PRACTICE EXAM 8: RED SEAL WELDER SIMULATION (125 QUESTIONS)

1. A workplace violence prevention program must contain which minimum elements under applicable Canadian OHS legislation?

A. A written policy statement, a mandatory waiting period before reporting incidents to allow collection of complete information, and a designated violence response officer available during all working hours

B. A written policy statement, procedures for workers to report incidents and threats without reprisal, an investigation process for reported incidents, and controls to protect workers from identified workplace violence hazards

C. A posted bulletin describing violent incident reporting, a suggestion box for anonymous submissions, and quarterly safety committee reviews of reported incidents throughout the calendar year

D. A written violence prevention policy signed by senior management and a designated safety officer with authority to immediately terminate any employee who commits an act of workplace violence

2. When a worker newly hired for a welding fabrication position is under 25 years of age, what orientation must the employer provide before the worker begins operating any welding equipment?

A. A written exam based on the employer's safety manual must be completed with a minimum score of 80% before any hands-on equipment operation is permitted under provincial OHS legislation

B. A minimum 40-hour classroom-based WHMIS orientation course delivered by a registered safety trainer before any site access is granted to the new young worker

C. A workplace orientation covering the specific hazards of the work, emergency procedures, first aid equipment locations, injury reporting procedures, and the safe work procedures specific to the equipment the worker will operate

D. Only a digital e-learning module covering general health and safety principles, completed within 30 days of hire, with no on-site walk-through required to satisfy the orientation obligation

3. A welding crew transfers flux paste from a large supplier container into smaller unlabeled squeeze bottles for convenience during field work. Under WHMIS 2015, what labeling obligation does this action create?

A. Each small container must have a workplace label applied that includes at minimum the product identifier, safe handling information, and a reference to the SDS location before the product is used from that container

B. No additional labeling is required provided the original supplier container with its compliant WHMIS label remains on-site in close proximity to where the decanted product is being used

C. The small containers only require labeling if the work is performed more than 10 metres from the original supplier container where the full supplier label cannot be read by the worker

D. The small containers must be returned to the supplier for proper labeling — decanting WHMIS products into unlabeled containers is prohibited regardless of the product hazard classification

4. A GMAW power source in the welding shop catches fire from an internal electrical fault. Which fire extinguisher classification is required, and why must water-based extinguishers not be used on this fire?

A. Class A extinguisher — electrical equipment fires are Class A because the combustible insulation on the windings is the primary fuel, and water is the most effective suppression agent for burning organic insulation materials

B. Class B extinguisher — electrical fires are classified as Class B because fumes from burning insulation create a vapor condition equivalent to a flammable liquid fire under the GHS physical hazard framework

C. Class D extinguisher — copper windings and aluminum components are combustible metals requiring Class D dry powder for effective fire suppression when energized electrical faults occur

D. Class C extinguisher — energized electrical equipment fires require a non-conductive extinguishing agent; applying water to an energized electrical fire creates an electrical shock hazard because water conducts electricity and could result in electrocution of the person applying it

5. Before using a personal fall arrest system at the start of a shift, which components must a welder inspect, and what specific condition requires the entire system to be removed from service immediately?

A. The welder must inspect only the connecting carabiner and lanyard for visible damage — harness webbing inspection is required only at annual scheduled maintenance intervals performed by a competent person

B. The welder must inspect the complete system including the body harness webbing, stitching, and hardware; the energy-absorbing lanyard or self-retracting lifeline; and all connecting hardware; any system that has arrested a fall must be immediately removed from service and not re-used until inspected and recertified by a competent person

C. Inspection is limited to verifying the anchor point strength rating — if the anchor is rated for the worker's weight with a 2:1 safety factor, the connecting hardware and harness require only monthly supervisor inspection rather than pre-shift checks

D. Full inspection is only required when work is performed above 6 metres — below 6 metres, a visual observation by the crew supervisor before work begins satisfies the fall arrest equipment inspection requirement

6. A welding crew is working a 12-hour rotation shift. What does Canadian OHS fatigue management guidance require regarding rest provisions during extended shifts?

A. Most Canadian OHS regulations require a minimum rest period within the shift and prescribe maximum consecutive hours before mandatory rest — in many jurisdictions, workers must not work more than five consecutive hours without a rest period, and employers must identify and manage fatigue risk factors through a written safety management system

B. No mandatory rest breaks are required in industrial workplaces because fatigue management is the individual worker's personal responsibility — employers are only required to intervene when a worker appears visibly impaired and presents an immediate hazard to others

C. Rest breaks are only required when work involves manual lifting above 15 kg — welding work qualifies as a fine motor task and is therefore classified as sedentary, exempting it from fatigue management requirements under occupational health standards

D. The only mandatory rest requirement is a single unpaid 30-minute meal break taken at the midpoint of the shift — no additional rest periods are required and any extra breaks are taken at the worker's own time

7. An ergonomics assessment identifies a production welder performing repetitive overhead SMAW welding for four hours per day. Which intervention most directly reduces cumulative musculoskeletal loading on the shoulder and neck?

A. Increasing the electrode diameter from 3.2 mm to 4.8 mm to reduce the number of electrode changes, thereby decreasing the number of times the welder must reach overhead to reposition the electrode holder

B. Providing a vibration-dampening electrode holder with a foam grip that reduces transmission of arc vibration from the electrode holder to the welder's wrist and forearm

C. Repositioning the work using a positioner, tilt table, or fixture that rotates the workpiece to flat or downhand orientation, eliminating the sustained overhead posture requirement and removing the root cause of shoulder and neck loading

D. Providing the worker with a cervical collar and shoulder support brace to be worn during all overhead welding periods while the overhead work continues at the same exposure duration and intensity

8. An emergency eyewash station in a fabrication shop delivers water at approximately 4°C in winter conditions. Why is this temperature problematic, and what is the required water temperature range for eyewash stations?

A. There is no temperature requirement for emergency eyewash water — any non-frozen temperature is acceptable because the cooling effect of cold water reduces ocular inflammation and is clinically beneficial for chemical eye injuries

B. Eyewash water must be a minimum of 30°C — chemical eye injuries cause acute inflammation and the flush water must approach body temperature to prevent thermal shock to the injured ocular tissues

C. Eyewash water temperature is regulated only for facilities using corrosives with pH below 3 or above 11 — for welding fluxes and cutting fluids, cold water temperature has no clinical effect and requires no regulation

D. Emergency eyewash water must be tepid — typically 15–37°C per ANSI Z358.1 — because water that is too cold causes reflex blinking that prevents adequate flushing, may cause the victim to abandon the 15-minute flush prematurely, and risks hypothermia during the required extended flushing period

9. A compressed argon/CO_2 welding shielding gas cylinder carries the WHMIS 2015 gas cylinder pictogram. Which physical hazard class does this pictogram represent, and what specific hazards does it communicate?

A. The gas cylinder pictogram identifies the gas as a Class 3 flammable liquid because CO_2 in the blend liquefies under pressure in the cylinder, classifying it with flammable liquids under the WHMIS physical hazard framework

B. The gas cylinder pictogram represents the gases under pressure hazard class, communicating that the container may explode if heated, that rapid release can cause cryogenic injuries, and that asphyxiants like argon can displace oxygen and create an oxygen-deficient atmosphere in enclosed spaces

C. The gas cylinder pictogram indicates the blend is flammable and requires storage in a ventilated flammable-material cabinet with a minimum 3-metre separation from ignition sources at all times

D. The gas cylinder pictogram is a general storage warning indicating the cylinder pressure must never drop below 500 kPa — the residual pressure prevents atmospheric contamination of the cylinder contents from the valve

10. A worker uses a supplied-air respirator connected to a Grade D breathing air supply for welding stainless steel in a confined space. What minimum and maximum oxygen content must Grade D breathing air contain?

A. Grade D breathing air must contain between 19.5% and 23.5% oxygen — below 19.5% creates hypoxic conditions, while above 23.5% creates an oxygen-enriched atmosphere that dramatically increases fire and explosion risk to an unacceptable level

B. Grade D breathing air must contain a minimum of 25% oxygen to provide adequate enrichment for the elevated metabolic demands of heavy physical labor in a confined space welding environment

C. Grade D breathing air has no specified oxygen content requirement — the pressure-demand regulator in the SAR or SCBA automatically compensates for any oxygen variation in the supply, making oxygen percentage irrelevant to Grade D compliance

D. Grade D breathing air must contain exactly 21% oxygen to replicate natural atmospheric air — any deviation from 21% in either direction renders the air supply non-compliant with Grade D specifications regardless of the application

11. A welding crew must perform SMAW repairs inside a large horizontal pressure vessel with a single 600 mm diameter manway and has been cleaned and purged with nitrogen after hydrocarbon service. How must this space be classified in most Canadian jurisdictions?

A. This is a hazardous open space because it has a single entry point, but since it has been cleaned and is at atmospheric pressure it does not meet the confined space definition and no confined space entry procedures are required

B. This is a Class 1 low-hazard confined space because the vessel has been cleaned and purged — no entry permit or atmospheric monitoring is required beyond standard fire watch procedures for remote welding

C. This is a permit-required confined space — the restricted manway entry, history of hydrocarbon service creating contamination potential, the nitrogen purge creating an oxygen-deficient atmosphere, and the welding activity creating additional atmospheric hazards all require a full confined space entry permit with a standby person

D. A confined space permit is only required if more than two workers will be inside simultaneously — for a single-welder repair, written supervisor authorization is sufficient without a full permit procedure under any Canadian jurisdiction

12. A welding grinding area measures 102 dB(A) time-weighted average. Which hearing protection combination provides the greatest total noise reduction, and what consideration governs the selection of double protection devices?

A. Two pairs of foam earplugs worn simultaneously provide the greatest theoretical attenuation because the double-layer foam creates a complete seal around the entire outer ear canal on both sides of the head

B. The greatest noise reduction is always achieved by the single device with the highest individual NRR rating — combining two lower-NRR devices cannot exceed the attenuation of a single maximum-NRR device under any conditions

C. No hearing protection can provide effective noise reduction at 102 dB(A) — the only acceptable engineering control at this level is complete enclosure of the grinding equipment or substitution with a lower-noise alternative cutting method

D. Earplugs worn beneath ear muffs provides greater attenuation than either device alone — when using double protection, the combined value is estimated by adding 5 dB to the higher NRR of the two devices; both devices must be comfortable and compatible to ensure consistent correct use throughout the full exposure period

13. A maintenance welder must service a robotic GMAW welding cell. The robot controller has been de-energized and locked out, but the welding power source remains energized for a scheduled electrical department test on the next shift. What hazard exists and what is the required corrective action?

A. The welding power source remains a hazardous energy source even with the robot locked out — contact with energized welding cables, connections, or the torch can cause serious electrical shock; the welding power source must also be isolated and locked out before any maintenance work begins inside the robot cell

B. A locked-out robot controller means all energy in the cell is controlled — the welding power source only activates when commanded by the controller, so no separate lockout of the welding power source is required for cell maintenance

C. The welding power source may remain energized if the robot arm is physically restrained with a mechanical stop — arm restraint protects against all cell hazards because robot motion is the primary danger and its elimination eliminates all risk

D. The welder can work in the cell with the welding power source energized provided the torch trigger safety lock is engaged — an engaged trigger safety lock is the recognized equivalent to lockout for welding power sources under all applicable OHS standards

14. A welding shop has workers developing manganese fume-related symptoms despite consistently wearing air-purifying respirators during SMAW operations. Which control hierarchy approach most effectively addresses this ongoing problem?

A. Upgrade the respirators to a higher protection factor — switching from P100 half-face to powered air-purifying respirators addresses the protection gap causing the symptom development without disrupting production operations

B. Install local exhaust ventilation with fume extraction at the arc to capture manganese fume at the source — engineering controls reduce the environmental exposure level and do not rely on correct PPE use for effectiveness, addressing the root cause rather than protecting workers against it

C. Rotate workers more frequently through the SMAW task — administrative controls that divide exposure time among multiple workers reduce each individual's daily manganese dose below the occupational exposure limit threshold

D. Increase the general ventilation air changes per hour throughout the entire shop — dilution ventilation is the most effective control for welding fume because it distributes fume evenly throughout the shop and reduces average concentration for all workers simultaneously

15. Following an arc flash incident where a welder received burns while connecting work leads near an energized panel, the investigation team applies root cause analysis methodology. Which approach yields the most useful information for preventing recurrence?

A. Identifying the specific worker who violated the procedure and documenting the disciplinary action taken to deter future procedural violations by all workers in the facility

B. Determining the proximate cause and writing a new procedure requiring workers to check panel status before connecting leads, then distributing the updated procedure to all workers via company email

C. Using root cause analysis techniques such as the 5-Whys or fishbone diagram to identify underlying systemic failures — organizational, procedural, training, supervision, and equipment factors — that created conditions for the incident; corrective actions at each systemic level prevent recurrence more effectively than addressing only the immediate cause

D. Calculating the statistical probability of incident recurrence from industry database rates and using the statistical result to determine if the risk is within the organization's defined acceptable tolerance range

16. Under the Canada Labour Code and provincial OHS legislation, what specific information must an employer provide to a new worker before they begin work at a worksite?

A. New workers must receive orientation covering the hazards specific to their job, first aid facility locations, emergency procedures and evacuation routes, their rights under OHS legislation including the right to refuse dangerous work, and the names of their JHSC representatives

B. New workers must complete a provincially administered certification exam before starting work — employers cannot deliver the required orientation themselves and must engage a provincially certified OHS trainer for all new worker sessions

C. The only mandatory component for federally regulated worksites is a company-specific WHMIS training program — all other orientation topics are voluntary and provided at employer discretion based on the specific risk level of the assigned work

D. Orientation requirements apply only to workers under 25 years of age or with less than one year of trade experience — experienced journeypersons are exempt from orientation requirements when changing employers within the same industry sector

17. A provincial OHS inspector visits a welding fabrication shop unannounced. Which statement correctly describes the inspector's legal authority during this visit?

A. The OHS inspector must provide 48 hours advance written notice before conducting a workplace inspection — unannounced inspections are only permitted when a fatality or critical injury has occurred within the preceding 24 hours

B. The inspector can only observe and discuss conditions with management — the inspector cannot speak directly to workers without a shop steward or union representative present during any conversation

C. The inspector's authority is limited to document review — the inspector cannot collect samples, make measurements, or access specific facility areas without a court-issued search warrant authorizing physical inspection activities

D. OHS inspectors have authority to enter the workplace at any reasonable time without advance notice, examine and copy records, conduct tests and measurements, interview workers privately without employer representation, and issue compliance orders or stop-work orders for conditions posing immediate danger to workers

18. Welding is being conducted on a structural steel beam in an industrial building and a fire watch is required. Which combination of requirements correctly describes the fire watch obligation?

A. The fire watch must be stationed at the work location only while the welder is actively welding — once the welder stops for a break or moves locations, the fire watch obligation ends and they may perform other assigned duties

B. The fire watch must observe the work area throughout the hot work operation and for a minimum period after hot work ends (typically 30 minutes), must have immediately accessible and properly rated fire extinguishing equipment, must know how to use that equipment, and must monitor areas on the other side of walls or floors that could receive conducted heat or sparks

C. A fire watch is only required when welding is performed within 10 metres of combustible materials — beyond this distance, the probability of spark travel is negligible and fire watch is not required under any applicable Canadian hot work standard

D. The fire watch obligation is eliminated if a "Hot Work in Progress" sign is posted at each building entrance and all combustible materials within 5 metres are removed or covered with non-combustible welding blankets before work begins

19. Two welders must move a structural steel plate 2400 mm × 1200 mm weighing 180 kg. No mechanical lifting equipment is available. Which approach most safely manages this task?

A. Two workers can safely lift this plate if each weighs more than 90 kg — body weight relative to load weight is the primary established indicator of safe manual handling capacity for team lifts

B. Each worker can lift 90 kg individually, and since the load is equally shared at 90 kg per person, the team lift proceeds within individual capacity limits without requiring additional workers

C. Even with two workers, this load exceeds safe manual handling limits — a team of three or four workers or the use of mechanical lifting equipment is appropriate; no definitive safe team-lift weight limit exists, but good practice suggests mechanical assistance for loads exceeding approximately 45 kg per person

D. Two properly trained workers can safely move this plate using the approved team-lift technique from a recognized provincial safe-lift training program — correct technique allows any load to be safely handled regardless of absolute weight

20. An acetylene cylinder stored in a welding shop is labeled with the WHMIS 2015 flame pictogram. What hazard class does the flame pictogram indicate for acetylene, and what additional hazard is unique to acetylene compared to other fuel gases?

A. The flame pictogram indicates a flammable gas — acetylene is uniquely hazardous because it is chemically unstable and can decompose explosively without oxygen when pressurized above approximately 103 kPa (15 psi) or exposed to heat, shock, or contact with certain metals; this is why acetylene must be dissolved in acetone in a porous filler material rather than stored as a pure compressed gas

B. The flame pictogram indicates a flammable liquid — acetylene becomes liquid when dissolved in acetone under pressure, classifying it as a Class 3 flammable liquid under the GHS physical hazard classification in the cylinder

C. The flame pictogram indicates an organic peroxide — acetylene reacts with atmospheric oxygen in the cylinder over time to form acetylene peroxides, requiring the same storage controls as hydrogen peroxide under WHMIS 2015

D. The flame pictogram indicates only that the gas burns at a higher temperature than air — no additional hazards distinguish acetylene from propane or natural gas, and all three can be stored and used interchangeably with only minor flame setting adjustments

21. A welding symbol for a PJP bevel groove weld shows "19(16)" to the left of the groove symbol on an engineering drawing. What do the two numbers communicate, and why are they different values?

A. "19" is the bevel angle in degrees and "16" is the root face dimension in mm — bevel angle and root face dimensions are always shown in this paired format when both deviate from the prequalified joint standard defaults

B. "19" is the total plate thickness and "16" is the required weld length for this joint location — the notation specifies both the material thickness and the minimum weld length when length verification is critical to the design

C. "19 mm" is the weld size required for structural capacity and "16 mm" is the maximum permitted groove depth — when the two values differ, the smaller parenthetical value governs and the groove must not exceed that depth

D. The "19" is the groove preparation depth (S) indicating the groove is prepared 19 mm deep, while "16" in parentheses is the effective weld throat (E) — the 3 mm difference reflects the code reduction for bevel groove angles less than 60 degrees, where E = S − 3 mm; this communicates both the fabrication requirement (prepare 19 mm deep) and the design basis (only 16 mm effective throat applies)

22. A drawing specifies a staggered intermittent fillet weld with the notation "6-50-100" on a T-joint assembly. What does this notation mean, and where are the welds located relative to each other?

A. The notation specifies 6 passes at 50 mm length each with 100 mm spacing between all passes — all six welds are on the same side of the joint and the 100 mm refers to center-to-center spacing between welds on the arrow side only

B. The "6" is the fillet weld leg size in mm, "50" is the weld length in mm, and "100" is the center-to-center pitch — in a staggered arrangement, the welds alternate between the arrow side and the other side of the joint, with the welds on each side offset by half the pitch so no two welds directly oppose each other across the joint

C. The notation means 6 fillet welds of 50 mm each distributed over 100 cm total span, with the welder determining the layout — the staggered arrangement must be explicitly stated in the drawing tail to require alternating sides rather than all welds on one side

D. The "6-50-100" notation applies only to the arrow side — a separate notation on the other reference line side would specify other-side welding; a staggered arrangement must always be explicitly stated in the tail specification and not communicated through the dimensional notation

23. On a piping isometric drawing, a vertical section of pipe shows a flow arrow pointing upward, a globe valve symbol, and a dimension to a horizontal branch connection shown with a reducing tee symbol. What does the reducing tee symbol communicate about the pipe diameters?

A. The reducing tee symbol indicates the tee must be fabricated by cutting and welding rather than purchased as a pre-manufactured fitting because the size reduction is too large for a commercial reducing tee to accommodate within the standard product range

B. The reducing tee symbol indicates the main run and the branch pipe have equal diameters — in piping terminology, "reducing" refers to reducing flow velocity through the transition, not changing the nominal pipe diameter

C. The reducing tee symbol indicates that the branch outlet is a different, smaller diameter than the main run pipe — the run-through dimensions of the tee remain constant while the branch outlet is a different nominal pipe size, requiring a specific reducing tee fitting rather than an equal tee

D. The reducing tee symbol indicates the main run pipe has been reduced in diameter at the tee location — both the downstream run pipe and the branch are smaller than the incoming run pipe that feeds the reducing tee fitting

24. A fabricator must choose between a single-V groove and a double-V groove for a 30 mm thick structural plate butt joint where full access to both sides is available. Which statement most accurately compares these configurations?

A. A double-V groove requires approximately 50% less weld metal than a single-V groove on the same plate thickness — the double-V distributes the groove to both sides, roughly halving the weld cross-section area; this reduced volume produces less distortion and is preferred when both-side access is available

B. A single-V groove always produces better mechanical properties than a double-V because the single-V creates a more uniform grain structure by eliminating the fusion line discontinuity that forms when welding from both sides

C. A double-V groove requires more total weld metal than a single-V on the same thickness because the metal must be deposited twice — once from each side — effectively doubling the total weld metal volume compared to a single-sided approach

D. There is no structural or economic difference between single-V and double-V grooves on 30 mm plate — the selection is purely based on operator preference and equipment availability rather than any technical or economic factors

25. Under CWB certification standards, which combination of plate groove weld test positions provides the broadest qualification coverage for a structural welder?

A. Testing in the 1G (flat) position alone provides universal plate groove weld coverage because all welds can be repositioned to flat using modern positioners, making all other test positions optional

B. Testing in the 2G (horizontal) position provides the broadest coverage because horizontal welding requires simultaneous control of the pool in both vertical and lateral directions, automatically qualifying all simpler positions

C. Testing in the 3G (vertical) position alone provides all-position plate coverage including horizontal and flat, because vertical is considered the most demanding plate position under CWB standards

D. Testing in both the 3G (vertical) and 4G (overhead) positions provides coverage for all plate groove weld positions — the combination of the two most demanding positions demonstrates competency across the full range of plate groove welding orientations under CWB certification standards

26. A pressure vessel fabrication shop uses a weld map document system for each vessel. Which statement best describes what a weld map accomplishes that a welding symbol drawing alone cannot?

A. Weld maps replace welding procedure specifications by consolidating all required welding parameters onto a single document per joint, eliminating the need for separate WPS documents during fabrication

B. A weld map assigns a unique identifying number to each specific weld joint on the vessel, linking each weld to its WPS, the qualified welder who deposited it, consumable lot numbers, measured preheat, NDE results, and any repair history — this traceability cannot be achieved from a welding symbol drawing alone

C. Weld maps indicate the inspection hold points for the QA inspector but do not provide any fabrication information beyond what is already shown on the vessel drawing or piping isometric

D. A weld map is only required for nuclear-class pressure vessels — for standard ASME VIII Div 1 vessels, the welding symbol drawing provides all required documentation and weld maps are optional administrative records

27. An engineering drawing shows a detail section view labeled "Section B-B" with a cutting plane indicated on the plan view. The section view shows a T-joint cross-section with two fillet welds. What

specific information does this section view provide that weld symbols on the plan view cannot fully communicate?

A. Section views on welding drawings indicate the required travel direction — the arrows on the section designation line indicate whether the welder must travel left-to-right or right-to-left when depositing the fillet welds shown

B. Section views replace the need for welding symbols entirely — all weld symbol information is conveyed more accurately in cross-sectional view, so the engineer provides either a section view or symbols, never both simultaneously

C. Section views provide the welder and inspector with actual joint cross-section geometry showing exact plate thicknesses, weld access conditions, physical relationships between the plates, any backing conditions, and required throat dimensions in a way that a plan-view weld symbol cannot fully convey

D. Section views only indicate material grain structure orientation — sections taken perpendicular to the rolling direction show grain orientation information affecting required preheat temperature and must be documented in the fabrication record

28. During inspection of a 6-metre fabricated I-beam, the inspector measures a lateral bow of 8 mm over the full member length. Under CSA W59 fabrication tolerances, what disposition applies to this condition?

A. CSA W59 fabrication standards typically limit sweep (bow) to L/1000 for the member length — for a 6-metre beam, the maximum permitted bow is 6000 ÷ 1000 = 6 mm; the 8 mm measured bow exceeds this limit and requires engineering review or correction before the member is incorporated into the structure

B. An 8 mm bow in 6 metres is always acceptable regardless of the code because shop tolerances are only enforced after installation — out-of-tolerance members found during shop inspection are automatically accepted by the engineer of record

C. An 8 mm bow represents a sweep of 1.33 mm per metre, which is below the absolute maximum of 3 mm per metre that applies universally to all structural fabrication regardless of the project specification or applicable code

D. The only applicable straightness tolerance applies to the web plate — beam flange bow is not addressed by CSA W59 and is governed exclusively by the project specification, which must explicitly state the tolerance or none applies

29. An NDT technician must perform magnetic particle testing on a completed groove weld in structural steel, with access to both an AC electromagnetic yoke and a DC permanent magnet yoke. Which technique combination provides the best sensitivity for detecting surface and near-surface discontinuities?

A. The DC permanent magnet yoke produces superior sensitivity for all surface discontinuities because its constant unidirectional field creates stronger flux density in the weld metal than an AC yoke at the same pole spacing

B. The AC electromagnetic yoke cannot detect near-surface discontinuities because alternating current's skin effect concentrates flux at the material surface — it detects only surface-breaking cracks and is blind to any subsurface discontinuity

C. AC and DC yokes produce identical sensitivity when the yoke lift force meets the minimum code specification — yoke type selection is purely an economic decision based on battery availability for DC versus power outlet access for AC units

D. For maximum surface crack sensitivity, the AC electromagnetic yoke is preferred because the alternating field promotes particle mobility, allowing fine particles to migrate to surface-breaking discontinuities; for near-surface subsurface indications, DC magnetization provides better depth penetration; combining both longitudinal and transverse orientations relative to the weld axis ensures all discontinuity orientations are detectable

30. After welding one side of a double-fillet T-joint, the fabricator observes that the vertical web plate has rotated slightly out of perpendicular relative to the base plate before the second side is welded. What is this distortion called, and what technique reduces it?

A. This is angular distortion caused by asymmetric heat, prevented by clamping the web rigidly before welding — the clamp transmits reaction force equally to both sides and prevents the web from rotating during the first-pass heat cycle

B. This is angular distortion caused by transverse weld shrinkage pulling the web toward the welded side — pre-setting the web slightly in the opposite direction before welding (pre-tipping), or depositing both fillet welds simultaneously using two welders, reduces the net angular distortion at weld completion

C. This distortion is longitudinal warping caused by the fillet weld length exceeding the critical length for the plate thickness — it is only preventable by using skip welding with individual weld segment lengths not exceeding one plate thickness

D. Angular distortion in T-joints is always permanent and cannot be prevented by technique — the only acceptable solution is cold straightening of the completed joint using a hydraulic press rated at 10 tonnes minimum force

31. A WPS requires a maximum interpass temperature of 250°C for SMAW on chrome-moly P5 alloy steel in a heavily restrained groove joint. Why is the maximum interpass temperature limit important for this material, and what temperature measurement method is most appropriate?

A. The 250°C maximum is required to maintain a previous PWHT tempering effect — exceeding 250°C causes already heat-treated zones to lose their design strength in the same way that re-tempering reduces hardness in tool steel

B. Maximum interpass temperature limits only apply to the root pass — once the root has been deposited, fill and cap passes are not subject to interpass temperature controls because the weld cross-section is already established

C. The maximum interpass temperature for P5 chrome-moly prevents the HAZ microstructure from experiencing excessively slow post-pass cooling rates caused by continuous high heat buildup — if the joint temperature is too high between passes, the cooling rate after each completed pass slows, potentially affecting the final HAZ microstructure and toughness; a contact thermometer, thermocouple, or calibrated infrared thermometer should verify temperature at the joint location before each pass

D. The 250°C limit prevents the chrome-moly steel from becoming fully austenitized between passes — exceeding 250°C causes complete austenite transformation and the re-solidified austenite has unacceptably poor impact toughness for chrome-moly alloys in pressure service

32. Welder A holds a GTAW qualification using ER70S-2 filler metal (F-Number 6). Welder B holds an SMAW qualification using E7018 electrode (F-Number 4). The production WPS requires SMAW with E7018 electrodes. Which statement correctly interprets the qualification coverage for Welder A?

A. Welder A's GTAW qualification with F-Number 6 filler does not automatically qualify Welder A to use F-Number 4 electrodes in SMAW — in ASME Section IX, qualifying with one F-Number does not provide coverage for lower F-Number groups the same way P-Numbers work; a separate SMAW qualification using F-Number 4 electrodes is required for Welder A to perform this work

B. Welder A's F-Number 6 GTAW qualification covers all lower F-Number groups including F-Number 4 — in ASME Section IX, qualification with a higher F-Number always provides coverage for all lower F-Number groups for the same P-Number base metal

C. F-Numbers do not affect welder qualification — they are only used for procedure qualification to identify which filler metals can be substituted in a WPS without requalification, and they have no application to welder qualification coverage decisions

D. Both Welder A and Welder B are qualified to perform the SMAW production work because the base metal P-Number is the only variable restricting welder qualification — F-Number differences between the qualification test and production filler metal are irrelevant to welder qualification

33. After PWHT of a chrome-moly pressure vessel, the QC inspector must verify the weld metal and HAZ hardness does not exceed the code maximum of 250 HBW. Which hardness test method is most practical for field verification on an in-service vessel?

A. Rockwell C scale testing using a bench-top machine is the required method for ASME code compliance — the HRC scale is the only scale capable of measuring the hardness range typical of PWHT chrome-moly weld metals in pressure vessel applications

B. Portable Brinell or portable Vickers hardness testing is the most practical field method — results in HBW or HV can be verified directly against the 250 HBW limit using conversion tables, and portable instruments provide the versatility needed for in-situ post-PWHT vessel inspection

C. A calibrated hardness test file is the only method permitted by ASME for field hardness verification — the file test produces a pass/fail result based on whether the file cuts the surface at a specified applied load

D. Shore durometer (Shore D scale) is appropriate for weld metal hardness verification in pressure vessel inspection because the Shore scale was specifically developed for metallic weld deposits and correlates directly to HBW through a conversion formula in ASME Section V

34. A structural engineer must specify a welded connection for a tensile load-carrying member under a fully reversed cyclic stress cycle (R = -1). Which joint configuration provides the best fatigue resistance?

A. A full-penetration groove weld with the backing bar left in place provides the best fatigue resistance — the backing bar doubles the cross-sectional area at the joint root, reducing the stress range at the critical weld root location under cyclic loading

B. A pair of longitudinal fillet welds running the full length of the gusset plate provides the best fatigue resistance because the distributed shear load creates more uniform stress distribution than a transverse groove weld under cyclic tension

C. A transverse fillet weld with maximum convexity provides the best fatigue resistance because the larger effective throat created by the convex profile reduces the weld metal stress range under the fully reversed cyclic loading condition

D. A full-penetration groove weld with the weld reinforcement ground flush with the base metal provides the best fatigue resistance for cyclic tension — the smooth flush surface eliminates the geometric stress concentration at the weld toe that serves as the primary fatigue crack initiation site in welded connections under cyclic loading

35. A structural drawing specifies a fillet weld along the edge of a 10 mm thick plate. During inspection, the fillet weld legs both measure 10 mm. Under CSA W59, what is the disposition of this weld?

A. A 10 mm fillet on a 10 mm plate is acceptable — CSA W59 imposes no maximum fillet weld size limitation; only the minimum size table is a dimensional requirement under the standard

B. A 10 mm fillet on a 10 mm plate is oversized but acceptable — maximum fillet size limits only apply to plates thicker than 25 mm, and the 10 mm plate in this example is below the applicability threshold

C. A 10 mm fillet weld on a 10 mm plate exceeds the permitted maximum — CSA W59 limits the maximum fillet weld leg size along the edge of plate 6 mm or thicker to the plate thickness minus 2 mm; for a 10 mm plate the maximum is 10 − 2 = 8 mm, making the 10 mm fillet oversized and subject to repair or engineering disposition

D. The maximum fillet on any plate is limited to half the plate thickness — a 10 mm plate allows a maximum 5 mm fillet weld; a 10 mm fillet is double the maximum and must be completely removed and re-welded to the correct size

36. A pipe spool drawing bill of materials lists "1 ea. 100 NPS, LR 90° ELL, BW, SCH 80." What does the designation "LR" communicate about this elbow fitting?

A. "LR" stands for long-radius — the elbow has a centreline radius of 1.5 times the nominal pipe diameter, which is the standard elbow radius used in most piping systems; a short-radius elbow (SR) has a centreline radius equal to 1.0 times the pipe diameter and is used where space constraints prevent use of the standard fitting

B. "LR" stands for left-right reversible — the elbow can be installed rotating either left or right depending on the isometric routing, and the BW suffix indicates reversibility for both butt-weld installation directions

C. "LR" stands for low-resistance — this designation indicates a pressure drop coefficient below the ASME maximum for the pipe schedule, reducing head loss in the piping system compared to a standard elbow fitting

D. "LR" stands for load-rated — the elbow has been proof-tested to a higher pressure rating than standard fittings and the LR designation indicates the allowable pressure is 1.5 times greater than a standard fitting of the same nominal size and schedule

37. A chrome-moly pressure vessel requires PWHT per ASME Section VIII Div 1. The wall thickness is 75 mm and the soaking temperature is 700°C. What minimum soaking time is required and what does the soaking phase accomplish?

A. The minimum soaking time is 30 minutes regardless of wall thickness — ASME VIII Div 1 specifies a universal 30-minute hold at temperature for all chrome-moly vessels with no calculation based on wall thickness

B. The minimum soaking time is 60 minutes per 25 mm of thickness — for 75 mm: 75 ÷ 25 = 3 hours minimum hold, ensuring complete temperature equalization through the wall thickness and allowing tempering reactions to go to completion

C. The minimum soaking time equals the heating rate time — if the vessel heats at 100°C per hour to reach 700°C, the soaking time must equal 7 hours to match the heating phase duration, ensuring thermal equilibrium

D. For ASME VIII P5 chrome-moly steel, the minimum holding time is 1 hour per 25 mm of base metal thickness with a 1-hour minimum regardless of thickness — for 75 mm: 75 ÷ 25 = 3 hours minimum hold; the soaking phase tempers the martensitic weld and HAZ microstructure, reduces residual stresses, lowers hardness below the code maximum, and improves toughness and creep properties of the chrome-moly alloy at its intended service temperature

38. An inspector uses a weld gauge on a completed horizontal fillet weld and measures one leg at 7 mm and the other at 8 mm. The drawing specifies a 6 mm fillet. A convexity measurement shows 1.5 mm of weld face convexity. What is the correct disposition?

A. The weld is rejectable because the 1.5 mm convexity exceeds the maximum of 1 mm that applies to all fillet welds regardless of weld size under CSA W59

B. The weld is acceptable — both legs of 7 mm and 8 mm exceed the 6 mm minimum required; the convexity of 1.5 mm is within the typical CSA W59 maximum for a 6 mm fillet; and the slight leg asymmetry does not represent a deficiency as long as both legs exceed the minimum required size

C. The weld must be rejected because the specified size is 6 mm and both legs at 7 mm and 8 mm represent oversized welds — over-welding a specified fillet constitutes a drawing deviation requiring an engineering change notice before acceptance

D. The weld is acceptable only for statically loaded connections — for cyclically loaded connections, the 1.5 mm convexity requires additional fatigue crack inspection at both weld toes before the weld can be accepted regardless of the dimensional measurements

39. During a scheduled maintenance inspection of a 10-year-old ASME VIII Div 1 pressure vessel, the inspector finds minor localized pitting corrosion on the interior shell surface. What action is required before the vessel is returned to service?

A. Any corrosion on a pressure vessel shell requires immediate permanent decommissioning — vessels showing any measurable corrosion cannot be returned to service under ASME Section VIII; a replacement vessel must be procured

B. Minor localized pitting that has not reduced wall thickness below the minimum structural thickness requires no action — cosmetic corrosion is exempt from all reporting requirements under the applicable in-service inspection code

C. The remaining wall thickness at the pitted locations must be measured by ultrasonic thickness testing and compared to the calculated minimum required wall thickness at the inspection pressure — if remaining wall exceeds the minimum required including corrosion allowance, the vessel may be returned to service with the corrosion documented and the area scheduled for re-inspection; if below minimum, the vessel requires repair, re-rating, or retirement

D. Any corrosion found during in-service inspection must be reported to the provincial boiler authority before thickness measurements are taken — the provincial inspector must be present during all subsequent measurements to maintain the chain of evidence for regulatory action

40. A fabrication shop must prepare 50 mm thick plate edges for double-V groove butt welds on 200 plates per week. Which groove preparation method is most economical for this production volume?

A. Machine beveling using a milling machine or dedicated plate beveling machine provides the most economical and consistent groove preparation for high-volume production — mechanized processing produces accurate, repeatable groove angles at lower unit cost than hand grinding or manual thermal cutting at this throughput level

B. Manual grinding using a 9-inch angle grinder is the most economical method for all production volumes because grinding equipment has low capital cost and each welder can prepare their own joint without requiring separate dedicated equipment

C. Hand oxy-fuel cutting is the most economical method regardless of volume because fuel gas costs are lower than both electricity for mechanized methods and capital equipment costs for dedicated beveling machines

D. Plasma arc cutting is the correct choice for all groove preparation regardless of volume because it produces a cleaner cut surface than all alternatives, eliminating surface dressing before welding and reducing total production time despite its higher capital cost

41. During structural steel repair welding, a crack is found that propagated from a weld toe. Before depositing any repair weld, what preparation and sequencing steps are required?

A. The repair weld can be deposited directly over the cracked area after visual inspection confirms the crack location — preheat and excavation are only required for pressure-retaining components, not structural steel repairs

B. The cracked area must be excavated and cleaned, but no further verification is needed — cracks in structural steel are always clean and defect-free at their tips and require no additional investigation beyond what is visible

C. The only step required before repair welding is marking the crack ends with paint so the welder knows where to start and stop — excavation or stop drilling is not required because the repair weld will fill the crack and restore the original joint capacity

D. The full extent of the crack must be established by MT or PT to locate the actual crack tips; the crack must be completely removed by grinding, gouging, or drilling stop holes; the excavated cavity must be verified as defect-free by MT or PT; preheat must be applied per the applicable WPS; the repair weld deposited within the qualified procedure; and the completed repair NDE-inspected per the original code requirement — repairing over a remaining crack tip is not permitted as the crack will continue to propagate

42. During SMAW welder qualification testing in the 3G vertical-up position per ASME Section IX, one of the four bend specimens shows a crack 3.5 mm long on the tension surface after bending. What is the disposition?

A. All bend test specimens must be absolutely crack-free — any crack of any length results in immediate test failure and the welder must re-test without any opportunity for examiner review of the specimen

B. A 3.5 mm crack exceeds the ASME Section IX maximum permitted crack or open discontinuity of 3 mm on any bend test specimen — the qualification test is a failure and the welder must wait the applicable period before re-testing

C. The ASME Section IX maximum allowable crack in a bend test is 6 mm in any direction — a 3.5 mm crack is within the acceptance criteria and the welder passes this portion of the qualification test

D. The 3.5 mm crack must be evaluated by the CWB examiner who will determine whether it originates from a process discontinuity or a base metal lamination — process discontinuities fail the test while base metal laminations at specimen edges are exempt from the crack length limit

43. A procedure qualification record shows Charpy V-notch impact test results for weld metal at −40°C that all exceeded the 27 J minimum. If additional tests show that absorbed energy drops sharply between −20°C and −40°C test temperatures, what does this indicate?

A. A sharp energy drop between temperature levels indicates non-uniform weld metal composition across the cross-section — the compositional variation is reported as temperature sensitivity and requires remelt or re-qualification of the procedure

B. A steep energy drop between levels indicates the specimens were machined to incorrect dimensions — Charpy specimens that are too thick produce artificially low absorbed energy at temperatures below 0°C regardless of the actual material toughness

C. A sharp drop in absorbed energy between temperature levels means the material is transitioning from upper-shelf ductile fracture behavior to lower-shelf brittle fracture behavior — the temperature at which this transition occurs most rapidly is the ductile-to-brittle transition temperature (DBTT), and a steep transition above the design service temperature indicates a risk of brittle fracture during service

D. A sharp Charpy energy drop between −20°C and −40°C is expected for all weld metals and indicates no quality concern — all welded joints have the same transition temperature range regardless of composition, and the DBTT is a standard feature of the steel phase diagram

44. A welding symbol shows two reference lines — a solid first line attached to the arrow and a dashed second line above it. A groove weld symbol and dimension appear on the first reference line; a fillet weld symbol appears on the second reference line. What does the presence of two reference lines communicate?

A. Two reference lines indicate a sequence of operations — the weld on the first solid reference line closest to the arrow is made first, followed by the weld on the second reference line; in this case, the groove weld is the first operation and the fillet weld is the second sequential operation at the same joint

B. Two reference lines indicate that two separate inspectors must review the joint — the first line identifies the first inspector's scope and the second line identifies the second inspector's scope to prevent jurisdictional conflicts

C. Two reference lines indicate that two welders must work simultaneously — the double-line symbol is a production control designation requiring concurrent deposition of both referenced welds to minimize thermal distortion of the connection

D. Two reference lines indicate two joints at different structural locations that must be welded in sequence — the arrow points to the first joint and the double reference line extends to indicate the location of the second joint elsewhere on the structure

45. During visual inspection of a completed structural T-joint fillet weld, the inspector finds the weld terminates abruptly at the joint end with a visible concave crater depression rather than a filled termination. Under CSA W59 visual inspection acceptance criteria, what is the correct disposition and why are craters a quality concern?

A. Crater depressions at weld terminations are automatically acceptable under CSA W59 because the reduced cross-section at the joint end is compensated by the run-off length of the weld; no corrective action is required regardless of crater depth or profile

B. A crater depression is acceptable provided it falls within 25 mm of the joint end — the terminal region of any structural fillet weld is classified as a low-stress zone and is exempt from the full-throat requirement under CSA W59 visual inspection provisions

C. The crater requires filling only when the joint is subject to tensile or dynamic loading — craters at weld terminations in statically loaded compression or shear connections do not represent a rejectable condition under CSA W59 visual inspection criteria

D. A visible crater depression is rejectable under CSA W59 visual inspection criteria because it reduces the effective weld throat at the termination — craters concentrate segregated low-melting constituents at the shrinkage center during cooling and are one of the most common initiation sites for crater cracks, which are linear discontinuities that can propagate into the weld body under service loading

46. A structural welding project under CSA W59 requires 100% visual inspection and 10% UT of all groove welds, all of which are found acceptable. What documentation must the inspector produce?

A. The inspector need only produce a daily diary log — formal inspection reports are not required under CSA W59 for projects below $10 million in value; the daily diary sufficiently documents all inspection activities

B. The inspector must produce a formal written inspection record documenting the welds inspected, inspection methods applied, reference standard used, NDE results for each weld, any rejectable conditions and their disposition, and the inspector's signature and certification number — this record becomes part of the project quality documentation package and may be required by the authority having jurisdiction

C. Documentation of visual inspection results is the only written record required — UT results need not be formally documented because UT is a real-time process and only the final accept/reject decision needs to be communicated verbally to the contractor

D. Only the QC manager signs the inspection documentation — individual inspectors do not sign records under CSA W59 because personal liability is held by the certification body that issued the qualification, not the inspector individually

47. A welding engineer is reviewing a PQR to determine if it supports a new WPS. Which items would always appear on a PQR but not on a WPS?

A. The welding process, base metal P-Number, filler metal classification, and preheat temperature appear on the PQR but not on the WPS because the WPS only documents the qualified parameter ranges

B. The QC manager's certification stamp appears on the PQR but not the WPS — a WPS is signed by the responsible welding engineer while a PQR is signed exclusively by the QC manager under CWB certification requirements

C. The actual measured and recorded values from the qualification test — including actual preheat measured, heat input calculated from recorded voltage, amperage, and travel speed, actual PWHT temperatures and hold times, and test specimen results including tensile strength and bend and impact values — appear on the PQR but not the WPS, which states only the qualified ranges

D. The WPS number that the PQR supports must appear on the PQR but not on the WPS — the WPS does not reference its supporting PQRs by number to prevent unauthorized use of qualification test data by other parties

48. A fabricator receives structural steel plates with an MTR showing yield strength 385 MPa and tensile strength 520 MPa against a CSA G40.21 Grade 350W specification. Using the IIW CE formula with C=0.16%, Mn=1.35%, Cr=0.05%, Mo=0.02%, V=0.01%, Ni=0.10%, Cu=0.15%, which statement is correct?

A. The plates meet minimum requirements; CE = 0.16 + 1.35/6 + (0.05+0.02)/5 + (0.10+0.15)/15 = 0.416; this CE falls in the marginal category requiring mandatory PWHT for all structural welding regardless of plate thickness

B. The plates meet minimum requirements; CE = 0.16 + 1.35/5 + (0.05+0.02+0.01)/6 + (0.10+0.15)/15 = 0.460; the elevated CE indicates the plates are too highly alloyed for use without full PWHT on all connections

C. The plates fail the specification because the tensile-to-yield ratio of 520/385 = 1.35 is below the CSA G40.21 minimum ratio of 1.4 required for Grade 350W — the plates must be rejected on this basis regardless of the yield and tensile values

D. The plates meet the minimum yield (385 MPa ≥ 350 MPa) and tensile (520 MPa ≥ 450 MPa) requirements; CE = 0.16 + 1.35/6 + (0.05+0.02+0.01)/5 + (0.10+0.15)/15 = 0.16 + 0.225 + 0.016 + 0.017 = 0.418; the CE of 0.418 indicates moderate hardenability requiring careful preheat application based on plate thickness and restraint level

49. An OFC operator cutting 50 mm structural steel plate observes that the top edge of the cut is melted and rounded rather than sharp and clean, while the bottom shows clean ejection with minimal dross. What does this condition indicate and what is the correction?

A. The rounded melted top edge indicates the preheat flame is too large for the plate thickness — the excess preheat is melting the top surface before the cutting oxygen is applied; reducing the preheat to the correct size for the plate thickness will produce a sharp, clean top edge

B. The rounded top edge indicates cutting oxygen pressure is too high — excess pressure creates turbulence at the kerf entry that melts the top surface before clean severance; reducing cutting oxygen pressure will sharpen the top edge

C. The melted top edge and clean bottom ejection indicate travel speed is too fast — the torch is moving forward before the top surface is fully preheated, causing surface melting rather than clean oxidation

D. A slightly melted and rounded top edge is an indicator of correct technique — it confirms the preheat achieved the steel ignition temperature before cutting oxygen was applied; a sharp clean top edge would indicate premature cutting oxygen activation

50. A plasma arc cutting operator must cut 12 mm 6061-T6 aluminum plate. The machine offers both air plasma and nitrogen plasma capability. Which plasma gas and shielding arrangement produces the best cut quality on aluminum?

A. Compressed air plasma is the best choice for aluminum cutting because the oxygen component reacts with the aluminum oxide surface layer and provides oxidation energy to initiate and sustain the cutting reaction

B. Nitrogen plasma gas with argon shielding (or argon-hydrogen mixture) produces the best cut quality on aluminum — nitrogen provides arc energy without the oxidation damage of air plasma, and argon shielding reduces oxidation of the cut face, producing brighter and smoother cut edges than air plasma

C. Oxygen plasma gas is required for aluminum above 6 mm — the higher energy density of oxygen plasma provides the heat needed to penetrate thicker aluminum sections that air plasma cannot adequately cut

D. The plasma gas composition has no effect on aluminum cut quality — all plasma gases produce equivalent results on aluminum because aluminum does not oxidize the same way as ferrous metals; only amperage and travel speed affect aluminum cut quality

51. An OFC operator switches from a tip rated for 25 mm plate to a tip rated for 50–75 mm plate when cutting 30 mm material. What effect does using an oversized tip have on cut quality?

A. An oversized tip improves cut quality on thinner plate because the larger orifices provide more cutting oxygen volume and velocity, resulting in faster travel and a cleaner cut face than a correctly sized tip

B. An oversized tip has no effect on cut quality — the tip rating is a maximum capacity and the tip operates equally well at any thickness below its rating; operators routinely use larger tips without any quality impact

C. An oversized tip on thinner-than-rated plate results in excessive preheat and cutting oxygen for the thickness — the oversized preheat flame overheats the cut zone, the excess cutting oxygen widens the kerf, melts the top edge, causes heavy dross on the underside, and produces a rough undulating cut surface; the tip must be matched to the actual plate thickness for optimum cut quality

D. An oversized tip is safe but slows the cutting process because the operator must reduce travel speed to compensate for the extra heat input — cut quality remains acceptable but productivity decreases proportionally with the degree of tip size overcapacity

52. A maintenance welder preparing a repair groove using CAC-A obtains a V-shaped profile with a sharp narrow root rather than the specified U-shaped profile. What technique adjustment produces the correct U-shaped groove profile?

A. A V-shaped profile on DCEP indicates incorrect polarity — switching to DCEN immediately converts the groove to a U-profile because reversed polarity changes the arc deflection pattern at the root

B. The V-shaped profile results from using too large an electrode for the groove width — reducing the electrode to approximately one-third of the required groove width creates the U-profile specified for repair welding

C. The V-shaped profile results from insufficient air pressure — increasing compressed air pressure above 700 kPa creates the U-profile by widening the molten pool at the root and allowing expelled metal to spread uniformly across the groove bottom

D. The V-shaped profile results from holding the electrode at too steep an angle, nearly perpendicular to the work — reducing the electrode lead angle to approximately 35–45° from the work surface and directing the electrode tip toward the groove root while maintaining working distance allows the arc to form the characteristic U-shaped groove profile required for repair preparation

53. An OFC operator increases the cutting travel speed above the optimum for 20 mm plate. What visible changes in cut quality indicate that speed is excessive?

A. Excess travel speed produces drag lines that sweep backward at a greater angle, causes incomplete severance at the bottom of the cut, may cause the cut to fail to propagate fully through the plate, and produces heavy attached dross at the base because molten material cannot be fully expelled during the shortened reaction time

B. Excessive travel speed produces a straighter cut with minimal kerf width — faster speed reduces heat input per unit length, creating a narrower more precise kerf that is actually superior to the optimum-speed cut

C. Excessive travel speed causes the preheat flame to automatically increase in size as a self-regulating safety response — the torch self-adjusts to a larger preheat when travel speed increases to maintain the required temperature ahead of the cutting oxygen stream

D. Excessive travel speed produces heavy top-edge melting and rounded corners — at high speed the preheat intensity per unit area increases, melting the steel before cutting oxygen can oxidize it, producing top-surface damage identical to that caused by an oversized preheat tip

54. During mechanized plasma arc cutting production, cut quality gradually deteriorates — faces become rougher, dross accumulates on the underside, and electrode and nozzle wear accelerates. The plasma gas is nitrogen from a compressed-air-driven generator. What is the most likely cause?

A. The gradual deterioration is caused by voltage creep — as the power source heats up during continuous operation, arc voltage increases above optimal, causing increased kerf width and rougher cut faces throughout the shift

B. Moisture accumulating in the nitrogen supply from the air-driven generator is the most likely cause — as the generator's desiccant becomes saturated during extended operation, moisture enters the nitrogen supply, degrading cut quality and dramatically accelerating consumable wear by creating steam in the plasma column; regular desiccant regeneration and a moisture indicator at the torch inlet are the corrective measures

C. Gradual quality deterioration is caused by normal progressive electrode erosion — as the electrode tip wears predictably throughout the consumable set, arc characteristics change in a predictable way; this is expected behavior requiring no investigation

D. Gradual quality deterioration is caused by thermal expansion of the torch height control mounting bracket — as the machine structure heats up, standoff distance increases gradually above the set point, causing the described cut quality changes throughout the production run

55. A welder must back-gouge the root of a completed single-V groove butt weld from the reverse side using OFC before depositing the back-weld. What is the most important quality criterion for the back-gouging operation?

A. The most important criterion is total volume of material removed — the back-gouge must remove a minimum of 3 mm more material than the visible width of the root pass to ensure all potential root defects are captured

B. The most important criterion is the backgouge profile shape — a U-shaped groove with a minimum radius at the root is always required; V-shaped grooves are never acceptable for back-gouging regardless of the welding code or application

C. The most important criterion is complete removal of all weld metal and base metal to a depth where no cracks, lack of fusion, incomplete penetration, or other defects originating at the root remain — the adequacy of the backgouge is typically verified by MT or PT inspection before the back-weld is deposited

D. The most important criterion is achieving exactly half the plate thickness in depth — the backgouge must remove precisely half the weld cross-section to maintain the mechanical properties of the completed joint; removing more than half reduces joint efficiency below code requirements

56. A CAC-A operator using DCEP at 500 A with a 10 mm copper-coated carbon electrode finds the electrode is consuming very rapidly and the arc generates more heat at the electrode tip than at the work surface. What does this indicate and how should it be corrected?

A. Rapid electrode consumption on DCEP is normal because the electrode is always the anode and anode heating is required to maintain the electrode tip temperature for effective metal removal — this can only be slowed by switching to DCEN

B. Rapid electrode consumption indicates compressed air pressure is too low — at low air pressure, carbon vapor recondenses on the electrode rather than being expelled, increasing the consumption rate; raising air pressure to 620 kPa corrects the problem

C. Rapid electrode consumption indicates the amperage is too low for the electrode diameter — the arc energy is insufficient to maintain the carbon arc at the work and instead burns primarily at the electrode tip; increasing to the maximum rated amperage corrects this

D. Rapid electrode consumption and excessive electrode-end heating at 500 A with a 10 mm electrode indicates the current exceeds the maximum rated value for that electrode diameter — the rating for a 10 mm electrode is typically 200–450 A; at 500 A the electrode exceeds its capacity, causing excessive burn-off; selecting a 12.7 mm electrode or reducing the amperage to within the 10 mm electrode's rated range corrects the condition

57. A fabrication manager evaluates laser cutting as an alternative to plasma arc cutting for precision parts from 6 mm stainless steel sheet. Which statement most accurately compares these two processes for this application?

A. Laser cutting produces a narrower kerf width, a smaller heat-affected zone, and better dimensional accuracy than plasma arc cutting for thin sheet metal — the focused laser beam provides extremely precise energy delivery; however, laser cutting has higher capital and operating costs than plasma, and CO_2 lasers have reduced efficiency on highly reflective metals such as copper and aluminum compared to plasma

B. Plasma arc cutting always produces better cut quality than laser cutting on stainless steel because the plasma generates higher arc temperatures, ensuring more complete melting of the stainless oxide layer that causes quality problems with laser processes

C. Laser and plasma arc cutting produce identical cut quality and HAZ width on 6 mm stainless steel — the only practical difference is that laser cutting is more environmentally friendly because it does not require compressed shielding or plasma gas

D. Laser cutting cannot be used on stainless steel because the chromium oxide surface layer reflects the laser beam, making the cutting process ineffective — plasma arc cutting is the only viable thermal cutting method for all grades of stainless steel

58. An OFC operator must cut 100 mm thick structural steel that has been stored outdoors at −15°C overnight. The plate surface temperature is approximately −10°C. What provisions are required before making the cut?

A. No preheat is required for OFC of structural steel at any ambient temperature — the preheat flame provides the required temperature at the cutting point automatically and ambient temperature affects only productivity, not cut quality

B. The plate should be preheated to remove surface moisture and bring the surface temperature to a minimum of approximately 20°C before cutting begins — cutting very cold structural steel increases the risk of hardened cut edges and cracking due to rapid quenching of the cut edge by the cold base metal mass; additionally, cold surfaces promote moisture condensation that interferes with torch operation and produces porosity in adjacent weld preparations

C. Structural steel below 0°C must be heated to 50°C minimum before OFC is permitted — failure to preheat cold plate before thermal cutting is a recordable code violation under CSA W59

D. Cold 100 mm plate requires the same preheat as required for welding that steel grade and thickness — the minimum preheat for this steel (typically 100°C for thick high-strength structural plate) must be fully applied before any cutting begins

59. A plasma arc cutting operator can choose between a water injection nozzle system and a standard dual-gas system for cutting structural steel. What advantage does the water injection system provide?

A. A water injection nozzle system allows plasma arc cutting of materials that cannot be cut by standard plasma, such as titanium and zirconium, because the water provides an oxygen-free cutting environment that prevents explosive oxidation of reactive metals

B. Water injection nozzle systems reduce electrical energy consumption by 40% compared to standard plasma systems because the water absorbs heat from the plasma arc and reduces the power required to maintain the plasma column at cutting temperature

C. The water injection system constricts the plasma arc by cooling the outer boundary of the plasma jet, producing a narrower, denser arc compared to standard plasma — the improved arc constriction reduces the kerf bevel angle, narrows the kerf width, reduces the heat-affected zone, and produces a harder, smoother cut surface on structural steel

D. Water injection systems provide a safety benefit by preventing the plasma arc from exceeding 8,000°C, which is the maximum temperature permitted for plasma equipment operated in occupied industrial buildings — the water acts as a continuous temperature moderator

60. An OFC operator is cutting structural steel plate with heavy mill scale on the top surface and finds it difficult to initiate the cut despite correct tip selection and gas pressures. What is the cause and solution?

A. Heavy mill scale has a higher melting point than steel and inhibits ignition by insulating the steel surface from the preheat flame and preventing the base metal from reaching the ignition temperature — the solution is to burn away the mill scale at the cut start point with the preheat flame before applying cutting oxygen, or to grind away the scale in the initiation area before starting the cut

B. Heavy mill scale actually improves OFC initiation because the iron oxide in the scale reacts exothermically with the cutting oxygen, providing additional heat to initiate the cutting reaction at lower travel speeds than clean plate requires

C. Mill scale on plate surfaces prevents OFC entirely — the only solution is sandblasting or shot blasting the plate to white metal before any OFC operation can be performed regardless of scale thickness or density

D. The scale absorbs moisture, and this moisture is the actual cause of the ignition difficulty — drying the plate in a preheating furnace at 200°C for one hour before cutting removes the moisture and eliminates the ignition problem without any surface preparation

61. A maintenance welder attempts CAC-A to prepare a repair groove on a 25 mm thick 5083 aluminum structure. What specific challenges apply to CAC-A on aluminum compared to carbon steel?

A. CAC-A cannot be used on aluminum under any conditions — the aluminum oxide coating is so chemically stable that the carbon arc cannot penetrate it; grinding is the only acceptable groove preparation method for aluminum repair work

B. CAC-A on aluminum requires DCEN because aluminum's high thermal conductivity rapidly dissipates arc heat; DCEN concentrates heat at the work surface anode to compensate for the rapid dissipation

C. CAC-A on aluminum produces identically shaped grooves to steel CAC-A because the two metals have similar melting points and the carbon arc interacts with both at the same temperature range

D. CAC-A can be performed on aluminum but requires higher amperage than equivalent steel work due to aluminum's higher thermal conductivity dissipating heat away from the arc faster; the groove surface will contain carbon deposits and an oxide-contaminated zone requiring aggressive cleaning — including stainless steel wire brushing and grinding — before MIG or TIG repair welding proceeds

62. A production shop performs continuous OFC cutting for eight hours per day. What is the primary advantage of a machine-mounted torch over a hand-held torch for this production application?

A. Machine-mounted torches cut faster than hand torches because they maintain higher cutting oxygen pressure than is safe for hand operation — hand torches are pressure-limited for operator safety while machine torches have no such limitations

B. Machine-mounted torches produce more consistent, reproducible cut quality because the machine maintains constant speed, height, and angle throughout the cut — hand torch quality varies with operator fatigue, especially significant during eight-hour production; machine cutting also eliminates the ergonomic hazards of sustained manual torch operation

C. Machine-mounted torches eliminate the need for operator certification because the machine controls all parameters automatically — any untrained worker can operate a mechanized OFC system without completing torch certification or safety training

D. Machine torches use significantly less fuel gas than hand torches for the same cut length because the mechanized system recycles unburned fuel gases through the flame for re-combustion, reducing overall fuel consumption per metre of cut

63. During mechanized plasma arc cutting of 19 mm structural steel, the operator consistently observes that one face of the kerf is nearly vertical while the opposite face has a 3–4° bevel. What causes this asymmetric kerf profile and how is it corrected?

A. The asymmetric kerf angle is caused by asymmetric magnetic fields from the CNC machine's drive motors — the left-side motor produces a stronger field that deflects the plasma arc to the right; adding magnetic shielding around the torch assembly corrects the asymmetry

B. The asymmetric kerf results from worn consumables — as the electrode and nozzle wear, the arc becomes off-center within the nozzle bore, producing the asymmetric bevel; replacing the consumable set restores the kerf to a square profile

C. The asymmetric bevel in plasma arc cutting is inherent to the process — the plasma arc rotates helically due to the tangential gas flow through the swirl ring, producing one side that is approximately square (the "good" side) and an opposite side with a slight bevel (the "bad" side); the good side is always to the right of the torch travel direction for standard clockwise gas swirl, and parts must be programmed so the finished part falls on the good side

D. The bevel is caused by the torch height being too low — when the standoff is below optimal, the plasma arc contacts the plate at an angle, creating one vertical and one beveled face; raising the torch to the specified standoff height makes both faces equally beveled and eliminates the asymmetry

64. Why does standard oxy-fuel cutting fail when attempted on gray cast iron, and what alternative thermal cutting process is effective?

A. Gray cast iron contains 2–4% carbon and 1–3% silicon — the silicon forms refractory silicon dioxide slag that blocks cutting oxygen from reaching fresh metal, and the graphite phase provides additional fuel that causes the cut zone to overheat and melt rather than oxide-cut cleanly; plasma arc cutting works on cast iron because it does not rely on the oxidation reaction and can cut any electrically conductive material

B. Cast iron cannot be thermally cut by any process — the graphite phase is electrically non-conductive, preventing plasma arc cutting, while the high silicon content prevents oxy-fuel cutting; cast iron must always be cut using mechanical processes such as sawing

C. Cast iron fails during oxy-fuel cutting only because of its high carbon content — increasing preheat to approximately 300°C provides enough thermal energy to overcome the carbon-related resistance and allows consistent cuts with a standard cutting tip

D. Cast iron can be cut by oxy-fuel using iron powder injection — injecting iron powder into the flame creates sufficient exothermic heat to overwhelm the silicon oxide barrier and allow the cutting reaction to proceed; this technique has no effective alternatives for field repair cutting of cast iron components

65. A shop CAC-A operator is assigned to gouge weld defects from a deep groove using 12.7 mm copper-coated electrodes with a manufacturer-specified range of 600–1000 A. Why must the power source be specifically rated for this current level, and what type is most appropriate?

A. CAC-A requires a constant-voltage power source similar to GMAW because the carbon arc is a high-impedance load requiring stable voltage to maintain the arc column — a constant-current source allows too much arc fluctuation for effective metal removal

B. CAC-A can use any available SMAW power source regardless of current rating — operators can reduce the electrode size to match whatever power source is available without affecting the excavation result or groove quality

C. High current for CAC-A is required to heat the compressed air to plasma temperatures for efficient metal expulsion — lower current produces unheated air that cannot expel the molten metal effectively from the excavation groove

D. High current in CAC-A is required to melt a sufficient volume of metal rapidly for efficient excavation — the power source must be a constant-current type capable of sustained output at the full rated current without significant output droop; AC transformer units and some DC rectifiers used for light SMAW may not provide sustained output at 600–1000 A; a heavy-duty DC constant-current power source rated for the electrode's full current range is required

66. An OFC operator hears a loud "pop" and the flame goes out, but the flame relights normally when the oxygen valve is quickly opened. Later the operator hears a continuous squealing from inside the torch body and sees smoke coming from the torch body. What events have occurred and which requires immediate shutdown?

A. Both events are backfires — the squealing indicates a gas-rich mixture backfiring inside the mixing chamber; the correct response to both events is to immediately reduce oxygen pressure by partially closing the oxygen valve

B. The first event is a backfire — a brief flame extinction and normal relighting is a minor event that may continue if the torch is in good condition; the second event is a flashback — combustion propagating back into the torch body, indicated by the squealing from inside the torch — requiring immediate shutdown of both gas supplies and torch inspection before any further use

C. The first event is a flashback requiring immediate shutdown; the second event is a backfire caused by turbulent flow at a partially blocked tip orifice that can be corrected by cleaning the tip without shutting down

D. Both events are normal torch operating sounds — the pop is from minor oxygen pressure fluctuations at the regulator and the squealing from inside the torch indicates proper fuel-oxygen mixing in the torch mixing chamber

67. A fabricator is evaluating high-definition plasma cutting (HDP) as an alternative to conventional plasma for precision structural parts. What specifically distinguishes high-definition plasma from conventional plasma?

A. High-definition plasma is defined specifically by operating above 400 A — the "high definition" designation refers to high amperage operation, not to any specific arc confinement technique

B. High-definition plasma uses water instead of shielding gas for all materials — the water provides better arc cooling and a sharper cut than any gaseous shielding arrangement in conventional plasma systems

C. High-definition plasma uses a more constricted arc through an optimized nozzle and swirl gas design that produces a narrower kerf, reduced bevel angle approaching 1–2°, smaller heat-affected zone, and smoother cut surface compared to conventional plasma at equivalent power — this improved quality allows HDP to produce near-laser quality cuts on metals from 1–25 mm thick

D. High-definition plasma achieves higher cut speeds by using oxygen plasma gas for all materials including stainless steel and aluminum — the oxidation energy from oxygen plasma allows 3× faster speeds without any reduction in cut quality for any material

68. When setting up structural steel plate on OFC cutting table slats, which arrangement of support slats is required and why does the arrangement affect cut quality?

A. The support slats should be oriented so that cut lines pass through the air gaps between slats rather than directly over slat tops — if the cut line passes over a slat, the cutting oxygen jet deflects upward at the slat contact, causing cut deviation and poor quality; arranging slats so all cuts pass through open gaps ensures unobstructed slag ejection and consistent cut completion

B. Support slats should be as closely spaced as possible — a maximum of 50 mm spacing maximizes plate support contact area and creates more consistent plate temperature during cutting, improving cut quality throughout the full plate

C. Slat orientation has no effect on cut quality — the only requirement is that slats be made of steel and a minimum of 6 mm thick to resist warping from the thermal effects of the cutting operation

D. Support slats must be positioned directly under all cut lines to provide a heat sink that absorbs energy from the cutting oxygen jet, preventing excessive temperature buildup at the bottom of the kerf throughout the cut

69. A maintenance welder must perform CAC-A back-gouging on an overhead weld root. What specific technique modifications apply to overhead CAC-A compared to flat position work?

A. Overhead CAC-A is not permitted under any safety standard — the combination of molten metal ejection, compressed air, and overhead position creates an unacceptable hazard that cannot be mitigated with available PPE

B. Overhead CAC-A requires switching from DCEP to DCEN because gravity-assisted metal removal on DCEP causes molten metal to fall directly onto the electrode holder; DCEN reverses the metal transfer direction so expelled metal is directed away from the holder

C. The only modification required for overhead CAC-A is using a longer electrode to keep the holder further from the hot metal splash — a minimum electrode extension of 200 mm is required to protect the holder from overhead metal ejection

D. Overhead CAC-A requires increasing the electrode lead angle to more steeply forward of the gouge line, reducing amperage by approximately 10–15% from the flat position setting to reduce molten metal volume, protecting all exposed skin from hot metal ejection, and confirming that all workers below the work area are excluded from the fall zone for hot ejected metal and slag

70. A mechanized OFC system produces inconsistent cut quality — some cuts on the same plate and same setup show good quality while others show rough faces and heavy dross. The equipment has been verified as defect-free. What is the most likely cause?

A. Inconsistent quality on a verified mechanized system is caused by microstructural variation within the structural steel plate — harder microstructure zones resist the cutting reaction and produce the poor-quality cuts in specific plate areas

B. Contamination of the cutting oxygen supply is the most likely cause — water, oil, or other contaminants in the cutting oxygen create intermittent gas purity problems that alternately improve and degrade cut quality; the supply should be checked for moisture using an inline dryer or indicator, oil contamination from the compressor, or debris in the regulators

C. Inconsistent mechanized OFC quality is always caused by CNC program errors — variations in programmed cutting speed produce the described quality variations, and only reviewing and correcting the CNC program restores consistent results

D. Inconsistent mechanized OFC quality is most likely caused by the torch height control system drifting — a malfunctioning THC allows the torch-to-plate standoff to change, altering the preheat distribution and cutting oxygen dynamics in a way that produces quality variation throughout the plate

71. A plasma arc cutting operator gradually increases the nitrogen plasma gas flow rate above the manufacturer's specified setting. What effect does excessive plasma gas flow rate have on cut quality and consumable life?

A. Increasing plasma gas flow above the specified setting always improves cut quality by providing more torch cooling and a more stable plasma column — manufacturer settings are conservative minimums and experienced operators routinely exceed them without penalty

B. Excessive gas flow rate has no effect on cut quality but reduces consumable life by creating turbulence in the nozzle bore — the turbulence increases mechanical wear on the nozzle orifice without affecting the plasma cut produced

C. Excessive plasma gas flow disrupts plasma arc column stability — too much gas creates turbulence in the nozzle bore and plasma column, causing arc wandering, increased kerf width, higher bevel angle, rougher cut faces, and accelerated electrode and nozzle wear; the manufacturer's specified flow rate is the optimal setting and must not be exceeded in production

D. Excessive plasma gas flow rate is only problematic with nitrogen plasma gas — oxygen plasma systems are flow-insensitive and can be operated at any flow rate above the minimum because oxygen's chemical reactivity compensates for any gas dynamic disruption

72. An apprentice welder uses E6013 electrodes set to DCEP on a DC transformer-rectifier for welding a 2 mm mild steel lap joint. What results should the apprentice expect with E6013 on DCEP compared to DCEN for this thin sheet application?

A. E6013 electrodes work acceptably on AC and either DC polarity — on DCEN, E6013 produces slightly shallower penetration than on DCEP; for 2 mm sheet, DCEN reduces the burn-through risk by providing shallower penetration; on DCEP the apprentice should expect acceptable results but deeper penetration and higher burn-through risk on the thin material

B. E6013 electrodes can only be used on AC power sources — the rutile coating chemistry requires alternating polarity to produce correct slag characteristics; DCEP with E6013 produces an unstable arc with uncontrollable spatter on any material thickness

C. E6013 on DCEP produces a wider, flatter bead compared to AC because DCEP concentrates heat at the electrode, which increases the electrode melt rate, reduces penetration into the base metal, and results in a shallower, wider bead profile

D. E6013 electrodes are exclusively for DCEP and cannot be used on AC or DCEN — the "13" classification suffix specifies DCEP-only operation, and substituting AC or DCEN will cause the electrode coating to separate from the core wire

73. A maintenance welder must repair a crack in a 4340 alloy steel hydraulic cylinder housing in the as-quenched condition at approximately 45 HRC. What preheat approach is most critical for preventing hydrogen-induced cracking in this repair?

A. No preheat is required for 4340 alloy steel if low-hydrogen E12018-M electrodes are used — the very low hydrogen eliminates the cracking source and prevents HAZ cracking regardless of base metal hardness

B. A preheat of 50°C minimum with a maximum interpass temperature of 100°C is sufficient because 4340 in the as-quenched condition is actually softer than in the tempered condition and does not require aggressive preheat

C. The welded area must be quenched in water immediately after each pass to prevent austenitizing the HAZ between passes — rapid cooling prevents grain coarsening in 4340 and maintains the high hardness needed for hydraulic service

D. High preheat of typically 250–370°C and careful interpass temperature control are critical — the combination of high carbon equivalent, high hardenability, and joint restraint in the 45 HRC base material creates maximum susceptibility to hydrogen-induced delayed cracking; even with low-hydrogen electrodes, preheat slows the HAZ cooling rate, reduces the as-welded hardness gradient, and extends the time for diffusible hydrogen to escape before the temperature drops to the cracking-susceptible range

74. An E7024 electrode contains iron powder in its coating. Why are iron powder electrodes used for flat and horizontal structural work?

A. Iron powder in the coating neutralizes impurities in the base metal — it reacts with phosphorus and sulfur to prevent these elements from concentrating in the weld metal and causing brittle fracture

B. Iron powder in the coating increases the electrode's deposition rate and deposition efficiency — the iron powder melts and adds to the deposited weld metal, increasing the weight of weld metal produced per length of electrode consumed; E7024 electrodes can achieve deposition efficiencies of 120–140% compared to approximately 70–75% for rutile electrodes without iron powder, allowing the welder to deposit larger welds more quickly

C. Iron powder in the coating improves impact toughness of the weld metal by diluting alloying elements from the base metal that reduce toughness, improving low-temperature Charpy performance of the completed weld deposit

D. Iron powder in the coating reduces the cost of the electrode because iron powder is less expensive per kilogram than other flux ingredients — the iron filler allows reduced proportions of expensive flux components while maintaining the mechanical properties of the deposit

75. A structural welder depositing horizontal fillet welds consistently produces undercut along the upper vertical plate weld toe. Which adjustment most directly eliminates this undercut?

A. Undercut at the upper toe of a horizontal fillet weld is caused by insufficient amperage — increasing amperage by 10–15% provides more heat to fully fuse the upper plate toe and eliminates the undercut by improving fusion at the toe transition

B. Upper-toe undercut in horizontal fillets is caused by using too large an electrode — switching to a smaller diameter reduces current density and arc force at the weld toe; E7018 electrodes above 4.0 mm diameter always produce upper-toe undercut on horizontal fillet welds

C. Upper-toe undercut in horizontal fillet welding is most commonly caused by excessive arc length or a work angle directed too steeply toward the vertical plate — the correction is to reduce the arc length and redirect the electrode more toward the bottom plate, directing the arc force away from the vertical plate toe

D. Upper-toe undercut is caused by insufficient iron powder in the electrode coating — switching from E7018 to E7024 or E7028 iron powder electrodes fills the undercut zone with additional coating powder and eliminates the defect condition

76. A welding procedure specifies that the first pass in a highly restrained joint on A514 structural steel must be deposited using E7018 as a "butter" layer before switching to E11018-M for fill passes. What metallurgical reason justifies this approach?

A. E7018 is required for the root pass because E11018-M electrodes produce excessive penetration in any root configuration and must only be used for fill and cap passes

B. The E7018 butter layer reduces joint cost by replacing expensive E11018-M electrodes in the high-volume fill passes — the butter layer is an economic choice rather than a metallurgical requirement

C. The E7018 butter layer produces a lower hardness deposit that reduces the risk of arc blow when the higher-strength E11018-M electrode is used for subsequent fill passes over the more magnetic root area

D. Buttering the root with E7018 reduces the dilution of high-strength E11018-M fill passes by the high-carbon A514 base metal — without the butter layer, direct dilution of E11018-M with A514 can produce a high-carbon, high-alloy deposit at the fusion boundary susceptible to solidification hot cracking and cold cracking; the lower-strength E7018 buffer also accommodates the large mismatch strain without cracking before the full-strength fill passes are deposited

77. On a multi-pass SMAW groove weld on P91 chrome-moly alloy steel, the WPS specifies stringer beads with a maximum weave width of 2× electrode diameter. Why is the wider weave prohibited for P91?

A. Wide weave beads are prohibited on P91 purely because the welder cannot maintain consistent bead geometry at wide weave widths — the restriction is a quality assurance measure to ensure predictable bead dimensions rather than a metallurgical requirement

B. Wide weave beads on P91 create excessively wide heat-affected zones with coarse-grained regions that have poor creep properties at elevated service temperatures — P91 strength depends on fine-grained tempered martensite with precise vanadium, niobium, and nitrogen precipitation; the elevated heat input from wide weave passes overheats these precipitate-forming elements and produces larger, more widely-spaced precipitates that reduce in-service creep strength

C. Wide weave beads are prohibited on P91 because they produce a flat bead profile with excessive convexity — the weave technique causes weld metal to pile up faster than it wets out, and the resulting convex profile creates a stress concentration at the weld toes that causes premature creep cracking at operating temperature

D. Wide weave beads are permitted on P91 only above 400°C preheat — the restriction to stringers applies only when ambient temperature is below 20°C, and in a heated environment the wider weave assists temperature equalization across the joint

78. A pipe welder uses a "J-weave" technique during fill passes of a 5G pipe weld. What motion does the J-weave describe, and what benefit does it provide compared to a straight stringer bead?

A. The J-weave involves a brief pause at the sidewalls of the groove (the two uprights of the J) and a fast traverse across the groove bottom (the curve of the J) — the pause-at-toe and quick-traverse technique ensures adequate fusion and buildup at the groove sidewalls where solidification of the pool tends to cause incomplete fusion if the arc traverses evenly across the groove face

B. The J-weave moves in a J-shaped pattern parallel to the pipe axis rather than transverse to it — the motion deposits extra metal at the start of each weave stroke to compensate for the shrinkage that occurs at each weld restart

C. The J-weave and figure-8 weave are identical techniques — both are common names for the same electrode oscillation pattern and either name may be used without distinction in any Canadian welding training context

D. The J-weave is used exclusively for root passes in 6G pipe welding — it is the only technique that produces root reinforcement on the pipe interior when the welder is positioned outside, and it is never used for fill or cap passes in any pipe position

79. An SMAW welder switches from E6013 rutile electrodes to E7016 basic low-hydrogen electrodes for a structural application requiring improved impact toughness. What changes in arc characteristics and slag behavior should the welder expect when using the E7016 basic electrodes?

A. E7016 basic electrodes produce a more fluid, self-releasing slag compared to E6013 rutile — the basic slag has a lower solidification temperature than rutile and floats more rapidly to the pool surface, making inter-pass cleaning easier and reducing cleaning time compared to rutile electrode slag

B. E7016 basic electrodes produce a softer, more stable arc than E6013 rutile — the basic coating contains higher concentrations of arc-ionizing compounds than rutile coatings, resulting in a smoother, lower-spatter arc that is easier to control across all welding positions

C. E7016 basic electrodes produce a stiffer, more forceful arc and a heavier, less fluid slag with a higher solidification temperature than E6013 rutile slag — the basic slag requires significantly more mechanical effort to remove between passes, and the arc is more sensitive to arc length variation than E6013, producing noticeably more spatter when the arc is held too long

D. E7016 and E6013 are identical in arc behavior because both belong to the same AWS A5.1 usability category — coating chemistry affects only the mechanical properties of the deposited weld metal and has no measurable effect on arc characteristics, spatter level, or slag removal difficulty

80. A pipe welder making a root pass in the 2G position using E6010 electrodes finds that the root bead drops through excessively (drops through internally) at the 3–9 o'clock clock positions. What is most likely causing the excessive internal root bead at these positions?

A. Excessive internal bead at the 3–9 o'clock positions results from using too small an electrode — a small electrode cannot maintain sufficient arc force to control the pool at the side positions, and a larger electrode provides more control

B. Excessive internal root bead at the side positions results from insufficient amperage — higher amperage creates more arc force that maintains pool control and prevents the excessive drop-through at the difficult side clock positions

C. The excessive root bead at the side positions is caused by the horizontal position being the most inherently difficult position — the drop-through is unavoidable and represents acceptable variation in root pass geometry for the 2G position

D. Excessive root bead drop-through at the 3–9 o'clock positions in 2G welding results from excessive heat input at the side — gravity acts perpendicular to the weld axis at these positions and the pool tends to fall through the root opening; the remedy is to reduce amperage slightly when the torch is at the side positions, increase travel speed to reduce heat input per unit length, or use a tighter shorter arc at these positions

81. A welder significantly increases travel speed while maintaining the same amperage and arc length on an E7018 flat position weld. What changes occur in the bead profile and dimensional adequacy?

A. Increasing travel speed while keeping other parameters constant increases bead convexity and width while reducing weld length per electrode — faster travel forces molten metal to pile up at the leading edge of the pool, producing a taller, wider bead

B. Increasing travel speed reduces heat input per unit length of weld, producing a narrower bead with less penetration and reduced weld throat; the bead width and crown height decrease; the HAZ narrows; and if speed increases too much, the deposited metal per unit length drops below the minimum required, producing an undersized weld that fails dimensional acceptance criteria

C. Increasing travel speed has no effect on bead profile as long as amperage and arc length are held constant — bead shape in SMAW is determined exclusively by amperage and arc length settings, not by travel speed

D. Increasing travel speed while keeping amperage constant increases penetration because the arc force is concentrated over a smaller area per unit time — the higher current density from faster travel produces deeper penetration and a narrower more deeply-penetrating bead profile

82. During pressure vessel fabrication, a welder uses self-shielded FCAW wire (E71T-11) for fill passes after a root pass made with E7018 SMAW electrodes. The WPS specifies E7018 SMAW for all passes. Is this acceptable?

A. This is acceptable because self-shielded FCAW and SMAW are both arc welding processes, and changing electrode type within a joint is always permitted under ASME IX as long as both consumables share the same F-Number group

B. This is acceptable for fill passes only — ASME IX allows process substitution in fill passes without WPS revision, as fill passes do not affect the mechanical properties tested during procedure qualification

C. This is not acceptable — the WPS specifies E7018 SMAW for all passes, and substituting a different welding process without a WPS amendment or separate process combination qualification is an unqualified procedure deviation; welding process is an essential variable under both ASME Section IX and CWB standards

D. This is only unacceptable for the cap pass — fill passes may use any welding process at the welder's discretion because filled material is not directly inspectable after completion and only the root and cap are subject to WPS process-specific requirements

83. A structural welder deposits horizontal fillet welds and finds the lower toe (base plate side) consistently shows cold lap — weld metal flowing over the base plate without fusing and creating a notch at the lower toe. What is the primary cause and correction?

A. Cold lap at the lower toe of a horizontal fillet weld is most commonly caused by too-low amperage combined with a work angle directed too far toward the upper vertical plate — the correction is to increase amperage slightly and adjust the work angle to direct more arc energy toward the base plate, ensuring sufficient arc force to fuse the lower toe before the pool solidifies

B. Cold lap at the lower toe is caused by a travel angle too steep — the steep travel angle blasts the molten pool forward and away from the lower toe before it can fuse; reducing the travel angle to 0–5° from perpendicular eliminates the cold lap condition

C. Cold lap at the lower toe is always caused by an electrode that is too large — the large electrode deposits a high-volume pool that flows to the lower plate before fusion is complete; switching to a smaller electrode diameter always eliminates cold lap in horizontal fillet welding

D. Cold lap at the lower toe results from the base plate exceeding 12 mm thickness — when the base plate's heat sink capacity prevents fusion, preheating the base plate to 100°C minimum eliminates the heat sink effect and prevents cold lap in all horizontal fillet weld applications

84. Why must low-hydrogen E7018 electrodes be used with a power source having an open-circuit voltage above 65 V, and what happens to arc quality when OCV is too low?

A. High OCV is required for E7018 because the iron powder in the coating requires higher voltage to melt — iron's higher melting temperature compared to other flux ingredients requires the additional OCV to consistently melt the coating powder component

B. Low-hydrogen electrodes require high OCV because the moisture-free basic coating has a higher electrical resistance than rutile coating — the higher resistance requires higher OCV to force sufficient current through the coating to ionize the arc column

C. High OCV is required to prevent moisture re-absorption during welding — OCV above 65 V creates an electromagnetic field around the electrode that acts as a moisture barrier between passes when the arc is extinguished and the electrode cools

D. Low-hydrogen E7018 electrodes require OCV above 65 V because the basic coating (calcium fluoride, calcium carbonate) has a higher ionization potential than rutile coating; with OCV below 65 V, arc starting with basic electrodes becomes unreliable and the arc tends to be unstable with increased spatter; AC power sources for low-hydrogen electrodes specify minimum OCV values to ensure adequate arc starting and stable operation throughout the weld

85. Why are manganese additions included in the flux coatings of structural SMAW electrodes, and what metallurgical role does manganese play in the deposited weld metal?

A. Manganese is added to SMAW electrode coatings primarily as a cost-reduction measure — manganese ore is abundant and inexpensive, and its addition reduces the required proportion of more expensive alloying elements in the flux formulation

B. Manganese is added to SMAW electrode coatings to increase the melting temperature of the flux — higher melting temperature flux creates a more viscous slag that provides better pool support during out-of-position welding in vertical and overhead positions

C. Manganese in SMAW electrode coatings serves as a deoxidizer that removes oxygen from the weld pool forming MnO that becomes part of the slag — the dissolved manganese remaining in the deposit increases strength through solid solution hardening, improves impact toughness by refining the grain structure, and counteracts the embrittling effect of sulfur by forming MnS inclusions that are less detrimental to toughness than iron sulfide

D. Manganese is added to all SMAW electrode coatings exclusively as an arc stabilizer — the manganese vapor created during electrode melting ionizes in the arc column and lowers the arc voltage required to maintain the arc, making the welding process more electrically efficient

86. A welder qualified for 5G position pipe welding must complete a root pass on 8-inch NPS pipe. In what direction should the weld progress and what is the general technique sequence?

A. On large-diameter pipe in the 5G position, the conventional approach is to weld uphill from the 6 o'clock position to the 12 o'clock position — two welders working simultaneously from 6 to 12 on each side completes the root pass more efficiently; alternatively, a single welder completes each half from 6 to 12 o'clock; the keyhole technique with E6010 cellulosic electrodes provides full-penetration root pass deposition with the penetration control required for a complete internal root bead

B. On large 5G pipe the root pass must always be welded downhill from 12 o'clock to 6 o'clock — gravity assists the molten pool to flow forward and fill the root gap more completely than uphill welding, which requires more technique skill

C. 5G position requires a two-pass root technique — a first thin wash pass deposited downhill using low amperage E6013 to establish fusion boundaries, followed by a second uphill hot pass using E6010 to complete root penetration

D. 5G pipe welding requires the welder to position at the 3 o'clock position and weld horizontally from 3 to 9 o'clock in both directions — never from the top or bottom — to avoid the gravitational effects that create uneven bead profiles at the 12 and 6 o'clock positions

87. A quality inspector reviewing structural bridge welds finds that welds made during wet weather show clustering of small distributed porosity throughout multiple consecutive weld deposits. The electrodes are E7018. What is the most likely cause?

A. The distributed porosity is caused by wet weather increasing humidity, which magnetizes the base metal — moisture in the air aligns magnetic domains in the structural steel, causing arc blow that produces distributed porosity throughout the weld deposits

B. The most likely cause is moisture-contaminated E7018 electrodes — if electrodes were exposed to wet weather conditions without protection in a heated storage container or sealed canister, the basic calcium carbonate/fluoride coating absorbs moisture; the moisture decomposes in the arc and releases hydrogen that causes distributed porosity; the solution is to verify electrode storage and recondition or replace affected electrodes

C. Wet weather causes porosity because cold rain falling on freshly deposited weld metal creates thermal shock — the rapid quenching traps gas bubbles in the solidifying weld metal before they can escape through the pool surface

D. The distributed porosity is caused by nitrogen pickup — wet weather creates conditions that attract nitrogen to the weld area, where it dissolves in the pool and forms nitride porosity that is indistinguishable from hydrogen porosity but requires different corrective action

88. A welding engineer must specify either E7016 or E7018 basic low-hydrogen electrodes for high-restraint joints on Grade 500W structural steel. What is the key difference between these two electrode types and which is preferred for this application?

A. E7016 contains iron powder and E7018 does not — the iron powder in E7016 increases the deposition rate but reduces the minimum hydrogen content, making E7018 the lower-hydrogen option for critical structural applications

B. E7016 can be used on AC power sources while E7018 is DC-only — for sites with only AC transformer-type power sources E7016 is the required choice, while on DC either can be used without meaningful distinction

C. E7016 and E7018 are exactly equivalent in all mechanical and metallurgical properties — the only difference is the manufacturer's individual coating formulation, and either may be substituted for the other on any structural application

D. E7018 contains iron powder in the coating that provides higher deposition rates and efficiency (typically 110–125%) compared to E7016 (typically 90–100%); both are basic low-hydrogen classifications; for high-restraint Grade 500W structural joints, E7018 is preferred because it provides a more fluid slag that improves fusion, higher productivity from the iron powder, and E7018 H4 designation provides lower diffusible hydrogen levels that further reduce cold cracking risk in high-restraint, high-strength steel applications

89. A welder is welding a 4 mm thick steel plate lap joint using 3.2 mm E7018 at 130 A and experiences consistent burn-through along the joint. The drawing specifies a 4 mm fillet weld. Which combination of changes is most appropriate to prevent the burn-through?

A. The correct solution is to switch to E6010 cellulosic electrodes — the deep-penetrating characteristic of E6010 concentrates heat more precisely, reducing the spread of heat that causes burn-through on thin material

B. Switching to a 4.8 mm electrode eliminates burn-through by reducing current density at the work — larger electrodes distribute amperage over a larger contact area and reduce the heat concentration that causes burn-through on thin plate

C. Reducing the amperage to approximately 85–100 A for 3.2 mm E7018, increasing travel speed, and maintaining a consistent work angle that does not direct the arc too directly at the plate edge will reduce the heat input per unit length and prevent burn-through on 4 mm plate without sacrificing the required fusion quality

D. Burn-through on 4 mm plate with E7018 can only be prevented by repositioning to the flat 1G position — burn-through in lap joint welding always results from position orientation and cannot be corrected by parameter adjustment alone

90. A GMAW welder decreases the contact-tip-to-work distance from 19 mm to 10 mm while keeping wire feed speed and voltage constant. What changes in welding parameters and bead profile result from this reduction?

A. Reducing CTWD from 19 mm to 10 mm reduces the I^2R resistance preheating of the wire stub — less stub preheat means the wire arrives at the arc cooler, requiring the arc to supply more energy to melt it; on a constant-voltage machine, this increases arc current to maintain the set voltage, producing deeper penetration, a narrower bead, and more spatter

B. Reducing CTWD reduces deposition rate because the shorter electrode extension provides less preheat to the wire — the reduced preheat increases the arc energy required to melt the wire, increasing the melt-off rate per unit arc length and depositing more metal than the longer CTWD

C. Reducing CTWD to 10 mm has no effect on welding parameters as long as machine settings remain unchanged — CTWD is an ergonomic adjustment that only affects welder comfort and visibility, not the electrical characteristics or bead profile

D. Reducing CTWD increases deposition rate by concentrating the I^2R preheating in a shorter wire segment — a shorter stub length concentrates the resistive heating more intensely, increasing the wire temperature per unit length and increasing the melt-off rate per ampere

91. A welding engineer is selecting FCAW wire for a high-restraint joint on 75 mm A709 bridge steel where cold cracking risk is the primary concern. Two options are available: E71T-1C (rutile flux, CO_2) and E71T-5C (basic flux, CO_2). Which selection is correct?

A. E71T-1C is preferred for bridge steel because the rutile flux system produces superior bead appearance and self-releasing slag required for the high-quality visual specifications of bridge fabrication contracts

B. E71T-5C (basic flux) should be selected — the basic flux system produces lower diffusible hydrogen (typically achieving H8 or H4 levels) compared to T-1 rutile wires; lower diffusible hydrogen is the critical property for reducing cold cracking risk in high-restraint joints on thick, high-strength bridge steel; the more difficult-to-remove T-5 slag is secondary to the cold cracking resistance benefit

C. E71T-1C and E71T-5C produce identical diffusible hydrogen levels — the T-designation indicates only positional capability and slag characteristics, not hydrogen content, so both are acceptable for this cold cracking-sensitive application

D. E71T-5C cannot be used on A709 bridge steel because the basic flux contains fluoride compounds that react with manganese in the bridge steel, producing manganese fluoride inclusions that embrittle the weld metal; only T-1 rutile wires are code-permitted for AASHTO bridge steel fabrication

92. A GMAW operator welding 1.6 mm stainless steel sheet with 0.9 mm ER308L wire and 90/10 Ar/He shielding gas experiences burn-through at the weld start. Which technique most effectively prevents burn-through at the weld start on thin-gauge stainless?

A. Starting the arc on a copper strike pad attached to the joint start and sliding the arc from the copper pad onto the stainless is most effective — copper absorbs heat without melting, preventing the initial high heat burst from burning through the stainless

B. Increasing wire feed speed at the start and quickly reducing it after the arc establishes prevents burn-through by delivering more metal to fill the arc start zone before the base metal heats up sufficiently to burn through

C. Starting in the middle of the joint and welding toward each end prevents burn-through at any single location because heat distribution is more uniform when the arc starts at maximum restraint at the joint midspan

D. Using a slope-in function to ramp welding current from a low start value to normal welding parameters over the first 0.5–1.0 seconds allows the arc to establish and begin depositing metal before full current reaches the thin base metal, preventing the initial burst of heat that causes burn-through at the cold-start location

93. A fabricator must weld gusset plates to weathering steel (CSA G40.21 350A) using self-shielded FCAW outdoors in wind conditions exceeding 15 km/h. The weld requires −20°C minimum impact toughness in the deposited weld metal. Which wire classification is most appropriate?

A. E70T-4 self-shielded wire is preferred for all outdoor welding because the "4" suffix indicates enhanced wind-resistance compounds in the core that maintain shielding effectiveness up to 40 km/h wind speeds

B. E71T-11 is the best choice because it can be used in all positions without restriction, and versatile all-position capability makes it suitable for any orientation of the gusset plate joints

C. E71T-8 self-shielded FCAW wire is the appropriate selection — T-8 wires are designed for all-position welding (indicated by the "1" position digit), are self-shielded for wind resistance, and the T-8 flux system produces improved notch toughness and low diffusible hydrogen characteristics that meet the −20°C impact toughness requirement; T-8 wires are commonly specified for outdoor structural applications requiring notch toughness certification

D. No self-shielded FCAW wire can meet the −20°C impact toughness requirement — self-shielded wires inherently deposit higher nitrogen content weld metal that fails Charpy testing below 0°C; gas-shielded FCAW or GMAW must be used for all toughness-critical outdoor structural welding

94. A production supervisor is considering switching from conventional GMAW spray transfer to pulsed GMAW for structural welding on 8 mm A516 pressure vessel shell plates. What is the primary advantage of pulsed GMAW?

A. Pulsed GMAW alternates between a low background current that maintains the arc and a high peak current that creates one droplet transfer per pulse cycle — this enables spray-like droplet transfer at an average current level below the conventional spray threshold, allowing the process to be used in all positions including vertical and overhead where conventional spray is impractical; the lower average heat input also reduces distortion compared to conventional spray transfer

B. Pulsed GMAW eliminates all spatter because the precisely timed pulse current causes each droplet to detach exactly at the electrode tip with zero excess energy — conventional spray produces spatter from droplets that detach with residual momentum while pulsed creates perfectly controlled detachment

C. Pulsed GMAW achieves higher deposition rates than conventional spray because the pulsed current creates larger electromagnetic force that accelerates droplet transfer velocity, depositing more metal per unit time than a continuous spray current

D. Pulsed GMAW operates at lower gas consumption rates than conventional spray — the pulsed arc creates a more efficient gas coverage pattern that allows flow rates 30% lower than conventional spray while providing equivalent atmospheric protection

95. What technical characteristics of a FCAW wire determine whether it can be used in vertical-up and overhead positions, and why cannot all FCAW wires be used in all positions?

A. Position capability in FCAW is determined by the electrode polarity required — wires requiring DCEP are limited to flat and horizontal while wires usable on DCEN are approved for all positions including vertical-up and overhead

B. All FCAW wires can be used in all positions if the operator reduces wire feed speed by 30% from the flat-position setting — the reduced WFS decreases heat input sufficiently to allow out-of-position pool control for any FCAW wire classification

C. Position capability in FCAW is determined by wire diameter — only FCAW wires below 1.2 mm diameter can be used in all positions; larger diameter wires have too much mass at the electrode tip and cannot maintain a controllable pool in vertical or overhead positions

D. Position capability in FCAW is determined primarily by the solidification behavior of the flux system — for out-of-position welding the slag must solidify quickly enough to support the cooling weld pool against gravity; the "1" digit in classifications like E71T-1C indicates the flux solidifies fast enough for all-position use, while the "0" digit (E70T-1C) indicates only flat and horizontal capability because that flux remains molten too long to support the pool against gravity

96. A production manager is evaluating tandem GMAW (two wire electrodes simultaneously in the same weld pool) for increasing productivity on long structural welds. What is the primary advantage and the specific challenge compared to single-wire GMAW?

A. Tandem GMAW doubles deposition rate because two electrodes deposit simultaneously — the primary challenge is that tandem systems require double the shielding gas volume because each electrode needs its own independent gas coverage from separate nozzles

B. Tandem GMAW's primary advantage is approximately double the single-wire deposition rate — the lead electrode establishes penetration and the trail electrode fills and caps; the primary challenge is controlling the electromagnetic interaction (arc blow) between the two arcs and the coupled thermal effect on the weld pool, requiring precise optimization of the phase relationship between the two power sources to prevent arc instability

C. Tandem GMAW's primary advantage is eliminating multi-pass welding — any joint requiring multiple single-wire passes can be completed in one tandem pass; the challenge is that tandem systems require a dedicated CNC controller that cannot be used with any other welding process

D. Tandem GMAW's primary advantage is reduced spatter — the two electrodes create competing arc forces that cancel each other out, producing spatter-free deposition; the challenge is that tandem is limited to flat and horizontal positions because the combined heat input creates a pool too fluid for out-of-position work

97. A safety officer is measuring fume generation rates comparing SMAW E7018 and FCAW-G E71T-1M in the fabrication shop. Which statement most accurately describes the relative fume generation characteristics of these processes?

A. SMAW E7018 produces significantly more fume per kilogram of deposited weld metal than FCAW-G E71T-1M — the basic coating produces a larger fume volume than the tubular wire design; ventilation requirements for SMAW always exceed those for FCAW-G

B. SMAW and FCAW-G produce identical fume generation rates because both deposit equivalent weld metal from the same electrode strength class — fume generation is entirely determined by the electrode strength classification, not the process type

C. FCAW-G E71T-1M typically generates more welding fume per unit time than SMAW E7018 because FCAW-G operates at higher deposition rates with higher current density; however, the fume composition from FCAW-G is generally lower in certain toxic components per unit of deposited weld metal; both processes require adequate local exhaust ventilation, but high-deposition-rate FCAW-G requires more robust fume control due to its higher total fume generation rate

D. Fume generation rate in FCAW-G is always lower than SMAW because the flux is enclosed inside the wire tube rather than exposed on the electrode exterior — enclosed flux cannot produce fume and all FCAW-G fume originates from the base metal rather than the consumable

98. A GMAW operator welds galvanized steel structural components using ER70S-6 wire and 75/25 Ar/CO_2 shielding gas. The zinc coating has been ground off the joint preparation area but remains on surfaces immediately adjacent to the weld. The welder notices porosity near the weld toes. What is the most likely cause?

A. The zinc coating adjacent to the weld joint vaporizes from the arc heat — zinc has a relatively low boiling point (907°C) and zinc vapor is generated when the adjacent coating is heated; if zinc vapor enters the solidifying pool before escaping, it creates porosity; the solution is to remove the zinc coating for a wider zone (typically 25 mm on both sides) beyond the width of the heat-affected zone

B. The porosity near the toes is caused by shielding gas flowing over the zinc-coated surfaces and picking up zinc vapor contamination — the solution is to increase shielding gas flow rate to dilute the zinc vapor before it reaches the weld pool

C. The porosity is caused by the cleaning agent used to remove the zinc — most zinc removal processes use acid washes that leave trace acid on the plate surface; the acid decomposes in the arc and produces hydrogen porosity at the weld toes

D. The porosity near the toes is caused by the grounding cable being connected to the zinc-coated base metal — current flowing through the zinc creates zinc ions that deposit in the molten pool and cause porosity when they solidify

99. A FCAW-G welder using E71T-1M wire with 75/25 Ar/CO_2 shielding gas finds that welds made in the first hour of the shift are of excellent quality, but welds made later in the shift show increasing porosity levels while all machine parameters remain unchanged. What is the most likely cause?

A. Progressive porosity throughout the shift indicates cumulative base metal surface contamination — oil and grease from handling equipment migrate to the plate surface over the course of the shift and are not visible until they react with the arc

B. Progressive porosity is caused by the wire spool warming up — FCAW wire absorbs atmospheric moisture as the spool warms to room temperature, and accumulated moisture on warm wire causes hydrogen porosity in later welds

C. Progressive porosity indicates a wearing contact tip — as the contact tip bore increases from wear, the wire guidance deteriorates and the arc becomes less stable, producing increasing porosity throughout the shift

D. The most likely cause is depletion of the shielding gas cylinder — as the gas supply decreases throughout the shift, delivery pressure drops and flow rate may fall below the minimum required for adequate atmospheric protection; reduced coverage progressively worsens porosity as the cylinder nears empty; the welder should check cylinder pressure and replace the cylinder if below the minimum operating pressure

100. A production manager asks a welding engineer to compare the economics of switching from solid wire GMAW to FCAW-G for high-volume 9–12 mm plate horizontal fillet welds. Which statement accurately addresses the key economic comparison factors?

A. FCAW-G is always more economical than solid wire GMAW for any production application because the higher deposition rate makes the slightly higher wire cost insignificant — deposition rate per kilogram of wire purchased is the only relevant economic factor

B. FCAW-G typically achieves higher deposition rates than solid wire GMAW for the same electrode diameter, but the higher wire purchase cost partially offsets the productivity gain; the complete economic comparison must include wire cost per kg, deposition efficiency (solid wire ≈95–98% vs. FCAW ≈80–85%), slag removal time, and fume control costs; for this high-volume horizontal fillet application, FCAW-G typically provides a net economic advantage because the deposition rate improvement more than compensates for the other cost factors

C. Solid wire GMAW and FCAW-G produce identical deposition rates and bead profiles for horizontal fillet welds at the same current and voltage settings, making the decision purely based on wire purchase price — whichever wire is cheaper per kilogram is the correct selection for this application

D. FCAW-G cannot be used for horizontal fillet welding because the flux-cored wire produces insufficient fusion at the fillet toes in the horizontal position — solid wire GMAW is the only process that reliably achieves complete toe fusion for structural horizontal fillet welds

101. A FCAW-G operator is welding a 4-metre circumferential fillet weld around a nozzle-to-shell connection on a pressure vessel and observes significant angular distortion pulling the nozzle toward the shell. Which welding technique reduces this angular distortion compared to continuous welding?

A. Welding the joint in two halves simultaneously using two welders working from opposite sides and moving in the same direction reduces angular distortion because simultaneous heat inputs from both sides cancel each other's angular distortion effects

B. Increasing travel speed and reducing amperage for the full 4-metre weld completely eliminates angular distortion regardless of joint configuration — lower heat input reduces all shrinkage forces

C. The backstep welding technique — depositing short segments in the direction opposite to the overall progression — reduces angular distortion by distributing thermal shrinkage forces more uniformly around the joint circumference rather than concentrating them; skip weld patterns also allow completed segments to act as restraints for adjacent unwelded areas

D. Angular distortion in circumferential nozzle welds can only be controlled by welding during cold ambient temperatures when the higher thermal gradients restrain the joint — warm-weather welding always produces uncontrollable angular distortion

102. In a production GMAW application, a welder increases electrode extension (stick-out) from 12 mm to 25 mm while keeping wire feed speed and voltage constant. What effect does the increased stick-out have on the welding parameters?

A. Increasing electrode extension from 12 mm to 25 mm increases the I^2R resistive preheating of the wire in the longer unsupported stub — on a constant-voltage machine, the increased preheat reduces the arc energy required to melt the wire, resulting in decreased welding current; the bead becomes wider and flatter with shallower penetration as the lower current and higher preheat contribution change the energy balance at the arc

B. Increasing electrode extension increases welding amperage because the longer wire path increases the circuit resistance — on a CV machine, higher resistance requires higher current to maintain the set voltage, so amperage increases proportionally with stick-out length

C. Increased electrode extension has no effect on welding amperage because CV power sources maintain the set voltage regardless of circuit resistance changes from stick-out variation — only the WFS setting determines welding current

D. Increasing electrode extension from 12 to 25 mm doubles the deposition rate because the I^2R preheating of the longer stub melts the wire twice as fast as the shorter stick-out, independent of the arc energy at the contact point

103. A welder using self-shielded FCAW wire (E71T-11) observes globular metal transfer — the wire depositing large irregular drops that sometimes short-circuit to the pool. Is this the correct transfer mode and does it indicate a problem?

A. Self-shielded FCAW wires should always operate in spray transfer mode — globular transfer with E71T-11 indicates voltage is too low and wire feed speed too high; increasing voltage and decreasing WFS transitions the wire to spray transfer for correct operation

B. Self-shielded FCAW wires inherently operate in globular transfer mode by design — unlike gas-shielded GMAW where spray transfer is achievable at high currents, self-shielded FCAW wires contain core compounds that stabilize the arc but preclude the electromagnetic constriction needed for spray transfer; globular mode is the correct expected transfer mode for E71T-11 and does not indicate a parameter problem

C. Self-shielded FCAW wires should operate in short-circuit transfer mode — globular transfer produces excessive spatter and indicates operation above the maximum rated current; reducing WFS to transition to short-circuit transfer corrects the globular condition

D. Globular transfer in self-shielded FCAW indicates wire moisture contamination — dry E71T-11 wire should always operate in spray transfer, and the presence of moisture in the wire core causes the irregular globular transfer pattern observed

104. An operator uses a power source with surface tension transfer (STT) or regulated metal deposition (RMD) technology for root pass welding on pipe. What specific capability does this technology provide that conventional CV GMAW cannot offer for root pass applications?

A. STT/RMD enables spray transfer at current levels below the conventional spray transition threshold — the special waveform control creates spray behavior at low current, allowing high deposition efficiency of spray transfer in a thin root pass

B. STT/RMD technology eliminates the need for back purging in stainless steel pipe root welds — the precisely controlled heat input prevents root surface oxidation even without argon back purge gas coverage

C. STT/RMD allows GMAW root passes with the wire electrode touching the pool at all times — this contact arc mode eliminates the conventional arc gap requirement and allows the wire tip to act as a brush dragged through the pool

D. STT/RMD technology controls each short-circuit cycle electronically — it actively controls the current waveform to separate the short-circuit pinch event from the re-ignition burst, dramatically reducing spatter and providing highly controllable heat input for open root welding; this precise control allows GMAW open root passes with minimal spatter, controlled penetration, and good fusion in all positions, making it viable for applications previously restricted to GTAW or SMAW

105. Why cannot E70T-1C FCAW-G wire be used for vertical-up or overhead welding, and what classification replaces it for those positions?

A. E70T-1C cannot be used out-of-position because the CO_2 shielding designation is only approved for flat and horizontal — switching to an argon-mixture gas (M suffix) converts the wire to all-position capability for vertical and overhead applications

B. E70T-1C is not all-position because the wire diameter is too large — T-1C wires are only manufactured in diameters above 1.6 mm, which cannot be controlled out-of-position; the equivalent 1.2 mm wire carries a different classification code that includes all-position approval

C. E70T-1C is limited to flat and horizontal positions (indicated by the "0" position designator between the tensile strength designation and the T) because its rutile flux remains molten too long after the arc passes to support the weld pool against gravity in out-of-position work; the equivalent all-position classification is E71T-1C, where the "1" position designator indicates the faster-freezing slag that supports vertical-up and overhead positions

D. E70T-1C cannot be used vertically or overhead because its 70-ksi minimum tensile strength produces weld metal too hard and strong for out-of-position welding — code provisions restrict vertical and overhead weld metal to a maximum of 60 ksi to prevent brittle fracture under the high restraint conditions of out-of-position applications

106. A GMAW operator is experiencing erratic arc characteristics, inconsistent penetration, and a wandering arc during production welding despite verified correct machine settings and shielding gas. What mechanical cause in the wire delivery system should be investigated?

A. The erratic arc is caused by worn spool bearings — worn bearings create variations in wire tension causing the wire to accelerate and decelerate as it unwinds, creating the alternating wire feed speeds that produce erratic arc behavior

B. The wire may have excessive cast (the natural coil curvature from the spool) or helix (the tendency to spring sideways off the spool) — excessive cast or helix causes the wire to exit the contact tip at an inconsistent angle, directing the arc in different directions with each coil rotation; this produces the observed arc wander and inconsistent penetration; the wire straightener rollers on the feeder should be checked and adjusted to correct wire straightness

C. The erratic arc is caused by incorrect drive roll tension — if tension is set too low, the drive rolls cannot maintain a constant grip on the wire, resulting in momentary slippage; increasing drive roll tension to the maximum setting corrects all wire feed instability issues

D. The erratic arc is caused by the contact tip being in the wrong longitudinal position — the contact tip must be flush with the end of the gas nozzle for stable arc operation; when the contact tip is recessed into the nozzle, wire extension varies and creates arc instability

107. A welding engineer specifies E70T-4 self-shielded FCAW wire for a structural connection. A newly hired inspector asks for the difference between T-4 and T-8 self-shielded wires. Which description is most accurate?

A. E70T-4 is a self-shielded wire for flat and horizontal positions only (indicated by the "0" position designator), with high deposition rates achieved by metallic additions in the core — it does not provide notch toughness in the deposited weld metal and is limited to statically loaded structural connections not requiring impact testing; E71T-8 is a self-shielded all-position wire (indicated by "1") providing improved notch toughness, lower diffusible hydrogen, and is specified for structures requiring Charpy V-notch impact test certification

B. E70T-4 and E71T-8 are identical in all welding characteristics — the only difference is the manufacturer's country of origin, with T-4 indicating domestic production and T-8 indicating imported wire; both classifications are fully interchangeable for any structural application

C. E70T-4 is a gas-shielded wire requiring CO_2 shielding while E71T-8 is self-shielded — the "4" suffix indicates a gas shielding requirement while "8" indicates the self-shielding capability of the core flux compounds

D. E71T-8 is limited to base metal grades below 350 MPa while E70T-4 can be used on base metals up to 700 MPa — the T-8 wire produces a softer deposit that would underperform on high-strength structural steel applications

108. For GTAW welding of aluminum, AC is required. What specific physical mechanism makes AC necessary for aluminum GTAW, and what would happen if DC electrode negative were used instead?

A. AC is required because aluminum's thermal conductivity is too high for the arc to sustain itself on DC — the alternating polarity of AC creates a pulsed arc that overcomes the heat dissipation rate, while DC produces a continuous arc extinguished by the rapid heat flow away from the weld zone

B. AC is required because aluminum only melts at elevated AC frequencies above 50 Hz — at DC (0 Hz), the electromagnetic skin effect that DC creates around the metal prevents heat penetration into the aluminum lattice

C. DC electrode negative (DCEN) is the standard for aluminum GTAW — DCEN concentrates arc heat at the workpiece anode, necessary for aluminum due to its high thermal conductivity; the AC requirement for aluminum is a common misconception applying only to thin aluminum below 2 mm

D. Aluminum forms a dense refractory aluminum oxide (Al_2O_3) layer that melts at approximately 2050°C, far above aluminum's melting point of 660°C — the electrode-positive (EP) half-cycles of AC provide cathodic cleaning where positive ions bombard the work surface and mechanically disrupt and remove the oxide layer; without this cleaning, the oxide prevents fusion because the arc cannot reach the base metal; DCEN provides no cleaning and the oxide layer would prevent fusion entirely

109. During GTAW of austenitic stainless steel, the tungsten electrode contacts the molten pool. What specific quality problem does tungsten contamination create, and how can the contaminated area be identified?

A. Tungsten contact with the stainless steel pool creates a hot crack — tungsten's melting point of 3422°C is far above the pool temperature, and the solid tungsten particle acts as a rigid inclusion that prevents solidification shrinkage and causes cracking around the inclusion

B. Tungsten contact creates a fusion line defect — the tungsten cools the pool surface at the contact point, preventing fusion and creating a lack-of-fusion discontinuity running along the length of the weld

C. Tungsten contamination creates a hard brittle tungsten inclusion in the weld metal at the contact point — the tungsten may fracture the electrode tip and embed fragments in the pool, which appear as bright high-density inclusions on radiographic film because tungsten is much denser than the stainless steel weld metal; the contaminated area must be ground out and re-welded after the electrode tip is re-prepared

D. Tungsten contact with a stainless steel pool is harmless because tungsten is inert and does not react with austenitic stainless steel at welding temperatures — slight electrode shape change may occur but the weld metal and mechanical properties are unaffected

110. A GTAW welder repeatedly experiences porosity from weld-start spatter entering the back of the shielding gas cup at the filler rod introduction point when the rod is held nearly perpendicular to the work. What is the correct filler rod introduction angle and what does it prevent?

A. The filler rod should be introduced at exactly 90° to the work surface — perpendicular introduction provides the most direct deposit into the pool with the minimum disturbance to the arc and is the standard technique for all GTAW applications

B. The filler rod should be introduced at approximately 15–20° from the work surface — at this shallow angle, the filler rod is dipped into the leading edge of the pool without the rod tip entering the arc column or the gas cup; introducing the rod at a steep angle risks the hot rod tip entering the cup and contaminating the tungsten or shielding gas, and may cause the rod to melt and spatter into the pool rather than being dipped incrementally

C. The filler rod angle has no effect on weld quality — any angle between 0° and 90° produces equivalent results as long as the rod tip is introduced into the pool rather than into the arc column

D. The filler rod must be held at exactly 45° in all GTAW applications — the 45° angle is the internationally standardized filler rod introduction angle and any deviation requires supervisor approval before continuing

111. A GTAW procedure for Inconel 625 specifies 100% argon shielding gas. The engineer considers switching to a 75/25 Ar/He blend to improve productivity on thick sections. What specific effect does adding helium to argon have in GTAW?

A. Adding helium to argon in GTAW reduces arc stability — helium's high ionization potential makes it harder to ionize than argon, reducing plasma temperature and creating an arc more prone to extinction and weld pool turbulence

B. Adding helium to argon has no effect on GTAW heat input — shielding gas composition in GTAW does not affect arc voltage, amperage, or heat input; the only change is in the atmospheric protection characteristics of the shielding gas mixture

C. Adding helium to argon reduces the required welding current because helium combusts in the arc column and its combustion energy supplements the electrical arc energy, allowing the same fusion at lower current levels

D. Adding helium to argon increases arc voltage for a given arc length because helium has a higher ionization potential — higher arc voltage at the same current increases total arc power (V × A), delivering more heat to the base metal; on thick nickel alloys with poor thermal conductivity, this added heat input from helium allows higher travel speeds and improves productivity; the practical tradeoffs are reduced arc stability and the need for higher shielding gas flow rates because helium's low density causes it to be displaced from the weld zone more readily than argon

112. A GTAW procedure for duplex stainless steel specifies a heat input range of 0.5–1.5 kJ/mm and a maximum interpass temperature of 150°C. Why are both heat input and interpass temperature controls critical for duplex stainless steel?

A. Both controls are critical because the mechanical properties and corrosion resistance of duplex stainless steel depend on maintaining approximately equal austenite and ferrite proportions — excessive heat input or high interpass temperature increases thermal exposure above 900°C, causing ferrite to transform to austenite and shifting the phase balance away from the target 50/50 ratio; conversely, too-rapid cooling can produce excessive ferrite with insufficient austenite reformation; both extremes degrade the duplex microstructure and reduce toughness and pitting corrosion resistance

B. Heat input controls the tensile strength of the deposit while interpass temperature controls the hardness — the combination of both controls ensures the final weld metal has adequate strength and appropriate hardness for the duplex service application

C. The heat input limit is required only for the root pass while the interpass temperature limit applies only to fill passes — the two controls are independent and apply to different passes without overlap in their metallurgical effects on the duplex microstructure

D. Both controls prevent sensitization — the heat input limits prevent chromium carbide precipitation while the interpass temperature limits prevent sigma phase formation; duplex stainless is uniquely susceptible to both sensitization mechanisms simultaneously

113. Prior to GTAW welding of 6061-T6 aluminum after cleaning, the welder notices a slight yellowish-brown discoloration on the joint preparation surface. What does this indicate, and should welding proceed?

A. The yellowish-brown discoloration indicates the correct preheat has been applied — aluminum discolors to yellow-brown at the correct preheat temperature of 150–180°C for 6061-T6; welding should proceed immediately after observing this color change

B. The discoloration indicates oil or grease contamination from cutting fluid — yellowish-brown discoloration in 6061-T6 always results from organic contamination and welding must not proceed until the surface is re-cleaned with acetone or MEK

C. The yellowish-brown discoloration indicates a recently reformed aluminum oxide layer — oxide begins reforming almost immediately after cleaning, and the color indicates the re-formed oxide; welding should proceed promptly to minimize further oxide thickness buildup, as the freshly reformed thin oxide layer will be partially disrupted by the cathodic cleaning action of the AC GTAW arc during the weld; if the surface was cleaned recently, the oxide thickness should be minimal and welding can proceed without re-cleaning

D. Yellowish-brown discoloration on aluminum definitively indicates stress corrosion cracking propagating from the joint surface — welding over a stress-corrosion-cracked aluminum surface is prohibited because the cracks propagate into the weld metal

114. A GTAW operator switches from a 2.4 mm EWCe-2 tungsten electrode to a 1.6 mm EWCe-2 electrode for welding thin stainless steel sheet at 80 A DCEN, and later increases the amperage to 120 A without changing the electrode. What is the risk?

A. Switching to 1.6 mm tungsten for thin material at 80 A is incorrect — the minimum recommended current for 1.6 mm DCEN electrodes is 120 A, and operating below 120 A causes the electrode tip to extinguish from insufficient ionization at lower current levels

B. The 1.6 mm electrode is appropriate at 80 A, but increasing to 120 A may exceed the maximum current capacity for a 1.6 mm electrode on DCEN — operating a tungsten electrode at or above its maximum rated current causes the electrode tip to overheat, the tungsten to melt, the tip shape to change from pointed to balled or blunted, and potentially causes tungsten inclusions to enter the weld pool; the amperage should be reduced to within the 1.6 mm electrode's rated range or the electrode should be upgraded to 2.4 mm

C. There is no risk associated with operating any tungsten electrode at any amperage on DCEN polarity — DCEN always concentrates arc heat at the workpiece, not the electrode, so electrode temperature is constant regardless of current level

D. The risk is to the base metal, not the electrode — operating 1.6 mm tungsten above 100 A narrows the arc to a point that exceeds the maximum allowable current density on thin stainless steel sheet, burning through the base metal rather than affecting the electrode

115. A GTAW operator is performing high-amperage welding (250 A+) using a water-cooled torch. The cooling water supply is interrupted during welding. What must the operator do and why?

A. The operator may continue welding for up to 5 minutes without cooling water — water-cooled torches contain sufficient thermal mass to absorb 5 minutes of high-current heat without damage; this built-in safety margin is provided by torch manufacturers specifically for temporary cooling interruptions

B. The operator should reduce amperage by 50% and can continue welding indefinitely at the reduced current — the lower amperage is within the air-cooled capability of the water-cooled torch design and no damage occurs at half power

C. The operator should complete the current weld pass and then stop — stopping mid-pass would cause a crater crack in the weld; the cooling water loss is only critical for the torch body after welding is complete, not during the active welding pass

D. The operator must immediately stop welding and extinguish the arc — water-cooled torches at high amperage rely entirely on cooling water to maintain the torch handle, power cable connections, and nozzle assembly below their thermal damage temperature; without cooling water even a brief continuation causes thermal damage to the torch body, handle insulation, cable connections, and shielding cup; the water supply must be restored and the torch inspected before welding resumes

116. A GTAW welder uses the backstep technique rather than welding continuously around a circumferential 316L stainless steel pressure vessel nozzle seam. What specific quality benefit does backstep welding provide for this application?

A. Backstep welding on a circumferential nozzle seam distributes heat input more uniformly around the circumference rather than concentrating it in the progression direction — this reduces angular distortion of the nozzle flange, reduces residual stress in the HAZ adjacent to the last deposited segment, and prevents the hot zone buildup from continuous welding; for stainless steel, backstep also reduces sensitization risk by reducing the time each zone spends above the sensitization temperature range

B. Backstep welding is required for all pressure vessel nozzle welds under ASME Section VIII because the code mandates that no single weld pass exceed 300 mm in length without a backstep reversal to verify back-purge effectiveness at the mid-length position

C. Backstep welding provides superior weld metal mechanical properties because the overlapping heat cycles refine grain structure in the same way as normalizing heat treatment — each backstep cycle progressively reduces grain size and improves toughness throughout the completed weld

D. Backstep welding provides no quality benefit for circumferential nozzle welds — the technique is only applicable to linear structural welds and causes adverse thermal effects when applied to the curved geometry of a nozzle circumferential joint

117. A GTAW welder exceeds the maximum interpass temperature of 175°C specified for a 316L stainless steel pressure vessel nozzle, depositing a pass at 220°C. What metallurgical risk has been created and what inspection should be performed?

A. Exceeding 175°C interpass on 316L causes the weld metal to transform from austenite to martensite in the HAZ — martensite in stainless steel is extremely hard and brittle, and cracking visible on the weld surface will occur immediately without any further inspection

B. Exceeding the interpass limit on 316L causes ferrite to dissolve — above 175°C, molybdenum diffuses away from the ferrite phase, transforming it fully to austenite and creating a fully austenitic deposit susceptible to solidification hot cracking

C. While 316L filler reduces sensitization risk compared to standard 316, exceeding the interpass temperature limit still increases total thermal exposure of prior passes in the 425–870°C sensitization range — with multiple passes above the limit, cumulative time at sensitization temperature may produce chromium carbide precipitation at grain boundaries; for a pressure vessel in corrosive service, PT inspection of the final weld surface should be performed and a review of the heat treatment history conducted to assess whether the corrosion resistance for the specific service conditions has been compromised

D. Exceeding the interpass limit by 45°C on 316L has no metallurgical significance because the L-grade designation of both the base metal and filler provides unlimited immunity to sensitization at any interpass temperature below 500°C

118. A GTAW welder producing a fillet weld at a T-joint in 6 mm 304L stainless steel with the electrode at 45° observes lack of fusion at the vertical plate toe while the base plate has adequate fusion. What is the likely cause?

A. Lack of fusion at the vertical plate toe in stainless T-joint GTAW always results from the wrong filler metal — ER316L has lower fluidity than ER308L and cannot wet out the vertical plate surface; switching to ER308L eliminates the fusion problem

B. Lack of fusion at the vertical plate toe results from the shielding gas being directed at the base plate — the gas stream pushes the pool away from the vertical plate before fusion can be completed at the upper toe

C. Lack of fusion at the vertical plate toe results from the tungsten being too large — a large electrode creates a wide arc that cannot focus fusion energy at the vertical plate toe zone; reducing from 2.4 mm to 1.6 mm tungsten concentrates heat more precisely

D. Lack of fusion at the vertical plate toe is most likely caused by insufficient directed heat at the vertical plate — if the arc remains on the base plate side too long (slower travel or longer arc on base plate), the vertical plate toe never reaches fusion temperature; the correction is to direct slightly more arc energy toward the vertical plate by adjusting the work angle and maintaining a consistent arc length and travel speed to ensure both toes receive adequate heat

119. A GTAW welder on 316L stainless steel pipe finds randomly distributed small spherical porosity throughout the weld cross-section. The back purge was confirmed adequate and the weld bead surface appears bright silver. What is the most likely cause?

A. Distributed spherical porosity in GTAW stainless is caused by inadequate back purge — if the back purge oxygen level is too high, the oxygen reacts with carbon in the base metal at the root and produces CO gas that rises through the pool and creates the described porosity pattern

B. Distributed spherical porosity in GTAW stainless is most likely caused by contamination on the filler rod surface — moisture, oil, or metallic contamination from improper storage, handling with contaminated gloves, or manufacturing and storage conditions is the most common cause of randomly distributed porosity in GTAW; substituting new filler rod from a sealed undamaged container is the appropriate diagnostic and corrective step

C. Distributed spherical porosity in GTAW stainless is caused by the power source frequency being too low — 60 Hz produces too-slow current reversals for austenitic grain structure, creating gas pockets at grain boundaries that manifest as spherical porosity throughout the cross-section

D. Distributed spherical porosity in stainless steel GTAW is caused by using argon shielding gas — argon dissolves in the molten stainless pool and creates argon bubbles as it outgasses during solidification; switching to helium shielding eliminates this porosity type

120. A production engineer is considering automating a GTAW operation on a titanium pressure vessel. Manual GTAW currently achieves 65% acceptable welds per inspection cycle. What specific quality improvement should automated GTAW provide?

A. Automated GTAW eliminates the human skill variable from the welding operation — once the welding parameters are optimized and programmed, the automated system reproduces them exactly for every weld; this typically increases weld consistency and first-pass acceptance rates dramatically for titanium welding where cleanliness requirements and parameter sensitivity are extreme; operator fatigue, technique variation, and distraction are eliminated as sources of weld defects

B. Automated GTAW provides better arc performance than manual GTAW because the machine maintains high-frequency AC above 400 Hz that manual power sources cannot achieve — the high frequency improves arc stability and cathodic cleaning on titanium alloys

C. Automated GTAW only improves speed and production rate — weld quality is identical to manual GTAW for titanium because operator skill is not a factor; quality in titanium welding is entirely determined by gas shielding effectiveness and base metal cleanliness

D. Automated GTAW requires additional operator certification — the operator must hold both a manual GTAW qualification and a separate automated welding machine operator certification under CWB standards before being permitted to set up or monitor any automated GTAW system

121. For SAW welding of structural carbon steel, DCEP is standard polarity. What is the effect of switching to DCEN for SAW, and when might this be intentionally selected?

A. Switching to DCEN for SAW is always prohibited — SAW power sources are single-polarity units that only operate correctly on DCEP, and reversing the leads causes the control circuitry to malfunction and produces an unstable uncontrollable arc

B. Switching to DCEN in SAW has no effect on the process because SAW operates as a constant-current process where polarity has no influence on energy distribution at the arc — DCEP and DCEN are interchangeable for all SAW applications

C. Switching to DCEN in SAW increases penetration significantly and must never be done on any application — excessive penetration causes carbon pickup from the base metal and creates hard brittle deposits in all carbon steel welding applications

D. Switching from DCEP to DCEN in SAW shifts arc energy from the wire electrode to the work surface — DCEN increases the wire melt-off rate and deposition rate while reducing penetration depth; this intentional choice is used in SAW surfacing and hardfacing applications where high deposition rate with minimal base metal dilution is desired, and in overlay welding on pressure vessel cladding where minimizing penetration into the carbon steel base preserves the alloy composition of the corrosion-resistant deposited layer

122. A SAW operator receives a new batch of flux with a coarser particle size distribution than the previously used flux. What specific effect does the coarser particle size have on weld quality compared to the finer flux?

A. Coarser flux particles always produce better weld quality because the larger particles create a more stable blanket over the arc that is less susceptible to disturbance from high-current arc energy; fine particles are blown away by arc force and provide inadequate arc coverage

B. Flux particle size has no effect on SAW weld quality because the flux melts completely in the high-temperature SAW arc regardless of particle size — once all particles are in the liquid state their original size is irrelevant to the metallurgical reactions

C. Coarser flux particles produce a more open permeable blanket that allows arc gases to escape more freely — this may reduce surface porosity but may reduce penetration because coarser granules transmit less heat back into the joint; fine particles create a denser blanket with higher thermal conductivity that increases penetration depth and may produce a more convex bead profile; very fine flux can also create pinholes from trapped CO and CO_2 gases that cannot escape through the dense flux layer

D. Coarser flux particles reduce the deposition rate in SAW because large particles absorb arc energy during melting, leaving less energy for melting the wire electrode — fine particles melt faster and transmit more energy to the wire, increasing the wire melt-off rate proportionally

123. During SAW of a pressure vessel shell longitudinal seam, extension tabs are attached at both ends of the joint. What are these tabs called and what specific weld quality function do they perform?

A. The extension plates are called backing bars — they prevent weld metal from flowing past the end of the shell plate, keeping the weld on the joint line; backing bars are consumed into the weld and become part of the finished pressure boundary joint at both ends

B. The extension plates are called run-on and run-off tabs (or start and end tabs) — the run-on tab allows the SAW arc to establish stable conditions including proper flux coverage, stable arc, correct bead profile, and correct fusion depth before reaching the actual pressure vessel joint; the run-off tab allows the arc to be extinguished and the crater to solidify outside of the actual pressure boundary; after welding, both tabs are removed by cutting and the weld ends dressed flush to produce complete, defect-free weld terminations at both ends of the pressure vessel joint

C. The extension plates are called run-out plates and are used exclusively to prevent longitudinal distortion — they extend the rigidity of the joint to prevent the shell plate ends from lifting off the fixture during the SAW heat cycle

D. The extension plates are called chill bars and are made of copper — their primary function is to absorb heat at the joint ends and prevent end cracking by rapidly quenching the weld metal as the arc approaches and leaves the joint termination

124. A SAW procedure qualifies a maximum heat input of 3.5 kJ/mm for notch toughness reasons on a low-alloy high-strength steel pressure vessel. A malfunctioning travel carriage causes the travel speed to drop by 30% for one weld pass, resulting in a calculated heat input of 4.8 kJ/mm. What metallurgical changes should the engineer expect and what action is required?

A. Excessive heat input in SAW on high-strength low-alloy steel increases the time the HAZ spends above the grain-coarsening temperature — the resulting coarser grain structure in the CGHAZ reduces Charpy impact toughness below the values achieved during qualification at 3.5 kJ/mm; the engineer must evaluate whether the toughness of this weld meets the design requirements, which may require removing the pass and re-welding within the qualified range or performing impact test verification from the affected area

B. Excessive heat input from the slow-travel pass has no effect on vessel structural integrity because the additional weld metal deposited by the extra-slow pass provides reinforcement that more than compensates for any toughness reduction

C. The excessive heat input creates a softer HAZ that improves notch toughness — the higher heat input anneals the martensitic HAZ regions and produces a more uniform ferritic microstructure with better low-temperature toughness than the harder microstructure produced at the qualified heat input

D. The only corrective action required is to increase preheat temperature by 50°C for the next adjacent pass to compensate for the softer HAZ produced by the excessive heat input — the adjusted preheat restores mechanical properties equivalent to the qualified procedure

125. A welding engineer is considering implementing a two-wire tandem SAW system for thick-wall pressure vessel shells. What specific configuration uses two wire electrodes simultaneously in SAW, and what is the primary metallurgical consideration when using this system?

A. Two-wire SAW uses both wires energized from the same power source in parallel — the parallel connection provides double the current at the same voltage, doubling the wire melt-off rate without requiring a second power source; the metallurgical consideration is that the doubled current creates excessive penetration that must be controlled by increasing travel speed

B. Two-wire SAW is only applicable to surfacing and cladding — the two wires deposit different chemical compositions simultaneously to create a functionally graded deposit between the carbon steel base and the corrosion-resistant cladding layer; it cannot be used for structural groove welding applications

C. Two-wire SAW uses the same single power source with a Y-connector that splits the current between two wires — this reduces the current per wire to half the total, allowing double the wire diameter to be used while maintaining the same total heat input as a single-wire system

D. Two-wire tandem SAW uses two separately powered electrodes — one leading (typically DCEP for penetration) and one trailing (typically AC to reduce magnetic arc blow between the two wires) — operating in the same weld pool simultaneously; the primary metallurgical consideration is that heat input is approximately doubled compared to a single-wire pass; the larger weld metal volume and greater thermal mass require optimization of the flux chemistry and heat input limits to maintain the required mechanical properties, particularly impact toughness, in the completed weld

Practice Exam 8: Answer Key and Explanations

1. B — A workplace violence prevention program must contain a written policy, procedures for workers to report incidents without reprisal, investigation procedures, and controls to protect workers from identified violence hazards. Canadian OHS legislation universally mandates both reactive elements (reporting and investigation) and proactive elements (controls) to create a complete program. Without reporting procedures and implemented controls, the program addresses neither the identification nor the elimination of the hazard.

2. C — New worker orientation must cover the job-specific hazards, emergency procedures, first aid locations, injury reporting procedures, and safe work procedures for the specific equipment the worker will operate. This orientation must be provided before equipment operation begins — it is a precondition to exposure, not a follow-up training requirement. The information must be task-specific, not generic, because generic orientation does not adequately prepare a worker for the particular hazards of their assigned work.

3. A — Under WHMIS 2015, any WHMIS-controlled product decanted into a smaller container creates an obligation to apply a workplace label on that container before use. The workplace label must include at minimum the product identifier, safe handling information, and a reference to the SDS location. The purpose is to ensure hazard information travels with the product to the point of use, regardless of proximity to the original container.

4. D — Energized electrical equipment fires require a Class C extinguisher (or CO_2/dry chemical rated for energized equipment) because these agents are non-conductive. Applying water to an energized electrical fire creates a direct electrocution path from the energized equipment through the water stream to the person applying it. Class A, B, and D designations address different fuel types and are either ineffective or dangerous on energized electrical fires.

5. B — Every component of the fall arrest system — harness webbing, stitching, hardware, energy-absorbing lanyard or SRL, and connecting hardware — must be inspected before each use. Any system that has arrested a fall must be immediately removed from service because the energy-absorbing element may have deployed and cannot be relied upon to arrest a subsequent fall. This requirement is universal across all Canadian OHS regulations and fall arrest equipment standards.

6. A — Most Canadian OHS regulations require workers not to exceed five consecutive hours of work without a rest period, and employers must manage fatigue as an identifiable workplace hazard through a safety management system. Fatigue impairs judgment, reaction time, and fine motor control — all of which are critical during welding operations. The legal duty to manage fatigue applies to the employer, not solely to the individual worker.

7. C — The hierarchy of controls places engineering controls (elimination of the hazard at source) above all other control levels. Repositioning the work with a positioner or tilt table eliminates the overhead posture entirely — removing the root cause of musculoskeletal loading. No amount of PPE or reduced exposure time can replicate this because they manage the consequence of the hazard rather than removing the hazard itself.

8. D — ANSI Z358.1 requires emergency eyewash water to be tepid — typically 15–37°C — because water below this range triggers involuntary blinking and reflex withdrawal that prevent the victim from sustaining the required 15-minute flush. Incomplete flushing allows continued chemical injury to ocular tissues beyond the initial exposure. Cold water also poses a hypothermia risk during the extended flushing period required for adequate decontamination.

9. B — The WHMIS 2015 compressed gas pictogram represents the "gases under pressure" physical hazard class, communicating the risk of cylinder explosion from heating, cryogenic injury from rapid gas release, and for asphyxiants like argon, the displacement of oxygen in enclosed spaces. Argon is an asphyxiant — it is odorless and colorless and can reach fatal concentrations in a confined space with no sensory warning. These hazards are distinct from flammability or toxicity and require specific storage and use controls.

10. A — CSA Z180.1 and equivalent North American standards require Grade D breathing air to contain between 19.5% and 23.5% oxygen. Below 19.5% creates hypoxic conditions that cause rapid incapacitation; above 23.5% creates an oxygen-enriched atmosphere that dramatically increases the fire and explosion risk in an environment where welding sparks and hot metal are present. Both limits are equally important — the range is designed to protect against both oxygen deficiency and enrichment hazards simultaneously.

11. C — The vessel meets the three defining characteristics of a permit-required confined space: restricted entry/egress through a small-diameter manway, actual hazardous atmospheric conditions (oxygen-deficient atmosphere from nitrogen purging), and additional hazards created by the work activity (welding fumes). The previous hydrocarbon service adds a potential residual contamination hazard. All of these conditions together require a full confined space entry permit with a designated standby person — not merely a supervisor authorization.

12. D — Double protection (earplugs under earmuffs) provides greater attenuation than either device alone, estimated by adding 5 dB to the higher NRR of the two devices. At 102 dB(A), a single device may provide borderline protection even after applying the NIOSH NRR de-rating factor of (NRR − 7) ÷ 2. Both devices must be correctly fitted and worn consistently throughout the full exposure period — improperly fitted double protection provides no benefit over a single well-fitted device.

13. A — Lockout procedures must address every individual hazardous energy source in the work area, not just the primary machine that is being locked out. The robot controller lockout controls the robot motion but leaves the welding power source (with its energized cables, torch, and connections) as a live electrical hazard. Contact with GMAW-voltage components causes serious electrical shock injury — the

welding power source is an independent hazardous energy source requiring its own isolation and lockout before any maintenance begins inside the cell.

14. B — The continued development of symptoms despite respirator use indicates the engineering control is needed rather than just improved PPE. Installing local exhaust ventilation captures manganese fume at the arc — the generation point — reducing the ambient concentration for all workers regardless of individual PPE use or compliance. Engineering controls at the top of the hierarchy address the hazard at its source and are the required response when PPE alone proves insufficient to prevent health effects.

15. C — Root cause analysis techniques like the 5-Whys and fishbone diagrams identify the organizational, procedural, training, and supervision failures that created conditions where the incident could occur — not just the immediate proximate cause. Addressing only the proximate cause (the energized panel) without examining why it was accessible and why the procedure was not followed means the systemic vulnerability remains. Systemic corrective actions prevent the entire class of incident, not just the specific event that was investigated.

16. A — OHS legislation across Canadian federal and provincial jurisdictions requires new worker orientation to address job-specific hazards, emergency procedures, first aid locations, the right to refuse dangerous work, and workplace health and safety committee contacts before the worker begins the assigned work. The orientation must be job-specific — generic safety information does not constitute a compliant orientation because it does not prepare the worker for the specific hazards of their particular assignment.

17. D — Provincial OHS inspectors have broad statutory authority under applicable OHS acts to enter workplaces at any reasonable time without advance notice, examine and copy records, conduct tests and measurements, interview workers privately, and issue compliance orders or stop-work orders. The right to interview workers privately without employer representation is a significant protection — it prevents intimidation and ensures workers can report hazardous conditions without fear of retaliation during the inspector's visit.

18. B — Fire watch obligations extend beyond the active welding period: the watch must continue for a minimum period after all hot work ends (typically 30 minutes) because fires can smolder in insulation, wood blocking, or wall cavities before becoming visible. The fire watch must have immediately accessible and operational fire extinguishing equipment and must know how to use it. The watch must also monitor areas on the other side of walls, floors, and ceilings where conducted heat or flying sparks may have reached combustible materials not visible from the work location.

19. C — A 180 kg plate divided between two workers is 90 kg per person, which far exceeds safe manual handling limits for individual workers. Good occupational health practice considers approximately 45 kg per person the upper limit for team lifts, requiring three to four workers or mechanical assistance for this load. No technique eliminates the biomechanical forces of lifting extreme loads — correct technique reduces injury risk only at manageable load weights.

20. A — The WHMIS 2015 flame pictogram on an acetylene cylinder indicates a flammable gas. Acetylene's unique hazard — chemical instability — distinguishes it from all other fuel gases: it can decompose explosively through self-decomposition without any oxygen at pressures above approximately 103 kPa (15 psi) or when subjected to heat or mechanical shock. This is why acetylene is dissolved in acetone within a porous filler material in the cylinder rather than stored as a free compressed gas — the acetone and porous matrix prevent any free acetylene from accumulating above the critical pressure.

21. D — In AWS A2.4 groove weld symbol notation, the number outside the parentheses to the left of the groove symbol (S) is the groove preparation depth — the physical depth the groove is machined or prepared to. The number in parentheses (E) is the effective weld throat that the designer uses for strength calculations. The 3 mm difference (19 − 16 = 3 mm) is the CSA W59/AWS D1.1 mandated reduction for bevel or J-groove angles less than 60 degrees: E = S − 3 mm. This notation tells the fabricator exactly how deep to cut and tells the engineer exactly how much load-carrying throat to count on.

22. B — In AWS A2.4 intermittent fillet weld notation, the three numbers are always size-length-pitch: "6-50-100" means a 6 mm leg fillet, 50 mm long, on a 100 mm center-to-center pitch. In a staggered arrangement, the welds on each side of the joint are offset by half the pitch (50 mm in this case) so that no weld on the arrow side directly faces a weld on the other side. This staggered pattern distributes heat and stress more uniformly along the joint and is the standard meaning when staggered weld symbols appear on both sides of the reference line.

23. C — A reducing tee has a branch outlet at a smaller nominal pipe size than the main run-through pipe. The main run pipe continues at its original diameter through the tee, while the branch takes off at a reduced diameter — hence "reducing tee" rather than an equal tee. This is one of the most common piping branch configurations and requires a specific fitting (reducing tee or reducing outlet tee) rather than the simpler equal tee when the branch diameter differs from the run.

24. A — A double-V groove distributes the groove preparation to both sides of the joint, sharing the preparation depth between the two faces and requiring approximately half the total weld metal cross-sectional area of a single-V groove on the same plate thickness. This reduction in weld metal volume directly reduces the total transverse shrinkage force and thermal distortion and typically reduces welding

time by approximately 50%. The double-V is always the preferred choice for thick plate when access to both sides is available.

25. D — Under CWB certification, testing in both the 3G (vertical) and 4G (overhead) plate groove weld positions provides coverage for all plate groove weld positions. The 3G provides coverage for flat, horizontal, and vertical; the 4G adds overhead coverage. Together these two positions represent the most demanding plate welding orientations and their combination demonstrates competency across the full range. Testing only in 1G or 2G alone does not qualify the welder for out-of-position work.

26. B — A weld map creates a unique numbered identity for every weld on the vessel and links that weld number to its specific WPS, the welder(s) who deposited it, consumable heat and lot numbers, measured preheat and interpass temperatures, NDE results, and any repair records. This individual weld traceability enables focused quality audits, failure investigations, and regulatory compliance in ways that a welding symbol drawing — which shows only what the weld should be, not who made it or how it performed — cannot provide.

27. C — A section view provides the actual cross-sectional geometry of the joint: exact plate thicknesses, the physical relationship between joined members, access space for electrode manipulation, any backing or insert details, and required throat dimensions in a form that can be directly measured and verified. Complex joints with asymmetric members, tight access corridors, or unusual fit-up geometries cannot be fully communicated through plan-view weld symbols alone. The section view provides the three-dimensional context that prevents fabrication misinterpretation.

28. A — CSA W59 and referenced structural fabrication standards typically limit sweep (lateral bow) in fabricated members to L/1000. For a 6-metre beam: 6000 mm ÷ 1000 = 6 mm maximum. The 8 mm bow measured exceeds this limit and the member cannot be incorporated into the structure without either engineering review or correction. The engineer may accept the out-of-tolerance condition with justification, require cold or hot straightening, or reject the member — but the fabricator cannot proceed without a formal disposition.

29. D — AC electromagnetic yokes are preferred for surface crack detection in MT because the alternating magnetic field keeps the particles in continuous motion, allowing them to migrate to and accumulate at surface-breaking discontinuities. For near-surface subsurface indications, DC magnetization provides better depth penetration because the unidirectional flux can penetrate more deeply into the material cross-section. Using both longitudinal and transverse field orientations relative to the weld axis ensures that discontinuities at all angular orientations — including those running parallel to the weld axis — are detectable.

30. B — Transverse shrinkage of the first fillet weld pulls the web plate toward the welded side, rotating it out of perpendicular relative to the base plate. Pre-tipping the web in the opposite direction (pre-setting) before welding the first side compensates for the expected angular pull so that after welding the web returns to (or close to) perpendicular. Alternatively, deploying two welders simultaneously on both sides of the web creates equal and opposing shrinkage forces that cancel each other, producing minimal net angular distortion at completion.

31. C — The maximum interpass temperature limit for P5 chrome-moly steel controls the cooling rate of each completed weld pass. If continuous welding heats the joint above the maximum interpass limit, the post-pass cooling rate slows below what the WPS qualification was based on, potentially producing an adverse HAZ microstructure that differs from what was characterized in the PQR qualification tests. Measurement must be performed at the specific joint location with a contact thermometer, thermocouple, or calibrated infrared thermometer — measurement at the torch or a remote location is not representative.

32. A — ASME Section IX F-Numbers group filler metals by similar usability characteristics for procedure qualification purposes, but for welder qualification, holding one F-Number does not automatically qualify the welder to use lower F-Number consumables. Welder A's F-Number 6 GTAW qualification only qualifies Welder A for GTAW with F-Number 6 filler materials. To weld in SMAW production with F-Number 4 (E7018) electrodes, Welder A must complete a separate SMAW qualification test specifically with F-Number 4 electrodes.

33. B — For in-situ post-PWHT hardness verification on a pressure vessel, portable hardness testers (portable Brinell or portable Vickers instruments) provide the ability to make measurements at any accessible location on the vessel without removing material. Results in HBW or HV units are directly comparable to the 250 HBW code limit using standard conversion tables. Bench-top Rockwell testing requires bringing the specimen to the instrument, which is impractical for in-service heat-treated vessels; portable instruments are specifically designed to solve this field verification need.

34. D — Under fully reversed cyclic loading ($R = -1$), the weld toe is the primary fatigue crack initiation site because it creates a geometric stress concentration (notch) where the weld reinforcement meets the base metal surface. Grinding the weld cap flush eliminates this notch and removes the stress concentration that drives crack initiation, directly increasing the fatigue life. A full-penetration groove weld ensures no root defects that could serve as alternative initiation sites under the tensile half-cycles of the loading.

35. C — CSA W59 Clause 5.7 limits the maximum fillet weld leg size along the edge of plate 6 mm or thicker to the plate thickness minus 2 mm (T − 2 mm). For a 10 mm plate, the maximum is $10 - 2 = 8$

mm. A 10 mm fillet on a 10 mm plate exceeds this maximum and requires engineering disposition. The limit exists because a fillet weld deposited to the full edge thickness can cause fusion into the plate corner and potentially initiate laminar tearing or edge cracking in susceptible steels.

36. A — In piping and fitting designations, LR stands for long-radius, specifying that the fitting's centreline bend radius equals 1.5 times the nominal pipe diameter. This is the standard commercial elbow used in the vast majority of piping systems because it provides lower pressure drop and less turbulence than a short-radius (SR = 1.0D) elbow. SR elbows are used only in space-constrained layouts where the larger sweep of the LR fitting cannot be accommodated.

37. D — For ASME VIII P5 chrome-moly steel PWHT, the minimum holding time is 1 hour per 25 mm of base metal thickness (1 hour minimum). For 75 mm: 75 ÷ 25 = 3 hours minimum hold. The soaking phase provides the time required for the martensitic HAZ and weld metal microstructure to temper, residual stresses to relax through creep mechanisms at temperature, carbide morphology to adjust, and hardness to reduce below the code maximum. These diffusion-dependent processes require adequate time at temperature and cannot be achieved by simply reaching the soaking temperature.

38. B — Both fillet weld leg measurements of 7 mm and 8 mm exceed the specified 6 mm minimum — an oversized fillet weld is generally acceptable unless it is located along a plate edge where the maximum fillet limit (T − 2 mm) applies. The slight asymmetry (7 mm versus 8 mm leg) does not constitute a deficiency as long as both legs individually satisfy the minimum size requirement. A convexity of 1.5 mm on a 6 mm fillet is within the typical CSA W59 maximum (approximately 3 mm plus 10% of the weld face width), and the weld is acceptable as measured.

39. C — The critical decision in pressure vessel in-service inspection after discovering corrosion is whether the remaining wall thickness at the corroded locations still satisfies the minimum thickness required for continued safe operation at the inspection pressure. This requires ultrasonic thickness measurement followed by an engineering calculation comparing measured thickness to the code-required minimum including the corrosion allowance. If remaining thickness exceeds the required minimum, the vessel continues in service with the anomaly documented; below minimum, corrective action is mandatory before return to service.

40. A — For a production volume of 200 plates per week, mechanized beveling — using a milling machine or dedicated plate beveling unit — provides the optimum combination of consistent groove geometry, repeatable bevel angles, high throughput, and low unit cost. Manual grinding produces variable geometry and is labor-intensive; hand oxy-fuel cutting requires post-cut dressing; plasma cutting is fast but may produce a hardened surface layer on some structural steels that requires grinding before welding proceeds.

41. D — The overriding principle in structural repair welding of cracks is that every bit of the crack must be completely removed before any repair weld is deposited. MT or PT must be used to find the actual crack tips (visual inspection typically underestimates crack length), and the cavity must be re-inspected by MT or PT after excavation to confirm it is defect-free. Depositing a repair weld over a remaining crack tip encapsulates the crack, which will propagate from the un-removed root through the repair weld — creating the same failure that the repair was intended to correct.

42. B — ASME Section IX QW-163 specifies that no crack or open discontinuity on the tension surface of a bend test specimen shall exceed 3 mm in any direction. A 3.5 mm crack exceeds this limit and constitutes a failed test specimen. Since only one specimen needs to fail for the test to fail, the welder does not pass this qualification and must complete the applicable waiting period before attempting another test. There is no provision for averaging, re-bending, or marginal acceptance above the code limit.

43. C — The ductile-to-brittle transition temperature (DBTT) is the temperature range where a material transitions from high-energy ductile fracture to low-energy brittle (cleavage) fracture. A steep drop in Charpy absorbed energy between two test temperatures means the DBTT falls within that interval. For any safety-critical application, the service temperature must be well below the material's DBTT — if the DBTT is between −20°C and −40°C, there is real risk of brittle fracture at service temperatures above −40°C, which is why the test temperature for toughness qualification must be set at or below the design minimum temperature.

44. A — In AWS A2.4, two reference lines on a welding symbol indicate two sequential welding operations to be performed in order. The first reference line (attached to the arrow) specifies the first operation; the second specifies the second operation. This symbol format is used for joints requiring a specific sequence — such as a groove weld that must be completed before a reinforcing fillet is deposited — where performing the operations out of order would create fit-up or quality problems.

45. D — CSA W59 requires weld craters to be filled to provide full weld cross-section at all terminations. Unfilled craters reduce the effective throat at the termination point and contain a high concentration of segregated impurities that form during the final stages of weld pool solidification. This combination of reduced cross-section and segregated composition makes craters the most common initiation site for crater cracking, which if undetected can propagate longitudinally into the body of the weld under cyclic or sustained service loading.

46. B — CSA W59 and the CWB certification system require formal written inspection records for all NDE activities performed on structural welding projects. The records must identify each weld inspected, the methods applied, the reference standard used, the acceptance/rejection result for each weld, any

rejectable conditions and their disposition, and the inspector's certification number and signature. This formal documentation becomes part of the permanent quality record package and may be required for project closeout by the authority having jurisdiction.

47. C — A WPS states qualified parameter ranges for production use; a PQR records the actual measured values during the qualification test weld and the mechanical test results that demonstrate the procedure's soundness. Actual recorded voltage, amperage, travel speed, calculated heat input, measured preheat and interpass temperatures, actual PWHT parameters, and all test specimen results (tensile, bend, impact) appear only on the PQR. The WPS is derived from the PQR ranges but does not reproduce the specific test measurements — that is the exclusive function of the PQR.

48. D — The IIW CE formula: $CE = C + Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15 = 0.16 + 1.35/6 + (0.05+0.02+0.01)/5 + (0.10+0.15)/15 = 0.16 + 0.225 + 0.016 + 0.017 = 0.418$. Both yield strength (385 MPa ≥ 350 MPa) and tensile strength (520 MPa ≥ 450 MPa) satisfy the CSA G40.21 Grade 350W minimum requirements. A CE of 0.418 places the material in the range requiring careful preheat management — the required preheat increases with plate thickness, joint restraint, and heat input.

49. A — A rounded, melted top edge combined with clean bottom ejection is the definitive indicator that the preheat flame is oversized for the plate thickness. The excess preheat melts the top surface before the cutting oxygen is applied, instead of uniformly heating it to ignition temperature. The clean bottom ejection confirms that the cutting oxygen and penetration are correct — the problem is isolated to the excessive preheat energy at the top surface. Matching the tip size to the actual plate thickness resolves this directly.

50. B — Nitrogen plasma gas with argon shielding (or argon-hydrogen mixture) is the preferred combination for precision aluminum cutting. Nitrogen provides the arc energy needed to maintain the plasma column and cut through the material, while argon shielding reduces oxidation of the cut face — producing brighter, smoother cut surfaces than air plasma. Air plasma introduces oxygen that reacts with the aluminum surface, creating an oxidized, discolored, and rough cut face with increased dross formation. The nitrogen/argon combination is the standard specification when cut face quality is the priority.

51. C — An oversized preheat tip delivers more thermal energy than the plate thickness requires, overheating the top surface and causing it to melt rather than being uniformly brought to the steel's ignition temperature. The oversized cutting oxygen flow simultaneously widens the kerf, causes heavy dross formation on the underside from the excess oxygen, and produces a rough undulating cut surface throughout the cut length. Tip selection must match the actual plate thickness — using the manufacturer's tip-to-plate-thickness chart directly.

52. D — The groove profile in CAC-A is governed primarily by the electrode lead angle (the angle the electrode makes with the work surface). When the electrode is held nearly perpendicular to the work, the arc concentrates directly below the electrode tip and creates a narrow V-shaped excavation. Reducing the lead angle to approximately 35–45° from the work surface allows the arc to excavate outward from the root in a sweeping motion, forming the rounded U-shaped bottom required for repair groove preparations that provide adequate root access for subsequent weld passes.

53. A — When OFC travel speed exceeds the optimum, the oxidation reaction cannot keep pace with the torch movement — the cutting front lags progressively further behind the torch, producing drag lines on the cut face that are inclined at a steep backward angle. If the speed is sufficiently excessive, the cut fails to propagate through the full plate thickness and the bottom remains uncut. Heavy attached dross forms at the lower edge because the molten iron solidifies before the cutting oxygen jet can fully eject it from the bottom of the kerf.

54. B — The diagnostic pattern — excellent quality at shift start with progressive deterioration throughout the production run — is the classic signature of desiccant saturation in an air-driven nitrogen generator. As the desiccant bed saturates with absorbed moisture during extended operation, moisture breakthrough into the nitrogen supply increases progressively through the shift. Water entering the plasma column creates steam that destabilizes the arc, roughens the cut face, promotes dross formation, and dramatically accelerates electrode tip oxidation and nozzle bore erosion beyond their rated service lives.

55. C — The sole objective of back-gouging before depositing the back-weld is to completely remove all defects originating at the root — cracks, lack of fusion, incomplete penetration, inclusions, and porosity — so the back-weld is deposited on clean, sound weld metal. Leaving any portion of a crack or fusion defect in the cavity means it will be encapsulated in the completed joint and will continue to propagate under service loading. MT or PT inspection of the excavated cavity before welding begins is the standard industry verification that the cavity is defect-free.

56. D — The current capacity of copper-coated carbon electrodes is proportional to their cross-sectional area. For a 10 mm electrode, the manufacturer-rated maximum current for DCEP operation is typically in the 200–450 A range depending on the application. Operating at 500 A exceeds this maximum, causing the electrode to heat above its self-regulating temperature range — the excess energy burns the electrode tip rather than the work, resulting in accelerated electrode consumption and poor metal removal efficiency. Upgrading to a 12.7 mm electrode (rated for 450–1000+ A) or reducing the current to within the 10 mm electrode's rated range is the correct action.

57. A — For 6 mm stainless steel sheet, laser cutting produces a narrower kerf (typically 0.1–0.3 mm versus 1–3 mm for plasma), a smaller heat-affected zone, and superior dimensional accuracy because the focused laser beam delivers energy in an extremely small spot. These advantages come at significantly higher capital and operating costs than plasma systems. CO_2 lasers also have reduced coupling efficiency on highly reflective metals — copper and aluminum reflect a significant proportion of the CO_2 laser wavelength, making plasma more practical for those materials in production environments.

58. B — Cutting structural steel at −10°C creates a steep thermal gradient between the heated cut zone and the large cold plate mass. This rapid quenching of the cut edge can produce a martensitic hardened layer susceptible to hydrogen-assisted cracking, particularly for medium-carbon or alloy structural steels. Cold surfaces also attract moisture condensation that contaminates adjacent weld preparations and can cause problems with torch operation. Warming the plate to approximately 20°C minimum eliminates both the rapid quench effect and the moisture condensation risk before cutting proceeds.

59. C — The water injected circumferentially around the plasma arc in a water injection system cools and constricts the outer boundary of the plasma column, creating a narrower, denser, and more energetically concentrated plasma jet than standard dual-gas plasma at equivalent power settings. This improved arc constriction reduces the bevel angle of the cut face toward square (approaching 1°), narrows the kerf width, and reduces the heat-affected zone width — all directly resulting from the tighter energy delivery cross-section produced by the water constriction mechanism.

60. A — Mill scale (iron oxide, Fe_2O_3 and Fe_3O_4) has a melting point significantly higher than steel's oxidation ignition temperature and acts as a refractory thermal insulator. When the preheat flame is directed at a mill-scaled surface, the scale absorbs much of the heat without allowing it to conduct through to the steel beneath, preventing the base metal from reaching the critical ignition temperature needed for the OFC oxidation reaction to initiate. Clearing the scale at the cut start point — by burning it away with the preheat flame or grinding it off mechanically — exposes the bare steel and allows proper ignition.

61. D — CAC-A can be performed on aluminum, but aluminum's thermal conductivity (approximately five times greater than carbon steel) dissipates arc heat away from the excavation zone much faster, requiring higher amperage settings to maintain the same metal removal rate as on steel. The carbon electrode deposits carbon into the groove surface and the arc creates a thicker, more tenacious aluminum oxide layer than steel CAC-A produces. Both the carbon contamination and the oxide layer must be completely removed by dedicated stainless steel wire brushing and grinding before GMAW or GTAW repair welding can proceed — failure to do so results in porosity and lack of fusion.

62. B — Machine-mounted OFC torches maintain constant travel speed, height, and angle mechanically throughout the entire cut — factors that human operators cannot hold constant during an eight-hour production shift due to fatigue. This consistency produces reproducible cut quality on every cut throughout the shift. The machine also eliminates the ergonomic risks of sustained manual torch operation: sustained heat exposure, torch vibration, awkward postures, and repetitive upper-extremity loading that accumulate significantly over an eight-hour period.

63. C — The helical rotation of the plasma arc (caused by tangential gas injection through the swirl ring) produces asymmetric energy distribution across the kerf — one side receives more energy per unit arc length than the other. For standard clockwise swirl, the right side of the torch's travel direction is the "good" (nearly square) side and the left side has the bevel angle. This is an inherent characteristic of the PAC process, not a malfunction. Parts programming must be designed so the finished part falls on the right (good) side of the cut path.

64. A — The two chemical properties of gray cast iron that defeat the OFC process are its silicon content (forming refractory SiO_2 slag that blocks the cutting oxygen from reaching fresh metal) and its graphite carbon phase (which burns exothermically rather than oxidizing cleanly, causing the cut zone to overheat and melt). Plasma arc cutting bypasses both problems completely because it removes material by thermal melting and kinetic ejection — no oxidation chemistry is required, and the process works on any electrically conductive material regardless of composition.

65. D — Efficient CAC-A metal removal requires a sustained, stable high-energy carbon arc that melts a large metal pool volume for the compressed air to eject. Many lighter SMAW power sources have internal thermal protection circuits that reduce output during prolonged high-current operation, or simply cannot sustain 600–1000 A continuously — causing arc instability and ineffective metal removal. A heavy-duty constant-current DC power source rated for the full electrode current at the required duty cycle is the fundamental requirement; selecting inadequate power source capacity is one of the most common CAC-A operational problems.

66. B — A backfire is a brief flame extinguishment caused by momentarily insufficient gas flow, tip-to-work contact, or minor pressure fluctuation — followed by immediate relighting. It is a minor event that may continue without serious risk if the torch equipment is in good condition with functional check valves. A flashback is combustion propagating back inside the torch body, indicated by a continuous squealing from inside the torch and smoke emerging from the body. Flashback is a serious emergency requiring immediate simultaneous shutdown of both fuel and oxygen supplies before the flame front reaches the hose connections, regulators, or cylinders.

67. C — High-definition plasma achieves its superior cut quality through an optimized nozzle design and precision swirl gas geometry that constricts the plasma arc more tightly than conventional plasma at equivalent power levels. This tighter constriction narrows the kerf width, reduces the bevel angle of the cut face to approximately 1–2° (approaching square), reduces the HAZ width, and produces a smoother surface finish. These characteristics position HDP between conventional plasma (economical but lower quality) and laser cutting (highest quality but highest cost) for metals in the 1–25 mm thickness range.

68. A — The cutting oxygen jet in OFC must eject the molten slag downward and away from the cut at high velocity. If a support slat is positioned directly under the cut line, the jet contacts the slat surface and deflects upward — disrupting the cut at that location and producing a visible defect in the cut face at the slat crossing point. The slat arrangement must be oriented so that all programmed cut lines pass through the open air gaps between slats, allowing unrestricted slag ejection through the full plate thickness.

69. D — In overhead CAC-A, gravity works against the technique: expelled molten metal falls back toward the electrode holder and the operator rather than away from the work. Increasing the electrode lead angle (pointing more steeply forward) helps direct the ejected metal away from the holder. Reducing amperage by 10–15% from flat position settings reduces the pool volume per pass, making the material easier to fully eject and reducing the quantity of metal that can fall back. All exposed skin must be covered and all personnel below must be excluded from the fall zone for ejected hot metal and slag.

70. B — When the mechanized system has been verified as defect-free and all machine parameters remain unchanged, the contamination must originate from the supply side. Contamination of the cutting oxygen — from moisture, oil from an upstream compressor, or debris in the regulator — creates intermittent purity problems as contamination slugs pass through the system. These intermittent contamination events alternately degrade and improve cut quality as they pass through, producing the described quality variation. Systematic inspection of the oxygen supply train from cylinder to torch is the correct diagnostic response.

71. C — The manufacturer's specified plasma gas flow rate is the result of engineering optimization — it creates the correct gas dynamic conditions inside the nozzle for stable plasma column formation and effective arc constriction. Exceeding this rate creates turbulence in the nozzle bore that destabilizes the plasma column, causing the arc to wander within the kerf, increasing the bevel angle, widening the kerf, and roughening the cut surface. The turbulence also increases the mechanical erosion rate on the electrode tip and nozzle bore, shortening consumable life below the rated service interval.

72. A — E6013 electrodes are specifically formulated for use on AC and both DC polarities — this versatility is a design feature of the rutile electrode classification. The polarity primarily affects where

arc heat is concentrated: on DCEN (electrode negative), slightly more heat goes to the work surface, producing shallower penetration; on DCEP, slightly more heat goes to the electrode, producing marginally deeper penetration. For 2 mm thin sheet, the shallower penetration and lower burn-through risk of DCEN makes it the better technical choice — but DCEP is not prohibited and will produce acceptable results with correct technique.

73. D — Hydrogen-induced delayed cracking (HIDC) requires three simultaneous conditions: susceptible microstructure (hard, high-carbon martensite), diffusible hydrogen in solution, and tensile stress. 4340 at 45 HRC satisfies the "susceptible microstructure" condition at maximum — the HAZ will be similarly hard after welding. High preheat (250–370°C) slows the cooling rate to reduce as-welded HAZ hardness, extends the time the HAZ remains above the hydrogen diffusion temperature before cracking-susceptible temperatures are reached, and provides a driving force for hydrogen to diffuse out of the weld before the joint cools completely.

74. B — Iron powder is incorporated into the E7024 electrode coating so that as the electrode melts during welding, the iron powder fuses with the arc and deposits as additional weld metal. This is why E7024 achieves deposition efficiencies of 120–140% — the weld deposit weighs more than the electrode core wire because the coating's iron powder adds to the deposit mass. The resulting higher deposition rate per electrode means larger welds can be deposited faster with fewer electrode changes, directly improving productivity for flat and horizontal production fillet welding applications.

75. C — Upper-toe undercut in horizontal fillet welds results from the arc force and molten pool being directed too far toward the upper (vertical) plate rather than toward the root of the joint. This is caused either by an arc that is too long (which increases the arc force and directs it outward from the weld center) or by a work angle too steeply directed at the upper plate (which physically points the arc and pool toward that toe). Reducing the arc length decreases the arc force, and reducing the work angle toward the lower plate redirects the pool and arc force away from the vulnerable upper toe.

76. D — When E11018-M is deposited directly onto A514 high-carbon base metal, the dilution zone at the fusion boundary contains both the electrode's high alloy content and the base metal's high carbon — creating an elevated-carbon, high-alloy composition susceptible to both solidification hot cracking (from the solute enrichment during freezing) and hydrogen cold cracking (from the high hardenability of the alloy mixture). The E7018 butter layer dilutes with A514 first, producing a lower-carbon, lower-alloy buffer; the E11018-M fill passes then dilute only with the lower-carbon butter, maintaining a composition within the electrode's qualified performance range.

77. B — P91 steel (9Cr-1Mo-V) achieves its creep strength through a fine-grained, tempered martensite matrix reinforced by vanadium carbonitride (VN, V_4C_3) and niobium carbonitride (NbCN) nano-

precipitates. These precipitates impede dislocation movement at elevated service temperatures. Wide weave beads create excessive inter-pass heat input that overheats previously deposited passes above the temperature at which these precipitates coarsen and dissolve — reducing their number density and increasing their spacing, directly reducing the creep rupture strength of the completed weld in service.

78. A — The J-weave derives its name from the motion's shape: the electrode pauses briefly at each sidewall (the two vertical uprights of the J) and traverses quickly across the groove floor (the curve of the J bottom). The brief pause at each sidewall allows the weld pool to flow into and fully wet the fusion line at the side of the groove — the location most prone to incomplete fusion in multi-pass groove welds where sidewall fusion must be deliberately cultivated. The quick traverse across the floor prevents excessive heat buildup and root concavity at the groove bottom.

79. C — Basic electrode coatings (calcium carbonate, calcium fluoride) produce a slag with higher viscosity and higher solidification temperature than rutile coatings (titanium dioxide, silicates), making basic slag significantly harder to chip off between passes and requiring more mechanical force for removal. The basic arc is stiffer and more forceful than the soft, forgiving rutile arc, and is noticeably more sensitive to arc length — holding too long an arc with E7016 produces substantially more spatter than the same technique error would with E6013, requiring the welder to maintain a consistently short arc throughout the weld.

80. D — At the 3 and 9 o'clock clock positions in 2G pipe welding, gravity acts perpendicular to the weld axis and pulls the molten root pool toward the inside of the pipe. The pool volume determines how much weight the surface tension and arc force must support — an excessively large pool falls through the root gap before the arc can advance forward. Reducing the amperage (and therefore heat input) at these clock positions, or increasing travel speed, produces a smaller pool that can be supported without dropping through. This is the standard technique adjustment all experienced 2G pipe welders apply as they pass through the side positions.

81. B — Heat input per unit length equals (voltage × amperage) ÷ travel speed — increasing travel speed with constant voltage and amperage reduces the heat input per unit weld length proportionally. The reduced heat input deposits less metal per unit length, reducing the bead width and weld throat. If travel speed increases sufficiently, the deposited metal per unit length falls below the minimum required for the specified fillet or groove weld size, producing an undersized weld that fails dimensional acceptance criteria regardless of the quality of the fusion achieved.

82. C — The welding process (SMAW vs. FCAW-S) is classified as an essential variable under both ASME Section IX (QW-402.1) and CWB standards — a change in welding process requires either a separate process qualification or an amended WPS qualified for the combined process. Using E71T-11

FCAW-S where E7018 SMAW is specified is an unqualified procedure deviation, regardless of which pass the substitution occurs in. The WPS is the legal authorization to weld — welding outside the WPS means the joint lacks a valid qualified procedure.

83. A — Cold lap at the lower toe of a horizontal fillet weld is a fusion defect caused by the arc not delivering sufficient energy to the lower plate surface before the pool solidifies. The two most common contributing causes are: insufficient amperage (not enough total heat to fuse the lower plate) and incorrect work angle (too much angle toward the upper plate, directing the arc force and heat away from the lower toe). Increasing amperage by a moderate amount and redirecting the work angle to deliver more heat toward the base plate are the two direct corrective adjustments that address these causes simultaneously.

84. D — Basic electrode coatings (calcium fluoride, calcium carbonate) have a higher ionization potential than rutile coatings (titanium dioxide, silicates), meaning they require higher voltage to establish and maintain an ionized arc plasma. If the power source OCV falls below approximately 65 V, the voltage available for arc initiation may be insufficient to ionize the basic coating chemistry reliably — leading to difficult arc starting and an unstable arc with high spatter during welding. This is why basic electrodes are specified only for use on power sources with a minimum OCV of 65–70 V.

85. C — Manganese in SMAW coatings serves two metallurgical roles simultaneously. First, it deoxidizes the weld pool by reacting with dissolved oxygen to form MnO, which reports to the slag and removes the oxygen that would otherwise cause porosity or oxide inclusions. Second, manganese that remains in the weld metal provides solid solution hardening (increasing strength) and controls sulfur's morphology — Mn preferentially combines with S to form MnS inclusions (rounded) rather than allowing iron sulfide (FeS) grain boundary films, which cause severe hot shortness and impact toughness degradation.

86. A — The standard technique for 5G pipe root pass welding is uphill progression — welding from 6 o'clock to 12 o'clock on each half of the pipe circumference. The keyhole technique with E6010 cellulosic electrodes (which provides deep, forceful penetration) is used to push through the root gap and maintain a visible keyhole that confirms complete root penetration throughout the weld. Two welders working simultaneously from 6 to 12 on each side is the most efficient approach for large-diameter pipe and prevents the weld from cooling and contracting on one side while the other half is being welded.

87. B — E7018 basic electrodes have hygroscopic coatings (calcium carbonate and calcium fluoride absorb atmospheric moisture). When stored or transported in wet weather conditions without a heated rod oven or sealed moisture-resistant canister, the coating absorbs sufficient moisture that when the electrode is used, the absorbed water decomposes in the arc into hydrogen and oxygen. The hydrogen

dissolves in the molten pool and is released as gas during solidification, creating the characteristic distributed spherical porosity throughout multiple consecutive welds. The progressive clustering across multiple welds confirms this is a consumable source rather than a base metal or technique issue.

88. D — E7018 contains iron powder in the basic coating, giving it a deposition efficiency of 110–125% compared to E7016's ~90–100% (no iron powder). Both electrodes are basic low-hydrogen classifications with equivalent minimum mechanical properties. For high-restraint Grade 500W structural joints, E7018 H4 is preferred because the iron powder improves fusion at the weld toes (more fluid slag) and increases productivity, while the H4 diffusible hydrogen designation (≤4 mL/100g deposited weld metal) provides the maximum hydrogen control — the most critical single variable for preventing hydrogen-induced delayed cracking in high-strength, high-restraint applications.

89. C — At 130 A, the 3.2 mm E7018 electrode is operating above its recommended range for thin material — the appropriate range for 3.2 mm E7018 is approximately 80–120 A, with the lower end used for thin material. Reducing amperage to approximately 85–100 A lowers the total heat delivered per unit length; combining this with a slightly faster travel speed further reduces heat input per unit length, preventing burn-through while still maintaining adequate fusion. This two-parameter adjustment (lower amperage + faster travel) addresses the burn-through cause without introducing other quality problems.

90. A — On a constant-voltage GMAW machine, reducing CTWD from 19 mm to 10 mm shortens the unsupported wire stub between the contact tip and the arc. The shorter stub has less electrical resistance, which means less I^2R preheat is added to the wire before it reaches the arc. The arc must then supply more energy to complete the melt — the CV machine responds by increasing current to maintain the set voltage. The higher current produces deeper penetration, a narrower bead, and more spatter. Understanding this relationship is essential for optimizing GMAW bead geometry through CTWD adjustment.

91. B — The E71T-5 classification uses a basic flux chemistry (calcium fluoride, calcium oxide) that produces significantly lower diffusible hydrogen levels than the rutile-based T-1 system — typically achieving H8 or H4 classification (≤8 or ≤4 mL/100g deposited weld metal). For thick, high-restraint A709 bridge steel joints, diffusible hydrogen level is the most critical consumable selection criterion for preventing hydrogen-induced delayed cracking. While T-5's more difficult slag removal is an operational disadvantage, it is secondary to the cold cracking resistance benefit that makes T-5 the required choice for this application.

92. D — The slope-in (soft-start) function electronically ramps the welding current from a low initial value to the normal programmed welding parameters over a preset time interval (typically 0.5–1.0

seconds). This allows the arc to establish and a small initial deposit to form at the low start current before the full welding current reaches the cold thin base metal at the weld start location. Without slope-in, the instantaneous application of full welding current to a cold, unrestricted start point on thin stainless steel typically produces a burn-through before the welder can react.

93. C — E71T-8 self-shielded FCAW wire is specifically engineered for applications requiring both all-position capability and certified notch toughness. The "1" position designator confirms all-position suitability (fast-freezing slag for out-of-position work), and the T-8 basic flux system produces lower diffusible hydrogen and deposits weld metal with Charpy V-notch energy values meeting −20°C (and lower) requirements. T-8 wires are the standard specification for seismic-resistant structural applications and outdoor structural work in Canada's cold-climate environments where both self-shielding (wind resistance) and notch toughness are required simultaneously.

94. A — Pulsed GMAW's key advancement is one-droplet-per-pulse transfer: during the brief high peak current, one droplet detaches and transfers in spray mode; during the low background current, the arc is maintained but no transfer occurs. The average current across the pulse cycle is well below the conventional spray transfer threshold, making the effective heat input low enough for all-position welding while retaining spray transfer's benefits of low spatter and good fusion. This combination of spray-quality transfer at reduced average heat input is the fundamental advantage that opened welding positions and thin materials previously inaccessible to conventional spray.

95. D — The position designation in FCAW wire classifications (the digit between the tensile designator and the T) reflects whether the flux solidification behavior is suitable for out-of-position work. For vertical-up and overhead welding, the slag must freeze quickly enough after the arc passes to support the pool against gravity before it runs. A "1" designator (E71T-1C) indicates a flux engineered to solidify fast enough for all positions. A "0" designator (E70T-1C) indicates a slower-freezing, more fluid slag optimized for flat and horizontal work that cannot provide adequate pool support against gravity in out-of-position applications.

96. B — Tandem SAW's primary advantage is approximately doubling the deposition rate by operating two independently powered wire electrodes simultaneously in the same weld pool. The primary engineering challenge is managing the electromagnetic arc interference between the two adjacent DC arcs — each arc's magnetic field deflects the other's plasma column in a phenomenon called arc blow or arc interference. The standard solution is to operate one electrode on DC (typically lead on DCEP for penetration) and one on AC (trail wire), so the continuously changing AC field prevents sustained magnetic deflection between the arcs.

97. C — FCAW-G operating at high production deposition rates and high current densities generates more total welding fume mass per unit time than SMAW in the same application — because more metal is being melted and vaporized per minute. However, per kilogram of deposited weld metal, SMAW basic-coated electrodes like E7018 can generate high concentrations of manganese fume and other specific toxic components from the coating chemistry. Both processes require local exhaust ventilation, but the high total fume mass generation rate per unit time from high-production FCAW-G makes robust fume extraction systems especially critical for maintaining acceptable ambient concentrations in the welder's breathing zone.

98. A — Zinc has a boiling point of approximately 907°C, which falls within the temperature range reached by the base metal adjacent to the weld zone during GMAW. As the zinc coating heats above its boiling point, zinc vapor is generated at the plate surface near the weld toes and can be drawn into the leading edge of the weld pool. When the pool solidifies, trapped zinc vapor forms porosity at the toes. Removing the zinc coating for 25 mm on both sides of the weld preparation — a width sufficient to exceed the extent of the HAZ — prevents zinc vapor generation within the thermal influence of the arc.

99. D — The progressive quality deterioration pattern — good quality at shift start with worsening porosity through the shift — is the diagnostic signature of gas cylinder depletion rather than equipment malfunction, technique error, or base metal contamination. As the cylinder pressure decreases during use, the delivery pressure eventually drops to the point where the regulator can no longer maintain the specified flow rate. The reduced flow rate decreases the shielding effectiveness, allowing progressive atmospheric contamination of the weld pool. Checking the cylinder pressure and replacing a low cylinder is the most direct and common corrective action for this shift-long deterioration pattern.

100. B — A complete economic comparison between solid wire GMAW and FCAW-G must account for all relevant cost factors, not just the deposition rate alone. FCAW-G's advantages include higher deposition rate (more metal per unit time) and generally better out-of-position performance. FCAW-G's cost disadvantages include higher wire purchase price per kilogram, lower deposition efficiency (approximately 80–85% versus 95–98% for solid wire, due to slag losses), and additional inter-pass slag removal labor. For high-volume horizontal fillet welding at the volumes described, the deposition rate advantage of FCAW-G typically delivers a positive net economic result when all factors are correctly included.

101. C — Backstep welding deposits short segments in the direction opposite to the overall weld progression, distributing the thermal shrinkage forces more uniformly around the full joint length or circumference. For a circumferential nozzle weld, this prevents the progressive thermal distortion that results when continuous welding accumulates heat and shrinkage forces on one side of the nozzle at a time. Skip welding achieves a similar effect by allowing each completed cold segment to act as a

physical restraint against the distortion forces generated when adjacent segments are subsequently welded.

102. A — On a constant-voltage GMAW machine, increasing the electrode extension (stick-out) from 12 mm to 25 mm increases the I^2R preheating of the wire in the longer unsupported stub between the contact tip and the arc. This preheat contribution means the arc requires less electrical energy to complete the melt — the CV machine responds by reducing current to maintain the set voltage. The lower current produces a wider, flatter bead with shallower penetration. This is the direct opposite of reducing CTWD: longer stick-out = more I^2R preheat = lower current = shallower penetration and wider bead.

103. B — Self-shielded FCAW wires contain core compounds (aluminum, barium fluoride, and other elements) that provide arc stabilization, shielding functions, and deoxidation but that also suppress the electromagnetic pinch force that drives droplet transfer toward spray mode in GMAW. Regardless of the current level, self-shielded FCAW wires operate in globular transfer mode as a characteristic of their design. This is the normal, expected transfer behavior — the large irregular drops are not an indication of incorrect parameters. Attempting to achieve spray transfer with self-shielded FCAW wires is not possible and overdriving the current damages the consumable and workpiece.

104. D — STT (Lincoln Electric) and RMD (Miller Electric) technologies apply closed-loop electronic control to each individual short-circuit event in real time. The system monitors the current waveform, detects the moment the wire short-circuits the pool, actively reduces current at the magnetic pinch moment before detachment (preventing the explosive "blob" that causes conventional spatter), then delivers a precise controlled re-ignition burst to restore the arc without excess energy. The result is highly controllable low-spatter transfer with very low average heat input — enabling open root passes in all positions that previously required the more demanding skills of GTAW or SMAW.

105. C — In the AWS A5.20 FCAW-G wire classification system, the digit between the tensile strength designator (7 = 70 ksi) and the T (tubular) indicates the usable welding positions. A "0" (as in E70T-1C) indicates flat and horizontal positions only; a "1" (as in E71T-1C) indicates all positions. The difference is the flux solidification rate — E71T-1C's flux is formulated to solidify more rapidly after the arc passes, providing adequate slag support for the weld pool against gravity in vertical-up and overhead positions where E70T-1C's slower-freezing flux provides insufficient support.

106. B — Excessive wire cast or helix causes the wire to exit the contact tip at a continuously changing angle as the coil rotates — the arc exit point and direction change with every revolution of the wire, directing the arc randomly around the weld pool. This produces the characteristic wandering arc pattern with inconsistent penetration at different positions. Wire straightener rollers on the feeder reduce the

cast and helix before the wire enters the drive rolls, and adjusting the roller pressure and alignment is the first mechanical corrective action for this presentation of arc instability.

107. A — E70T-4 self-shielded wire is designed for flat and horizontal positions only (the "0" position designator in the classification), achieves high deposition rates through metallic iron additions in the core, but does not provide the metallurgical control for notch-tough deposits required by codes for dynamically loaded or low-temperature structural applications. E71T-8 self-shielded wire carries the "1" all-position designator, uses a basic flux system to produce lower diffusible hydrogen, and deposits weld metal that meets Charpy V-notch impact requirements at −20°C and below. T-8 wires are the code-specified choice wherever both outdoor self-shielding capability and notch toughness certification are required simultaneously.

108. D — The dense aluminum oxide layer (Al_2O_3, melting point ~2050°C) that forms on all aluminum surfaces is far more refractory than the aluminum base metal (melting point 660°C). Without oxide removal, the arc cannot contact the aluminum base metal and fusion is impossible. The electrode-positive (EP) half-cycles of AC GTAW provide "cathodic cleaning" — positive argon ions are accelerated from the arc plasma toward the work surface with sufficient kinetic energy to mechanically disrupt and eject the oxide particles, revealing clean metal for fusion. DCEN has no EP half-cycles and cannot clean the oxide, making aluminum fusion impossible on DCEN without mechanical pre-cleaning on every pass.

109. C — When the tungsten electrode tip contacts the molten stainless steel pool, the temperature differential and mechanical contact fracture the electrode tip, embedding tungsten fragments in the solidifying deposit. Tungsten has a density of approximately 19.3 g/cm^3 compared to ~7.9 g/cm^3 for stainless steel weld metal — this large density difference causes tungsten inclusions to appear as bright, high-attenuation spots on radiographic film. The contaminated area must be completely excavated and re-welded from sound metal, and the electrode tip must be re-ground to a clean point on a dedicated grinding wheel before welding can resume.

110. B — The correct GTAW filler rod introduction angle is approximately 15–20° from the work surface — a very shallow approach angle. At this angle, the rod tip approaches the leading edge of the pool from outside the shielding gas cup without entering the arc column or the cup. Introducing the rod at a steep angle (near perpendicular) risks the hot rod tip entering the gas cup, which overheats the cup, contaminates the tungsten with filler metal, and can disturb the shielding gas envelope — all of which immediately degrade weld quality and require torch re-setup before welding can continue properly.

111. D — Helium's ionization potential (24.6 eV) is significantly higher than argon's (15.8 eV), requiring more voltage to sustain the same arc length. The higher arc voltage at a given welding current

increases the total arc power (P = V × A), delivering more heat energy to the base metal and weld pool per unit time. On thick nickel alloys like Inconel 625 — which have approximately one-quarter the thermal conductivity of carbon steel and are prone to heat sinking — the additional heat input from helium addition enables higher travel speeds for the same fusion depth, directly improving productivity on thick-section work.

112. A — Duplex stainless steel's combined corrosion resistance and mechanical properties depend critically on maintaining an approximately equal balance of austenite and ferrite phases (target ~50/50). Excessive heat input or high interpass temperature increases the total time above ~900°C, driving ferrite-to-austenite transformation in ferrite grains and pushing the balance toward austenite-excess — degrading pitting resistance and toughness. Insufficient heat input produces too-rapid cooling after solidification, with insufficient time for austenite to reform from the ferrite matrix, leaving excess ferrite and similarly compromised properties.

113. C — Aluminum oxide begins reforming on a cleaned aluminum surface within seconds, growing as an extremely thin layer that increases in thickness over time. The yellowish-brown tint indicates a recently reformed oxide layer — a normal condition that is expected after cleaning in ambient air. The AC GTAW process's cathodic cleaning action during welding will disrupt this thin reformed oxide layer and establish fusion. Welding should proceed promptly after cleaning to minimize additional oxide growth; a recently cleaned surface with a thin reformed oxide does not require re-cleaning before GTAW begins.

114. B — The 1.6 mm EWCe-2 tungsten electrode on DCEN is appropriate for welding thin stainless at 80 A, which is within its rated current range. Increasing to 120 A may approach or exceed the electrode's maximum rated current for DCEN operation (typically 80–130 A for 1.6 mm, depending on the manufacturer). Above the maximum current rating, the electrode tip temperature exceeds the tungsten's ability to maintain its shape — the tip melts, transforms from the pointed profile to a ball or blunted end, and may shed tungsten particles into the weld pool as hard, brittle inclusions. The amperage must be reduced or the electrode upgraded to 2.4 mm before continuing.

115. D — Water-cooled GTAW torches operating at high amperage (200–600+ A) depend entirely on flowing cooling water to keep the torch body, power cable connections, and shielding cup below their thermal damage threshold — the heat generated at these current levels far exceeds what can be safely dissipated by air convection through the torch materials. Without cooling water, even a brief continuation of high-current welding causes rapid thermal damage: the nozzle assembly melts, the handle insulation softens and degrades, and the cable connections inside the torch may develop electrical faults. The torch must be inspected for damage before returning to service.

116. A — Backstep welding distributes the thermal deposits in short, non-sequential segments around the nozzle circumference rather than as a continuous progressive heat application. This prevents the "hot hemisphere / cold hemisphere" temperature differential that develops during continuous circumferential welding and that drives angular distortion of the nozzle flange toward the welded side. For 316L stainless steel, the distributed backstep technique also reduces the peak heat input in any single circumferential zone, reducing the time each HAZ location spends in the 425–870°C sensitization temperature range where chromium carbide precipitation risk is highest.

117. C — 316L filler metal and base metal use low carbon (≤0.03% C) to reduce sensitization risk, but the low carbon does not provide complete immunity to sensitization — it reduces the kinetics, not the thermodynamics. With multiple passes deposited above the interpass limit, the cumulative time that previously deposited passes spend in the 425–870°C range increases beyond what the procedure qualification accounted for. For pressure vessels in corrosive service where intergranular corrosion is a service failure mode, PT inspection of the final weld surface and a formal review of the thermal exposure history by the responsible engineer is the required quality assurance response.

118. D — In GTAW T-joint welding, the 45° electrode bisects the angle between the two plates equally. However, if the welder allows the arc to dwell longer on the base plate — by moving too slowly through the base plate arc position or holding a longer arc there — the base plate receives excess heat while the vertical plate toe remains below fusion temperature. The pool solidifies at the vertical toe without achieving fusion, creating the characteristic toe cold lap. The correction is to angle slightly toward the vertical plate and maintain consistent arc length and uniform travel to ensure equal heat delivery at both toes.

119. B — Randomly distributed, uniform, spherical porosity throughout the weld cross-section with a bright, unoxidized bead surface and confirmed adequate back purge rules out shielding failures and atmospheric contamination. The filler rod surface is the most accessible remaining hydrogen source in this scenario — moisture from packaging, oils from handling, or manufacturing contamination on the rod all introduce hydrogen directly into the pool during rod dipping. Replacing the filler rod with a clean, dry rod from a sealed manufacturer's package resolves the issue and simultaneously confirms the diagnosis if the replacement rod produces porosity-free welds.

120. A — Automated GTAW replaces the human variables — arc length consistency, travel speed uniformity, torch angle, filler rod dip timing, and operator fatigue — with precisely programmed, electronically controlled parameters that are reproduced identically for every weld. For titanium welding, where any parameter deviation causes contamination, porosity, or fusion defects from the metal's extreme chemical reactivity at welding temperatures, this repeatability provides the most significant quality improvement. The 35% rejection rate of the manual operation represents directly the magnitude of human skill variation that automation eliminates.

121. D — In SAW, switching from DCEP to DCEN shifts the primary arc heating zone from the electrode (wire) to the work surface. On DCEN, the wire is the cathode — cathode emission requires less voltage to sustain, allowing the wire to melt faster (higher melt-off rate and deposition rate) at the same current level. Simultaneously, less arc energy goes into the base metal, resulting in shallower penetration and lower base metal dilution. This combination of high deposition rate with low dilution is exactly what is required for overlay cladding and hardfacing applications where preserving the alloy composition of the deposited layer is paramount.

122. C — Coarser flux particles create a more permeable, lower-density blanket over the SAW arc, allowing arc-generated gases (CO, CO_2) to escape more freely through the flux layer — which can reduce surface pinholes from trapped gas. However, the coarser, more open blanket has lower thermal conductivity back into the joint and provides less thermal insulation of the arc, which tends to reduce penetration depth compared to the same flux in finer particle size. Very fine flux creates a dense, low-permeability blanket that traps arc gases and can produce pinholes from CO/CO_2 that cannot escape, while also increasing penetration and bead convexity from the improved heat recirculation.

123. B — Run-on and run-off tabs are extension pieces tack-welded to both ends of the vessel joint before SAW begins. The run-on tab allows the SAW arc to reach stable operating conditions — consistent flux coverage, stable arc voltage and amperage, correct bead profile, and full penetration depth — before the arc crosses onto the actual pressure boundary joint. The run-off tab receives the weld termination crater, which inherently has different geometry and composition from the steady-state weld. After welding, both tabs are removed by cutting and the weld ends are dressed flush, ensuring the entire pressure boundary weld consists only of steady-state, fully characterized weld metal.

124. A — For HSLA pressure vessel steels qualified with a maximum heat input limit for toughness purposes, the coarse-grained heat-affected zone (CGHAZ) is the most toughness-critical microstructural region. Excessive heat input increases the peak temperature and time above the grain-coarsening threshold (~1100°C) in the CGHAZ, producing coarser prior austenite grains that transform to a coarser, lower-toughness martensitic or bainitic microstructure upon cooling. Since the pass was deposited at 4.8 kJ/mm versus the qualified maximum of 3.5 kJ/mm, the weld is outside the qualified procedure envelope and requires a formal engineering disposition — which may include impact test sampling or weld removal and replacement.

125. D — Two-wire tandem SAW uses two independently powered electrodes — typically DCEP for the lead wire (to provide the required penetration) and AC for the trailing wire (to prevent arc blow between the two arcs by continuously changing the magnetic field orientation). Both electrodes operate simultaneously in the same flux blanket and weld pool, with the pool volume and total heat input approximately doubling compared to single-wire SAW at equivalent wire feed speeds. The doubled heat input and larger pool require specific optimization of flux basicity and heat input limits to maintain the

required impact toughness in the larger-volume weld metal deposit and coarser CGHAZ produced by the increased thermal cycle.