competitive advantage over FCAW-G is deposition rate — SAW can sustain very high amperages (400–1200 A) far beyond FCAW-G's practical range, producing 3–5 times the deposition rate per hour in flat and horizontal positions. However, SAW's limitation to horizontal-only positions, its requirement for granular flux handling, delivery, and recovery infrastructure, and its dependence on fixed, mechanized torch travel restrict it to production environments where the setup overhead can be amortized over long, straight welds. FCAW-G's positional flexibility and portability make it the preferred choice whenever these SAW conditions cannot be met.

98. D — ER70S-6 wire contains elevated silicon and manganese as deoxidizing additions — these react with dissolved oxygen in the molten pool to form silicon and manganese oxides that are less dense than the weld metal and float to the top of the solidifying pool, forming the characteristic brownish glassy islands on the cooled weld surface. They are a normal, expected product of the deoxidation reaction and are not themselves a weld defect. However, they must be completely removed by wire brushing or grinding before any subsequent passes are deposited over them — if buried, they become slag inclusions, which are a real rejectable weld defect.

99. C — MCAW uses a tubular wire with a metal powder core (iron powder, deoxidizers, alloy additions) rather than flux — like solid wire GMAW, it requires external shielding gas, but provides higher deposition rates from the metal powder, wider arc coverage for improved fusion on imperfect joint geometries, and significantly reduced silica island formation compared to ER70S-6 solid wire. Unlike FCAW-G, it produces no slag (eliminating inter-pass cleaning time, which is a significant productivity benefit in multi-pass groove welds). MCAW bridges the performance gap between solid wire GMAW and FCAW-G.

100. B — After ruling out tip bore size, liner match, and drive roll groove match, the three most common remaining birdnesting causes are: over-tightened drive rolls that deform the wire cross-section and increase downstream friction, a blocked or kinked conduit liner that creates progressive back-pressure against wire advancement, and an over-tightened spool hub brake that resists unwinding and creates wire back-tension. All three prevent the wire from advancing despite the drive rolls' constant rotation, causing the wire to accumulate (birdnest) in the drive section rather than feeding forward. Systematic sequential checking of each factor identifies the specific cause.

101. D — The pattern of good initial arc followed by gradual wire feed speed reduction and eventual arc extinction is characteristic of a progressive feed path restriction developing over time — the drive rolls rotate at constant speed but the wire slips rather than advancing as back-resistance builds. The most common causes are progressive liner debris accumulation, a developing kink in the conduit, or the spool hub brake tightening as it warms from the spool's rotation. The gradual onset (not sudden failure) distinguishes this from an empty gas cylinder (immediate quality change) or a power source fault (immediate arc failure at start).

102. A — ER70S-6: E = electrode or filler rod (the designation covers both forms); R = rod form included in the classification scope; 70 = 70 ksi (approximately 480 MPa) minimum tensile strength of the deposited weld metal; S = solid wire construction (distinguishing it from flux-cored wire); 6 = chemical composition designator indicating elevated silicon (approximately 1.4–1.85%) and manganese (approximately 1.65–2.15%) content for enhanced deoxidation, improved wetting characteristics, and better performance on mill-scaled or lightly contaminated base metal surfaces compared to lower-numbered S-grade designators.

103. C — A humped, irregular bead profile with alternating peaks and valleys along the bead length in FCAW-G is the characteristic signature of excessive travel speed — the deposition rate produces weld metal faster than the pool can flow forward and wet continuously into the base metal at the current travel rate, resulting in discrete "heaps" of deposited metal rather than a continuous smooth bead ribbon. Reducing travel speed extends the time the pool remains molten at each arc position, allowing it to flow out, wet the base metal surfaces on both sides, and form a continuous, uniform bead profile.

104. B —  $350 \text{ inches per minute} \times 0.0254 \text{ m/inch} = 8.89 \text{ m/min}$ , approximately 8.9 m/min. This conversion matters because the US welding industry routinely specifies WFS in inches per minute while Canadian industry commonly uses m/min — a supervisor unfamiliar with the conversion might attempt to set the wire feeder to "350" in m/min units, which would be dramatically excessive and immediately birdnest. Parameter documentation and communication between US and Canadian facilities requires explicit unit identification and systematic conversion at every WPS parameter exchange.

105. D — In E71T-1M: the digit before the T (here "1") is the position designator — "1" indicates all positions including vertical-up and overhead; "0" before the T would indicate flat and horizontal only. The "M" is the shielding gas designator — M-class wires are qualified for mixed argon-CO<sub>2</sub> shielding gases (typically 75/25 or 80/20 Ar/CO<sub>2</sub>), as opposed to "C" designation which specifies CO<sub>2</sub>-only shielding. The combination of all-position capability (the "1" position digit) and mixed-gas compatibility (the M suffix) directly confirms E71T-1M is appropriate for vertical-up field welding with standard Ar/CO<sub>2</sub> field FCAW-G shielding gas.

106. C — Without back-purging, atmospheric oxygen contacts the back side of the root bead while it is above 300°C, producing a rough, porous, oxide-contaminated root surface called "sugaring." This oxidation consumes chromium from the root face, creating a sensitized, chromium-depleted zone with significantly reduced corrosion resistance and surface quality — both structural concerns for pressure piping. Argon back-purging displaces oxygen from the pipe interior and maintains an inert atmosphere in contact with the root bead backside until it cools below the critical oxidation threshold, preserving both surface integrity and chromium content.

107. A — Cold wire feed (wire advancing without arc establishment) means the welding circuit is open — physical contact is occurring but current is not flowing. The most common cause is a work return clamp making inadequate electrical contact with the workpiece — clamped to a painted surface, corroded area, non-conductive coating, or structural member with poor electrical continuity. Confirming the work clamp is securely attached to clean, bare metal on the workpiece is always the first diagnostic step before investigating power source faults or other more complex electrical issues.

108. B — HF arc starting ionizes the shielding gas gap with high-frequency, high-voltage spark discharge, allowing the arc to establish without the tungsten touching the work — preserving the tungsten tip geometry, preventing tungsten contamination of the weld initiation zone, and avoiding the tungsten inclusions that scratch starting can introduce at the arc start location. Scratch starting requires tungsten-to-base-metal contact that can deposit tungsten particles (visible as high-density inclusions on radiographs), reshape or damage the electrode tip, and require re-grinding to restore arc characteristics before the next weld start.

109. D — For DCEN carbon steel GTAW, a ground pointed tip concentrates the arc into a narrow, precisely defined plasma column providing focused penetration and precise pool control — the electrode's cathode role on DCEN means the tip remains cool enough to maintain its pointed shape during operation. For AC aluminum GTAW, the electrode-positive (EP) half-cycles heat the tungsten tip above the pointed geometry's thermal stability limit, melting the point into a hemispherical ball within the first few seconds. This ball is the stable and correct operating geometry for AC aluminum GTAW — it should be pre-formed on a copper block before welding to prevent the initial uncontrolled balling from contaminating the weld pool.

110. C — The gas lens contains a series of fine stainless steel mesh screens that homogenize and straighten the turbulent gas flow from the supply line into uniform, laminar flow across the entire nozzle cross-section at the cup exit. This laminar gas column maintains atmospheric exclusion more effectively at a given flow rate, resists light air movement better than turbulent flow, and extends the effective shielding zone further from the cup exit — allowing slightly longer arc lengths, greater nozzle standoff, and improved pool visibility compared to standard collet body assemblies at the same gas flow rate.

111. A — Copper's thermal conductivity is approximately 7 times greater than carbon steel, dissipating arc heat from the weld zone so rapidly that standard steel or stainless GTAW parameters cannot achieve fusion — the heat sink simply overwhelms the available arc energy. Compensating measures include higher amperage, helium-argon shielding gas (helium dramatically increases arc enthalpy), preheat of 200–400°C for sections above approximately 3 mm, and slower travel speed. ERCu filler metal is specified rather than matching copper because the filler contains deoxidizers that prevent porosity from the residual oxygen that deoxidized copper inherently contains.

112. B — Hot wire GTAW applies a separate AC resistance heating current between the wire contact tube and the weld pool, pre-heating the filler wire to near its melting temperature just before it enters the weld pool. Because the wire arrives almost pre-melted, the GTAW arc must contribute far less energy to achieve complete wire melting — allowing wire feed rates 2–5 times higher than cold wire GTAW without a proportional increase in total heat input to the base metal. The combination of high deposition rate and controlled, low dilution makes hot wire GTAW the preferred process for stainless steel cladding applications where both productivity and cladding integrity are critical.

113. D — Titanium reacts strongly with oxygen, nitrogen, and hydrogen at temperatures above approximately 300–400°C, producing brittle surface oxides, nitrides, and hydrides that discolor and embrittle the weld and HAZ. The torch cup shielding gas protects only the molten pool and its immediate solidification zone — the hot weld metal and HAZ behind the torch remain above 300–400°C for several seconds after the arc advances and are no longer covered by the torch cup gas. The trailing shield extends inert gas coverage over these still-hot zones until they cool below the critical contamination temperature, preventing the surface contamination and embrittlement that would otherwise occur.

114. C — A larger nozzle cup has a larger cross-sectional area — the same volumetric flow rate (8 L/min) fills the larger area with lower gas velocity than it did in the smaller cup. Insufficient exit velocity in the larger cup means the shielding gas column lacks the momentum to exclude the atmosphere, particularly at longer arc lengths or in light air movement. The practical guideline of approximately 8–10 L/min per US cup size number ensures adequate exit velocity in proportion to the cup area — a #8 cup requires approximately 12–15 L/min rather than the 8 L/min that was adequate for the smaller #4 cup.

115. B — Through-the-arc seam tracking uses the arc electrical signal itself as the sensing element — monitoring changes in welding voltage (constant current mode) or current (constant voltage mode) that occur when the torch drifts and the arc-to-work distance to each groove wall changes. A centered torch produces symmetrical electrical characteristics; a lateral drift creates a detectable asymmetry in the arc signal that the controller interprets as a position error and corrects with a repositioning movement. This

approach requires no additional sensor hardware, uses the arc's own physics as the feedback signal, and responds in real time during welding.

116. A — Pre-purge establishes a complete inert gas atmosphere throughout the torch cup, gas lens, and the gap between the tungsten and work before the arc is struck — without it, residual air in the torch contaminates the arc initiation zone, causing oxidation and tungsten contamination at the weld start. Post-purge maintains shielding gas flow for the specified time after arc extinguishment while the tungsten tip, nozzle, and recently deposited weld metal are still hot enough to oxidize on atmospheric contact. Eliminating either purge accepts contamination risk at the weld start or stop locations — the exact zones where NDE most often reveals defects on incomplete GTAW procedures.

117. D — GTAW on 2 mm 304L stainless produces a smooth, shiny surface finish with no spatter and no silica islands — all three of these quality attributes are directly relevant to food processing equipment, which must meet food contact surface cleanliness standards. GMAW on thin stainless produces silica islands (requiring mandatory inter-pass brushing), risk of spatter burns (which create surface defects requiring repair or polishing), and a slightly rougher weld bead surface even in short-circuit transfer. GTAW's quality advantages for this specific application justify its lower deposition rate.

118. C — Increasing arc length in GTAW increases arc resistance and therefore arc voltage at constant current, which increases total arc power ( $P = V \times I$ ). However, this higher power is distributed over a wider contact area at the work surface rather than concentrated in the small spot of a short arc, so the power density ( $W/mm^2$ ) actually decreases — producing a wider, shallower pool. As arc length increases further, the laminar shielding gas envelope can no longer bridge the gap effectively, degrading atmospheric protection and creating contamination risk for sensitive alloys like stainless steel.

119. A — As the tungsten extension beyond the cup exit increases, the turbulent gas boundary of the shielding envelope approaches the electrode tip progressively sooner, reducing the inert gas coverage at the tip and the immediately adjacent weld zone. At extensions beyond the recommended maximum, the electrode tip and the solidifying weld metal may be inadequately shielded, creating atmospheric contamination risk. The shortest extension that provides adequate joint access and pool visibility is always the best practice — sacrificing visibility for shielding gas effectiveness is the correct trade-off for quality-critical GTAW applications.

120. B — Tungsten inclusions in stainless steel weld metal are hard, brittle, extremely dense (approximately 2.4× the density of steel), and appear as bright high-density indications on radiographic film. The contaminated zone must be fully mechanically removed until all discoloration is excavated, confirmed defect-free by MT or PT, re-welded using a freshly prepared electrode with correct tip geometry, and re-inspected by the original NDE method to confirm the repair is compliant. A

contaminated tungsten electrode must be re-ground or replaced because a damaged tip will continue depositing inclusions in subsequent welds.

121. D — Active SAW fluxes intentionally transfer manganese, silicon, and other alloying elements into the deposit — the amount transferred is heat-input dependent, meaning any change in current, voltage, or travel speed changes the weld metal composition and therefore the mechanical properties of the deposit. This heat-input sensitivity means that even minor parameter variations can push the weld metal outside the qualified procedure range, requiring requalification whenever parameters change. Neutral fluxes transfer minimal alloying elements, producing stable, consistent weld metal composition across a range of heat inputs — the predictability that makes neutral fluxes preferable for pressure vessel applications requiring tightly controlled mechanical properties.

122. A — Under ASME Section IX, the SAW wire/flux combination is an essential variable because the wire and flux interact chemically at arc temperature to produce the deposited weld metal composition and microstructure — the combination, not the individual components, determines the mechanical properties. Each unique combination must be independently qualified through actual mechanical testing (tensile, bend, impact) to establish its performance record. The EM12K/neutral flux PQR documents only the properties of that specific combination and provides no qualification basis for the EB3/basic flux Cr-Mo alloy system, regardless of how similar the equipment or base metal might be.

123. C — For inside longitudinal seam SAW, the pipe is positioned on turning rolls with the seam at the 6 o'clock (bottom) position so the torch travels along the inside bottom of the pipe where gravity holds the granular flux blanket against the plate surface — normal SAW flux behavior applies at the bottom position without any special flux retention system. The pipe diameter must be large enough to physically accommodate the complete SAW torch assembly plus the flux hopper, delivery nozzle, and flux recovery equipment inside the pipe bore. This setup is standard practice for large-diameter pipe manufacturing.

124. B — A permanent backing strip creates a crevice at the strip-to-shell interface that can trap corrosive process fluid, concentrating corrosive attack on the base metal and weld at the most stress-critical location. ASME VIII Division 1 restricts or prohibits permanent backing in cyclic service (Appendix 5) and some lethal service applications (UW-2) because of these compounded fatigue and corrosion risks. The joint efficiency assigned to the completed joint may also differ from a double-welded joint, potentially requiring increased shell plate thickness — all of which must be evaluated before specifying permanent backing as the fabrication approach.

125. D — Tandem SAW's two simultaneous arcs produce higher total heat input per pass than single-wire SAW at equivalent wire speeds, resulting in longer time above the grain-coarsening temperature

(~1100°C) in the HAZ and larger prior austenite grains in both the CGHAZ and weld metal microstructure. Larger grain size reduces the number of grain boundary triple junctions that serve as fracture arrest sites, directly reducing the Charpy energy. Corrective actions include reducing the tandem heat input (lower amperage or higher travel speed), selecting a higher-basicity flux for better grain refinement, or accepting that single-wire SAW is required to meet the specified toughness requirements for this vessel's service conditions.