PRACTICE EXAM 7: RED SEAL WELDER SIMULATION (125 QUESTIONS)

1. A welder splashes an unidentified cutting fluid on their forearm and needs to consult the Safety Data Sheet immediately. Which section of a WHMIS 2015compliant SDS contains first aid measures for skin exposure?

A. Section 3 — Composition and Information on Ingredients, which lists concentrations of chemical components and their individual toxicity threshold values for all skin exposure scenarios

B. Section 6 — Accidental Release Measures, which covers emergency response procedures including skin decontamination protocols for all uncontrolled chemical exposures

C. Section 4 — First Aid Measures, which provides recommended emergency response for all routes of exposure including skin contact, eye contact, inhalation, and ingestion

D. Section 11 — Toxicological Information, which contains clinical treatment guidelines and doseresponse data for dermal exposure to all classified chemical substances

2. A welder is setting up an SMAW station and connects the work lead clamp to an identical structural beam approximately 3 metres away from the actual weld joint, allowing welding current to return through the bolted beam connections between them. What specific hazard does this work lead placement create?

A. The welding current flowing through the structural bolt connections between the beams can cause arcing at the bolt interfaces, generating localized heat that damages fastener integrity and creates stray current paths through the building structure to any grounded equipment in the return current circuit

B. The extended current return path through 3 metres of structural steel increases arc voltage beyond the safe limit for SMAW, creating an elevated shock hazard to the electrode holder operator during arc interruptions

C. The stray current through the building structure activates the GFCI on the 120 V power circuit serving the welding area, tripping the SMAW power source during root pass welding and causing unacceptable arc interruptions

D. The asymmetric return current path through structural connections causes electromagnetic interference that disrupts the constantcurrent regulation circuit, randomly varying arc amperage during deposition and producing irregular bead geometry

3. A welder must perform maintenance on a watercooled GMAW wire feeder connected to a 480 V primary power source. Before reaching inside the feeder cabinet to service the wire drive components, what is the correct lockout/tagout sequence?

A. Apply the personal lock to the 480 V disconnect, verify isolation by attempting to start the feeder, then proceed with maintenance with only the electrical lockout applied

B. Notify the supervisor verbally and attach a caution tag to the front panel — verbal notification satisfies LOTO compliance requirements for welding equipment maintenance in all industrial settings

C. Disconnect the watercooled torch first, then apply the lock to the 480 V disconnect — the torch water circuit must be isolated before electrical lockout because water conducts stored energy from the cooling system to the worker

D. Identify all energy sources including 480 V electrical, capacitor stored energy, and cooling water pressure; isolate each at its designated isolation point; apply personal locks to all isolation points; verify zero energy state at the work location; then perform the maintenance task

4. A delivery of acetylene, oxygen, and argon cylinders arrives at the shop loading dock. Which storage arrangement complies with applicable Canadian standards for compressed gas cylinder storage?

A. All cylinders may be stored together in a single secured area if all valve caps are installed and all cylinders are chained upright — gas separation is only required for cylinders in active use, not stored inventory

B. Oxygen cylinders must be separated from acetylene cylinders by at least 6 metres of clear space, or by a noncombustible barrier at least 1.5 metres high with a minimum 30minute fire resistance rating; full and empty cylinders of each gas should be stored separately

C. Acetylene cylinders must be stored horizontally and separated from all other gases — the dissolved acetone carrier in acetylene cylinders becomes unstable and migrates to the valve if the cylinder remains upright for more than 24 hours

D. Argon and oxygen may be stored together since both are nonflammable, but acetylene must be in a completely separate building from all other compressed gases due to its classification as an unstable explosive material under all conditions

5. A welder is exposed to manganese fume during SMAW using E7018 electrodes. The measured 8hour timeweighted average (TWA) is 0.015 mg/m³, below the 8hour TWA OEL of 0.02 mg/m³. However, welding is performed in intense 45minute bursts separated by nonexposure periods. What additional exposure assessment is required?

A. No further assessment is needed — any 8hour TWA below the established OEL confirms compliance with all applicable exposure standards for manganese fume during SMAW operations

B. A second 8hour TWA measurement on a different workday must confirm that the first measurement was not anomalously low due to nonrepresentative working conditions that day

C. A shortterm exposure limit (STEL) assessment is needed — the 15minute STEL captures peak concentrations during the most intensive exposure bursts; even when the 8hour TWA complies, the STEL can be exceeded during short highintensity periods and must be independently verified against the applicable 15minute limit

D. A biological monitoring program must be established immediately — blood manganese levels must be measured quarterly whenever measured air concentration exceeds 50% of the TWA OEL, regardless of whether the 8hour average is compliant

6. A welder arrives at a scaffold work platform and sees a red tag attached to the main frame. What does the red tag indicate, and what action must the welder take?

A. A red tag means the scaffold has been inspected and declared unsafe — the scaffold must not be used under any circumstances until a competent person has corrected all identified deficiencies, reinspected the scaffold, and replaced the red tag with a green tag authorizing safe use

B. A red tag means the scaffold was recently inspected and found safe — red indicates an active inspection was completed within the last 24 hours, and the welder may proceed after signing the tag to confirm they reviewed the inspection record

C. A red tag means the scaffold requires a preshift inspection by each individual user — the red tag triggers the user to perform their own assessment, and if no obvious defects are visible, the welder may use the scaffold for the shift without further action

D. A red tag means the scaffold is reserved for the contractor named on the tag — other trades are excluded during the period specified, and the welder must contact the tagged contractor for access authorization

7. A welder must deposit stitch welds on a structural support frame located directly adjacent to an energized 480 V distribution panel that cannot be deenergized for the duration of the work. What arc flash protection standard must be followed for this welding task?

A. No arc flash protection is required because arc flash hazards apply only to electrical workers performing switching or maintenance on energized conductors, not to welding workers in proximity to energized equipment

B. Standard welding PPE including leather jacket, helmet, and gauntlets inherently provides adequate protection for proximity to all 480 V energized equipment in standard industrial environments

C. Closing and latching the panel door during the welding work provides a sufficient physical barrier to eliminate all arc flash exposure risk for personnel working immediately adjacent to the energized panel

D. An arc flash hazard assessment by a qualified electrician or engineer must determine the incident energy at the welder's working position, and arc flash PPE appropriate to that energy level per NFPA 70E or the applicable Canadian standard must be worn in addition to standard welding PPE throughout the task

8. On a new construction site, a welder and apprentice are assigned a daily structural welding task. The site safety program requires a prejob hazard assessment before each shift. Which statement most accurately describes who bears responsibility for completing the hazard assessment?

A. The site safety officer is solely responsible for completing all prejob hazard assessments and must physically attend each task start to review it with workers before any tools are used

B. The workers assigned to the task should be directly involved in completing the hazard assessment — workers performing the task are best positioned to identify sitespecific hazards, and the supervisor or lead hand confirms the assessment before work begins

C. The apprentice is solely responsible for all prejob hazard assessments as part of their onthejob learning obligations — hazard identification is a foundational trade skill that apprentices must develop independently

D. Prejob hazard assessments are only required at project start and when major scope changes occur — repeating the assessment at each shift start is administrative duplication that reduces productive work time without improving worker safety

9. A welder receives a seconddegree thermal burn approximately 25 mm × 35 mm on the forearm from a large spatter ball that lodged inside the gauntlet cuff. What is the correct immediate first aid response?

A. Cool the burn with cool running water for at least 10 minutes to stop the burning process, remove contaminated clothing and jewelry from the area, do not apply ice or home remedies such as butter, cover loosely with a clean dressing, and seek medical attention for a burn of this size and depth

B. Apply burn ointment or aloe vera gel immediately, wrap tightly with a compression bandage to limit swelling, and continue working — minor seconddegree burns do not require medical attention when properly dressed in the field

C. Immerse the burned area in an ice water bucket for 20 minutes — ice water is specifically recommended for partialthickness burns because it reduces tissue damage depth more effectively than cool running water for metallic spattersource injuries

D. Do not apply water — molten metal spatter may contain zinc or other reactive metals that react with water; the burn must be treated dry with a sterile dressing and transported directly to a medical facility without any fluid application

10. During pipe welding operations, a power source malfunction delivers an uncontrolled highcurrent arc causing a welder to drop the electrode holder and sustain a superficial hand burn. The power source is deenergized immediately and the welder is treated on site. Which reporting obligation applies?

A. No external notification is required for incidents resulting in firstaidlevel treatment only — internal documentation in the company first aid log and an incident report filed with the supervisor within 72 hours satisfies all applicable requirements

B. Only the joint health and safety committee must be notified — the JHSC reviews the incident at the next monthly meeting and determines whether regulatory reporting to the OHS authority is warranted based on severity classification

C. The provincial OHS authority must be notified of workplace incidents resulting in worker injury — the employer must investigate, document findings, and implement corrective measures; most jurisdictions require reporting to the OHS authority for any injury to a worker, with specific notification timelines based on severity classification

D. The electrical equipment manufacturer must be notified before the OHS authority — the equipment defect must be formally documented with the manufacturer to trigger a product recall investigation before any regulatory workplace reporting can proceed

11. After completing a weld, a welder chips slag from the hot finished bead using a chipping hammer with the welding helmet raised in the up position. Why is the raised welding helmet insufficient for the chipping task, and what PPE should the welder use?

A. The raised helmet provides no protection because the autodarkening lens does not activate in response to chipping sparks — only chipping in the closed helmet position with an activated lens provides adequate eye protection for this task

B. The raised welding helmet is insufficient only because the autodarkening shade is too dark for postweld viewing — switching to a passive shade 2 or 3 in the helmet before chipping provides both adequate visibility and the ballistic protection required

C. The raised helmet provides no arc radiation protection, but since no arc is present during chipping this is irrelevant — the helmet's ballistic resistance to flying slag particles when raised is equivalent to a face shield and provides adequate protection

D. When the welding helmet is raised, it no longer protects the eyes and face — a full face shield worn over safety glasses provides the required eye and face protection against flying slag chips and hot particles during mechanical chipping operations

12. A welder has been issued a new halfface airpurifying respirator for SMAW on galvanized steel. A fit test on an identical make and model was completed two years ago. When is a new fit test required under the applicable respiratory protection standard?

A. No additional fit test is required — a fit test on the same make and model is permanently valid regardless of time elapsed or any physical changes to the worker's face

B. A new fit test is required when the worker changes to a different make, model, style, or size of respirator; when significant physical changes occur to facial structure such as weight change, dental work, or scarring; or at the interval specified by the employer's written respiratory protection program — periodic retesting is typically required annually

C. Fit test validity is always limited to 12 months — once 12 months have elapsed, the respirator may not be used under any circumstances until a new fit test is performed, even if no physical changes have occurred and the identical respirator model is continued

D. Fit testing is required only for SCBA and suppliedair respirators — halfface APRs providing a protection factor below 10× the OEL are exempt from fit testing requirements because the face seal is not considered structurally critical at this protection factor level

13. A welding crew is working outdoors in wet conditions following overnight rain, using 120 V power tools fed from a portable generator. Which protective device is mandatory for the 120 V tool circuits in this application?

A. An RCD rated at 30 mA is required only for tools with exposed metal housings — doubleinsulated plastic tools are exempt from ground fault protection requirements in wet outdoor applications

B. No additional device is required beyond the generator's builtin overcurrent protection — generator circuit breakers provide adequate shock protection for all 120 V power tools below 20 A in wet outdoor environments

C. A ground fault circuit interrupter (GFCI) is required for all 120 V circuits used in outdoor and wet or damp locations — the GFCI detects current leakage of 4–6 mA that would not trip the overcurrent breaker but is sufficient to cause serious or fatal electrocution

D. A GFCI is required only when tools are used within 1.5 metres of standing water — tools operated more than 1.5 metres from pooled rainwater are exempt from the ground fault protection requirement

14. A welder reads the SDS for a welding flux and notices the OEL for one component is listed as a ceiling (C) value rather than a TWA. What does the ceiling limit mean and how does it differ from an 8hour TWA?

A. A ceiling limit is a concentration that must never be exceeded at any moment during the work shift, regardless of how brief the excursion — unlike a TWA that averages exposure over 8 hours and permits brief highconcentration periods to be balanced by lowerexposure periods, a ceiling limit applies instantaneously and continuously throughout the shift

B. A ceiling limit applies only to the first 2 hours of the shift — the body adapts to the substance during this initial period, and after adaptation the ceiling limit is replaced by the standard TWA for the remaining 6 hours

C. A ceiling limit and a TWA are interchangeable designations — both represent the maximum allowable average concentration across the standard 8hour workshift as published by the applicable occupational health authority

D. A ceiling limit applies exclusively to confirmed carcinogens — the ceiling classification identifies substances with proven carcinogenic properties, while all other noncarcinogenic substances use only TWA standards regardless of the shape of their toxicological doseresponse curve

15. During a shutdown maintenance job, a welder must make repairs inside a pressure vessel without any natural light. The only available lighting is a portable trouble light providing approximately 150 lux at the work surface. What lighting concern applies to this situation?

A. 150 lux is adequate for all welding applications — the minimum illumination standard for welding specifies 100 lux at the work surface, and any lighting above this minimum satisfies the applicable occupational health standard

B. 150 lux is specifically adequate for confined space welding because the enclosed area reflects light back onto the work surface, doubling the effective illumination at the joint preparation compared to openair applications

C. The 40watt equivalent LED classification is the concern, not the illumination level — any nonintrinsicallysafe light source creates a fire and explosion hazard inside a pressure vessel and must be replaced with a certified confinedspacerated lowvoltage lamp regardless of lux output

D. 150 lux is insufficient for precision welding and inspection work — the recommended minimum illumination for welding tasks requiring precision joint preparation verification, root pass inspection, and closetolerance work is typically 500 lux or higher; inadequate lighting contributes to weld defects, missed preweld inspection items, and eye fatigue

16. A SMAW power source is rated at 300 A, 60% duty cycle at 40°C. The welder runs at 250 A in a shop where ambient temperature is 45°C. Which statement correctly explains how the elevated ambient temperature affects the power source?

A. Elevated ambient temperature has no effect on duty cycle — duty cycle is a fixed electrical specification determined by transformer and rectifier ratings and applies at any temperature up to the maximum operating limit regardless of ambient conditions

B. Elevated ambient temperature reduces the effective duty cycle below the nameplate rating — power source components operate at higher temperatures when ambient exceeds the rated test temperature of 40°C, requiring more frequent rest periods to prevent overheating; the rated duty cycle applies only at the stated test temperature

C. Elevated ambient temperature above 40°C resets the duty cycle upward — thermal protection circuits in modern SMAW power sources recalibrate the duty cycle based on ambient temperature feedback, providing a higher ontime allowance in warm conditions to compensate for reduced arc voltage at elevated temperature

D. Elevated ambient temperature requires the operator to reduce welding current by 10 A for every degree above 40°C — this derating formula maintains the 60% duty cycle by compensating for the increased thermal loading on internal power source components at elevated shop temperatures

17. A fabrication shop uses various flux pastes and cleaning solutions classified as WHMIS eye and skin hazards. At what maximum distance or travel time must an emergency eyewash station be located from any work area using these materials?

A. The emergency eyewash station must be reachable within 10 seconds of travel time, approximately 10 metres — this response time is established because the first 10–15 seconds of flushing are most critical for limiting chemical injury depth, and longer travel allows deeper penetration of the chemical into eye tissue before flushing begins

B. The emergency eyewash must be within 30 metres — the 30metre distance allows the worker time to read the SDS and confirm the correct flushing procedure before beginning irrigation, ensuring proper decontamination rather than uninformed premature flushing

C. The emergency eyewash must be within 5 metres — all chemical hazard areas require an adjacent eyewash station because any travel time exceeding 5 seconds prevents effective decontamination for corrosive splashes

D. No specific distance or travel time requirement exists — the employer must make eyewash stations reasonably accessible, and appropriateness of location is determined casebycase based on hazard severity and the time available before tissue damage occurs

18. A welder is completing heavy SMAW fabrication inside a partially enclosed welding booth with curtains on all four sides and limited ventilation. Near the end of the shift, the welder notices the normally cool metal floor feels warm through their boots. The welder has been drinking water regularly. Which heatrelated concern specifically associated with this enclosed configuration warrants immediate attention?

A. The warm floor indicates the building's floor heating system has activated beneath the slab — the welder should request maintenance to shut off the floor heating before the next shift, but no immediate concern exists for the current work period

B. Water intake without electrolyte replacement during prolonged heat exposure risks hyponatremia — the warm booth confirms heat accumulation, and the regular water intake without sodium replenishment creates a hyponatremia risk more serious than dehydration at this stage

C. The warm floor confirms that radiant heat from completed welds and hot metal has elevated the effective temperature inside the enclosed booth above the ambient shop temperature — cumulative radiant heat in enclosed spaces can create heat stress conditions that the welder may not perceive as acutely as convective heat; the actual thermal load should be assessed using WBGT methodology before continuing under these conditions

D. The warm floor is normal and confirms the booth is functioning correctly as a heat containment structure — welding booths are designed to retain radiant heat within the booth specifically to protect adjacent workers, and no action is required

19. A JHSC member asks a welding foreman to explain the difference between a critical part inspection and a general workplace inspection. Which description correctly distinguishes these two inspection types?

A. A critical part inspection examines only newly installed equipment, while a general inspection covers all existing equipment and work areas — the distinction is based solely on equipment age, not the potential consequence of failure

B. A critical part inspection is performed only following a workplace incident, while a general inspection is scheduled periodically regardless of whether an incident has occurred — the distinction is based on the triggering event

C. A critical part inspection requires a certified safety professional to perform the assessment, while a general inspection can be performed by any JHSC member — the distinction is based on the required credentials of the inspector

D. A critical part inspection examines specific highhazard components — lifting equipment, pressure vessels, fall arrest systems, scaffolding — that have the potential to cause death or serious injury if they fail, often at greater frequency than general inspections; a general inspection provides a broad review of the entire workplace for all hazard types

20. A newly hired welding apprentice asks about a solvent used to degrease pipe joint preparations. The container has only a transportation shipping label and no supplier label. Under WHMIS 2015, what is the employer's specific obligation?

A. The employer may continue using the product as long as the transportation shipping document is available on site — WHMIS supplier label requirements apply only to products manufactured after the employer purchased the current inventory

B. The employer must apply a workplace label to any WHMIS product whose supplier label is missing, illegible, or noncompliant — the workplace label must include the product identifier, safe handling instructions, and reference to the SDS; a compliant SDS must be accessible to all workers who use the product

C. The employer's obligation is limited to verbally informing workers of the product hazards — physical labeling requirements are satisfied when hazard information is provided during the worker's annual WHMIS refresher training

D. The employer must immediately remove the product from service and return it to the supplier — any container without a WHMIS 2015 supplier label must not be used in any Canadian workplace until the supplier provides a compliant replacement container

21. A structural welding drawing shows a welding symbol with a groove weld symbol on the arrow side, the notation "AWS D1.1" written in the tail of the symbol, and a filled flag at the reference line junction. What does the tail notation communicate to the welder and inspector?

A. The tail notation "AWS D1.1" identifies the governing welding standard that applies to this specific weld — all inspection acceptance criteria, procedure qualification requirements, and welder certification requirements for this joint are governed by the AWS Structural Welding Code – Steel, AWS D1.1

B. The tail notation identifies the welding process to be used at this joint — AWS D1.1 is the process code designation for SMAW welding in the American Welding Society process classification system used on structural fabrication drawings

C. The tail notation specifies that only an AWS Certified Welding Inspector may inspect this joint — nonAWS certified inspectors with equivalent CWB certification are excluded from inspecting welds where the AWS D1.1 code is referenced in the symbol tail

D. The tail notation indicates the weld was preapproved by the AWS engineering review department — a tail notation citing a specific code number indicates the weld design was stamped by an AWSregistered professional engineer prior to fabrication

22. A pipefitter must fabricate a 3piece 90degree elbow from straight pipe using equal miter cuts at each joint. What is the correct cut angle for each miter face, and how many welded joints will the completed assembly contain?

A. 30 degrees per miter face; 3 welded joints — each of the three pieces is cut at 30 degrees, and the three pieces are joined at three separate weld joints to achieve the 90degree direction change

B. 15 degrees per miter face; 3 welded joints — the 90degree change is divided across 3 joints at 30 degrees each, and the miter face cut at each joint is half of 30 degrees, yielding 15 degrees; three weld joints are required to join the four pipe ends

C. 22.5 degrees per miter face; 2 welded joints — for a 3piece equalcut 90degree elbow: two weld joints connect the three pipe pieces; each joint changes direction by 45 degrees (90° ÷ 2 joints); each miter face is cut at half the joint angle = 45° ÷ 2 = 22.5° from perpendicular; the two end pieces each have one cut and the center piece has two cuts

D. 45 degrees per miter face; 2 welded joints — the 90degree direction change is split equally between two welded joints, and each miter face cut equals the full joint angle of 45 degrees; the center piece provides a simple straightthrough section with the two angular cuts at each end piece

23. A CJP groove weld on structural steel is completed with a steel backing bar on the underside. The engineer specifies the backing bar must be removed after welding. What process and inspection requirements apply to the backing bar removal?

A. The backing bar may be removed by any cutting method and the resulting surface requires only a visual check for completeness — backing bar removal is a postweld finishing step with no specific code quality requirements

B. The backing bar is typically removed by CACA, grinding, or other cutting method to flush with the base metal, and the resulting surface must be inspected by NDE — MT or PT as required — to confirm complete removal without residual notches, gouges, or sharp corners that could act as stress concentrators at the weld root

C. Backing bar removal requires returning the joint to the original fabricating company — only the company that designed and made the original welds is authorized to perform backing bar removal, since the removal affects the certified aswelded root geometry

D. Backing bars may only be removed by mechanical grinding — thermal cutting methods cannot be used for backing bar removal because the heat from thermal cutting remelts the root of the original weld and creates a nonconforming heataffected zone at the root face

24. A pressure vessel procedure specifies PNumber 1, Group 2 base metal. A fabricator proposes substituting PNumber 1, Group 1 material that is slightly lower in yield strength but meets all other dimensional and composition requirements. Under ASME Section IX, is this substitution acceptable without requalification?

A. The substitution is not acceptable — changes in both PNumber and Group number always require complete procedure requalification; the proposed change involves a Group number change that cannot be made without a new PQR under any circumstances

B. The substitution requires only a WPS amendment — changing within the same PNumber but a different Group is an administrative revision that requires no additional testing, only documentation of the revised base metal in the WPS

C. The substitution is acceptable only if postweld heat treatment is performed at 620°C for 1 hour per 25 mm — the Group number change within PNumber 1 triggers a mandatory PWHT requirement under ASME IX for any interGroup combination regardless of the reason for the change

D. Under ASME Section IX, a WPS qualified on PNumber 1 Group 2 material also qualifies welding on PNumber 1 Group 1 — qualification on a higher group number within the same PNumber qualifies welding on lower groups within that PNumber, making this substitution acceptable without requalification

25. A structural welder places 10 mm long tack welds at 300 mm spacing to hold a large platetoplate butt joint fitup before automated SAW. The welding supervisor immediately rejects these tack welds before any production welding begins. What quality concern does the supervisor most likely have?

A. The 10 mm tack welds are too short — AWS D1.1 and CSA W59 specify minimum tack weld lengths for structural applications; tacks shorter than the specified minimum (typically 38 mm or 4× the largest base metal thickness) are inadequate to maintain joint alignment and resist distortion forces during root pass welding

B. The 300 mm tack spacing is too close — structural tack welds must be spaced at least 600 mm apart to allow the joint to expand and contract freely during tack cooling without inducing bow into the fitup plate assembly

C. The 10 mm tack welds are too long for SAW — tack welds must be removed before SAW passes over them, and any tack exceeding 8 mm creates a thermal mass that disrupts the SAW arc continuity as the automatic head encounters the tack location

D. Tack welds on SAW joints must be deposited using the same SAW process — using any other process for tacks on a SAW joint requires separate WPS qualification, and SMAW or GMAW tacks on SAW joints are categorically not permitted by the applicable code

26. A fabricator is welding a long fillet weld on one side only of a Tjoint assembly. Angular distortion causes the assembly to pull toward the weld side after cooling. The fabricator wants to apply a preset method before welding to compensate for the expected distortion. Which preweld action accomplishes this?

A. Preheat the base metal to 150°C before welding — preheating reduces the temperature differential between the weld zone and the surrounding plate, preventing the differential contraction that is the root cause of angular distortion in singlesided Tjoint fillet welds

B. Increase the electrode diameter by one size to reduce the number of passes — fewer thermal cycles acting on the joint reduces the total cumulative angular distortion compared to completing the same joint with smaller electrodes and more passes

C. Clamp the assembly rigidly to a flat table after tacking and maintain the clamps until the assembly has fully cooled to ambient temperature — rigid restraint prevents the distortion force from developing during the cooling cycle

D. Before welding, deliberately set the free plate edge at an angle opposite to the expected distortion direction — when welding thermal contraction pulls the assembly toward the weld side, the preset angle is consumed by the distortion, and the final cooled assembly approximates the intended flat geometry; the preset angle is determined from experience or distortion analysis for the specific joint configuration

27. A quality inspector oversees extraction of Charpy Vnotch impact specimens from a pressure vessel PQR test coupon. The test coupon is 20 mm thick plate welded with the weld axis perpendicular to the rolling direction. For weld metal specimens, where must the notch be positioned and in what direction must it be oriented?

A. The notch must be parallel to the plate rolling direction and positioned at the weld root — root positioning captures the highest residual stress location and represents the worstcase impact performance point in the weld crosssection

B. The notch must be oriented vertically through the plate thickness and positioned at the weld cap surface — cap surface positioning ensures the notch samples the highesthydrogencontent region of the multipass deposit, representing the minimum toughness condition for the joint

C. For weld metal specimens, the notch axis runs parallel to the plate surface with the notch bisecting the weld centerline at the specified depth — for HAZ specimens, the notch is positioned at the specified distance from the fusion line; the orientation and depth requirements for each specimen type are specified in ASME Section IX and the applicable impact testing standard

D. The notch must always be longitudinal (parallel to the weld axis) and positioned at midthickness — the longitudinal orientation tests the weld metal's resistance to delamination cracking, which is the primary failure mode under Charpy impact loading for groove weld deposits

28. During multipass SMAW welding of a pressure vessel seam, the inspector must verify that the maximum interpass temperature of 250°C is not exceeded. Which temperature measurement method provides the most accurate interpass reading at the critical weld location?

A. A temperatureindicating crayon (Tempilstik) applied to the weld surface immediately after the previous pass — the color change at the mark confirms the temperature at the moment of application and provides a visible permanent record on the weld surface

B. A calibrated contacttype pyrometer or thermocouple placed directly on the weld metal between passes, at the specific location where the next pass will be deposited — this provides the most accurate measurement of the actual interpass temperature at the critical weld zone location

C. An infrared noncontact thermometer aimed at the weld from approximately 300 mm distance — noncontact IR thermometers provide the most accurate interpass readings because they do not conduct heat away from the weld metal through physical probe contact

D. Holding the back of an ungloved hand near but not touching the weld surface — if the worker can hold their hand within 50 mm of the weld for more than 3 seconds, the temperature is below 60°C, confirming the interpass temperature is well within the 250°C maximum

29. A pressure vessel inspector must select an NDE method to detect potential delayed hydrogen cracking that may have formed 24 hours after welding in the HAZ of a P91 alloy steel longitudinal seam. The cracking, if present, would be subsurface at approximately 2–5 mm depth and oriented transverse to the weld axis. Which NDE method is most appropriate?

A. Ultrasonic testing is the most appropriate method — UT can detect subsurface cracks at the 2–5 mm depth range and can be configured to detect transversely oriented defects; phased array UT is particularly effective for nearsurface subsurface cracking in this depth range on alloy steel pressure vessels

B. Magnetic particle testing is most appropriate because HAZ cold cracks typically propagate from the weld toe and are connected to the outer surface, making surfacesensitive MT the most direct detection method for this specific defect type

C. Radiographic testing is most appropriate because transverse HAZ cracks produce a characteristic dark linear indication easily distinguished from background on the film

D. Penetrant testing is most appropriate because cold cracks are always open to the surface and the liquid penetrant fills the crack and produces a highly visible linear indication after developer application

30. A fabrication shop cuts structural steel plates from master plates and must maintain material traceability throughout the cutting and fabrication process. Which practice correctly maintains traceability when multiple components are cut from a single master plate?

A. No marking action is required once the master plate heat number is recorded in the purchase order file — individual component identity is maintained through the purchase order number alone, and no additional marking on individual pieces is needed for structural steel fabrication

B. Components must be identified using plastic tags tied through predrilled holes — only tagbased identification is acceptable because paint stick or vibroengraved marks are not considered permanent enough for codecompliant structural steel traceability

C. Before any cuts are made, each component's location on the master plate should be marked with the heat number and piece mark using paint stick or vibroengraved stamp — this ensures each piece retains its identity after separation from the master plate, when the original mill marking may no longer be present on all pieces

D. Material traceability requires a fulltime inspector to witness all cutting operations and countersign each piece as it is separated — witnessed cutting is the only method recognized by structural steel fabrication codes for maintaining individual material identity during the cutting and separation process

31. A welder is depositing multiple passes in a wide singleV groove on 38 mm structural plate. After several fill passes, a narrow deep slot has formed at the center of the groove crosssection, and the last pass produced a narrow, deep concave bead. What quality risk does this slot geometry create, and what technique correction applies?

A. The narrow deep slot creates risk of incomplete fusion at the groove sidewalls — increasing arc voltage widens the bead to ensure the sidewalls are properly fused before the slot becomes too narrow to reach with the electrode

B. The narrow deep slot creates risk of lack of penetration at the groove base — increasing amperage and reducing travel speed forces deeper penetration into the slot bottom before the weld metal bridges the opening

C. The narrow deep slot creates a chimney effect causing atmospheric porosity — increasing the shielding gas flow and redirecting the nozzle directly into the slot before the next pass prevents air contamination in the deep narrow groove geometry

D. The narrow deep slot creates risk of centreline solidification cracking — the high depthtowidth ratio of a bead deposited in the slot concentrates solidification stresses at the centreline; the concave surface creates a notch at the centreline; the correction is to deposit tiein passes on each sidewall to build the groove width before depositing a fullwidth pass over the slot

32. A material test report shows the following plate composition: C=0.18%, Mn=1.20%, Si=0.35%, Cr=0.15%, Mo=0.05%, V=0.03%, Ni=0.10%, Cu=0.20%. Using the IIW CE formula CE = C + Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15, what is the CE and what minimum preheat does CSA W59 typically associate with this value at 25 mm plate thickness?

A. CE = 0.18 + (1.20/6) + (0.15+0.05+0.03)/5 + (0.10+0.20)/15 = 0.18 + 0.200 + 0.046 + 0.020 = 0.446; at CE = 0.446 and 25 mm thickness, CSA W59 typically specifies a minimum preheat in the range of 50–80°C — the moderate CE and thickness combination warrants precaution without requiring elevated preheat

B. CE = 0.18 + (1.20/6) + (0.15+0.05)/5 + (0.10+0.20)/15 = 0.18 + 0.200 + 0.040 + 0.020 = 0.440; at CE below 0.45 and 25 mm, CSA W59 provides a blanket exemption from preheat requirements regardless of material thickness

C. CE = 0.18 + (1.20/6) + (0.15+0.05+0.03)/5 + (0.10+0.20)/15 = 0.446; at CE above 0.40 for any thickness, CSA W59 mandates a minimum 150°C preheat regardless of the section thickness specified in the applicable preheat table

D. CE = 0.18 + (1.20/6) + (0.15+0.05+0.03+0.10+0.20)/5 = 0.18 + 0.200 + 0.106 = 0.486; at CE = 0.486, CSA W59 requires full PWHT rather than preheat for all material thicknesses above 15 mm

33. A drawing specifies a partial joint penetration (PJP) bevel groove weld with a 45-degree groove angle and a groove preparation depth of 16 mm. Under CSA W59 provisions for bevel grooves with included angles less than 60 degrees, what is the correct effective throat for this joint?

A. 16 mm — the effective throat of a PJP groove weld always equals the full groove preparation depth regardless of groove angle, since the welder must fill the groove preparation completely during deposition and the full depth is available for load transfer

B. 13 mm — for bevel or J-groove welds with an included angle less than 60 degrees, CSA W59 specifies that the effective throat equals the groove preparation depth minus 3 mm, accounting for the inability to achieve complete root fusion in a tight-angle groove; for a 16 mm groove: 16 − 3 = 13 mm

C. 11.3 mm — the effective throat for a 45-degree bevel groove is calculated as the groove depth multiplied by sin(45°): 16 × 0.707 = 11.3 mm, representing the perpendicular distance from the root to the weld face across the groove preparation

D. 8 mm — the effective throat equals the groove preparation depth divided by two when the groove angle is less than 60 degrees: 16 ÷ 2 = 8 mm minimum, per the CSA W59 reduced-penetration provision for tight-angle groove configurations

34. A quality inspector measures a circumferential pipe joint and finds a peaking condition — the joint has a localized flat spot creating a visible angular change across the weld joint rather than a smooth circular profile. Under ASME B31.3, what is the primary structural concern with this condition?

A. Peaking is a cosmetic concern only — the flat spot changes the appearance of the weld but does not affect the mechanical performance of the joint; no maximum peaking limit is specified in ASME B31.3 for pressure piping applications

B. Peaking creates a fatigue stress amplification that reduces fatigue life of the joint — ASME B31.3 specifies a maximum peaking of 12 mm specifically to limit the stress concentration factor to an acceptable level for vibrating piping systems

C. Peaking creates a bending stress concentration at the angular misalignment that amplifies the hoop stress under pressure loading — ASME B31.3 and related piping codes limit angular misalignment to specified tolerances to prevent the local bending stress at the peaking location from combining with the pressure hoop stress to exceed the material allowable

D. Peaking creates a systematic dimensional error that prevents the pipe from meeting its outside diameter tolerance — ASME B31.3 specifies peaking limits for dimensional compliance purposes only, not for any structural or stressrelated reason

35. A SMAW procedure has been qualified without Charpy Vnotch impact testing. The completed vessel will operate at −29°C service temperature. Under ASME Section IX, what change to the procedure qualification does this service requirement trigger?

A. No change is required — ASME IX procedure qualifications are not servicetemperaturedependent, and the PQR remains valid for all service temperatures as long as WPS parameters stay within the qualified ranges

B. The WPS must be rewritten to include a 150°C minimum preheat — lowtemperature service requirements are addressed through preheat requirements in ASME Section VIII Div 1, and modifying the preheat in the WPS satisfies the cold service requirement without additional PQR testing

C. The welding process must change to GTAW — ASME IX requires GTAW as the mandatory process for all weldments intended for service below −20°C; SMAW procedures require complete requalification to GTAW regardless of joint configuration

D. The supplementary essential variables in ASME IX become mandatory when impact testing is required by the construction code — a service temperature of −29°C triggers impact testing requirements under ASME VIII; once impact testing is specified, a new PQR with Charpy specimens at the required test temperature must be generated to support an amended WPS

36. A pressure vessel has a Type 1 longitudinal seam (full penetration butt weld, 100% RT) with a joint efficiency of E=1.00 and an original wall thickness of 12 mm at a MAWP of 1,000 kPa. If the joint type is changed to Type 3 (singleV butt weld, no NDE) with E=0.70, what minimum wall thickness is required to maintain the same MAWP, assuming all other design variables are constant?

A. Approximately 17 mm — wall thickness is inversely proportional to joint efficiency; the original 12 mm at E=1.00 must increase to 12 ÷ 0.70 = 17.14 mm, rounded up to the next standard plate thickness, to maintain the same MAWP with the lower joint efficiency

B. Approximately 8.4 mm — a lower joint efficiency means the joint can accommodate more strain before failure, which actually reduces the required wall thickness; the new minimum wall = 12 × 0.70 = 8.4 mm

C. Approximately 12 mm — wall thickness is not affected by joint efficiency type; efficiency only governs the inspection requirement, not the structural pressure design calculation

D. Approximately 20 mm — the required wall for a Type 3 joint is the original wall plus a 50% safety margin: 12 × 1.50 = 18 mm, rounded up to 20 mm for standard plate availability

37. An eccentric load is applied at a distance from the centroid of a weld group connecting a structural bracket to a column using two parallel vertical fillet welds. What type of combined loading does this eccentric condition create on the weld group?

A. Pure axial tension only — the offset from the weld centroid does not create bending or torsion because the parallel fillet welds on both sides of the bracket web fully balance each other under any eccentric load orientation

B. Combined direct shear and moment — the vertical load component creates direct shear stress on the weld throat, and the eccentricity from the weld group centroid creates a bending moment; the most critically loaded weld element receives the vector sum of the direct shear component and the momentinduced shear component

C. Pure torsion only — the load eccentricity creates a torque about the weld group centroid that is resisted entirely by torsional shear in the weld throat; the direct vertical shear component is negligible compared to the torsional contribution

D. Pure bending stress only — the moment arm between the load and the weld centroid creates a pure bending condition; the bending stress is the only weld stress component the designer needs to evaluate for this eccentric connection configuration

38. A fillet weld 300 mm long joins a gusset plate to a structural column and must carry a factored shear force of 200 kN. Using an allowable shear stress on the fillet throat of 0.67 × 480 MPa for E480XX electrode, what is the minimum calculated fillet weld leg size?

A. 5 mm minimum — the calculated minimum under any conditions rounds up to 5 mm because CSA W59 specifies a universal minimum of 5 mm for all E480XX fillet welds in structural steel applications regardless of the calculated throat requirement

B. 4 mm minimum — required throat = 200,000 ÷ (0.67 × 480 × 300) = 200,000 ÷ 96,480 = 2.07 mm; leg = 2.07 × 2.0 = 4.14 mm, which rounds to 4 mm; the throattoleg conversion factor for fillet welds is 2.0

C. Required throat = 200,000 ÷ (0.67 × 480 × 300) = 200,000 ÷ 96,480 = 2.07 mm; leg = 2.07 × √2 = 2.07 × 1.414 = 2.93 mm; the minimum calculated leg is 3 mm — this calculated minimum and the applicable code minimum for the base metal thickness must both be checked, with the larger value governing

D. 2 mm minimum — required throat = 200,000 ÷ (480 × 300) = 200,000 ÷ 144,000 = 1.39 mm; leg = 1.39 × 1.414 = 1.97 mm, rounded to 2 mm; the 0.67 reduction factor applies only under dynamic loading conditions and is not used for standard static structural connections

39. After completing a multipass SMAW Tjoint fillet weld on structural steel, the welder performs a selfinspection before calling the quality inspector. In what sequence should the visual inspection be conducted?

A. Inspect the weld size first, then the surface condition, then the length — verifying size confirms the design requirement is met before investing time in surface quality inspection that may be irrelevant if the weld must be removed for an undersized leg dimension

B. Inspect slag removal completeness first, then weld profile, then surface defects — slag must be removed before any other inspection can occur, and completing removal before any measurements prevents the need to reinspect after partial cleaning

C. Inspect only the arc start and stop locations — start and stop locations are statistically the highest risk areas for defects in fillet welds, and focusing only on these locations provides the most efficient use of visual inspection time in a production environment

D. Clean the weld surface completely by removing all slag and spatter, then inspect the full weld length systematically: verify leg size and throat against the drawing, inspect bead profile for convexity and concavity, check for surface defects including cracks and undercut, verify weld length and location, then confirm compliance with the governing acceptance criteria

40. A welder is certified by CWB for SMAW (process 111) on carbon steel in the 3G and 4G positions. The same welder is now required to weld in the 4G position using GMAW (process 131) on the same carbon steel. What qualification action is required?

A. Yes, a new GMAW qualification test is required — welding process is an essential variable under CWB welder certification; certification in SMAW does not extend coverage to GMAW even on the same base metal group, position, and joint type

B. No new qualification is required — the 4G position was already established by the SMAW qualification, and once a position is qualified in any process on a given material group it applies across all processes on the same material and position

C. No new qualification is required for flat plate groove welds — CWB position qualifications on plate apply to all processes for the same base metal group; the process restriction applies only to pipe welding qualifications

D. Yes, a new qualification is required because the base metal subclassification has changed — different subgrades within the same PNumber 1 group require separate qualification tests regardless of the process and position being the same

41. A fatigueloaded structural connection uses a cover plate lapped onto a beam flange with two parallel longitudinal fillet welds. The ends of the cover plate are transverse (perpendicular) to the primary applied stress direction. Under cyclic loading, where is the fatigue crack most likely to initiate?

A. At the weld midpoint on the compression side — fatigue cracks in lap joint fillet welds always initiate at the midlength on the compression side where the peel stress component is highest during reverse loading

B. At the weld toe at the transverse end of the cover plate — the geometric discontinuity where the cover plate terminates creates the highest stress concentration at the weld toe at the transverse end; the abrupt stiffness change at the plate termination produces a stress riser that is the most common fatigue crack initiation site for this connection type under cyclic loading

C. At the weld root on the underside of the cover plate — root cracks are preferred because the uninspected root location allows cracks to grow larger before detection; fatigue cracks statistically initiate at uninspected locations rather than at inspectable weld toe locations

D. At the arc start location on the tensile side — weld arc start locations have lower toughness than runout areas due to partial fusion during arc establishment, and the tensile side carries the highest stress range, making the start a location of heightened fatigue risk

42. A quality inspector measures a completed 12 mm leg fillet weld and finds a bead convexity of 6 mm — the weld face rises 6 mm above the theoretical flat face line. The applicable code is CSA W59 for statically loaded structures. What quality concern does this excessive convexity create, and what is the acceptance status?

A. Excessive convexity is not a quality concern for statically loaded structures — CSA W59 imposes no convexity limit for fillet welds on static connections, and any convex profile is acceptable because the additional metal provides more resistance to the applied shear force than the design minimum

B. The weld is acceptable and represents superior quality — high convexity means more weld metal than the minimum design requirement, providing additional shear capacity; the fillet weld is stronger than specified and no corrective action is warranted

C. The weld is acceptable because the total weld metal deposit exceeds the minimum requirement — convexity adds to the measured throat dimension, and welds with convex beads have effectively larger throats that exceed the design minimum

D. Excessive convexity is rejectable per CSA W59 — the steep weld toe angle from high convexity creates a stress concentration at the toe that reduces fatigue performance and creates a notch condition; maximum convexity is typically limited to 3 mm plus 10% of the weld face width; for a 12 mm leg fillet (face width ≈ 17 mm), the limit is approximately 3 + 1.7 = 4.7 mm, and the measured 6 mm convexity exceeds this limit and requires correction

43. During a SMAW welder qualification test, the inspector specifies two face bend and two root bend specimens from the test coupon. What is the correct description of the specific difference in purpose between face bend and root bend test specimens?

A. Face bend and root bend are performed on opposite ends of the same specimen — the face bend deforms the weld face side into compression and the root end into tension, providing both compression and tension data from each individual test piece

B. Face bend specimens are used exclusively for stainless steel coupons and root bend specimens only for carbon steel — the specimen type is dictated by base metal specification rather than the position in the weld crosssection

C. Face bend specimens are bent with the weld face in tension (on the outside of the bend), testing the quality of cap passes and the outer weld surface for fusion and defects; root bend specimens are bent with the weld root in tension, testing root pass penetration and fusion quality — both types are required to evaluate the complete weld crosssection from face to root

D. Face bend specimens evaluate the base metal heataffected zone only, while root bend specimens test the deposited weld metal at the joint center — separating these evaluations allows defects in each zone to be attributed to the correct metallurgical location

44. A pipefitter needs to cut a branch saddle opening in a 200 mm OD header pipe for a 100 mm OD branch pipe joining at 90 degrees. A template is created before cutting by projecting the intersection profile onto paper wrapped around the branch pipe. What geometric shape does this 90degree cylindertocylinder intersection produce on the branch pipe surface?

A. The intersection creates an apparent elliptical curve on the branch pipe surface — the intersection of the 100 mm branch cylinder with the curved 200 mm header surface produces a curve that appears elliptical when developed; the template development uses coordinate projection or wrapandmark methods to transfer this curve onto the branch pipe for cutting

B. The intersection creates a perfect true circle on the branch pipe — when any two cylinders of equal or different diameters intersect at exactly 90 degrees, the resulting branch cut line is always a mathematically true circle; this simplifies the template to a simple radius circle

C. The intersection creates a square outline on the branch pipe — the rightangle intersection of two cylindrical surfaces produces a square pattern when the branch surface is unrolled to a flat template; this is why pipefitters use squarecorner references to lay out saddle cuts

D. The intersection creates a straight line on the flat template — when the branch pipe surface is unrolled, the cylindertocylinder intersection at 90 degrees unfolds to a perfectly straight line that can be transferred directly without any curve plotting

45. A welder holds current CWB certification for SMAW (process 111) on carbon steel in 3G and 4G positions. The welder is now assigned to complete GMAW (process 131) welds on the same carbon steel and position. What qualification action is required?

A. No additional qualification is required — the welding process is not an essential variable under CWB standards, and certification in any process on a given material group and position automatically qualifies the welder for all other processes on the same material and position

B. A separate GMAW qualification test is required — welding process (SMAW versus GMAW) is an essential variable under CWB welder certification; qualification in one process does not extend to a different process even when the base metal group, position, and joint type are identical

C. The welder must first complete a twoday GMAW theoretical refresher course — CWB regulations require formal classroom training before a qualified SMAW welder can attempt a GMAW qualification test at any certification level

D. The SMAW certification automatically covers GMAW within the same base metal group — CWB material group certifications are processindependent for arc welding processes, and the carbon steel group certification provides unlimited process coverage for all arc welding processes on carbon steel base metal

46. A structural connection involves welding a steel angle clip to the web of a loaded wideflange beam using fillet welds all around. Under cyclic fatigue loading, which fatigue stress category and associated provisions should the engineer apply for this connection?

A. Category A (plain base metal) — the beam web is parent material and fatigue performance should be evaluated as unaffected base metal since the clip is a nonstructural attachment that does not alter the beam web fatigue category

B. Category B (base metal at weld toe) — fillet welded connections always improve fatigue performance by reducing stress concentration at the attachment, placing all welded clips and attachments in Category B, which represents the best available category for any welded structural connection

C. Category C (groove welds under tension) — groove welds in this configuration create residual tensile stresses that assign the connection to Category C regardless of whether the applied loading is tensile or compressive in direction

D. Category E or E' (attachments welded to base metal with fillet welds) — welded attachments are classified in the lower fatigue categories because the weld toe on the beam web creates a geometric stress concentration; the actual category depends on the attachment length parallel to the direction of applied stress, per AISC and CSA S16 fatigue provisions

47. An inspector reviewing a WPS before production welding finds that the document lists "E7018 per CSA W48" as the electrode but does not specify electrode diameter or amperage range for any pass type. Is this WPS complete for production use?

A. Yes, the WPS is complete — electrode diameter and amperage are welderselected variables that the certified welder chooses from experience; the WPS governs only essential variables affecting mechanical properties, not the operating parameters the welder adjusts for technique

B. Yes, the WPS is complete — electrode diameter is specified separately in the material procurement specification; the WPS is required to identify only the electrode classification and standard, not the specific diameter for each pass type

C. No, the WPS is incomplete — a complete WPS must include all essential and nonessential variables; welding parameters including electrode diameter range, amperage range, voltage range, and travel speed range must be specified for each pass type (root, fill, cap) to guide the welder during production and allow the inspector to verify compliance

D. No, the WPS is incomplete — a WPS without specified amperage ranges must be returned to the engineering department; amperage ranges cannot be added by the certified welding supervisor and must be established and approved by a licensed professional engineer

48. A structural designer specifies a connection where a plate is welded perpendicularly to the flange of a loaded wideflange beam using a fullpenetration weld. The applied load direction is parallel to the plate surface and perpendicular to the flange face. A stress analyst flags the connection for review. What specific structural concern justifies this flag?

A. The throughthickness stress from the perpendicular plate loading acts in the direction of the flange plate's rolling plane — structural steel flanges can exhibit reduced throughthickness ductility due to sulfide inclusion stringers aligned parallel to the plate surface; the throughthickness tensile stress from the perpendicular load can fracture these inclusion planes, producing lamellar tearing in the flange during or after welding

B. Fullpenetration welds in this orientation always fracture at the weld face because the filletgroove combination creates a metallurgical discontinuity weaker than either weld type alone in throughthickness loading

C. The perpendicular plate increases the applied load on the weld by a factor of π due to geometric amplification — perpendicular plate connections require a minimum connection length of 3× the flange width to reduce the amplification factor to an acceptable level

D. The perpendicular plate causes unbalanced angular distortion in the flange that reduces the beam's crosssectional moment of inertia by the amount of angular deformation — this reduction must be included in the beam capacity calculation for all perpendicular plate connections

49. An OFC operator explains to an apprentice the difference between a singlestage and a twostage oxygen regulator. Which statement accurately describes the operational difference between these two types?

A. A singlestage regulator automatically switches between two pressure settings, allowing the operator to select either a highpressure cutting oxygen or a lowpressure preheat flame setting from one control valve without separately adjusting cylinder pressure

B. A twostage regulator reduces cylinder pressure to delivery pressure in two steps — first to an intermediate pressure, then to the final delivery pressure; this produces a more stable, consistent delivery pressure as the cylinder pressure drops during extended use, making the twostage design preferred for precision cutting and longduration operations

C. A singlestage regulator provides two separate delivery pressure gauges — one for cutting oxygen and one for preheat oxygen — while a twostage regulator provides only a single delivery pressure for both circuits through an automatic splitting valve

D. A twostage regulator contains two completely separate gas chambers that allow two different gas mixtures to be used simultaneously from a single regulator body, while a singlestage regulator supplies only one gas composition per connected cylinder

50. A plasma arc cutting operator must choose between a shielded nozzle assembly and an unshielded nozzle for precision cuts on 10 mm stainless steel where the cut edges will be visible in the finished product. What is the primary operational difference that determines the correct selection?

A. Shielded nozzles are used exclusively for aluminum and copper cutting — the ceramic shield prevents arc conduction to the base metal at close standoff distances, which is essential for nonferrous materials that conduct electricity more readily than structural steel

B. Unshielded nozzles are used only for plate thicknesses above 25 mm — the absence of the ceramic shield allows the plasma column to extend further from the nozzle exit, which is necessary for the longer arc required to penetrate thick material sections

C. Shielded nozzles reduce standoff sensitivity and protect against doublearcing — shielded nozzles are preferred for precision applications where standoff distance must be closely controlled, while unshielded nozzles are used in applications requiring the closest possible torchtoplate distance for maximum energy density

D. The shielded nozzle uses compressed nitrogen as the secondary shield while the unshielded nozzle uses compressed air — the selection determines only which secondary gas supply is required and has no effect on cut quality, precision, or dimensional accuracy

51. An OFC operator experiences a loud squeal followed by the flame going out, then reestablishing inside the tip body with visible smoke. The operator shuts down immediately. What phenomenon occurred and what is the most likely cause?

A. This is a standard extinguishing event caused by accidentally releasing the cutting oxygen lever — the noise and smoke are normal byproducts of the flame selfextinguishing when the oxygen flow stops, and the operator may relight normally without further investigation

B. This is a backfire — the flame temporarily entered the tip opening due to insufficient gas flow, an overheated tip, or the tip being held too close to the work; after the tip cools, the operator may relight and reduce the work distance before continuing

C. This is a flashback — the flame burned back past the tip and into the torch body, producing the characteristic squeal and smoke; flashback is distinguished from a simple backfire by its travel into the torch body; the torch must be shut down immediately, disassembled, and the check valves and flashback arrestor inspected before the torch may be returned to service

D. This is a normal backpressure event during initial warmup — the squeal and smoke are caused by thread lubricants on the tip burning off during the first minutes of operation, and the operator may continue working once the noise stops

52. Which safety requirements specifically apply to CACA (Carbon Arc Air Cutting and Gouging) that differ from standard SMAW at comparable amperage?

A. CACA produces significantly higher levels of fume, noise above 100 dB requiring impulserated hearing protection, and intense UV radiation requiring a minimum shade 12 filter lens — the compressed air jet creates a highvelocity metal spray generating elevated fume concentrations, and the exposed carbon arc emits intense radiation that exceeds the intensity of a SMAW arc at equivalent amperage

B. CACA requires 100% argon shielding gas through a dedicated secondary nozzle — the compressed air jet provides metal ejection only while argon provides fume control; this argon shielding requirement distinguishes CACA from SMAW, which uses no external shielding gas supply

C. CACA requires a fullbody Tyvek coverall in addition to standard welding PPE — the compressed air jet disperses molten metal particles significantly farther than welding spatter, creating a contamination hazard requiring fulllength skin coverage

D. CACA requires a minimum 21% oxygen concentration in the work area and cannot be performed in any confined space — the process consumes oxygen from the atmosphere to sustain the carbon arc and causes oxygen depletion in confined spaces more rapidly than any other welding or cutting process

53. A welder asks why acetylene and propane fuel gas regulators cannot be interchanged even though they connect to similarly sized cylinders. Which explanation is correct?

A. Acetylene regulators are lubricated with petroleumbased oil that reacts with propane's hydrocarbon chemistry, while propane regulators use synthetic lubricants — lubricant incompatibility is the primary reason the two regulator types cannot be safely interchanged

B. Acetylene regulators are limited to a maximum delivery pressure of approximately 103 kPa because acetylene becomes dangerously unstable and potentially explosive at pressures above this limit — propane regulators are designed for much higher delivery pressures; using an acetylene regulator for propane creates risk if propane is delivered above the acetylene's safe pressure ceiling; and the connection thread standards differ between the two gases to prevent accidental interchange

C. Propane is heavier than acetylene and pools at the bottom of the regulator body — acetylene regulators are designed for vertical mounting with the pressure chamber at the top, while propane regulators require horizontal orientation; using an acetylene regulator for propane causes propane pooling in the gauge port that damages the pressure diaphragm

D. The only difference between acetylene and propane regulators is the thread direction on the cylinder connection — lefthand threads for acetylene and righthand threads for propane; the internal components are identical, and a wrench adapter allowing thread interchange permits safe use of either regulator for either gas

54. A fabricator is programming a CNC plasma cutting machine for the first time to produce parts from 16 mm structural steel plate. Before running the first part, which set of parameters must the operator enter to produce acceptable cut quality?

A. Only the plate dimensions (length and width) and starting point need to be entered — the CNC machine automatically calculates all cutting parameters from the plate dimensions and the profile shape in the imported DXF file

B. Only amperage and travel speed are required — all other parameters including gas pressures, standoff height, and kerf compensation are factoryprogrammed settings that apply to all materials and thicknesses and cannot be adjusted by the operator

C. The operator enters only material type and plate thickness — the CNC controller selects all plasma parameters from its internal database based on these two inputs and dynamically adjusts them throughout the cut

D. The operator must enter the material type, plate thickness, plasma and shielding gas types and pressures, amperage, standoff height, cutting speed, kerf width offset for dimensional accuracy, and piercing parameters including pierce height and pierce delay time — these parameters collectively determine cut quality, dimensional accuracy, and consumable service life

55. An OFC operator inspects the underside of a completed cut on 25 mm structural steel plate and finds firmly attached dross that forms a continuous bead along the full cut length with a glossy spherical outer surface. Which parameter adjustment most likely corrects this dross condition?

A. Reduce the cutting oxygen pressure — the firm spherical dross indicates excessive oxygen pressure is pushing molten oxidized material back against the plate bottom where it solidifies before it can fall clear of the kerf

B. Increase the preheat flame size — the spherical hard dross indicates the preheat flame is insufficient to maintain the kerf bottom at temperature; the dross solidifies before it can be ejected because the kerf tip cools too rapidly without adequate preheat

C. Increase the travel speed — the continuous bead of firmly attached spherical dross along the full cut length is characteristic of insufficient travel speed; the torch is moving too slowly, overoxidizing material at the kerf bottom and depositing excess iron oxide that solidifies before expulsion; increasing travel speed allows cleaner ejection of the cutting reaction products

D. Increase the cutting tip size by two sizes — hard spherical dross on the lower edge is caused by insufficient cutting oxygen volume from an undersized tip; the larger tip delivers more oxygen flow to maintain the reaction front through the full plate thickness and expel molten material cleanly

56. An OFC operator needs to clean a blocked preheat orifice on the cutting tip while the torch remains connected to the hose assembly. What is the correct procedure before using the tip cleaner?

A. Close only the oxygen torch needle valve before cleaning — the oxygen circuit feeds the preheat orifice that is blocked, and closing only the oxygen valve is sufficient to allow safe cleaning while fuel gas pressure remains in the hose

B. Close both torch needle valves, close both cylinder valves, then bleed the pressure from both hoses by briefly opening each needle valve directed away from the torch tip — only after both hose circuits are fully depressurized is it safe to work on the tip; residual hose pressure can cause gas injection or ignition during tip maintenance

C. Extinguish the torch flame and allow the tip to cool for 30 seconds — the cooling period lowers the tip temperature below fuel gas ignition point, making it safe to use the tip cleaner without any further depressurization steps

D. Close only the cylinder valves and leave the hose pressure intact — cylinder valves prevent additional gas from entering the hose, and the retained hose pressure provides positive pressure that prevents air from entering the tip end during the cleaning procedure

57. A welder must remove a defective section of a completed butt weld to allow rewelding. CACA gouging and disc grinding are both available. Which statement most accurately compares the two methods for this repair excavation?

A. CACA is faster and more efficient for removing larger volumes of weld metal in confined joint geometries — however, the carbon electrode deposits a carburized layer on the groove surface that must be ground back before rewelding on carbonsensitive materials such as austenitic stainless steel, lowalloy chromemoly steel, and any material where carbon pickup would compromise the weld deposit quality; grinding alone avoids carbon contamination but is slower for largevolume removal

B. Grinding is always preferred over CACA for repair excavations on all materials — grinding produces a HAZfree surface consistently superior for rewelding, while CACA introduces so much heat that it effectively heattreats the surrounding base metal and requires postexcavation PWHT before any rewelding

C. CACA and grinding produce identical surface conditions after excavation — no difference in surface chemistry, microstructure, or preparation quality exists between the two methods when standard technique is applied, and selection is based purely on equipment availability

D. CACA cannot be used for weld repair excavations on any carbon steel — the carbon arc permanently alters the base metal composition throughout the full excavation depth in a way that cannot be corrected by surface grinding, making CACA categorically prohibited for carbon steel repair work

58. A CNC PAC operator is producing intricate architectural components from 6 mm stainless steel plate where cut edges will be visible in the finished product and must be smooth, square, and drossfree. Which set of parameters most significantly affects the edge quality on this thin material?

A. Only the shielding gas type affects edge quality on thin stainless — nitrogen shielding is required for clean edges; all other parameters (amperage, speed, standoff) have no significant effect compared to the shielding gas selection

B. Only the amperage setting affects edge quality — higher amperage always produces cleaner cuts regardless of material thickness because the higherenergy arc melts material more completely and uniformly

C. Only travel speed affects edge quality on thin plate — slower travel speed produces the cleanest edges because the greater heat input at lower speed melts more material cleanly before it resolidifies in the kerf

D. The combination of amperage, travel speed, standoff height, and gas type and pressure all significantly affect cut edge quality — an optimized combination for the specific plate thickness, material, and plasma system produces minimal dross, good squareness, and smooth surface finish; any parameter outside its optimal range degrades cut quality even when all others are correctly set

59. An OFC operator notices that preheat flames from the multiorifice cutting tip are not their normal rounded conical shape — they appear elongated, asymmetric, and slightly offset from the cutting oxygen stream centerline, with individual flames not parallel to each other. What condition does this flame pattern indicate?

A. This asymmetric flame pattern is normal during the initial 5minute warmup period — uneven heating of the tip body causes the asymmetry, and the flames selfcorrect once the tip body reaches uniform operating temperature throughout

B. This pattern indicates the tip was installed crossthreaded in the torch body — the offset and nonparallel flames indicate incorrect seating, and the tip must be removed, cleaned, and properly reinstalled before cutting can proceed

C. This flame pattern indicates the cutting tip is physically damaged — damage to the preheat orifices from contact with the workpiece, rough handling, or use of an oversized tip cleaner produces distorted flame shapes; a damaged tip must be replaced because the distorted flames reduce cut quality and can cause the cutting reaction to fail partway through the plate

D. This flame pattern indicates the oxygentofuel ratio requires adjustment — asymmetric flames are always caused by an imbalanced gas mixture and can be corrected by adjusting the oxygen regulator pressure alone while the fuel gas pressure remains unchanged

60. A fabricator must OFCcut a piece of 1045 medium carbon steel (0.45% C) to length. Unlike lowcarbon structural steel, medium carbon steel requires a modified approach. What specific condition distinguishes cutting this material, and what accommodation is required?

A. Medium carbon steel produces significantly more cutting oxygen consumption than mild steel at the same thickness — the higher carbon content requires a cutting tip two sizes larger to provide the additional oxygen volume needed to sustain the cutting reaction through the highercarbon matrix

B. The HAZ of medium carbon steel airhardens rapidly during OFC cutting — the higher carbon content (0.45% C) elevates the carbon equivalent above the threshold for significant airhardening during the rapid HAZ cooling that follows OFC; preheating the plate to 150–200°C before cutting slows the HAZ cooling rate and reduces the risk of cracking in the cut edge during and after the thermal cutting operation

C. Medium carbon steel cannot be OFCcut under any conditions — the higher carbon content inhibits the iron oxidation reaction by forming carbon monoxide that neutralizes the cutting oxygen stream, preventing propagation of the cutting reaction through any steel above 0.30% carbon content

D. Medium carbon steel requires specialty iron powder flux injected through the cutting tip during the operation — the iron powder provides additional exothermic energy to compensate for reduced cutting efficiency caused by higher carbon at the kerf front interfering with the standard iron oxidation mechanism

61. A PAC operator notices that when increasing the standoff height while keeping all other parameters constant, the cut transitions from fully throughcut to only partial penetration. Returning to the specified standoff restores complete cutting. What does this voltagepenetration relationship demonstrate about PAC operation?

A. Arc voltage in PAC is directly related to standoff distance — as standoff increases, the arc length increases and requires higher voltage to sustain the same arc current; the longer arc dissipates energy before reaching the plate and reduces effective energy density at the kerf, limiting penetration; for any given amperage and gas combination, a maximum standoff distance exists beyond which the plasma cannot fully penetrate the plate

B. Arc voltage is inversely related to standoff in PAC — decreasing standoff increases arc resistance and requires higher voltage through the shorter path; partial penetration at excessive voltage indicates the power source has entered its currentlimiting protection mode

C. The voltagestandoff relationship is irrelevant to cutting penetration — penetration depth is governed entirely by the amperage setting, and any observed penetration changes with standoff adjustment are coincidental calibration artifacts

D. Voltage increases from excessive standoff indicate a plasma gas pressure problem — the penetration loss is caused by gas pressure dropping below the minimum required to sustain the plasma column at the increased arc length, not by any change in the arc voltage itself

62. An OFC operator must cut a 30degree bevel preparation on the edge of 25 mm structural steel plate with the torch tilted at 30 degrees from vertical. What additional adjustment to normal cutting parameters is required for bevel cutting compared to vertical squareedge cutting?

A. No parameter adjustments are needed — the 30degree tilt has no effect on gas flows, pressures, or travel speed required to produce a clean cut; only the torch angle needs to change from the normal vertical position

B. The cutting oxygen pressure must be reduced by 30% when the torch is tilted — the 30degree tilt reduces the effective oxygen delivery rate by the cosine of the tilt angle, requiring an upward pressure adjustment to compensate for the reduced flow to the kerf

C. The preheat flame size must be significantly increased for bevel cutting — the angled approach requires a much larger preheat to heat the additional plate surface that the angled torch traverses before the cutting reaction can be sustained through the full plate depth

D. The travel speed must typically be reduced compared to vertical squareedge cutting at the same thickness — the angled torch traverses a longer cutting path through the plate than the nominal plate thickness (actual path = plate thickness divided by cos(30°)), requiring slower travel to maintain the cutting reaction through the full material depth

63. A CACA operator is selecting electrodes for gouging austenitic stainless steel. Three types are available: plain carbon, coppercoated carbon, and graphite. Which type is most appropriate, and what additional step is always required after CACA gouging on stainless steel regardless of electrode type?

A. Plain carbon electrodes are best for stainless steel — uncoated carbon deposits the minimum amount of surface contamination compared to coated or graphite types, reducing the grinding depth needed before repair welding

B. Graphite electrodes are required for all stainless steel — graphite's lower chemical reactivity prevents the chromiumcarbon reactions that reduce the stainless steel's chromium content below the minimum needed for corrosion resistance

C. Coppercoated carbon electrodes are the standard choice for most CACA applications including stainless steel — the copper coating improves currentcarrying capacity and arc stability; however, regardless of electrode type, all CACA grooves on stainless steel require subsequent mechanical grinding to remove the carburized surface layer before repair welding proceeds

D. All three electrode types produce identical results on stainless steel — electrode coating type is irrelevant to carbon deposition behavior in CACA; selection should be based only on available power source current capacity relative to the electrode diameter required for the groove dimensions

64. An OFC operator assigned to cut 75 mm thick structural steel plate applies the same travel speed used for 25 mm plate. The result is heavy hardtoremove dross on the underside and severely sweptback drag lines throughout the cut length. What adjustments are required to produce acceptable cut quality?

A. Increase the preheat flame size only — thick plate requires a larger preheat flame to supply adequate heat to the full depth of the kerf bottom; increasing preheat while maintaining the same travel speed is the primary correction for heavy dross and severe drag on thick plate

B. Reduce the travel speed and use the cutting oxygen pressure and tip size specified for 75 mm plate — the travel speed appropriate for 25 mm plate is too fast for 75 mm; at the higher speed the cutting reaction cannot complete through the full plate depth, producing the rearward drag; the correct tip and oxygen pressure for 75 mm ensure adequate cutting oxygen to sustain the reaction through the greater depth

C. Increase the travel speed only — severely backward drag lines indicate the cut front is lagging behind the torch position due to insufficient cutting velocity; increasing travel speed pushes the reaction front forward and straightens the drag lines

D. Change to a tip three sizes larger than the current tip and maintain the same travel speed — the only adjustment needed for thick plate cutting is the tip size; travel speed for a given plate thickness is fixed and must not be adjusted when changing between tip sizes on different material thicknesses

65. During mechanized PAC production, the operator notices that kerf width varies from 3 mm to 6 mm on different sections of the same cut line, despite constant programmed parameters. Cut quality is otherwise acceptable at the narrower width. What component failure is most likely causing this kerf width variation?

A. Inconsistent standoff height from a malfunctioning torch height control (THC) system — the THC uses arc voltage feedback to maintain constant standoff; when the THC malfunctions or the feedback signal is noisy, the torch height fluctuates; at greater standoff the plasma jet diverges and produces wider kerfs, while correct standoff produces the specified narrow kerf width

B. Inconsistent shielding gas pressure from a failing pressure regulator — shielding gas pressure variation changes the gas temperature in the plasma column, alternately contracting and expanding the plasma jet and directly causing the kerf width variation independent of standoff changes

C. Inconsistent CNC servo motor travel speed — variations in servo motor performance cause the cutting head to travel faster or slower than programmed, producing wider kerfs at slower speed and narrower kerfs at the programmed speed

D. Variable base metal composition along the cut line — kerf width variation within a single cut in structural steel always indicates a mixedheat plate with variable carbon content; the carbon variation affects the oxidation rate and therefore the reactionzone width and kerf width

66. An OFC operator must use propane rather than acetylene for a large plate cutting job. The preheat neutral flame adjustment procedure must be modified from the acetylene technique. What specific difference applies when setting a neutral flame with propane versus acetylene?

A. Propane requires a higher oxygentofuel ratio for a neutral flame — propane burns neutral at 2.5:1 while acetylene burns neutral at 1:1; the oxygen regulator must be set correspondingly higher when using propane to achieve the neutral flame appearance

B. Propane requires a lower oxygentofuel ratio than acetylene for a neutral flame — the 1:1 ratio for propane produces the neutral condition while acetylene requires approximately 1.5:1; the oxygen regulator must be set lower for propane

C. Propane and acetylene require identical oxygentofuel ratios — both gases produce a neutral flame at 1:1 volumetric ratio, and the same adjustment procedure applies when switching fuels with no modification required

D. Propane requires a substantially higher oxygentofuel volumetric ratio than acetylene — complete combustion of propane (C_3H_8) to CO_2 and H_2O requires approximately 3.5–4 volumes of oxygen per volume of propane, compared to approximately 1–1.5 volumes for acetylene; the neutral flame for propane requires the oxygen regulator to be set at a proportionally higher pressure relative to the fuel pressure than when using acetylene

67. An apprentice sets up a CACA operation and connects the electrode holder to the negative terminal of the DC power source (DCEN setup). The supervisor corrects this to DCEP. What performance difference does the polarity change create?

A. DCEN is the correct setup for CACA — DCEN concentrates more arc energy at the electrode (cathode), sustaining the carbon arc at lower current settings and producing shallower, wider grooves; DCEP is used only for weld metal deposition applications, not for gouging operations

B. DCEP is required for CACA — on DCEP the electrode is the anode, concentrating approximately twothirds of the arc energy at the electrode tip where it is needed to maintain the high temperature required for the carbon arc to operate effectively; DCEN produces a less stable arc with lower operating temperature, resulting in poor groove quality, excessive electrode consumption, and carbon deposits on the groove surface

C. Either DCEP or DCEN can be used for CACA — the polarity selection affects only the distribution of arc heat between the electrode and the work surface; DCEN is preferred for shallow grooves and DCEP for deep grooves; the apprentice's DCEN connection was not wrong

D. DCEN is mandatory for CACA on aluminum while DCEP is required on carbon and alloy steel — the polarity selection in CACA is basemetaldependent, and the apprentice's connection was correct only if the application involved aluminum rather than steel

68. An OFC operator is asked to cut structural steel supports on a construction site in light rain with some surface moisture on the steel. What specific safety concern must the operator address before beginning the OFC work?

A. Wet conditions prevent the OFC cutting reaction from initiating — moisture on the steel surface extinguishes the preheat flame before the steel can reach ignition temperature, making OFC impossible in any rain or wet conditions regardless of flame adjustment

B. Wet acetylene cylinders must be returned to the supplier — moisture penetrating the cylinder top contaminates the acetone carrier and affects regulator performance, requiring cylinder replacement before cutting can proceed in any wet conditions

C. The operator must protect the OFC equipment connections from moisture accumulation, assess the risk of steam generation if large water accumulations are rapidly heated by the preheat flame, confirm that wet working surfaces do not create fall hazards, and verify that all PPE is appropriate for working in wet conditions — these conditions collectively represent elevated risk compared to drycondition OFC

D. Water on structural steel improves OFC cut quality by quenching the cut edge — rapid cooling produces a harder, cleaner cut edge and suppresses scale formation on the cut face; wetsurface OFC is specifically recommended for highquality structural steel cutting when available

69. A PAC operator finds a mixed bin of electrodes, nozzles, and shield cups from different plasma cutting systems. How should the operator determine which consumables belong to which system?

A. Plasma consumables must be matched by manufacturer part number to the specific power source model and amperage range — mixing consumables from different systems can result in doublearcing, rapid wear, incorrect arc characteristics, and fire hazards even when consumables physically fit; part number, amperage rating, and material type are marked or etched into each consumable

B. Any consumable that physically fits into the torch body is compatible — the fit dimension is the universal standard ensuring electrical and gas compatibility between all major plasma system components regardless of brand or amperage rating

C. International color coding identifies all plasma consumables — manufacturers follow the ISO system where red = electrode, blue = nozzle, and yellow = shield regardless of brand; checking the color alone identifies the correct component without needing part numbers

D. Trialfitting and testfiring determines compatibility — if the arc strikes successfully in transferred mode, the consumable is compatible; if the consumable glows red within the first 5 seconds of operation, it belongs to a different system

70. An OFC operator is cutting at a highaltitude construction site at 2,000 metres elevation where atmospheric pressure is approximately 80 kPa compared to 101 kPa at sea level. How does the reduced atmospheric pressure affect the OFC process, and what adjustment may be needed?

A. No adjustment is required — OFC cutting reactions occur at pressures far above atmospheric inside the kerf, and the small atmospheric pressure difference at 2,000 metres has no measurable effect on the cutting process, flame characteristics, or resulting cut quality

B. The cutting oxygen pressure must be increased by 20% at 2,000 metres — the reduced atmospheric back pressure on the cutting oxygen stream reduces effective oxygen pressure at the kerf, requiring a compensating upward pressure adjustment at the regulator

C. OFC must switch to electric cutting methods at high altitude — the reduced atmospheric pressure expands oxygen molecules below the minimum concentration required to sustain the exothermic iron oxidation reaction, making OFC thermodynamically impossible above 1,500 metres elevation

D. At reduced atmospheric pressure, the fuel gastoair combustion ratio in the preheat flame is affected — the lower ambient pressure produces a richer (more fuelheavy) burning condition; a preheat flame set to neutral at sea level may appear slightly carburizing at reduced pressure, requiring slight upward adjustment of the oxygen regulator to restore the neutral balance at altitude

71. A CACA operator discovers the shop air supply can only deliver 415 kPa (60 psi) rather than the recommended 550–690 kPa (80–100 psi). The operator proceeds with the work. What quality and safety issues arise from operating at belowrecommended air pressure?

A. Belowrecommended air pressure has no effect on CACA quality — compressed air in CACA serves only as a cooling medium to prevent base metal overheating; air pressure does not affect arc characteristics, groove depth, or surface carbon deposition

B. Insufficient air pressure reduces the rate of molten metal expulsion from the groove — instead of being blown clear, some molten metal remains in the arc zone causing arc instability, irregular groove profiles, and carbon deposits embedded in the groove walls as partially solidified metal is repeatedly remelted; the reduced expulsion rate also allows molten metal to fall back onto the electrode holder and ground cable, creating a fire hazard

C. Belowrecommended air pressure immediately extinguishes the CACA arc — compressed air directly cools the carbon arc electrode tip, and insufficient air fails to maintain the electrode above the minimum temperature for arc stability, causing the arc to extinguish within the first few seconds of operation

D. Belowrecommended air pressure increases groove depth beyond specification — the reduced air expulsion velocity allows the molten pool to sink deeper under gravity before expulsion, producing grooves significantly deeper than the electrode diameter guideline predicts

72. An SMAW electrode is classified as E8018C2. What does the "C2" suffix designation indicate about the alloy content and intended application of this electrode?

A. The C2 suffix designates a 2% chromium and 0.5% molybdenum deposit used for PNumber 4 (1.25Cr0.5Mo) pressure piping applications as the CSA classification for chromemoly alloy electrodes

B. The C2 suffix designates a Category 2 holding oven requirement — the category number after C identifies the storage temperature classification under CSA W48 for hydrogencontrolled lowalloy electrodes

C. The C2 suffix designates a deposit containing approximately 3.25% nickel — under AWS A5.5, the Cseries suffixes classify nickelalloy lowhydrogen electrodes for lowtemperature service; C1 ≈ 2.5% Ni, C2 ≈ 3.25% Ni, C3 ≈ 1% Ni; the nickel additions provide improved Charpy Vnotch toughness at subzero service temperatures

D. The C2 suffix designates a cellulosic coating (C) with hydrogen content class 2, where class 2 corresponds to a maximum diffusible hydrogen of 16 mL per 100 g of deposited weld metal under the CSA W48 classification system

73. A SMAW operator using E7018 electrodes experiences persistent difficulty establishing a stable arc when starting new electrodes, particularly in cold ambient conditions. The power source display shows

an opencircuit voltage of 55 V. What specific concern does this OCV level create for E7018 arc starting?

A. E7018 basiccoated electrodes require higher OCV than rutilecoated electrodes such as E6013 to establish a stable arc — the basic coating has lower ionization efficiency than rutile, and OCV in the range of 65–90 V is typically required for reliable E7018 arc starting; a 55 V OCV is often inadequate for consistent arc initiation, particularly in cold conditions that further reduce ionization efficiency

B. A 55 V OCV is excessive for E7018 electrodes and represents a shock hazard — SMAW safety standards limit OCV to a maximum of 45 V for all lowhydrogen electrode applications in industrial environments

C. A 55 V OCV is the precisely correct value for E7018 — this electrode classification requires exactly 55 V OCV for optimal arc starting and stable deposition; any deviation above or below requires power source recalibration

D. OCV has no effect on arc starting difficulty — persistent arc starting problems with E7018 in cold conditions are caused exclusively by moisture absorption in the basic coating, and the OCV value is irrelevant to the arc initiation process

74. A welder attempts to use E6010 electrodes on an AC power source and finds the arc is extremely unstable, sputtering, and extinguishing every few seconds. The welder asks the supervisor why E6010 does not work on AC. Which explanation is correct?

A. E6010 is designed for DC only because the cellulosic coating chemistry reacts with the current reversal in AC to produce carbon monoxide that extinguishes the arc — this chemical reaction is prevented by using DC, where electrode polarity remains constant throughout welding

B. AC power sources operate at too low a frequency for E6010 — the cellulosic coating requires at least 400 Hz to maintain arc stability, which is only available on specialized highfrequency power sources, not standard 60 Hz shop equipment

C. E6010 fails on AC because the cellulosic flux requires a minimum OCV of 125 V for reliable arc starting — standard AC SMAW power sources are limited to 80 V OCV maximum, preventing arc initiation with the cellulosic coating regardless of amperage

D. On 60 Hz AC, the arc extinguishes and must reignite 120 times per second at each zero crossing — cellulosic E6010 coating does not contain the potassium ionizing compounds found in rutile coatings (such as E6011) that maintain ionization across the zero crossing and allow reliable reignition; the arc extinguishes and fails to reestablish after each zero crossing with the cellulosic coating

75. A radiographic interpreter finds distributed porosity — multiple small rounded voids spread uniformly through all passes including root, fill, and cap — in a multipass SMAW butt weld. The porosity is not concentrated at any specific location. What is the most likely cause of this distributed porosity pattern?

A. Surface contamination at the root of the joint — oil or moisture at the root face creates gas that distributes through all passes because the root contamination source continuously generates gas throughout all subsequent deposited passes

B. Compromised shielding from the electrode coating — moistureabsorbed E7018 basic coating or cracked coating affects every pass because the shielding deficiency is consistently present across all arcon periods; the gas source is the electrode itself, not the base metal or any positionspecific factor, producing porosity uniformly through all pass levels

C. Incorrect polarity — wrong polarity creates porosity only in the root pass; fill and cap passes are unaffected by polarity errors, so porosity affecting all pass levels cannot be caused by polarity

D. Groove sidewall contaminants — porosity from paint or mill scale on groove sidewalls appears only in the first fill passes after the root because the root pass establishes a clean base; subsequent passes on clean, previously melted sidewalls do not encounter contaminants

76. A structural welder must deposit a fillet weld joining a 12 mm thick gusset plate to a 50 mm thick main structural plate, both Grade 350W. The preheat chart requires 100°C minimum preheat for Grade 350W at 50 mm thickness. Does the 100°C preheat apply to both plates, only the thick plate, or differently to each?

A. Preheat is required only on the 50 mm thick plate — the 12 mm gusset is thin enough that its temperature is controlled by conduction from the thick plate, and applying preheat specifically to the thin plate is unnecessary and potentially causes overheating of the thinner member

B. Different preheats apply to each member simultaneously — welding codes specify different preheat temperatures for each member of a dissimilarthickness joint, with the thicker member requiring the higher temperature and the thinner member requiring the lower temperature for its own thickness

C. The thinner plate governs the preheat — preheat for dissimilarthickness joints is always selected from the thinner member's requirement, since the thinner member controls the cooling rate of the joint as it has less thermal mass to affect the HAZ thermal cycle

D. The preheat for the joint as a whole is governed by the member with the more demanding preheat requirement — the 100°C preheat applies to both plates as the joint must reach 100°C throughout; the thicker member's cooling behavior dominates the HAZ thermal cycle, and preheating only one member of a welded joint is impractical and ineffective

77. A quality inspector measures a completed SMAW butt joint groove weld and finds the cap reinforcement is 5 mm above the parent plate surface. The plate thickness is 12 mm and the applicable code is CSA W59. What is the acceptance status, and what concern does excessive reinforcement create?

A. The 5 mm reinforcement is excessive and rejectable — CSA W59 limits groove weld cap reinforcement to prevent stress concentration at the weld toe where a sharply rising reinforcement meets the flat plate surface; under transverse loading, excessive reinforcement creates a notch effect at the toe; the typical maximum is 3 mm (1/8 inch) for plate welds, making this 5 mm condition noncompliant and requiring grinding to reduce the reinforcement to within specification

B. The 5 mm reinforcement is acceptable — no maximum reinforcement limit exists in CSA W59 because higher reinforcement represents more deposited weld metal and a proportionally stronger joint; inspectors should flag only welds with insufficient or negative reinforcement

C. The 5 mm reinforcement is acceptable for statically loaded structures — cyclic loading requirements limit reinforcement to 2 mm, but static loading permits unlimited cap reinforcement provided the weld toes blend smoothly into the plate surface

D. The 5 mm reinforcement requires engineering review — the height falls within the discretionary zone between 3 mm and 6 mm where the structural engineer must evaluate the applied stress direction; automatic rejection applies only to reinforcement exceeding 6 mm under CSA W59 provisions

78. A pressure vessel fabricator must weld P22 base material (2.25Cr1Mo alloy steel) using SMAW. Which electrode classification provides the deposit composition specifically matched to P22 base metal chemistry?

A. E8018B2 — the B2 designation produces a 1.25Cr0.5Mo deposit, which is the closest available match to P22 composition among SMAW electrode classifications in common use for this application

B. E9018B3L — the B3L designation produces a lowcarbon 2.25Cr1Mo deposit; the L suffix indicates reduced carbon for improved HAZ toughness after PWHT, making this the preferred choice for all P22 welding applications

C. E9018B3 — the B3 designation specifically identifies SMAW electrodes whose deposit chemistry matches P22 (2.25Cr1Mo) alloy steel; this electrode provides the correct alloy content for both ambient and elevatedtemperature strength matching and is the standard classification for P22 SMAW welding procedures

D. E7018A1 — the A1 designation indicates a 0.5% molybdenum deposit that provides adequate creep resistance for P22 applications at service temperatures below 450°C; the lower strength level of the E7018 base is compensated by the joint efficiency factor in the design allowable stress calculation

79. A welding engineer specifies E8018G from AWS A5.5 rather than a standard AWS A5.1 carbon steel electrode for a highstrength structural connection. What does the AWS A5.5 classification signify and what distinguishes it from A5.1?

A. AWS A5.5 covers electrodes certified for all welding positions — the 5.5 suffix indicates the electrode has been tested for all positions including overhead; A5.1 carbon steel electrodes are limited to flat and horizontal positions only

B. AWS A5.5 covers lowalloy steel SMAW electrodes containing deliberate alloying additions — elements such as Cr, Mo, Ni, V, and elevated Mn provide enhanced properties including higher tensile strength, improved toughness, and better elevatedtemperature performance not achievable with A5.1 carbon steel electrodes; E8018G from A5.5 provides 80 ksi minimum tensile strength with a flexible G alloy designation covering various alloying approaches to meeting the mechanical requirements

C. AWS A5.5 covers electrodes specifically designed for welding galvanized steel — the 5.5 designation identifies a coating chemistry that neutralizes zinc vapor during welding on galvanized surfaces, distinguishing these from A5.1 standard carbon steel electrodes

D. AWS A5.5 covers largediameter electrodes 7 mm and above — the standard was developed for heavysection structural welding requiring electrode diameters above those covered by A5.1; the G suffix indicates the gauge (diameter) classification rather than an alloy content designation

80. A welding engineer is implementing a hydrogen control program for SMAW welding of 690 MPa highstrength steel. Which combination of practices provides the most comprehensive hydrogen control?

A. Using E8018H4 electrodes stored in a holding oven at 120°C is sufficient — the H4 designation guarantees less than 4 mL diffusible hydrogen per 100 g of deposit from any electrode maintained at holding oven temperature; no additional measures are required when the correct electrode is properly stored

B. Preheat alone is sufficient — applying the appropriate preheat derived from the material CE and section thickness provides all the hydrogen control needed for 690 MPa steel; electrode storage practices are a secondary concern when preheat is correctly applied

C. Torch predrying the base metal immediately before welding is the primary hydrogen control measure — torch drying removes all moisture from the joint surface, which is the main hydrogen source in all SMAW applications on highstrength steel

D. Maximum hydrogen control requires all of the following combined: H4 or H2 classified electrodes stored in a holding oven at 120–150°C until immediately before use, minimum preheat per CE and section thickness, maintained minimum interpass temperature, joint surfaces cleaned of all moisture and hydrocarbon contamination, and a postweld hydrogen release soak if required — each measure addresses a different potential hydrogen source and all are necessary for reliable cold cracking prevention on highstrength steel

81. A welder must perform SMAW field welding over a primercoated structural steel surface where complete primer removal before welding is not practical. Which primer type is most compatible with SMAW field welding and produces the least weld quality compromise?

A. Zincrich primer applied within the thickness limits specified in the applicable welding code (typically 25–75 microns maximum) is more tolerable in SMAW field welding than other primer types — some codes permit welding over zincrich primer within specified thickness limits because the zinc deposits preferentially to the slag rather than causing severe porosity; weld quality is still lower than on bare steel, and the specified maximum coating thickness must be confirmed

B. Oilbased alkyd primer is the most weldcompatible — alkyd paints burn completely in the arc heat and leave no residue in the weld deposit; the hydrocarbon combustion products are fully expelled through the flux sheath before the weld solidifies

C. Epoxy primers are the most weldcompatible — epoxy forms a protective ceramic oxide when exposed to arc heat, adding to the flux slag and improving slag fluidity and completed weld surface appearance

D. All primer types produce equal weld quality degradation — only the primer coating thickness affects porosity and mechanical properties; primer chemistry does not influence weld quality because all organic materials decompose completely at welding temperatures

82. An SMAW welder switches from DCEP to DCEN while using E7018 electrodes in an attempt to reduce penetration on a thin material application. What bead geometry change results, and why is this approach problematic?

A. DCEN with E7018 increases penetration compared to DCEP — the polarity reversal concentrates more arc energy at the base metal (anode on DCEN), forcing more heat into the parent material and deepening the penetration profile

B. DCEN with E7018 produces a wider flatter bead with less penetration — the reduced base metal heating on DCEN distributes heat more broadly; however, this is acceptable because E7018 can be used on either polarity and produces lower hydrogen on DCEN

C. Switching E7018 to DCEN does reduce penetration but creates a serious quality problem — E7018 is classified and tested only for DCEP; operating on DCEN produces an unstable arc, excessive spatter, poor bead appearance, and potentially elevated diffusible hydrogen compared to DCEP; using E7018 on DCEN is a deviation from the WPS essential variable for polarity and is not an acceptable field adjustment regardless of whether reduced penetration is the goal

D. The polarity change has no effect on E7018 bead geometry — E7018 produces identical penetration profiles on both DCEP and DCEN, and the polarity variable in the WPS addresses only arc initiation quality, not the resulting weld bead geometry

83. A structural welder is completing horizontal (2F) fillet welds on a Tjoint using E7018 electrodes. Visual inspection of a completed pass shows adequate fusion along the base plate but a cold lap condition on the vertical web plate — the bead appears to sit on the vertical surface without true fusion. What technique adjustment directly corrects this cold lap at the vertical plate?

A. Increase travel speed — faster travel speed concentrates heat at each location for less time, raising the peak surface temperature at the vertical web and improving fusion at the web toe

B. Direct the electrode working angle more toward the vertical plate — adjusting the working angle so the arc force is directed more toward the vertical web surface deposits more arc energy at the web fusion line; with the electrode aimed at the root of the joint and sufficient arc force directed toward the vertical plate, proper fusion at the vertical toe is achieved

C. Reduce the amperage — lower amperage produces a smaller weld pool that is less likely to overrun the vertical plate toe, improving the chance of proper contact and fusion before the pool solidifies

D. Switch to a larger electrode diameter — a larger electrode produces greater arc force that automatically redistributes heat uniformly across both the horizontal and vertical members, eliminating the directional bias responsible for the cold lap on the vertical plate

84. A welder is completing fill passes in a singleV groove on 50 mm thick plate where the current groove width at the working level is 16 mm. The procedure specifies E7018 electrodes. What maximum electrode diameter is practical for this groove width?

A. 6.4 mm maximum — the electrode, coating, and clearance requirements mandate a groove opening at least 2.5× the electrode core diameter; 16 mm ÷ 2.5 = 6.4 mm maximum electrode for this groove geometry

B. 4.8 mm maximum — grooves wider than 15 mm allow 4.8 mm electrodes with adequate clearance; grooves below 15 mm require reducing to 3.2 mm regardless of the specified electrode classification

C. No limitation — electrode diameter has no relationship to groove width; any electrode diameter may be used in any groove provided the welder can maintain the electrode angle to achieve the required fusion and penetration

D. A practical guideline is that the electrode overall diameter including coating should not exceed approximately onehalf the groove width to allow adequate manipulation, arc visibility, and prevention of coatingtosidewall contact; for a 16 mm groove and E7018 electrodes whose coating adds approximately 2–3 mm to each side, a 4.0 mm core electrode (overall diameter approximately 6–7 mm) is the largest practical diameter that allows confident operation without coating contact on the groove sidewalls

85. A SMAW welder approaching the end of a long butt joint notices the arc deflecting strongly in the direction of travel, becoming more severe within the last 200 mm of the joint. The weld pool is being pushed ahead and it is impossible to maintain a proper bead. What is occurring and what is the most direct technique correction?

A. This is forward arc blow — as the electrode approaches the joint end, the magnetic flux from the welding current in the remaining unbalanced steel path ahead of the electrode creates an asymmetric field that deflects the arc in the travel direction; corrections include tilting the electrode tip backward toward the alreadycompleted weld, moving the work lead connection to the end of the joint being approached, or switching to AC if the electrode type permits

B. This is arc wander caused by welding fume condensate buildup on the autodarkening helmet lens — the visual distortion from the fumecoated lens makes it appear the arc is deflecting when the arc is actually straight; cleaning the helmet lens corrects the apparent arc wander immediately

C. This is steel magnetic memory — structural steel retains magnetic orientation from mill processing that strengthens near the plate edges; the only correction is demagnetizing the plate end with an external coil before completing the final weld segment

D. This is backward arc blow — arc blow toward the joint end means the completed weld section is pulling the arc backward through its residual field; the correct technique is increasing amperage to overcome the magnetic deflection and welding toward the completed section

86. A power source rating plate shows "Rated output: 400 A, 36 V, 60% DC." What does this rating mean and how does a welder use it to prevent overheating?

A. The rating means the power source can deliver 400 A continuously for 60 hours before requiring scheduled maintenance service — the "60% DC" designates the 60hour service interval for the DC output rectifier components

B. The rating means the power source produces a continuous 400 A output with a maximum of 60 amplitude variations per second in the DC output — the 60% DC refers to acceptable ripple content in the rectified output, which is normal for singlephase rectification

C. The rating means the power source can deliver 400 A at 36 V for 6 minutes in every 10minute period — the 60% duty cycle is the maximum arcon fraction at rated current before overheating occurs; above 400 A the allowable ontime decreases below 60%, while below rated current the allowable ontime increases; the 10minute test period is the standard for SMAW power source duty cycle ratings

D. The rating means the power source can deliver 400 A with a maximum of 60 current transients per minute — the DC designation identifies the current waveform type and the 60 refers to the ripple frequency of the unfiltered DC output at standard line frequency

87. A welder must complete a root pass in the 5G position on 4inch NPS Schedule 80 pipe (wall 8.56 mm) using 3.2 mm E6010 electrodes. The manufacturer's amperage range for 3.2 mm E6010 is 75–125 A. An experienced welder sets the machine to 70 A — below the manufacturer's minimum. What justifies the belowrange amperage setting?

A. Belowminimum amperage is never acceptable — the manufacturer's minimum ensures adequate heat for full fusion; any deviation below the minimum constitutes a WPS violation that must be reported to the supervisor before welding can continue

B. The manufacturer's amperage range is established for flat position welding — for the overhead segment of fixed pipe (5G), experienced welders often reduce amperage slightly below the tabulated flat position range to improve pool control where gravity opposes the welding direction; the WPSspecified range governs code compliance, not the manufacturer's flatposition table

C. Belowrange amperage settings activate the power source's lowcurrent stabilization mode, which filters arc instability and improves root pass quality in the vertical and overhead positions compared to inrange amperage settings

D. Operating below the manufacturer's minimum range is acceptable only for tack welds — tack welds are not structural welds and are not subject to amperage minimums; the root pass must always be deposited within the manufacturer's specified range without exception

88. In field pipeline welding, the second pass after the E6010 root pass is called a "hot pass." What is the specific purpose of the hot pass, and at what amperage relative to the root pass is it typically deposited?

A. The hot pass is deposited at the same amperage as the root pass and adds the second reinforcement layer required for the specified final weld height — "hot" refers to the elevated temperature at which this pass must be deposited, not to the heat input parameter

B. The hot pass is deposited at lower amperage than the root pass to create a buffer layer that prevents excessive heat from the fill passes from conducting through to the root pass and causing burnthrough on thinwall pipeline

C. The hot pass is deposited with the same E6010 electrode at the same amperage as the root pass but in the opposite travel direction to cancel the distortion induced by the root pass

D. The hot pass is deposited immediately after the root pass at slightly higher amperage than the root pass (often 5–10 A higher) using E6010 electrodes — it burns off the characteristic slag slivers and root ripple marks from the cellulosic root pass, smooths the root bead crown profile, and provides a clean base for subsequent fill passes; the slightly higher amperage ensures sufficient penetration to tie in the root pass margins and remove any irregular crown features

89. A SMAW instructor observes a student deposit a horizontal (2F) fillet weld with the electrode pointed directly at the base (horizontal) plate at 90 degrees from the vertical member. The resulting weld has a large, poorly shaped bead that slumped away from the vertical web plate, depositing mostly on the base plate. What caused this result, and what is the correct electrode angle?

A. The student used excessive amperage — at 90 degrees to the vertical plate, the pool is too large to be controlled by the arc force at this angle and slumps away; reducing the amperage while maintaining the same electrode angle corrects the bead profile

B. The student used too fast a travel speed — insufficient time was allowed for the weld pool to wet onto the vertical plate surface before moving forward; slowing travel speed allows the pool to contact both plates equally

C. The student used an incorrect work angle of 90 degrees — for a 2F horizontal fillet weld, the correct work angle positions the electrode at approximately 45 degrees to the horizontal plate (bisecting the angle between the two plates), directing arc force equally at both the horizontal base and vertical web; the 90degree angle directed all arc force against the horizontal plate, pushing the pool away from the vertical member

D. The student deposited in the wrong travel direction — horizontal fillet welds must always be deposited right to left regardless of the welder's dominant hand; lefttoright deposition causes the pool to slump toward the vertical plate rather than riding correctly on both base plate members simultaneously

90. A GMAW operator produces a narrow, highcrowned bead with deep penetration using a drag (trailing) gun angle. The supervisor requests a wider, flatter bead with shallower penetration. How does switching to a push (leading) gun angle change the bead profile?

A. Switching to the push technique produces a wider, flatter bead with shallower penetration compared to the drag technique — the push angle directs arc force forward ahead of the pool, spreading heat ahead of the weld, producing a wider, flatter pool with reduced penetration depth; push technique is often preferred for surfacing and heatsensitive applications requiring controlled, lower penetration

B. Switching to the push technique increases penetration compared to drag — the forward arc force pushes the pool ahead and forces the arc deeper into the base metal, resulting in higher penetration and a narrower bead compared to drag technique at the same parameters

C. Push versus drag technique has no effect on bead geometry in GMAW — the travel angle affects only shielding gas coverage adequacy and has no measurable influence on penetration depth or bead width when all electrical parameters remain constant

D. Switching to the push technique reduces penetration but increases bead height — the forward arc force pushes the pool upward rather than downward, creating a taller convex crown and shallower penetration than the drag technique at the same amperage and wire feed speed

91. An apprentice asks how selfshielded FCAW wires provide atmospheric protection without any external shielding gas supply. Which explanation is accurate?

A. Selfshielded FCAW wires contain a highargon core fill that vaporizes during the arc, providing argon shielding similar to GTAW — the argon is stored in compressed form within the hollow wire and released as the wire is consumed in the arc zone

B. Selfshielded FCAW wires contain metallic scavengers (aluminum, titanium) and gasgenerating compounds in the core — when these materials react in the arc, they generate CO_2, CO, and other protective gases within the arc zone itself, and the metallic deoxidizers combine with atmospheric nitrogen and oxygen before they can enter the molten pool; this internally generated protection functions independently of any external gas supply

C. Selfshielded FCAW wires create a solidifying ceramic tube during the arc that physically prevents air from reaching the molten pool — the slag solidifies into a rigid barrier before the pool surface is exposed, providing complete physical shielding without requiring any chemical protective mechanism

D. Selfshielded FCAW wires generate protection from the metal vapor cloud produced when the wire melts — the vapor pressure above the molten pool is sufficient to displace atmospheric gases and prevent nitrogen and oxygen from reaching the liquid metal during the brief arc exposure period

92. A GMAW operator using 0.9 mm ER70S6 wire switches to 1.2 mm ER70S6 wire to increase deposition rates on thick structural plate. At the same wire feed speed (m/min), how does the 1.2 mm wire change the welding process parameters compared to the 0.9 mm wire?

A. At the same wire feed speed, 1.2 mm wire produces the same welding current as 0.9 mm — wire diameter has no effect on amperage when WFS is held constant because the power source adjusts its output to maintain the set voltage regardless of wire diameter

B. At the same wire feed speed, 1.2 mm wire produces lower amperage than 0.9 mm — the larger wire has greater crosssectional area and lower electrical resistance, requiring proportionally less current to melt at the same linear wire speed

C. At the same wire feed speed, 1.2 mm wire produces the same deposition rate (kg/hr) as 0.9 mm — deposition rate depends only on the WFS in m/min regardless of wire diameter

D. At the same wire feed speed, 1.2 mm wire produces significantly higher amperage and deposition rate (kg/hr) than 0.9 mm — the larger crosssectional area requires more current to melt at the same linear speed, and the greater mass per metre means more metal is deposited per unit time; both the welding current and the deposition rate increase substantially when switching to the larger diameter at identical WFS

93. A welding engineer must select a selfshielded FCAW wire for verticalup structural welding in a windy outdoor environment. Two selfshielded wires are available: E71T8 and E70T4. Which selection and rationale are correct?

A. E70T4 is the better choice for verticalup welding — the T4 classification indicates higher current capacity than T8, allowing faster deposition and better pool control in outofposition applications

B. Either wire can be used interchangeably — both T4 and T8 are selfshielded wires providing equivalent atmospheric protection and both are rated for all welding positions under standard conditions

C. E71T8 is the correct selection — the digit "1" in E71T8 indicates allposition capability; the digit "0" in E70T4 limits that wire to flat and horizontal positions only; for the windy outdoor condition, both wires provide adequate selfshielding, but only E71T8 carries the positional qualification for verticalup welding

D. E70T4 is preferred because the T4 classification provides higher Charpy Vnotch toughness at low temperatures — T4 wires are specifically designed for outdoor coldtemperature applications where impact performance is required, while T8 wires do not meet lowtemperature impact toughness requirements

94. A fabrication shop is evaluating switching from 100% CO_2 to 75/25 Ar/CO_2 for structural GMAW production. Which statement accurately describes the key operational difference between these two shielding gas choices?

A. Switching from 100% CO_2 to 75/25 Ar/CO_2 reduces spatter, improves bead appearance, and enables spray transfer at higher amperage — the higher argon content stabilizes the arc and allows the higher arc voltage needed for spray transfer that 100% CO_2 cannot support at any amperage; the tradeoff is higher gas cost and slightly reduced penetration compared to 100% CO_2

B. 100% CO_2 produces higher deposition rates than 75/25 Ar/CO_2 at the same wire feed speed — the CO_2 decomposes in the arc and the released oxygen reacts with the wire, increasing the deposition rate per ampere by approximately 15% compared to argonrich gas mixtures

C. 75/25 Ar/CO_2 cannot be used for root pass welding — the argon content destabilizes shortcircuit transfer required for root pass applications, and all root passes with mixed gas shielding must use spray transfer regardless of material thickness

D. 100% CO_2 provides better corrosion protection for the completed weld — carbon from the CO_2 shielding atmosphere reacts with the weld metal during cooling to form a protective carbide layer, while argonmixed shielding leaves the weld surface bare and more susceptible to early oxidation

95. A GMAW/FCAW operator repeatedly experiences burnback — the wire electrode fuses to the contact tip, requiring tip replacement and wire stub removal. Which parameter adjustment most directly addresses burnback?

A. Increase the arc voltage — burnback occurs when voltage is too low for the set wire feed speed, causing an arc too short for proper melting; the wire contacts the puddle before the arc can melt it, and the shortcircuit current fuses wire to the tip

B. Increase the wire feed speed — burnback occurs when the wire feed rate is insufficient for the arc energy; the arc burns faster than the wire advances, causing the burnback to propagate up to the contact tip; increasing WFS feeds wire more quickly into the arc zone to stay ahead of the arc recession

C. Use a contact tip with 0.2 mm larger bore — the standard tip bore creates friction that slows wire advance and allows burnback to propagate; a larger bore eliminates the friction and allows the wire to advance before the burnback reaches the tip

D. Reduce the inductance setting — burnback is caused by excessive inductance that stores energy and releases it in a surge when the short circuit clears; reducing inductance decreases the surge current that fuses the wire to the tip during the transition from short circuit to open arc

96. A GMAW operator notices that when welding at the far end of a large structural steel plate from the work lead connection, the arc consistently deflects strongly away from the travel direction. Moving the work lead closer to the arc area reduces the problem. What does this observation indicate?

A. The arc deflection is caused by heat buildup in the steel at the far end — elevated base metal temperature causes the arc plasma to expand asymmetrically, deflecting toward the cooler region where the work lead is attached

B. The arc deflection is caused by insufficient shielding gas at the far end — at distances exceeding 3 metres from the work lead connection, the shielding gas circuit resistance increases, reducing delivery pressure and causing atmospheric interference that deflects the arc

C. The arc deflection results from DC current creating proportionally stronger electromagnetic fields with increasing distance from the work lead — current concentration increases proportionally with distance, creating an asymmetric magnetic field that deflects the arc toward the highest current density region

D. This is magnetic arc blow caused by an asymmetric magnetic field — the DC welding current magnetizes the steel around the return current path; when the work lead is far from the arc, the completed weld and base metal path create a concentrated magnetic flux that deflects the arc backward;

the magnetic field asymmetry is directly related to work lead position relative to the welding arc, and moving the work lead closer to the arc location reduces the flux asymmetry and corrects the arc blow condition

97. A FCAWG operator sets the wire feed speed significantly above the machine voltage setting capacity, producing a harsh crackling arc, extremely heavy spatter, and an irregular pileup bead. The arc appears to extinguish and restrike continuously. What is happening, and what adjustment corrects it?

A. The excessive wire feed speed has pushed the arc voltage above the power source maximum, triggering the overcurrent protection circuit; reducing WFS allows the power source to maintain stable output within its rated limits

B. The excessive WFS has extended the wire beyond the contact tip onto the work surface, causing the wire to stub directly into the molten pool; increasing the contacttiptowork distance by extending the torch corrects the stubbing

C. The excessive WFS is feeding wire faster than the arc energy can melt it — the wire contacts the molten pool before being melted, causing repeated stubbing and arc interruption; reducing WFS to match the set voltage allows the arc to continuously and stably melt the wire at the correct rate

D. The excessive WFS has created an oversized weld pool that exceeds the surface tension limit — when the pool grows too large, surface tension fails and molten metal falls away from the pool; reducing voltage corrects the pool size without changing the wire feed speed

98. A GMAW operator using 100% CO_2 shielding gas on carbon steel is instructed to set up for spray transfer mode at high amperage. Despite meeting the minimum current threshold for spray transition on the 1.2 mm wire, the operator cannot achieve stable spray transfer and the process remains in globular mode. What fundamental requirement for spray transfer is not being met?

A. Spray transfer requires a minimum argon content in the shielding gas — 100% CO_2 cannot support spray transfer at any amperage; a minimum of approximately 80% argon is required because the argon plasma provides the electromagnetic conditions necessary for the pinch force mechanism that creates fine spray droplets; CO_2 plasma does not provide these electromagnetic conditions regardless of the amperage level

B. Spray transfer requires a minimum plate thickness of 12 mm — the heat input required to achieve spray transition causes burnthrough on material below this minimum thickness, and all spray transfer applications are inherently limited to material above the 12 mm threshold

C. Spray transfer requires the electrode wire to be preheated by an inline heating element in the feeder — without preheating, the wire requires too much arc energy to melt at the transition current level, preventing the pinch force from dominating over gravity and surface tension

D. Spray transfer requires DC electrode negative (DCEN) polarity — the electron flow from electrode to base metal on DCEN creates the electromagnetic pinch force that produces spray transfer; DCEP (the polarity being used) does not provide the correct electromagnetic conditions for spray transfer on carbon steel wire

99. A fabricator completing multipass FCAWG in a Vgroove joint on 50 mm plate uses clamps to control distortion. To minimize angular distortion when the clamps are removed, which bead sequencing approach is most effective when welding from one side only?

A. Deposit each pass at maximum weave width allowed — fullwidth passes reduce the total number of passes and thermal cycles, minimizing the cumulative angular shrinkage force on the joint

B. Deposit passes in a block sequence — divide the joint length into short blocks and complete the full crosssection fill of each block before advancing to the next; this allows completed sections to act as restraint for adjacent sections, distributing the thermal shrinkage forces more uniformly along the joint and reducing the total angular distortion at clamp removal

C. Deposit all passes in the downhill direction only — downhill FCAW produces lower heat input per unit length than uphill, reducing the heated volume per pass and the angular distortion force per individual pass

D. Use the backstep technique — deposit each segment progressively away from the previous, with each individual bead running forward while the overall progression moves backward; the opposing thermal shrinkage patterns cancel cumulative distortion effectively

100. A GMAW welder makes a root pass on an openroot Vgroove butt joint using shortcircuit transfer. After completing the root pass, the inside of the joint shows the root bead has washed out — creating a concave recess rather than a convex bead. What technique adjustment prevents the washout condition in the root pass?

A. Increase the amperage to ensure full penetration — root bead washout is caused by insufficient heat failing to achieve proper root fusion; increasing amperage provides more energy to produce a sound convex root bead without melting through

B. Increase wire feed speed and travel speed simultaneously — washout occurs because pool velocity is too slow relative to wire deposition; simultaneously increasing both parameters provides the correct balance between deposition and travel

C. Change the shielding gas from 75/25 Ar/CO_2 to 100% CO_2 — higher CO_2 content produces greater arc force that pushes molten metal through the root opening instead of allowing it to burn back, eliminating the washout condition

D. Reduce the amperage by lowering wire feed speed and maintain a consistent controlled travel speed — washout occurs when the heat input is excessive for the root gap, causing the root opening to enlarge beyond the wire's ability to bridge it and the arc to fall through; matching the heat input to the root gap size prevents the pool from overheating and washing out of the joint

101. A GTAW operator must weld pure copper pipe joints. The copper heats and dissipates heat very rapidly due to its extremely high thermal conductivity. What challenges does this create and what technique modifications are required compared to stainless steel GTAW?

A. Copper's extremely high thermal conductivity (approximately 400 W/m·K compared to 16 W/m·K for stainless steel) rapidly conducts heat away from the weld zone — this requires significantly higher preheat (typically 200–400°C depending on section size), higher welding current than comparable stainless steel thickness, and preheating of the entire fitting or assembly to maintain adequate pool temperature throughout the weld; copper's higher coefficient of thermal expansion also increases distortion risk and hot cracking susceptibility during rapid cooling after welding

B. Copper has lower thermal conductivity than stainless steel, meaning heat builds up in the weld zone more rapidly than expected — the technique modification is reducing welding current by 30–40% from the stainless steel values to prevent overheating and burnthrough in copper

C. Copper must be welded using AC current only — AC provides the cathodic cleaning action required to remove the copper oxide surface layer before the arc reaches base metal; DCEN on copper is prohibited because it causes unacceptable spatter and weld metal porosity

D. Copper GTAW requires 100% helium shielding gas — pure argon causes copper sulfide inclusions to form because argon reacts chemically with trace sulfur in the copper alloy; helium is the only inert gas that is chemically compatible with copper for GTAW applications

102. A GTAW welder assigned to Alloy 625 (Inconel 625) nickel alloy tubing observes that the weld pool is unusually sluggish and slow to flow compared to carbon steel GTAW. What characteristic of nickel alloys causes this, and how does it affect the welding technique?

A. Nickel alloys have a lower melting point than carbon steel, causing the pool to solidify unusually quickly before the welder can complete the intended bead length — the technique modification is to increase amperage to keep the pool liquid longer during deposition

B. Nickel alloys are strongly ferromagnetic, causing arc blow in all orientations — the sluggish pool appearance results from repeated arc deflection disrupting pool flow; switching to AC GTAW eliminates the magnetic arc blow and restores normal pool behavior

C. Nickel alloys have significantly higher surface tension and viscosity in the molten state than steel — the sluggish pool is normal behavior for nickel alloys; the technique implication is that the pool does not flow and selflevel like carbon steel; the welder must place filler metal precisely where needed, use slightly higher heat input to ensure proper sidewall fusion, and avoid wide weaving because the viscous pool does not wet out as readily

D. Nickel alloys produce a tenacious oxide film that continuously reforms over the pool surface, making it appear sluggish — this oxide can be disrupted by using a foot pedal to pulse the current, which mechanically agitates the pool and breaks up the film at each pulse cycle

103. A welder must join a 1.6 mm steel insert plate to a cast iron housing using GTAW. The procedure specifies silicon bronze (ERCuSiA) filler wire. What is the metallurgical principle behind using silicon bronze filler for this dissimilar metal joint?

A. Silicon bronze filler produces a eutectic deposit that bonds to both steel and cast iron by simultaneously melting all three materials at a shared lower eutectic temperature — the eutectic reaction allows fusion without reaching the cast iron graphitization temperature

B. Silicon bronze brazewelding deposits the filler metal at temperatures below the cast iron fusion temperature — the iron substrate is wetted by the bronze filler through a brazing mechanism rather than fusion, allowing the joint to be made without melting the cast iron and without creating the hard white iron HAZ that causes cracking in cast iron fusion welds; silicon improves wetting on both cast iron and steel surfaces

C. Silicon bronze is used because its coefficient of thermal expansion exactly matches cast iron — the CTE match eliminates all thermal stress at the joint interface during cooling, preventing HAZ cracking in the brittle cast iron

D. Silicon bronze provides electromagnetic shielding at the joint interface — the coppersilicon alloy's electrical conductivity prevents galvanic corrosion between the steel insert and cast iron housing in longterm service

104. An engineer evaluates orbital GTAW for highpurity foodgrade stainless steel tubing joints. What specific advantage does orbital GTAW provide over manual GTAW for this application?

A. Orbital GTAW allows welding without back purge — the automated torch rotation creates an argon curtain on both sides of the weld simultaneously, eliminating the need for internal back purge on all tubes below 50 mm OD

B. Orbital GTAW can weld stainless steel tubing without filler metal — the precise thermal control of automated orbital welding allows autogenous fusion of any stainless wall thickness with zero filler metal requirement regardless of tube size

C. Orbital GTAW uses a proprietary nitrogen shielding mixture that replaces argon, eliminating postweld passivation that manual GTAW requires for every weld in pharmaceutical and foodgrade applications

D. Orbital GTAW provides highly consistent and repeatable weld quality with complete electronic documentation of all welding parameters for each joint — automation eliminates the human skill variable, and the parameter logging capability provides full traceability for each joint; this documentation is critical for pharmaceutical, foodgrade, and highpurity applications where regulatory standards require proof of welding process compliance for each individual joint

105. A GTAW welder working inside a tube section with limited access extends the tungsten electrode 20 mm beyond the nozzle end instead of the standard 5–8 mm. What quality concern does the excessive electrode extension create?

A. Excessive electrode extension exposes the hot tungsten beyond the effective radius of the nozzle gas shielding — the extended electrode tip is outside the protective gas cone, causing rapid oxidation of the hot tungsten and contamination of the weld pool with tungsten oxide inclusions; the contamination darkens the weld surface and introduces hard tungsten particles that can nucleate weld metal cracks

B. Excessive electrode extension adds approximately 15 V to the arc voltage — the extended electrical path through the tungsten increases the arc voltage above the WPS maximum and potentially causes burnthrough on the tube wall

C. Excessive electrode extension increases the electrical resistance of the tungsten and reduces the welding current to below the minimum required for fusion — the longer electrical path reduces the current density at the electrode tip and prevents the arc from reaching the required heat level

D. Excessive electrode extension causes the CC power source to enter constantvoltage mode — when the arc length exceeds the standard setting, GTAW CC power sources automatically switch to CV characteristics, causing arc instability until the electrode is retracted to the standard extension length

106. A GTAW welder completes a root pass on 6inch stainless steel pipe in the 5G position. The root bead shows proper slight convexity from the 6 o'clock to 9 o'clock positions but drops to a concave profile at the 12 o'clock overhead position. What causes the overhead root drop and what technique corrects it?

A. The concave root at 12 o'clock is caused by insufficient preheat — the overhead position is the coolest location in 5G welding and requires higher preheat dwell time at 12 o'clock to prevent the root from cooling too rapidly before the pool fills the root gap

B. The root drop at 12 o'clock is caused by using ER316L rather than ER308L filler — ER316L has lower surface tension than ER308L and drops out of the root keyhole at the overhead position where gravity opposes the pool; switching filler metal corrects the root drop specifically at the overhead zone

C. The concave root at 12 o'clock results from excessive heat input at the overhead position — the same amperage and travel speed that produce correct root geometry at the sides and bottom create an oversized, overly fluid pool at the overhead position; the correction is reducing amperage via foot pedal at the overhead zone and/or increasing travel speed to reduce heat input and prevent the pool from falling through the root gap

D. The root drop at 12 o'clock is caused by the back purge argon flowing upward through the pipe and pushing the root bead away from the joint at the overhead position — reducing the back purge flow rate prevents the upward gas pressure from displacing the molten root bead at the 12 o'clock location

107. During GTAW root pass welding on thinwall (3 mm) stainless steel pressure tubing, the welder uses a foot pedal to continuously modulate current. What specific quality benefit does the foot pedal provide that a fixedamperage setup cannot?

A. The foot pedal reduces the need for back purging — varying current with the foot pedal creates a pulsing action that disrupts oxide formation on the root underside, eliminating the back purge requirement on tube diameters below 50 mm

B. The foot pedal allows the welder to dynamically respond to changes in pool conditions throughout the joint — as the fitting or joint heats up during the weld, the required heat input decreases; as tube geometry changes at fittings or tees, the welder adjusts current accordingly in real time; this adaptive response prevents burnthrough on thin material where fixed preset parameters cannot account for the changing thermal conditions at each unique location

C. The foot pedal allows the welder to control bead width independently from penetration depth — by pressing the pedal, the welder selectively increases width while maintaining constant penetration, a capability not available through any other GTAW control method

D. The foot pedal eliminates the need for interpass cooling — by reducing current to the minimum arc maintenance level between passes rather than extinguishing the arc, the foot pedal allows continuous arc operation while maintaining interpass temperature within specification

108. A GTAW welder notices that the rotametertype gas flowmeter (floating ball in a tapered tube) shows the same ball position for both argon and helium at the "15 L/min" scale setting. What specific issue does this create?

A. No issue exists — rotameter flowmeters are factorycalibrated to read accurately for any gas type at standard temperature and pressure; the ball position correctly indicates 15 L/min for both argon and helium without requiring any correction factor

B. The helium flow is understated — helium is denser than argon, and the same ball position in an argoncalibrated rotameter indicates lower actual volume flow for helium; the actual helium flow is approximately 7.5 L/min when the argon scale reads 15 L/min

C. The argon flow is overstated — argon is lighter than helium, and the same ball position indicates higher actual volume flow for argon; the actual argon flow is approximately 25 L/min when the heliumcalibrated meter reads 15 L/min

D. Rotameter flowmeters are calibrated for a specific gas, typically argon — when used with a different gas such as helium (which is less dense than argon), the actual flow at the same ball position differs from the scale reading; an argoncalibrated meter underestimates actual helium flow because the lighter helium requires a higher volumetric flow rate to lift the ball to the same height as argon; a conversion factor must be applied when using the meter with a gas that differs from its calibration gas

109. A GTAW welder backpurging a 304L stainless steel nozzle connection receives an 800 ppm oxygen reading at the downstream vent after 20 minutes of purging. The WPS requires below 1,000 ppm. The welder declares the purge complete. An experienced supervisor questions the adequacy of this declaration. What additional consideration should the supervisor explain?

A. The 800 ppm reading at the downstream vent represents the oxygen level at the furthest point from the weld zone, which is the last location to clear during purging — while the vent reading confirms that area is within specification, complex nozzle or fitting geometry may trap air pockets where the actual weld zone could have locally higher oxygen than the vent reading indicates; for complex geometries, measurements as close to the actual weld zone as possible or multiple measurement points are needed to confirm a truly uniform purge

B. The 800 ppm reading indicates moisture interference rather than actual oxygen — all portable oxygen analyzer readings below 1,000 ppm in stainless steel back purge applications indicate moisture interference and must be disregarded; purging is only confirmed complete when the reading drops below 500 ppm

C. The reading must remain stable for 60 minutes before the purge can be declared complete — the dynamic equilibrium between purge flow and residual air requires 60 minutes to reach a final stable level, and readings before 60 minutes always understate the actual steadystate oxygen content

D. The 800 ppm reading indicates contaminated argon — highpurity argon reduces oxygen to below 500 ppm by thermodynamic equilibrium; any reading above 500 ppm with argon shielding indicates a contaminated cylinder that must be replaced before welding proceeds

110. Which application represents the most critical situation where wide weave beads must be avoided in GTAW, and what is the metallurgical reason?

A. Wide weaving must be avoided during all cap passes on carbon steel pipe — wide weaving creates simultaneous undercut at both weld toes; cap pass toe undercut specifically is prohibited by all applicable pipe welding codes regardless of material type or pipe diameter

B. Wide weaving must be avoided when preheat exceeds 100°C — elevated base metal temperature reduces heat dissipation, and the additional heat from a wide weave at elevated preheat can raise the previous pass into the liquation cracking temperature range

C. Wide weaving must be strictly avoided on austenitic stainless steel and nickel alloys — wide weave beads create large, elongated weld pools that allow lowmelting impurity segregates to concentrate along the pool centerline; the high lengthtowidth ratio of a weave pool creates conditions for centreline solidification hot cracking that stringer beads avoid by maintaining a compact pool geometry with a more favorable solidification front orientation

D. Wide weaving must be avoided on all GTAW root passes regardless of material — the keyhole technique required for GTAW root pass penetration needs a narrow, consistent arc; any weave oscillation disrupts the keyhole, causing irregular root reinforcement and incomplete fusion at the root gap of the joint

111. A GTAW operator working in a hospital clean room is required to disable the highfrequency arc starting feature on the power source and instead uses a lift arc method. What concerns are associated with operating without HF arc starting, and what precaution must be taken?

A. Without HF arc starting, GTAW requires DC negative polarity — the HF unit provides the voltage boost needed for DCEP arc starting; without it, the process is limited to DCEN and cannot be used for applications requiring DCEP or AC

B. Without HF arc starting, the electrode must make physical contact with the work surface to initiate the arc — the scratch start or lift arc method risks tungsten contamination from the initial base metal contact; using a copper starting tab to initiate the arc before moving to the joint prevents tungsten contamination from being introduced into the production weld metal

C. Without HF arc starting, GTAW can only be used outdoors — HF arc starting is mandatory for all indoor applications because scratchstart electromagnetic interference disrupts sensitive equipment in enclosed facilities

D. Without HF arc starting, helium must replace argon as the shielding gas — helium's lower ionization potential allows reliable arc initiation without highfrequency voltage, while argon's higher ionization potential prevents reliable arc starting using the lift arc method

112. A GTAW welder is preparing to weld 6061T6 aluminum plates with a visible mill oxide layer on the joint surfaces. What specific preweld preparation is required, and what constraint applies to the timing of welding after preparation?

A. No surface preparation is required — the cathodic cleaning action of AC GTAW removes all surface oxide during welding; precleaning before welding actually reduces the arc's oxide removal efficiency by eliminating the oxide baseline needed for the cathodic cleaning cycle to function

B. The aluminum must be preheated to 200°C to dissolve the surface oxide — aluminum oxide has a melting point of approximately 200°C, and preheating allows the oxide to run off the joint surface before welding begins

C. The aluminum surface must be sandblasted with fine silica sand to remove the oxide mechanically — sandblasting is the only method that removes aluminum oxide uniformly without introducing chemical contamination that affects GTAW arc stability

D. The joint area should be cleaned mechanically with a stainless steel wire brush dedicated exclusively to aluminum use, or chemically cleaned with an acetone wipe followed by appropriate acid or alkaline etch — the dedicated brush prevents contamination transfer from previously worked materials; chemical cleaning provides more uniform results; the area must be welded promptly after cleaning because aluminum oxide begins reforming immediately on any freshly cleaned surface exposed to air

113. A GTAW welder making a root pass on 3 mm wall stainless steel pipe produces a root bead that is smooth and convex on the pipe inside surface but the outside of the joint shows no depression and no oxidation typical of penetration heat. The welder asks what is wrong. What does this bead appearance indicate?

A. The absence of any external indication combined with a convex inside bead indicates the weld metal was deposited inside the pipe on the back side without penetrating through the pipe wall — the filler metal was deposited onto the inside surface from the backpurge access side rather than through the root gap from the outside; the root gap may be too tight or the amperage too low to achieve throughwall penetration from the outside

B. The described appearance indicates a correctly executed root pass — a smooth convex root bead on the inside and a flush unaffected outer surface is the accepted quality standard for stainless steel root passes in foodgrade piping systems

C. This appearance indicates excessive amperage causing burnthrough — the root has melted through and resolidified in a convex shape; reducing amperage by 50% corrects this burnthrough condition on subsequent welds

D. The appearance indicates wrong shielding gas — argon shielding produces a convex inside root bead while helium produces a flat bead; the described combination confirms argon on the outside and helium on the inside, creating a mismatched bead profile at the inside root surface

114. A GTAW welder completes a bead on mild steel plate and notices the finished bead surface has a goldenbrown discoloration across its full length rather than the expected bright silver. DC with argon shielding at 10 L/min was used. What does the goldenbrown discoloration indicate?

A. The goldenbrown color is normal for carbon steel GTAW with DCEN — the brown iron oxide forms as the weld metal cools through 300–400°C and confirms the weld was made at correct parameters

B. The goldenbrown color indicates elevated silicon content from ER70S2 filler — silicon oxide naturally produces the goldenbrown color and confirms adequate deoxidizer activity in the filler, which is a positive quality indicator

C. The goldenbrown discoloration indicates marginal shielding gas protection during the weld cooling cycle — while not as severe as dark blue or black heavy oxidation, the goldstraw color indicates shielding coverage was insufficient to fully protect the cooling weld metal from atmospheric oxidation;

for stainless steel this color would be rejectable; for mild steel it indicates the postflow time or flow rate should be increased to prevent oxidation during the critical cooling period

D. The goldenbrown color indicates the welder failed to add filler metal — autogenous GTAW on mild steel always produces this discoloration because the absence of filler deoxidizers allows base metal oxides to form freely on the weld surface

115. A GTAW welder using an AC power source with adjustable balance increases the electrodepositive (EP) percentage from 30% to 50% of the AC cycle. What change in arc behavior and electrode condition results?

A. Increasing EP from 30% to 50% increases penetration significantly — the EP phase is responsible for deeper penetration in AC GTAW; a higher EP proportion directs proportionally more energy into the base metal and deepens the fusion zone without changing the electrode condition

B. Increasing EP from 30% to 50% increases cathodic cleaning intensity but increases the thermal load on the electrode — during the EP phase, current flows from the work to the electrode, concentrating energy at the electrode tip; a higher EP percentage means more time with energy concentrated at the electrode, which increases the ball size on the tungsten tip and requires either a larger electrode diameter or reduced total amperage to prevent electrode overheating and contamination

C. Increasing EP from 30% to 50% reduces both penetration and cathodic cleaning — increasing the EP percentage simultaneously reduces the EN percentage, which is responsible for both penetration and cleaning; higher EP decreases both characteristics proportionally

D. The AC balance control has no effect on electrode temperature — electrode temperature is determined entirely by total RMS amperage; the balance percentage affects only the width of cathodic cleaning visible on the aluminum oxide surface and has no influence on the electrode thermal condition

116. A GTAW welder notices intermittent porosity at irregular intervals along a stainless steel joint length. Amperage, travel speed, and shielding gas flow are within specification. Investigation traces the most likely cause to filler wire storage. What storage issue produces this distributed intermittent porosity pattern?

A. Filler wire stored below 15°C — cold filler wire causes thermal shock when it contacts the hot weld pool, creating microshrinkage voids that appear as intermittent porosity distributed along the completed weld length

B. Filler wire stored on a copper shelf — copper contamination from the shelf surface transfers to the outer surface of the stainless filler wire; the copper melts into the pool and produces copper sulfide inclusions appearing as dark irregular porosity on the weld face

C. Filler wire stored with SMAW electrodes — flux particles from SMAW electrode coatings contaminate the GTAW filler wire outer surface; these particles deposited into the pool produce gas from the organic binder and slag from the flux minerals, generating the intermittent porosity at each contaminated dip location

D. Filler wire stored in a humid environment without protection — moisture adsorption on the stainless filler wire surface introduces hydrogen into the pool at each wire dip, generating intermittent hydrogen porosity distributed along the weld at the dip locations; filler wire must be stored clean and dry in a sealed container and used promptly after extended storage

117. A GTAW welder uses a 75% helium/25% argon blend for welding thick (25 mm) aluminum plate. Compared to 100% argon, what operational characteristic changes when using this heliumrich blend?

A. The helium content significantly increases arc energy and weld pool temperature — helium's higher ionization potential and thermal conductivity produce a hotter, more energetic arc that provides greater penetration and enables faster travel speeds on thick aluminum sections; the tradeoffs include higher gas cost, reduced arc stability compared to pure argon (helium arcs are harder to initiate and sustain), and the need for higher flow rates because helium's lower density causes it to disperse from the arc zone more rapidly than argon

B. The helium content converts the AC arc to DC — helium's lower ionization potential stabilizes the DC component of the AC output, effectively converting it to DC and providing superior penetration while eliminating the cathodic cleaning action required for oxide removal on aluminum

C. The 75% helium blend reduces required welding current by 40% — helium's superior thermal conductivity delivers more energy per ampere to the base metal, allowing significant current reduction while maintaining the same fusion depth as 100% argon at higher current

D. The 75% helium blend eliminates the argon back purge requirement — helium's extremely low chemical reactivity with aluminum prevents all oxidation on the weld underside, removing the need for back purge protection in any GTAW application on aluminum using heliumcontaining shielding gas blends

118. A GTAW welder completing a fillet weld on 2 mm thin stainless steel sheet is experiencing meltthrough in a region where two sheets overlap at a backing attachment. What combination of technique adjustments most effectively prevents burnthrough while maintaining adequate fusion?

A. Switch to a smaller nozzle and reduce argon flow to 5 L/min — the smaller nozzle concentrates the gas shield at the exact weld zone, preventing atmospheric contamination that causes irregular heat distribution and the burnthrough

B. Increase travel speed by 50% and keep all other parameters constant — faster travel speed reduces heat input per unit length and prevents the excess energy from melting through the thin material at the overlap zone

C. Reduce amperage using the foot pedal when approaching and traversing the overlap area, increase travel speed through the overlap, and use a slight weave to distribute heat more broadly across the thin section — the combination of lower amperage and faster travel at the material transition reduces the localized heat input at the critical overlap junction where burnthrough occurs

D. Clamp a copper backing bar beneath the overlap region — copper's high thermal conductivity rapidly extracts heat from the thin section and prevents meltthrough at the overlap junction; this is the only reliable technique for preventing burnthrough at thinsection transitions in stainless sheet GTAW

119. A GTAW welder making a root pass on duplex stainless steel pressure pipe with argon back purge examines the completed root bead back side color. The color ranges from silver at some locations to a uniform strawgold throughout most of the weld length. The WPS requires a maximum of "light straw" on the back side. What is the acceptance status?

A. Accept the weld — straw and gold colors are both classified as "light oxidation" under the applicable stainless steel back side color chart, and any color except dark blue, gray, or black meets the "light straw" maximum requirement

B. Reject the root pass and repurge for rewelding — the strawgold color indicates moderate oxidation of the back surface beyond the "light straw" (silver to very light yellow) specification; duplex stainless steel is particularly sensitive to surface oxidation effects on its corrosion performance and phase balance, and the strawgold color confirms insufficient argon protection during the weld cooling cycle; the root pass must be removed and rewelded with an improved purge

C. Accept the weld with engineering disposition — straw and gold are adjacent on the oxidation scale, and a ±1 color step from the specification is permitted under the 10% comparison tolerance; engineering review confirms acceptability

D. No disposition is possible without XPS analysis — color chart assessment is a preliminary screening only; the actual chromium depletion depth must be quantified by Xray photoelectron spectroscopy before the root pass can be formally accepted or rejected

120. A GTAW welder qualified on 2inch NPS pipe (OD = 60.3 mm) is now required to complete root passes on 12inch NPS pipe (OD = 323.9 mm) using the same process, base metal, and 5G position. Under CWB standards, does the 2inch qualification cover the 12inch application?

A. Yes — CWB pipe groove weld qualifications are positionbased; qualification on any diameter in the 5G position covers all other diameters in the same position on the same base metal group with the same process

B. No — CWB requires a separate qualification test for every nominal pipe size used in production; each NPS size is a separate qualification category independent of the test pipe size

C. Yes — the 2inch NPS qualification covers all pipe diameters because smalldiameter pipe presents the greatest welding difficulty; once a welder qualifies on 2inch pipe, all larger diameters are covered by inference under the CWB system

D. Yes, within a diameter range — under CWB standards, a pipe groove weld qualification on 60.3 mm OD covers welding on pipe from 60.3 mm OD and above; the 2inch test pipe falls below the threshold where diameterspecific upper limits apply, and the larger 323.9 mm OD pipe is within the qualified range for diameters at or above the test piece diameter

121. A SAW welding engineer adds a wire oscillation unit to the SAW torch for welding 40 mm wide groove fills on a heavy pressure vessel shell. What is the primary reason for using wire oscillation rather than multiple adjacent stringer beads to fill the wide groove?

A. Wire oscillation reduces heat input per pass — distributing arc energy over a wider area reduces localized heat input compared to a stringer bead, producing lower distortion on heavy sections

B. Wire oscillation covers the required groove width in fewer arc passes while maintaining adequate fusion to both groove sidewalls — a single oscillated pass covers the full groove width; this reduces the number of torch setups, arcon periods, and interpass cleaning cycles required compared to depositing multiple stringer beads to cover the same width

C. Wire oscillation is mandated by ASME VIII for all groove welds exceeding 30 mm in width — the code requires oscillation to prevent centreline segregation that inevitably forms when adjacent stringer beads are deposited without fullwidth overlap

D. Wire oscillation eliminates the need for flux recovery — the oscillating arc creates a continuous overlapping slag blanket that fully covers the groove at each pass, preventing the recoveryandreuse cycle that unoscillated SAW requires on multipass applications

122. A SAW procedure specifies 4.0 mm wire diameter for the root pass. The supervisor approves changing to 3.2 mm wire for the root pass only, maintaining all other parameters constant. How does reducing the wire diameter from 4.0 mm to 3.2 mm at the same current affect the SAW operation?

A. Reducing wire diameter from 4.0 mm to 3.2 mm at the same current increases the current density in the smaller wire crosssection — the higher current density increases the wire melting rate and produces a deeper, narrower bead profile with more penetration per unit width; this characteristic makes smallerdiameter wire wellsuited for root pass applications where penetration and root face fusion are critical to sound root pass quality

B. Reducing the wire diameter decreases total arc energy at the same current — the smaller crosssection wire has lower resistance requiring less voltage, which reduces total arc power (watts); this decreases penetration depth compared to the larger wire operating at the same amperage

C. Reducing wire diameter has no effect on any process parameter — in SAW, wire diameter affects only physical handling characteristics; all arc and bead geometry parameters are governed solely by the electrical settings of voltage, current, and travel speed

D. Reducing from 4.0 mm to 3.2 mm at the same current reduces the deposition rate proportionally — the smaller wire deposits proportionally less metal per amperehour than the larger wire, making smaller diameter wire economically less efficient while producing a wider, flatter bead profile

123. A SAW welding engineer selects a basic flux (high basicity index) for a pressure vessel application requiring excellent Charpy Vnotch impact toughness at −40°C. What is the relationship between flux basicity and weld metal toughness in SAW?

A. Higher basicity fluxes always produce lower toughness — basic flux slag contains calcium and magnesium compounds that transfer to the weld metal and embrittle the microstructure; acidic fluxes produce cleaner, tougher deposits for all impact testing applications

B. Flux basicity has no effect on weld metal toughness — Charpy impact performance in SAW weld metal is determined entirely by the wire chemistry and PWHT temperature; flux type affects only bead appearance and slag removal characteristics

C. Higher basicity fluxes generally produce weld metal with better impact toughness — basic fluxes deoxidize the pool more effectively than acidic fluxes and reduce the total inclusion content, particularly oxygencontaining inclusions; fewer inclusions mean fewer sites for cleavage crack initiation under impact loading, improving the transition temperature and Charpy absorbed energy at subzero temperatures; this is the metallurgical basis for specifying basic flux for lowtemperature impacttested SAW applications

D. Basic flux improves toughness only in singlepass SAW — in multipass applications, cumulative slagmetal reactions over successive passes reduce the toughness benefit of the basic flux to zero, and flux basicity is only a relevant selection factor for singlepass butt weld applications

124. A fabrication supervisor is asked why SAW cannot be used for vertical or overhead welds in the same way that SMAW or FCAW can be adapted to outofposition welding. What fundamental process characteristic limits SAW to flat and horizontal positions?

A. SAW cannot be used outofposition because the molten SAW flux is electrically conductive — in the vertical position, the molten flux would flow downward and shortcircuit the electrode to the workpiece, causing immediate power source trips and equipment damage

B. SAW cannot be used outofposition because SAW power sources lack adequate constantcurrent characteristics for outofposition applications — the constantvoltage characteristic creates excessive amperage variation in outofposition orientations

C. SAW cannot be used outofposition because the SAW wire is too stiff to be fed through flexible conduit directed at angles other than vertically downward

D. The granular flux in SAW is deposited by gravity from a hopper above the arc and covers the weld pool by flowing downward over the arc zone — in the vertical or overhead positions, gravity prevents the granular flux from accumulating over and around the arc; without the flux covering the arc, the flux cannot provide its shielding, arc confinement, and metallurgical functions, making the SAW process impossible to operate in these positions

125. Radiographic examination of a multipass SAW production weld reveals linear slag inclusion indications running parallel to the weld axis at the interface between the second and third fill passes. The weld surfaces appeared visually acceptable and were cleaned between passes. What condition most likely caused these interpass slag inclusions?

A. The slag from the second pass was removed too quickly — removing SAW slag before it has fully solidified traps air pockets in the semimolten slag layer that solidify as inclusion voids at the pass interface; slag must cool to at least 200°C before removal

B. The second pass bead profile was convex with steep, sharp transitions at the weld toes — a convex SAW bead creates a narrow crevice between the bead crown and the groove sidewalls; when the third pass is deposited, the flux and subsequent molten slag cannot flow into and fully cover this crevice, trapping residual slag at the toetosidewall transition; the remedy is to adjust SAW parameters to produce a flatter, wider bead that blends smoothly into the sidewalls without sharp toe transitions at the bead edges

C. The travel speed for the third pass was too fast — excessive travel speed left insufficient time for residual flux from the previous pass to be expelled ahead of the advancing pool, trapping the flux at the secondtothird pass interface and solidifying as slag inclusions

D. The SAW flux was contaminated with carbon steel grinding dust — iron particles in the flux at the secondtothird pass interface reacted with the flux slag to create iron oxide linear inclusions that appear as the detected linear indications on the radiographic film

Practice Exam 7: Answer Key and Explanations

1. C — Section 4 of a WHMIS 2015 SDS is titled "First Aid Measures" and covers emergency response for all exposure routes: skin, eye, inhalation, and ingestion. Other sections address composition (Section 3), accidental release (Section 6), and toxicological data (Section 11) — none of which substitute for the emergency response guidance in Section 4.

2. A — Routing welding return current through structural bolt connections causes arcing at each interface, generating localized heat that can damage fastener integrity and create uncontrolled stray current paths through the building structure to any grounded equipment in the return circuit. The work lead must be connected directly adjacent to the actual weld joint to confine current to the intended path.

3. D — Lockout/tagout requires identifying and isolating all energy sources, not only the most obvious one. A water-cooled GMAW feeder has three potential sources: 480 V electrical, capacitor stored energy, and water pressure. Personal locks applied to all isolation points and zero-energy verification at the work location are mandatory before any maintenance begins.

4. B — Canadian fire codes and CGA standards require a minimum 6-metre separation between oxygen and flammable fuel gas cylinders, or an equivalent non-combustible barrier at least 1.5 m high with a 30-minute fire resistance rating. This prevents a fuel-gas fire or leak from contacting oxygen cylinders, which would dramatically accelerate combustion and create an explosion hazard. Storing full and empty cylinders of each type separately prevents inadvertently issuing empties.

5. C — The 8-hour TWA measures average exposure and cannot detect short-duration peak concentrations during intense 45-minute welding bursts. The 15-minute STEL is specifically designed to evaluate these peak exposures and must be independently assessed against its own limit. TWA

compliance alone does not confirm STEL compliance when high-intensity short-duration work periods are part of the job cycle.

6. A — The scaffold tagging system uses red to mean "do not use" — a competent person has inspected and declared the scaffold unsafe. No worker may use the scaffold for any purpose until all deficiencies are corrected, the scaffold is re-inspected, and the red tag is replaced with a green tag. Ignoring a red tag is a serious OHS violation regardless of the apparent condition of the scaffold.

7. D — Working adjacent to an energized 480 V panel creates an arc flash exposure hazard for all nearby workers, not only electrical workers directly manipulating the panel. NFPA 70E and applicable Canadian standards require an arc flash hazard assessment by a qualified person to determine the incident energy at the worker's position, with PPE selected to match that energy level.

8. B — Pre-job hazard assessments are most effective when the workers performing the task participate in identifying the hazards, because they have direct knowledge of the site conditions, tools, work sequence, and practical hazards. The supervisor confirms adequacy before work begins. This participatory model is consistent with the internal responsibility system underlying Canadian OHS legislation.

9. A — For a second-degree burn, immediate cooling with cool running water for at least 10 minutes is the most critical first step — it stops the burning process and limits injury depth. Ice is contraindicated because it can cause additional tissue damage. A 25 × 35 mm partial-thickness burn requires medical evaluation for depth classification, infection risk assessment, and appropriate wound management.

10. C — Canadian OHS legislation across all provinces requires employers to report workplace incidents resulting in worker injury to the provincial OHS authority, investigate, document findings, and implement corrective measures. The JHSC receives the investigation results but does not gate the regulatory reporting requirement; notification timelines depend on injury severity, but the reporting obligation applies for any injured worker.

11. D — When the welding helmet is raised, it provides zero protection to the face and eyes. Chipping hot slag produces high-velocity flying particles requiring full ballistic face protection. A full face shield worn over safety glasses provides both impact-resistant face coverage and secondary eye protection from debris entering from the sides or above.

12. B — Fit test validity is not permanent. A new fit test is required when the worker changes to a different make, model, or size of respirator; when significant physical changes occur to the face (weight change, dental work, scarring); or at the interval specified in the employer's written respiratory protection program — annual re-testing is the most common industrial requirement.

13. C — Ground fault circuit interrupters detect leakage currents of 4–6 mA — far below the trip threshold of a standard circuit breaker but sufficient to cause electrocution. The Canadian Electrical Code and provincial OHS regulations mandate GFCI protection on all 120 V circuits in outdoor locations and wet or damp environments. Standard breakers only protect against overcurrent, not the shock-level leakage currents that GFCI is designed to interrupt.

14. A — A ceiling (C) limit is an instantaneous maximum that must never be exceeded at any moment during the work period, regardless of how brief the excursion. This is fundamentally different from a TWA, which allows brief high-concentration periods to be averaged down across the shift. Ceiling values are assigned to substances capable of causing immediate, severe harm from even very short exposures.

15. D — The minimum recommended illumination for precision welding, joint preparation inspection, and close-tolerance verification is typically 500 lux or higher. At 150 lux, the welder cannot adequately see weld pool behavior, surface condition details, or dimensional features — inadequate lighting is a documented contributing factor to missed defects and weld quality problems in production environments.

16. B — Power source duty cycle ratings are established at a specific test ambient temperature (40°C for this unit). When ambient temperature exceeds the rated value, the internal components (transformer windings, rectifiers, thermal protectors) operate at higher temperatures than the rating was based on, requiring more frequent rest periods. The nameplate duty cycle only applies at the stated test temperature.

17. A — ANSI Z358.1 and equivalent Canadian standards require emergency eyewash stations to be reachable within 10 seconds of travel (approximately 10 metres) from any hazardous chemical work area. This 10-second requirement is based on medical evidence that the first 10–15 seconds of flushing are most critical — any delay allows chemicals to penetrate deeper into the ocular tissues before dilution and flushing can remove them.

18. C — Enclosed welding booths with curtained sides and limited ventilation trap radiant heat from completed welds, hot steel, and spatter, elevating the effective temperature inside the booth significantly

above the ambient shop level without the welder necessarily perceiving the cumulative thermal load. WBGT methodology accounts for radiant heat, humidity, and air movement — all three factors needed to accurately assess heat stress risk in this configuration.

19. D — Critical part inspections focus on specific high-consequence components whose failure could directly cause death or serious injury: lifting gear, pressure vessels, fall arrest systems, scaffolding. These are inspected more frequently and in greater depth than a general workplace inspection, which provides a broad review of all hazard types across the entire workplace on a scheduled periodic basis. The distinction is based on the consequence of failure, not on inspector credentials or triggering events.

20. B — WHMIS 2015 requires the employer to apply a workplace label whenever a product's supplier label is missing, illegible, or non-compliant. The workplace label must identify the product, provide safe handling instructions, and reference the SDS. The SDS must be accessible to all workers before they use the product — this obligation applies regardless of when the product was purchased or what transportation documentation exists.

21. A — Welding symbol tail notations identify the governing standard, specification, process code, or special instruction for the specific weld joint. "AWS D1.1" in the tail communicates that the AWS Structural Welding Code – Steel governs all aspects of this weld: acceptance criteria, procedure qualification, and welder certification requirements. This single notation aligns the fabricator and inspector on the authoritative technical reference for the joint.

22. C — For a 3-piece 90-degree equal-cut elbow, two weld joints connect the three pieces, dividing the 90-degree direction change: 90° ÷ 2 joints = 45° direction change per joint. Each miter face is cut at half the joint angle: 45° ÷ 2 = 22.5° from perpendicular to the pipe axis. The two end pieces each receive one cut; the center piece receives two cuts.

23. B — Backing bar removal is typically accomplished by CAC-A or grinding flush with the base metal surface. The resulting surface must then be NDE-inspected (MT or PT per the applicable code) to confirm complete removal and the absence of notches or sharp geometric discontinuities — any remaining stress concentrators at the fatigue-critical weld root location can initiate cracking under cyclic loading.

24. D — ASME Section IX QW-403.11 establishes that a WPS qualified on a higher Group number within a P-Number also qualifies welding on all lower Group numbers within that P-Number. Qualification on P1 Group 2 automatically covers P1 Group 1 without additional testing, because higher

Group numbers generally represent more restrictive material conditions within the same alloy class; qualifying the more demanding material covers the less demanding one.

25. A — Structural welding codes (CSA W59, AWS D1.1) specify minimum tack weld lengths to ensure tacks provide sufficient restraint against the thermal distortion forces during root pass welding. The minimum is typically 38 mm or 4 times the larger base metal thickness, whichever is greater. A 10 mm tack is far below this threshold and cannot prevent the joint from misaligning or closing under root pass thermal forces.

26. D — Pre-setting (pre-cambering) the free plate edge in the direction opposite to the expected distortion is the standard technique for compensating angular distortion without additional fixtures. When the weld shrinks during cooling, the preset angle is consumed and the final assembly approximates the intended flat geometry. The preset angle is determined from experience or distortion analysis of the specific joint configuration and heat input.

27. C — For ASME Section IX impact-tested procedures, weld metal Charpy specimens are oriented with the notch axis parallel to the plate surface with the notch bisecting the weld centerline at the required test depth. HAZ specimens have their notch at the specified distance from the fusion line. Both zones are independently evaluated because a weld can have adequate toughness in the deposit but inadequate toughness in the HAZ, or vice versa.

28. B — A calibrated contact pyrometer or thermocouple placed directly on the weld metal between passes — at the specific location where the next pass will be deposited — provides the most accurate reading of actual interpass temperature at the critical location. IR non-contact thermometers introduce emissivity uncertainty on rough weld surfaces, and temperature sticks provide a go/no-go indication rather than a precise calibrated measurement.

29. A — Subsurface defects at 2–5 mm depth require a volumetric examination method for reliable detection. Phased array UT can detect near-surface subsurface cracks in this depth range and can be configured with transducer angles optimized for transversely oriented defects. PT and MT are surface-only methods. RT has limited sensitivity for tight transverse cracks due to unfavorable orientation relative to the X-ray beam direction.

30. C — Transferring the heat number and piece mark to each component's location on the master plate before making any cuts is the most reliable method for maintaining individual piece traceability. Once the master plate is cut, the original mill marking may appear on only a few of the resulting pieces. Pre-

cut marking ensures each piece carries the correct identification from the moment of separation through all subsequent fabrication operations.

31. D — A narrow, deep slot in a multi-pass groove creates a bead with a depth-to-width ratio exceeding 1.0, concentrating solidification contraction stresses at the weld centerline and allowing low-melting impurity segregates to form a continuous liquid film there during solidification. The combination creates a high susceptibility to centerline solidification hot cracking. The correction is depositing tie-in passes on the sidewalls to build groove width before depositing a wider capping pass.

32. A — CE = 0.18 + (1.20/6) + (0.15+0.05+0.03)/5 + (0.10+0.20)/15 = 0.18 + 0.200 + 0.046 + 0.020 = 0.446. At CE = 0.446 and 25 mm thickness, CSA W59 typically indicates a 50–80°C minimum preheat range — the moderate CE warrants precaution without triggering the higher preheat levels associated with CE values above 0.45–0.50 or thicker sections.

33. B — For PJP bevel and J-groove welds with included angles less than 60 degrees, CSA W59 and AWS D1.1 specify effective throat equals groove preparation depth minus 3 mm (1/8 inch), accounting for the inability to consistently achieve complete root fusion in tight-angle groove configurations during production welding. For a 16 mm groove: 16 − 3 = 13 mm effective throat.

34. C — Peaking (angular misalignment) at a piping joint creates a local bending moment at the angular change under pressure loading, adding to the primary hoop stress. ASME B31.3 limits angular misalignment to prevent the combined stress — hoop plus local bending — at the weld toe from exceeding the material's allowable design stress, particularly because this stress concentrates at an already-critical location under cyclic pressure loading.

35. D — Under ASME Section IX, supplementary essential variables become mandatory when the construction code requires impact testing. A service temperature of −29°C triggers impact testing requirements under ASME VIII Div 1, which activates the ASME IX supplementary essential variables related to toughness (heat input, preheat, interpass temperature, PWHT parameters). A new PQR with Charpy specimens at the required test temperature must be generated to support the revised WPS.

36. A — In the ASME VIII pressure design formula, wall thickness and joint efficiency are inversely proportional when all other variables are constant. Reducing E from 1.00 to 0.70 requires wall thickness to increase by the reciprocal factor: $t_{new} = 12 \times (1.00/0.70) = 17.14$ mm, rounded up to the next standard plate thickness. This relationship explains why uninspected joints require significantly thicker vessel walls than fully examined joints.

37. B — An eccentric load applied away from a weld group centroid simultaneously creates direct shear stress from the vertical load component and a bending moment from the eccentricity. The most critically loaded weld element carries the vector sum of both stress components — direct shear plus moment-induced shear — and vector addition is mandatory to correctly determine the maximum resultant stress on that element.

38. C — Required throat = 200,000 N ÷ (0.67 × 480 MPa × 300 mm) = 200,000 ÷ 96,480 = 2.07 mm. Required leg = 2.07 × √2 = 2.07 × 1.414 = 2.93 mm, rounding to a 3 mm calculated minimum. The final design selects the larger of this calculated value or the applicable code minimum fillet size for the base metal thickness — the calculation provides the structural minimum and the code minimum prevents welds too small for reliable deposition.

39. D — The correct post-weld visual inspection sequence is: (1) clean the weld completely by removing all slag and spatter; (2) inspect weld size and throat against the drawing; (3) evaluate bead profile for convexity and concavity; (4) check for surface defects including cracks, porosity, undercut, and overlap; (5) verify weld length and location; (6) render the accept/reject decision against the governing code. This systematic sequence ensures complete coverage without missing defects.

40. A — CWB certification lists welding process as an essential variable. Certification in SMAW (process 111) does not extend to GMAW (process 131) even when base metal, joint type, and positions are identical. The physical skills, arc physics, and operator technique differ fundamentally between the two processes, requiring a separate GMAW qualification test before any production GMAW work begins.

41. B — Under AISC and CSA S16 fatigue provisions, the weld toe at the transverse end of a longitudinal cover plate is the highest stress concentration location in this connection. The abrupt change in cross-section stiffness at the plate termination creates a stress riser that, combined with the flexural stresses in the beam flange under cyclic loading, produces the highest fatigue damage rate — which is why this detail is classified in the lower fatigue categories (E or E').

42. D — CSA W59 limits fillet weld convexity because a steep weld toe angle creates a geometric stress concentration at the plate-weld interface. The limit is typically 3 mm plus 10% of the weld face width; for a 12 mm leg fillet (face ≈ 17 mm), the maximum is 3 + 1.7 = 4.7 mm. The measured 6 mm exceeds this limit and is rejectable — the steep toe profile reduces fatigue performance by creating a notch at the most stress-critical location.

43. C — Face bend specimens are bent with the weld face (cap side) in tension, testing cap pass quality and fusion at the outer surface. Root bend specimens are bent with the root in tension, testing root pass

penetration quality and fusion at the root. Both must pass independently because a weld can have excellent cap quality but deficient root fusion, or vice versa — testing only one side of the cross-section would allow joints with root defects to pass inspection.

44. A — The intersection of a 100 mm OD branch cylinder with the curved surface of a 200 mm OD header cylinder at 90 degrees produces a 3D space curve on the branch pipe surface that appears elliptical. This curve cannot be simplified to a true geometric shape, so the template is developed by coordinate projection or wrap-and-mark methods to accurately transfer the intersection profile onto the branch pipe for cutting.

45. B — CWB certification lists welding process as an essential variable; SMAW certification (process 111) does not extend to GMAW (process 131) under any conditions. The two processes involve different equipment, arc physics, and operator technique, and CWB maintains separate qualification tests for each. No production GMAW work may be performed based solely on an SMAW qualification certificate.

46. D — Under AISC and CSA S16, welded attachments to structural members are classified in Category E or E' because the weld toe on the main member creates a geometric stress concentration. The fatigue category depends on the attachment length measured parallel to the primary stress direction — longer attachments cause more severe stress concentration and fall into lower (worse) categories, which determines the allowable fatigue stress range for the connection.

47. C — A complete WPS must document all essential and non-essential variables for each pass type, including electrode diameter range, amperage range, voltage range, and travel speed range. Without these parameters, the welder cannot verify that actual operating settings are within the qualified range, and the inspector cannot confirm procedural compliance during production. The WPS is the production instruction document, not merely a summary of qualification test records.

48. A — Through-thickness loading of a structural flange plate is the primary concern for lamellar tearing — fracture of MnS sulfide inclusion planes aligned parallel to the plate rolling surface by through-thickness tensile stress. Rolled structural steel flanges can have significantly reduced through-thickness ductility, and the stress analyst is correct to flag this joint geometry for review, particularly if the material was not produced with enhanced Z-direction ductility (Z-grade steel).

49. B — A two-stage regulator reduces cylinder pressure to the delivery pressure in two sequential steps — first to an intermediate pressure, then to the final delivery pressure. This two-step buffering provides more stable and consistent delivery pressure as the cylinder depletes, because the intermediate stage

isolates the delivery stage from the large pressure drop on the cylinder side. Single-stage regulators reduce pressure in one step, resulting in more delivery pressure variation throughout the cylinder's service life.

50. C — Shielded nozzles incorporate a ceramic secondary shield around the nozzle exit that prevents double-arcing — the arc jumping from the electrode to the nozzle tip rather than transferring to the workpiece. Double-arcing rapidly destroys the nozzle and degrades cut quality. Shielded nozzles are preferred for precision applications requiring accurate, consistent standoff distance, providing protection against double-arc conditions that degrade dimensional accuracy and edge quality.

51. C — Flashback occurs when the combustion flame burns back past the tip and into the torch body or hoses, producing a characteristic high-pitched squeal from burning inside the equipment and visible smoke. Unlike a backfire, which briefly extinguishes at the tip, a flashback travels into the torch or hose assembly. After a flashback, the equipment must be disassembled, check valves and flashback arrestors inspected, and the root cause identified before returning the torch to service.

52. A — CAC-A produces three hazards not shared with standard SMAW at comparable amperages: significantly higher fume generation from the compressed air dispersion of molten metal; noise levels typically exceeding 100 dB, requiring impulse-rated hearing protection; and intense UV radiation from the exposed carbon arc requiring a minimum shade 12 lens. All three must be specifically addressed by PPE selection, which exceeds what SMAW demands.

53. B — Acetylene becomes unstable and potentially explosive when compressed above approximately 103 kPa (15 psi) in its pure form, so acetylene regulators are designed with a maximum delivery pressure limited to this safe threshold. Propane regulators are designed for much higher delivery pressures. Using a propane regulator on acetylene risks delivering acetylene above the safe pressure ceiling; thread standards differ between the two gases specifically to prevent accidental interchange.

54. D — CNC PAC requires complete manual parameter entry for each application because no internal database can automatically optimize all parameters for every combination of plasma system, material type, and thickness. Material type and thickness, plasma and shielding gas types and pressures, amperage, standoff height, cutting speed, kerf width compensation, and piercing parameters must all be correctly specified before the first production cut to achieve acceptable quality and dimensional accuracy.

55. C — The continuous bead of firmly attached spherical dross along the full cut length is the characteristic indicator of too-slow travel speed. At low travel speed, the excess heat over-oxidizes

material at the kerf bottom, producing molten iron oxide that has sufficient time to flow together and re-solidify as the firmly attached spherical bead before it can be expelled. Increasing travel speed allows the cutting products to be expelled cleanly before re-attachment occurs.

56. B — Before any OFC tip maintenance, both gas circuits must be fully depressurized. Closing both cylinder valves stops supply, but residual pressure remains in the hose lines. Both hoses must be bled by briefly opening each needle valve (directed away from the torch) to achieve zero pressure throughout both circuits. Residual hose pressure can project gas from a cleaned orifice into the worker's face or ignition zone during tip maintenance.

57. A — CAC-A is faster for bulk weld metal removal, especially in confined groove geometries where electrode access is easier than angle grinder access. However, the carbon electrode deposits carbon into the groove surface through arc diffusion, creating a carburized layer that must be mechanically ground back (approximately 1–2 mm) before re-welding on carbon-sensitive materials such as austenitic stainless steel, chrome-moly alloys, and duplex stainless. Grinding avoids carbon contamination but is slower for large volumes.

58. D — Cut edge quality in PAC on thin stainless steel results from the interaction of all four key parameters: amperage, travel speed, standoff height, and gas type and pressure. Any single parameter set outside its optimal range degrades cut quality even when all others are correctly set. Optimization requires establishing the correct combination for the specific material-thickness-system application — no single parameter governs quality independently.

59. C — Physical damage to the preheat orifices — from contact with the workpiece, rough handling, or use of an oversized tip cleaner — deforms or enlarges the orifice geometry, producing distorted, asymmetric, or non-parallel flame patterns. A damaged tip must be replaced because the distorted flame creates uneven preheat distribution across the cutting front, causing the reaction to be inconsistent or fail partway through the plate.

60. B — Medium carbon steel (0.45% C) has an elevated carbon equivalent that causes the heat-affected zone to air-harden rapidly during the fast cooling that follows OFC, creating a hard, brittle martensitic microstructure susceptible to cracking. Preheating to 150–200°C before and during cutting slows the HAZ cooling rate through the martensite transformation range, substantially reducing hardness and preventing cut-edge cracking during and after the thermal cutting operation.

61. A — In PAC, standoff distance determines arc length, which determines arc voltage. As standoff increases, the plasma jet diverges before reaching the plate, reducing the energy density at the kerf

below the threshold needed to sustain the cutting reaction through the full plate thickness. This relationship demonstrates why torch height control systems are essential in production PAC and why standoff is the primary determinant of penetration capacity at a fixed amperage.

62. D — When the OFC torch is tilted for bevel cutting, the cutting oxygen must traverse a longer path through the plate than the nominal plate thickness. For a 30-degree tilt on 25 mm plate, the actual cutting path = 25 ÷ cos(30°) = 25 ÷ 0.866 = 28.9 mm. This longer effective thickness requires reduced travel speed to allow the iron oxidation reaction sufficient time to propagate completely through the plate from top to bottom.

63. C — Copper-coated carbon electrodes are the standard for all CAC-A applications because the copper coating improves current transfer, arc stability, and electrode service life. The critical additional requirement for stainless steel specifically is that all CAC-A operations deposit carbon into the groove surface regardless of electrode type, and this carburized layer must be removed by mechanical grinding before repair welding to prevent carbon contamination of the repair weld deposit.

64. B — The two primary corrections for thick plate OFC are: (1) reducing travel speed to allow sufficient time for the iron oxidation reaction to propagate through the full plate depth; and (2) using the cutting oxygen pressure and tip size specified for the actual plate thickness. Using thin-plate parameters on thick plate is the most common first-time error — the cutting front falls behind the torch, producing severe backward drag lines and hard re-solidified dross that are the diagnostic indicators of this problem.

65. A — Varying kerf width on the same cut line — narrow where correct, wide where incorrect — is the diagnostic signature of a malfunctioning torch height control (THC) system. THC uses arc voltage feedback to maintain constant standoff; when the THC malfunctions, torch height oscillates. Correct standoff produces a focused plasma jet (narrow kerf); excessive standoff produces a diverged jet (wider kerf). No other common failure mode produces this specific width-variation pattern within a single cut.

66. D — Complete combustion of propane (C_3H_8) requires approximately 5 volumes of oxygen stoichiometrically — substantially more than the approximately 1–1.5 volumes required for acetylene. This chemical difference means the neutral preheat flame for propane requires the oxygen regulator to be set at proportionally higher pressure relative to the fuel gas pressure than when using acetylene. Operators must re-establish the neutral flame setting whenever switching fuel gases.

67. B — CAC-A requires DCEP (electrode positive) because the carbon arc must be maintained at very high temperature for effective operation. On DCEP, the electrode is the anode and receives approximately two-thirds of the arc energy, keeping the electrode tip at the required operating

temperature. On DCEN, energy concentrates at the workpiece (anode) rather than the electrode, producing an unstable, lower-temperature arc with poor groove quality, excessive electrode consumption, and surface carbon deposits.

68. C — Wet field conditions create multiple simultaneous hazards for OFC: electrical shock risk at moistened hose and torch connections, risk of steam generation if the preheat flame contacts pooled water, increased slip and fall hazard on wet surfaces, and potential equipment damage from water ingress. Each requires a specific control measure, and the combination substantially elevates overall risk compared to dry-condition OFC operations.

69. A — PAC consumables are system-specific: each manufacturer designs electrode, nozzle, and shield as a dimensionally and electrically matched set for a specific power source and amperage range. Mixing consumables from different systems — even when they physically fit — produces incorrect arc geometry, double-arcing, rapid premature failure, or fire hazards. Part number identification marked on each consumable is the only reliable method for assembling the correct matched set.

70. D — At high altitude, reduced atmospheric pressure creates a richer (more fuel-heavy) preheat flame at the same regulator settings that produced a neutral flame at sea level, because lower atmospheric pressure reduces the available ambient oxygen supporting secondary combustion. A carburizing preheat flame deposits soot on the plate before the cutting reaction begins, affecting cut initiation and quality. The oxygen regulator requires a slight upward adjustment to restore the neutral balance at altitude.

71. B — CAC-A depends on the compressed air jet to forcibly expel molten metal from the groove before it re-solidifies. Below the recommended air pressure (415 vs. 550–690 kPa), expulsion velocity and volume are insufficient to consistently clear molten metal from the arc path, causing arc instability, irregular groove profiles, embedded carbon deposits in the groove walls, and the fire hazard of expelled molten metal falling back onto the electrode holder and cables rather than being directed away from the operator.

72. C — AWS A5.5 C-series suffixes designate nickel alloy additions for enhanced sub-zero impact toughness: C1 ≈ 2.5% Ni, C2 ≈ 3.25% Ni, C3 ≈ 1% Ni. Nickel refines weld metal grain structure and lowers the ductile-to-brittle transition temperature, making E8018-C2 suitable for applications requiring impact toughness at temperatures as low as approximately −60°C, including cold-climate structural work, pressure vessels, and cryogenic storage applications.

73. A — E7018 uses a basic flux coating with lower ionization efficiency than rutile-coated electrodes. Reliable arc initiation with basic-coated electrodes requires higher open-circuit voltage (typically 65–90

V) to supply adequate ionization energy. A 55 V OCV is at or below the reliable arc-starting threshold for basic-coated electrodes, particularly in cold ambient conditions that further reduce electron emission efficiency from the electrode tip.

74. D — On 60 Hz AC, the arc extinguishes 120 times per second at each zero crossing and must re-ignite to continue. Rutile-coated electrodes (E6011) contain potassium compounds with low ionization potential that maintain plasma ionization across each zero crossing, enabling reliable re-ignition. E6010's cellulosic coating lacks these potassium ionizing agents, so the plasma recombines after each zero crossing and fails to re-establish, producing the characteristic unstable, sputtering behavior.

75. B — Uniformly distributed porosity through all pass levels — root, fill, and cap — points to a continuously deficient shielding source present throughout the entire welding sequence. Moisture-absorbed E7018 basic coating or a cracked electrode coating compromises shielding across all arc-on periods, making the electrode the continuous contamination source. Root contamination or sidewall paint would produce porosity concentrated in specific pass levels rather than uniformly through all levels.

76. D — The preheat requirement for any welded joint is governed by the member with the more demanding specification — in this case, the 50 mm thick plate at 100°C minimum. The thicker plate's higher thermal mass and higher CE dominate the HAZ cooling behavior, and the preheat must be applied and verified across the entire joint area. Preheating only one member of a welded joint is impractical and ineffective in controlling the actual HAZ cooling rate.

77. A — CSA W59 limits groove weld cap reinforcement to prevent the stress concentration created at the weld toe where a sharply rising reinforcement meets the flat plate surface, creating a notch that concentrates stress under transverse loading. The typical maximum for structural plate groove welds is 3 mm (1/8 inch). A 5 mm reinforcement exceeds this limit and requires grinding to bring the weld into compliance.

78. C — AWS A5.5 B-series suffixes designate the Cr-Mo alloy content of the weld deposit: B2 = 1.25Cr-0.5Mo, B3 = 2.25Cr-1Mo (matching P22 base metal), B9 = 9Cr-1Mo-V. The B3 designation in E9018-B3 specifically identifies the 2.25Cr-1Mo composition matching P22, providing both the required tensile strength (80 ksi minimum) and the correct alloy content for creep resistance at elevated service temperatures. E9018-B3 is the standard SMAW electrode for P22 pressure piping.

79. B — AWS A5.5 covers low-alloy steel SMAW electrodes containing deliberate alloying additions (Cr, Mo, Ni, V, and/or elevated Mn) that produce enhanced properties not achievable with A5.1 carbon

steel electrodes. These additions provide higher tensile and yield strength, improved notch toughness, and sometimes better elevated-temperature performance. The E8018-G designation provides 80 ksi minimum tensile strength with a flexible alloy composition approach to meeting the mechanical requirements.

80. D — Hydrogen-induced cold cracking requires the simultaneous presence of hydrogen, susceptible microstructure, and tensile stress. Maximum hydrogen control addresses all three: H4/H2 electrodes from a maintained holding oven minimize hydrogen in the deposit; preheat and interpass temperature slow the cooling rate and extend the diffusion time for hydrogen to escape; joint surface cleaning removes extraneous hydrogen sources; and post-weld soak provides extended diffusion at elevated temperature. Each measure addresses a different source — all are necessary for reliable prevention on high-strength steel.

81. A — CSA W59 and AWS D1.1 permit welding over zinc-rich primer within specified maximum dry film thickness (typically 25–75 microns) because zinc in thin coats deposits preferentially to the slag rather than causing severe weld metal porosity. All other primer types — alkyd, epoxy, chlorinated rubber, intumescent — generate organic decomposition products that consistently produce weld metal porosity, HAZ contamination, or excessive fume at levels that exceed what structural welding codes tolerate, requiring their complete removal.

82. C — E7018 is classified and tested exclusively for DCEP. Switching to DCEN alters the energy distribution (more to the base metal, less to the electrode), changes the ionization behavior of the basic coating, and produces arc instability, excessive spatter, and potentially elevated diffusible hydrogen. More critically, changing polarity is a WPS essential variable — welding on DCEN constitutes use of an unqualified procedure, which is not acceptable regardless of the intended operational benefit.

83. B — The work angle is the primary control for distributing arc force in horizontal fillet welding. The correct bisecting angle of approximately 45° from horizontal directs arc force equally toward both the vertical web and the horizontal base plate fusion zones simultaneously. Setting the electrode at 90° to the vertical plate (nearly parallel to the floor) concentrates all arc force against the horizontal plate only, preventing the arc from reaching the vertical plate toe and causing the observed cold lap.

84. D — The practical guideline is that electrode overall diameter (including coating) should not exceed approximately one-half the groove width to allow adequate manipulation, pool visibility, and prevention of coating contact with groove sidewalls. E7018 coating adds approximately 2–3 mm per side to the core diameter. A 4.0 mm core electrode (approximately 6–7 mm overall) is the largest practical size for a 16 mm groove without risking coating-to-sidewall contact that would contaminate the weld or produce slag inclusions.

85. A — Forward arc blow at the joint end occurs because the unbalanced steel path ahead of the electrode concentrates magnetic flux in the direction of travel, deflecting the arc forward. The most effective corrections are: tilting the electrode backward toward the completed weld (redirecting the arc into the joint); moving the work lead to the end of the joint being approached (providing a symmetric return path); or switching to AC (eliminating the DC-generated magnetic field asymmetry).

86. C — The 60% duty cycle rating on a 10-minute basis at rated amperage means the power source can arc for 6 minutes and must rest for 4 minutes per 10-minute period at 400 A. Using less than rated amperage reduces thermal loading and increases the allowable on-time above 60%; using higher amperage increases thermal loading and reduces the allowable on-time below 60%. Understanding this relationship prevents tripping the thermal protection in production.

87. B — The manufacturer's amperage tables are calibrated for flat-position welding. For the overhead and lower-vertical segments of 5G fixed pipe welding, experienced welders deliberately reduce amperage below the flat-position table minimum to improve pool control where gravity opposes the weld pool. The WPS-specified amperage range governs code compliance — it is the authoritative reference for pipe welding applications, not the manufacturer's flat-position table.

88. D — The hot pass is deposited immediately after the E6010 root pass at slightly higher amperage (5–10 A above root pass), burning off the slag slivers, worm-holes, and irregular crown profile characteristic of cellulosic root beads, and providing a clean, fully-tied-in surface for subsequent fill passes. Depositing it while the root is still warm allows the slightly elevated heat to be effective without needing to re-establish the full preheat cycle on a cold joint.

89. C — For a horizontal (2F) fillet weld, the correct work angle bisects the angle between the horizontal base plate and the vertical web at approximately 45° from horizontal, directing arc force equally toward both fusion zones. Setting the electrode at 90° to the vertical plate (nearly parallel to the floor) concentrates all arc force against the horizontal plate, bypassing the vertical plate toe entirely and producing the cold lap condition observed at the vertical member.

90. A — The push (forehand) technique in GMAW directs the arc and shielding gas ahead of the pool, preheating the parent metal before the pool arrives and producing a wider, flatter, shallower penetration profile. The drag (backhand) technique directs arc force back into the existing pool, concentrating energy more deeply and producing a narrower, higher-crowned, deeper penetration bead. Push is selected when wide, flat beads with controlled shallow penetration are required.

91. B — Self-shielded FCAW wires contain metallic scavengers (aluminum, titanium) and gas-generating flux compounds in the hollow core. In the arc, these react with atmospheric nitrogen and oxygen before they can contaminate the pool (scavenging), while flux decomposition gases (CO_2, CO) displace air from the arc zone to provide shielding from within the arc itself. This self-contained protection mechanism functions independently of any external gas supply.

92. D — Switching from 0.9 mm to 1.2 mm wire at the same WFS (m/min) increases wire cross-sectional area by approximately $(1.2/0.9)^2 = 1.78\times$. The power source must supply substantially more current to melt this greater wire volume per unit time, directly increasing the welding amperage. The larger wire also deposits more mass per metre, so both the welding current and the deposition rate (kg/hr) increase significantly when switching to the larger diameter at identical WFS.

93. C — In AWS A5.20, the second digit in FCAW classification communicates positional capability: "0" (E70T-4) = flat and horizontal positions only; "1" (E71T-8) = all positions including vertical-up and overhead. Both wires are self-shielded and suitable for windy outdoor conditions, but only E71T-8 carries the "1" all-position designation required for vertical-up welding.

94. A — Switching from 100% CO_2 to 75/25 Ar/CO_2 provides: a more stable arc with significantly less spatter; the ability to use spray transfer mode (which 100% CO_2 cannot support at any amperage); and slightly better deposition efficiency. The primary trade-offs are higher gas cost and marginally less penetration depth — both are typically acceptable in structural production GMAW where bead quality and reduced cleanup time are priorities.

95. B — Burnback occurs when arc energy melts wire faster than the wire feed system advances it, allowing the arc to burn back to the contact tip. Increasing WFS directly corrects this by advancing fresh wire into the arc zone faster than the arc can recede, preventing the back-burn from propagating to the tip. Burnback is fundamentally a speed mismatch problem: the wire advance rate is slower than the arc burn-off rate.

96. D — DC welding current magnetizes structural steel around the return current path. When the work lead is distant from the arc, the long magnetized path creates an asymmetric magnetic field around the arc, deflecting it in the direction of concentrated flux. Moving the work lead closer to the arc reduces the length of the magnetized return path, decreasing the magnetic field asymmetry and correcting the arc deflection.

97. C — When WFS exceeds what the arc energy can melt, unmelted wire contacts the molten pool before the arc melts it, causing a short circuit. The short circuit clears explosively, extinguishing the arc

and ejecting spatter. The wire re-advances, the arc re-ignites, the wire reaches the pool before melting again, and the cycle repeats continuously. Reducing WFS to match the set voltage allows the arc to continuously and stably melt the advancing wire.

98. A — Spray transfer is physically dependent on the electromagnetic pinch force mechanism, which requires the specific plasma electromagnetic environment provided by argon-rich shielding gas (minimum approximately 80% Ar). The argon plasma generates the conditions needed for the electromagnetic pinch force to dominate over gravitational and surface tension forces, creating fine spray droplets. CO_2 plasma does not provide these conditions at any amperage — spray transfer is physically impossible with 100% CO_2.

99. B — Block sequencing — completing the full cross-section fill of short sections before advancing — allows each solidified block to physically restrain thermal contraction of the adjacent section being welded. This distributed restraint prevents the entire joint from contracting in an unrestrained way and distributes shrinkage forces more evenly along the joint length, substantially reducing net angular distortion at clamp removal compared to full-length sequential pass deposition.

100. D — Root bead washout in GMAW open root welding occurs when the heat input is excessive for the root gap — the arc burns through rather than bridging the root opening with deposited metal. Reducing WFS (which directly reduces amperage in CV GMAW) lowers the heat input at the root. Controlling travel speed and keyhole size matches the energy input to the root gap geometry, preventing both washout from excess heat and lack of penetration from insufficient heat.

101. A — Copper's exceptionally high thermal conductivity (approximately 400 W/m·K versus ~16 W/m·K for stainless steel) conducts heat away from the weld zone so rapidly that GTAW on copper requires significantly higher welding current, extensive preheat (typically 200–400°C depending on section size), and often preheating of the entire fitting assembly to maintain an adequate pool temperature throughout. Copper's high CTE also increases hot cracking susceptibility and distortion risk.

102. C — Nickel alloys such as Inconel 625 have significantly higher surface tension and viscosity in the molten state than carbon or stainless steels, producing the characteristic sluggish pool that surprises welders transitioning from steel. The practical implications are: direct filler metal precisely to where it is needed rather than relying on pool flow; use slightly higher heat input for complete sidewall fusion; and use stringer beads exclusively, as wide weaving creates elongated pools susceptible to centerline hot cracking in these alloys.

103. B — Silicon bronze braze-welding (ERCuSi-A) deposits filler metal at temperatures below the cast iron's fusion point through a brazing-type wetting mechanism, without melting the cast iron base metal.

This prevents formation of white iron (iron carbide) in the HAZ — the metallurgical event responsible for cracking in cast iron fusion welds. Silicon in the filler promotes wetting adhesion on both the steel insert and cast iron housing surfaces at the braze temperature.

104. D — Orbital GTAW's primary advantage for regulated industries is its ability to produce highly consistent, repeatable welds with complete electronic documentation of all parameters for each individual joint. Automation eliminates the human skill variable, while parameter logging provides the per-joint records required by FDA, ASME BPE, and similar regulatory frameworks — this combination of consistency and traceability is the defining advantage over manual GTAW for food-grade and pharmaceutical applications.

105. A — Extending the tungsten electrode 20 mm beyond the nozzle places the hot tip well outside the effective protective radius of the shielding gas stream. The tungsten oxidizes rapidly in air above approximately 200–300°C, forming tungsten oxides that are carried into the weld pool, contaminating the deposit with dark inclusions. The resulting contamination darkens the weld face and introduces hard tungsten particles that can nucleate cracks in the weld metal.

106. C — At the 12 o'clock overhead segment of 5G root pass welding, gravity acts directly downward against the molten pool. The same heat input that produces correct root geometry at the side positions — where gravity acts laterally — creates an oversized, overly fluid pool at the overhead position that falls through the root gap. Reducing amperage via foot pedal as the arc approaches the overhead zone, or increasing travel speed, reduces heat input per unit length to prevent pool washout.

107. B — The foot pedal allows the welder to dynamically adjust amperage in real time as conditions change throughout the joint — reducing current as heat builds up in the fitting, and increasing it as geometry or fitup demands more energy. A fixed pre-set amperage cannot adapt to these changing thermal conditions, frequently resulting in burn-through on late passes as residual heat accumulates in thin-wall assemblies. Real-time adaptive control is the foot pedal's primary quality benefit.

108. D — Rotameter flowmeters are calibrated for a specific gas, typically argon for GTAW applications. The ball floats when the hydrodynamic lifting force from the flowing gas equals the ball's weight. Since helium is approximately 10 times less dense than argon, a higher volumetric flow rate of helium is required to generate the same lifting force at the same ball height position. This means an argon-calibrated meter reading for helium understates the actual helium flow, and a gas-specific correction factor must be applied to obtain the true flow rate.

109. A — The downstream vent of a back purge system is the last point through which atmospheric air is displaced, and readings there represent the state of the most downstream area of the spool. For

complex geometries with internal baffles, pockets, or obstructions, air can remain locally trapped near the actual weld zone even after the vent achieves an acceptable reading. For critical or geometrically complex applications, oxygen measurement must be taken as close to the actual weld zone as possible to confirm adequate purge throughout.

110. C — Wide weaving on austenitic stainless steel and nickel alloys creates elongated weld pools with high length-to-width ratios. During solidification, low-melting phosphorus- and sulfur-containing compounds segregate toward the pool centerline, forming a continuous liquid film. Solidification contraction stresses pull this centerline liquid film apart, producing centerline solidification hot cracks. Stringer beads maintain compact pool geometry that disrupts this segregation pathway.

111. B — Without HF arc starting, GTAW requires the electrode to make physical contact with the work surface to initiate the arc. This contact risks transferring tungsten fragments from the electrode tip into the weld deposit as dark inclusions. Using a separate copper starting tab to initiate the arc — then moving to the joint — prevents tungsten contamination from entering the production weld metal in safety-critical applications.

112. D — Aluminum oxide begins reforming immediately on any freshly cleaned surface, so welding must follow cleaning promptly. The preferred cleaning methods are mechanical (dedicated stainless steel brush used exclusively on aluminum to prevent cross-contamination from previously worked materials) or chemical (acetone wipe followed by appropriate acid or alkaline etch). The dedicated brush requirement is critical because a brush used on both carbon steel and aluminum transfers iron particles to the aluminum surface, causing inclusions and arc contamination.

113. A — A convex inside root bead combined with no visible external indication of through-penetration means the filler metal was deposited on the pipe's interior surface without melting through the root gap. The arc never achieved through-wall fusion — the filler built up on the inside surface as a deposit without any metallurgical bond through the pipe wall. This results from a root gap too tight for through-penetration or amperage too low to achieve full-wall fusion from the outside.

114. C — Straw-gold discoloration on a completed GTAW bead indicates the weld metal surface oxidized during cooling after arc extinction, while still above the temperature at which steel reacts with atmospheric oxygen (approximately 300–400°C). This occurs when post-arc argon flow duration or flow rate is insufficient to maintain protective coverage until the metal cools below the oxidation threshold. Extending post-flow time or increasing flow rate prevents this surface oxidation.

115. B — Increasing the EP percentage increases the proportion of the AC cycle during which the electrode is the anode, receiving concentrated arc energy. More time as the anode increases the thermal

load on the tungsten tip, grows the electrode ball larger, and requires either a larger electrode diameter or reduced overall amperage to prevent electrode overheating and pool contamination. Higher EP percentage also increases cathodic cleaning intensity on the aluminum oxide surface.

116. D — Moisture adsorbed onto GTAW filler wire during storage in humid conditions is a direct hydrogen source. At each filler dip, surface moisture is instantly dissociated by the arc, releasing atomic hydrogen that dissolves into the pool and causes porosity as it escapes during solidification. The intermittent dip frequency creates the irregular, distributed pattern of individual pore locations that characterize this source. Sealed, dry storage and prompt use after any extended storage period prevents this contamination.

117. A — Helium-argon blends provide significantly higher arc energy and plasma temperature than pure argon on thick aluminum sections, enabling deeper penetration and faster travel speeds — major productivity advantages on thick material. The trade-offs are that helium arcs are less stable than pure argon arcs, require higher shielding gas flow rates because helium's low density causes it to disperse from the arc zone quickly, and helium costs more per unit volume. These trade-offs must be balanced against the penetration and speed benefits for each specific application.

118. C — The combination of reduced amperage (via foot pedal), increased travel speed, and slight weaving collectively manages the three key variables causing melt-through at thin-section transitions: the foot pedal limits heat input per unit time; increased travel speed limits heat input per unit length; and weaving distributes thermal load more broadly, preventing concentration of all arc energy at a single point. No single adjustment provides as effective control as the combination for managing these transitions in thin stainless sheet.

119. B — For duplex stainless steel, the acceptable back-side color is limited to silver to very light straw. A visible straw-gold color indicates moderate chromium oxidation above the acceptable level. Duplex stainless is particularly sensitive because surface oxidation can locally alter the ferrite-to-austenite phase balance and deplete the passive layer, affecting both corrosion resistance and mechanical properties in the weld zone. The root pass must be removed and re-welded with an improved purge.

120. D — Under CWB qualification standards, a pipe groove weld qualification on a given OD covers welding on pipe at or above that diameter. The 2-inch (60.3 mm OD) test pipe establishes the lower diameter limit; all larger diameters including 12-inch (323.9 mm OD) fall within the qualified range without additional testing. The restriction is on minimum pipe diameter — a welder cannot use this qualification for pipe smaller than the test OD without re-qualifying on the smaller size.

121. B — Wire oscillation's primary efficiency advantage is enabling a single arc pass to cover the full groove width with adequate fusion to both sidewalls, replacing 3–4 adjacent stringer beads with one oscillated pass. This reduces arc starts and stops, eliminates most inter-pass cleaning cycles between adjacent stringers, and substantially reduces total arc-on time for the groove fill — the main production justification for investing in an oscillation unit on heavy vessel shell work.

122. A — Reducing wire diameter from 4.0 mm to 3.2 mm at constant current increases current density in the smaller cross-section, which increases the melt-off rate and concentrates arc energy more narrowly, producing a deeper, narrower bead profile with greater penetration per unit width. This is why smaller-diameter SAW wire is preferred for root passes — the higher current density improves penetration into the root face and enhances complete root fusion.

123. C — Basic SAW fluxes are more effective deoxidizers than acidic fluxes, producing weld metal with lower total oxide inclusion content. Oxide inclusions serve as stress concentration sites and cleavage initiation points under impact loading — fewer, smaller inclusions require more energy for fracture propagation, raising the Charpy absorbed energy and lowering the ductile-to-brittle transition temperature. This is the metallurgical basis for specifying basic flux in all SAW applications requiring low-temperature Charpy impact performance.

124. D — SAW flux is granular material applied from a hopper above the torch by gravity, requiring the weld pool to be in the flat or near-horizontal position so the flux can accumulate and remain over the arc zone. In vertical or overhead orientations, the granular flux falls away from the arc zone immediately, exposing the arc to the atmosphere and eliminating the flux's shielding, arc confinement, and metallurgical functions simultaneously. This gravity dependence is the fundamental process limitation restricting SAW to flat and horizontal positions.

125. B — Convex SAW bead profiles with steep, sharp weld toe transitions create geometric crevices between the bead crown and the groove sidewalls that subsequent flux and molten slag cannot fill when the next pass is deposited, trapping slag at the toe-to-sidewall interface. Adjusting SAW parameters to produce flatter, wider beads that blend smoothly into the sidewalls eliminates these slag-trapping geometries and prevents the linear interface inclusions detected by radiographic examination.