PRACTICE EXAM 6: RED SEAL 421A SIMULATION (135 QUESTIONS)

1. A technician is preparing to service a wheel tractorscraper that has been parked on a 5% grade with the bowl lowered to the ground and the engine shut down. The parking brake is applied. Before beginning work underneath the machine, what additional precaution is required beyond standard LOTO?

A. Chock the wheels on the downhill side — the parking brake alone may not hold the machine on a grade if a mechanical failure occurs, and wheel chocks provide a positive physical barrier against rolling

B. Release the parking brake and reapply it while observing for any movement — this verifies the brake is holding before the technician positions themselves under the machine

C. Raise the bowl off the ground to provide clearance underneath, then install safety stands under the bowl arms to mechanically support the raised implement

D. Lower the ejector plate to its fully forward position to reduce the machine's centre of gravity and improve its stability on the grade surface

2. A technician receives a container of partswashing solvent with a WHMIS 2015 supplier label that shows both the flame pictogram and the health hazard pictogram. What do these two pictograms together indicate about the product?

A. The product is a corrosive material that is also toxic — it can cause chemical burns on contact and systemic poisoning through skin absorption

B. The product is an oxidizer that also causes acute toxicity — it can accelerate fires and cause immediate health effects from a single exposure

C. The product is a flammable liquid that also presents a chronic health hazard — it can ignite if exposed to spark or heat and may cause longterm organ damage with repeated exposure

D. The product is a compressed gas that is also an environmental hazard — it may explode if heated and is toxic to aquatic organisms if released

3. A technician must remove and replace a hydraulic cylinder on a machine in the field. The work requires disconnecting pressurized hydraulic lines. Before cracking any fitting, what step must be performed on the hydraulic circuit?

A. Wrap rags around each fitting before loosening to absorb the initial spray of oil that occurs when the pressurized fitting is cracked open

B. Loosen each fitting onequarter turn and wait 30 seconds for pressure to equalize before removing the fitting completely

C. Wear safety glasses only — hydraulic oil at low pressure does not present an injection injury hazard and standard PPE is sufficient

D. Relieve all residual hydraulic pressure from the circuit by cycling the controls with the engine off to zero the system, then verify zero pressure at the work area before loosening any fitting

4. A technician observes a coworker grinding a weld on a structural boom repair. The grinder guard has been removed to access a tight area, and the coworker is wearing only safety glasses. What hazard has the coworker created by removing the guard?

A. The removed guard reduces the grinder's cutting efficiency because the guard directs the airflow that cools the grinding disc during operation

B. The removed guard exposes the operator to the full disc area — if the disc fractures, fragments can be launched at high velocity in any direction without the guard containing them

C. The removed guard allows sparks to contact the boom surface and damage the newly applied weld repair, requiring the grinding operation to be repeated

D. The removed guard voids the power tool warranty and the shop will be liable for the replacement cost if the grinder fails during the unguarded operation

5. A technician is servicing a machine equipped with a fire suppression system that protects the engine compartment. During the service, the technician accidentally activates the suppression system, discharging the extinguishing agent throughout the engine compartment. What must happen before the machine can be returned to service?

A. Wipe the extinguishing agent residue from the engine surfaces and refill the suppression system reservoir with the correct agent before returning to service

B. Run the engine for 15 minutes at high idle to burn off the extinguishing agent residue from the exhaust manifold and turbocharger before returning to normal operation

C. No action is required — fire suppression agents are nondamaging to engine components and the system will recharge automatically from the reserve cylinder

D. The suppression system must be recharged or replaced by a certified fire suppression technician and the entire system must be tested before the machine returns to operation

6. A technician discovers that the emergency eyewash station nearest to the battery charging area is blocked by a stack of pallets. The technician needs to begin charging batteries immediately. What is the correct action?

A. Begin charging operations and use the nearest alternative eyewash station located in an adjacent building if an acid splash occurs during the work

B. Proceed with charging while wearing a full face shield — the face shield eliminates the need for the eyewash station by preventing any acid from reaching the eyes

C. Clear the obstruction from the eyewash station before beginning any work with battery acid — the station must be accessible within the required response time at all times

D. Begin charging and assign a coworker to stand by the blocked station and clear the pallets if an emergency arises during the charging process

7. A technician is using a crane to lift a diesel engine from a machine. The rigging includes two chain slings in a bridle configuration at a 60degree included angle. The technician selects slings rated at the engine weight when used at a vertical hitch angle. Is this sling selection adequate for the 60degree bridle?

A. No — as the included sling angle increases from vertical, each sling must carry a greater share of the load. At 60 degrees, each sling carries approximately 58% of the total load, requiring slings rated above the simple weight division

B. Yes — a bridle hitch distributes the load equally between two slings regardless of the sling angle, and each sling carries exactly 50% of the total load

C. No — the 60degree angle reduces each sling's capacity by 75%, requiring slings rated at four times the engine weight to provide an adequate safety margin

D. Yes — the rated capacity of a sling is the same at any angle up to 90 degrees from vertical, and the angle only affects the sling's reach, not its load capacity

8. A technician is decommissioning an old fuel storage tank at a heavy equipment yard. The tank has been emptied and drained but has not been cleaned. What hazard classification applies to this empty, uncleaned tank?

A. The tank is safe to work on because the liquid fuel has been removed and the remaining vapour will dissipate through the open fill port within 24 hours

B. The empty uncleaned tank contains residual fuel vapour that may be within the explosive range — it must be treated as a confined space with a flammable atmosphere until professionally cleaned, tested, and certified gasfree

C. The tank requires only ventilation through both access ports for one hour before any work begins — natural airflow will reduce the vapour concentration below the explosive limit

D. The tank is classified as an environmental hazard only — the residual fuel film on the interior surfaces must be removed to prevent groundwater contamination during disposal

9. A supervisor instructs a technician to operate an overhead bridge crane to move a transmission assembly across the shop. The technician holds a valid heavy equipment technician Red Seal certificate. Does this qualification authorize the technician to operate the overhead crane?

A. Yes — a Red Seal heavy equipment technician certificate covers the operation of all lifting equipment including overhead cranes, mobile cranes, and rigging operations

B. Yes — operating an overhead crane in a maintenance shop is classified as a routine shop task that does not require a separate operator certification

C. No — but the technician may operate the crane under the direct supervision of a certified crane operator who remains present throughout the entire lifting operation

D. No — overhead crane operation requires specific training and certification for that equipment type. The Red Seal technician certificate does not include crane operator qualification

10. A technician is tasked with performing maintenance on a machine located in an area posted as a designated radiation zone due to nearby industrial radiography (weld inspection using gamma radiation). The technician does not hold radiation safety training. What is the correct response?

A. Proceed with the maintenance while wearing a leadlined apron and dosimetry badge borrowed from the radiography team working in the adjacent area

B. Wait for the radiography to finish and verify the area has been cleared of all radiation sources before entering, or request the machine be moved outside the zone

C. Do not enter the radiation zone — only personnel with appropriate radiation safety training and authorization may enter a designated radiation zone while the source is exposed

D. Enter the zone and complete the work quickly — limiting the exposure time to less than 15 minutes reduces the radiation dose below the regulatory threshold

11. A technician is troubleshooting a diesel engine that starts and runs for approximately 30 seconds before stalling. It restarts immediately but stalls again after the same period. Fuel tank level is adequate. What is the most probable cause?

A. The engine's intake air system has a large leak that allows unmetered air to enter, disrupting the fueltoair ratio after the initial startup fuel enrichment expires

B. The fuel system is drawing air through a compromised connection between the tank and the transfer pump — the initial fuel in the filter housing sustains the engine until it is consumed, then the airladen supply causes stalling

C. The ECM is entering a protective shutdown after detecting a fault condition that appears only after the engine has run long enough for the sensor readings to stabilize

D. The engine's turbocharger is seized and the increasing exhaust backpressure after startup chokes the engine within 30 seconds of initial firing

12. A diesel engine produces a single loud knock from the upper block area at a specific RPM. The knock disappears above and below that RPM. A cylinder cutout test (disabling injectors one at a time) eliminates the knock when cylinder number 3 is cut out. What does this indicate?

A. Cylinder 3 has a failing connecting rod bearing that produces an impact noise at the RPM where the bearing's natural resonance matches the engine's firing frequency

B. Cylinder 3 has a piston that is slightly heavier than the others, producing an imbalance force that is amplified at the resonant RPM of the crankshaft assembly

C. The crankshaft has a stress crack near the number 3 journal that opens and closes at one specific RPM, producing the singleknock symptom that coincides with that cylinder's firing

D. Cylinder 3 has a combustionrelated fault — such as an injector producing an abnormal spray pattern or an incorrect valve clearance that creates excessive combustion pressure rise at that specific RPM

13. A technician replaces the air filter on a turbocharged diesel engine and notices the old filter's inner element (safety element) has been previously removed and is missing. The outer primary element was still in place. What protection has been lost?

A. The safety element provides additional filtration during periods of high dust concentration, supplementing the primary element when the dust load exceeds its singlepass capacity

B. The safety element houses the air restriction indicator sensor port and without it, the ECM cannot detect when the primary element has reached its service limit

C. The safety element prevents unfiltered air from entering the engine if the primary element is damaged, dislodged, or incorrectly installed — it is the last line of defence against catastrophic dirt ingestion

D. The safety element preheats intake air during cold starting by using a builtin electric grid that the engine block heater circuit powers during the preheat cycle

14. A diesel engine's fuel injector has a nozzle opening pressure (NOP) specification of 350 bar. A technician tests the injector on a pop tester and measures a NOP of 280 bar. What is the consequence of operating with this reduced opening pressure?

A. The injector opens prematurely at lower cylinder pressure, producing a longer injection duration and a coarser fuel spray pattern that reduces combustion efficiency, increases smoke output, and accelerates exhaust system contamination

B. The injector delivers a larger fuel volume per injection event because the lower opening pressure allows the nozzle to remain open longer, enriching the fuel mixture

C. The injector produces a finer atomization pattern because the lower pressure creates smaller fuel droplets that vaporize more readily in the combustion chamber

D. The reduced NOP has no operational effect because the ECM compensates by reducing the electrical pulse duration to maintain the correct fuel quantity per injection

15. A heavy equipment engine's oil analysis program has tracked the oil condition over four consecutive samples. The TBN (Total Base Number) has decreased steadily from 9.2 at the first sample to 2.1 at the fourth sample. What does the declining TBN indicate?

A. The oil's viscosity has broken down from thermal stress and the oil can no longer maintain an adequate lubricating film at operating temperature and pressure

B. The oil's alkaline reserve — which neutralizes acidic combustion byproducts — is nearly depleted. If TBN reaches zero, the acids will begin attacking internal metal surfaces, causing corrosive wear

C. The oil has absorbed excessive moisture from the crankcase atmosphere, and the water content has diluted the base additive package below its effective concentration

D. The oil has exceeded its oxidation stability limit and has begun forming sludge and varnish deposits on internal engine surfaces that restrict oil flow passages

16. A technician notices the engine coolant has changed from its original orange colour to a dark brown colour with visible particles floating in the overflow tank. The coolant was changed one year ago. What does this condition indicate?

A. The colour change is a normal characteristic of OAT coolant that darkens after exposure to heat cycling and does not indicate a problem with the coolant or system

B. An incorrect coolant type was mixed with the existing OAT coolant, causing a chemical reaction that produces the discoloration and the precipitated particles

C. The engine has been operated above its normal temperature range for an extended period, which has thermally degraded the coolant beyond its specified heat tolerance

D. Internal corrosion or contamination is present — the dark colour and particles suggest the inhibitor package has failed or incompatible fluids have been mixed, causing corrosion products to circulate in the system

17. A technician is replacing cylinder head bolts on a diesel engine. The service manual specifies new bolts must be used and provides a specific bolt length measurement that the technician must verify before installation. Why must the bolt length be checked before installing new head bolts?

A. The bolt length confirms the bolt threads will engage the correct number of turns in the block, preventing the bolt from bottoming out before developing full clamping force

B. The bolt length verification ensures the bolt is the correct hardness grade — bolt length is proportional to the grade rating in the OEM's bolt specification system

C. New bolts are supplied slightly longer than the installed specification and must be cut to length during installation using the OEM's bolt preparation procedure

D. The bolt length confirms the replacement bolt has not been stretched during manufacturing — a bolt that exceeds the maximum length specification has been yielded and will fail during torquing

18. A diesel engine equipped with a variablespeed cooling fan drive runs the fan at maximum speed during a cold start on a −20°C morning, even though the engine is far below operating temperature. No fault codes are active. What is the most likely cause?

A. The fan control sensor — typically a coolant temperature sensor or intake air temperature sensor — has failed in a state that reads hot, causing the ECM to command maximum fan speed regardless of actual temperature

B. The variable fan drive clutch has seized internally due to the coldthickened silicone fluid, causing the fan to be mechanically locked to the drive at maximum speed

C. The ECM is programmed to run the fan at maximum speed during cold starts to provide additional air mass for improved coldstart combustion quality

D. The alternator is overcharging and the excess electrical load is causing the beltdriven fan to spin faster than the engine's commanded fan speed through the clutch

19. A technician is investigating an engine that consumes one litre of coolant every 50 operating hours. There are no visible external leaks. The oil is clean with no milky discoloration. Exhaust smoke appears normal. A cooling system pressure test holds pressure correctly. Where is the coolant going?

A. The coolant is evaporating through the overflow tube during normal thermal cycling and the rate of loss is within acceptable limits for this engine's operating conditions

B. The coolant is being consumed through normal water pump weep hole seepage, which is designed to vent a small amount of coolant to prevent seal pressure buildup

C. The coolant is leaking internally through an EGR cooler crack that allows coolant to enter the exhaust stream, where it vaporizes without visible white smoke at the low leak rate

D. The coolant is bypassing the head gasket into one or more cylinders at a rate small enough to be consumed during combustion without visible smoke, but detectable through coolant level tracking over time — a combustion gas test on the coolant may confirm the path

20. A technician is measuring intake manifold boost pressure on a turbocharged diesel engine at rated load and RPM. The measured boost is 15 kPa below the OEM specification. The exhaust system and air filter are confirmed unrestricted. What component should be investigated first?

A. The intake manifold gasket — a boost leak at the manifoldtohead joint allows pressurized charge air to escape before entering the cylinders

B. The charge air cooler (CAC) piping — a boost leak in the CAC hose connections, clamps, or the CAC core itself allows pressurized charge air to escape before reaching the intake manifold

C. The turbocharger wastegate — if the wastegate is opening prematurely, it bypasses exhaust gas around the turbine, reducing turbine speed and boost pressure below the rated specification

D. The exhaust manifold — a cracked manifold reduces the exhaust energy available to the turbocharger turbine by allowing gas to escape before reaching the turbine inlet

21. A diesel engine's piston cooling jets are supplied by engine oil pressure. During an engine overhaul, a technician discovers that one cooling jet is missing — it has broken off and is not found in the oil pan. What risk does this create if the engine is assembled without replacing the missing jet?

A. The oil pump will be unable to maintain rated pressure because the missing jet creates an unrestricted orifice that continuously dumps oil to the sump at full flow

B. The adjacent piston cooling jets will receive increased flow because the system pressure is reduced by the missing jet, causing overcooling of the adjacent pistons

C. The piston above the missing jet will operate at a significantly higher crown temperature because it receives no oil cooling spray — the elevated temperature causes crown erosion, ring groove distortion, and potential piston failure

D. The connecting rod bearing serving the cylinder with the missing jet will be starved of oil because the cooling jet and the rod bearing share a common supply gallery

22. A technician is diagnosing a diesel engine that produces a rhythmic ticking noise from the valve cover area. The noise rate is exactly half the engine RPM. A valve lash check reveals all valves are within specification. What other component in the valve train could produce this noise?

A. A worn camshaft lobe — a cam lobe with a flat spot or material loss produces a ticking impact once per cam revolution (half engine speed) as the follower drops into the worn area and snaps back onto the remaining lobe profile

B. A cracked rocker arm pedestal that flexes under valve spring pressure and produces an audible click at each valve opening event on the affected cylinder

C. A broken valve spring that allows the valve to float momentarily at each opening event, producing a ticking noise as the retainer contacts the rotator housing

D. A worn oil pump drive gear that produces a singletooth impact noise once per pump revolution, which runs at half engine speed in many engine designs

23. A Tier 4 Final engine's DPF soot loading model in the ECM calculates expected soot accumulation based on fuel consumption, engine hours, and operating conditions. The actual DPF differential pressure reading is significantly lower than the model predicts. What does this discrepancy suggest?

A. The DPF has a cracked substrate or a bypass leak — exhaust is flowing around or through a broken section of the filter rather than through the wallflow channels, resulting in lowerthanexpected restriction

B. The DPF is more efficient than the model predicts because the DOC is converting an unusually high percentage of soot to CO_2 before the exhaust reaches the DPF

C. The differential pressure sensor lines are partially blocked, producing artificially low readings that do not reflect the actual DPF restriction level

D. The DPF is performing passive regeneration at a higher rate than the model accounts for — the actual soot level is lower than predicted because continuous passive burnoff is exceeding the model's assumptions

24. A technician is adjusting the injector height (protrusion) on a mechanically actuated, electronically controlled unit injector (MEUI). The service manual specifies a precise dimension from the injector tip to the cylinder head surface. What is the purpose of this adjustment?

A. The injector height determines the compression ratio of the cylinder — an injector set too deep increases the clearance volume and reduces the compression ratio

B. The injector height sets the point at which the rocker arm actuates the injector plunger — incorrect height changes the injection timing and fuel delivery volume for that cylinder

C. The injector height positions the nozzle tip at the correct depth in the precombustion chamber to optimize the spray cone angle relative to the piston bowl geometry

D. The injector height controls the injector return fuel flow rate — a deeper setting increases the return fuel restriction and raises the fuel supply pressure to that cylinder

25. A diesel engine's coolant filter (also known as a conditioner filter) is used in some cooling systems. What purpose does this filter serve beyond removing particulate matter?

A. It provides a chemical treatment port for adding supplemental coolant additive (SCA) or diesel coolant additive (DCA) to maintain the correct inhibitor concentration that protects wetsleeve liners from cavitation erosion

B. It filters combustion gases that have entered the cooling system through a failed head gasket, preventing the gases from forming acidic compounds in the coolant

C. It removes air bubbles from the coolant stream to prevent air locks from forming in the cylinder head and heater core circuits during normal thermal cycling

D. It regulates the coolant flow rate through a builtin flow restrictor that maintains the correct velocity past the cylinder liners for optimal heat transfer

26. A technician performs an overhead valve adjustment on a diesel engine and sets the intake valve lash 0.10 mm tighter than specification. What performance effect will this have on the affected cylinder?

A. The intake valve opens slightly earlier and closes slightly later than designed — altering the valve timing events and potentially reducing cylinder sealing at low RPM because the valve may not fully seat during the compression and power strokes

B. The intake valve will produce less noise because the reduced lash eliminates the impact between the rocker arm and the valve stem that creates the ticking sound

C. The tight lash increases the effective compression ratio by holding the intake valve open longer during the compression stroke, causing a harder, louder combustion event

D. The tight lash has no measurable effect on engine performance — a 0.10 mm difference is within the manufacturing tolerance of the feeler gauge

27. A diesel engine's aftertreatment system includes a NOx sensor located after the SCR catalyst. The sensor reads 50 ppm NOx during loaded operation. The OEM maximum allowable tailpipe NOx for this engine is 35 ppm. No fault codes are active. What should the technician investigate?

A. The engine is producing higher than normal raw NOx levels that exceed the SCR catalyst's conversion capacity — this could indicate an EGR system fault that is allowing excessive peak combustion temperatures

B. The SCR system is not reducing NOx adequately — the DEF dosing rate, catalyst condition, exhaust temperature, and upstream DOC function must all be evaluated to determine why the postSCR NOx exceeds the limit

C. The NOx sensor has drifted out of calibration and is reading 15 ppm high — sensor drift is the most common cause of NOx readings slightly above the limit without a corresponding fault code

D. The DPF is restricting exhaust flow and creating backpressure that reduces the residence time of exhaust gas in the SCR catalyst, limiting the conversion efficiency

28. A technician discovers that a diesel engine's crankcase breather system vents to a separator that captures oil mist and returns the recovered oil to the sump. The separator element is heavily clogged with oil sludge. What consequence does this clogged separator have on the engine?

A. The clogged separator reduces crankcase vacuum, which decreases the oil pump's efficiency because the pump must work against higher crankcase pressure on the suction side

B. The clogged separator prevents blowby gases from being routed to the intake for recombustion, increasing the engine's tailpipe hydrocarbon emissions above the regulatory limit

C. The clogged separator reduces the oil return flow to the sump, causing the oil level to drop progressively as captured oil accumulates in the separator housing

D. The clogged separator restricts the crankcase ventilation path, raising crankcase pressure and forcing oil past gaskets and seals — producing external oil leaks identical to those caused by excessive blowby

29. A machine's diesel engine has been operated exclusively at low idle for 90% of its operating hours in a generator set application. The engine has 12,000 hours. The technician observes heavy carbon buildup on the intake valves and significant wetstacking residue on the exhaust manifold. What caused these conditions?

A. Chronic lowload operation prevents the engine from reaching adequate combustion temperature to completely burn the fuel charge and selfclean the intake and exhaust components — the unburned fuel and carbon accumulate progressively

B. The fuel injectors have worn and are delivering excessive fuel at idle speed, flooding the combustion chambers with more fuel than can be burned at the low air volume

C. The EGR system has been operating at its maximum rate during the idle period, reintroducing excessive exhaust soot to the intake that deposits on the valves

D. The turbocharger bearings have worn from the lack of oil pressure at idle, allowing oil to enter both the intake and exhaust streams and producing the observed deposits

30. A technician measures the fuel supply (transfer pump) pressure at the inlet of the highpressure fuel pump on a common rail system. The reading is 2 bar. The OEM specification is 4–6 bar. What is the most likely consequence of operating with this low supply pressure?

A. The engine runs normally at idle and low load but loses power at high RPM and heavy load because the low supply pressure cannot provide adequate fuel volume to the HP pump at peak demand

B. The HP pump generates excessive heat from cavitating at the inlet, which thermally degrades the fuel and produces coking deposits on the pump's internal plungers

C. The HP pump cannot generate adequate rail pressure across the entire operating range — the engine may exhibit hard starting, reduced power, rough running, and fuel system fault codes from the rail pressure falling below the ECM's commanded target

D. The low supply pressure has no operational effect because the HP pump generates its own suction and does not rely on the transfer pump for inlet pressure assistance

31. A wheel loader operator reports that the machine's steering feels heavier than normal and requires more effort to turn. The HMU and steering pump have been tested and are functioning within specification. What other component could cause increased steering effort?

A. Worn or seized steering cylinder pivot pins — corroded or dry pins create friction resistance that the steering system must overcome in addition to the normal turning force, increasing the operator's perceived steering effort

B. Low tire pressure on the front axle — underinflated tires increase the contact patch area and ground friction that resists turning, requiring more steering force

C. The steering gear ratio has changed due to a worn sector shaft, reducing the mechanical advantage available to the operator at the steering wheel

D. The hydraulic oil temperature is below the normal operating range and the increased viscosity is creating additional resistance in the steering valve and cylinder circuits

32. A technician is inspecting the undercarriage of a dozer used in a sandy, abrasive environment. The track rollers, idlers, and sprocket all show wear rates significantly higher than the OEM's projected wear curves for this machine's operating hours. What is the most likely contributing factor?

A. The machine was manufactured with a standardduty undercarriage rather than the heavyduty option, and the lighter components are wearing faster in the abrasive material

B. The operator is consistently operating at maximum ground speed, which increases the chaintosprocket contact velocity and accelerates wear proportionally

C. The abrasive sand packs between the track chain components and acts as a grinding compound — each articulation of the chain grinds the pin, bushing, roller, and sprocket surfaces, dramatically accelerating wear beyond projections for less abrasive materials

D. The undercarriage lubrication intervals are twice the OEM specification, and the reduced lubricant presence is allowing metaltometal contact at every joint

33. A machine equipped with airoverhydraulic brakes experiences a spongy brake pedal with excessive travel before firm braking occurs. The air system pressure is correct and all air components test within specification. What is the most probable cause?

A. The airoverhydraulic intensifier diaphragm has a small hole that allows air to leak into the hydraulic side, creating an air pocket in the hydraulic circuit

B. Air is trapped in the hydraulic circuit downstream of the airoverhydraulic intensifier — the compressible air in the hydraulic lines absorbs pedal travel before the incompressible fluid can build clamping pressure at the calipers or wheel cylinders

C. The brake master cylinder internal seals are worn and bypassing fluid internally, reducing the volume of fluid delivered to the calipers per pedal stroke

D. The brake fluid has absorbed moisture from the atmosphere over time, lowering its boiling point to the threshold where vapour pockets form under normal braking temperature

34. A rigidframe mining truck uses rear axle planetary hub reduction. During a scheduled inspection, the technician finds the hub oil on one side is severely contaminated with water — the oil has a milky white appearance. The other side is clean. What is the most likely entry point for the water?

A. The hub oil fill plug gasket has deteriorated and is allowing rainwater to enter the hub during washdown operations at the truck wash station

B. The hub oil cooler on that side has an internal failure that allows engine coolant to mix with the hub oil through the heat exchanger tubes

C. The hub oil breather vent on that side is damaged or missing, allowing washdown water and rainwater to enter the hub directly through the open vent port

D. The hub seal (floating seal or lip seal) on the inboard side has failed, allowing water from the haul road surface that is thrown up by the tire to enter past the compromised seal

35. A motor grader's circle drive — the gear mechanism that rotates the moldboard — produces a chattering noise during blade rotation and the blade occasionally slips under sideloading during grading. What is the most likely cause?

A. The circle drive motor is producing insufficient torque because the hydraulic supply pressure has dropped below the motor's minimum operating requirement

B. The circle drive worm gear lubrication has dried out due to a failed grease seal, causing metaltometal contact noise and reduced friction resistance to blade rotation

C. The circle drive gear mesh is worn — the worm gear and ring gear teeth have excessive backlash and cannot maintain positive engagement under load, causing the chatter and the slipping under side force

D. The moldboard mounting shoes (wear plates) have worn, allowing the moldboard to tilt and shift on the circle, changing the engagement angle between the drive gear and the circle gear

36. A technician discovers a hydraulic steering cylinder rod on an articulated dump truck is deeply scored with visible chrome flaking. The machine is currently being operated. What immediate action is required?

A. Remove the machine from service — the scored rod will destroy the cylinder seal on each stroke, producing progressive external oil leakage and eventual steering failure that could result in loss of directional control

B. Apply a temporary rod repair sleeve over the scored area and return the machine to limitedduty service until the cylinder can be rebuilt during the next scheduled maintenance window

C. Monitor the rod condition at each daily preshift inspection and schedule a repair when external oil leakage becomes visible at the rod seal area

D. Wrap the scored rod area with Teflon tape to provide a smooth surface for the seal to ride on and reduce further seal damage during the interim period

37. A pipelayer machine uses a sidemounted boom and counterweight system. During a pipelaying operation, the machine tips sideways momentarily when the operator lowers the pipe into the trench too quickly. What machine system or operator technique prevents tipping during pipelaying operations?

A. The pipelayer's counterweight prevents tipping — the counterweight must be correctly sized for the pipe weight and the boom radius, and the operator must follow the load chart precisely

B. The pipelayer's hydraulic system automatically limits the boom lowering speed based on the load weight to prevent dynamic load swing that could destabilize the machine

C. The pipelayer's track width automatically extends when the boom is loaded to increase the machine's base of support during lifting and lowering operations

D. The operator must control the lowering speed to prevent dynamic loads from exceeding the machine's rated capacity at the working radius — a sudden stop or rapid lowering creates inertia forces that exceed the static load chart rating

38. An operator of a large mining truck reports that the service brakes pull the truck to the right during straightline braking on a dry, level haul road. Both brake circuits show correct system pressure at the test ports during application. What should be investigated?

A. The steering system is introducing an unintended input during braking because the brake pedal linkage is mechanically interfering with the steering column

B. The brake components on the left and right sides should be inspected for asymmetric condition — a seized caliper piston, contaminated pad, glazed rotor, or worn disc on one side produces unequal braking force between sides despite equal supply pressure

C. The front tires are at different inflation pressures, creating different contact patch sizes that produce unequal braking grip between the left and right front wheels

D. The machine's frame is twisted from a previous overload event, causing the axle alignment to direct braking force asymmetrically to the left and right wheels

39. A compact track loader's rubber track tension is being adjusted. The OEM specification states the correct sag measurement between the front idler and the rear sprocket with the machine on level ground and the track off the ground. The technician sets the tension with the machine sitting on the ground. Why is this incorrect?

A. Measuring track sag with the machine on the ground includes the machine's weight in the measurement — the weight deflects the lower track run and produces a tighter reading than the actual running tension, resulting in a track that is set too loose when the machine lifts

B. Measuring sag with the machine on the ground compresses the rubber track against the ground surface, hiding any internal damage that would be visible with the track suspended

C. Ground contact prevents the technician from accessing the tensioner adjustment fitting, which is located on the underside of the track frame between the lower rollers

D. The machine's weight on the ground pushes the idler forward against its stops, preventing the tensioner from adjusting the idler position during the measurement

40. A technician is inspecting the brake rotors on an articulated dump truck. One rotor has a visible blueblack heat discoloration band around the friction surface. The other rotors show normal grey colouring. What does the discolored rotor indicate?

A. The rotor was manufactured with a different cast iron alloy that changes colour faster under normal operating temperature and the discoloration has no structural significance

B. The discolored rotor is harder than the others due to a heat treatment during manufacturing and will last longer than the grey rotors under identical braking conditions

C. The rotor has been heated to a level that may have damaged the brake pad friction material on that corner, but the rotor itself is not affected by the discoloration

D. The rotor has been overheated — the blueblack colour indicates the cast iron has been heated beyond its normal operating range, which may have caused structural changes (hard spots) that produce brake pulsation and premature pad wear

41. A technician is performing a brake efficiency test on a heavy equipment machine using a portable brake tester (roller type). The test results show the right rear brake produces 70% of the force of the left rear brake. What is the maximum allowable imbalance between brakes on the same axle?

A. Any imbalance greater than 10% indicates the brakes are significantly out of balance and requires correction — a 30% imbalance will produce noticeable pull and uneven braking

B. A 30% imbalance is within acceptable limits for heavy equipment because the large mass and slow operating speeds dampen any pulling tendency during braking

C. The maximum allowable imbalance is 30% — the measured 30% imbalance is at the threshold and requires monitoring but not immediate correction

D. The imbalance is acceptable only if the machine is equipped with ABS, which compensates for brake force differences between sides during every application

42. A technician discovers that a wheel loader's front axle oscillation pivot bearing has seized. The machine was reported as steering normally but producing unusual tire wear on the front axle. What does a seized oscillation pivot cause?

A. The machine cannot turn — the seized pivot locks the front axle to the frame and prevents any lateral movement required for steering articulation

B. One front tire loses ground contact when the machine traverses uneven terrain because the axle cannot oscillate to follow the ground contour — the unloaded tire wears unevenly from the repeated liftandsetdown cycle, and the loaded tire wears from the concentrated weight

C. Both front tires develop cupping wear because the seized pivot transmits vertical impact forces directly from the terrain to the tires without the dampening effect of the oscillation movement

D. The front differential is overloaded because the seized pivot forces the differential to compensate for all terrain variations through speed differences between the wheels rather than axle oscillation

43. A technician needs to measure the brake lining thickness on a large excavator's swing brake. The swing brake is an enclosed wet disc type that is not visible without disassembly. The OEM provides a brake pack clearance measurement as an alternative to direct lining measurement. What does increasing brake pack clearance indicate?

A. The friction discs are wearing thinner over time — as the total disc thickness decreases, the gap between the pressure plate and the housing increases, and this measurable clearance correlates directly to the remaining disc life

B. The brake housing bore has worn larger from repeated application cycles, increasing the clearance between the piston and the housing wall

C. The brake spring pack has weakened from fatigue, allowing the springs to compress further than their designed travel and increasing the measured clearance

D. The brake apply piston seal has extruded into the clearance gap, reducing the piston's effective travel and producing a false clearance measurement

44. A technician is replacing the track chain on a crawler excavator. The new chain is connected in a loop around the undercarriage, and the track tensioner is used to take up the slack and establish the correct tension. When the tensioner is fully extended but the track is still loose, what does this indicate?

A. The technician has installed the wrong chain length — the replacement chain has too many links for this machine's undercarriage configuration

B. The front idler bearing has seized and the idler is not moving forward on the track frame as the tensioner extends, preventing tension from being applied

C. The track frame has been damaged and is shorter than its designed length, which requires a chain with fewer links than the standard replacement specification

D. The replacement chain has more links than required for this undercarriage configuration — a link must be removed before the tensioner can establish correct tension within its adjustment range

45. An OTR tire on a wheel loader shows a bulge on the sidewall approximately 150 mm in diameter. The tire is not leaking and the inflation pressure is at the correct specification. What does the sidewall bulge indicate?

A. The bulge is a cosmetic defect in the rubber molding process and does not affect the structural integrity of the tire as long as the inflation pressure holds correctly

B. The internal cord plies beneath the bulge have separated or broken — the weakened area cannot contain the inflation pressure uniformly and the tire can fail catastrophically without warning

C. The tire has been operated at excessive inflation pressure at some point, permanently stretching the rubber in the bulge area without damaging the cord reinforcement

D. The tire's bead has shifted on the rim, creating a localized area of higher stress on the sidewall that produces the outward bulge at the point of maximum displacement

46. A technician is replacing the pads on a hydraulic disc brake caliper. After installing the new pads and reassembling the caliper, the technician pumps the brake pedal several times before the pedal feels firm. Why is this pedal pumping required after pad replacement?

A. The pumping action bleeds residual air from the caliper bore that entered during the pad replacement when the caliper was opened to atmosphere

B. The pumping action primes the brake fluid reservoir by drawing fluid from the supply tank into the master cylinder bore to replace the volume consumed during bleeding

C. The pumping action resets the ABS modulator valves to their normal operating position after the pressure loss that occurred when the caliper was opened for service

D. The pumping action advances the caliper pistons from their retracted position — where they were pushed back to create room for the new thicker pads — until they contact the new pads and eliminate the free travel

47. A technician is diagnosing a circuit that should produce 24 volts at the load but measures only 19 volts. The battery voltage is confirmed at 25.8 volts. Using the voltage drop method, the technician measures 4.1 volts dropped across the positive supply wiring and 2.7 volts dropped across the ground path. What can be concluded?

A. The ground path has a higher resistance fault because 2.7V exceeds the typical groundside voltage drop allowance of 0.5V or less for most circuits

B. The measurements are inconsistent — the voltage drops (4.1 + 2.7 = 6.8V) plus the load voltage (19V) total 25.8V, confirming Kirchhoff's Voltage Law and identifying that both sides have excessive resistance

C. Both the positive and ground paths have excessive voltage drop — the 4.1V on the positive side and 2.7V on the ground side exceed acceptable limits, and both paths must be inspected for corroded connections, damaged wiring, or undersized conductors

D. Only the positive side has a fault because 4.1V exceeds the maximum specification; the 2.7V groundside drop is within normal limits for a 24V system

48. A machine's 24volt starting system cranks the engine slowly. The technician measures 22.5 volts at the battery terminals during cranking and 18.2 volts at the starter motor terminals during the same cranking event. What does the 4.3volt difference indicate?

A. The starter motor is drawing excessive current due to an internal fault, which creates a voltage drop at the battery terminals that propagates to the starter

B. The 4.3 volts is consumed by resistance in the cables, connections, or switches between the battery and the starter — one or more highresistance points in the starting circuit are reducing the voltage available to the starter motor

C. The battery internal resistance is too high and the battery cannot sustain adequate voltage under the cranking load regardless of cable condition

D. The starter solenoid contacts are burned and creating the voltage drop between the battery input post and the motor output post within the solenoid housing

49. A technician is measuring the current draw of an individual circuit by placing a clampon ammeter around the wire. The ammeter reads zero even though the circuit is confirmed active and the load is operating. What is the most likely cause?

A. The clampon ammeter is positioned around a cable bundle containing both the positive supply wire and the return ground wire — the opposing magnetic fields cancel each other and produce a net zero reading

B. The clampon ammeter requires calibration and is not detecting the magnetic field produced by the current flowing through the single wire

C. The circuit current is below the ammeter's minimum detection threshold and the current draw is too small to register on the meter's scale

D. The clampon ammeter is a DConly meter and the circuit is producing an AC current component that the meter cannot detect or display

50. A technician connects a diagnostic tool to a machine and finds 47 stored DTCs accumulated over the last 2,000 operating hours. Many are duplicates from repeated occurrences of the same fault. The

machine is currently operating normally with no active DTCs. What is the correct approach to this stored code history?

A. Clear all 47 stored codes immediately — the machine is operating normally and the stored codes serve no diagnostic purpose once the faults have resolved

B. Delete only the duplicate codes and retain one instance of each unique fault for the maintenance record, then clear the duplicates to improve diagnostic tool response time

C. Record all 47 codes with their occurrence counts and timestamps but do not clear them — clearing codes before the fleet manager reviews them removes diagnostic history needed for trend analysis

D. Review the stored codes for patterns — recurring faults, codes that appeared at the same time suggesting a common cause, and any codes related to the current operating complaint — then clear only after the review is documented

51. A heavy equipment machine's lighting circuit uses a relay to switch the work lights. The relay coil circuit includes the light switch and a fuse. The relay contact circuit includes a separate higherrated fuse and the work lights. The technician finds the relay coil fuse blown but the contact circuit fuse intact. What does this tell the technician?

A. The work light bulbs are drawing excessive current that is backfeeding through the relay contacts into the coil circuit and blowing the coil fuse

B. The relay coil circuit has a fault — either the coil winding has shorted internally (drawing excessive current through the coil fuse), or the wiring between the switch and the relay coil has a short to ground

C. The relay contacts have welded closed, and when the operator turned the light switch off, the coil fuse blew from the backEMF generated by the relay coil attempting to deenergize against the welded contacts

D. The light switch has a mechanical fault that is sending intermittent voltage spikes through the coil circuit, causing the fuse to blow from the transient overcurrent events

52. A technician tests a battery disconnect switch (master disconnect) on a heavy equipment machine. With the switch in the OFF position, the technician measures 0.5 volts between the battery positive post and the positive cable terminal on the starter side of the disconnect. Should any voltage be present with the disconnect off?

A. Yes — some machines have a constantpower circuit that bypasses the disconnect to maintain ECM memory, clock, and security system functions even when the disconnect is open

B. No — any measurable voltage with the disconnect off indicates a wiring fault that bypasses the switch and creates a potential fire hazard during maintenance

C. Yes — the 0.5V is residual capacitance stored in the wiring that will dissipate within a few minutes after the disconnect is opened

D. No — the disconnect should create a complete open circuit with zero voltage measurable on the load side under any condition

53. A machine's electronic display shows an intermittent "Check Engine" warning that appears for 23 seconds and then clears itself. No stored DTCs are found in the ECM when checked with the diagnostic tool. The operator reports the warning appears randomly during operation. What should the technician investigate?

A. The instrument cluster display module has a failing internal driver that produces false warning indications independent of any actual ECMgenerated warning signal

B. The engine wiring harness has a connector with a marginal contact that momentarily loses connection under vibration, briefly triggering the warning before the connection is restored

C. The ECM software has a known bug that produces transient false warnings on specific display models — an ECM software update should be checked for availability

D. The CAN bus communication between the ECM and the display is experiencing intermittent data errors — a brief message corruption can produce a momentary false warning on the display without generating a stored DTC in the ECM

54. A machine's charging system produces 28.4 volts at the alternator output terminal but only 27.1 volts at the battery positive terminal while the engine is running. The total current output is 85 amperes. What is the power loss in the charging circuit wiring?

A. 110.5 watts — calculated as the voltage drop multiplied by the current (1.3V × 85A = 110.5W). This power is dissipated as heat in the cables and connections, which should be inspected for undersized conductors or corroded connections

B. Power loss cannot be calculated without knowing the total wire length and the conductor crosssectional area for each segment of the charging circuit

C. 1.3 watts — calculated as the voltage drop alone (1.3V × 1A), because the voltage drop is independent of current in a lowresistance circuit

D. 2,414 watts — calculated by multiplying the alternator output voltage by the current (28.4V × 85A), which represents the total power generated rather than the loss

55. A technician replaces a crankshaft position sensor on a diesel engine. After replacement, the engine cranks but does not start. No DTCs are logged. The old sensor was confirmed failed. What should be checked on the new sensor?

A. The sensor air gap — if the new sensor is not adjusted to the correct distance from the reluctor wheel teeth, the signal amplitude during cranking may be too weak for the ECM to recognize as a valid crank signal, preventing injection and start

B. The sensor supply voltage — if the new sensor requires a different supply voltage than the circuit provides, it will produce a signal outside the ECM's detection range

C. The sensor output polarity — if the sensor leads are reversed at the connector, the ECM receives an inverted signal that it interprets as reverse engine rotation and refuses to fire the injectors

D. The sensor resistance — if the new sensor has a slightly different coil resistance than the original, the ECM's signal conditioning circuit cannot process the output correctly

56. A technician is diagnosing a machine where the operator reports that all dash gauges read at their maximum position simultaneously. The engine appears to be running normally. What is the most likely cause?

A. The alternator is producing excessive voltage (overcharging), which pushes all gauge sending units to their maximum deflection through the elevated supply voltage

B. The instrument cluster has lost its ground connection — without a ground reference, all gauges default to their maximum reading because the full supply voltage appears across each gauge's internal coil

C. All gauge sending units have failed simultaneously in the shortcircuit position, each producing the minimum resistance reading that drives its respective gauge to maximum

D. The CAN bus data feed to the instrument cluster has failed, and the cluster's default fault mode displays all gauges at maximum to alert the operator of the communication loss

57. A heavy equipment machine's battery cables are being replaced. The existing 2/0 AWG cables are in stock, but the parts room also has 4 AWG cables available. The technician considers using the 4 AWG cables because they are easier to route. Why is this substitution not acceptable?

A. The smaller gauge cables have a higher currentcarrying capacity that could overload the starter motor during cranking and cause armature damage

B. The 4 AWG cables are only suitable for alternating current circuits and cannot carry the direct current required for the starting system

C. The smaller cables would produce slightly more heat during cranking but the temperature rise is within the cable insulation's thermal rating

D. The 4 AWG cables have significantly higher resistance than 2/0 AWG — the increased resistance produces excessive voltage drop under the high cranking current, reducing voltage at the starter to a level that prevents adequate cranking speed

58. A technician is diagnosing a machine where the ECM intermittently loses power and resets during operation, causing momentary engine shutdown. The battery connections, fuse, and power wiring have been inspected and are tight and clean. What should be investigated next?

A. The ECM's internal power supply circuit — the ECM may have a failing internal voltage regulator or a cracked solder joint on the power input circuit board that opens intermittently under vibration or thermal cycling

B. The alternator output — intermittent voltage spikes from a failing diode may be corrupting the ECM's power input and causing it to reset as a selfprotection measure

C. The engine ground strap — intermittent ground continuity between the engine block and the frame causes the entire machine's electrical reference to shift during operation

D. The battery internal connections — an intermittent open inside the battery (failing cell strap) can cause a momentary total power loss that resets the ECM during vibration events

59. A technician is testing a pressure sensor with a known applied pressure and a DMM. The sensor specification states it produces 0.5V at 0 bar and 4.5V at 500 bar. The technician applies 250 bar of test pressure and reads 2.5V on the DMM. Is this reading correct?

A. No — the reading should be 3.75V at 250 bar because the sensor output is logarithmic, not linear, and the midpoint pressure does not produce the midpoint voltage

B. Yes — the sensor output is linear. The midpoint pressure (250 bar) produces the midpoint voltage (2.5V) — calculated as (0.5V + 4.5V) ÷ 2 = 2.5V

C. No — the correct reading at 250 bar should be 2.25V because the sensor output range starts at 0.5V, not 0V, which shifts the midpoint reading below the apparent halfscale value

D. Yes — but only if the sensor is powered by exactly 5.0V reference. Any variation in the reference voltage shifts the sensor output proportionally

60. A machine is equipped with a keypadoperated security system that allows only authorized personnel to start the engine. A technician needs to program a new operator code. The system requires the master code to be entered before new operator codes can be added. The fleet manager has lost the master code. What is the correct procedure?

A. Reset the security module by disconnecting the battery for 24 hours — this clears all programmed codes and restores the factory default master code

B. The master code can be extracted from the security module's memory using the OEM diagnostic software connected to the module's data port

C. Contact the OEM and follow their documentation — master codes cannot be recovered or generated in the field because this would compromise the security system's purpose

D. The OEM dealer can retrieve the master code using the machine serial number and the owner's verification of identity — the code is stored in the OEM's secure database and provided only to verified owners

61. A technician measures the voltage at a fuel level sender connector that is disconnected from the sender. With the ignition on, the reading is 5.0V between the signal wire and the ground wire. What does this reading confirm?

A. The ECM is providing a correct 5V reference voltage and ground to the sender circuit — the circuit wiring between the ECM and the sender connector is intact and ready for the sender to be reconnected

B. The fuel gauge is stuck at full because the 5.0V reading indicates maximum fuel level is being reported to the dashboard display

C. The fuel sender has failed in the maximumresistance (empty) position, causing the 5V reference to appear at the connector because no current is flowing through the sender

D. The ECM's internal fuel level calculation is malfunctioning and is outputting a fixed 5V signal that does not change regardless of the sender's resistance

62. A technician finds that an ECM connector has a bent pin that is making intermittent contact with the mating socket. The pin carries the engine coolant temperature sensor signal. What symptoms would this intermittent connection produce?

A. The engine runs at a constant temperature regardless of actual coolant temperature because the ECM uses a fixed default value when it detects an unstable sensor signal

B. The engine exhibits intermittent performance issues — erratic fan speed, fluctuating fuel trim, and inconsistent idle quality — as the ECM reacts to the random temperature signal produced by the makeandbreak contact

C. The ECM generates a continuous active DTC for the coolant temperature circuit that remains stored until the pin is straightened and the code is cleared

D. The engine shuts down immediately when the pin loses contact because the ECM cannot operate safely without a valid coolant temperature signal

63. A technician is reading a wiring schematic and encounters a symbol showing a normally open (NO) and normally closed (NC) contact pair controlled by a single relay coil. What does this symbol represent?

A. A singlepole doublethrow (SPDT) relay — it has one common terminal that switches between connecting to the NC terminal (when deenergized) and the NO terminal (when energized), allowing one relay to control two separate circuits

B. Two separate relays packaged in a single housing that must be controlled by two independent coil circuits for redundancy

C. A changeover relay that alternates between the NO and NC contacts at a fixed frequency to produce a pulsing output for the controlled circuits

D. A latching relay that stays in whichever position (NO or NC) it was last commanded to and does not return to a default state when the coil is deenergized

64. A machine has a circuit that uses a resistive (analog) fuel level sender wired to the ECM. The ECM processes the resistance signal and sends a digital fuel level value to the dashboard display over the CAN bus. The display shows the fuel level as "" (invalid). No DTCs are active. What is the most likely cause?

A. The sender resistance is at a value that the ECM cannot convert to a valid fuel level — the sender may be stuck between two positions and producing a resistance that falls outside the ECM's programmed valid range

B. The CAN bus data rate has been reduced by a network fault, and the fuel level data packet is the lowestpriority message that is being delayed beyond the display's timeout threshold

C. The dashboard display firmware does not support the fuel level message format that this ECM broadcasts, producing a compatibility error that displays as ""

D. The fuel level sender wire has a short to the 5V reference that produces a resistance reading below the ECM's zerobar minimum, which the ECM reports as an invalid reading to the display

65. A technician is measuring the resistance of a starter motor's field coils. The resistance should be 0.015 ohms. The technician's DMM reads 0.5 ohms. Before condemning the field coils, what should the technician consider?

A. The DMM leads themselves have a contact resistance that must be subtracted from the reading — at the low resistance values of starter field coils, the lead resistance can be a significant percentage of the total measured reading

B. The 0.5ohm reading confirms the field coils are open and must be replaced because the expected resistance is far below the measured value

C. The DMM's autoranging function may have selected the wrong range for the low resistance measurement, producing an inaccurate reading that does not reflect the actual coil resistance

D. The field coils must be disconnected from the starter housing ground before measuring to prevent the housing's resistance from being included in the measurement

66. A technician discovers a machine's wiring harness has been repaired previously using butt connectors crimped with household pliers and wrapped with electrical tape. The repair is in the engine compartment. What is wrong with this repair?

A. The electrical tape adhesive dissolves in engine oil, exposing the bare conductors to moisture and chemical attack that causes corrosion and eventual open circuit failure

B. Butt connectors crimped with noncalibrated tools may produce an insufficient crimp that creates a highresistance connection — combined with electrical tape that cannot seal against moisture, the repair will fail from corrosion, overheating, or intermittent contact

C. Butt connectors are prohibited by all OEMs in engine compartment repairs and must be replaced with solder joints wrapped in heatshrink tubing

D. Electrical tape cannot withstand the vibration environment of the engine compartment and will unravel within the first 100 operating hours regardless of the application method

67. A machine's ECM monitors the voltage of its own internal 5V reference supply as a selfdiagnostic function. If the internal reference drops to 4.2V, the ECM logs a reference voltage fault code. What causes the ECM to monitor its own reference?

A. If the 5V reference drops, all sensors sharing that reference produce proportionally incorrect readings — a 16% low reference produces 16% low readings on every sensor, which the ECM would interpret as valid but incorrect data without the selfcheck

B. The reference voltage monitoring provides a backup power measurement that the ECM uses to calculate the battery's state of health during operation

C. The reference monitoring detects when the alternator output exceeds the maximum charging voltage, which would damage the ECM's internal circuits

D. The reference monitoring provides the ECM with a temperature measurement of the internal circuit board, because the reference voltage decreases proportionally with increasing module temperature

68. A technician needs to verify the operation of an ECM output that controls a groundsideswitched relay. The technician commands the output on using the OEM diagnostic software while measuring voltage at the relay coil's ECMcontrolled terminal. The expected result is near 0V when commanded on and near battery voltage when commanded off. The actual result is 12.1V when commanded on and 12.4V when commanded off. What does this indicate?

A. The relay coil has an open circuit — the voltage at the ECM terminal is floating near battery voltage because no current path exists through the coil to the positive supply

B. The ECM output driver is functioning correctly and the relay coil is energized — the 0.3V difference between on and off states represents the voltage drop across the active driver

C. The ECM output driver has failed open — it cannot connect the terminal to ground when commanded, so the voltage remains near battery level in both commanded states

D. The relay coil's positive supply wire is disconnected — without a positive supply, the ECM ground command cannot pull current through the coil and the terminal reads near battery through the ECM's internal pullup circuit

69. A machine equipped with an electronic throttle has a throttle position sensor (TPS) that sends a variable voltage to the ECM. During a test drive, the technician monitors the TPS voltage with the diagnostic software. At full throttle, the reading is 4.5V. When the operator abruptly releases the throttle, the voltage drops instantly to 0.3V but then jumps to 1.8V before gradually settling at 0.8V (the idle position). What does the 1.8V transient indicate?

A. The TPS wiper has a momentary open contact zone between the fullthrottle and idle positions that produces the transient voltage spike as the wiper crosses the damaged section of the resistive track

B. The throttle linkage has a binding point that momentarily holds the throttle at a midrange position before releasing to the idle stop

C. The ECM is applying a signal conditioning filter that smooths the rapid voltage transition and produces the overshoot before stabilizing at the idle value

D. The TPS return spring is weak and allows the throttle lever to bounce off the idle stop before settling, producing the voltage transient that corresponds to the physical bounce

70. A technician is testing the alternator output of a 24V system using a carbon pile load tester. The test procedure requires loading the alternator to its rated output and measuring the voltage. The technician applies the carbon pile until the ammeter reads the alternator's rated current. The voltage reads 25.2V during the test. What is the correct interpretation?

A. The alternator is overcharging and the voltage regulator needs replacement because 25.2V exceeds the 24V nominal system voltage

B. The alternator is producing its rated current at 25.2V, which is below the typical 27.5–28.5V charging voltage specification for a 24V system — the alternator is not performing correctly and requires further diagnosis of the regulator, stator, or rotor

C. The alternator is performing correctly — 25.2V at rated load is within the acceptable range for a 24V charging system under maximum current output conditions

D. The test is invalid because the carbon pile was applied while the engine was running, which loads both the alternator and the batteries simultaneously

71. A technician discovers that a previous repair has spliced a 16 AWG wire into a circuit that was originally 10 AWG. The splice is in a section that feeds a 30ampere hydraulic solenoid valve circuit. What hazard does this create?

A. The 16 AWG wire can only safely carry approximately 10–15 amperes continuously — at 30 amperes, the wire will overheat, melt the insulation, and potentially cause an electrical fire

B. The undersized wire produces a minimal voltage drop that is within acceptable limits for most 24V heavy equipment circuits

C. The 16 AWG splice reduces the circuit's maximum voltage to the wire's rated voltage, which is lower than the 10 AWG wire's rating

D. The undersized wire acts as a fusible link that protects the circuit from overcurrent — the 16 AWG section will melt before the 30ampere fuse blows

72. A torque converter's stall test reveals the engine reaches only 1,800 RPM. The OEM stall speed specification is 2,100–2,200 RPM. Engine performance has been independently verified as correct. What does the low stall speed indicate?

A. The torque converter is oversized for the engine — the fluid coupling resistance is higher than the engine's torque output can overcome, holding the RPM below specification

B. The transmission oil is too thick — elevated viscosity from cold oil or incorrect oil grade creates excessive resistance in the converter that the engine cannot overcome

C. The torque converter stator oneway clutch is locked (functioning correctly but the converter design produces a naturally lower stall for this engine) and the specification is for a different engineconverter pairing

D. Nothing is wrong — stall speed below specification with a verifiedgood engine simply confirms the converter is in good condition and is resisting the engine more effectively than minimum specification

73. A powershift transmission shifts from 1st to 2nd gear with a noticeable delay — the engine RPM flares for approximately 2 seconds before 2nd gear engages. All other shifts are smooth with no flare. What is the most likely cause?

A. The 2nd gear clutch circuit has a hydraulic leak or slow fill condition — the clutch piston requires longer than normal to fill the apply chamber and build engagement pressure, producing the delay between release of 1st and engagement of 2nd

B. The transmission governor is generating an incorrect speed signal that delays the shift command for the 1stto2nd transition in the valve body

C. The torque converter lockup clutch is attempting to engage during the 12 shift and the resistance is slowing the clutch apply circuit's pressure build rate

D. The transmission oil cooler has a restriction that limits the total flow available to the clutch apply circuits, but the effect is only noticeable on the 12 shift because it requires the highest fill volume

74. A technician is investigating a vibration complaint on a machine with a twopiece driveshaft connected by a centre support bearing. The vibration is present at all speeds above 10 km/h and worsens with speed. The Ujoints and phasing are confirmed correct. What should be checked next?

A. The driveshaft tubes — a dent or damage to either tube shifts the rotating mass offcentre, producing an imbalance vibration proportional to speed

B. The transmission output shaft spline — a worn spline allows the front driveshaft section to orbit offcentre at all speeds above the vibration threshold

C. The centre support bearing mount — if the rubber isolator has deteriorated, the bearing housing can move under centrifugal force, introducing a wobble that worsens with speed

D. The centre support bearing rubber isolator — a deteriorated, collapsed, or broken isolator allows the bearing housing to shift, introducing misalignment between the two shaft sections that produces speedproportional vibration

75. A wheel loader differential makes a howling noise during loaded acceleration in forward that disappears during coast (decelerating). The noise is not present in reverse. What does this symptom pattern indicate?

A. The ring gear teeth are worn or damaged on the drive (convex) side, which is loaded during forward acceleration — the coast (concave) side is loaded during deceleration and reverse, and its surfaces are still serviceable

B. The ring and pinion gear set has a driveside tooth contact pattern concentrated at the heel, causing the howling noise during forward load that disappears when the load shifts to the coast side during deceleration

C. The pinion bearings are worn and allowing the pinion to shift under the forward drive load, changing the gear mesh alignment — the bearings center correctly under coast load due to the reversed force direction

D. The differential carrier is cracked on one side, allowing the ring gear to flex under forward load and produce the howl — the crack closes under coast load and the noise disappears

76. A machine's automatic transmission has a line pressure test port. The technician measures line pressure at idle in neutral and obtains a reading 30% below the OEM specification. What is the most common cause of low line pressure?

A. The transmission oil level is overfilled, causing the pump to aerate the oil and lose pumping efficiency from the entrained air

B. The torque converter lockup clutch is slipping, creating a secondary flow path that bleeds pressure from the main circuit

C. The transmission pump is worn and has lost volumetric efficiency, or the pressure regulator valve is stuck in a position that dumps excess oil to the sump — both conditions reduce the pressure available to the clutch apply circuits

D. The transmission oil cooler is bypassing oil to the sump through a stuck bypass valve, reducing the available volume in the main pressure circuit

77. A machine uses a fullfloating rear axle design. The technician needs to remove the rear wheel for tire service. After removing the wheel nuts and the wheel, the axle shaft is still in place. How is the axle shaft removed on a fullfloating design?

A. The axle shaft is retained by a flange bolted to the hub at the outer end — removing the flange bolts allows the shaft to be pulled straight out of the axle tube independently of the hub and wheel

B. The axle shaft is pressfit into the hub bore and requires a hydraulic puller to extract it from the hub after the wheel is removed

C. The axle shaft and hub are removed as an assembly by pulling the entire hub off the spindle after releasing the bearing lock nut

D. The axle shaft is retained by an internal Cclip at the differential carrier end and can only be removed by pulling the differential cover and removing the clip

78. A hydrostatic drive machine produces a whining noise from the drive pump that increases with engine RPM but does not change with the drive control position. The charge pressure is within specification. What is the most likely cause?

A. The pump's servo pistons are worn, allowing the swashplate to vibrate at high speed and produce the whining noise independent of displacement

B. The pump's case drain filter is clogged, creating internal backpressure that produces the audible whining as oil is forced through the restricted path

C. The drive motor has an internal failure that creates a pressure pulse in the loop that transmits back to the pump as an audible vibration through the fluid

D. The pump has a worn or damaged bearing, cracked piston, or scored barrel/valve plate that produces mechanical noise proportional to pump speed regardless of the pump's displacement setting

79. A technician is rebuilding a clutch assembly on a heavy equipment machine. The pressure plate fingers are measured for height and found to be uneven — varying by 1.5 mm across the set. The OEM maximum allowable variation is 0.5 mm. What is the consequence of installing this pressure plate?

A. The uneven fingers produce uneven clutch release travel across the disc, which causes the clutch to drag (not fully disengage) on the low side while overreleasing on the high side

B. The uneven fingers have no operational effect because the release bearing selfadjusts to contact all fingers simultaneously regardless of height variation

C. The uneven fingers cause the release bearing to contact only the highest fingers, producing a rocking motion that accelerates release bearing wear and produces a cyclical grabandrelease clutch chatter

D. The uneven fingers increase the required pedal effort because the release bearing must deflect the highest fingers further before all fingers contact the bearing face simultaneously

80. A machine's final drive produces a clunking noise at low speed during directional changes (forward to reverse). The noise is a single distinct clunk rather than a continuous grinding or whining. What is the most likely cause?

A. The final drive planetary gear teeth are chipped and produce an impact noise when the chipped tooth engages during each revolution at low speed

B. Excessive backlash in the final drive gear train — when the drive direction reverses, the gears must travel through the backlash gap before engaging in the new direction, producing the single distinct clunk

C. The final drive mounting bolts have loosened, allowing the entire drive assembly to shift on the frame when the drive direction reverses

D. The drive motor shaft spline has worn and the clearance between the motor shaft and the planetary input produces the impact during directional reversal

81. A wheel loader's torque converter is being replaced. The technician installs the new converter and bolts it to the flywheel. Before connecting the transmission, the technician should verify one critical convertertoflywheel relationship. What must be checked?

A. The converter pilot must be fully seated in the flywheel bore and the converter must be free to rotate — if the converter is not fully engaged on the transmission pump hub and pilot, bolting the transmission to the engine will damage the pump

B. The converter flywheel bolt pattern must match the flywheel exactly — a mismatched bolt pattern will crack the converter flex plate during the first torque load

C. The converter drain plug must face downward at the 6 o'clock position to ensure complete oil drainage during future transmission service events

D. The converter balance weight must be aligned with the flywheel's timing mark to maintain the engine's crankshaft balance during operation

82. A technician is diagnosing an automatic transmission that shifts correctly from 1st to 2nd and 2nd to 3rd, but will not shift into 4th gear (overdrive). The transmission operates normally in all other respects. What should be checked?

A. The governor — a faulty governor that underreports output shaft speed will prevent the shift valve from opening at the speed threshold required for the 34 shift

B. The torque converter lockup clutch — if the lockup has failed, the TCM may be programmed to inhibit the 4th gear shift because overdrive requires lockup for efficiency

C. The main pressure regulator — if main pressure is slightly low, the 4th gear clutch may not receive adequate apply pressure to engage, but the lower gears still function because they require less pressure

D. The 4th gear shift solenoid, the 4th gear clutch apply circuit, or the overdrive clutch pack itself — an isolated failure to shift into a single gear range points to a component specific to that gear's engagement circuit

83. A machine equipped with a wet disc service brake produces a grinding metallic noise during every brake application. The brake was recently serviced with new friction discs. What is the most likely cause?

A. The new friction discs were installed without soaking them in brake oil before assembly, causing dry metaltometal contact during the initial applications

B. The new friction discs are an incorrect specification — the wrong material, thickness, or spline profile is causing interference with the separator plates during application

C. The separator plates (steel reaction plates) were not inspected during the friction disc replacement — a scored, warped, or damaged separator plate creates metaltometal contact with the new discs

D. The brake housing bore has rust pitting that is catching the new friction disc tangs during application, preventing the discs from sliding freely in the housing

84. A technician notices that a driveshaft universal joint on one side of a machine has been fitted with a grease zerk, while the opposite side Ujoint has no zerk (it is a sealed, nongreaseable design). Can different Ujoint styles be used on opposite ends of the same driveshaft?

A. Yes — but only if both joints are from the same manufacturer, which ensures the bearing cap material and cross spider hardness are matched for identical wear rates

B. Yes — greaseable and sealed Ujoints are interchangeable as long as both meet the same load rating and dimensional specifications for the application

C. No — both joints must be the same type to ensure identical performance characteristics, because a sealed joint has different torsional stiffness than a greaseable joint

D. No — mixing joint types on the same shaft creates a maintenance inconsistency that virtually guarantees one joint will be serviced incorrectly during routine maintenance

85. A tracktype machine uses a steering clutch and brake system. The operator reports the machine turns left normally but turns right sluggishly and requires more lever effort. What is the most likely cause on the right side?

A. The right track final drive has an internal hydraulic restriction that limits the maximum speed of the right track during straight travel and turning

B. The right steering clutch friction discs are worn or glazed — the clutch does not fully disengage when the right turn is commanded, causing the right track to continue driving partially during the turn and resisting the turn direction

C. The right track tension is set significantly tighter than the left, creating higher rolling resistance that the steering system must overcome during the right turn

D. The right steering brake is not applying fully — the brake cannot stop the right track to complete the turn, and the reduced braking force produces the sluggish, higheffort turn

86. A technician is replacing a chain in a chaindriven final drive. The old chain pitch elongation measured 4.5% against a 3% service limit. The sprockets are at 65% wear. Should the sprockets be replaced with the chain?

A. Yes — installing a new chain (with zero pitch elongation) on worn sprockets causes accelerated chain wear because the sprocket tooth profile no longer matches the new chain's pitch, and the mismatch concentrates loading on fewer teeth

B. No — the sprockets are only at 65% wear and have significant remaining life that would be wasted by premature replacement with the chain

C. Yes — but only the drive sprocket requires replacement; the driven sprocket can remain in service because it carries less load than the drive sprocket

D. No — the sprockets and chain wear together as a matched set, and replacing the chain alone allows the sprockets to continue wearing at their established rate

87. A powershift transmission uses a sump magnet to capture ferrous particles from the oil. During a scheduled service, the technician removes the magnet and finds a heavy accumulation of fine metallic paste covering the entire magnet surface. What does this indicate?

A. The accumulation is normal — the magnet is performing its function by capturing the fine ferrous wear particles generated during normal clutch pack and gear operation over the service interval

B. The heavy accumulation indicates the filter bypass valve has been open, allowing unfiltered oil to circulate and deposit all captured particles on the magnet instead of the filter

C. The heavy metallic paste indicates abnormal internal wear — the quantity exceeds normal accumulation and the transmission should be evaluated through oil analysis and further inspection before returning to service

D. The metallic paste is residue from the magnetic drain plug's own surface coating that degrades over time and is not actual wear debris from internal transmission components

88. A machine equipped with a mechanical shuttle (directional) shift between forward and reverse produces a harsh engagement when the operator shifts from forward to reverse at 5 km/h. The service manual states the machine should be brought to a complete stop before shifting direction. Why does the manual require a full stop?

A. The transmission oil pump cannot reverse flow direction while the machine is moving, and the reversed flow damages the pump's internal check valves

B. The forwardtoreverse shift at speed forces the directional clutch pack to absorb the full kinetic energy of the moving machine — this energy is converted to heat in the clutch, producing the harsh engagement and accelerating clutch wear far beyond what the clutch is designed to sustain

C. The mechanical shuttle linkage can only engage the reverse idler gear when the transmission output shaft is stationary — engaging at speed damages the idler gear teeth

D. The hydraulic brake system is interlocked with the directional shift and cannot apply during a rolling direction change, leaving the machine without braking during the transition

89. A technician is evacuating an A/C system and the vacuum pump has been running for 30 minutes. The gauge reads 800 microns. The OEM specification requires evacuation to below 500 microns. What should the technician do?

A. Close the manifold valves and begin charging — 800 microns is close enough to the 500micron target and the remaining moisture is insignificant

B. Replace the vacuum pump — a pump that cannot reach 500 microns after 30 minutes is worn and cannot generate adequate vacuum for proper moisture removal

C. Add 50 ml of fresh vacuum pump oil to the pump — low oil level is the most common cause of a vacuum pump that cannot reach deep vacuum levels

D. Continue evacuating — the system may have residual moisture that is boiling off under the vacuum and requires additional time. If the vacuum does not progress below 500 microns, inspect for a leak or excessive moisture source

90. A machine's A/C compressor clutch engages when commanded by the ECM but the system produces no cooling. The manifold gauges show equal pressure on both the high and low sides when the compressor is running. What does this indicate?

A. The compressor has failed internally — the piston, scroll, or vane mechanism is not compressing the refrigerant, so no pressure differential develops between the high and low sides despite the clutch spinning the compressor shaft

B. The system has been overcharged and the excess refrigerant has equalized the pressure between both sides of the circuit

C. The expansion valve is stuck fully open, allowing free flow between the high and low sides and equalizing the pressure during operation

D. The compressor drive belt is slipping on the clutch pulley and the compressor shaft is not actually rotating despite the clutch being engaged

91. An operator reports that the A/C system cools well initially but after 20 minutes of operation, the cooling capacity gradually diminishes until the system is producing only slightly cool air. Shutting the A/C off for 10 minutes and restarting it restores full cooling for another 20 minutes. What is the most likely cause?

A. The condenser fan is cycling off after 20 minutes due to a defective fan relay, causing the highside pressure to rise until the highpressure switch cuts the compressor out

B. The compressor is overheating after 20 minutes of operation due to insufficient oil charge, and the internal clearances increase from thermal expansion until the compression ratio drops to near zero

C. The evaporator is gradually icing over during operation due to a failed evaporator thermostat or pressure cycling switch — the ice blocks airflow through the evaporator until the system is shut off and the ice melts

D. The receiverdrier desiccant is saturated and is releasing captured moisture back into the refrigerant after 20 minutes, causing ice formation at the expansion valve that restricts refrigerant flow

92. A technician is adding refrigerant to an A/C system using a charging scale. The system specification is 2,200 grams of R134a. The scale reads 2,200 grams removed from the refrigerant container. However, the sight glass still shows bubbles. What should the technician do?

A. Add additional refrigerant beyond the specified charge until the bubbles disappear from the sight glass — the sight glass is the definitive charge indicator

B. Trust the scale — the correct charge weight has been installed per the OEM specification. Bubbles in the sight glass may persist briefly until the system stabilizes, or may indicate a restriction elsewhere in the circuit that is not related to charge level

C. Remove 200 grams of the charge and reweigh — the bubbles indicate the system has been slightly overcharged and removing a small amount will eliminate the bubbles

D. Recover the entire charge, pull a fresh vacuum, and recharge from empty — the bubbles indicate air was introduced during the charging process and the entire charge is contaminated

93. A machine's cab heater uses engine coolant as its heat source. The operator reports the heater takes 15 minutes to produce warm air after starting the engine on a cold morning. The engine reaches operating temperature within 5 minutes. The heater hoses are both hot after 5 minutes. What is the most likely cause of the delayed heat?

A. The heater core is partially restricted and cannot transfer heat to the air passing through it as efficiently as a clean core, requiring longer to warm the cab air to a noticeable temperature

B. The heater blower motor is running at maximum speed from startup, moving too much cold cab air across the heater core too quickly for the core to warm it noticeably — the operator perceives the output as cold until the cab air temperature rises

C. The thermostat is opening too early and directing coolant to the radiator before it is fully heated, reducing the temperature of coolant reaching the heater core

D. The cab's thermal mass (metal, glass, insulation) absorbs the initial heat output without producing a noticeable temperature rise — the operator perceives no warmth until the cab structure itself has absorbed enough energy to stop being a heat sink

94. A technician services the cab air filtration system on a machine operating in a silica dust environment. The HEPArated cabin filter is replaced with a standard particulate filter because the HEPA filter is not available from the parts supplier. What risk does this substitution create?

A. Standard particulate filters produce more airflow restriction than HEPA filters, which will cause the cab pressurization fan to overheat from the increased backpressure

B. Standard particulate filters capture the same particle sizes as HEPA filters but have a shorter service life, requiring more frequent replacement

C. The standard filter cannot provide adequate positive cab pressure and the pressurization system will not function until the correct HEPA element is installed

D. A standard particulate filter does not capture particles in the respirable silica size range — the operator is exposed to crystalline silica dust that the HEPA filter would have removed, creating a serious respiratory health hazard

95. A machine's A/C system uses R1234yf refrigerant. The technician recovers the refrigerant using an R134a recovery machine because the shop does not have a dedicated R1234yf machine. Is this acceptable?

A. Yes — R134a and R1234yf are chemically compatible and use the same recovery equipment, fittings, and procedures without any crosscontamination risk

B. Yes — but only for recovery (extraction from the system). The same machine must not be used for recharging R1234yf because the residual R134a in the machine's hoses will contaminate the new charge

C. No — R1234yf must be recovered with a dedicated certified machine. Crosscontamination of recovery equipment between refrigerant types contaminates the recovered refrigerant, damages equipment seals rated for different chemistries, and violates environmental regulations

D. No — but only because R1234yf is flammable and the R134a recovery machine's pump is not rated for flammable refrigerant. If the pump were explosionproof, the machine could be shared between refrigerant types

96. A machine equipped with a dieselfired coolant heater has the heater programmed to start automatically at 4:00 AM and run for 2 hours before the operator arrives at 6:00 AM. The heater warms the engine coolant, which circulates through the engine block and heater core. What is the primary benefit of this preheat cycle?

A. The preheat cycle charges the batteries by running the alternator for 2 hours before the operator arrives, ensuring maximum CCA is available for cold starting

B. The preheated engine coolant warms the block and cylinders, improving coldstart reliability and reducing the wear that occurs during the first minutes of cold engine operation when oil viscosity is highest and clearances are tightest

C. The preheat cycle circulates coolant to prevent the cooling system from freezing during the overnight period, protecting the block and radiator from freeze damage

D. The preheated cab provides operator comfort from the first minute of the shift, eliminating the 15minute warmup wait that reduces productive work time

97. A machine's air conditioning system has been diagnosed with an internal compressor failure that has distributed metallic debris throughout the circuit. The technician replaces the compressor, receiverdrier, and expansion valve, and thoroughly flushes all other components. What additional component should be inspected or replaced before the system is reassembled?

A. The condenser — metallic debris from the compressor may be trapped in the condenser tubes and baffles where the flushing process cannot fully reach, and this debris will reenter the circuit and destroy the new compressor

B. The evaporator — the evaporator's internal baffles and narrow passages are the most likely location for trapped debris that resists flushing

C. The suction line hose — the largediameter suction hose between the evaporator and compressor is the most common debris accumulation point after a compressor failure

D. The discharge hose — the metallic debris is carried by the highpressure oil from the compressor discharge and accumulates at the first restriction point in the discharge line

98. A hydraulic system has a pump that delivers 100 L/min to a cylinder with a 100 mm bore. How fast will the cylinder extend? (Piston area = 78.5 cm^2 = 0.00785 m^2; 100 L/min = 0.1 m^3/min)

A. 1.27 m/min — calculated by dividing the flow rate in m^3/min by the piston area in m^2 (0.1 ÷ 0.0785 = 1.27 m/min), which converts to approximately 12.7 m/min

B. The cylinder extends at approximately 12.7 m/min — calculated as flow rate (0.1 m^3/min) divided by the piston area (0.00785 m^2) = 12.74 m/min extension speed

C. 7.85 m/min — calculated by multiplying the piston area by the flow rate rather than dividing, producing an incorrect speed value

D. 100 m/min — assuming 1 litre of flow produces 1 metre of cylinder travel regardless of bore diameter

99. A hydraulic system's main relief valve is set at 280 bar. During loaded operation, the system pressure reaches 280 bar and the implement stalls — the cylinder stops moving. The operator reports this happens frequently during normal digging operations. What adjustment should be investigated?

A. The relief valve should be increased to 350 bar to provide more force for the digging operations that are currently stalling the cylinder

B. The pump displacement should be increased to provide more flow, which will allow the cylinder to continue moving at pressures above the current relief setting

C. The operator should be trained to reduce the digging force to prevent the system from reaching relief pressure, as operating at full relief is a normal system limitation

D. The relief valve setting should be compared to the OEM specification — if 280 bar is the correct setting, the system is functioning as designed and the operator is exceeding the machine's rated digging force

100. A hydraulic cylinder that operates normally during manual control drifts when placed in a float position. The float circuit is designed to allow the cylinder to move freely in both directions by connecting both cylinder ports to the tank. Is the drift normal in float mode?

A. No — a cylinder in float mode should hold its position because the float circuit still maintains a pressure lock on both cylinder ports

B. No — the float circuit is malfunctioning because it should only allow the cylinder to move in one direction (extend) while blocking movement in the other direction (retract)

C. Yes — float mode connects both cylinder ports to the tank, removing all hydraulic holding force. The cylinder is free to move in either direction under external forces such as gravity or ground contact forces

D. Yes — but only if the float mode is activated with the engine running. With the engine off, the float circuit locks both ports to prevent uncontrolled movement

101. A technician is troubleshooting a hydraulic system where the pump makes a loud rattling noise and the oil in the reservoir appears foamy with visible air bubbles on the surface. What is the primary cause of these symptoms?

A. Air is being drawn into the hydraulic system through the pump inlet — a loose suction fitting, cracked suction hose, low oil level, or failed pump shaft seal is allowing atmospheric air to enter the circuit and aerate the oil

B. The hydraulic oil has reached its flash point and is beginning to vaporize inside the reservoir, producing the visible bubbles and the pump noise from the vapour pockets

C. The return line filter is so restricted that it is creating a vacuum in the return line that pulls dissolved air out of the oil as it passes through the filter element

D. The pump's internal relief valve is chattering at a high frequency, which aerates the oil passing through the relief port and creates the visible bubbles in the reservoir

102. A wheel loader's hydraulic system uses a variabledisplacement piston pump with a pressure compensator. The operator reports the boom raises more slowly than normal during loaded operation. System pressure at the pump outlet reads 250 bar — which is at the compensator setting. What does this tell the technician?

A. The pump is producing maximum pressure and has destroked to minimum displacement because the compensator has activated — the pump cannot produce more flow at this pressure, indicating the system is at its designed capacity limit

B. The pump compensator is functioning correctly — the slow boom speed at 250 bar indicates the load is at the system's maximum capacity and the pump is operating as designed at its pressurelimited minimum displacement

C. The pump compensator may be set too low — if the OEM specification is higher than 250 bar, the pump is destroking prematurely, limiting the available flow below the system's designed capacity for loaded boom raise

D. The pump has lost displacement capacity due to internal wear — the compensator is activating at 250 bar but the pump's actual maximum displacement is less than its rated specification

103. A hydraulic system includes a heat exchanger (oil cooler) that uses engine coolant to cool the hydraulic oil. The technician notices the hydraulic oil temperature has been running 15°C higher than normal. The engine cooling system temperature is correct. What should be checked?

A. The hydraulic system's relief valve — a relief valve that is cracking open prematurely dumps flow at reduced pressure, generating less heat than full relief but still more than normal operation

B. The engine thermostat — a thermostat opening at a higher temperature than specified reduces the coolant's ability to cool the hydraulic oil in the heat exchanger

C. The hydraulic oil level — a low oil level reduces the system's total thermal mass, causing the smaller oil volume to heat up faster during normal operation

D. The hydraulic oil cooler — internal fouling, external contamination, or reduced coolant flow through the cooler reduces its heat transfer capacity and allows the hydraulic oil temperature to rise above normal

104. A hydrostatic transmission exhibits a "neutral drift" — the machine creeps slowly forward when the control is in the neutral position. The technician adjusts the neutral position using the mechanical neutral adjustment on the pump servo. After adjustment, the drift stops. What was the cause?

A. The charge pump was producing excessive flow that pressurized the forward side of the loop above the neutral threshold

B. The hydrostatic pump's control valve servo linkage had shifted slightly, positioning the swashplate offcentre so a small forward displacement existed even with the control in neutral

C. The forward crossport relief valve was set lower than the reverse relief, creating a pressure imbalance that drove the motor slowly in the forward direction

D. The drive motor had excessive internal leakage on the return side, creating a vacuum that drew the motor forward against the resistance of the stalled pump

105. An air brake system's compressor develops a knocking noise during the loaded (pumping) phase and the noise disappears during the unloaded phase. What is the most likely cause?

A. The compressor drive belt is slipping during the loaded phase when the compressor resistance increases, producing a rhythmic knocking as the belt grabs and slips

B. The compressor has a worn piston, cracked connecting rod, or damaged valve plate component that produces mechanical impact noise under the compression load — the noise disappears in the unloaded phase because the cylinders are not compressing air

C. The governor is rapidly cycling between loaded and unloaded states, and the pressure pulsation from the cycling produces the knocking noise

D. The air dryer purge valve is opening prematurely during the loaded phase, creating a backpressure wave that causes the compressor discharge valve to chatter

106. A technician is performing a hydraulic system oil change. The reservoir holds 200 litres. After draining the reservoir and refilling it with 200 litres of new oil, the technician checks the oil level and finds it is correct. However, approximately how much of the system's total oil volume has actually been changed?

A. Only the reservoir volume has been changed — a significant portion of the total system oil remains in the cylinders, hoses, motors, cooler, filter housings, and valve bodies, which were not drained. The actual exchange may be only 50–60% of the total system volume

B. 100% of the system oil has been changed because draining the reservoir creates a vacuum that draws all oil from the connected circuits back into the reservoir during draining

C. Approximately 90% has been changed — the remaining 10% is trapped in the return line filter housing and cannot be drained without removing the filter

D. The complete system volume has been exchanged because all hydraulic lines slope back to the reservoir and gravity drains them completely when the reservoir drain plug is removed

107. A pneumatic system's service reservoir has a manual drain valve that the operator opens during the pretrip inspection. When the valve is opened, a large burst of water comes out along with the air. What does this indicate?

A. The air dryer is functioning correctly — it is capturing atmospheric moisture during the compression cycle and depositing it in the wet tank, which then transfers it to the service reservoir during normal system cycling

B. The reservoir's internal corrosion has produced condensation that has accumulated from the rusted metal surfaces reacting with the compressed air moisture

C. The air dryer is failing to remove adequate moisture from the compressed air — the large volume of water in the service reservoir (which should be dry) indicates moisture is passing through the dryer and accumulating downstream

D. The air dryer is functioning correctly — the water in the service reservoir is condensation that forms on the interior walls of the cold metal tank during overnight temperature drops and is unrelated to the air dryer's performance

108. A hydraulic excavator's main pump is a variabledisplacement axial piston pump. The pump's loadsensing controller maintains system pressure at the highest active circuit pressure plus a 20bar margin (LS differential). The technician measures the LS differential at only 8 bar during loaded operation. What is the consequence?

A. The 8bar differential produces excessive pump displacement, causing all functions to operate faster than designed and consuming more engine power than necessary

B. The 8bar differential has no operational consequence — the LS differential only affects standby pressure and does not influence working pressure or actuator speed

C. The reduced LS differential means the pump is only 8 bar above the load pressure — this reduced margin limits the available flow to the actuators, causing all functions to operate more slowly than normal because the pump cannot produce adequate excess flow

D. The 8bar differential causes the pump to maintain constant pressure regardless of load, eliminating the loadsensing function and converting the system to a pressurecompensated mode

109. A hydraulic motor driving a conveyor belt operates at 150 RPM when unloaded but drops to 120 RPM when the conveyor is fully loaded. The system pressure increases from 80 bar to 200 bar under load. What explains the speed reduction?

A. The hydraulic oil temperature increases under load, which reduces the motor's mechanical efficiency and causes it to rotate slower at the same flow rate

B. The pump's volumetric efficiency decreases at higher pressure — more fluid bypasses internally at 200 bar than at 80 bar, reducing the actual flow delivered to the motor and therefore reducing its speed

C. The motor's displacement automatically increases under higher pressure to produce more torque, consuming more flow per revolution and reducing speed at the same pump output

D. The flow control valve upstream of the motor is pressurecompensated and reduces flow proportionally as system pressure increases to protect the motor from overspeed damage

110. A technician is troubleshooting a hydraulic cylinder that retracts normally but extends very slowly. The DCV spool has been checked and moves freely. System pressure and pump flow are within specification. What component specific to the extend circuit should be investigated?

A. The check valve or restrictor in the capend supply line — a partially blocked or stuck check valve limits the flow entering the cap end during extension, while the unrestricted rodend return line allows normal retraction

B. The cylinder's piston seals — if the seals are worn, the cylinder would drift under load and operate slowly in both directions, not just during extension

C. The counterbalance valve in the return line — if the counterbalance valve is set too high, it restricts the oil leaving the rod end and slows the extension, but the same valve does not affect retraction flow

D. The pilotoperated check valve in the rodend line — if the POCV is not opening fully during extension, it restricts the flow leaving the rod end and limits extension speed while having no effect on retraction

111. A hydrostatic drive system is equipped with a "limp home" feature that activates when the electronic displacement control (EDC) fails. In limphome mode, what typically happens?

A. The engine shuts down automatically to protect the hydrostatic system from damage that would result from uncontrolled pump displacement

B. The pump defaults to maximum forward displacement, providing fullspeed forward drive that cannot be controlled until the vehicle reaches the shop

C. The pump defaults to a fixed reduced displacement that provides limited forward travel at reduced speed — enough to move the machine to a service location but not for productive work

D. The pump displacement is controlled by the backup mechanical lever that the operator must manually position to command forward or reverse travel

112. An air brake system's ABS warning light illuminates during a test drive when the machine reaches approximately 10 km/h. The light was not on during the initial system powerup selftest. What does this indicate?

A. The ABS control module detected a fault during dynamic testing — a wheel speed sensor may be producing an erratic signal that only becomes apparent when the wheels are rotating above a minimum threshold

B. The ABS selftest is programmed to occur at 10 km/h and the illuminated light indicates the selftest is in progress, not that a fault exists

C. The ABS accumulator has lost its precharge and cannot generate the modulating pressure required for antilock braking at vehicle speeds above the minimum threshold

D. The ABS system has detected a difference in wheel speeds between the left and right sides that exceeds its tolerance — this indicates a tire size mismatch or an incorrect tire on one position

113. A hydraulic pump test produces the following results: theoretical flow at test RPM = 120 L/min; measured flow at 0 bar = 118 L/min; measured flow at rated pressure (280 bar) = 100 L/min. Calculate the overall efficiency and determine the pump condition.

A. Overall efficiency is 97% — the pump is in excellent condition and will provide many more hours of service before any maintenance is needed

B. The volumetric efficiency at rated pressure is 83.3% (100 ÷ 120 = 0.833), which is below the typical minimum of 85% for a healthy pump — the pump is approaching end of serviceable life and should be scheduled for rebuild

C. The pump is performing above specification because the 0bar flow of 118 L/min is within 2% of the theoretical maximum, confirming the pump displacement is correct

D. The overall efficiency cannot be determined from a flow test alone — a pressure test with a calibrated gauge is also required to calculate the true overall efficiency percentage

114. A hydraulic system uses a pilotoperated pressurereducing valve to provide a constant 35bar supply to a brake accumulator circuit. The valve's pilot section uses a small orifice to sense downstream pressure. If this pilot orifice becomes partially blocked, what symptom will occur?

A. The valve will produce erratic downstream pressure because the blocked orifice slows the valve's response to pressure changes in the accumulator circuit

B. The valve will lock open, delivering full system pressure to the accumulator circuit because the blocked orifice prevents the pilot signal from reaching the valve spool

C. The valve will produce a gradual increase in downstream pressure above 35 bar because the reduced pilot flow through the blocked orifice causes the valve to respond sluggishly to the rising pressure

D. The valve will close completely, cutting off all flow to the accumulator circuit because the blocked pilot orifice traps pressure on the spring side of the spool

115. An air brake system equipped with spring brakes has an auxiliary air supply connection point on each spring brake chamber. What is the purpose of this connection?

A. It provides a port for connecting an external air supply to release the spring brakes when the machine's onboard air system has failed and the brakes cannot be released for towing

B. It provides a test port for measuring the spring brake application pressure during a brake system performance test

C. It provides a connection for the spring brake modulator valve that controls the proportional application of the spring brakes during emergency braking

D. It provides a mechanical release point for caging the spring using a caging bolt when the chamber must be removed for service — the air port is used for access, not for air supply

116. A technician is checking the hydraulic system's fluid condition and notices the oil has a dark brown colour and a strong burnt smell. The oil analysis report shows oxidation levels above the OEM maximum specification. What does this indicate?

A. The oil has been subjected to excessive heat for an extended period — the high temperature has broken down the base oil and additive package through oxidation, forming acids and varnish that damage components and clog filters

B. The dark colour is from normal diesel fuel contamination that has entered the hydraulic system through a failed enginetohydraulic pump seal

C. The strong smell is from biological contamination — bacteria or fungal growth in the reservoir has degraded the oil and produced the odour

D. The oil has been contaminated with coolant from a failed hydraulic oil cooler, which produces the dark colour and burnt smell when heated to operating temperature

117. A hydraulic system's DCV has a float detent position for the blade circuit on a motor grader. When the operator places the spool in float, the blade rests on the ground and follows the terrain contour. The technician notices the blade bounces excessively when the machine travels over undulations at moderate speed. What is the most likely cause?

A. The float detent mechanism is worn and is not holding the spool in the true float position, allowing it to shift toward a partial raise or lower position during the bouncing motion

B. The hydraulic oil viscosity is too high, creating damping resistance in the cylinder that delays the blade's response to terrain changes and causes it to oscillate rather than follow smoothly

C. The blade is too heavy for the float circuit's capacity — the weight of the blade compresses the oil in the cylinder faster than the float circuit can evacuate it, creating a rebound effect

D. The hydraulic cylinders are too stiff at the operating pressure — there is no accumulator or dampening mechanism in the blade circuit to absorb the vertical acceleration forces during travel, causing the blade to bounce rather than float smoothly

118. A machine's hydraulic return line has a temperaturesensing oil sampling port. The technician draws a sample from this port and sends it to the analysis laboratory. The results show the oil condition is good, but the particle count is significantly higher than the previous sample despite the filter being recently changed. What is the most likely explanation?

A. The new filter element is a different brand with a coarser micron rating than the original, allowing more particles to pass through untrapped

B. A component upstream of the return line filter is generating wear debris at an increased rate — the new filter is capturing its rated particle size, but the incoming contamination rate exceeds the filter's capacity between service intervals

C. The sample was drawn from a port upstream of the return filter, so the analysis reflects the prefiltered condition of the oil rather than the system's overall cleanliness

D. The sampling technique introduced contamination — the port cap was not cleaned before the sample was drawn, and external dirt entered the sample bottle with the first flush of oil

119. A hydrostatic drive machine is equipped with a highpressure filter in each loop line between the pump and motor. One filter has triggered its differential pressure indicator. What action should be taken?

A. Replace the indicated filter immediately — highpressure loop filters protect the motor from catastrophic damage by capturing debris generated by pump wear or component failure upstream

B. Monitor the indicator at each daily inspection — loop filters in hydrostatic systems have a higher restriction tolerance than standard circuit filters

C. Replace both loop filters simultaneously — if one filter has loaded, the opposite filter has likely captured equal contamination from the return flow through the loop

D. Replace the indicated filter and immediately draw an oil sample from the loop to determine whether the captured debris indicates a developing pump or motor failure that requires further investigation

120. A hydraulic system with a loadsensing pump and DCV produces a highpitched squeal when one specific function is operated at partial joystick deflection. The squeal disappears at full joystick deflection and does not occur with any other function. What is the most likely cause?

A. The DCV spool metering edge for that function is creating a highvelocity flow restriction at the partial opening — the oil passing through the narrow metering slot generates a highpitched noise that ceases when the spool opens fully and the flow velocity drops

B. The loadsensing signal from that function's work port is oscillating due to a loose LS shuttle check ball, causing the pump to hunt and produce the squealing noise

C. The cylinder or motor on that function has an internal bypass that resonates at the specific flow rate produced by the partial joystick position

D. The pilot pressure for that joystick axis has an air bubble that compresses and releases at a frequency that produces the audible squeal during partial deflection

121. A technician connects a flow meter and pressure gauge to the output of a hydraulic gear pump to perform a pump performance test. With the flow control valve on the test unit fully open (zero backpressure), the pump produces 90 L/min. As the technician progressively increases backpressure by closing the flow control valve, the flow drops. At the system's rated pressure of 250 bar, the flow reads 78 L/min. The OEM minimum flow at rated pressure is 81 L/min. What is the conclusion?

A. The pump is within acceptable limits — the 78 L/min at rated pressure is close enough to the 81 L/min minimum that the pump can continue in service for another 500 hours

B. The pump's flow at rated pressure (78 L/min) is below the OEM minimum (81 L/min) — the pump has worn beyond its serviceable limit and must be rebuilt or replaced to restore the system's designed performance

C. The test is invalid because the engine RPM must be verified at the exact OEMspecified test speed before the flow readings can be compared to the specification

D. The flow drop from 90 to 78 L/min (13.3%) represents the pump's mechanical efficiency loss, not its volumetric efficiency — the pump's actual volumetric efficiency is still above minimum

122. A technician is installing a new hydraulic hose assembly. The hose is the correct length, pressure rating, and fitting type. Before installation, the technician notices a printed date code on the hose that shows it was manufactured 8 years ago but has never been used. The OEM's maximum shelf life for stored hydraulic hose is 6 years. Should the hose be installed?

A. Yes — the 6year shelf life applies only to hose stored in outdoor conditions; indoorstored hose has an unlimited shelf life

B. Yes — the hose has never been pressurized and the shelf life recommendation applies only to hose that has been in service under pressure

C. No — but the hose can be pressuretested to 1.5 times working pressure, and if it passes, it may be installed with a reduced service interval

D. No — rubber hose degrades chemically from ozone, UV exposure, and aging regardless of whether it has been used. A hose beyond its shelf life may have weakened reinforcement and degraded seals that are not visible externally and could fail in service

123. A technician is using magnetic particle testing (MT) on a steel boom weld. After magnetizing the test area and applying iron particles, the technician observes a strong linear particle accumulation along the weld toe. After demagnetizing and cleaning the area, no visible crack is apparent to the naked eye. What should the technician conclude?

A. The particle accumulation is a false indication caused by residual magnetism in the weld metal and does not represent an actual discontinuity

B. The particle indication was caused by the weld profile geometry (change in section) and is not a defect — the abrupt geometry change at the weld toe naturally attracts particles

C. The strong linear accumulation indicates a crack or cracklike discontinuity at or near the surface — the particles are attracted to the magnetic flux leakage caused by the defect, even though it is too small to see with the naked eye

D. The indication is slag trapped at the weld surface that is magnetic and attracts the particles — the slag should be ground out and the area retested

124. A technician is inspecting the boom and stick on an excavator after a reported highimpact event (the bucket struck a large buried boulder at full digging force). No visible cracks are found during the visual inspection. What further action is recommended?

A. Perform NDE (nondestructive examination) at all highstress weld joints on the boom and stick — highimpact events can initiate microcracks that are not visible to the naked eye but will propagate under continued service loading

B. Return the machine to service — if no visible damage is found during a thorough visual inspection, the boom and stick are confirmed structurally sound

C. Replace the boom and stick assembly as a precaution — any highimpact event that exceeds the machine's rated digging force compromises the structural integrity beyond repair

D. Monitor the affected area with weekly visual inspections for the next month — any developing crack will become visible within this timeframe

125. A machine's bucket teeth are worn to approximately 30% remaining length. The operator requests new teeth. The technician inspects the teeth and discovers one tooth is completely missing — it has broken off and likely entered the material being loaded. What concern does this lost tooth create?

A. The lost tooth is an aesthetic concern only — it will be processed with the material and has no operational or safety significance

B. The lost steel tooth may damage downstream processing equipment (crushers, screens, conveyors) or contaminate the processed material — the missing tooth must be reported and efforts made to locate and recover it from the loaded material

C. The missing tooth creates a structural weak point on the bucket lip that may cause adjacent teeth to fail in a cascade pattern under the next digging load

D. The missing tooth adapter is now exposed and will wear rapidly, but this is a maintenance concern only and does not affect the material being processed

126. A technician is replacing a worn cutting edge on a grader blade. The new cutting edge is manufactured with a specific bevel orientation (one face is bevelled while the opposite face is flat). The cutting edge can be physically installed in either orientation. Does the orientation matter?

A. No — the cutting edge is symmetrical in function and the bevel provides the same cutting action regardless of which face is oriented toward the ground

B. No — the bevel is a manufacturing artifact from the rolling process and has no functional significance in the cutting edge's performance

C. Yes — the bevelled face must be installed facing the correct direction (typically toward the ground or toward the material) as specified by the OEM. Incorrect orientation reduces cutting efficiency and accelerates uneven wear

D. Yes — but only for finish grading applications. For rough grading, the orientation has no measurable effect on cutting performance or wear life

127. A technician is installing a new hydraulic quick coupler on an excavator. The installation requires the technician to set the coupler's maximum working pressure parameter in the machine's ECM. The coupler's OEM rates it at 350 bar maximum. The machine's auxiliary circuit can produce 400 bar. What should the pressure parameter be set to?

A. Set the parameter to 350 bar — the auxiliary circuit pressure must be limited to the coupler's maximum rating to prevent overpressuring the coupler's hydraulic lock mechanism and risking an attachment release under load

B. Set the parameter to 400 bar — the machine's maximum pressure should be used to ensure the coupler receives full system capability during heavy digging operations

C. Set the parameter to 280 bar — a 20% safety margin below the coupler's rated maximum provides additional protection against pressure spikes during impact loading

D. No parameter adjustment is needed — the coupler has its own internal relief valve that limits the pressure to its rated maximum regardless of the machine's auxiliary circuit setting

128. A technician discovers a heavy equipment machine's cab door latch is broken and the door cannot be securely closed. The operator has been wedging the door shut with a piece of wood during operation. What safety concern does this create?

A. The wedged door reduces cab ventilation airflow, causing the cab pressurization system to create excessive positive pressure that is uncomfortable for the operator

B. The wedged door is an acceptable temporary repair provided the operator verifies the door remains closed before each work cycle

C. The broken latch is a cosmetic issue that does not affect any safety system — the cab door is not part of the ROPS or FOPS certification

D. A door that is not positively latched may open during a rollover event, allowing the operator to be ejected from the cab — the cab door latch is a component of the ROPS restraint system and must be repaired before operation

129. A machine's auxiliary hydraulic circuit is being configured for a rotating drum cutter attachment. The attachment requires a specific flow rate range of 80–100 L/min and a specific pressure range of 250–300 bar. The machine's auxiliary circuit can deliver 150 L/min at 350 bar maximum. What adjustments must be made?

A. No adjustments are needed — the machine's auxiliary output exceeds the attachment's requirements, which ensures the attachment always receives adequate flow and pressure

B. Only the pressure needs adjustment — reduce the auxiliary pressure to 300 bar maximum. The excess flow will simply return to tank through the attachment's internal bypass circuit

C. Both flow and pressure must be adjusted to match the attachment's specification — excessive flow overspeeds the attachment and excessive pressure overloads the motor, both of which cause premature failure

D. Only the flow needs adjustment — reduce the flow to 100 L/min maximum. The pressure is selfregulating and will only reach the level demanded by the attachment's load

130. A technician is performing a periodic inspection of a telehandler's boom and discovers that the wear pads (slide pads) between the inner and outer boom sections show uneven wear — one side is worn nearly through while the opposite side shows minimal wear. What does this indicate?

A. The uneven wear is normal — the loaded side of the boom (bottom pads) always wears faster than the unloaded side (top pads) due to the weight of the load and boom selfweight

B. The boom sections are misaligned — the inner boom is cocked to one side within the outer boom, concentrating the load on one set of pads while the opposite pads carry minimal weight

C. The uneven wear is caused by consistently lifting loads offcentre, and the wear pattern will selfcorrect when the operator begins centring the load properly

D. The boom has a manufacturing defect — the inner boom section is not straight and contacts the outer boom unevenly throughout the extension range

131. A heavy equipment machine's operator reports that the seat belt retractor no longer locks during sudden stops — the belt extends freely regardless of deceleration forces. The webbing appears undamaged. What is the most likely cause?

A. The retractor's internal locking mechanism has failed — the inertiasensitive latch or the webbingsensitive clutch inside the retractor housing no longer engages under deceleration, and the complete retractor assembly must be replaced

B. The seat belt webbing has stretched beyond its elastic limit and the retractor mechanism cannot take up the excess length fast enough to lock before the deceleration event has passed

C. The retractor is functioning correctly — modern seat belt retractors are designed to allow extension during normal deceleration and lock only during a sudden impact event exceeding a specific gforce threshold

D. The retractor housing mount has loosened from the cab floor, allowing the entire retractor to move rather than the internal mechanism engaging against the housing

132. A hybrid excavator uses a supercapacitor bank instead of a lithiumion battery for its energy storage system. What characteristic of supercapacitors makes them suitable for this application?

A. Supercapacitors store more total energy than lithiumion batteries of the same weight, providing longer run time between charges

B. Supercapacitors are inherently explosionproof and require no thermal management system, simplifying the installation on the machine

C. Supercapacitors operate at lower voltage than batteries, reducing the HV safety requirements for the installation and service procedures

D. Supercapacitors can charge and discharge at extremely high rates, making them ideal for capturing brief bursts of regenerative energy from swing braking and boom lowering that occur in rapid cycles during excavation

133. A technician is performing a scheduled inspection on a batteryelectric machine's highvoltage system. The machine has been deenergized following the OEM's isolation procedure. The technician measures 0V at the main bus but notices the HV warning light on the dashboard is still illuminated. What should the technician do?

A. Proceed with service — the 0V measurement confirms the system is safe and the illuminated warning light is a latent indicator that has not reset since the isolation procedure was completed

B. Do not proceed — the illuminated HV warning light may indicate a residual energy source, a failed interlock, or a secondary HV circuit that is still energized despite the main bus reading 0V. Investigate the warning before touching any HV component

C. Proceed with service after disconnecting the 12V/24V auxiliary battery — this will extinguish the warning light, which is powered by the auxiliary system and does not indicate HV presence

D. Proceed after verifying the 0V reading at three additional test points — if all four readings confirm 0V, the warning light is confirmed as a false indication

134. A batteryelectric compact loader's traction battery is equipped with a liquid cooling system that circulates a dielectric (nonconductive) coolant through cooling plates between the battery modules. Why is a dielectric coolant required instead of standard engine coolant?

A. Standard engine coolant produces more thermal expansion than dielectric coolant, which would create excessive pressure inside the sealed battery cooling circuit

B. Standard engine coolant freezes at a higher temperature than dielectric coolant, which would damage the battery cooling plates during coldweather storage

C. If a cooling plate develops a leak inside the battery enclosure, a dielectric coolant will not create an electrical short circuit between the HV cell terminals and the cooling circuit — standard conductive coolant would create a potentially catastrophic short

D. Dielectric coolant has a higher specific heat capacity than standard coolant, providing superior heat absorption per unit volume circulated through the battery

135. A fleet manager asks a technician to explain why a batteryelectric machine's available range decreases significantly during winter operation compared to summer. What is the primary cause of the reduced winter range?

A. Cold temperatures increase the battery's internal resistance, reduce the available capacity, and the battery thermal management system consumes additional energy to keep the cells within their operating temperature range — all of these factors reduce the net energy available for traction

B. The electric drive motors produce less torque at cold temperatures because the permanent magnet field strength decreases, requiring higher current draw to maintain the same performance

C. The regenerative braking system is disabled during cold weather to prevent ice formation on the brake components, eliminating the energy recovery that extends range during warmer conditions

D. The machine's tire rolling resistance increases on frozen ground, and the additional energy required to overcome this resistance accounts for the majority of the range reduction

Practice Exam 6: Answer Key and Explanations

1. A — Parking brakes can fail from mechanical wear, air leak, or hydraulic bleed-down. On a grade, a single brake failure allows the machine to roll. Wheel chocks provide a positive physical barrier that holds the machine regardless of brake condition, and are required as a secondary safeguard whenever working beneath a machine parked on any grade.

2. C — The flame pictogram indicates the product is a flammable liquid (ignites if exposed to spark, heat, or open flame). The health hazard pictogram (silhouette with starburst on chest) indicates a chronic health hazard such as carcinogenicity, organ toxicity, or respiratory sensitization from repeated

exposure. Together, these pictograms tell the technician the product requires both fire prevention and long-term health protection measures.

3. D — Residual hydraulic pressure trapped in the circuit can cause high-velocity oil injection through the fitting gap when cracked open. Hydraulic injection injuries drive oil through the skin at pressures as low as 7 bar and can cause limb loss. All pressure must be relieved by cycling the controls with the engine off, and zero pressure must be verified at the work area before any fitting is loosened.

4. B — The grinder guard serves as a physical barrier that contains disc fragments if the disc fractures during operation. Grinding discs rotate at high RPM and store significant kinetic energy — a fracture launches fragments at velocities capable of causing fatal penetrating injuries. Without the guard, the full 360-degree disc perimeter is exposed and fragments can travel in any direction.

5. D — Fire suppression systems are engineered, pressure-tested, and certified as complete assemblies. An accidental discharge depletes the extinguishing agent, may damage detection sensors and distribution nozzles, and leaves the engine compartment unprotected. Only a certified fire suppression technician can properly recharge or replace the system components and test the complete system before the machine returns to service.

6. C — Emergency eyewash stations must be accessible within the required response time (typically 10 seconds of travel) at all times when work with corrosive materials is being performed. A blocked station cannot provide the immediate flushing required to prevent permanent eye damage from acid splash. The obstruction must be cleared before any work with battery acid begins.

7. A — At a 60-degree included angle, each sling in a bridle does not simply carry half the load. The sling load increases as the angle widens because each sling must also resist the horizontal component of the force. At 60 degrees, each sling carries approximately 58% of the total load (load ÷ 2 ÷ cosine of the half-angle). Slings rated for 50% at vertical are inadequate for this configuration.

8. B — An empty fuel tank that has not been professionally cleaned, tested, and certified gas-free contains residual fuel vapour that may be within the explosive concentration range. The tank is classified as a confined space with a potentially flammable atmosphere. No hot work, grinding, or spark-producing activities may be performed until the tank is confirmed gas-free by a competent person using a calibrated combustible gas detector.

9. D — Overhead crane operation requires specific training and certification for that equipment type under Canadian OHS regulations. A Red Seal heavy equipment technician certificate qualifies the holder to service and repair heavy equipment — it does not include crane operator training, which covers load calculation, rigging, signalling, and the specific operation of the crane type being used.

10. C — A designated radiation zone with an active gamma radiation source presents an ionizing radiation hazard that requires specific training and authorization to enter. Only personnel with radiation safety training and appropriate dosimetry may work in the zone while the source is exposed. The technician must either wait for the radiography to be completed and the zone cleared, or have the machine relocated outside the zone.

11. B — The engine starts on the fuel that was retained in the filter housing and supply lines from the previous operation. After approximately 30 seconds, this fuel is consumed and the engine must draw new fuel from the tank. A compromised suction line connection allows air to enter the fuel stream, which the transfer pump cannot separate. The air-laden fuel cannot sustain combustion and the engine stalls. It restarts on the remaining fuel in the lines each time.

12. D — A cylinder cut-out test isolates the source of a knock by eliminating each cylinder's combustion event one at a time. When disabling injector 3 eliminates the knock, the fault is confirmed as combustion-related on that specific cylinder. An abnormal injector spray pattern, incorrect valve lash creating excessive pressure rise rate, or a timing error on that cylinder can produce a single knock at a specific RPM.

13. C — The inner safety element serves as the last line of defence against unfiltered air entering the engine. If the primary (outer) element is damaged, improperly sealed, or dislodged, the safety element prevents dirt from reaching the turbocharger and cylinders. With the safety element missing, any failure of the primary element allows abrasive particles to enter the engine, causing rapid and catastrophic wear of the turbo compressor, pistons, rings, and liners.

14. A — An injector with a reduced nozzle opening pressure opens earlier in the compression stroke than designed, before the cylinder pressure has reached the optimal level. The premature opening produces a longer injection duration and a coarser fuel spray with larger droplet sizes. Larger droplets burn less efficiently, increase unburned hydrocarbon emissions, produce more soot, and reduce power output from the affected cylinder.

15. B — Total Base Number (TBN) measures the oil's alkaline reserve — the additive package that neutralizes sulfuric and nitric acids produced as combustion byproducts. As TBN depletes, the oil loses

its ability to neutralize these acids. If TBN reaches zero, the acids attack bearing surfaces, cylinder walls, and other metal components, producing corrosive wear that is far more damaging than abrasive wear.

16. D — Dark brown coolant with visible particles indicates the inhibitor package has failed or incompatible fluids have been mixed, allowing internal corrosion to progress. The particles are corrosion products — metal oxides from aluminum, cast iron, and copper components — circulating through the system. The root cause (wrong coolant type, contamination, or expired additive life) must be identified, the system flushed, and the correct coolant installed.

17. A — Head bolt length verification confirms the bolt threads will engage the correct depth in the block's tapped holes. A bolt that is too long will bottom out in the hole before the bolt head clamps the head gasket, preventing the bolt from developing full clamping force. A bolt that is too short will not engage sufficient threads, risking pull-out under the extreme cylinder firing loads. Both conditions can cause catastrophic head gasket failure.

18. A — The fan speed control system relies on a temperature sensor to determine the cooling demand. If the sensor has failed in a state that reports a high temperature value, the ECM responds by commanding maximum fan speed to address the perceived overheating — regardless of the actual coolant or air temperature. The absence of a fault code indicates the sensor is producing a value within its valid range but at an incorrect point.

19. D — One litre of coolant loss per 50 hours with no external leaks, clean oil, normal exhaust, and a pressure test that holds points to a very small internal leak. The most common path is a marginal head gasket breach or a hairline cylinder head crack that allows coolant to enter one or more cylinders in a quantity small enough to be consumed during combustion without visible smoke. A combustion gas test on the coolant can confirm this path by detecting exhaust gases in the cooling system.

20. B — With the air filter and exhaust system confirmed unrestricted, the remaining boost leak path between the turbocharger compressor outlet and the intake manifold is the charge air cooler piping. Loose clamps, cracked hoses, or a damaged CAC core allow pressurized charge air to escape before it reaches the manifold. These leaks are common because the CAC piping is exposed to vibration and thermal cycling.

21. C — Piston cooling jets spray oil onto the underside of the piston crown to remove combustion heat. Without the cooling jet, that piston's crown temperature rises significantly above design limits. The elevated temperature causes the aluminum alloy to weaken, leading to crown erosion, ring groove

distortion, ring seizure, and potential piston failure. The missing jet also dumps oil to the sump unrestricted, reducing system pressure.

22. A — The valve train operates at half engine speed (one camshaft revolution per two crankshaft revolutions). A worn camshaft lobe with a flat spot or material loss produces an audible ticking impact once per camshaft revolution as the follower drops into the worn section and snaps back onto the remaining profile. This rate — exactly half engine RPM — distinguishes cam lobe wear from crankshaft-speed or firing-frequency noise sources.

23. D — The DPF soot loading model predicts a certain restriction level based on operating parameters. If the actual differential pressure is significantly lower than the model predicts, less restriction exists than expected. This can indicate the DPF substrate has cracked or developed a bypass channel — exhaust flows through the broken section or around the filter element rather than through the intact wall-flow channels.

24. B — On a mechanically actuated unit injector (MEUI), the rocker arm's contact point with the injector plunger is determined by the injector's installed height (protrusion). If the injector sits too high or too low in the bore, the rocker arm actuates the plunger at the wrong point in the cam rotation — effectively advancing or retarding the injection timing and changing the fuel delivery volume for that cylinder.

25. C — A coolant conditioner filter contains a supplemental coolant additive (SCA) or diesel coolant additive (DCA) charge that is released into the coolant as the fluid passes through the filter element. This additive maintains the correct inhibitor concentration — particularly the nitrite level that forms a protective film on wet-sleeve cylinder liner surfaces, preventing cavitation erosion from combustion-induced liner vibration.

26. A — Setting the intake valve lash 0.10 mm tighter than specification effectively changes the valve timing events — the valve opens earlier and closes later than designed. If the lash is tight enough, the valve may not fully seat during the compression and power strokes, allowing a small amount of compression and combustion pressure to leak past the partially open valve. This reduces cylinder performance and can eventually burn the valve.

27. B — A post-SCR NOx reading of 50 ppm against a 35 ppm maximum indicates the SCR system is not adequately reducing NOx. Multiple components contribute to SCR efficiency: the DEF dosing rate and quality, the SCR catalyst condition, the exhaust temperature (must be above the minimum for

catalyst activity), and the upstream DOC (which converts NO to NO_2 for passive SCR function). All must be systematically evaluated.

28. D — The crankcase breather separator is the restriction point in the ventilation system. When clogged, blowby gases cannot exit the crankcase through the designed path. Crankcase pressure builds until it exceeds the sealing capability of the weakest gasket or seal, forcing oil past those barriers. The external oil leaks mimic the symptoms of excessive blowby, but the root cause is the restricted ventilation path.

29. A — Chronic low-load operation (90% idle) prevents the engine from reaching the combustion temperatures needed to completely burn the fuel charge and to self-clean carbon from the intake and exhaust components. Unburned fuel condenses as wet-stacking residue on the exhaust manifold, and carbon from incomplete combustion deposits on the intake valves. This is a well-documented consequence of undersizing an engine for a generator application or chronic light-load operation.

30. C — The transfer pump's purpose is to provide a positive, pressurized fuel supply to the high-pressure pump's inlet. At 2 bar — half the minimum specification — the HP pump is fuel-starved across most of its operating range. The HP pump cannot generate adequate rail pressure from an inadequate supply, resulting in hard starting (insufficient rail pressure during cranking), reduced power (rail pressure sag under demand), rough running, and fuel system DTCs.

31. A — Worn or seized steering cylinder pivot pins and frame pivot bearings introduce friction resistance into the steering linkage that the hydraulic system must overcome in addition to the normal tire-to-ground turning resistance. This additional friction load is felt by the operator as increased steering effort. The HMU and pump testing confirms the hydraulic system is producing correct pressure and flow — the resistance is mechanical.

32. C — Abrasive sand packs between every articulating joint in the undercarriage — between pins and bushings, roller treads and link rails, sprocket teeth and chain bushings, and idler treads and chain links. Each movement grinds these surfaces together with the sand acting as a continuous lapping compound. This dramatically accelerates wear rates beyond the OEM's projections, which assume less abrasive operating material.

33. B — An air-over-hydraulic brake system uses compressed air to actuate a hydraulic intensifier that pressurizes the hydraulic brake circuit. Air in the hydraulic circuit downstream of the intensifier is compressible — when the pedal is applied, the air pocket compresses before the incompressible

hydraulic fluid can build pressure at the calipers. This absorbs pedal travel and produces the spongy feel with excessive pedal stroke before firm braking develops.

34. D — The hub seal — either a floating seal (duo-cone) or a lip seal on the inboard side of the hub — is the barrier between the hub interior and the external environment. If this seal fails, water from the haul road surface that is thrown up by the tire and sprayed against the hub can enter past the compromised seal. The one-sided contamination confirms the entry point is specific to that hub's seal.

35. C — The circle drive worm gear and ring gear mesh depends on correct tooth engagement to hold the moldboard against side-loading forces during grading. Worn gear teeth produce excessive backlash that prevents positive engagement under load — the gears chatter as they repeatedly lose and regain contact, and the blade slips (rotates) when side forces from the grading material exceed the weakened mesh's holding capacity.

36. A — A deeply scored steering cylinder rod with visible chrome flaking will destroy the rod seal with each stroke cycle. The sharp edges of the exposed base metal and the flaking chrome cut the seal lip progressively, producing increasing external oil leakage. Loss of steering cylinder oil leads to loss of steering function — a critical safety failure on any machine, particularly an articulated dump truck. The machine must be removed from service immediately.

37. D — The pipelayer's stability is governed by the load chart, which assumes static conditions. When the operator lowers the pipe rapidly, the deceleration at the bottom of the lowering motion creates a dynamic force that adds to the static pipe weight — momentarily exceeding the load chart rating at that radius. The operator must control the lowering speed to keep the total (static + dynamic) load within the chart limits.

38. B — Equal system pressure at both sides confirms the hydraulic supply is not the cause. The brake pull must originate from a mechanical difference between the left and right brake assemblies. A seized caliper piston, contaminated pad, glazed rotor surface, or worn friction material on one side produces a different braking force than the opposite side — even with identical supply pressure — because the force at the wheel depends on both pressure and the mechanical condition of the friction components.

39. A — Measuring track sag with the machine sitting on the ground includes the machine's weight in the lower track run tension. The weight tightens the lower run, producing a sag reading that shows less deflection than the actual running tension. The technician sets the tension to match this artificially tight reading, and when the machine lifts off (during travel over obstacles), the track is looser than intended — risking derailment.

40. D — Blue-black heat discoloration on a cast iron brake rotor indicates the rotor has been heated to temperatures exceeding approximately 400–500°C. At these temperatures, the metallurgical structure of the cast iron changes — the carbon structure transforms and produces localized hard spots. These hard spots resist wear differently than the surrounding material, causing uneven pad wear, brake pulsation, and potential rotor cracking.

41. C — A 30% imbalance between brakes on the same axle (right side producing only 70% of left side force) exceeds all standard brake balance specifications. Most jurisdictions and OEMs specify a maximum allowable imbalance of 25–30% between brakes on the same axle. At 30%, the machine is at or beyond the threshold and the weaker side must be inspected and corrected to restore balanced braking.

42. B — A seized oscillation pivot prevents the front axle from rocking (oscillating) to follow the ground contour. When the machine traverses uneven terrain, one front tire lifts off the ground while the opposite tire carries the full front axle load. The unloaded tire wears unevenly from the repeated lift-and-set-down cycle, and the overloaded tire wears from the concentrated weight it carries each time the opposite tire lifts.

43. A — The brake pack clearance is the total gap between all friction discs and separator plates when the brake is released. As the friction discs wear thinner, this total gap increases proportionally. The measured clearance directly correlates to the total disc wear — the OEM provides a maximum clearance specification that corresponds to the minimum acceptable disc thickness.

44. D — The track tensioner has a finite adjustment range. If the replacement chain has too many links for the undercarriage configuration, the tensioner reaches full extension before the chain is tight. The excess chain length must be corrected by removing a link to bring the chain within the tensioner's working range. Installing a chain with excess links results in a permanently loose track.

45. B — A sidewall bulge indicates the internal cord reinforcement plies beneath the bulge have separated or broken. The weakened area can no longer contain the inflation pressure uniformly — the rubber outer layer stretches outward under the internal pressure, forming the visible bulge. This is a structural failure of the tire's load-bearing reinforcement, and the tire can rupture catastrophically and without warning at any time.

46. C — New brake pads are thicker than the worn pads they replaced. To accommodate the new thickness during installation, the caliper pistons must be pushed back into their bores. After assembly,

the pistons are fully retracted — far from the pad surface. Pumping the brake pedal advances the pistons through the free-travel distance until they contact the new pads and the system pressurizes normally.

47. C — Kirchhoff's Voltage Law confirms the measurements are consistent: 4.1V + 2.7V + 19V = 25.8V (the source voltage). Both the positive-side drop (4.1V) and the ground-side drop (2.7V) exceed the typical allowable maximum for their respective paths (generally 0.5V or less for ground, and less than 3% of system voltage for supply wiring). Both sides must be inspected for corroded connections, damaged wiring, or undersized conductors.

48. B — The 4.3V difference between the battery terminal (22.5V) and the starter terminal (18.2V) represents voltage consumed by unwanted resistance in the cables, connections, or solenoid contacts between these two points. This resistance reduces the voltage available to operate the starter motor, directly causing the slow cranking. A voltage drop test on each connection in the circuit identifies the specific high-resistance point.

49. A — A clamp-on ammeter measures the magnetic field generated around a conductor carrying current. If the ammeter clamp encircles both the supply wire and the return wire together, their magnetic fields are equal and opposite — they cancel, producing a net zero reading. The ammeter must clamp around only the individual wire carrying the current to be measured.

50. D — Stored DTCs provide a historical record of every fault the machine has experienced. Before clearing, the technician should review the codes for patterns — recurring faults that indicate a developing problem, multiple codes with the same timestamp suggesting a common cause, and codes that correlate with the current complaint. Clearing before this review erases diagnostic history that informs both the current repair and future trend analysis.

51. B — The relay coil fuse and contact fuse protect separate circuits. The blown coil fuse with an intact contact fuse localizes the fault to the coil circuit. Either the relay coil has developed an internal short (drawing excessive current), or the wiring between the switch and the coil has a short to ground that draws current through the coil fuse. The contact circuit is not involved.

52. A — Many modern machines include a constant-power circuit that bypasses the battery disconnect switch to maintain power to the ECM's keep-alive memory, clock, security system, and telematics module. The 0.5V measured on the load side confirms this bypass circuit is functioning. This is an intentional design feature, not a wiring fault.

53. D — An intermittent warning with no stored DTC points to a data communication issue rather than a genuine engine fault. A brief CAN bus data corruption — from a loose connector pin, a chafed wire, or an electromagnetic interference event — can produce a momentary garbled message that the display interprets as a warning. The event is too brief for the ECM to validate and store as a DTC.

54. C — Power loss = voltage drop × current. The 1.3V dropped across the wiring at 85A current produces 1.3 × 85 = 110.5 watts of heat dissipated in the cables and connections. This 110.5W is power that should be reaching the battery for charging but is instead being wasted as heat — indicating undersized conductors or high-resistance connections that should be inspected.

55. A — Many magnetically inductive CKP sensors require a specific air gap between the sensor tip and the reluctor wheel teeth. If the gap is too wide, the signal amplitude during the low rotational speed of cranking may be too weak for the ECM to detect as a valid crank signal. Without recognizing a crank signal, the ECM does not command fuel injection and the engine cranks without starting.

56. B — All dashboard gauges reading maximum simultaneously indicates a common fault rather than multiple individual sensor failures. The instrument cluster ground provides the return path for all gauge circuits. If the ground connection is lost, the full supply voltage appears across each gauge's internal coil with no return path to limit the current, driving all gauge indicators to their maximum deflection.

57. D — Wire gauge determines the conductor's resistance per unit length. The 4 AWG cable has significantly higher resistance than 2/0 AWG. Under the high current draw of engine cranking (hundreds of amperes), the increased resistance produces a voltage drop that reduces the voltage at the starter below the minimum required for adequate cranking speed. The engine may not crank fast enough to start.

58. A — With all external connections verified clean and tight, the intermittent power loss points to a fault inside the ECM itself. A failing internal voltage regulator, a cracked solder joint on the power input circuit board trace, or a degraded internal connector can produce an intermittent open that resets the module under vibration or thermal cycling. This is confirmed by the fact that external circuit checks are normal.

59. B — The sensor has a linear output from 0.5V at 0 bar to 4.5V at 500 bar. The total output range is 4.0V (4.5 − 0.5) across 500 bar. At 250 bar (the midpoint of the pressure range), the output should be the midpoint of the voltage range: (0.5 + 4.5) ÷ 2 = 2.5V. The measured 2.5V confirms the sensor is producing the correct linear output at the test pressure.

60. D — Master codes for security systems are maintained in the OEM's secure database and provided only to verified machine owners through the dealership network. The code cannot be extracted from the module in the field, cannot be reset by disconnecting the battery, and cannot be bypassed without defeating the security system. This controlled process protects the machine from unauthorized access.

61. A — With the sender disconnected, the circuit is open — no current flows. The 5.0V reading between the signal wire and ground confirms the ECM is supplying the correct 5V reference voltage and the wiring from the ECM to the connector is intact with a good ground path. When the sender is reconnected, its variable resistance will divide this voltage proportionally to the fuel level.

62. B — An intermittent coolant temperature signal produces erratic ECM responses because the ECM continuously adjusts multiple parameters based on coolant temperature — fan speed, fuel trim, idle speed, and emission system operation. Each time the pin makes and breaks contact, the temperature reading jumps randomly, and the ECM responds with corresponding adjustments that the operator perceives as erratic and unpredictable performance.

63. C — A single-pole double-throw (SPDT) relay has three contact terminals: common (C), normally open (NO), and normally closed (NC). When the coil is de-energized, the common terminal is connected to the NC terminal. When energized, the common switches to the NO terminal. This allows a single relay to control two separate circuits — one active when the coil is off and the other active when the coil is on.

64. D — The fuel level sender's signal wire shorted to the 5V reference produces a resistance value near zero — well below the minimum resistance (33 ohms) that the ECM recognizes as a valid fuel level. The ECM cannot convert this out-of-range value to a meaningful fuel level and reports "---" (invalid) to the dashboard. A short to reference pulls the signal below the programmed minimum, which the ECM flags as invalid data.

65. A — Starter motor field coils have extremely low resistance (0.01–0.02 ohms). At these values, the DMM test lead resistance — typically 0.1–0.5 ohms from the lead wire and probe contact points — represents a significant percentage of the total reading. The technician must zero the leads (short them together and note the reading) and subtract that value from the measurement to obtain the true coil resistance.

66. B — Non-calibrated crimping tools cannot guarantee the correct crimp dimension and force, which may produce a loose crimp with high contact resistance. The loose connection generates heat under current flow and corrodes internally from moisture ingress. Electrical tape cannot seal the connection

against the engine compartment's moisture, heat, and vibration environment — it unravels, shrinks, and admits moisture, accelerating the connection's failure.

67. A — The 5V reference supplies multiple sensors through a common bus. If the reference drops from 5.0V to 4.2V, every sensor sharing that reference produces a reading that is proportionally low — appearing to the ECM as if all monitored parameters (temperature, pressure, position) are lower than their actual values. The ECM's self-monitoring catches this drift before the incorrect readings can produce dangerous operating decisions.

68. C — A low-side driver connects the relay coil terminal to ground when commanded on, which should pull the voltage at that terminal from near-battery voltage (floating) to near 0V. The terminal reading 12.1V when commanded on (and 12.4V when off) shows the driver cannot pull the terminal to ground — the ECM output driver has failed open internally and must be addressed by ECM repair or replacement.

69. B — The throttle linkage has a physical binding or interference point between the full-throttle position and the idle position. When released from full throttle, the linkage catches momentarily at the binding point (producing the 1.8V reading corresponding to that mid-range position), then releases and drops to the idle stop at 0.8V. The physical binding must be located and corrected.

70. B — A 24V charging system should produce 27.5–28.5V at rated load. The measured 25.2V at full rated current output is below the minimum specification — the alternator is not maintaining adequate voltage under load. This indicates a failing voltage regulator that cannot command sufficient field current, a weak rotor field winding, or a stator phase with reduced output capacity.

71. C — A 16 AWG wire has a continuous current rating of approximately 10–15 amperes depending on the installation conditions. The 30-ampere solenoid circuit will force 30 amperes through the undersized wire section, generating heat that far exceeds the wire insulation's temperature rating. The insulation melts, exposing the bare conductor to adjacent wiring and the machine frame — creating a direct fire hazard.

72. C — A stall speed below specification with a verified-good engine means the torque converter is presenting more resistance to the engine than designed. The most common cause is the converter being mismatched (too large), incorrect transmission oil viscosity (too thick), or a stator one-way clutch that is seized — preventing the stator from freewheeling in the coupling phase and adding permanent resistance that the engine cannot overcome.

73. A — A 2-second flare during the 1-2 shift — with all other shifts smooth — isolates the fault to the 2nd gear clutch apply circuit. The clutch piston requires longer than normal to fill the apply chamber because a hydraulic leak (piston seal, shaft seal ring, or circuit seal) allows fluid to escape during the fill phase. The engine flares during this delay because no element is firmly engaged.

74. D — With U-joints and phasing confirmed correct, the centre support bearing is the remaining rotating component that could produce speed-proportional vibration. A deteriorated rubber isolator in the centre bearing mount allows the bearing housing to shift off-centre under centrifugal and drive forces. This introduces a misalignment between the two shaft sections that worsens proportionally with speed.

75. B — A howling noise during loaded forward acceleration that disappears during coast isolates the fault to the drive (convex) side of the ring gear teeth. The drive side is loaded during forward acceleration and unloaded during coast. The coast (concave) side is loaded during deceleration and shows a different noise pattern. The tooth contact pattern on the drive side should be checked for heel or toe concentration.

76. C — Low line pressure at idle in neutral — when no clutch is being applied — points to the source of pressure for the entire system. The transmission pump provides the base pressure through the pressure regulator valve. A worn pump with reduced volumetric efficiency or a pressure regulator stuck in a bypass position allows oil to dump to the sump rather than building the specified line pressure.

77. A — In a full-floating axle design, the axle shaft is retained at the outer end by a flange that bolts to the wheel hub. After removing the wheel and tire, the technician removes the flange bolts and withdraws the axle shaft straight out of the axle tube. The hub remains on the spindle supported by its own bearings — completely independent of the axle shaft.

78. D — A pump noise that is proportional to RPM and does not change with the drive control position indicates the noise source is within the pump itself — independent of displacement. A worn bearing, cracked piston, or scored barrel/valve plate produces mechanical noise that is directly proportional to the pump's rotational speed. Since the pump turns at engine RPM regardless of displacement, the noise is present at all control positions.

79. C — Uneven pressure plate finger height produces uneven release bearing contact. The release bearing touches only the highest fingers first, creating a rocking motion. On the high side, the clutch over-releases (excessive clearance), while on the low side, the clutch does not fully disengage (drags).

This uneven release produces clutch chatter during engagement and accelerates release bearing wear from the rocking contact.

80. B — A single distinct clunk during directional changes is the characteristic sound of drivetrain backlash. When the drive reverses, the gears must travel through the total accumulated backlash in the gear train — from the motor shaft spline through the planetary gears to the output — before the teeth engage in the new direction. The impact when the teeth contact produces the single clunk.

81. A — The torque converter must be fully seated on three engagement points: the pilot bore in the flywheel, the pump drive hub in the front of the transmission, and the stator support shaft. If the converter is not fully engaged on all three points (particularly the pump hub), bolting the transmission to the engine will force the converter against the pump and crack the pump housing or bend the pump drive.

82. D — An isolated failure to shift into a single gear range — with all other shifts functioning correctly — points to a component specific to that gear's engagement circuit. The 4th gear shift solenoid, the clutch apply circuit, or the overdrive clutch pack itself has a fault. System-wide causes (pump pressure, governor, TCM) would affect multiple or all shifts.

83. C — New friction discs were installed, but the separator plates (steel reaction plates) were not inspected or replaced. A scored, warped, or damaged separator plate creates metal-to-metal contact points with the new friction discs during application. The metallic grinding noise is the steel separator plate's damaged surface contacting the new disc through the friction material at the high spots.

84. B — Greaseable and sealed (non-greaseable) U-joints are interchangeable provided both meet the same dimensional specifications (cross spider diameter, cap diameter, overall width) and load rating for the application. The greasing method differs, but the mechanical function, load capacity, and operating characteristics are identical for joints of the same size and rating.

85. D — The right steering brake is not applying fully when the operator commands a right turn. The steering clutch disengages the right track's power input, but the steering brake must then stop the right track to pivot the machine. If the brake cannot generate sufficient stopping force (from worn linings, incorrect adjustment, or a hydraulic supply issue), the right track continues to coast and the turn is sluggish.

86. A — A new chain with zero pitch elongation does not mesh correctly with sprockets worn to a 4.5% elongated tooth profile. The pitch mismatch concentrates loading on fewer teeth rather than distributing it across the full engagement arc. This accelerated loading produces rapid chain and sprocket wear — the new chain stretches quickly to match the worn sprocket, consuming a large portion of the new chain's service life in a short period.

87. C — A heavy accumulation of metallic paste on the sump magnet exceeds normal wear debris collection for a standard service interval. The excessive quantity indicates internal wear rates are higher than acceptable — clutch discs, gears, bearings, or thrust surfaces are generating debris at a rate that warrants investigation. An oil sample should be analyzed to identify the wear source before the transmission returns to service.

88. B — Shifting from forward to reverse while the machine is moving at 5 km/h forces the directional clutch pack to absorb the entire kinetic energy of the moving machine. The clutch must first stop the forward motion and then accelerate the machine in reverse — all through controlled slipping of the clutch friction surfaces. This energy is converted to heat that rapidly degrades the clutch material and produces the harsh engagement.

89. D — Evacuation is a process that requires sufficient time for residual moisture in the system to boil off under the vacuum. If the vacuum level stalls at 800 microns, it may indicate moisture is still evaporating (a normal condition that requires additional evacuation time) or a system leak. Continue evacuating and monitor the progress — if the vacuum does not improve below 500 microns, investigate for a leak or excessive moisture.

90. A — Equal pressure on both the high and low sides with the compressor engaged and running confirms the compressor is not compressing the refrigerant. The clutch is spinning the compressor shaft, but the internal mechanism (pistons, scroll, or vanes) is not creating a pressure differential. No differential means no refrigerant circulation, no heat absorption at the evaporator, and no cooling output.

91. C — Gradual cooling loss over 20 minutes that recovers after a 10-minute shutdown cycle is the classic pattern of evaporator icing. A failed evaporator thermostat or pressure cycling switch does not cycle the compressor off before the evaporator surface drops to 0°C. Ice builds progressively on the coil, blocking airflow until no air can pass through. Shutting off the system allows the ice to melt, temporarily restoring performance.

92. B — The charging scale is the definitive charge measurement tool — it confirms the correct weight of refrigerant has been installed. Bubbles in the sight glass after correct weight charging may persist

briefly during system stabilization as the refrigerant distributes throughout the circuit. If bubbles persist after 10–15 minutes of operation, investigate for a restriction or air contamination, but do not add additional refrigerant beyond the specification.

93. A — The heater hoses are hot after 5 minutes, confirming hot coolant is flowing through the heater core. The 15-minute delay before the operator perceives warmth is caused by the heater core's reduced heat transfer efficiency due to internal restriction. Scale, debris, or corrosion coating the internal tube surfaces insulates them from the passing airflow, reducing the rate at which heat transfers from the coolant to the cabin air.

94. D — HEPA filters are specifically rated to capture particles in the respirable size range — including crystalline silica dust particles that cause silicosis. A standard particulate filter has a coarser filtration rating that allows these small particles to pass through and enter the cab air. Substituting a standard filter in a silica dust environment removes the operator's respiratory protection against a known occupational health hazard.

95. C — R-1234yf requires dedicated certified service equipment. Using an R-134a machine contaminates both the recovered R-1234yf (with R-134a residue in the machine's hoses and tank) and the R-134a machine (with R-1234yf residue). Cross-contamination renders both refrigerant supplies unusable and violates environmental regulations. Additionally, R-1234yf's mild flammability requires equipment rated for A2L refrigerants.

96. B — The diesel-fired coolant heater pre-heats the engine block and cylinders to a temperature that significantly improves cold-start reliability by ensuring adequate compression heat for diesel autoignition. Equally important, the warm block reduces the extreme wear that occurs during the first minutes of cold operation — when oil viscosity is highest, clearances are tightest, and metal-to-metal contact is most severe.

97. A — The condenser is the component most likely to trap metallic debris from a compressor failure because the first place the debris-laden discharge oil encounters after leaving the compressor is the condenser inlet. The narrow tubes and baffles inside the condenser trap particles that the flushing process cannot fully reach. If the condenser is not replaced or thoroughly cleaned, the trapped debris will re-enter the circuit and destroy the new compressor.

98. B — Cylinder extension speed = flow rate ÷ piston area. Converting units: 100 L/min = 0.1 m^3/min; piston area = 0.00785 m^2. Speed = 0.1 ÷ 0.00785 = 12.74 m/min. This calculation demonstrates how a relatively small bore cylinder extends rapidly with a high flow rate — and why cylinder speed is determined by flow, while force is determined by pressure.

99. D — The relief valve at 280 bar is the system's maximum pressure — it is a safety limit, not a performance target. If the implement stalls at relief pressure during normal digging, the system is functioning as designed — the operator is simply exceeding the machine's rated digging force at that working geometry. The relief valve setting should match the OEM specification, not be increased to accommodate aggressive operation.

100. C — Float mode intentionally connects both cylinder ports to the tank return, removing all hydraulic holding force from the cylinder. The cylinder is free to move in either direction under external forces — gravity, ground contact, or terrain undulation. This is the designed function of float mode, used for blade trailing, boom flotation during travel, and similar applications where the implement must follow external forces.

101. A — Foamy oil in the reservoir and a loud rattling pump noise are the hallmark symptoms of system aeration — air being drawn into the hydraulic circuit. The air enters through the pump inlet (loose suction fitting, cracked hose, low oil level exposing the suction port, or a failed pump shaft seal). The entrained air compresses and decompresses inside the pump, producing the rattling noise and creating the visible foam in the reservoir.

102. B — The pump has reached its compensator setting (250 bar) and has destroked to minimum displacement. At the compensator pressure, the pump produces only enough flow to maintain pressure and compensate for internal leakage. If the OEM compensator specification is higher than 250 bar, the pump is destroking prematurely — limiting available flow below the system's designed capacity and producing the slow boom speed complaint.

103. D — The hydraulic oil cooler is the heat exchanger between the hydraulic oil and the engine coolant. Internal tube fouling (scale, debris), external fin contamination (dirt, debris on the oil side), or reduced coolant flow through the cooler all reduce its heat transfer capacity. Since the engine coolant temperature is normal, the problem is within the cooler itself — not the coolant supply.

104. C — The hydrostatic pump's control valve servo linkage positions the swashplate based on the operator's control input. If the linkage has shifted slightly from its calibrated neutral position, the swashplate rests at a small forward displacement angle when the control is in the neutral detent. This small displacement produces a low flow to the motor that causes the machine to creep forward.

105. B — The compressor's mechanical components — pistons, connecting rods, and valve plates — operate under significant stress during the loaded (compressing) phase. When unloaded, the cylinders vent to atmosphere and no compression occurs. A worn piston, cracked connecting rod, or damaged

valve plate component produces mechanical impact noise only during the compression phase when forces are present, and falls silent during the unloaded phase.

106. A — After draining and refilling the 200-litre reservoir, a significant volume of oil remains in the system's cylinders, hoses, motors, cooler, filter housings, valve bodies, and the torque converter or transmission if sharing a common circuit. This undrained volume can be 40–50% of the total system capacity. The actual oil exchange is typically only 50–60% of the total system volume with a simple reservoir drain and fill.

107. D — The service reservoir is downstream of the air dryer and should contain dry, clean air. A large volume of water in the service reservoir confirms moisture is passing through the air dryer and accumulating in the downstream reservoirs. The air dryer's desiccant is saturated, the purge cycle is not functioning, or the dryer is otherwise failing to remove moisture from the compressed air supply.

108. C — The load-sensing differential is the pressure margin the pump maintains above the highest active circuit pressure. A 20-bar differential provides adequate excess pressure to maintain flow through the DCV metering edges. At only 8 bar, the reduced margin limits the pressure available to push flow through the metering restrictions — all functions operate more slowly because the pump cannot deliver adequate flow at the reduced differential.

109. B — The pump's volumetric efficiency decreases at higher operating pressure because internal clearances allow more fluid to bypass from the high-pressure side to the low-pressure side. At 80 bar, minimal bypass occurs and the pump delivers near its theoretical output. At 200 bar, significantly more fluid bypasses internally, reducing the actual flow delivered to the motor and therefore reducing the motor's rotational speed.

110. A — The cylinder extends slowly but retracts normally, isolating the fault to the extend circuit. A partially blocked check valve or restrictor in the cap-end supply line limits the flow entering the cap end during extension. The rod-end return path is unrestricted, so retraction (which uses the rod-end supply) operates at normal speed. The cap-end supply path must be inspected for the restriction.

111. C — Limp-home mode activates when the EDC fails, defaulting the pump to a fixed reduced displacement that provides limited forward travel capability. This allows the operator to move the machine to a service location at reduced speed — enough for travel but not for productive work. The fixed displacement is typically achieved by a mechanical spring return or a default solenoid position.

112. D — The ABS self-test at power-up passed (no light during initial check), but the light illuminates at 10 km/h during dynamic operation. This indicates the ABS module detected a fault that is only apparent when the wheels are rotating — most commonly a wheel speed sensor producing an erratic signal, or a difference in wheel speeds between sides that exceeds the module's tolerance. A tire size mismatch or damaged tone ring are common causes.

113. B — Volumetric efficiency at rated pressure = actual flow at rated pressure ÷ theoretical flow = 100 ÷ 120 = 0.833 = 83.3%. The typical minimum acceptable volumetric efficiency for a healthy hydraulic pump is approximately 85%. At 83.3%, the pump has worn below the serviceable threshold and should be scheduled for rebuild or replacement.

114. C — The pilot-operated pressure-reducing valve uses the pilot orifice to sense downstream pressure and modulate the main spool accordingly. A partially blocked orifice slows the feedback signal, causing the valve to respond sluggishly to downstream pressure changes. The valve remains open longer than intended during pressure rises, allowing downstream pressure to climb above the 35-bar set point before the valve reacts to close.

115. D — The auxiliary air supply connection on each spring brake chamber provides a port for connecting an external air source to release the spring brakes when the machine's onboard air system has failed completely. This allows the brakes to be released for towing without using the caging bolt method, which requires physical access to the rear of each chamber.

116. A — Dark brown oil colour with a strong burnt smell and elevated oxidation levels on the analysis confirm the oil has been subjected to excessive heat over an extended period. High temperature breaks down the base oil's molecular structure and depletes the antioxidant additives, producing acids and varnish that attack seals, corrode metal surfaces, and form deposits that clog filters and restrict passages.

117. B — The hydraulic cylinders in float mode have no damping — they are connected directly to tank with no orifice or accumulator to absorb shock. As the blade encounters terrain undulations at speed, the cylinders extend and retract freely, but the inertia of the heavy blade causes it to overshoot the terrain contour at each bump, producing a bouncing oscillation. An accumulator or shock absorber in the blade circuit would provide the missing damping.

118. C — The oil sampling port is located in the return line — if the port is upstream of the return filter, the sample reflects the pre-filtered contamination level. This is the dirtiest oil in the circuit at that point. The particle count will be significantly higher than a post-filter sample and does not represent the system's overall cleanliness level. The sampling location relative to the filter must be documented for meaningful trend analysis.

119. D — A loop filter that has triggered its differential pressure indicator has captured significant contamination. Replace the indicated filter immediately, but also draw a loop oil sample for analysis. The debris captured by the filter may indicate a developing pump or motor failure upstream that is generating wear particles at an elevated rate. The sample analysis identifies the debris material and guides further investigation.

120. A — At partial joystick deflection, the DCV spool metering edge creates a narrow flow restriction. The high-velocity oil passing through this narrow slot generates an audible high-pitched noise from the fluid dynamics of the restricted flow. At full joystick deflection, the spool opens fully, the flow velocity drops dramatically across the wider opening, and the noise ceases.

121. B — The pump's measured flow at rated pressure (78 L/min) falls below the OEM minimum specification (81 L/min). The pump has worn beyond its serviceable limit — internal clearances have increased to the point where internal leakage at operating pressure reduces the delivered flow below the minimum required for the system to perform as designed. The pump must be rebuilt or replaced.

122. D — Hydraulic hose rubber compounds degrade chemically from ozone attack, UV radiation, and molecular aging — regardless of whether the hose has ever been pressurized or used. A hose stored beyond its rated shelf life may have weakened internal reinforcement wires and deteriorated rubber that are not detectable by visual or pressure testing. The OEM shelf life limit accounts for this invisible aging.

123. C — Magnetic particle testing detects discontinuities by identifying magnetic flux leakage at defect locations. A strong linear particle accumulation along the weld toe — even when no visible crack is apparent to the naked eye — indicates a crack or crack-like discontinuity at or just below the surface. MT is specifically designed to detect these small defects that visual inspection cannot identify.

124. A — High-impact events can initiate micro-cracks at weld toes and other stress concentration points that are invisible to the naked eye. These micro-cracks propagate under continued service loading until they reach a critical size and cause catastrophic failure. NDE (UT, MT, or PT) at all high-stress joints provides the sensitivity needed to detect these cracks before they grow to a dangerous size.

125. B — A lost tooth that enters the loaded material is a significant concern for downstream processing operations. The hardened steel tooth can damage crushers, screens, conveyors, and other processing equipment. In aggregate production, the steel contaminant may also affect product quality specifications. The missing tooth must be reported to the site management and reasonable efforts made to locate and recover it.

126. C — A reversible cutting edge with a bevelled face has a designed orientation — the bevel must face the direction specified by the OEM (typically toward the ground or toward the material being cut). Incorrect orientation changes the cutting geometry, reduces cutting efficiency, increases required blade down-pressure, and produces an uneven wear pattern that shortens the edge's effective service life.

127. A — The auxiliary circuit pressure must be limited to the quick coupler's maximum rated working pressure. Setting the pressure above the coupler's rating risks overpressuring the coupler's hydraulic lock mechanism — which could fail and release the attachment during operation. The machine's 400-bar capability must be reduced to the coupler's 350-bar maximum through the parameter setting.

128. D — The cab door latch is a component of the ROPS restraint system. During a rollover event, the operator must remain inside the cab's protective envelope — secured by the seat belt and contained by the closed, latched door. A door that is not positively latched may open during the rollover, allowing the operator to be partially or fully ejected from the cab.

129. C — Both flow and pressure must be adjusted to match the attachment's specifications. Excessive flow (150 vs. 80–100 L/min) overspeeds the rotating drum cutter, risking bearing failure, seal damage, and potential drum disintegration. Excessive pressure (350 vs. 250–300 bar) overloads the attachment's hydraulic motor and housing, causing premature failure. Both parameters must be set within the attachment manufacturer's range.

130. B — Uneven wear pad wear — one side worn nearly through while the opposite shows minimal wear — indicates the inner boom sections are not centred within the outer boom. The inner boom is cocked to one side, concentrating the sliding load on one set of pads. This misalignment may be caused by worn pads that were not replaced in time, a bent boom section, or incorrect pad installation.

131. A — The seat belt retractor's internal locking mechanism — either the inertia-sensitive pendulum or the webbing-sensitive centrifugal clutch — has failed and no longer engages during deceleration events. The retractor allows the belt to extend freely regardless of the applied deceleration force. The complete retractor assembly must be replaced — internal retractor mechanisms are not field-serviceable.

132. D — Supercapacitors excel at high-rate charge and discharge cycles — they can absorb or release large amounts of energy in seconds, which matches the brief, intense energy bursts generated during excavator swing braking and boom lowering. Each excavation cycle produces a few seconds of regenerative energy followed by a few seconds of power demand. Supercapacitors handle these rapid cycles far better than batteries, which prefer slower, steadier charge rates.

133. B — An illuminated HV warning light after an isolation procedure with a 0V main bus reading requires investigation before proceeding. The warning light may indicate a secondary HV circuit that was not de-energized by the main isolation, a capacitor that retains charge on a circuit not measured by the main bus test point, a failed interlock that has not properly confirmed de-energization, or a genuine residual energy source. No HV work should begin until the warning is resolved.

134. C — If a cooling plate develops a leak inside the battery enclosure, the coolant contacts the HV cell terminals and interconnects. A conductive coolant (standard engine coolant containing glycol and inhibitors) would create an electrical short circuit between cell terminals through the conductive fluid path. A dielectric (non-conductive) coolant does not conduct current, preventing a potentially catastrophic short circuit even if a leak occurs.

135. A — Cold temperatures affect battery-electric machines through three compounding mechanisms: the battery's internal resistance increases (reducing available capacity and power), the available energy decreases (cold cells cannot discharge fully), and the battery thermal management system consumes significant energy to keep the cells within their operating temperature range. Together, these factors reduce the net energy available for traction, directly decreasing the machine's operating range.