PRACTICE EXAM 8: RED SEAL 421A SIMULATION (135 QUESTIONS)

1. A technician is dispatched to a remote site to repair a machine that has broken down on a steep incline. The machine cannot be moved to flat ground. Before beginning the repair, the technician must complete a fieldlevel hazard assessment (FLHA). Which hazard specific to this scenario must be documented and controlled in the FLHA before work begins?

A. The distance from the nearest hospital — the FLHA must document the travel time to emergency medical services and establish a communication protocol

B. The ambient temperature forecast for the duration of the repair — cold stress or heat stress must be documented as a primary hazard for field repairs

C. The availability of a cell phone signal at the repair location — communication capability must be confirmed as the primary safety control for field repairs

D. The machine's position on the incline — gravity creates a rolling/sliding hazard, and the FLHA must identify specific controls such as wheel chocks, frame blocking, and secondary restraint to prevent machine movement during the repair

2. A technician is replacing hydraulic hoses on a forestry processor. The machine has been shut down and the accumulator circuits have been depressurized. Before disconnecting the hoses, the technician wraps a shop rag around the first fitting and cracks it open. A fine mist of oil sprays from the fitting at high velocity despite the depressurization procedure. What was missed?

A. The accumulator circuit was depressurized but the technician did not wait the required 15minute settling time for the residual pressure to dissipate naturally

B. The work circuit being serviced is separate from the accumulator circuit and still contains trapped pressure — each circuit must be individually depressurized by cycling its specific controls before disconnecting any fittings in that circuit

C. The highpressure filter downstream of the pump contains a springloaded bypass valve that traps pressure inside the filter housing after shutdown

D. The oil temperature was above 50°C, which increases the oil's vapour pressure enough to create the mist even without residual hydraulic pressure in the circuit

3. A heavy equipment technician is asked by a site supervisor to modify a machine's exhaust system by removing the DPF to improve engine performance. The supervisor states the machine operates on private property and is not subject to emission regulations. What is the correct response?

A. Decline the modification — tampering with or removing emission control devices is prohibited under federal environmental legislation regardless of where the machine operates, and the technician may be personally liable for performing the work

B. Perform the modification if the supervisor provides written authorization on company letterhead that accepts full responsibility for any regulatory consequences

C. Perform the modification only if the machine's OEM provides a written technical bulletin that approves DPF removal for the specific operating conditions described

D. Perform the modification and install a straight pipe in place of the DPF, but document the original DPF part number so it can be reinstalled if the machine is sold

4. A technician is assigned to work inside the bucket of a large mining shovel to replace wear liner plates. The bucket is resting on the ground with the machine shut down. Another technician will be operating a crane to lift the new liner plates into position. What specific hazard requires control before the technician enters the bucket?

A. The bucket's internal lighting is insufficient for welding operations and portable explosionproof lighting must be installed before entry is permitted

B. The bucket's sharp internal edges require the technician to wear cutresistant gloves and forearm protection in addition to standard PPE

C. The bucket interior is a confined space during liner plate work — the overhead crane operation creates a suspended load hazard above the technician, requiring a signal person, an exclusion zone, and communication protocol between the crane operator and the technician inside the bucket

D. The machine's swing brake must be tested under load before entry because hydraulic drift could rotate the upper structure and drag the bucket while the technician is inside

5. A technician discovers that a coworker has been storing oily rags and a partially full container of partswashing solvent inside a metal locker next to the welding bay. The locker door is closed. What fire hazard category does this represent?

A. No hazard exists because the closed metal locker contains any fire that might start inside, preventing it from spreading to the adjacent welding bay

B. The oily rags are a hazard but the closed solvent container is not — sealed containers of flammable liquids are exempt from storage regulations within the shop

C. The storage is acceptable provided the locker is equipped with a builtin fire suppression system and the locker is grounded to prevent static accumulation

D. The combination of oily rags (spontaneous combustion potential) and flammable solvent in close proximity to a welding ignition source creates a serious fire hazard — both must be moved to approved storage locations immediately

6. A technician needs to verify the capacity of an overhead lifting beam installed in the shop before using it to suspend a transmission during removal. The beam has no visible capacity tag or rating plate. What must be done before using the beam?

A. Estimate the beam's capacity based on its physical dimensions and the type of steel — a structural steel Ibeam of a known size has a published load capacity that can be referenced from engineering tables

B. Do not use the beam for lifting until its rated capacity has been established — a qualified engineer must assess the beam, its connections, and its supporting structure and provide a documented capacity rating before it is used for any suspended load

C. Perform a proof load test by suspending a known weight from the beam at 125% of the intended load — if the beam holds without visible deflection, it is rated for the intended load

D. Use the beam at the capacity of the smallest component in the rigging system — the chain hoist, sling, or shackle rating limits the total load regardless of the beam's actual capacity

7. A technician is performing maintenance on a machine equipped with a supplemental restraint system (SRS) airbag in the operator's seat. The service manual specifies disconnecting the battery and waiting a minimum time before working near the SRS components. Why is this wait period necessary?

A. The wait period allows the SRS control module to complete its shutdown diagnostic sequence and store any active fault codes before power is removed

B. The wait period allows the engine oil pressure to drop to zero, which prevents the oilfilled SRS cushion from deploying under residual oil pressure

C. The SRS system contains a backup capacitor that retains enough energy to deploy the airbag for a period after battery disconnect — the wait period allows this capacitor to discharge to a safe level

D. The wait period is a precautionary cooling time that allows the pyrotechnic initiator in the airbag module to reach ambient temperature before the module is handled

8. A technician is reviewing the job safety analysis (JSA) for a task that requires two technicians to work simultaneously on the same machine — one in the engine compartment and one in the cab. The engine is shut down and locked out. What specific coordination hazard must the JSA address?

A. Both technicians must communicate before any control is operated from the cab — even with the engine locked out, some controls (accumulatorstored energy, springloaded mechanisms, gravityheld implements) can cause movement or release energy when operated

B. Both technicians must wear differentcoloured hard hats so each can identify the other's location visually during the simultaneous work activities

C. The technician in the cab must maintain visual contact with the technician in the engine compartment at all times through the rear window to prevent any inadvertent control operation

D. Both technicians must wear fall protection because the engine compartment and cab are both elevated work surfaces that require fall arrest systems regardless of the work height

9. A technician finds a crack in a welding helmet's autodarkening lens filter during a preuse inspection. The crack does not extend through the outer clear cover lens — it is only in the autodarkening filter element behind it. Can the helmet be used for welding?

A. Yes — the outer clear cover lens provides adequate UV and IR protection regardless of the autodarkening filter condition, and the helmet is safe for all welding processes

B. Yes — but only for lowamperage TIG welding where the arc brightness is below the threshold that requires autodarkening protection

C. No — but the helmet can be used temporarily with a fixedshade filter lens inserted in place of the cracked autodarkening filter until a replacement is obtained

D. No — a cracked autodarkening filter may not transition to the correct shade density uniformly, potentially allowing harmful radiation to reach the technician's eyes through the crack. The filter must be replaced before the helmet is used for any welding operation

10. A technician is servicing a machine at a facility that processes foodgrade materials. The facility has strict contamination control requirements. The technician must top up the machine's hydraulic reservoir with oil from a bulk supply. What contamination control measure is specific to this work environment?

A. Use hydraulic oil that has been filtered through the machine's installed return line filter by pumping it from the bulk tank through the machine's filter circuit before directing it to the reservoir

B. Transfer the oil from the bulk supply through a portable filtration unit with a micron rating equal to or finer than the machine's system specification, and ensure the transfer hose and connections are cleaned before use to prevent introducing external contamination

C. Pour the oil directly from the bulk supply through the reservoir fill strainer — the strainer built into the reservoir filler neck provides adequate contamination control for any work environment

D. Use only prepackaged sealed oil containers rather than bulk supply — bulk oil is inherently contaminated beyond the level acceptable for foodprocessing facility equipment

11. A technician is diagnosing a diesel engine that runs at full power but cannot maintain governed idle speed — the engine stalls when the operator removes the throttle input. The engine restarts immediately and runs normally at any speed above idle. What system should be investigated first?

A. The fuel filter restriction — a partially clogged filter passes adequate fuel at high demand but cannot sustain flow at the precise lowdemand metering required for stable idle

B. The turbocharger — compressor surge at idle creates pressure fluctuations in the intake manifold that destabilize the idle speed control loop

C. The idle speed control — the ECM's commanded idle fuel delivery, the idle validation sensor inputs, or the electronic throttle's returntoidle calibration may have a fault that prevents stable idle fuel metering

D. The exhaust backpressure — a partially restricted DPF creates enough exhaust resistance to stall the engine at idle while being manageable at higher RPM where exhaust energy is greater

12. A large mining truck diesel engine is equipped with prelubrication system that operates the engine oil pump electrically for 15 seconds before cranking is permitted. What is the purpose of this prelubrication cycle?

A. It fills the oil galleries, bearings, and turbocharger bearing housing with pressurized oil before the engine begins rotating — eliminating the drystart wear that occurs during the first seconds of cranking when the enginedriven pump has not yet built pressure

B. It heats the engine oil through friction in the pump, raising the oil temperature enough to reduce coldstart cranking resistance

C. It pressurizes the crankcase to assist piston ring sealing during the first compression strokes when cylinder wall oil film is minimal

D. It tests the oil pump's delivery capability before each start event and prevents cranking if the pump cannot build the minimum specified oil pressure

13. A technician notices a diesel engine's coolant temperature fluctuates cyclically between 75°C and 95°C during steadystate loaded operation. The thermostat opening temperature is rated at 82°C. What does this cycling pattern indicate?

A. The cooling fan clutch is cycling on and off at too wide a temperature differential, overcooling the engine before the fan disengages and allowing overcycling

B. The water pump impeller has cavitation damage that produces intermittent flow disruptions as the damaged blades alternately create and collapse cavitation zones

C. The radiator cap pressure rating is too low, allowing the coolant to boil at the upper temperature and recondense during the lower temperature phase

D. The thermostat is cycling open and closed — it opens at 82°C, allows coolant to flow to the radiator, the engine cools below the thermostat's closing point, the thermostat closes, and the cycle repeats. A thermostat that cycles this widely is either stuck partially or is the wrong temperature rating

14. A diesel engine's turbocharger produces a cyclical pulsing whistle that varies with exhaust flow. The noise is most pronounced during midrange RPM under moderate load. A visual inspection of the compressor wheel through the intake duct shows no blade damage. What is the most likely cause?

A. The turbocharger wastegate is fluttering at the midrange operating point where the boost pressure is transitioning between the wastegateclosed and wastegateopen regimes

B. A crack or leak in the exhaust manifold or turbine housing is allowing exhaust gas to escape intermittently, creating the pulsing whistle as the exhaust pulses pass the leak point at certain RPM and load combinations

C. The charge air cooler has an internal resonance at the specific air volume and velocity produced during midrange operation, acting as an acoustic chamber

D. The turbocharger bearing housing oil drain is restricted, causing oil to accumulate and intermittently contact the turbine wheel, producing the cyclical pulsing sound

15. A technician is testing a diesel engine's crankcase ventilation system flow using a manometer connected to the oil fill port. With the engine at rated RPM and load, the manometer reads a slight vacuum (negative pressure) inside the crankcase. Is this correct?

A. No — the crankcase should be at slight positive pressure during loaded operation because combustion blowby always pressurizes the crankcase above atmospheric

B. No — the crankcase should be at exactly atmospheric pressure at all operating conditions because the CCV system is designed to maintain equilibrium

C. Yes — a properly functioning CCV system maintains a slight vacuum in the crankcase by drawing blowby gases out faster than they are produced, which reduces the pressure differential across engine seals and minimizes oil leakage

D. Yes — but only during cold operation when blowby gases condense and reduce their volume, creating the temporary vacuum that disappears at operating temperature

16. A technician is investigating a roughrunning diesel engine. Cylinder cutout testing reveals that disabling cylinders 1 through 5 individually each worsens the idle roughness equally. Disabling cylinder 6 produces no change in idle quality. What does this confirm about cylinder 6?

A. Cylinder 6 is not contributing to engine power — the cylinder is either not receiving fuel, has no compression, or has a valve timing error that prevents it from producing a useful power stroke

B. Cylinder 6 has the highest compression in the engine and its contribution is masked during the cutout test by the dominance of its combustion event

C. Cylinder 6's injector is delivering twice the normal fuel quantity, and the excess fuel is being consumed during the cutout test's compensation cycle

D. Cylinder 6 has a bent connecting rod that has shortened the effective stroke, reducing its displacement below the threshold needed to affect idle quality

17. A machine operator reports the engine oil pressure warning light flickers briefly during hard cornering on a side slope. The oil level on the dipstick reads at the full mark on level ground. The oil pressure is normal during straightline operation. What is the cause?

A. The oil pressure sensor is failing intermittently and produces a false lowpressure signal during the vibration and gforce of the cornering event

B. The main bearing on the high side of the engine is worn and the reduced oil film on that bearing triggers the pressure switch when the oil shifts away during cornering

C. The oil pump pickup tube has a small crack that draws air when the oil sloshes away from the pickup during cornering, causing a momentary pressure drop

D. The oil level is at the full mark but is not high enough to keep the oil pump pickup submerged during the cornering oil surge — the pickup draws air momentarily as the oil shifts to one side of the pan, causing the brief pressure loss

18. A diesel engine fitted with a common rail fuel system exhibits a hardstart condition only during the first start of the day after sitting overnight. Once started, the engine restarts immediately at any time during the day. There are no fault codes. What is the most likely cause?

A. The intake air heater (grid heater) has failed and cannot preheat the intake charge for the first cold start, but subsequent hot restarts do not require air preheating

B. The fuel system is losing rail pressure overnight through a leaking injector, a faulty pressure control valve, or a check valve in the highpressure pump that allows fuel to bleed back to the tank — extended cranking is required to refill and repressurize the rail each morning

C. The engine oil viscosity is too high for the ambient temperature, slowing the cranking RPM below the minimum for fuel injection during the first cold start only

D. The glow plug relay timer is set too short for the overnight ambient temperature, not providing adequate preheat for the cold soak start condition

19. A diesel engine's oil analysis report shows a sudden appearance of tin in the oil sample. Tin was not present in any previous samples. All other wear metals are at trending levels. What is the most likely source of the tin?

A. Tin is present in the overlay layer of some engine bearing types (leadtin or aluminumtin bearings) — a sudden appearance indicates the bearing overlay has begun to wear through at one or more bearing locations, exposing the tin content to the oil

B. Tin is a component of the piston ring chrome plating process and its appearance indicates the chrome rings are delaminating from the ring body

C. Tin originates from the solder used in the oil cooler tube joints — a thermal cycling failure has begun to dissolve the solder into the circulating oil

D. Tin is released from the camshaft's surface treatment as the hardened layer wears through on one or more cam lobes

20. A Tier 4 Final engine's SCR system is equipped with a DEF dosing valve that atomizes the DEF into the exhaust stream. The technician observes white crystalline deposits around the DEF injector nozzle and on the inside of the exhaust pipe near the injection point. What is this material and what does it indicate?

A. The deposits are calcium carbonate from the engine coolant that has leaked into the exhaust stream through a cracked EGR cooler and crystallized at the hot injection point

B. The deposits are unburned diesel fuel residue that has condensed on the cooler surfaces near the DEF injection point and crystallized from the urea contact

C. The deposits are calcium sulfate from the diesel fuel's sulfur content reacting with the DEF's urea solution at the injection point temperature

D. The deposits are urea crystallization — the DEF is not fully atomizing or the exhaust temperature is too low for complete decomposition, causing urea to crystallize and accumulate rather than converting to ammonia for NOx reduction

21. A technician discovers an engine's coolant pressure cap has a pressure rating of 69 kPa (10 PSI). The OEM specification for this engine is 103 kPa (15 PSI). The engine has been overheating intermittently. How could the incorrect cap contribute to the overheating?

A. The lower cap pressure reduces the water pump's flow rate because the pump must work against less backpressure in the system

B. The lower cap pressure reduces the coolant's flow velocity through the radiator, which reduces the heat rejection rate per unit of coolant volume

C. The lower cap pressure reduces the coolant's boiling point — at 69 kPa, the coolant boils at a lower temperature than designed, causing localized boiling at hot spots that creates steam pockets which displace liquid coolant from the cylinder head and prevent effective heat transfer

D. The lower cap pressure allows atmospheric air to enter the cooling system through the cap's vacuum valve at a higher rate, introducing dissolved oxygen that accelerates internal corrosion

22. A technician is measuring the fuel injection timing on a mechanically timed diesel engine using a timing light and the injection pump's timing marks. The measured timing is 4 degrees BTDC. The OEM specification is 12 degrees BTDC. What symptoms would this retarded timing produce?

A. Reduced combustion noise, higher fuel consumption, elevated exhaust temperature, excessive black smoke under load, and reduced engine power — the fuel ignites later in the power stroke, producing less usable work from each combustion event

B. Excessive combustion noise, lower exhaust temperature, reduced fuel consumption, and increased engine power — the late injection improves thermal efficiency by compressing the fuel charge longer before ignition

C. No observable symptoms — a 4degree timing deviation is within the normal operating tolerance for mechanically timed injection systems

D. Engine stalling at idle because the retarded timing prevents the fuel from igniting before the piston passes TDC and begins the expansion stroke

23. A technician discovers that a diesel engine's fan drive belt has been contaminated with engine coolant from a leaking water pump weep hole. The belt is not slipping and appears to be in good condition otherwise. Should the belt be replaced?

A. Yes — coolant contamination degrades the belt's rubber compound, weakening the internal reinforcement fibres and causing the belt to stretch, crack, or fail prematurely — even though the belt appears functional now, its service life has been significantly shortened

B. No — coolant contamination only affects the belt's surface appearance and does not degrade the rubber compound or the internal reinforcement structure

C. Yes — but only because the wet belt surface will slip during cold starts until the coolant evaporates, causing intermittent charging and cooling fan speed issues

D. No — but the technician should clean the belt with a solvent and inspect it again in 100 hours to verify no degradation has occurred from the exposure

24. A large diesel engine is equipped with an engine protection system that monitors oil pressure, coolant temperature, and coolant level. The system has three response levels: Level 1 (warning), Level 2 (derate), and Level 3 (shutdown). During a loaded haul, the engine enters a Level 2 derate from a high coolant temperature event. The operator reduces the load and the temperature drops to normal. Does the derate clear automatically?

A. Yes — all Level 2 derates clear automatically as soon as the monitored parameter returns to the normal range, restoring full engine power immediately

B. No — all derates require a physical key cycle (engine off/on) to reset, regardless of whether the parameter has returned to normal

C. The behaviour depends on the specific parameter — some Level 2 derates are selfclearing and others require a manual reset through the diagnostic software or a key cycle

D. The derate clears automatically but leaves a progressive warning that remains active until the diagnostic software is connected and the event history is acknowledged by the fleet manager

25. A technician is troubleshooting a diesel engine with a rough idle that improves when the technician momentarily restricts the intake air by partially blocking the air inlet. What does this improvement indicate?

A. The engine has an exhaust restriction that is corrected when the intake restriction balances the exhaust backpressure, equalizing the pressure across the cylinder

B. The engine has a fuel delivery issue — the excess air at idle creates a lean mixture, and restricting the intake enriches the mixture toward the correct ratio, temporarily smoothing the idle

C. The engine has excessive valve overlap — restricting the intake reduces the charge dilution that occurs when intake and exhaust valves are both open simultaneously

D. The engine has a failed intake manifold pressure sensor that overestimates the air mass, causing the ECM to underfuel at idle — restricting the air reduces the actual air mass toward the value the sensor is reporting

26. A technician replaces the coolant temperature sensor on a diesel engine. The engine was overheating before the sensor replacement. After installing the new sensor, the overheating symptom resolves. However, the engine is now operating at a coolant temperature 10°C below its normal range. No fault codes are present. What is the most probable explanation?

A. The original overheating was real, but the replacement sensor has an incorrect resistance curve that reports a lower temperature than actual — the engine is still operating at the correct temperature but the gauge reads low

B. The replacement sensor has corrected the overheating and the engine is now operating at its true normal temperature, which is 10°C lower than the previous sensor indicated

C. The new sensor's resistance range is reading 10°C lower than actual, causing the ECM to command the cooling fan to engage earlier and reduce the engine's operating temperature below the designed range

D. The thermostat has opened further to compensate for the new sensor's calibration, and the additional coolant flow through the radiator is reducing the engine's operating temperature

27. A diesel engine produces a single sharp metallic "crack" noise once per engine revolution from the bottom end. The noise is present at all RPM and does not change character between idle and loaded operation. A cylinder cutout test does not change the noise when any individual cylinder is disabled. What does this indicate?

A. The noise source is not combustionrelated — it is a mechanical impact occurring once per crankshaft revolution from a component that rotates at crankshaft speed regardless of which cylinders are firing. Likely sources include a damaged crankshaft counterweight, a cracked flywheel, or a loose harmonic balancer

B. All six cylinders have equally worn connecting rod bearings, and disabling one cylinder cannot change the noise because the remaining five maintain the same impact pattern

C. The oil pump drive gear has a broken tooth that impacts once per pump revolution, which is geared at 1:1 with the crankshaft in this engine design

D. The starter pinion has not fully retracted and is contacting the flywheel ring gear once per revolution as the tooth passes the partially engaged pinion

28. A diesel engine's turbocharger wastegate actuator is connected to the boost pressure sensing port on the intake manifold by a smalldiameter hose. The technician discovers this hose is cracked and leaking. What effect does this leak have on turbocharger operation?

A. The wastegate remains closed at all times because the leaking hose cannot build sufficient pressure on the actuator diaphragm to open the wastegate — the engine overboosts at high RPM because exhaust gas is never bypassed around the turbine

B. The wastegate opens prematurely because the leak allows atmospheric pressure to assist the spring in pushing the actuator rod, opening the wastegate at a lowerthanspecified boost pressure

C. The leak has no effect because the wastegate is springloaded closed and only opens when boost pressure exceeds the spring force — the leak simply delays the opening by a few milliseconds

D. The leak prevents the actuator from receiving the full boost pressure signal — the wastegate does not open (or opens late) because the actuator never sees sufficient pressure to overcome its internal spring, causing uncontrolled overboosting at high RPM and load

29. A technician is measuring exhaust gas temperature at each cylinder's exhaust manifold runner on a sixcylinder diesel engine. The readings (in °C) are: 1:340, 2:345, 3:520, 4:350, 5:340, 6:345. All other cylinders are within 10°C of each other except cylinder 3. What is the most probable cause of the elevated temperature on cylinder 3?

A. Cylinder 3 has a stuckopen EGR valve port that is routing additional exhaust gas back through the cylinder, raising the exhaust temperature from the recirculated hot gas

B. Cylinder 3's injector is overfuelling — the excess fuel burns during the exhaust stroke, elevating the exhaust gas temperature significantly above the other cylinders that are receiving the correct fuel quantity

C. Cylinder 3 has a collapsed intake valve seat insert that has reduced the valve opening, restricting the intake air charge and creating a rich condition that burns hotter

D. Cylinder 3's exhaust manifold runner has a thinner wall than the other runners from a manufacturing variation, which reduces its heat dissipation and produces a higher surface temperature reading

30. A diesel engine equipped with a dualstage turbocharger system (series turbochargers — a small highpressure turbo feeding a large lowpressure turbo) produces adequate boost at high RPM but poor boost response at low RPM. The highpressure turbo's bypass valve is controlled by the ECM. What is the most likely cause of the poor lowspeed response?

A. The lowpressure turbo has worn bearings that prevent it from achieving the rotational speed needed to contribute to the boost charge at low RPM

B. The highpressure turbo's compressor wheel is damaged, reducing its ability to accelerate the charge air at the low exhaust energy available during lowRPM operation

C. The highpressure turbo's bypass valve is stuck open — exhaust gas is bypassing the small highpressure turbine at all operating points, eliminating the lowspeed boost response that the small turbo is designed to provide

D. The intercooler between the two stages has an internal restriction that limits the airflow at low RPM where the pressure differential is insufficient to push air through the restricted passage

31. A technician is diagnosing a wheel loader that exhibits steering drift — the machine gradually veers to the right during straightline travel even though the operator holds the steering wheel centred. The steering valve spool centering has been verified correct, and the HMU orbital unit passes the leak test. What should be checked next?

A. The steering cylinder seals — if one steering cylinder has internal bypass, the cylinder slowly retracts under the steering forces, causing the machine to drift toward the leaking cylinder's side

B. The steering pump's flow output — a weak pump may produce insufficient flow to maintain equal pressure in both steering cylinders during straightline travel

C. The tire pressures on the front axle — unequal inflation between left and right steered tires produces a consistent pull toward the lowerpressure side

D. The steering relief valve — a relief set too low on one side of the steering circuit limits the maximum pressure to that cylinder and produces asymmetric response

32. A technician is inspecting a large mining truck's suspension and discovers that the left front strut is visibly shorter than the right front strut — the machine sits noticeably lower on the left front corner. Both struts were charged to the same specification at the last service. What is the most likely cause?

A. The left strut's rebound damping orifice has worn larger than the right, allowing the strut to compress further under load without the designed resistance

B. The left strut's oil level is low from a rod seal leak that has allowed oil to weep past the seal during operation, reducing the oil volume inside the strut

C. The machine consistently carries heavier loads on the left side, compressing the left strut further during each load cycle and permanently reducing its static height

D. The left strut's nitrogen gas has leaked through the gas valve, seal, or piston — the reduced gas precharge provides less spring force, allowing the machine's weight to compress the strut further than the correctly charged right strut

33. A tracked machine's rightside bottom rollers are producing a rhythmic thumping noise during travel. The left side is quiet. The technician inspects the rightside bottom rollers and finds one roller has developed a flat spot on its tread surface. What caused the flat spot?

A. The machine was operated with the right track locked (steering brake applied) for an extended period, and the stationary roller wore a flat spot from the chain passing over it repeatedly at the same contact point

B. The roller seized momentarily from a bearing failure — while seized, the track chain ground a flat spot on the roller's tread before the bearing freed and the roller resumed rotating

C. A large rock wedged between the track chain and the roller held the roller stationary while the chain continued to move, wearing the flat spot from the abrasive grinding contact

D. The roller was manufactured with a soft spot in the tread hardening process, and normal wear has preferentially removed material from the soft zone faster than the surrounding hardened tread

34. A heavy equipment machine's hydraulic brakes produce a pulsating pedal feel during application. The technician suspects rotor runout (lateral wobble). What is the correct procedure to verify this diagnosis?

A. Drive the machine at a steady speed and apply the brakes while monitoring the dashboard brake pressure gauge — pressure fluctuations confirm rotor runout

B. Remove the wheels and visually inspect the rotor face for discoloration patterns that indicate the high spots where the rotor contacts the pads unevenly

C. Mount a dial indicator against the rotor face and rotate the hub slowly by hand — the total indicated runout (TIR) reading compared to the OEM specification confirms whether the rotor is within the acceptable runout limit

D. Replace the brake pads with a new set and test drive — if the pulsation disappears, the old pads were at fault; if it persists, the rotor runout is confirmed

35. A dozer equipped with a hydrostatic drive and wet disc steering clutches has difficulty turning in one direction. The operator must apply significantly more lever force to turn left than to turn right. The hydrostatic drive pressures are equal on both sides. What should be investigated?

A. The leftside track motor displacement — if the motor cannot destroke fully when a left turn is commanded, the left track continues to drive and resists the turning motion

B. The rightside track final drive planetary gears — if the planetary set has excessive friction from a worn thrust washer, the additional drag on the right track creates asymmetric turning resistance

C. The left track tension — if the left track is significantly tighter than the right, the additional rolling resistance makes left turns harder than right turns

D. The left steering clutch hydraulic apply circuit — if the clutch circuit has a restriction or a leaking apply piston seal, the left clutch cannot fully disengage, and the partially engaged clutch resists the left turn by continuing to drive the left track

36. A heavy equipment machine is equipped with an inboard wet disc parking brake that applies when hydraulic pressure is removed (springapplied). During a service, the technician releases the parking brake hydraulically and notices the machine moves slightly before the brake fully releases. What does this movement indicate?

A. The brake discs and separator plates are sticking together from the dried residue of old brake oil — the initial application force of the hydraulic release must overcome this adhesion before the discs separate and the brake fully releases

B. The spring brake apply pressure is higher than the hydraulic release pressure, creating a brief delay where the spring force must be overcome before the hydraulic release takes full effect

C. The parking brake control valve has an internal leak that delays the delivery of full hydraulic release pressure to the brake piston, creating a momentary time gap between the command and the full release

D. This is normal operation — the machine's weight shifts slightly as the brake transitions from the applied state to the released state, and the weight transfer is perceived as movement

37. A technician inspects the undercarriage of a crawler excavator and finds that the sprocket teeth on one side are worn significantly more on the leading (drive) face than the trailing face. What does this asymmetric tooth wear indicate?

A. The track tension on that side is too loose — the excess slack allows the chain to accelerate into the sprocket teeth rather than engaging smoothly, concentrating wear on the driving face

B. The machine is primarily used for forward travel with minimal reverse operation — the forward driving face carries all the torque load and wears preferentially, while the trailing face (loaded only during reverse) sees minimal wear

C. The sprocket was installed backward on the final drive hub, exposing the nonhardened face to the driving load and the hardened face to the unloaded trailing position

D. The final drive motor has an internal bypass that produces a pulsating torque output, which impacts the driving face of each tooth cyclically during operation

38. An offhighway truck equipped with oilcooled wet disc service brakes produces a gradual increase in pedal travel over a 2hour operating period. At the start of the shift, the pedal travel is within specification. After 2 hours, the travel approaches the maximum limit. Cooling the brakes by parking for 30 minutes returns the pedal travel to the startofshift value. What is the most likely cause?

A. The brake oil is overheating from sustained heavy braking and the hot oil expands, pushing the pistons back into the caliper bore and increasing the pedal travel required to contact the discs

B. The brake oil is absorbing moisture from the atmosphere through a degraded reservoir cap seal, and the absorbed moisture vapourizes when the brake oil heats, creating compressible gas pockets that increase pedal travel

C. The brake discs are expanding from heat and the increased disc thickness pushes the pads away from the rotor, increasing the pedal travel needed to bring the pads back to contact

D. The brake oil is overheating and the resulting thermal expansion causes the brake oil cooler bypass valve to open, diverting hot oil to the reservoir and leaving less oil volume in the caliper circuit to maintain pedal position

39. A technician finds that a large mining truck's rear axle housing has a visible oil weep at the pinion seal location. The oil level is correct. Before replacing the pinion seal, what should the technician investigate as a possible root cause of the seal failure?

A. The pinion bearing preload — worn pinion bearings allow the pinion shaft to wobble, causing the seal lip to ride on a nonconcentric path that wears the seal unevenly and creates the leak path

B. The differential oil type — some synthetic gear oils contain additive packages that are incompatible with specific seal lip materials and cause the seal to swell, harden, or shrink

C. The ring and pinion backlash — excessive backlash allows the pinion to shift axially under load, creating a cyclical seal loading that accelerates wear

D. The axle breather — a blocked breather traps internal pressure from heat expansion that forces oil past the pinion seal. Replacing the seal without clearing the breather will result in the new seal failing from the same root cause

40. A technician is measuring track roller flange wear on a crawler dozer. The flanges guide the track chain laterally across the roller tread. The OEM specification provides a maximum allowable flange wear dimension. If the flanges wear below the minimum height, what is the consequence?

A. The worn flanges can no longer guide the track chain laterally — the chain is free to drift sideways off the roller during sidehill operation, counterrotation steering, or when debris pushes the chain laterally, increasing the risk of track derailment

B. The worn flanges increase the rolling resistance of the track chain because the chain rides on the flange lip rather than the roller tread, creating friction drag

C. The worn flanges allow the chain to ride higher on the roller, reducing the effective contact area between the roller tread and the chain link rail, which accelerates both roller and chain wear

D. Worn flanges have no functional consequence because the track shoes' centre guides provide all lateral chain guidance and the roller flanges are secondary backup guides only

41. A technician discovers that the parking brake on a wheel loader does not hold the machine on a specified 15% grade. The parking brake is a springapplied, hydraulically released caliper acting on a disc mounted on the transmission output shaft. The springs, caliper, and disc all appear to be in serviceable condition. What should be checked?

A. The transmission — if the transmission is in neutral but the torque converter allows the turbine to freewheel, the converter's drag may be overcoming the parking brake's holding force at the transmission output

B. The parking brake disc material — if the disc has been contaminated with transmission oil from a nearby seal leak, the reduced friction coefficient may prevent the spring force from generating adequate holding torque

C. The parking brake caliper mounting bolt torque — loose mounting bolts allow the caliper to shift under the parking load, reducing the effective clamping force on the disc

D. The parking brake springs have been replaced with a stronger set that exceeds the caliper bore's stroke limit, preventing the pistons from fully retracting and limiting the padtodisc contact area

42. A heavy equipment machine's power steering system uses a priority valve to guarantee steering flow before any other function. The technician measures the flow to the steering circuit at the priority valve's steering port. With the engine at rated RPM and the steering wheel stationary (neutral), the measured flow is 20 L/min. The OEM specification is 35 L/min. What does the low flow indicate?

A. The steering pump has worn and is producing reduced total flow — the priority valve is delivering all available pump output to the steering circuit but the pump's reduced capacity limits the available flow below specification

B. The priority valve is functioning correctly — the 20 L/min reading represents the standby flow that the priority valve delivers to the steering in neutral, and it increases to 35 L/min only when the steering wheel is turned and demand increases

C. The priority valve's spring has weakened, causing the valve to divert more flow to the implement circuit than designed and starving the steering circuit of its guaranteed flow

D. The priority valve's steering port orifice is partially restricted by contamination, limiting the flow to the steering circuit regardless of the pump's output capacity

43. A technician is inspecting the air brake system on a machine and finds the brake chamber pushrod boot (rubber dust cover) on one chamber is torn and the pushrod is corroded and pitted. What consequence does the exposed pushrod condition have on brake performance?

A. The corroded pushrod surface has increased friction against the chamber diaphragm seal, which reduces the diaphragm's ability to push the rod to full stroke during application

B. The pitted pushrod has reduced crosssectional area that may not withstand the full spring brake application force during a parking brake event

C. The corrosion has no effect on brake performance — the pushrod boot is a cosmetic cover and the pushrod functions identically regardless of surface condition

D. The corroded pushrod can seize in the chamber bushing during cold weather, preventing the spring brake from fully applying or preventing the service brake from fully releasing — both conditions compromise safe brake operation

44. A wheel loader's front axle uses a locking differential that the operator can engage from the cab. The differential lock is controlled by a hydraulic clutch pack inside the differential carrier. The operator reports the lock does not engage when commanded. Hydraulic supply pressure to the differential lock solenoid is confirmed correct at the solenoid inlet. What should be tested next?

A. The solenoid output — verify the solenoid is opening and delivering hydraulic pressure to the differential lock clutch pack. If the solenoid is receiving supply pressure but not delivering it to the clutch, the solenoid valve is stuck closed or the wiring command to the solenoid is absent

B. The differential spider gear preload — if the spider gears are too tight, the lock clutch cannot overcome the gear mesh resistance to force both axle shafts to the same speed

C. The ring and pinion mesh pattern — an incorrect gear mesh creates a lateral force on the differential case that prevents the lock clutch from engaging fully

D. The axle shaft spline — a worn axle shaft spline allows the shaft to slip inside the side gear bore, and the lock clutch engagement force is absorbed by the spline movement rather than locking the differential

45. A tracktype machine operates in a demolition environment where steel reinforcing bar (rebar) and wire are routinely encountered in the demolition debris. What specific undercarriage damage should the technician inspect for on machines working in this environment?

A. The rebar cuts into the track roller seals and housing bores, creating flat spots on the roller treads that produce the characteristic thumping noise during travel

B. Steel rebar and wire wrap around the sprocket, rollers, and idler, accumulating as a dense mass that prevents the undercarriage components from rotating freely and accelerates wear on the chain, rollers, sprocket teeth, and idler from the abrasive friction of the trapped material

C. The rebar penetrates the bottom of the track shoes and damages the grouser tips, reducing ground penetration and traction in soft material after the demolition phase

D. The rebar damages the track guide lugs by bending them laterally, which alters the chain's lateral guidance path and increases the risk of derailment

46. A technician is performing a brake system performance test on a machine equipped with hydraulic disc brakes on all four wheels. The test shows the front brakes produce 95% of their specification but the rear brakes produce only 60%. The hydraulic supply pressure to both circuits is equal. What is the most likely cause of the rear brake underperformance?

A. The rear brake pads are a different friction material specification than the front pads, which reduces their friction coefficient despite receiving the same application pressure

B. The rear brake caliper pistons are smaller than the front calipers, producing less clamping force at the same supply pressure — but this is a design feature, not a fault

C. The rear brake calipers, pads, rotors, or mounting hardware have a condition that reduces their mechanical effectiveness — possible causes include contaminated pads, glazed rotors, seized caliper slide pins, or air in the rear circuit that absorbs pedal force

D. The rear tires are larger in diameter than the front tires, which creates a longer mechanical lever arm between the brake caliper and the tire contact patch, reducing the effective braking force at the rear wheels

47. A technician connects a DMM across a heavy equipment machine's starter motor terminals during cranking and reads 2.3 volts. The battery terminal voltage during the same cranking event is 22.8 volts. Using Kirchhoff's Voltage Law, how much voltage is being consumed by the starting circuit wiring and connections?

A. 20.5 volts — the wiring consumes the difference between the battery voltage and the voltage available at the starter motor terminals

B. The wiring voltage drop is 22.8 − 2.3 = 20.5 volts. This extreme drop confirms severe resistance in the cables or connections — under normal conditions, the starter should receive within 1–2 volts of the battery terminal voltage during cranking

C. 25.1 volts — calculated by adding the battery voltage and the starter voltage because the circuit is a series loop

D. 2.3 volts — the starter motor reading represents the wiring voltage drop, not the motor's operating voltage, because the DMM was connected at the wrong test points

48. A machine's electronic display shows erratic gauge readings that change randomly without corresponding to actual machine conditions. The ECM reports no fault codes and all sensor readings verified at the ECM connector are correct. What is the most likely cause?

A. The display module's internal memory has degraded from age and is producing random output data from corrupted memory addresses

B. The ECM is producing correct data but the display's software version is incompatible with the ECM's data format, causing the display to misinterpret the incoming values

C. The alternator is producing AC ripple that is corrupting the display's internal processor, causing it to misread its own memory contents during each screen refresh cycle

D. The CAN bus communication between the ECM and the display has intermittent data corruption — the ECM sends correct data but the display receives garbled messages due to wiring damage, connector corrosion, or electromagnetic interference on the bus segment serving the display

49. A technician measures the resistance of a solenoid coil and reads 8.2 ohms. The OEM specification is 8.0 ± 0.5 ohms. The technician then measures the insulation resistance between the coil terminals and the solenoid housing (ground) using a megohmmeter and reads 2 megohms. The OEM minimum insulation resistance is 10 megohms. What do these combined readings indicate?

A. The coil resistance is within specification (functional coil), but the insulation resistance is below the minimum — current is leaking from the coil winding through degraded insulation to the metal housing, creating a partial ground fault that may cause erratic solenoid operation or ECM driver damage

B. Both readings are within acceptable limits — a 2megohm insulation resistance is adequate for a 24V DC circuit and will not affect solenoid performance

C. The coil resistance indicates the solenoid is at end of life because it is at the upper end of the specification range, and the low insulation resistance confirms the aging diagnosis

D. The low insulation resistance is a measurement artifact caused by the solenoid's proximity to the engine block ground — relocating the solenoid to a nongrounded mounting surface would restore the insulation reading to specification

50. A machine's ECM is equipped with two separate power supply circuits — a primary and a backup. If the primary power supply fails, the backup maintains ECM operation at a reduced functionality level. The technician reads a DTC indicating "ECM backup power active." What should be investigated?

A. The ECM's internal power supply has failed and the module must be replaced regardless of whether the backup circuit restores normal operation

B. The backup power circuit is drawing excessive current from the battery, which will accelerate battery discharge and cause starting problems if the machine sits overnight

C. The primary power supply circuit — the fuse, wiring, connectors, and power relay serving the ECM's primary power input — has a fault that has caused the ECM to switch to backup power

D. The backup power DTC is informational only — the ECM routinely tests its backup circuit by switching to it briefly during each start cycle, and the DTC is a normal test record

51. A technician is diagnosing a machine where the engine runs normally but the transmission will not shift out of neutral. There are no active DTCs in either the engine ECM or the transmission ECM. The transmission manual valve (range selector) is confirmed in the correct position. What should be checked?

A. The engine ECM's output to the transmission ECM — some systems require the engine ECM to send a "ready" signal or torque permission before the transmission ECM will command any clutch engagement

B. The transmission oil filter — a severely clogged filter restricts flow to the clutch apply circuits and prevents engagement of any gear range despite correct valve body and solenoid commands

C. The torque converter lockup clutch circuit — a stuck lockup clutch can prevent the transmission from shifting because the locked converter does not allow the speed differential needed for clutch synchronization

D. The transmission main pressure — if the pump cannot generate adequate main line pressure (from low oil level, a worn pump, or a stuck regulator), no clutch pack receives enough force to engage

52. A technician measures the alternator output voltage on a 24V system at the alternator B+ terminal. With the engine at rated RPM and moderate electrical load, the reading is 29.6 volts. The OEM specification maximum is 28.5 volts. What risk does this overcharging create?

A. The elevated voltage accelerates the electrolysis of water in the battery electrolyte, producing excessive hydrogen gas and consuming water faster than normal — the battery overheats, the plates warp, and the battery life is dramatically shortened

B. The 29.6V reading is within the acceptable range for a 24V system during the initial battery equalization phase that occurs after a cold start and will decrease to the normal range within 15 minutes

C. The overcharging primarily affects the ECM's voltage regulator, which must work harder to step down the elevated supply voltage to its internal 5V reference

D. The elevated voltage will blow the dashboard gauge fuses because the instruments are rated for a maximum of 28V supply

53. A machine has a ground fault indicator light on the dashboard that illuminates during operation. The machine uses a 24V ungrounded (floating) electrical system for the main power distribution. What does the illuminated ground fault indicator mean?

A. A conductor in the electrical system has developed a connection to the machine chassis (ground) — in a floating system, this first ground fault does not immediately cause a malfunction, but a second ground fault on a different conductor would create a short circuit through the chassis that could cause fire or equipment damage

B. The main negative battery cable has become disconnected from the chassis ground point, creating an open ground that the indicator is detecting

C. The alternator's internal ground brush has worn through, interrupting the alternator's ground path and reducing the charging output to zero

D. The 24V system has been accidentally connected to the 12V auxiliary system through a crossed wire, and the voltage difference is detected as a ground fault by the monitoring circuit

54. A technician is testing a fuel level sender unit on a machine. With the fuel tank full, the sender resistance measures 33 ohms (matching the full specification). With the tank empty, the resistance measures 240 ohms (matching the empty specification). At half tank, the resistance reads 136 ohms. Is this halftank reading correct for a sender with these specifications?

A. No — the halftank reading should be 120 ohms (the arithmetic mean of 33 and 240), and the 136ohm reading indicates the float arm is bent and not descending at the correct rate

B. No — the halftank reading should be 103 ohms (calculated as 33 × 240 ÷ (33 + 240)), which is the geometric mean appropriate for a logarithmic sender taper

C. Yes — fuel level senders do not necessarily have a linear resistance change with level. The 136ohm reading at half tank is consistent with a sender that has a nonlinear resistance taper, which is common in automotive and heavy equipment fuel senders because tank shapes are not uniform cylinders

D. No — the reading should be exactly 136.5 ohms at half tank (the arithmetic mean of 33 and 240), and the 0.5ohm discrepancy indicates a worn resistive element on the sender card

55. A machine equipped with a CAN bus J1939 network has a gateway module that connects the engine CAN bus to the implement CAN bus. The engine bus operates at 250 kbit/s and the implement bus operates at 500 kbit/s. What function does the gateway perform?

A. The gateway converts the voltage levels between the two buses — the engine bus operates at 5V logic levels and the implement bus operates at 12V logic levels

B. The gateway translates and forwards selected messages between the two buses that operate at different speeds — it receives messages from one bus, buffers them, and retransmits them at the other bus's speed, allowing modules on differentspeed networks to share data

C. The gateway provides termination for both buses simultaneously — it contains the two 120ohm resistors needed by each bus and eliminates the need for modulebased termination

D. The gateway blocks all communication between the two buses to prevent the engine ECM from receiving implement commands that could interfere with engine protection strategies

56. A heavy equipment machine's cab interior lights remain on continuously and cannot be turned off from the cab switch. The switch has been verified as functional — it opens and closes correctly when tested with a DMM. What is the most likely cause?

A. The cab light circuit is controlled by both the cab switch and the ECM — the ECM has an active command keeping the lights on that overrides the cab switch position, possibly from a door switch fault, a cab entry detection fault, or a software parameter setting

B. The cab light relay has welded contacts that maintain the circuit regardless of the switch position — the welded relay bypasses the switch and provides continuous power to the lights

C. The cab light dimmer module has failed in the fullbrightness mode, supplying continuous power to the lights even when the switch is off

D. The cab light wiring has a short to battery voltage downstream of the switch that powers the lights through the alternate path regardless of the switch state

57. A technician is diagnosing a machine's alternator that produces correct voltage at the alternator output terminal but the battery remains undercharged. The battery has been independently verified as good. Voltage at the battery positive terminal during charging is 2.8 volts lower than the alternator output. What is the root cause?

A. The alternator's internal voltage regulator is sensing voltage at the alternator terminal (where it reads correctly) but does not have a remote sense wire to compensate for the 2.8V cable drop — the batteries receive 2.8V less than the target, which is insufficient for full charging

B. The 2.8V difference is normal for a 24V charging system under full alternator load — the cable resistance accounts for this designed voltage drop

C. The battery has a high internal resistance that consumes 2.8V during the charging process — the battery test showed it passed a CCA test but it may have a capacity issue

D. The 2.8V drop indicates excessive resistance in the main charging cable, connections, or fusible link between the alternator output and the battery positive terminal — the high resistance prevents adequate charging current from reaching the battery

58. A machine's electronic throttle pedal (APPS) produces a 0.5V signal at idle and a 4.5V signal at full throttle. The technician monitors the signal while slowly pressing the pedal from idle to full throttle. The signal increases smoothly from 0.5V to 3.2V, then jumps abruptly to 4.5V with no intermediate values between 3.2V and 4.5V. What does this indicate?

A. The ECM is applying a calibrated throttle map that intentionally produces a nonlinear response between 3.2V and 4.5V to provide aggressive throttle tipin for the final 30% of pedal travel

B. The throttle pedal's mechanical linkage has a detent at the 3.2V position that requires additional force to overcome before the pedal continues its travel — the abrupt voltage jump corresponds to the mechanical snap past the detent

C. The APPS potentiometer has a worn or damaged resistive track — the wiper loses contact with the track between the 3.2V and 4.5V positions, jumping from the last intact contact point to the next intact section of the track

D. The ECM is commanding a fuel quantity increase at the 3.2V threshold that changes the engine load, which feeds back through the drivetrain to the throttle linkage and pulls the pedal to full throttle mechanically

59. A machine has a fourpin diagnostic connector for the OEM diagnostic tool. The technician connects the tool and receives a "No Communication" error. The technician measures pin voltages at the connector: Pin 1 (CANH) = 2.5V, Pin 2 (CANL) = 2.5V, Pin 3 (ground) = 0V, Pin 4 (power) = 24V. What does the equal voltage on CANH and CANL indicate?

A. The CAN bus is in the recessive state (idle) — both lines sit at 2.5V when no module is transmitting. The "No Communication" error indicates no module is responding, which may be caused by the key being off, a fuse blown on the bus power supply, or all modules being in sleep mode

B. The CANH and CANL wires are shorted together — when both lines are at the same voltage, no differential signal can exist on the bus, and all communication stops because the transceivers cannot distinguish between dominant and recessive states

C. The readings are normal for a functioning bus — the diagnostic tool may have a firmware incompatibility or a damaged data pin that prevents it from communicating despite the bus being active

D. The ground pin (0V) and power pin (24V) are correct but the CAN pins have been swapped at the connector — reversing pins 1 and 2 would restore communication

60. A machine's battery disconnect switch is turned off every night. Each morning, the technician notices the batteries are slightly more discharged than expected overnight. The machine has no obvious electrical loads active when the disconnect is off. The technician measures a 45 mA draw on the battery side of the disconnect with the switch off. What could cause this draw with the disconnect open?

A. The battery's internal selfdischarge rate is 45 mA, which is within the normal range for a large leadacid battery and is not caused by any external circuit

B. A circuit that bypasses the disconnect switch — such as a constantpower ECM memory circuit, a security system, or a telematics module — is drawing 45 mA from the battery through a direct connection that does not pass through the disconnect switch

C. The disconnect switch has internal leakage across its contact gap that allows 45 mA to pass even in the open position

D. The alternator's rectifier diodes have a reverse leakage current that allows battery current to flow backward through the alternator windings to ground even with the disconnect switch open

61. A machine's ECM stores freeze frame data when a DTC is logged. The technician reads a stored DTC for "boost pressure low" and examines the freeze frame data. The freeze frame shows: engine RPM = 2,100, coolant temp = 92°C, boost pressure = 85 kPa, ambient temp = 35°C, barometric pressure = 95 kPa. What is the diagnostic value of this freeze frame data?

A. The freeze frame data provides limited value because it captures only a single snapshot that may not represent the actual conditions when the fault occurs during normal operation

B. The freeze frame data is only useful for warranty documentation and has no diagnostic application for the technician troubleshooting the fault in the field

C. The freeze frame data provides only the engine RPM and coolant temperature at the time of the fault — the other parameters are static calibration values stored in the ECM's memory, not live readings

D. The freeze frame captures the exact operating conditions at the moment the DTC was logged — the technician can reproduce these conditions during testing (2,100 RPM, 92°C coolant, 35°C ambient) to recreate the fault and verify the repair, and can analyze whether the recorded boost pressure is consistent with the other parameters

62. A technician is testing the starter motor circuit on a machine that cranks slowly. The battery load test passes. The technician performs a voltage drop test on the positive cable from battery to starter and reads 0.3V during cranking. The voltage drop on the negative cable from battery to engine block reads 1.8V during cranking. What do these readings indicate?

A. The positive cable is within specification (0.3V is acceptable) and the negative cable has excessive resistance (1.8V far exceeds the 0.5V maximum) — the groundside fault is the cause of the slow cranking

B. Both cables have excessive voltage drop — the combined 2.1V total is the sum of both faults and either cable alone would produce slow cranking

C. The positive cable has the fault — the 0.3V reading appears low but is the resistance on the smallergauge positive cable, while the 1.8V on the largergauge negative cable is within specification for its higher current capacity

D. The negative cable reading is normal — groundside cables are expected to show higher voltage drop than positive cables because they also carry current for all other chassisgrounded circuits simultaneously

63. A technician is replacing a temperature sensor that uses a twowire connection — a 5V reference/signal wire and a ground wire. The old sensor read 0.8V at the current operating temperature.

The new sensor reads 3.2V at the same temperature. Both sensors are the same part number. What is the most likely explanation?

A. The old sensor had drifted significantly from its calibration — its 0.8V reading at this temperature was incorrect, and the new sensor's 3.2V reading is the correct output for the actual temperature. The ECM was compensating for the drifted sensor through its adaptive learning, which must now relearn for the correct sensor output

B. The new sensor was wired with the reference/signal and ground wires reversed, inverting the voltage divider and producing the complementary voltage (5.0 − 0.8 = 4.2V, not 3.2V, so this explanation does not match the readings)

C. The new sensor is a PTC type while the old sensor was an NTC type — the different temperature coefficient produces the opposite voltagetotemperature relationship

D. The sensors are different internal resistance specifications despite sharing the same part number — a manufacturing batch variation has produced a sensor with a different resistance curve

64. A machine's CAN bus has 8 modules connected. The technician disconnects one module and the bus termination resistance changes from 60 ohms to 120 ohms. What does this reveal about the disconnected module?

A. The disconnected module was producing excessive bus traffic that was loading the bus electrically and reducing the apparent measured resistance

B. The disconnected module contains one of the two termination resistors — with it removed, only one 120ohm termination remains, producing the 120ohm reading. The technician must note this before leaving the module disconnected, as the bus will experience signal reflection issues

C. The disconnected module had an internal short between CANH and CANL that was adding a parallel resistance path and artificially reducing the measured bus impedance

D. All eight modules contribute to the total bus impedance, and removing one module increases the total resistance proportionally regardless of which module is disconnected

65. A machine's electronic fuel injection system uses a fuel temperature sensor to compensate for fuel density changes. Warm fuel has lower density than cold fuel. If the fuel temperature sensor fails and reads permanently cold (high density), how does this affect fuel delivery?

A. The ECM reduces the injection duration because it believes the fuel is dense and a shorter injection delivers the same mass — the engine runs lean and may lose power

B. The ECM does not adjust for fuel temperature and the failed sensor has no effect on fuel delivery or engine performance

C. The ECM increases the injection duration because it believes the fuel is cold and therefore occupies less volume per unit mass — it compensates by injecting a longer pulse to maintain the target fuel mass

D. The ECM increases fuel delivery because it believes the dense cold fuel requires a longer injection pulse to deliver the same mass — the engine runs rich, producing excessive smoke and reduced fuel economy

66. A machine has a transmission ECM that communicates shift commands to the valve body solenoids through a separate power driver module. The driver module receives serial data commands from the ECM and converts them to PWM outputs for each solenoid. If the driver module fails, what symptoms will the machine exhibit?

A. The engine will shut down because the transmission ECM and engine ECM share critical data through the driver module's communication relay function

B. The transmission will default to a single gear — typically 2nd or 3rd — through a mechanical default valve in the valve body that provides a limphome gear when all solenoids are deenergized

C. The transmission will shift normally using only the ECM's backup internal driver circuits that bypass the external driver module

D. The transmission will remain in the gear it was in when the driver failed — the solenoids maintain their last commanded state through magnetic latching

67. A technician is performing a parasitic draw test and finds a 500 mA draw from the implement ECM. The module should be in sleep mode with a maximum draw of 10 mA. Disconnecting the implement ECM drops the draw to normal. What should be investigated before condemning the ECM?

A. The implement ECM's input signals — a sensor or switch that is sending an active signal to the ECM may be preventing it from entering sleep mode. A stuck proximity switch, a grounded sensor wire, or a continuous voltage signal on an input pin can keep the ECM in an active wake state indefinitely

B. The implement ECM's software version — an outdated software may have a bug that prevents the module from entering sleep mode after a specific operating sequence

C. The implement ECM's CAN bus connection — network traffic from another module that is not entering sleep mode may be keeping the implement ECM awake through its bus interface

D. The implement ECM's power supply circuit — an overvoltage condition on the power supply input may be overriding the module's internal sleep command and holding the module in an active state

68. A machine's electronic display shows a battery symbol with a line through it. The engine is running and the alternator is producing correct output voltage at the B+ terminal. Battery voltage at the battery terminals reads 28.1V with the engine running. What does the crossedout battery symbol indicate?

A. The display is indicating that the battery disconnect switch is in the off position and the batteries are isolated from the charging circuit

B. The symbol indicates a communication fault between the alternator's internal voltage regulator and the machine's body controller module — the body controller cannot verify the alternator is charging and displays the warning

C. The symbol indicates the battery temperature sensor has failed, and the charging system has defaulted to a fixed voltage output that does not compensate for battery temperature

D. The symbol may indicate a charge current monitoring fault, a battery voltage sensor fault, or a communication error between the alternator monitoring system and the display — the actual charging voltage (28.1V) is correct, so the fault is in the monitoring or communication path, not the charging system itself

69. A technician measures the voltage at an injector connector while the ECM is commanding the injector. The expected reading is a PWM signal at 48V peak (boost voltage generated by the ECM's internal DCDC converter for fast injector opening). The measured voltage is 24V peak. What does this indicate?

A. The injector is operating on the standard 24V system supply instead of the boosted 48V — the injector will open more slowly, producing a delayed injection event that retards timing and increases emissions

B. The ECM's internal DCDC boost converter has failed — it cannot generate the elevated voltage needed for fast injector opening. The ECM defaults to operating the injector at system voltage, which reduces performance

C. The 24V reading is normal — the ECM only uses the 48V boost during cranking to assist cold starting, and operates at system voltage during normal running

D. The injector coil has developed increased resistance that limits the peak voltage the ECM driver can produce, dropping it from 48V to 24V due to the voltage divider effect of the highresistance coil

70. A machine's charging system includes a charge indicator light on the dashboard that illuminates when the engine is off (ignition on) and extinguishes when the engine starts and the alternator begins charging. The operator reports the light remains on with the engine running. What circuit function does the charge indicator light serve in addition to warning the operator?

A. The charge light provides the initial field current path to the alternator rotor winding through its filament — the light allows a small current to flow through the rotor, generating the initial magnetic field that enables the alternator to begin selfexciting and producing output

B. The charge light is a diagnostic tool only — it has no electrical function beyond indicating charging status to the operator

C. The charge light provides the ground reference for the voltage regulator — without the light, the regulator cannot sense the system voltage and cannot control the field current

D. The charge light acts as a current limiter for the alternator's field circuit — its filament resistance prevents the field from drawing excessive current during startup that could damage the regulator

71. A technician is checking a machine's electrical connector for water intrusion. The connector appeared dry externally, but when separated, green corrosion is visible on several terminal pins. The technician cleans the corrosion with electrical contact cleaner, reassembles the connector, and returns the machine to service. Is this repair complete?

A. Yes, but the technician should also apply dielectric grease to the terminals before reassembly — the grease prevents future moisture contact with the metal surfaces and provides a barrier against further corrosion

B. No — the root cause of the water intrusion must be identified. Cleaning alone does not prevent recurrence, and the technician must determine why water entered the connector (failed seal, missing grommet, damaged housing, incorrect routing) and correct it before the machine returns to service

C. Yes — electrical contact cleaner removes the corrosion and restores the connection to factory condition. No further action is required unless the corrosion reappears at the next scheduled inspection

D. No — all corroded terminals must be replaced with new terminals crimped onto the wire ends. Cleaning cannot restore a corroded terminal to its original contact resistance and reliability

72. A machine's torque converter operates with a coupling efficiency of 92% during travel at rated speed. The remaining 8% of the engine's power is lost in the converter. Where does this lost energy go?

A. The lost energy is stored as kinetic energy in the converter's rotating fluid mass and is released when the operator decelerates

B. The lost energy is consumed by the torque converter's internal oil pump that circulates fluid through the converter cooler circuit

C. The lost 8% is converted to heat in the transmission oil through fluid shearing between the pump and turbine — the transmission oil cooler must reject this heat to prevent the oil from overheating

D. The lost energy is consumed by the stator's oneway clutch as friction from the continuous engagement and disengagement of the clutch during the coupling phase

73. A large mining truck's automatic transmission uses a retarder to provide braking on downhill grades. The retarder is integrated into the torque converter housing. During retarder operation, what physical process produces the braking force?

A. The retarder works by reversing the turbine's fluid reaction inside the converter housing — the reversed fluid flow opposes the wheel rotation, decelerating the vehicle through hydraulic resistance

B. The retarder applies a multidisc friction brake inside the converter housing that clamps the turbine to the housing, stopping its rotation and using the resulting drag to decelerate the vehicle

C. The retarder energizes an electromagnetic coil that creates eddy currents in a rotating disc, producing a magnetic drag force that opposes wheel rotation

D. The retarder is an independent hydraulic device that does not share the converter housing — it uses a separate pump and valve circuit to generate braking force through controlled fluid restriction

74. A technician is performing a transmission clutch pack clearance check by compressing the pack with a pistontravel measuring tool. The measured clearance is 1.2 mm. The OEM specification is 1.5–2.5 mm. What does the belowspecification clearance indicate?

A. The clutch friction discs are swollen from oil absorption and have increased in thickness, reducing the clearance below specification and potentially causing the clutch to drag when released

B. The clutch pack clearance was set incorrectly during the last rebuild — too few friction discs or separator plates were installed, and the reduced pack thickness produces the tight clearance

C. The pistontravel measuring tool is not calibrated correctly and is producing a reading that is 0.3 mm lower than the actual clearance

D. The clutch return springs have weakened from fatigue and cannot fully retract the piston, which holds the pack compressed and produces the artificially tight clearance reading

75. A wheel loader's drivetrain produces a rhythmic clunking noise that occurs once per wheel revolution. The noise is present in all gears and both directions. Jacking one wheel off the ground and rotating it by hand reproduces the clunk. What is the most likely source?

A. The tire has a flat spot from sitting in one position for an extended period, and the flat spot produces a thump each time it contacts the ground during rotation

B. A broken tooth on the ring gear produces the clunk once per ring gear revolution, which corresponds to once per wheel revolution in a final drive with a 1:1 ratio

C. The axle shaft has a worn spline that produces a clunk once per revolution as the loose spline alternately loads and unloads during rotation

D. A loose or damaged wheel hub component — such as a broken wheel stud, a cracked hub, or a loose bearing retainer — produces the rhythmic clunk once per hub revolution as the damaged component passes through its loaded position

76. A technician discovers that a machine's automatic transmission is shifting at the correct shift points during acceleration, but the downshifts occur at a much lower speed than specified — the transmission holds each gear longer during deceleration. What is the most likely cause?

A. The shift solenoids are functioning correctly for upshifts but have reduced response time for downshifts due to contamination in the valve body that restricts fluid flow to the downshift side of the shift valve

B. The transmission cooler is restricting flow, which delays the fluid supply to the downshift circuits and causes the downshifts to occur later than specified

C. The transmission oil is at the upper limit of its viscosity specification, which slows the valve body spool movements during the downshift sequence and delays each downshift event

D. The governor or output speed sensor signal that triggers downshifts has drifted — the signal reads higher than actual output speed, causing the TCM or valve body to delay downshifts because it believes the vehicle is moving faster than it is

77. A technician replaces the input shaft seal on a powershift transmission. After reassembly, the transmission operates normally but the technician notices oil accumulating around the new seal after 50 hours. The seal was installed correctly and is the correct part number. What should be investigated as the root cause?

A. The input shaft surface where the seal lip rides — a groove worn into the shaft by the old seal prevents the new seal lip from making a leakfree contact on the worn surface

B. The transmission oil level — an overfilled transmission creates internal pressure above the seal's rated capacity, forcing oil past the lip

C. The seal installation depth — the new seal was pressed to the same depth as the old seal, but the correct depth may have changed due to shaft end play variation between the old and new thrust washer installed during the rebuild

D. The seal orientation — the seal lip spring was accidentally dislodged during installation and the seal cannot maintain adequate lip pressure against the shaft

78. A machine's differential produces a rhythmic clicking noise from the carrier area when the machine is driven in a straight line. The noise disappears during turns. What does this indicate?

A. The differential spider gears have worn teeth that produce a clicking noise when they are stationary (straightline travel) and mesh with the side gears — during turns, the spiders rotate and the clicking changes to a smooth gear mesh noise that is inaudible

B. The differential side gear thrust washers are worn, allowing the side gears to shift axially and contact the carrier housing during straightline travel. During turns, the differential action loads the gears laterally and pushes them away from the carrier wall

C. A loose differential ring gear bolt is contacting the carrier housing once per ring gear revolution — the bolt head is in a position that clears the housing during turns when the carrier shifts laterally under the turn load

D. A cracked differential carrier housing allows the ring gear to shift under the mesh load during straightline travel, producing the clicking noise — during turns, the load distribution changes and the crack closes

79. A technician is rebuilding a manual clutch assembly and discovers the flywheel's pilot bearing bore has been damaged — it is slightly oval rather than perfectly round. What consequence does this have for the new pilot bearing?

A. The oval bore causes the new pilot bearing outer race to be loaded unevenly — the tight spots overheat while the loose spots allow the race to creep, producing vibration and premature bearing failure

B. The oval bore has no consequence because the pilot bearing is a pressedfit component and the press force reforms the bore to a round shape during installation

C. The oval bore causes the input shaft to orbit at twice per revolution, producing a vibration that is felt at the clutch pedal during disengagement

D. The oval bore prevents the pilot bearing from seating fully — the bearing protrudes from the bore and the transmission input shaft cannot reach the correct engagement depth

80. A machine equipped with a powershift transmission has an oiltowater transmission cooler. The technician discovers the transmission oil has turned a pink/milky colour. What has occurred and what is the immediate risk?

A. The pink colour indicates the transmission fluid has oxidized from overheating and is no longer providing adequate lubrication to the clutch packs

B. The transmission cooler has crosscontaminated — water from the cooling system is mixing with the transmission oil through a failed heat exchanger tube

C. Water from the engine cooling system has entered the transmission oil through a failed tube in the transmission oil cooler — the emulsified oil has lost its lubricating and hydraulic properties, and continued operation will cause rapid clutch pack destruction, bearing wear, and potential planetary gear damage

D. The transmission oil has been contaminated with brake fluid from a shared hydraulic circuit, producing the characteristic pink discoloration

81. A hydrostatic drive machine produces a noticeable vibration during initial acceleration from standstill that smooths out once the machine reaches constant speed. The vibration is not present during deceleration. What is the most likely cause?

A. The charge accumulator has lost its precharge and cannot cushion the initial pressure spike when the pump swashplate moves from zero to working displacement

B. The drive motor has excessive internal leakage that produces cavitation vibration only during the initial flow demand before the loop pressure stabilizes

C. The hydrostatic pump's swashplate control has a dead band near the zerodisplacement position — the control must traverse this dead band during initial acceleration, causing the swashplate to jump rather than move smoothly, producing the vibration that settles once the pump is in its operating range

D. The drive coupler between the engine and the hydrostatic pump has a worn elastomeric element that produces torsional vibration under the initial torque load of acceleration, which dampens out at constant speed when the torque demand stabilizes

82. A technician inspects a set of wet disc brake friction discs that have been in service for 8,000 hours. The friction surfaces show a uniform brown glazed appearance across the entire contact area. The discs measure within the OEM minimum thickness specification. Are these discs serviceable?

A. Yes — uniform brown glazing on wet disc brakes is normal and indicates the friction surfaces are working correctly within their designed operating temperature range

B. No — the glazed surface indicates the discs have experienced sustained high temperatures that have altered the friction material's surface properties

C. Yes — but only if the brake's holding force tests within specification, because glazing may reduce the friction coefficient below the level needed for adequate braking even though thickness is within limits

D. No — glazed friction surfaces have a reduced and inconsistent friction coefficient compared to nonglazed surfaces. Even though the thickness is within specification, the brake may not produce adequate holding force — the discs should be replaced or scuffsanded to restore the friction surface profile

83. A machine's final drive planetary gear set has been rebuilt. During the test drive, the technician notices the final drive produces a highpitched whining noise that was not present before the rebuild. Oil level and type are correct. What is the most likely cause?

A. The planetary gear bearing preload has been set too tight during reassembly — the excessive preload generates friction that produces the highpitched whine as the gears rotate under load

B. The sun gear was installed backward — the tapered tooth profile is designed for one direction of engagement, and the reversed installation creates incorrect mesh geometry that produces the whine

C. The ring gear mounting bolts were not torqued to specification, allowing the ring gear to vibrate against the carrier housing under load

D. The replacement planet gears or bearings do not match the original specifications — a different tooth count, module, or bearing size from the same gear family but a different ratio produces the mismatched mesh noise

84. A technician discovers that a machine's driveshaft universal joint has been recently replaced but the grease zerk fitting is missing — the fitting hole is open. What is the consequence of operating with the open fitting hole?

A. The open hole allows water and debris to enter the Ujoint bearing caps during operation, contaminating the grease and accelerating needle bearing wear from abrasive contamination and moisture corrosion

B. The open hole allows the grease to escape from the bearing caps during each revolution from centrifugal force, rapidly depleting the lubricant and causing dry bearing failure

C. The open hole has no consequence because the bearing caps are sealed internally by needle bearing retainer clips that prevent contamination from reaching the needle rollers

D. The open fitting hole causes a slight imbalance in the Ujoint cross spider that produces a speedproportional vibration from the asymmetric mass distribution

85. A machine's automatic transmission has a torque converter with a damper assembly (torsional vibration damper) located between the lockup clutch disc and the turbine hub. What is the purpose of this damper?

A. It absorbs the shock load that occurs when the lockup clutch first engages, preventing the abrupt mechanical connection from transmitting engine firing pulses directly to the transmission input shaft

B. It limits the maximum torque that the lockup clutch can transmit, protecting the transmission from engine torque spikes that exceed the designed input limit

C. It absorbs engine torsional vibration when the lockup clutch is engaged — without the damper, the engine's firing pulses would transmit directly through the locked converter to the transmission, producing drivetrain vibration and noise

D. It provides a progressive engagement of the lockup clutch by allowing controlled slip between the clutch disc and the turbine hub during the initial engagement phase

86. A tracked machine's sprocket has been replaced. After 200 hours, the new sprocket shows accelerated tooth wear compared to the expected wear rate for the machine's application. The track chain is at 60% wear. What is the most likely cause of the accelerated sprocket wear?

A. The replacement sprocket is the wrong material specification — a lowerhardness sprocket wears faster than the original specification in the same application

B. The replacement sprocket tooth profile matches a new chain pitch, but the 60% worn chain has elongated pitch that does not mesh correctly with the new sprocket, concentrating load on fewer teeth and accelerating wear

C. The track tension was not readjusted after the sprocket replacement — the new sprocket has a different effective diameter that requires a corresponding tension adjustment

D. The replacement sprocket was manufactured with incorrect tooth geometry — the tooth profile does not match the chain pitch and link rail dimensions for this machine

87. A machine's powershift transmission shifts smoothly in all gear ranges when the machine is cold. After the transmission reaches operating temperature (approximately 30 minutes of operation), the 23 and 34 shifts become noticeably harsh. What is the most likely cause?

A. The transmission oil is too thin at operating temperature — the reduced viscosity allows the clutch apply pressure to rise faster than designed, producing the harsh engagement that is not present when the cold, thick oil slows the pressure rise rate

B. The transmission oil has exceeded its thermal stability limit and the degraded oil cannot maintain the cushioning effect needed for smooth shifts — the oil is due for replacement

C. The modulation valve springs have weakened from heat fatigue — at operating temperature, the springs cannot maintain the designed pressure ramp rate, allowing full pressure to reach the clutch pack too quickly

D. The accumulator springs in the valve body have weakened and cannot absorb the engagement shock at operating temperature when the thinner oil flows more freely — at cold temperature, the higher viscosity provides natural damping that masks the weakened accumulators

88. A technician is diagnosing a machine where the differential lock engages but does not disengage when the operator releases the control. The machine continues to drive with both axle shafts locked together, producing bind and stress during turns. What is the most likely cause?

A. The differential lock clutch pack friction material has bonded to the separator plates from overheating, creating a permanent mechanical connection that cannot be released by the hydraulic circuit

B. The lock mechanism is binding from corrosion or contamination on the sliding engagement components — the springs that return the lock to the disengaged position cannot overcome the friction

C. The differential lock release circuit has a fault — a stuck solenoid valve, a blocked return line, or a failed return spring prevents the hydraulic pressure from releasing the lock clutch pack

D. The lock is functioning correctly — some differential locks are designed to remain engaged until the machine's speed exceeds a threshold at which the differential speed sensors detect a speed difference that triggers the automatic release

89. A technician is diagnosing an A/C system where the compressor clutch engages and the system produces cold air, but the evaporator ices up within 5 minutes and airflow stops. After defrosting, the cycle repeats. What is the most likely cause?

A. The system is overcharged — the excess refrigerant floods the evaporator and reduces the surface temperature below the icing threshold faster than normal

B. The expansion valve is stuck fully open, flooding the evaporator with liquid refrigerant that drops the surface temperature below freezing before the evaporator thermostat can cycle the compressor off

C. The evaporator temperature control (thermostat or pressure switch) that should cycle the compressor off before the evaporator reaches freezing temperature has failed — the compressor runs continuously and the evaporator surface drops below 0°C, freezing condensate on the coil until airflow is blocked

D. The condenser is restricted and the high side pressure is elevated, which increases the expansion valve's pressure differential and drives more refrigerant through the evaporator than designed

90. A machine's cab HVAC system has been producing a vibration that is synchronous with the blower motor speed. The vibration increases as the blower speed is increased. What is the most likely cause?

A. The blower motor brushes are worn and producing an electrical pulsation that translates to a mechanical vibration at the motor speed

B. The blower wheel (squirrel cage) has accumulated debris, dirt, or ice on the blades that has created an imbalance — the unbalanced wheel produces a vibration proportional to its rotational speed

C. The blower motor's mounting bolts have loosened, allowing the motor to vibrate on its mount at a rate proportional to the motor's speed

D. The HVAC housing has a loose panel that resonates at the blower's operating frequency, producing a sympathetic vibration that increases with airflow velocity

91. A technician is servicing a machine's A/C system and discovers the previous technician used R12 refrigerant to top off an R134a system. The system has been operating for approximately 500 hours with the mixed charge. What damage may have occurred?

A. R12 and R134a are fully compatible — no damage has occurred and the system will function normally with the mixed charge

B. The mixed refrigerants produce a chemical reaction at operating temperature that forms a gellike compound that clogs the expansion valve orifice and condenser tubes

C. R12 contains chlorine that damages the POE oil used in R134a systems — the chlorine attacks the oil's molecular structure, reducing its lubricating capability and causing accelerated compressor wear

D. R12 is incompatible with the R134a system's seals, hose materials, and desiccant — the R12 may have degraded the hoses, deteriorated the receiverdrier desiccant, and swelled the compressor shaft seal, causing leaks and contamination

92. A machine's cab pressurization fan runs at full speed but the cab interior has a noticeable exhaust odour. The pressurization test shows adequate positive pressure (above the OEM minimum specification). What is the most likely cause?

A. The cab's fresh air intake is located too close to the engine exhaust outlet and is drawing exhaust gas directly into the HVAC system — the system has adequate pressure but the incoming air itself is contaminated with exhaust gas

B. The cab air filter has failed, allowing unfiltered exhaustcontaminated air to enter the cab despite the correct positive pressure

C. The engine's exhaust manifold has a crack that is directing exhaust gas toward the cab's underbody, where it infiltrates through the floor pan penetrations despite the positive pressure

D. The heater core has a pinhole leak that is introducing coolant vapour with an exhaustlike odour into the cab air stream during heating mode operation

93. A technician is checking the A/C system's condenser and finds the bottom 30% of the condenser face is packed with debris (mud, bugs, vegetation). The top 70% is clean. How does this partial blockage affect system performance?

A. The partial blockage has no measurable effect because the remaining 70% of clean condenser area provides more than adequate heat rejection for the system's total capacity

B. The partial blockage increases the highside pressure proportionally — the blocked area reduces the total heat rejection capacity, causing the condenser to work at higher pressure to reject the same heat load through the reduced surface area

C. The blocked condenser face acts as an insulator that radiates heat back toward the engine, increasing the engine compartment temperature rather than affecting the A/C system directly

D. The debris creates a pressure drop in the airflow through the condenser that is compensated by the condenser fan increasing its speed automatically

94. A technician replaces the cabin air filter on a machine and installs the new filter backward — with the airflow direction arrow pointing opposite to the designed flow direction. What consequence does this incorrect installation have?

A. The filter provides no filtration in the reverse direction because the filter media's tapered pore structure only traps particles when air flows in the designed direction

B. The reversed filter restricts airflow more than the correctly installed filter because the downstream support structure is now on the inlet side, reducing the effective filter area and increasing restriction — this reduces cab pressurization and airflow volume

C. The reversed filter has no operational consequence — cabin air filters function identically regardless of installation direction because the filter media traps particles from both sides equally

D. The reversed filter allows larger particles to pass through because the media's progressive density structure (coarsetofine from inlet to outlet) is reversed, exposing the fine layer to the initial dust load and causing it to clog rapidly while the coarse layer faces the clean side

95. A machine's dieselfired auxiliary heater has been running for 2 hours and the operator reports a strong diesel fuel odour inside the cab. The heater is a sealedcombustion type (combustion air and exhaust are separate from the cab air). What should be investigated?

A. The heater's fuel supply line has a leak near the cab entry point, and liquid fuel is dripping or vaporizing near the HVAC fresh air intake

B. The sealedcombustion heater's exhaust pipe has a crack or disconnected joint near the cab, and combustion exhaust (which carries unburned fuel odour) is entering the HVAC fresh air intake

C. The heater's fuel metering pump is overdelivering fuel, creating incomplete combustion that produces the fuel odour at the heater's external exhaust outlet — the odour enters the cab through the recirculation mode

D. The heater's heat exchanger has developed a crack — combustion gases containing unburned fuel are leaking from the combustion chamber into the heated air stream that supplies the cab

96. A technician is diagnosing an A/C system that produces intermittent cooling. The system cools normally for 3–5 minutes, then the evaporator outlet temperature rises to near ambient for 1–2 minutes before cooling resumes. This cycle repeats continuously. The compressor clutch remains engaged throughout the cycle. What is the most likely cause?

A. The expansion valve is cycling between full open and full closed due to a faulty sensing bulb that has lost its charge — the inconsistent bulb signal causes the valve to alternate between flooding and starving the evaporator

B. The condenser fan is cycling on and off due to a faulty relay, causing the highside pressure to fluctuate and alter the expansion device's behaviour

C. The compressor has a failing internal valve plate that intermittently loses compression, temporarily reducing the refrigerant flow through the evaporator before the valve plate reseats and compression is restored

D. The system has a moisture contamination issue — water in the refrigerant freezes at the expansion device orifice, blocking flow. The ice melts from the heat soak during the noncooling phase, restoring flow until it refreezes

97. A machine's cab defroster system is unable to clear the windshield despite the heater producing adequate heat at the floor and panel vents. The blower motor operates at all speeds. What is the most likely cause of the defroster's inability to clear the windshield?

A. The HVAC mode selection door that directs airflow to the defroster outlets is stuck, disconnected, or blocked — heated air is flowing through the system but is not being directed to the windshield defroster ducts

B. The windshield glass has degraded from age and UV exposure and its interior surface can no longer be cleared by heated air because the surface chemistry promotes condensation

C. The blower motor is running in reverse at the defroster speed setting, pulling air away from the windshield rather than pushing heated air toward it

D. The heater core's upper passages are blocked, preventing hot coolant from reaching the section of the core that supplies the defroster duct, while the lower passages supply the floor and panel vents normally

98. A hydraulic system has been experiencing repeated pump failures. Three pumps have failed in 2,000 hours. Each failed pump shows severe cavitation erosion on the inletside valve plate and piston shoes. What is the most likely root cause of the repeated failures?

A. The pump inlet circuit has a chronic restriction — a suction strainer that is too fine, a suction line that is too small, a reservoir that is too low, or a suction hose that has collapsed internally — starving the pump of fluid and causing the repeated cavitation destruction

B. The pump's displacement is oversized for the engine's available power, and the pump stalls under load, creating cavitation conditions on the discharge side that appear on the inletside components

C. The hydraulic oil viscosity is too low for the operating temperature, and the thin oil flashes into vapour under the negative pressure conditions at the pump inlet

D. The system relief valve is set too high, creating excessive discharge pressure that backfeeds through the pump's internal clearances and erodes the inletside components

99. A hydraulic cylinder must extend and retract at the same speed. The cylinder has a 100 mm bore and a 70 mm rod. What circuit feature is required to achieve equal speed in both directions?

A. A pressurecompensated flow control valve that maintains equal flow to both cylinder ports regardless of the differential piston area

B. A regenerative circuit that redirects the capend exhaust flow to the rod end during extension, increasing the effective extend speed to match the naturally faster retraction speed

C. A regenerative circuit on the extension side — the oil exhausting from the rod end during extension is directed back to the cap end, supplementing the pump flow and equalizing the extension speed with the retraction speed

D. Two separate pumps — one sized for the capend area and one sized for the rodend area — providing the different flow rates needed for each direction

100. A machine's hydraulic system has a case drain flow specification of 5% of pump displacement at rated pressure. The pump displacement is 200 cm^3/rev at 1,800 RPM (theoretical flow = 360 L/min). The measured case drain flow at rated pressure is 36 L/min. Is this within specification?

A. Yes — 36 L/min is exactly 10% of the theoretical flow, which is within the typical acceptable range of 5–15% for heavy equipment piston pumps

B. No — 36 L/min is double the 5% specification (5% of 360 = 18 L/min). The pump has excessive internal leakage and should be scheduled for rebuild

C. Yes — the 5% specification applies to the pump displacement per revolution (200 cm^3 × 5% = 10 cm^3), not to the total flow, and the 36 L/min is consistent with this perrevolution specification

D. The case drain exceeds the specification — 5% of 360 L/min theoretical output = 18 L/min maximum allowable case drain. The measured 36 L/min is double the limit, confirming the pump's internal clearances have worn beyond the serviceable threshold

101. A machine's implement hydraulic system produces a highpitched squeal from the main control valve area whenever the boom is lowered from full height. The squeal does not occur during boom raise, bucket curl, or any other function. What is the most likely cause?

A. The boom lower circuit has a cavitation condition — the boom descends faster than the pump can supply fluid to the rod end, creating a vacuum on the rod side that produces the squealing noise

B. The boom lower spool metering edge creates a highvelocity flow restriction at partial opening — the oil passing through the narrow metering slot at the pressure generated by the boom's weight produces the audible squeal

C. The boom lower relief valve is set slightly above the working pressure and is chattering at the threshold between open and closed during the lowering event

D. The pilot pressure signal for the boom lower function has air in the pilot circuit, and the compressing air produces the squealing sound as it passes through the pilot orifice

102. A hydrostatic transmission's charge circuit includes a charge pump, a charge relief valve, a charge filter, and two charge check valves. The charge pump draws oil from the main reservoir. If the reservoir's return line filter is severely clogged, what effect does this have on the charge circuit?

A. The clogged return filter creates backpressure in the return line that restricts the flow of oil returning to the reservoir — the reservoir level drops below the charge pump pickup, causing the charge pump to draw air and lose its prime, which reduces charge pressure and starves the main pump

B. The return filter has no connection to the charge circuit — the charge pump draws from the reservoir through its own dedicated suction line that is independent of the return filter

C. The clogged return filter increases the charge pressure because the backedup return oil adds to the charge pump's supply pressure

D. The clogged return filter causes the main pump to cavitate, which increases the case drain flow and reduces the charge pressure through the higher leakage rate

103. A hydraulic motor on a winch drive is equipped with a brake valve (counterbalance valve) on the motor's return port. During a loadlowering test, the load lowers smoothly at the controlled speed until the DCV is moved from the lower position to neutral. At that point, the load drops approximately 50 mm before stopping. What is the cause of this small drop?

A. The brake valve has a small internal leak past its poppet seat that allows a brief flow when the DCV shifts to neutral and the pilot signal is removed

B. The DCV spool passes through a brief midposition transition zone during its travel from lower to neutral where both work ports are momentarily connected to tank, allowing the load to drop before the spool reaches the fully blocked neutral position

C. The motor has internal leakage that allows the load to coast slightly after the DCV closes, until the brake valve's backpressure builds to the level that stops the motor from turning under the leaking flow

D. The hydraulic hose between the DCV and the motor expands slightly under the pressure of the load — when the DCV closes, the stored energy in the expanded hose allows the motor to turn until the hose returns to its unpressurized diameter

104. A machine's hydraulic system uses a return line filter with a visual clogging indicator (popup type). The technician notices the indicator has popped during cold morning operation but returns to the clean position after 30 minutes of operation. What is the explanation?

A. The filter element is partially loaded with contaminants — when the cold oil is thick, the combined restriction of the loaded element and the highviscosity oil creates enough pressure drop to trigger the indicator. As the oil warms and thins, the viscosityinduced restriction decreases and the indicator resets

B. The indicator mechanism is temperaturesensitive and produces false triggers during cold conditions — the spring inside the indicator contracts in the cold and triggers at a lower differential pressure than specified

C. The filter bypass valve is stuck open during cold operation, routing all flow around the element and creating a pressure pulsation that triggers the indicator incorrectly

D. The cold oil produces higher flow rates from the pump (cold oil is denser and the pump displaces more mass per revolution), which overwhelms the filter's rated flow capacity and triggers the clogging indicator

105. A machine's hydraulic system operates at 250 bar maximum working pressure. The system uses JIC 37degree flare fittings on all connections. The technician discovers one fitting has been replaced with an NPT (National Pipe Thread) fitting of the same thread size. The fitting appears tight and is not leaking. Should this fitting be replaced?

A. Yes — NPT fittings are taperedthread pipe fittings that seal on the threads using sealant or tape. They are not rated for the same pressure and vibration service as JIC flare fittings, which seal on the precision 37degree flare surface. The NPT fitting may fail under the pressure and vibration conditions that JIC fittings are designed to withstand

B. No — NPT and JIC fittings of the same thread size are interchangeable and provide equivalent sealing capability at hydraulic working pressures

C. No — but the NPT fitting should be monitored for leaks at each service interval because NPT fittings require periodic retightening that JIC fittings do not

D. Yes — but only because the thread sealant tape used on NPT fittings can shed fragments into the hydraulic circuit that contaminate the oil

106. A hydraulic excavator's main pump is a twopump tandem (two independent pump sections sharing a common drive). Each pump section supplies different functions. Pump section A's output has dropped by 30% while pump section B operates normally. What does this indicate?

A. Both pump sections share internal lubrication from a common case drain — section B's wear debris has contaminated section A's valve plate and caused the performance drop

B. The engine is not producing adequate RPM to drive both pump sections at their rated speed, and section A has a higher displacement that requires more input torque than section B

C. Pump section A has internal wear independent of section B — the two sections have separate pistons, barrels, valve plates, and swashplates, and one section can wear without affecting the other

D. The suction strainer in the common reservoir has partially clogged, and section A's inlet is positioned lower than section B's, causing section A to be starved while section B draws from above the restriction

107. A machine's pneumatic system governor has been replaced. After replacement, the technician measures the cutin and cutout pressures. The cutout is at 860 kPa (correct) but the cutin is at 760 kPa. The OEM specification states the differential (cutout minus cutin) should be 170 kPa (giving a cutin of 690 kPa). The actual differential is only 100 kPa. What is the consequence of this narrow differential?

A. The narrow differential has no operational consequence because both the cutin and cutout pressures are above the minimum system operating pressure

B. The compressor cycles more frequently because it reloads sooner (at 760 kPa instead of 690 kPa) after each unload — the more frequent cycling increases compressor wear, generates more heat, and reduces the air dryer's regeneration effectiveness

C. The narrow differential increases the system's maximum pressure above the safe operating limit because the compressor runs for longer periods during each loaded cycle

D. The narrow differential reduces the total stored air volume available for brake applications because the compressor unloads before the system reaches full capacity

108. A hydraulic system's pressurecompensated variable pump produces a constant 30 bar standby pressure when all DCVs are in neutral. The technician measures 30 bar at the pump outlet and 2 bar at the DCV inlet. What does the 28bar pressure loss between the pump and the DCV indicate?

A. The DCV inlet port has a designed pressurereducing orifice that drops the supply pressure to 2 bar before it enters the valve body

B. The loadsensing pilot line is connected between the pump and the DCV, and the 2bar reading at the DCV inlet represents the LS signal pressure, not the supply pressure

C. A restriction exists in the supply line between the pump and the DCV — a clogged highpressure filter, a partially closed shutoff valve, or a collapsed hose is consuming 28 bar of the 30bar standby pressure, leaving only 2 bar available at the DCV inlet

D. The 28bar drop is normal for a loadsensing system — the pump maintains 30 bar at its outlet, and the LS margin (28 bar) is consumed by the supply line to deliver 2 bar at the valve in standby conditions

109. A hydraulic cylinder on a forestry machine is equipped with a snubber (cushion) valve at the cap end. The snubber decelerates the piston near the end of the extension stroke. The operator reports the boom hits the mechanical stop with a hard jolt at the end of extension. The snubber was functioning correctly before the last service. What should be checked?

A. The snubber adjustment — during the last service, the snubber valve's adjustable orifice may have been inadvertently opened fully, eliminating the flow restriction that provides the deceleration cushioning at the end of stroke

B. The pump output — increased pump flow produces a higher piston velocity that overwhelms the snubber's designed deceleration rate

C. The DCV spool — a worn metering edge allows more flow to the cylinder than the snubber was designed to decelerate

D. The cylinder rod seal — a leaking rod seal reduces the backpressure on the rod side that provides part of the deceleration force during the cushion phase

110. A machine's hydraulic system includes a pilotoperated directional control valve. The main spool is shifted by pilot pressure acting on pistons at each end of the spool. The pilot pressure is supplied from the main pump through a pressurereducing valve set at 35 bar. What happens if the pilot pressurereducing valve fails and passes full system pressure (280 bar) to the pilot circuit?

A. The DCV spool shifts faster but the system otherwise functions normally because the spool only needs to reach the fullopen position regardless of the pressure used to shift it

B. The pilot control becomes extremely sensitive — the operator cannot make precise, proportional inputs because the full system pressure moves the spool at maximum velocity regardless of the joystick position

C. The excessive pilot pressure forces the DCV spool past its designed travel limit, damaging the valve body bore and spool lands, and potentially blowing out the pilot piston seals

D. The pilot circuit relief valve (if present) opens and dumps the excess pressure to tank, protecting the pilot circuit components from the overpressure — no damage occurs if the pilot relief is functioning

111. A hydrostatic drive system produces full speed and power in both directions, but the machine cannot hold position on a grade when the control is in neutral. The machine rolls slowly downhill. What is the most likely cause?

A. The loop relief valves are set correctly and the charge pressure is adequate — the brakes are the system responsible for holding position on a grade, not the hydrostatic drive, and the brake system should be investigated

B. The charge check valves are stuck open, allowing the loop pressure to bleed backward through the charge circuit when the pump is at zero displacement

C. The pump's swashplate control has a neutral offset that produces a very small reverse displacement when the operator commands neutral — the resulting slow reverse flow drives the motor and allows the machine to roll

D. The hydrostatic system is not designed to hold position on grades — the machine should always be parked with the parking brake applied, and the neutral roll is normal behaviour for a hydrostatic drive without brakes applied

112. A technician is measuring the flow output of a variabledisplacement piston pump at three different pressures: 0 bar = 195 L/min; 150 bar = 180 L/min; 300 bar = 155 L/min. The pump's theoretical displacement is 200 L/min at the test RPM. What trend do these measurements reveal?

A. The pump produces less flow as pressure increases because more fluid bypasses internally through the pump's clearances at higher pressure — this is the normal volumetric efficiency curve for any positive displacement pump

B. The declining flow indicates the pump has a progressive mechanical binding that worsens with increasing pressure and requires disassembly to identify the source

C. The declining flow indicates the pump's compensator is functioning correctly — the pump destrokes as pressure rises, reducing flow intentionally to match the system demand

D. The flow measurements are invalid because the test was performed at three different temperatures — the oil viscosity changed between measurements and produced the apparent flow decline

113. A hydraulic system uses two cylinders simultaneously to level a grading blade. Both cylinders are the same size and are supplied by the same DCV outlet. The left cylinder extends fully but the right cylinder stops at approximately 75% extension. What is the most likely cause?

A. The right cylinder has higher resistance from internal friction, a restricted supply hose, or a partially blocked port — the hydraulic fluid follows the path of least resistance and supplies the lowerresistance left cylinder preferentially until it stalls, then the remaining flow extends the right cylinder to completion

B. The left cylinder has internal leakage that allows it to extend further than the right cylinder by passing fluid through its worn piston seals

C. The DCV has an internal spool wear pattern that delivers more flow to the left work port than the right work port during simultaneous extension

D. The right cylinder is mounted at a greater mechanical disadvantage than the left, requiring more pressure to extend under the same load

114. A hydraulic accumulator is installed on a machine's brake circuit. The accumulator's bladder has been in service for 10 years. The machine passes all brake performance tests. Should the bladder be replaced based on age alone?

A. No — if the accumulator passes the functional performance test (correct precharge, correct usable volume, and system performance within specification), there is no reason to replace the bladder based on time alone

B. No — accumulator bladders have an indefinite service life because they are not exposed to UV radiation or atmospheric oxygen inside the sealed accumulator housing

C. Yes — rubber bladder material degrades from repeated flexing (fatigue), exposure to hydraulic oil additives, and heat cycling — OEMs typically recommend timebased replacement intervals (often 5–10 years) because a bladder that fails in service can prevent the brakes from functioning during an engineoff event

D. Yes — but only if the accumulator is a bladder type. Pistontype accumulators do not require timebased maintenance because their metal pistons do not degrade from flexing or chemical exposure

115. An air brake system's relay valve provides rapid air delivery to the brake chambers by using a small pilot signal from the brake valve to control a larger volume of air stored in the local reservoir near the axle. What advantage does this relay design provide compared to running a single large line from the brake valve directly to the chambers?

A. The relay valve reduces the total air consumption per brake application because the pilot signal uses less air than the full application volume

B. The relay valve provides faster brake response — the largediameter supply air from the local reservoir reaches the chambers almost instantly because the air only travels a short distance from the relay to the chambers, rather than traveling the full length of the machine through a single long line from the brake valve

C. The relay valve allows the brake valve to operate at a lower pressure than the application pressure, reducing the pedal effort required from the operator

D. The relay valve acts as a proportioning device that automatically reduces rear axle brake pressure under lightload conditions to prevent rear wheel lockup

116. A machine's hydraulic system is producing excessive heat. The technician measures the oil temperature at the pump outlet and at the reservoir return and calculates the temperature rise across the system. The rise is 25°C above the normal operating range. All relief valves, the oil cooler, and the oil level are confirmed correct. What other heat source should be investigated?

A. Worn DCV spools — internal spool leakage creates a continuous bypass from the pressure port to the tank port inside the valve body, converting hydraulic energy to heat as the pressurized oil passes through the tight spooltobore clearance. Multiple leaking spools can generate significant heat

B. The hydraulic oil's additive package has degraded and can no longer dissipate heat to the reservoir walls at the designed rate

C. The pump drive coupling is slipping, converting mechanical energy to heat at the coupling interface rather than transmitting it to the pump

D. The return line filter's bypass valve is open, and the unrestricted return flow generates heat from turbulence as it passes through the unfiltered bypass path

117. A hydrostatic transmission machine operates normally in forward but produces a whining noise and reduced speed in reverse. Forward and reverse loop pressures are within specification. Charge pressure is correct. What component is the most likely cause?

A. The hydrostatic motor has a directionally biased internal wear pattern — the valve plate and piston shoes are worn from the predominant forward operating direction, and the worn surfaces create increased leakage and noise when the motor operates in the reverse direction where the wear pattern does not align with the flow direction

B. The reverse crossport relief valve is set lower than the forward relief, which limits reverse pressure and produces the reduced speed and noise

C. The pump servo has a restriction in the reverse servo circuit that limits the swashplate angle in the reverse direction, reducing displacement and producing cavitation noise from the starved motor

D. The motor case drain filter is restricting the case drain flow during reverse operation because the reverse case drain port is on the opposite side of the motor housing from the forward port

118. A technician is installing a new hydraulic filter element and notices the element's bypass valve cracking pressure is printed on the filter housing: 3.5 bar. What does this mean for the system?

A. The bypass valve opens at 3.5 bar to protect the filter housing from rupturing under high system pressure

B. The bypass valve opens when the system supply pressure drops below 3.5 bar, routing oil around the element to prevent pump starvation

C. When the filter element becomes clogged and the pressure drop across the element exceeds 3.5 bar, the bypass valve opens to allow unfiltered oil to flow around the element — this prevents oil starvation but allows contaminated oil to enter the system until the element is replaced

D. The 3.5bar rating is the maximum allowable pressure in the return line and if exceeded, the bypass valve opens to protect the downstream components from overpressure

119. A hydraulic excavator's swing motor produces a clunking noise when the operator reverses the swing direction. The noise occurs at the instant of directional change only. What is the most likely cause?

A. The swing motor's internal pistons have excessive clearance that produces a mechanical impact when the direction of force on the pistons reverses

B. The swing gear ring bolts have loosened, allowing the upper structure to shift on the turntable bearing before the hydraulic force reengages the gears in the new direction

C. The swing motor's case drain check valve is stuck, causing a pressure spike in the motor housing at the moment of directional reversal

D. Excessive backlash in the swing gear mesh between the swing motor's pinion and the turntable ring gear — when the direction reverses, the pinion teeth must travel through the backlash gap before engaging the ring gear teeth in the new direction, producing the clunk

120. A technician connects a flow meter in series with a hydraulic motor's supply line to measure the flow being consumed by the motor. With the motor running unloaded at rated speed, the flow meter reads 80 L/min. Under full load at the same RPM (maintained by the pump's pressure compensator), the flow meter reads 92 L/min. Why is the loaded flow higher than the unloaded flow?

A. The pump's pressure compensator increases flow output at higher pressure to maintain the LS margin, and the additional flow passes through the motor

B. The motor's internal leakage increases at higher working pressure — the additional 12 L/min represents fluid bypassing through the motor's internal clearances under load that the pump must replace to maintain motor speed

C. The flow meter is producing an inaccurate loaded reading because the high pressure compresses the oil and changes the flow meter's calibration

D. The motor's displacement increases under load through a mechanical loadsensing mechanism that swings the motor to a higher displacement to generate more torque

121. A machine's hydraulic system has a priority valve that guarantees 40 L/min to the steering circuit. The pump produces 120 L/min total. During simultaneous operation of steering and implement functions, the operator notices the implements slow down when the steering wheel is turned. Why does this occur despite the priority valve?

A. The priority valve is functioning correctly — it guarantees the first 40 L/min to steering, leaving 80 L/min for implements. But when the operator turns the steering wheel and the HMU demands flow, the steering actually consumes up to 50–60 L/min (more than the 40 L/min minimum guarantee), reducing the excess flow available to the implement circuit

B. The priority valve has failed and is not diverting any flow to the steering circuit, causing the pump to supply all flow to implements until the steering demand creates backpressure

C. The steering circuit's return flow is routed to the implement circuit's tank port, and the steering return creates backpressure that slows the implement actuators

D. The priority valve is oversized and diverts more than 40 L/min to the steering circuit even when the steering demand is less than 40 L/min

122. A hydraulic system's main relief valve is tested by deadheading the pump (stalling a cylinder against its mechanical stop and reading the pressure gauge). The gauge reads 265 bar. The OEM specification is 280 bar. The technician adjusts the relief valve to 280 bar and retests. The gauge now reads 280 bar. Is the adjustment complete?

A. Yes — the relief valve has been set to the OEM specification and the test confirms correct operation. However, the technician should investigate why the relief valve had drifted from its original setting — contamination on the valve seat, a weakened spring, or a previous incorrect adjustment could be the root cause that may cause the valve to drift again

B. No — the deadhead test only verifies the relief valve's cracking pressure. The technician must also verify the valve's fullflow reseat pressure to confirm the valve closes cleanly without producing a pressure overshoot during normal operation

C. Yes — relief valve adjustment is a routine maintenance procedure that requires no rootcause investigation

D. No — the relief valve should never be adjusted in the field. The drift indicates the valve has reached end of life and must be replaced with a new, factoryset unit

123. A technician is inspecting the boomtoframe pivot connection on a wheel loader. The pivot uses a hardened steel pin pressed into bronze bushings in the frame lugs. The technician measures vertical and horizontal play at the pivot by placing dial indicators on the boom and operating the boom through its range. The measured play exceeds the OEM specification. What is the correct repair approach?

A. Replace the pivot pin only — the pin is the wear component and the bushings are designed to last the frame's full service life

B. Remove the pin, measure both the pin and the bushing bores, and replace whichever components are worn beyond their individual specifications — typically the bushings wear faster than the pin, but both must be measured to determine the correct replacement combination

C. Replace only the bushings — the hardened pin is designed to outlast multiple bushing sets and does not require replacement during a bushing service

D. Weld the existing bushings to close the clearance gap without removing the pin — this avoids the timeconsuming disassembly process and restores the designed tight fit

124. A technician discovers that a hydraulic excavator's bucket has been repaired by welding a steel plate over a crack in the bucket floor. The repair was performed without any visible preheat, postheat, or NDE verification. The plate is attached with fillet welds. What concern does this repair raise?

A. The fillet welds will fail from fatigue because they are loaded in shear rather than the tension loading that fillet welds are designed to resist

B. The plate repair adds unnecessary weight to the bucket that reduces the machine's net payload capacity below the rated specification

C. The uncontrolled repair process may have introduced hydrogen cracking, incomplete fusion, or residual stress that weakens the repair — without NDE verification, hidden defects in the weld may cause sudden failure during loaded bucket operation, potentially releasing the bucket contents or dropping the attachment

D. The plate repair is an accepted industry practice for bucket floor damage and does not require preheat, postheat, or NDE because bucket floors are nonstructural components

125. A machine's operator seat suspension has an air spring that the operator adjusts to their body weight using a control lever. The operator reports the seat will not maintain the adjusted height — it slowly sinks to the bottom of its travel during operation. What is the most likely cause?

A. The operator's weight exceeds the seat suspension's maximum rated capacity, and the air spring cannot maintain adequate pressure for the operator's weight class

B. The seat's height adjustment mechanical linkage has worn bushings that allow the seat to settle under the operator's weight regardless of air spring condition

C. The air spring's leveling valve is functioning correctly but the air supply line from the machine's pneumatic system has a restriction that limits the refill rate below the leak rate

D. The air spring has a slow leak — either in the air bladder, the leveling valve, or the air supply connections — that allows pressure to escape faster than the leveling valve can replenish it, causing the progressive height loss during operation

126. A technician is replacing a cutting edge on a grader blade. The new edge is a carbidetipped design rather than the standard hardened steel edge that was previously installed. What operational difference will the operator notice with the carbide edge?

A. The carbide edge maintains its cutting profile significantly longer than the standard steel edge because the carbide inserts resist abrasive wear far better than hardened steel — the edge stays sharp longer and requires less frequent replacement, but carbide is more brittle and may chip if the edge strikes hard objects

B. The carbide edge provides identical performance to the steel edge but weighs less, reducing the total blade weight and improving fuel efficiency

C. The carbide edge produces a smoother grading surface because the harder material creates less ground disturbance during cutting

D. The carbide edge eliminates the need for reversing the edge when one face is worn because the carbide inserts wear evenly on both faces simultaneously

127. A technician is inspecting a telehandler's attachment mounting plate and discovers one of the four quickattach pin bores has an oval shape — the bore has elongated from wear. The other three bores are round and within specification. What effect does the oval bore have on the attachment connection?

A. The oval bore has no effect because the quickattach pin is springloaded and selfadjusts to the bore geometry during engagement

B. The oval bore allows the attachment to rock or shift at that connection point, creating uneven loading on the remaining three pins, reducing the attachment's stability, and potentially allowing the attachment to disengage from the worn bore under dynamic loading

C. The oval bore reduces the clamping force at that pin location but the remaining three pins provide adequate retention for all normal operating conditions

D. The oval bore affects only the pin's insertion ease during attachment changes and does not impact the attachment's operational stability once engaged

128. A machine's cab windshield is laminated safety glass. During a scheduled inspection, the technician notices a small stone impact chip on the outer glass layer approximately 10 mm in diameter. The chip has not cracked or spidered. The PVB interlayer and inner glass layer are intact. What action is required?

A. Replace the windshield immediately — any damage to the outer layer compromises the FOPS protection that the laminated glass provides against falling objects

B. Monitor the chip at each inspection — small chips without cracks or spider patterns are common and do not require immediate replacement unless they are in the operator's primary vision zone or begin to propagate

C. Apply a windshield repair resin to fill the chip and prevent it from spreading — this is an accepted repair method that restores the glass's structural integrity at the impact point

D. Replace the windshield before the machine's next operating shift — stone chips in laminated glass propagate rapidly from vibration and thermal cycling, and the windshield will likely crack completely within 50 operating hours

129. A technician discovers that a machine's auxiliary hydraulic circuit has been modified by a previous technician who installed an adjustable needle valve in the return line from the attachment to "slow down" the attachment speed. The needle valve is partially closed. What concern does this modification raise?

A. The needle valve in the return line creates backpressure that heats the hydraulic oil excessively by converting hydraulic energy to heat through the restriction — this is an energywasting approach that produces system heating and may damage attachment seals from the elevated backpressure

B. The needle valve is the correct method for controlling attachment speed — it meters the return flow and provides proportional speed control without affecting the attachment's force capability

C. The needle valve in the return line creates excessive pressure at the return line filter and will cause premature filter clogging

D. The needle valve produces speed control but the cavitation potential on the downstream (lowpressure) side of the valve creates the risk of damage to the return line hose

130. A technician is installing a new set of bucket teeth on a loader bucket. The teeth use a pintype retention system. During installation, the technician notices one tooth does not seat fully on its adapter — a 5 mm gap exists between the tooth base and the adapter contact surface. The other teeth all seat flush. What should the technician do?

A. Install the tooth with the gap and monitor it during the first 50 hours — the digging forces will seat the tooth fully within the first few loading cycles

B. Do not install the tooth — the gap indicates either the tooth is the wrong specification for this adapter, the adapter has deformed from wear, or debris is trapped between the mating surfaces. The technician must identify and correct the cause of the gap before installing the tooth, because an improperly seated tooth will rock under load, accelerate adapter wear, and may break during operation

C. Apply antiseize compound between the tooth and adapter contact surfaces and force the tooth onto the adapter using a hydraulic press — the compound allows the tooth to slide to full engagement

D. Install the tooth and drive the retaining pin — the pin provides the structural connection and the 5 mm gap between the tooth base and adapter has no effect on the tooth's performance or retention

131. A technician is removing a large hydraulic cylinder pin from a boom connection on an excavator. The pin is seized in the bore from corrosion and requires a hydraulic press or a heavy drift pin and sledgehammer to remove. What precaution must be taken during this highforce pin removal?

A. The technician must ensure no personnel are positioned in the potential trajectory path of the pin — a seized pin that releases suddenly under hydraulic press force or hammer impact can eject from the bore as a highvelocity projectile that causes serious injury or death

B. The technician must heat the pin bore with a torch before attempting removal to expand the bore and release the corrosion bond — this eliminates the need for excessive force

C. The technician must remove the pin from the opposite side of the bore to avoid damaging the bushing on the access side during the removal process

D. The technician must apply penetrating oil and wait 24 hours before attempting removal — rushed removal of seized pins always damages the bore and requires bushing replacement

132. A hybrid excavator's energy storage system uses a highspeed flywheel instead of a battery or supercapacitor. The flywheel spins in a vacuum enclosure at up to 60,000 RPM. What is the primary advantage of a flywheel energy storage system for this application?

A. The flywheel produces zero electromagnetic interference, which eliminates the need for shielded cables and EMI filters in the machine's electronic control system

B. The flywheel is significantly lighter than an equivalent battery or supercapacitor, reducing the machine's total weight and improving fuel efficiency

C. The flywheel can absorb and release energy at extremely high power rates with virtually unlimited charge/discharge cycles — ideal for the rapid, repetitive energy capture and release cycles of excavator swing braking and acceleration

D. The flywheel provides energy storage that is unaffected by temperature, allowing the machine to operate at the same efficiency in all climates without thermal management

133. A technician is testing the insulation monitoring device (IMD) on a hybrid machine's HV system. The IMD continuously monitors the insulation resistance between the HV bus and the chassis ground. The OEM specification requires the IMD to trigger an alert at 500 kΩ/V. The system operates at 600 VDC. What is the minimum insulation resistance that must be maintained before the IMD triggers?

A. 500 kΩ total — the specification of 500 kΩ/V means the total minimum resistance is a fixed 500 kΩ regardless of operating voltage

B. 1,200 kΩ — calculated by multiplying 500 kΩ by the number of battery modules (typically 2 in a 600V system)

C. 300 MΩ — calculated by multiplying the specification (500 kΩ/V) by the voltage (600V) and expressing the result in megohms

D. 300 MΩ — the minimum insulation resistance is 500 kΩ/V × 600V = 300,000 kΩ = 300 MΩ. Any reading below this value indicates the insulation has degraded to a level where leakage current to chassis could present a shock hazard

134. A batteryelectric machine's onboard charger converts AC grid power to DC power for charging the traction battery. The charger has a rated efficiency of 93%. If the battery requires 100 kWh of energy to reach full charge, how much AC energy is consumed from the grid?

A. Approximately 107.5 kWh — the charger must draw more AC energy than the DC output to account for the 7% conversion loss. Calculated as 100 kWh ÷ 0.93 = 107.5 kWh consumed from the grid to deliver 100 kWh to the battery

B. 93 kWh — the charger's 93% efficiency means it only uses 93 kWh from the grid to fully charge the 100 kWh battery because the high efficiency reduces the grid demand

C. 100 kWh — a 93% efficient charger is close enough to 100% that the grid consumption equals the battery requirement for practical purposes

D. 114 kWh — calculated by adding 14% to the battery requirement to account for the charger efficiency and the battery's internal resistance losses during charging

135. A fleet operator notices that a batteryelectric loader's traction battery shows accelerated capacity degradation — the SOH has dropped from 95% to 82% in only 18 months of service. The manufacturer's expected degradation rate for this chemistry is 2–3% per year under normal conditions. What operating factor should be investigated as the primary contributor to the accelerated degradation?

A. The machine's duty cycle — aggressive operators who consistently discharge the battery to very low SOC and rapidcharge back to maximum accelerate degradation

B. The combination of deep discharge cycles, high charging rates, and sustained high operating temperatures — all three factors significantly accelerate lithiumion cell degradation, and the fleet's operating pattern should be analyzed for these conditions to determine which factor is dominant

C. The battery cooling system — if the thermal management system is not maintaining the cells within their optimal temperature range, sustained high temperatures during operation and charging dramatically accelerate the chemical degradation that reduces cell capacity

D. The charging infrastructure — if the machine is consistently fastcharged at the maximum rate rather than slowcharged during overnight downtime, the high charging current accelerates lithium plating on the cell anodes that permanently reduces capacity

Practice Exam 8: Answer Key and Explanations

1. D — A machine on an incline is subject to gravitational forces that can cause it to roll or slide if any restraint fails. The FLHA must identify this specific gravity hazard and document the controls — wheel chocks on the downhill side, frame blocking with rated supports, and secondary restraints — that prevent uncontrolled machine movement while the technician is positioned beneath or beside the machine.

2. B — Depressurizing the accumulator circuit only relieves pressure in the accumulator-connected circuits. The work circuit being serviced (boom, stick, bucket, or other implement) may be hydraulically isolated from the accumulator circuit and retain trapped pressure from the last operation. Each individual circuit must be depressurized by cycling its specific control with the engine off before disconnecting any fittings in that circuit.

3. A — Removing or disabling emission control devices (including DPFs, DOCs, SCR catalysts, and EGR systems) is prohibited under the Canadian Environmental Protection Act and provincial equivalents regardless of where the machine operates. The prohibition applies to all persons who perform the tampering, not just the equipment owner. The technician may be personally liable for regulatory penalties.

4. C — Working inside a bucket while a crane operates overhead creates a dual hazard: the bucket interior is a confined space (limited entry/exit, potential for atmospheric hazards from welding), and the suspended liner plates create a struck-by hazard above the technician. A signal person, exclusion zone protocols, and clear communication between the crane operator and the technician inside the bucket must be established before work begins.

5. D — Oil-soaked rags generate heat through chemical oxidation that can lead to spontaneous combustion, and a partially full solvent container provides a flammable liquid fuel source. Both stored together near a welding bay's ignition sources create a serious fire triangle — fuel, heat, and oxidizer are all present. Both items must be moved to their approved storage locations immediately.

6. B — An unrated overhead lifting beam is an unknown structural element. Without a documented capacity rating established by a qualified engineer, the beam's safe working load is unknown and it must not be used for any suspended load. The engineer assesses the beam's material, dimensions, connections, and supporting structure to determine and certify the maximum safe load.

7. C — The SRS airbag system contains a backup energy storage capacitor that retains enough electrical energy to deploy the airbag for a period after the battery is disconnected — typically 30 seconds to several minutes depending on the system. The wait period allows this capacitor to discharge to a level where accidental deployment cannot occur during service near the SRS components.

8. A — Even with the engine locked out, some machine systems retain stored energy — hydraulic accumulators, spring-loaded mechanisms, gravity-held implements, and pneumatic circuits can cause movement or release energy when controls are operated from the cab. Both technicians must communicate before any control is touched to ensure the other person is clear of all potential movement zones.

9. D — A cracked auto-darkening filter may not transition uniformly to the correct shade density across its entire surface. The crack can create a path for unfiltered UV and IR radiation to reach the technician's eyes during welding, even if the surrounding filter area darkens correctly. This radiation exposure causes arc eye (photokeratitis) and potential permanent retinal damage. The filter must be replaced.

10. B — In a food-processing facility, contamination control is critical. Transferring hydraulic oil through a portable filtration unit ensures the oil entering the machine meets the required cleanliness specification. The transfer hose and connections must also be cleaned to prevent external contamination from entering the reservoir during the fill process. Bulk oil may contain particles from storage and handling that the portable filter removes.

11. C — The engine runs at full power across the RPM range but cannot maintain idle — this isolates the fault to the idle speed control system specifically. The ECM's idle fuel delivery command, the idle validation sensor inputs (throttle position, pedal position), or the electronic throttle's return-to-idle calibration may have a fault that prevents the precise low-fuel-quantity metering required for stable idle without affecting higher-speed operation.

12. A — The pre-lubrication system fills all oil galleries, bearing clearances, and the turbocharger bearing housing with pressurized oil before the engine begins rotating. This eliminates the critical "dry start" wear period — the first 2–5 seconds of cranking when the engine-driven oil pump has not yet built pressure and all bearing surfaces are running without an oil film.

13. D — A thermostat rated at 82°C should open at that temperature and remain open, allowing coolant to flow continuously to the radiator during steady-state operation. Cycling between 75°C and 95°C indicates the thermostat is opening at its set point, overcooling the engine by allowing too much radiator flow, then closing when temperature drops, and repeating. The thermostat may be stuck partially, have the wrong rating, or the wax element may be failing.

14. B — A cyclical pulsing whistle from the turbocharger area that varies with exhaust flow and is most pronounced at mid-range RPM suggests an exhaust leak at the manifold or turbine housing. Exhaust gas escaping through a crack or gasket failure at certain pulse frequencies creates the whistling noise. The pulsing character corresponds to the exhaust pulse frequency at the RPM where the leak is most pronounced.

15. C — A properly functioning crankcase ventilation system draws blowby gases out of the crankcase through the intake manifold's vacuum, maintaining a slight negative pressure (vacuum) inside the crankcase at all operating conditions. This vacuum reduces the pressure differential across engine seals, minimizing the driving force that pushes oil past gaskets, front and rear main seals, and valve cover seals.

16. A — In a cylinder cut-out test, disabling a healthy cylinder removes one power impulse and the engine runs rougher. If disabling cylinder 6 produces no change in idle quality, that cylinder was not contributing any useful power to begin with. The cylinder is dead — it may have a failed injector (no fuel delivery), zero compression (failed valves or gasket breach), or a timing error that prevents combustion.

17. D — The oil level reads correctly on level ground, but during hard cornering the oil surges to one side of the pan. If the level is just barely at the full mark, the surge exposes the oil pump pickup tube on the opposite side, allowing the pump to draw air momentarily. The brief air ingestion drops the oil pressure until the machine straightens and the oil covers the pickup again.

18. B — A hard first-start-of-the-day condition that clears after the initial start confirms fuel system pressure is bleeding down overnight. A leaking injector, a faulty rail pressure control valve, or a failed check valve in the high-pressure pump allows fuel to drain back from the rail to the tank during the overnight sit. Each morning, extended cranking is required to refill and re-pressurize the rail before injection can occur.

19. A — Tin is a component of the overlay layer in some tri-metal engine bearings (lead-tin or aluminum-tin construction). A sudden first-time appearance of tin in the oil analysis confirms the bearing overlay has begun to wear through at one or more bearing locations. This is a significant finding because the overlay is the outermost (sacrificial) layer — once breached, the harder intermediate layer is exposed and wear accelerates.

20. D — The white crystalline deposits are urea that has not fully decomposed into ammonia. Incomplete decomposition occurs when the DEF is not adequately atomized by the dosing nozzle, or

when the exhaust temperature is too low for the thermolysis and hydrolysis reactions that convert urea to ammonia. The crystallized urea accumulates at the injection point and inside the exhaust pipe rather than converting to the ammonia needed for NOx reduction.

21. C — The cooling system pressure cap raises the coolant's boiling point. A 103 kPa cap raises the boiling point of 50% glycol coolant to approximately 129°C. A 69 kPa cap raises it to only approximately 121°C. This lower boiling point allows localized boiling at hot spots (cylinder head, exhaust valve bridge area) at a lower temperature. The resulting steam pockets displace liquid coolant from the critical heat transfer surfaces, causing overheating.

22. B — Retarded injection timing (4° BTDC vs. 12° BTDC specification) causes the fuel to ignite later in the expansion stroke, producing less mechanical work per combustion event. The late combustion continues into the exhaust stroke, elevating exhaust gas temperature. The reduced combustion efficiency increases fuel consumption, produces excessive black smoke from incomplete combustion, and reduces engine power output.

23. A — Coolant (ethylene glycol solution) is a chemical that degrades rubber and synthetic belt compounds. Even though the belt appears functional after the contamination, the glycol has begun to attack the internal reinforcement fibres and the rubber matrix. The belt's tensile strength, flexibility, and fatigue resistance are reduced, and the belt will fail prematurely from the chemical damage — often without visible external warning.

24. D — Engine protection system behaviour varies by parameter and severity level. Some Level 2 derates self-clear when the monitored parameter returns to the normal range (such as temporary high temperature from a momentary overload). Others require a manual reset through a key cycle or diagnostic tool command. The technician must consult the OEM's documentation for the specific parameter to determine the correct reset procedure.

25. B — Restricting the intake air reduces the air-to-fuel ratio, enriching the mixture. If the engine's rough idle improves with a restricted intake, the engine has excess air at idle — the mixture is too lean for stable combustion. This can result from a fuel delivery issue (low fuel pressure, a clogged idle fuel passage, or incorrect ECM calibration) that under-fuels the engine at the idle operating point.

26. C — The previous sensor may have been reading higher than actual temperature, causing the ECM to command more aggressive cooling (earlier fan engagement) and report the overheating condition. The replacement sensor's resistance curve reads 10°C lower than actual, which means the ECM commands

the cooling fan to engage at a lower actual temperature than designed. The engine operates at the correct mechanical temperature but the ECM believes it is 10°C cooler.

27. A — A single metallic crack occurring once per crankshaft revolution that does not change during a cylinder cut-out test is not combustion-related. The noise source rotates at crankshaft speed regardless of which cylinders are firing. Components that rotate at crank speed include the crankshaft itself, the flywheel, the harmonic balancer, and any 1:1 driven accessories. A damaged counterweight, cracked flywheel, or loose balancer are the primary suspects.

28. D — The wastegate actuator uses boost pressure to push against an internal spring to open the wastegate. The cracked sensing hose leaks the boost pressure signal to atmosphere before it reaches the actuator. The actuator never sees sufficient pressure to overcome its spring, and the wastegate remains closed at all operating points. Without the wastegate opening, the turbocharger over-boosts at high RPM and load.

29. B — One cylinder running 170°C hotter than all others indicates that cylinder is producing significantly more combustion energy per cycle. The most common cause is an over-fuelling injector — the excess fuel burns during the power and exhaust strokes, releasing additional heat energy that elevates the exhaust gas temperature well above the other correctly-fuelled cylinders.

30. C — In a dual-stage (series compound) turbo system, the small high-pressure turbo provides the rapid low-RPM response while the large low-pressure turbo handles high-RPM airflow. The bypass valve routes exhaust around the small turbo at high RPM when it is no longer needed. If the bypass is stuck open, exhaust bypasses the small turbo at all speeds — eliminating the low-speed response it was designed to provide.

31. A — The HMU and steering valve centering are confirmed correct, ruling out a control signal or valve fault. Steering drift toward one side with correct controls points to a cylinder that cannot hold its position. If one steering cylinder's piston seals are bypassing internally, the cylinder slowly retracts under the asymmetric steering forces during travel, causing the machine to drift toward the leaking side.

32. D — Both struts were charged identically at the last service, and the left is now visibly shorter. The most common cause is nitrogen gas loss from the left strut — through the gas valve, the piston seal, or a housing seal. Reduced nitrogen pre-charge provides less spring resistance, and the machine's weight compresses the left strut further than the correctly charged right strut.

33. B — A flat spot on a bottom roller tread indicates the roller was held stationary while the track chain continued to move over it. The most common cause is a momentary roller bearing seizure — the bearing locks, the track grinds a flat on the roller surface during the seizure, and the bearing subsequently frees. The flat spot then produces a rhythmic thump each time it contacts the chain during travel.

34. C — Rotor runout (lateral wobble) is measured with a dial indicator mounted against the rotor face while the hub is slowly rotated by hand. The total indicated runout (TIR) — the difference between the highest and lowest indicator readings during one full rotation — is compared to the OEM specification to determine whether the rotor is within acceptable limits.

35. D — The hydrostatic drive pressures are equal on both sides, ruling out the main pump and motors. Difficulty turning in one direction with correct hydraulic pressures points to the steering clutch system. If the left steering clutch's hydraulic apply circuit has a restriction or a leaking apply piston seal, the clutch cannot fully disengage the left track from the drive. The partially engaged clutch resists the left turn.

36. A — Spring-applied wet disc brakes use spring force to clamp the friction discs. Over time, the brake discs and separator plates can develop adhesion from the brake oil's residue drying between the contact surfaces during extended parking. The initial hydraulic release force must overcome this adhesion before the discs separate — producing the brief movement sensation before the brake fully releases.

37. D — Asymmetric sprocket tooth wear — heavier on the leading (driving) face than the trailing face — reflects the tooth loading pattern during operation. Forward drive loads the leading face of each tooth; reverse loads the trailing face. If the machine operates predominantly in forward with minimal reverse, the driving face carries virtually all torque loads and wears preferentially.

38. C — Oil-cooled wet disc brakes use brake oil that expands when heated. During 2 hours of operation, sustained braking heats the brake oil progressively. As the oil volume increases from thermal expansion, the expanded oil pushes the caliper pistons slightly back into their bores, increasing the clearance between pads and disc. The increased clearance requires more pedal travel to reestablish contact. Cooling the brakes allows the oil to contract and the pedal returns to normal.

39. D — Before replacing a pinion seal, the technician must investigate why the seal failed. A blocked axle breather traps the internal pressure generated by thermal expansion of the oil and air inside the housing. This trapped pressure forces oil past the pinion seal — the lowest point and weakest seal in the axle housing. Replacing the seal without clearing the blocked breather guarantees the new seal will fail from the same root cause.

40. A — The roller flanges provide the primary lateral guidance for the track chain as it travels over the undercarriage running gear. When flanges wear below their minimum height, they can no longer guide the chain laterally. The chain is free to drift sideways during side-hill operation, counter-rotation turns, or when debris pushes it laterally — creating a track derailment hazard.

41. C — The parking brake springs, caliper, and disc are all serviceable, and the parking brake is a spring-applied caliper on the transmission output shaft — an internal component that should be protected from external contamination. If the disc has been contaminated with transmission oil from a nearby seal leak, the reduced friction coefficient prevents the spring force from generating adequate holding torque on the contaminated disc surface.

42. B — The priority valve is designed to deliver the steering circuit's full required flow (35 L/min) before releasing any excess to the implement circuit. A measurement of only 20 L/min at the steering port with the engine at rated RPM and steering in neutral indicates the priority valve is not delivering the specified flow. The most likely cause is a weakened priority valve spring that is diverting more flow to the implement circuit than designed.

43. D — A torn pushrod boot exposes the pushrod to moisture, road spray, and contamination. The corroded, pitted pushrod surface can seize in the chamber bushing — particularly in cold weather when moisture freezes between the rod and bushing. A seized pushrod can prevent the spring brake from fully applying (if seized in the released position) or prevent the service brake from fully releasing (if seized in the applied position).

44. A — Hydraulic supply pressure is confirmed at the solenoid inlet, but the lock does not engage. The next diagnostic step is to verify the solenoid is receiving an electrical command and is opening to pass the hydraulic pressure to the differential lock clutch pack. If the solenoid has no electrical command (wiring fault, switch fault, or ECM output fault) or is mechanically stuck closed, no pressure reaches the clutch despite correct supply.

45. B — Demolition environments contain steel reinforcing bar and wire that wraps around rotating undercarriage components — sprockets, rollers, and idlers. The accumulated material prevents these components from rotating freely and grinds against the chain, shoe edges, and roller treads during every track revolution. The abrasive friction from the trapped material dramatically accelerates wear on all undercarriage components.

46. C — Both circuits receive equal supply pressure, so the hydraulic supply is not the cause. The rear brakes producing only 60% of specification at the same pressure as the fronts (at 95%) indicates a

mechanical effectiveness problem at the rear. Contaminated pads, glazed rotors, seized caliper slides, or air in the rear circuit all reduce the rear brakes' ability to convert hydraulic pressure into clamping force at the disc.

47. B — During cranking, the battery provides 22.8V at its terminals but only 2.3V arrives at the starter motor. The difference of 20.5V is consumed by resistance in the starting circuit — cables, connections, solenoid contacts, or ground straps between the battery and the starter. This extreme voltage drop confirms severe resistance that must be located and corrected.

48. D — The ECM data verified at the ECM connector is correct, ruling out sensor or ECM faults. Erratic gauge readings at the display with correct ECM data points to the communication path between the ECM and the display. Intermittent CAN bus data corruption from wiring damage, connector corrosion, or electromagnetic interference on the bus segment serving the display produces the random gauge behavior.

49. A — The coil resistance (8.2 ohms) is within the 8.0 ± 0.5 ohm specification, confirming the coil is electrically functional. However, the insulation resistance between the coil and the housing (2 MΩ) is below the 10 MΩ minimum, confirming current can leak from the winding through degraded insulation to the grounded housing. This partial ground fault may cause erratic solenoid operation or damage the ECM output driver.

50. C — The DTC indicates the ECM has switched to its backup power supply because the primary supply has failed. The primary power supply circuit — its fuse, wiring, connectors, power relay, and ground path — must be investigated to identify why the ECM lost its primary power source. The backup circuit is maintaining operation but is not a permanent solution.

51. B — A standard DMM set to DC volts averages a PWM signal and displays an approximate DC equivalent — it cannot show the individual switching pulses that characterize a PWM signal. The technician must use a DMM with duty cycle or frequency measurement capability, or connect an oscilloscope, to observe the actual PWM waveform and verify the 75% duty cycle command is reaching the injector.

52. D — The sensor air gap to the reluctor wheel is the most common cause of an ABS fault after a wheel speed sensor replacement. If the gap is too wide, the sensor cannot generate adequate signal amplitude for the ABS module to process. If too narrow, the sensor may contact the reluctor. The gap must be set to the OEM specification to produce a clean signal within the module's detection range.

53. B — Calculating: 15 mA × 2,160 hours (90 days) = 32.4 Ah consumed by the KAM circuit. A typical 210 Ah battery also self-discharges at approximately 3–5% per month (6.3–10.5 Ah per month × 3 months = 19–31.5 Ah). The combined drain of approximately 50–64 Ah represents 24–30% of total capacity, which can reduce the battery below the minimum voltage needed for reliable starting.

54. C — The 5V reference and ground are confirmed correct at the disconnected connector, verifying the wiring between the ECM and sensor 2 is intact. Sensors 1 and 3 function correctly on the same ECM, confirming the ECM's reference and processing are working. The isolated 0V output from sensor 2 with good supply confirms the sensor's internal sensing element has failed — either open-circuited or shorted to its own ground.

55. B — A high-pressure fuel line with a hairline crack produces a condition where fuel seeps at peak injection pressures that occur only under load. At idle and light load, the lower peak pressures do not open the crack. The reduced pressure pulse at the affected injector during heavy load prevents proper atomization, producing the misfire specifically under heavy-load conditions.

56. A — Operating an alternator continuously at 95% of rated output leaves virtually no reserve capacity for additional loads, cold-weather starting demands, or future accessory additions. The sustained near-maximum output generates excessive heat that shortens brush life, degrades bearing lubricant, and stresses the rectifier diodes. The electrical load analysis should be reviewed and the alternator may need to be upsized.

57. B — A proportional solenoid that produces only full-open or full-closed response to a variable PWM command has a spool that cannot hold an intermediate position. Contamination, varnish, or mechanical binding causes the spool to stick — it either does not move (full closed) or slams fully open when enough force builds to overcome the sticking point. The electrical command is correct but the mechanical response is binary.

58. D — A precisely repeating flash pattern (1 second on, 3 seconds off) is characteristic of a diagnostic blink code rather than a random wiring fault or intermittent sensor issue. Some ECMs communicate fault codes by flashing the check engine light in defined on/off patterns when specific diagnostic conditions exist. The pattern should be decoded using the OEM's blink code reference.

59. A — When two redundant throttle sensors disagree beyond the correlation window, the ECM cannot determine which sensor is providing the correct input. Rather than responding to a potentially faulty signal, the ECM enters a recessive state — either fixed idle or a reduced-power derate — until the sensor disagreement is resolved. This prevents unintended engine response from a failed sensor.

60. B — A 12V lead-acid battery passes a load test if the voltage remains above 9.6V (at 21°C) after 15 seconds under a load equal to 50% of its CCA rating. The 9.6V threshold represents the minimum voltage at which the battery can sustain adequate current for engine cranking. A voltage below 9.6V indicates insufficient plate capacity to deliver the rated current.

61. B — A sensor ground circuit should measure less than 0.5 ohms from the sensor connector to the frame ground reference. At 5.2 ohms, the ground path has excessive resistance that will produce an unwanted voltage drop under current flow. This voltage drop offsets the sensor's signal reading at the ECM, causing the ECM to interpret an incorrect value and make incorrect control decisions.

62. C — Before investigating the machine for a technical fault, the operating pattern should be compared to the fleet average. Different duty cycles — more idle time, heavier loads, steeper grades, longer haul distances — are the most common explanation for fuel consumption differences between identical machines. Confirming or eliminating the duty cycle variable focuses the investigation correctly.

63. A — A solenoid coil drawing 2.8A instead of the specified 2.0A has reduced resistance from shorted turns between windings inside the coil. The shorted turns reduce the coil's total impedance, allowing more current to flow at the applied voltage. The excess current overheats the coil and may exceed the ECM driver transistor's rated current capacity, potentially damaging both components.

64. B — The disconnected module contained one of the two termination resistors. With it removed, only one 120-ohm resistor remains, producing the 120-ohm reading instead of the 60-ohm parallel combination. The technician must be aware that operating the bus with the module disconnected removes one termination, which will cause signal reflections and communication errors on the remaining bus.

65. B — Fuel density decreases with temperature — warm fuel contains less mass per unit volume than cold fuel. If the temperature sensor fails and reads permanently cold (high density), the ECM believes the fuel is denser than it is and reduces the injection pulse width to compensate. The engine receives less fuel mass than intended, running lean with reduced power output and potential misfire.

66. C — The power driver module converts serial commands from the TCM to individual PWM outputs for each transmission solenoid. If the driver module fails, all solenoids lose their commanded signals simultaneously. The transmission's mechanical default valve in the valve body provides a single limp-home gear (typically 2nd or 3rd) when all solenoids are de-energized, allowing the machine to reach a service location.

67. A — Before condemning the ECM, verify that all input signals allow the module to enter sleep mode. A sensor or switch sending an active signal — such as a stuck proximity switch, a grounded input wire, or a continuous voltage on a wake-up pin — keeps the ECM in its active operating state indefinitely. Identifying and correcting the input fault allows the ECM to enter sleep mode normally.

68. D — The alternator is producing correct voltage at the B+ terminal (confirmed by the battery terminal reading of 28.1V with engine running). The crossed-out battery symbol indicates the monitoring or communication system cannot verify the charging status — a charge current sensor fault, a battery voltage sensor fault, or a CAN bus communication error between the alternator monitoring system and the display.

69. B — The ECM's internal DC-DC boost converter generates elevated voltage (typically 48–70V) for fast injector opening by overcoming the injector coil's inductance more rapidly than the 24V system supply can. If the converter fails, the ECM defaults to operating the injectors at system voltage. The injectors open more slowly, producing delayed injection timing and degraded atomization that reduces performance and increases emissions.

70. C — In many alternator designs, the charge indicator light provides the initial excitation current path to the rotor field winding. Before the alternator is self-exciting, a small current flows from the ignition switch, through the light filament, through the rotor winding, and to ground — this initiates the magnetic field. Once the alternator begins producing output, both sides of the light see equal voltage and it extinguishes. If the light stays on, the alternator is not producing output.

71. B — Cleaning the corrosion restores the connection temporarily, but the water intrusion path remains. Without identifying and correcting the root cause — a failed connector seal, a missing grommet, a cracked housing, or incorrect harness routing that exposes the connector to water — moisture will re-enter and the corrosion will return. The root cause must be found and corrected for a complete repair.

72. C — At 92% coupling efficiency, 8% of the engine's power output is not transmitted to the transmission — it is converted to heat through the viscous shearing of the transmission oil between the converter's pump and turbine. This heat energy is absorbed by the transmission oil and must be rejected through the transmission oil cooler to prevent the oil from overheating.

73. A — An integrated retarder within the torque converter housing works by redirecting transmission oil flow against a stator or set of vanes that resist the turbine's rotation. The fluid shearing between the

rotating turbine and the stationary stator converts the vehicle's kinetic energy into heat in the oil. The resistance to rotation decelerates the driveline and therefore the vehicle.

74. B — A clutch pack clearance below the OEM minimum (1.2 mm vs. 1.5–2.5 mm specification) indicates the friction discs have increased in thickness — typically from oil absorption that swells the friction material. The swollen discs reduce the pack clearance and may cause the clutch to drag when the piston is released, producing incomplete disengagement, heat generation, and premature wear.

75. D — A rhythmic clunk once per wheel revolution present in all gears and both directions — reproducible by rotating the wheel by hand — isolates the fault to a component at the wheel hub. A loose or damaged hub component — a broken wheel stud, a cracked hub flange, a loose bearing retainer, or a failed hub seal retainer — produces the clunk once per revolution as the damaged component cycles through its loaded position.

76. C — Correct upshift points with delayed downshifts suggest the speed signal used for downshift control is reading higher than actual. If the governor or speed sensor reports the machine is travelling faster than it is, the TCM delays the downshift because it believes the machine has not decelerated enough to warrant the lower gear. The speed signal should be verified against actual ground speed.

77. A — The input shaft surface at the seal lip contact area is the most commonly overlooked root cause of recurring seal leaks. The old seal's lip rides in one position on the shaft, wearing a groove into the surface over time. A new seal's lip seats in the same groove and cannot form a leak-free contact on the worn surface. The shaft must be repaired (with a seal sleeve or chrome repair) or replaced.

78. A — In a correctly functioning differential, the spider gears rotate on their pins only during turns (speed differential between wheels). During straight-line travel, the spider gears are stationary relative to the carrier. A clicking noise during straight-line operation that disappears during turns suggests a spider gear is making intermittent contact with the carrier housing or a side gear when stationary but moves away from the contact point when rotating during turns.

79. D — A flywheel pilot bore that has become oval cannot support the pilot bearing's outer race uniformly. The tight spots of the oval create excessive preload that generates friction heat, while the loose spots allow the race to creep (rotate) in the bore. The combined heating and movement destroy the bearing prematurely. The bore must be restored to round before installing a new bearing.

80. C — The pink/milky colour confirms water (from engine coolant) has emulsified with the transmission oil through a failed oil cooler tube. The contaminated oil has lost its lubricating film strength and its hydraulic control properties. Continued operation causes rapid clutch disc destruction (the water-contaminated oil cannot maintain the friction coefficient), bearing corrosion, and potential planetary gear damage from lubrication failure.

81. B — The hydrostatic pump's swashplate control has a dead band (non-responsive zone) near the zero displacement position. During initial acceleration, the control signal must traverse this dead band before the swashplate begins to move. The swashplate then jumps from zero to its first responsive position rather than moving smoothly from zero, producing the vibration that settles once the pump enters its linear operating range.

82. D — Glazed wet disc brake friction surfaces have a reduced and inconsistent friction coefficient compared to properly conditioned surfaces. Even though the disc thickness is within specification, the glazed surface may not produce adequate holding force when the springs apply. The discs should be replaced or the surfaces scuff-sanded to break the glaze and restore the designed friction profile.

83. A — A high-pitched whining noise from a rebuilt final drive that was not present before points to incorrect bearing preload. Excessive bearing preload generates friction between the rolling elements and races, producing the characteristic whine. The preload must be checked against the OEM specification and adjusted — either the shimming is incorrect or the bearing installation torque exceeds the specification.

84. B — The open grease zerk fitting hole allows the U-joint bearing caps' grease to escape from centrifugal force during operation and, more critically, allows water and abrasive contamination to enter the bearing caps. The contaminated, depleted lubricant rapidly accelerates needle bearing wear from both the abrasion of foreign particles and the corrosion from water intrusion.

85. C — The lockup clutch damper absorbs engine torsional vibration (firing pulses) when the lockup clutch mechanically connects the engine to the transmission input shaft. Without the damper, each engine firing pulse would transmit directly through the locked converter as a torsional impulse, producing drivetrain vibration, gear rattle, and noise that the fluid coupling of the unlocked converter would normally absorb.

86. D — A replacement sprocket with incorrect tooth geometry — wrong tooth profile, wrong module, or wrong pitch — does not mesh correctly with the chain. The mismatched mesh concentrates loading on incorrect portions of the tooth face, accelerating wear on both the new sprocket and the existing

chain. Even though the sprocket appears to fit physically, the tooth geometry must match the chain specification exactly.

87. A — At operating temperature, the transmission oil's reduced viscosity (compared to cold) allows the clutch apply pressure to rise faster than the modulation valve's designed ramp rate can control. Cold, thick oil naturally slows the pressure rise (providing inherent damping) and masks the underlying calibration issue. At operating temperature, the thin oil transmits pressure changes more rapidly, producing the harsh shifts.

88. A — If the differential lock clutch pack's friction material has bonded to the separator plates from overheating (a condition called clutch welding or bonding), the hydraulic release circuit cannot generate enough force to separate the bonded surfaces. The clutch remains mechanically locked regardless of the hydraulic command, forcing both axle shafts to rotate at the same speed and producing the bind during turns.

89. C — The evaporator temperature control (thermostat or pressure cycling switch) should cycle the compressor off before the evaporator surface drops below freezing. If this control has failed, the compressor runs continuously, the evaporator surface temperature drops below 0°C, and condensate on the coil freezes into an ice layer that progressively blocks all airflow until the system is shut off and the ice melts.

90. B — A blower wheel (squirrel cage fan) that has accumulated dirt, debris, moisture, or ice on its blades develops a mass imbalance. As the unbalanced wheel rotates, the heavy side creates a centrifugal force that produces vibration proportional to the rotational speed. Higher blower speed produces greater centrifugal force and therefore more vibration.

91. D — R-12 refrigerant is chemically incompatible with the materials used in R-134a systems. R-12 attacks the synthetic rubber compounds in R-134a hoses and seals, degrading them over time. It also contaminates the receiver-drier's desiccant (which is a different type for R-134a) and may produce chemical reactions with the R-134a system's PAG or POE oil. The system components may have sustained hidden damage over the 500 operating hours.

92. A — The sealed-combustion heater's air intake and exhaust are separate from the cab air stream — the combustion products should never contact the cab air. However, if the fresh air intake for the cab HVAC is located near the heater's exhaust outlet, the exhaust gas (carrying unburned fuel odour) enters the HVAC system despite the sealed combustion design. The intake location relative to the heater exhaust must be verified.

93. B — A condenser face that is 30% blocked reduces the total heat rejection area proportionally. The A/C system must reject the same total heat load through the reduced area, which requires the condenser to operate at a higher pressure differential to drive the heat through the smaller available surface. The high-side pressure increases, reducing system efficiency and cooling capacity.

94. B — Cabin air filters are designed with a progressive density structure — coarser media on the inlet side captures large particles first, progressively finer layers capture smaller particles deeper in the media. Installing the filter backward exposes the fine layer to the initial dust load (clogging it rapidly) while the coarse layer faces the clean side. The result is premature clogging, reduced airflow, and reduced cab pressurization.

95. D — A sealed-combustion heater isolates combustion gases from the cab air stream through the heat exchanger wall. If the heat exchanger cracks, combustion gases — including unburned fuel vapour — leak through the crack directly into the heated air supplied to the cab. The fuel odour inside the cab confirms combustion products are entering the cab air stream through a compromised heat exchanger.

96. C — Intermittent cooling with the compressor clutch remaining engaged eliminates the clutch, low-pressure switch, and high-pressure switch as causes. A failing compressor valve plate that intermittently loses its seal produces alternating periods of normal compression (cooling) and lost compression (no cooling). The valve plate reseats temporarily, restoring compression until it lifts again.

97. A — Heated air is available at the floor and panel vents (confirming the heater core, blower, and temperature system are functional), but none reaches the windshield defroster ducts. The HVAC mode selection door that directs airflow between floor, panel, and defroster outlets is the control point — if the door is stuck, disconnected, or blocked, airflow cannot reach the defroster outlets regardless of temperature or fan speed.

98. A — Three pumps failing from identical cavitation damage in 2,000 hours confirms a chronic suction starvation condition. The root cause is in the pump inlet circuit — a strainer that is too fine, a suction line that is too small, a collapsed suction hose, or a reservoir level that drops below the pickup during operation. Each replacement pump suffers the same cavitation destruction because the inlet restriction remains uncorrected.

99. C — A regenerative circuit on the extension side redirects the oil exhausting from the rod end during extension back to the cap end, supplementing the pump flow. This additional flow increases the extension speed to match the naturally faster retraction speed (which benefits from the smaller rod-end area requiring less flow). The regen circuit equalizes the two speeds.

100. D — The 5% specification means maximum allowable case drain = 5% of theoretical flow = 5% of 360 L/min = 18 L/min. The measured 36 L/min is exactly double the maximum, confirming the pump's internal clearances have worn well beyond the serviceable limit. The pump is bypassing 10% of its output internally and must be rebuilt or replaced.

101. B — The boom lower circuit has a specific characteristic: the boom's weight provides a force that drives the cylinder retraction faster than the pump can supply fluid to the rod end. This creates a vacuum condition on the rod side, producing cavitation-induced squealing noise. An anti-cavitation check valve or a meter-out flow control addresses this condition.

102. A — The return filter and the charge pump share the same reservoir. If the return filter clogs severely, the restricted return flow backs up in the return line and prevents oil from returning to the reservoir efficiently. The reservoir level drops, and if it drops below the charge pump's pickup tube, the charge pump draws air, loses prime, and charge pressure drops — starving the main pump.

103. C — The brake valve (counterbalance valve) requires pilot pressure from the lowering supply to remain open. When the DCV shifts to neutral, the pilot signal is removed and the brake valve closes. The small load drop corresponds to the volume of oil that flows through the system during the brief transition time — the DCV spool passing through mid-positions and the brake valve's closing response time.

104. D — A filter element that triggers its clogging indicator only during cold starts but resets after warm-up is experiencing the combined restriction of the partially loaded element plus the high-viscosity cold oil. Neither condition alone triggers the indicator, but together they exceed the differential pressure threshold. As the oil warms and thins, the viscosity-induced restriction drops and the indicator resets.

105. A — JIC 37-degree flare fittings seal on the precision-machined 37-degree flare surface and are designed for the high-pressure, high-vibration environment of hydraulic circuits. NPT fittings seal on tapered threads using sealant and are rated for lower-pressure, lower-vibration applications. The NPT fitting may not withstand the pressure cycling and vibration that the JIC fitting was designed for, and must be replaced with the correct JIC fitting.

106. C — A tandem pump has two independent pump sections sharing a common drive shaft. Each section has its own pistons, barrel, valve plate, and swashplate. Section A can wear independently of section B because they are mechanically separate — only the drive shaft is shared. A 30% output loss in one section with normal output in the other confirms wear specific to that section.

107. B — The narrow 100 kPa differential (instead of the specified 170 kPa) means the compressor reloads at 760 kPa instead of 690 kPa — much sooner after each unload. The more frequent load/unload cycling increases compressor wear, generates additional heat, and reduces the air dryer's effectiveness because the dryer's regeneration cycle depends on a sufficient unloaded period to purge moisture from the desiccant.

108. D — A 28-bar pressure loss between the pump outlet (30 bar) and the DCV inlet (2 bar) in a standby condition is catastrophic. The entire 30-bar standby pressure is being consumed by a restriction between the pump and the valve. A clogged high-pressure filter, a partially closed shut-off valve, or a collapsed supply hose could produce this extreme pressure drop. The restriction must be located and corrected.

109. A — The snubber (cushion) valve decelerates the piston near the end of stroke by restricting the exhaust flow through an adjustable orifice. If the orifice was inadvertently opened fully during the last service (perhaps while the technician was accessing another adjustment), the restriction is eliminated and no deceleration occurs — the piston strikes the end cap at full speed.

110. C — Pilot circuits operate at reduced pressure (typically 25–50 bar) to provide precise, proportional spool control. Full system pressure (280 bar) applied to the pilot pistons forces the DCV spool to maximum travel at maximum velocity regardless of the joystick input. The spool moves at maximum speed for any input, and the excessive force may damage the pilot piston seals, spool lands, and valve body bore.

111. D — A hydrostatic system without brakes applied should not be expected to hold a machine on a grade. When the pump is at zero displacement (neutral), there is no positive hydraulic lock — internal leakage through the pump and motor allows the motor to rotate slowly under the machine's weight. The parking brake is the system designed to hold the machine stationary on a grade.

112. A — The flow measurements show a classic volumetric efficiency curve — as pressure increases, more fluid bypasses internally through the pump's clearances, reducing the delivered output. At 0 bar, nearly all displaced fluid is delivered (195 of 200 L/min). At 300 bar, 45 L/min bypasses internally. This normal characteristic defines the pump's efficiency at each operating pressure.

113. A — Two identical cylinders supplied from a single DCV outlet will not extend simultaneously at equal speed if their resistances differ. The hydraulic fluid follows the path of least resistance — the cylinder with lower friction, a shorter hose, or a less restricted port receives preferential flow. The

lower-resistance cylinder extends first (or faster), and the higher-resistance cylinder receives flow only after the first reaches a pressure that exceeds the second's resistance.

114. C — Rubber accumulator bladders degrade from repeated flexing (fatigue), chemical interaction with hydraulic oil additives, and heat cycling. OEMs typically recommend time-based replacement at 5–10 year intervals because a bladder that fails during service can prevent the accumulator from storing energy for emergency brake applications. The functional test alone does not reveal a bladder that is near its fatigue life limit.

115. B — The relay valve provides faster brake application by placing a large-volume air supply close to the brake chambers. The small pilot signal from the brake valve travels the full length of the machine (a small volume in a small line), and the relay valve at the axle opens a large-diameter supply from the local reservoir to the nearby chambers. The short air travel distance from the relay to the chambers provides near-instantaneous application.

116. A — All relief valves, the oil cooler, and the oil level are confirmed correct, eliminating the most common heat sources. Worn DCV spools with internal leakage create continuous bypass from the pressure port to the tank port through the spool-to-bore clearance. This bypass converts hydraulic energy to heat as pressurized oil flows through the tight clearance. Multiple leaking spools can generate significant cumulative heat.

117. C — Full speed and power in both directions with correct loop pressures rules out the pump and motor under load. Whining noise in reverse only points to a directionally biased condition in the pump's servo system. A restriction in the reverse servo circuit limits the swashplate angle in reverse, causing the pump to operate at reduced displacement and producing cavitation noise from the flow deficit to the motor.

118. C — When the filter element clogs and the differential pressure across it exceeds the bypass valve's cracking pressure (3.5 bar), the bypass valve opens to prevent oil starvation downstream of the filter. However, all oil now flows around the element unfiltered, recirculating contamination through the system. The bypass protects flow continuity but sacrifices filtration until the element is replaced.

119. D — The clunk at directional reversal is caused by the swing gear backlash. When the swing direction reverses, the motor pinion teeth must travel through the backlash gap between the pinion and the turntable ring gear before engaging in the new direction. The impact of the teeth meeting after crossing the gap produces the single distinct clunk at the moment of reversal.

120. B — Under load, the motor's internal clearances allow more fluid to bypass than at no-load conditions. The higher working pressure drives fluid through the worn clearances at a greater rate. The pump must replace this additional internal leakage to maintain the motor's commanded speed — the flow meter registers the total flow entering the motor, including both the working flow and the leakage replacement flow.

121. C — The priority valve guarantees a minimum 40 L/min to steering. However, during active steering, the HMU may demand more than 40 L/min depending on the steering speed and the cylinder displacement. The priority valve allows the steering circuit to consume whatever flow it needs (up to the pump's total output), and only the excess goes to the implements. Heavy steering demand temporarily reduces the flow available for implements.

122. A — The relief valve has been adjusted to specification and tests correctly. However, the technician should investigate why the relief drifted from 280 to 265 bar — possible causes include contamination on the valve seat that prevented full closure, a weakened spring from fatigue or heat exposure, or a previous incorrect adjustment. The root cause may cause the valve to drift again if not identified.

123. B — Pivot pin and bushing wear is determined by measuring both components independently. The pin and bushings wear at different rates depending on their materials and lubrication condition. Measuring both identifies which component (or both) is worn beyond specification and determines the correct replacement combination. Replacing only one component when both are worn results in a repair that does not restore the designed clearance.

124. C — A welded plate repair on a bucket floor without documented pre-heat, post-heat, or NDE verification raises serious quality concerns. The uncontrolled welding process may have introduced hydrogen cracking, incomplete fusion, or high residual stress. Without NDE, these hidden defects are undetectable until they cause sudden failure during loaded bucket operation — potentially dropping material or releasing the bucket contents.

125. D — An air spring seat that progressively sinks during operation has a slow air leak. The air escapes from the bladder, the leveling valve, the air supply connections, or the control mechanism faster than the leveling system can replenish it. The progressive height loss corresponds to the leak rate exceeding the refill capacity of the leveling valve.

126. A — Carbide inserts embedded in the cutting edge resist abrasive wear far better than hardened steel, maintaining the edge's cutting profile and sharpness for significantly longer between replacements.

However, carbide is brittle — it can chip or fracture if the edge strikes a hard object (buried rock, concrete, reinforcing bar). The operator must be informed of this trade-off between wear resistance and impact vulnerability.

127. A — An oval pin bore on one of four attachment points allows the pin to move within the elongated bore under dynamic loading. This movement creates uneven loading on the remaining three pins (which are round and within specification), reduces the attachment's stability, and creates a risk of the attachment disengaging from the worn bore under high dynamic loads.

128. D — Laminated safety glass with a small stone chip that has not cracked or spidered — with the PVB interlayer and inner glass intact — is not an immediate safety failure. Applying a windshield repair resin fills the chip, prevents moisture intrusion, and stops the chip from propagating into a crack. This is an accepted repair method that restores the outer glass's integrity at the impact point.

129. C — A needle valve in the return line creates a flow restriction that converts hydraulic energy to heat. All the energy that the restriction removes from the return flow is dissipated as heat into the oil. This approach wastes energy, heats the hydraulic system, and creates elevated back-pressure at the attachment's motor or cylinder that may damage seals and reduce the attachment's service life.

130. B — A tooth that does not seat fully on its adapter has a gap that allows the tooth to rock under digging loads. Possible causes include a wrong tooth specification, a deformed adapter, or trapped debris between the mating surfaces. An improperly seated tooth concentrates stress at the contact edges, accelerates adapter wear, and may break during operation. The cause must be identified and corrected before installation.

131. A — A seized pin under hydraulic press force or heavy hammer impact can release suddenly and eject from the bore at high velocity. The pin becomes a projectile capable of causing fatal injury to anyone positioned in its trajectory path. All personnel must be cleared from both ends of the pin bore before force is applied, and appropriate barriers or PPE should be used.

132. C — High-speed flywheels can absorb and release energy at extremely high power rates (kilowatts to megawatts) with virtually unlimited charge/discharge cycles. An excavator's swing cycle produces brief, intense energy bursts during braking (lasting 2–3 seconds) followed by brief power demands during acceleration. The flywheel's ability to handle these rapid, repetitive high-power cycles without degradation makes it ideal for this application.

133. D — The IMD threshold = 500 kΩ/V × 600V = 300,000 kΩ = 300 MΩ. Any insulation resistance measurement below 300 MΩ indicates the insulation has degraded to a level where leakage current from the 600V bus to the chassis could present a shock hazard or cause equipment damage. The IMD triggers an alert to warn operators and maintenance personnel of the degraded insulation condition.

134. A — A 93% efficient charger must draw more energy from the grid than it delivers to the battery because 7% is lost as heat during the AC-to-DC conversion. Grid consumption = battery requirement ÷ efficiency = 100 kWh ÷ 0.93 = approximately 107.5 kWh. The 7.5 kWh difference is dissipated as heat by the charger's power electronics.

135. B — Accelerated battery degradation from 95% to 82% SOH in 18 months (versus the expected 2–3% per year) indicates one or more operating conditions are dramatically exceeding the cells' design parameters. The three primary accelerants for lithium-ion degradation are deep discharge cycling, high charging rates, and sustained high temperatures. All three factors should be analyzed from the operating and charging data to identify which is dominant.