PRACTICE EXAM 14: RED SEAL 421A SIMULATION (135 QUESTIONS)

1. A technician is assigned to perform maintenance on an underground LHD (loadhauldump) machine in an active mine heading. The mine's ventilation system is operating normally. Before commencing work, what specific atmospheric hazard must the technician verify even though the ventilation is confirmed operational?

A. The oxygen level is above the legal minimum — ventilation systems can malfunction locally even when the main system is running, and underground atmospheres can contain methane, carbon monoxide, or nitrogen that displace oxygen at the specific work location

B. The relative humidity is below 80% — high humidity in underground environments accelerates corrosion of the machine's electrical connectors and may produce short circuits during the maintenance procedure

C. The technician must perform a personal atmospheric test at the specific work location using a calibrated multigas detector — underground atmospheres can contain methane, carbon monoxide, hydrogen sulfide, or reduced oxygen levels that vary by location even when the ventilation system is operational. The work location's atmosphere must be confirmed safe before the technician enters and continuously monitored during the work

D. The dust level is below the occupational exposure limit — underground mining produces respirable dust that requires continuous monitoring at the specific work location during maintenance activities

2. A technician is using an oxyacetylene cutting torch to remove a seized bolt from a machine's frame. The bolt is located adjacent to a rubber hydraulic hose that cannot be removed. What specific precaution must be taken to protect the hose during the cutting operation?

A. Wrap the hose with aluminum foil to reflect the radiant heat from the cutting torch away from the rubber surface

B. Install a heatresistant blanket (welding blanket) between the torch work area and the hydraulic hose, and have an assistant continuously monitor the hose's temperature during the cutting — a burnedthrough hydraulic hose releases highpressure oil that ignites on contact with the cutting torch flame

C. Disconnect the hydraulic circuit and drain the hose before cutting — an empty hose will not release pressurized oil if burned through by the torch

D. Apply water to the hose surface continuously during the cutting to keep the rubber below its ignition temperature while the torch is in use nearby

3. A fleet manager asks the technician to prepare a written failure analysis report on a catastrophic engine failure. The report will be used to determine warranty eligibility and to prevent recurrence in the fleet. What information must the report contain to serve both purposes?

A. The report must include: the machine's identification and operating hours, a chronological description of the symptoms leading to the failure, the technician's diagnostic findings with supporting data (oil analysis trends, DTC history, physical evidence), photographs of the failed components, the identified root cause, and recommendations for preventing recurrence in the fleet — the report must distinguish between factual observations and the technician's professional opinion

B. The report must include only the failed component part numbers and the replacement part numbers — the warranty department determines the root cause independently from their own inspection

C. The report must include the operator's statement describing the failure event and the technician's cost estimate for the repair — the warranty department evaluates eligibility from the financial impact

D. The report must include the machine's maintenance history printout and the last three oil analysis reports — the warranty department uses these documents to determine if the failure resulted from a maintenance deficiency or a manufacturing defect

4. A technician is using a hydraulic press to straighten a bent machine component. The component is secured in the press and the hydraulic force is being applied gradually. During the pressing operation,

the technician hears a sharp metallic "ping" sound from the component. What does this sound indicate and what should the technician do?

A. The sound is normal — it is the component's internal grain structure realigning as the metal bends back to its original shape under the hydraulic force

B. The sound indicates the press's hydraulic relief valve has cracked open momentarily, limiting the force to the press's rated capacity before the component straightened fully

C. The sound is from a localized surface scale flaking off the component under the bending stress — the scale was formed during the original manufacturing process and breaks away during cold straightening

D. The sound may indicate the component has developed a crack from the bending stress — the technician must immediately stop pressing, release the force, and inspect the component for cracks using visual examination and NDE methods. Continuing to apply force to a cracked component risks sudden fracture and ejection of fragments

5. A technician discovers that a machine's ROPScertified cab has been modified — a hole has been cut in the roof for an aftermarket air conditioning unit that was not part of the original OEM design. The A/C unit is currently installed and functional. What is the safety concern with this modification?

A. The aftermarket A/C unit's refrigerant may not be compatible with the machine's original A/C system, creating a chemical compatibility issue if the two systems are connected

B. The aftermarket A/C unit adds weight to the roof that may exceed the cab's structural capacity during a rollover event

C. The hole cut in the ROPScertified cab roof has compromised the structure's engineered energy absorption capacity — the ROPS was certified as a complete, unmodified structure, and any unauthorized modification (cutting, welding, drilling, or adding holes) potentially invalidates the ROPS certification. The cab's ability to protect the operator during a rollover is no longer guaranteed

D. The aftermarket A/C unit's electrical draw may exceed the machine's charging system capacity, causing the battery to discharge during operation and potentially disabling the machine's electronic safety systems

6. A technician is performing a repair on a machine that requires working beneath the raised boom. The boom is held in the raised position by the hydraulic cylinders with the engine off. What specific procedure must be followed before the technician positions beneath the boom?

A. Lower the boom to a height that minimizes the potential injury from a fall — a boom at 1 metre height produces less impact energy than a boom at full height

B. Install the OEMspecified mechanical safety prop, lock pin, or support stand that physically prevents the boom from lowering — hydraulic cylinders can lose holding pressure from internal seal leakage, a failing pilotoperated check valve, or thermal contraction of the oil, and the boom can descend without warning. The mechanical support transfers the load from the hydraulic system to a fixed mechanical device

C. Verify the boom's pilotoperated check valves are holding by monitoring the cylinder pressure for 5 minutes — if the pressure remains stable, the boom is safe to work beneath

D. Engage the boom float position on the DCV — the float position allows the boom to rest on its mechanical stops and removes the hydraulic holding requirement

7. A technician must transport a fully charged nitrogen cylinder from the shop to a machine in the field using a service truck. What is the correct method for securing the cylinder during transport?

A. Lay the cylinder on its side in the truck bed and wedge it between two heavy toolboxes to prevent rolling during transport

B. Stand the cylinder upright in the truck bed and strap it to the headache rack with a single ratchet strap around the cylinder body

C. Place the cylinder in the cab's passenger footwell — the enclosed cab provides maximum protection from road hazards and weather during transport

D. Secure the cylinder upright in a dedicated cylinder rack or a properly designed transport bracket, with the valve cap installed and the cylinder chained or strapped to prevent movement — compressed gas cylinders must be transported upright with the valve protected and physically restrained against falling, sliding, or impacting other objects

8. A technician is working on a machine's electrical system and needs to test a circuit for voltage. The technician reaches for a test light (probestyle circuit tester with an incandescent bulb). A more experienced technician suggests using a digital multimeter (DMM) instead. Why is the DMM preferred over the test light for modern heavy equipment electrical testing?

A. A test light draws current through the circuit to illuminate its bulb — on modern electronic circuits with sensitive modules and lowcurrent logic signals, the test light's current draw can damage ECMs, overload sensor circuits, and produce false signals. A DMM has high input impedance (typically 10 megohms) that draws virtually no current from the circuit being measured

B. A test light cannot measure voltage — it only confirms the presence or absence of power, which is insufficient for diagnosing modern electronic circuits that require precise voltage measurement

C. A test light cannot detect DC polarity — connecting the test light with reversed polarity can damage diodes and transistors in the circuit being tested

D. A test light's incandescent bulb generates heat that can damage plastic connector housings and wire insulation at the test point during extended testing periods

9. A technician is assigned to repair a machine at a remote site accessible only by helicopter. The repair requires specific tools and parts. What planning consideration is MOST critical for this type of remote repair?

A. The repair time estimate — the helicopter's fuel range limits the available working time before the return flight must depart

B. The weather forecast — helicopter operations are weatherdependent and a weather change during the repair may strand the technician at the remote site

C. The technician must identify and bring every required tool, part, consumable, and diagnostic equipment in a single trip — if a critical item is forgotten or an incorrect part is brought, the repair cannot be completed and the machine remains down until a second trip can be arranged, which may take days depending on weather and helicopter availability

D. The site's cellular coverage — the technician must be able to contact technical support by phone if the repair encounters an unexpected complication during the field procedure

10. A technician completes a major repair on a machine's hydraulic system — replacing a main pump, flushing the system, and installing new filters. Before releasing the machine to the operator, the technician must perform a specific final step. What is this step?

A. Clean the machine's exterior — a clean machine demonstrates professional workmanship and allows the operator to visually inspect for leaks during the first operating shift

B. Perform a complete functional test of every hydraulic function at full operating temperature and pressure — verify all cylinders, motors, and valves operate correctly, check all connections for leaks under pressure, confirm system pressures and flow rates match the OEM specifications, and document the test results. A repair is not complete until the system is verified functional under operating conditions

C. Reset all fault codes in the ECM — active DTCs from the old pump's degraded performance must be cleared so the operator does not see warning lights that were caused by the previous fault

D. Run the engine at high idle for 30 minutes to break in the new pump — the extended noload run circulates the new oil through the system and seats the pump's internal components before the operator applies working loads

11. A technician is trending oil analysis data on a fleet of identical engines. Engine A has iron at 15 ppm at 6,000 hours. Engine B has iron at 45 ppm at 6,000 hours. Both engines use the same oil, filters, and maintenance intervals. Both operate in the same application. What does the difference between the two engines' iron levels indicate?

A. Engine B uses a different oil analysis laboratory than Engine A, and the laboratory variation accounts for the 30 ppm difference between the two results

B. Engine A operates on a day shift with experienced operators while Engine B operates on a night shift with less experienced operators — operator technique differences account for the wear rate difference

C. The difference is within the normal statistical variation for identical engines at the same hours — no investigation is required

D. Engine B has an abnormal wear condition — identical engines in the same application with the same maintenance should produce similar wear metal trends. A 3× higher iron level on Engine B indicates that engine has a specific condition (intake restriction, cooling deficiency, fuel system fault, or internal wear issue) driving accelerated wear that Engine A does not have

12. A diesel engine produces a light greyblue exhaust smoke during the first 30 seconds after a cold start. The smoke clears completely after the engine warms to approximately 40°C. During normal operating temperature, the exhaust is clear. The engine has 5,000 operating hours. What is the most likely cause?

A. The valve guide seals have hardened from age and thermal cycling — when cold, the hardened seals do not conform tightly to the valve stems, allowing oil to leak past the seals and enter the combustion chambers during the cranking and initial idle period. As the engine warms, the seals soften slightly and seal more effectively, stopping the oil leakage and clearing the smoke

B. The cold engine's fuel injectors produce poor atomization until the combustion chamber temperature rises — the large fuel droplets from cold injectors burn incompletely and produce the greyblue smoke until the chamber heat improves atomization

C. The engine's turbocharger seals leak oil into the intake manifold during the cold idle period when the oil viscosity is high and the turbocharger speed is low — the low centrifugal force on the cold oil allows it to migrate past the compressor seal

D. The cold engine's piston ring gaps are wider than normal from the thermal contraction — blowby allows oil to enter the combustion chamber from the crankcase until the rings expand to their operating clearance as the engine warms

13. A diesel engine's EGR cooler is a tubeandshell design where exhaust gas flows through the tubes and engine coolant flows through the shell. The technician performs an EGR cooler efficiency test: exhaust gas inlet temperature = 550°C, exhaust gas outlet temperature = 180°C, coolant inlet temperature = 85°C. What is the cooler's efficiency?

A. 67% — calculated as (inlet − outlet) ÷ inlet × 100 = (550 − 180) ÷ 550 × 100 = 67.3%. This uses the gas temperatures only and does not account for the coolant temperature

B. 32.7% — calculated as outlet ÷ inlet × 100 = 180 ÷ 550 × 100 = 32.7%

C. The cooler's thermal efficiency = (gas inlet − gas outlet) ÷ (gas inlet − coolant inlet) × 100 = (550 − 180) ÷ (550 − 85) × 100 = 370 ÷ 465 × 100 = 79.6%. This calculation uses the maximum possible temperature drop (inlet gas to coolant temperature) as the denominator, giving the true thermal effectiveness of the heat exchanger

D. 47.6% — calculated as (outlet − coolant inlet) ÷ (inlet − coolant inlet) × 100 = (180 − 85) ÷ (550 − 85) × 100 = 95 ÷ 465 × 100 = 20.4%

14. A diesel engine has been operating normally for 15,000 hours. The technician performs a crankshaft deflection test (web deflection) using a dial gauge installed between the crankshaft webs at the bottom of the engine. This test is typically performed on large, slowspeed diesel engines used in power generation or marine applications, and also on some large mining engines. What does the deflection measurement indicate?

A. The deflection measurement indicates the crankshaft's dynamic balance condition — excessive deflection confirms the crankshaft counterweights have shifted from their original positions

B. The deflection measurement indicates the alignment of the crankshaft's main bearings — excessive deflection at a particular journal location confirms the main bearing at that position has worn, allowing the shaft to sag or rise, which changes the web spacing and produces a measurable deflection. The test detects bearing wear without removing the crankshaft

C. The deflection measurement indicates the crankshaft's torsional vibration amplitude — excessive deflection confirms the torsional damper has failed and the crankshaft is experiencing torsional stress beyond its design limit

D. The deflection measurement indicates the crankshaft's thermal expansion pattern — the dial gauge records the dimensional change as the engine heats from ambient to operating temperature

15. A diesel engine equipped with a common rail fuel system produces a rough idle with random misfires across all cylinders. The rail pressure at idle reads 28 MPa (specification 30 MPa). All injector backleak rates are within specification. The fuel supply from the tank to the HP pump inlet has been verified as adequate. What is the most likely cause?

A. The common rail has developed a microcrack that leaks fuel internally — the rail cannot maintain the 30 MPa specification because the crack allows fuel to weep from the rail without visible external leakage

B. All six injectors have wear at the same rate and are collectively consuming more fuel per cycle than the HP pump can replace at idle — the combined excess demand reduces the rail pressure below specification

C. The fuel temperature at the rail is too high — hot fuel has reduced density that the rail pressure sensor reads as lower pressure, but the actual mechanical pressure is correct

D. The HP pump's inlet metering valve or the rail pressure control valve has a fault — the pressure is 2 MPa below specification across all conditions, indicating the fuel pressure regulation system cannot maintain the commanded pressure. The IMV may not be fully opening to admit adequate fuel, or the pressure control valve may be leaking fuel from the rail to the return circuit

16. A diesel engine's coolant level drops gradually over several weeks. The technician cannot find any external leaks — no visible coolant on the ground, no weeping from hoses, fittings, or the water pump. The oil analysis shows no coolant contamination. The exhaust shows no white smoke. Where should the technician investigate next?

A. The charge air cooler — engines with coolanttoair charge air coolers (CCACs) can develop internal leaks that allow coolant to enter the intake manifold through the CAC's failed tubes. The coolant is ingested and burned during combustion in quantities too small to produce visible white smoke but sufficient to explain the gradual level drop. A pressure test of the CAC's coolant circuit reveals the internal leak

B. The engine's EGR system — the EGR cooler's exhaust side can develop a pinhole leak that allows coolant to enter the exhaust stream and be expelled at the tailpipe as vapour that is indistinguishable from condensation

C. The coolant expansion tank cap — a weak cap allows coolant to boil over during peak temperature events and the steam escapes unnoticed through the overflow tube

D. The deaeration tank — a cracked tank allows coolant to seep out in small quantities that evaporate on the hot engine block before reaching the ground, producing no visible drip or puddle

17. A diesel engine's injector has been removed and the technician discovers the injector tip has heavy carbon deposits that have built up around the nozzle orifices. What effect do these deposits have on the injector's performance?

A. The deposits insulate the injector tip from the combustion heat, causing the tip to run cooler than designed and producing delayed fuel ignition from the cooler spray temperature

B. The carbon deposits alter the fuel spray pattern — the deposits deflect, restrict, or partially block the nozzle orifices, changing the spray angle, penetration depth, and droplet size. The disrupted spray pattern produces poor fuelair mixing, incomplete combustion, increased emissions, reduced power from the affected cylinder, and may cause fuel impingement on the piston crown or cylinder wall

C. The deposits increase the injector's internal fuel pressure by restricting the nozzle flow area, which produces an overpressurized spray that atomizes too finely and burns too quickly in the combustion cycle

D. The deposits seal microcracks in the injector tip that would otherwise leak fuel — removing the deposits by cleaning may expose the cracks and cause the injector to fail

18. A diesel engine equipped with a wastegate turbocharger produces the following test data at full load: boost pressure = 180 kPa (specification 200 kPa), wastegate rod = fully connected and adjusted to specification, exhaust temperature = 680°C (specification maximum 700°C), air filter restriction = within specification. What is the most likely cause of the low boost?

A. The wastegate actuator diaphragm has a small tear that allows boost pressure to leak from the actuator's pressure chamber — the weakened pressure signal cannot hold the wastegate fully closed, allowing exhaust to bypass the turbine and reducing the boost below specification

B. The engine is underfuelled and the reduced exhaust energy from the lean combustion cannot drive the turbocharger to rated boost — the exhaust temperature below the maximum supports this conclusion

C. The turbocharger's compressor wheel has eroded from FOD (foreign object damage) and the damaged wheel cannot compress the intake air to the rated pressure despite the turbine receiving adequate exhaust energy

D. The exhaust manifold has a crack or gasket leak that allows exhaust pulse energy to escape before reaching the turbine — the lost energy reduces the turbine's driving force and the turbocharger cannot produce rated boost despite the wastegate being correctly adjusted

19. A diesel engine has completed 250 hours since its last oil change. The oil analysis report shows the following: viscosity = 12.8 cSt at 100°C (new oil specification: 14.0 cSt), TBN = 7.2 (new oil: 12.0, condemning limit: 4.0), fuel dilution = 4.5% (condemning limit: 3.0%). Which parameter has exceeded its condemning limit?

A. The viscosity — the 1.2 cSt decrease from the new oil specification indicates the oil has sheared beyond its useful service life and cannot maintain adequate bearing film strength

B. The TBN — the drop from 12.0 to 7.2 indicates the oil has consumed more than 40% of its acidneutralizing capacity, requiring immediate oil change

C. All three parameters — the viscosity, TBN, and fuel dilution are all beyond their condemning limits, indicating the oil should have been changed before reaching 250 hours

D. The fuel dilution — at 4.5% against a 3.0% condemning limit, diesel fuel has entered the oil and reduced its viscosity below the useful service range. The fuel source (leaking injector, failed fuel supply component, or excessive postinjection for DPF regeneration) must be identified and corrected in addition to changing the oil

20. A diesel engine's aftertreatment system includes a DOC and a DPF. The ECM has initiated a stationary regeneration. During the regeneration, the technician monitors the DPF inlet temperature, which rises to 620°C. The OEM specification for regeneration temperature is 550–650°C. Midway through the regeneration cycle, the DPF inlet temperature suddenly drops to 400°C and the ECM aborts the regeneration. What is the most likely reason for the temperature drop?

A. The engine RPM or load decreased during the regeneration — either the operator reduced the throttle setting or an automatic loadshedding event occurred. The reduced engine output lowered the exhaust gas temperature below the minimum needed to sustain the regeneration reaction. The ECM detected the temperature departure and aborted the cycle to prevent an incomplete regeneration that would leave partially burned soot in the DPF

B. The DPF has developed an internal bypass channel where the exhaust gas passes around the sootloaded section rather than through it — the bypassed gas is cooler because it does not contact the burning soot

C. The DOC upstream of the DPF has suddenly lost its catalyst activity and can no longer produce the exothermic heat needed to maintain the DPF regeneration temperature

D. The DEF dosing system activated during the regeneration and the injected DEF absorbed heat from the exhaust stream, dropping the temperature below the regeneration threshold

21. A diesel engine's exhaust gas recirculation (EGR) valve is electronically controlled and uses a position feedback sensor to report its actual position to the ECM. The ECM commands the valve to 25% open. The position sensor reports 25%. However, a visual inspection through the intake manifold port reveals the valve is physically only 10% open — the valve plate is coated with carbon that restricts its movement. Why does the position sensor report 25% when the valve is physically only 10% open?

A. The position sensor is measuring the actuator motor's shaft rotation, not the actual valve plate position — the motor shaft has rotated to the 25% commanded position, but the carbon buildup creates a mechanical binding between the motor and the valve plate that prevents the plate from following the shaft. The sensor reports correct shaft position while the valve plate is stuck at a lesser opening

B. The position sensor is measuring the valve plate position correctly — the 25% reading refers to 25% of the sensor's electrical range, which corresponds to only 10% of the physical opening on this valve model due to the nonlinear relationship between sensor output and valve position

C. The ECM's software applies a correction factor that adjusts the sensor's raw reading before displaying it — the raw reading is 10% but the corrected display shows 25%

D. The carbon deposit is on the downstream side of the valve plate and does not affect the valve's opening position — the visual inspection is misleading because the carbon makes the opening appear smaller than it is

22. A diesel engine's oil analysis shows a gradual increase in potassium over three consecutive samples: 5, 12, 22 ppm. No other contaminants are abnormal. What is the most likely source of potassium in the engine oil?

A. Potassium is a component of certain fuel additives — a contaminated fuel supply is introducing potassium into the oil through combustion blowby

B. Potassium originates from the engine's intake air filter — certain filter media contain potassiumbased bonding agents that deteriorate with age and release potassium fibres into the intake airstream

C. Potassium is from a supplemental coolant additive (SCA) residue — the cooling system was treated with an SCA that contains potassium compounds, and a previous coolanttooil crosscontamination event left residual potassium in the oil passages

D. Potassium is a component of certain engine coolant formulations (particularly organic acid technology coolant) — the gradual increase confirms coolant is entering the oil system through a small, progressive leak path such as a developing head gasket breach, oil cooler seep, or a microcrack in a coolantwetted casting

23. A diesel engine is equipped with a twostage turbocharger system — a small highpressure (HP) turbo feeds into a large lowpressure (LP) turbo. During lowRPM, highload operation, the HP turbo provides quickresponse boost while the LP turbo spools up. At high RPM, the LP turbo produces the majority of the boost and a bypass valve diverts exhaust around the HP turbo. If the HP turbo's bypass valve sticks closed (exhaust cannot bypass the HP turbo at high RPM), what symptom develops?

A. The engine produces excessive boost at high RPM because all exhaust must pass through both turbines in series — the combined turbine work exceeds the designed boost pressure and the wastegate on the LP turbo may not have enough capacity to control the overboost

B. The engine runs normally at high RPM because the LP turbo produces the same boost regardless of whether the HP turbo is in the exhaust path or not

C. The stuck bypass valve creates excessive exhaust backpressure at high RPM — all exhaust must pass through the HP turbo's small turbine housing in addition to the LP turbo, producing restriction that the LP turbo alone would not create. The elevated backpressure reduces engine volumetric efficiency, increases pumping losses, raises exhaust temperatures, and reduces peak power

D. The engine runs normally at low RPM and stalls at high RPM because the excessive backpressure from the stuck bypass valve prevents the exhaust from exiting the cylinders during the exhaust stroke

24. A diesel engine's coolant system uses a coolant conditioner filter with an SCA (supplemental coolant additive) charge. The SCA maintains the correct nitrite level for wet cylinder liner cavitation protection. A technician replaces the coolant conditioner filter but installs a filter WITHOUT the SCA charge — a standard coolant filter element that is physically identical but contains no additive. What is the consequence?

A. The nitrite level in the coolant gradually depletes over the next service interval because no new SCA is being introduced — the wet cylinder liners lose their cavitation protection, and the linertocoolant interface becomes vulnerable to cavitation erosion. The erosion can perforate the liner wall within one to two service intervals depending on the engine's vibration characteristics

B. No consequence — the existing SCA in the coolant provides adequate protection for multiple service intervals without replenishment

C. The coolant pH increases above the safe operating range because the SCA normally provides the acid buffering — without fresh SCA, the coolant becomes alkaline and attacks the rubber hoses and gaskets

D. The coolant turns green from the missing SCA interaction with the coolant dye — the colour change is cosmetic only and does not indicate a functional deficiency

25. A diesel engine's crankcase ventilation system routes blowby gases through an oil separator before directing them to the intake manifold. The oil separator is a centrifugal type driven by the blowby gas pressure. The technician measures the crankcase pressure at +0.5 kPa (positive pressure). The OEM specification is −0.1 to −0.3 kPa (slight vacuum). What does the positive crankcase pressure indicate?

A. The engine's blowby rate has increased beyond the CCV system's capacity — the increased gas volume overwhelms the separator and the excess pressure builds in the crankcase

B. The crankcase ventilation system is restricted downstream of the separator — the restriction prevents the blowby gases from exiting the crankcase at the rate they enter. The restriction could be in the separator itself (clogged, seized rotor), the outlet hose, or the intake manifold connection. The positive pressure will push oil past the engine's external seals if not corrected

C. The intake manifold pressure is higher than the crankcase pressure, and the turbocharger boost is forcing pressurized air back through the CCV system into the crankcase

D. The crankcase pressure sensor is reading incorrectly — positive crankcase pressure is physically impossible on a functioning diesel engine because the blowby gases always create a pressure below atmospheric

26. A diesel engine equipped with a diesel particulate filter (DPF) has been operating in a lightload application (extended idle and lowpower operation) for several months. The ECM shows repeated failed passive regeneration attempts. The technician connects the diagnostic tool and reads the DPF soot loading at 95% — just below the threshold for a Level 2 derate. Why does lightload operation prevent successful passive regeneration?

A. Lightload operation produces low exhaust soot loading — the DPF does not accumulate enough soot to trigger the regeneration cycle

B. Lightload operation reduces the engine oil temperature, which prevents the oil's detergent additives from cleaning the DPF catalyst surfaces between regeneration cycles

C. Lightload operation produces low fuel rail pressure, and the ECM cannot command the late postinjection needed to raise the exhaust temperature for passive regeneration at the reduced rail pressure

D. Lightload operation produces low exhaust temperatures — the exhaust gas does not reach the minimum temperature (typically 350–400°C) needed to ignite the soot on the DPF substrate through passive oxidation. Without adequate exhaust heat, the soot accumulates continuously and cannot burn off through the normal passive regeneration process

27. A diesel engine has been rebuilt and is being broken in on a dynamometer. During the breakin procedure, the technician monitors the blowby rate. At the start of breakin, the blowby reads 40 L/min. After 4 hours of controlled loading, the blowby drops to 25 L/min. What does this decreasing blowby trend during breakin indicate?

A. The turbocharger seals are seating during breakin — the blowby reduction is from less pressurized intake air leaking past the turbocharger compressor seal into the crankcase

B. The head gaskets are seating during breakin — the gasket material compresses under the torqued head bolts during the thermal cycling and the improved seal reduces the combustion gas leakage into the crankcase

C. The piston rings are seating against the cylinder wall hone pattern — the new rings' running surfaces are conforming to the cylinder bore during the breakin loading, progressively improving the ringtobore seal. The improved seal reduces the combustion gas blowing past the rings into the crankcase, lowering the measured blowby

D. The oil is warming up during the 4hour run — the warmer oil fills the ring gaps more effectively and provides a better seal between the rings and the bore, reducing the blowby measurement

28. A technician is diagnosing a diesel engine that produces excessive black smoke under load. The engine has been in service for 20,000 hours. The technician has eliminated the following potential causes: intake restriction (within specification), exhaust restriction (within specification), turbocharger (boost within specification), and fuel injector spray pattern (all injectors tested and within specification). What remaining cause should the technician investigate?

A. The cylinder compression — at 20,000 hours, the cylinders may have lost compression from ring and liner wear. Reduced compression means less air mass is available per combustion cycle to burn the injected fuel. The fuel quantity (set by the ECM) does not change, but the reduced air charge produces an effectively rich mixture that generates black smoke under high fuel demand

B. The fuel quality — contaminated or offspecification fuel produces excessive soot regardless of the engine's mechanical condition

C. The exhaust aftertreatment — a failed DOC cannot oxidize the soot produced by normal combustion, allowing it to pass through as visible black smoke

D. The engine oil level — an overfilled crankcase allows the rotating assembly to churn the excess oil, forcing it into the combustion chambers through the ring gaps and producing the black smoke

29. A diesel engine's ECM has a "cylinder balance test" function that momentarily disables each injector in sequence while monitoring the engine speed change. The speed change for each cylinder cutout is recorded. The results show: Cylinders 15 each produce an 80 RPM drop, and Cylinder 6 produces only a 25 RPM drop. What does Cylinder 6's small RPM drop indicate?

A. Cylinder 6 contributes significantly less power to the crankshaft than the other cylinders — the 25 RPM drop (compared to 80 RPM for the others) confirms Cylinder 6's power output is already reduced, so disabling its injector has little additional effect on engine speed

B. Cylinder 6 is contributing more power than the other cylinders — the small RPM drop indicates the remaining 5 cylinders can nearly maintain the engine speed when Cylinder 6 is cut out because their combined output is close to the total engine requirement

C. Cylinder 6's injector did not actually disable during the cutout test — the ECM's driver circuit for Cylinder 6 has a fault that prevents it from responding to the cutout command

D. Cylinder 6 is the rearmost cylinder on the engine and its location near the flywheel provides a natural inertia advantage — the flywheel's stored energy masks the RPM drop from Cylinder 6's cutout

30. A diesel engine's fuel system uses a fuelwater separator with a manual drain valve at the bottom. The separator is designed to collect water that has settled to the bottom of the bowl by gravity. The technician discovers the drain valve has been left in the partially open position for an extended period. What has this caused?

A. The partially open drain has been continuously draining fuel from the separator into the drain pan, wasting fuel and reducing the fuel available to the engine during highdemand conditions

B. The partially open drain has allowed air to enter the fuel system from the drain opening — air drawn into the separator through the partially open valve migrates upward through the fuel column, enters the outlet line, and travels to the highpressure pump where it causes cavitation and erratic rail pressure

C. The partially open drain has allowed unfiltered ambient air to enter the fuel system's lowpressure circuit through the drain opening — the air entry point allows both air and contaminants to bypass the separator's filtration and enter the fuel supply. The air causes the highpressure pump to produce inconsistent rail pressure, and the contaminants damage the HP pump and injector precision surfaces

D. The partially open drain has reduced the separator's water collection capacity — the drain opening prevents the water from accumulating in the bowl because it drains out continuously, but this has no negative effect on the fuel quality because the water is being removed as intended

31. A large articulated dump truck's front and rear suspensions use nitrogenoil struts of different sizes. The front struts are smaller diameter than the rear struts. Why are the front struts different from the rear struts on this machine?

A. The front struts are smaller because the front axle carries only the cab and engine weight, while the rear axle carries the loaded dump body — the different strut sizes are matched to the different axle loads

B. The front struts are smaller because they must respond faster to road inputs for steering stability — a smaller diameter strut has a faster natural frequency that provides quicker response to directional changes

C. The front struts are smaller because they are mounted at a steeper angle than the rear struts, and the angular mounting amplifies the strut's effective force, allowing a smaller strut to support the same load

D. The front struts are designed with a different size to provide a softer ride at the cab — the front axle supports the operator's station, and the softer front suspension reduces the vibration transmitted to the cab for operator comfort, while the stiffer rear struts support the heavy payload

32. A machine's hydraulic brake system uses a brake accumulator that provides emergency brake applications after the engine shuts off. The technician tests the accumulator and it provides the required 4 emergency applications. However, the technician notices the brake pedal feel changes significantly between the first and fourth applications — the first application has a firm pedal, and the fourth has a soft, spongy pedal that requires more pedal travel. What does the progressive softening indicate?

A. The accumulator's precharge is at the low end of the acceptable range — the gas precharge volume is sufficient for 4 applications but the pressure drops enough between the first and fourth applications that the pedal feel changes noticeably. Recharging the precharge to the midpoint of the specification range provides more consistent pedal feel across all 4 applications

B. The brake fluid has air in the circuit that compresses more noticeably at the lower accumulator pressure during the fourth application — the air is present throughout the circuit but only produces a perceptible spongy feel when the supply pressure decreases during the accumulator discharge

C. The brake master cylinder's piston seals are bypassing at the lower accumulator pressure — the seals hold at the first application's high pressure but allow internal bypass at the fourth application's reduced pressure

D. The progressive pedal softening is a normal characteristic of accumulatorpowered brake systems — all accumulator brake systems exhibit this behaviour and the specification requires only that 4 applications are achieved, not that the pedal feel is identical across all 4

33. A tracked excavator has been operating in a rocky environment. During undercarriage inspection, the technician discovers the track link rail surfaces (the smooth upper surface that contacts the bottom rollers) have developed surface spalling — small pieces of hardened surface material have flaked away, leaving shallow craters. What caused this spalling?

A. The track link rails have been exposed to excessive moisture that has produced rust under the hardened surface layer, lifting and breaking the hardened material from the softer base metal beneath

B. The track chain tension is too tight, and the excessive preload on the linktoroller contact area produces fatigue stress that exceeds the hardened surface layer's fatigue limit, causing it to spall

C. The rocky environment has subjected the track link rail surfaces to repeated highimpact contact loading — rocks caught between the rollers and the link rails create concentrated impact forces that exceed the surface hardness at specific points. The repeated impact loading produces fatigue cracks beneath the hardened surface that propagate laterally, lifting and breaking the hardened material in flakes (spalling)

D. The bottom rollers have developed flat spots from wear, and the flat spots create a hammering effect on the track link rails during each roller revolution, producing the spalling damage at regular intervals along the chain

34. A wheel loader's rear axle uses a limited slip differential with a multidisc clutch pack. The clutch pack requires a specific friction modifier additive in the differential oil. A technician changes the differential oil but uses standard gear oil WITHOUT the friction modifier. What symptom will the operator notice?

A. The differential produces excessive heat from the clutch pack's continuous engagement — the missing modifier allows the clutch pack to generate more friction than designed during normal differential action

B. The differential produces a chatter or shudder during slow, tight turns — without the friction modifier, the clutch pack alternates between grabbing (static friction exceeds kinetic friction) and slipping during the speed differential between the two axle shafts in a turn. The grabslip cycle produces the chatter vibration felt through the machine

C. The differential lock does not engage because the clutch pack requires the modifier's lubricating properties to allow the discs to slide into engagement — without the modifier, the discs bind before full engagement

D. The differential produces a grinding noise during straightline travel because the clutch pack discs are running without the modifier's protective film between the friction surfaces

35. A machine's track has been installed with one track shoe installed backward — the grouser orientation is reversed compared to all other shoes. The operator has been working for 50 hours before

the technician discovers the error during a routine inspection. What consequence has the backward shoe produced?

A. The backward shoe has had no significant consequence — a single reversed shoe among dozens produces no measurable effect on machine performance or track wear over 50 hours

B. The backward shoe has worn the bottom rollers unevenly — the reversed grouser contacts the roller tread at a different angle than the correctly installed shoes, producing accelerated wear on the roller at the reversed shoe's position

C. The backward shoe has reduced the machine's traction — the reversed grouser pattern cannot grip the ground effectively during the shoe's contact period, reducing the pulling force by a small percentage

D. The backward shoe creates an uneven ground contact pattern that loads the track chain unevenly at that position — the reversed shoe's grouser contacts the ground at the wrong angle, creating an asymmetric force that accelerates pin and bushing wear at the adjacent links and may damage the shoe mounting hardware from the nondesigned loading angle

36. A technician is measuring the brake drum diameter on a machine equipped with drum brakes. The measured diameter is 410 mm. The OEM specification for a new drum is 400 mm, and the maximum allowable diameter (discard limit) is 412 mm. What does the 410 mm measurement tell the technician about the drum's service condition?

A. The drum is within specification and has significant remaining service life — the 410 mm measurement is well below the 412 mm discard limit

B. The drum is near the end of its service life — at 410 mm, the drum is only 2 mm from the 412 mm discard limit. The drum wall has thinned significantly from repeated machining and wear, reducing its thermal mass and its ability to dissipate braking heat. The drum should be monitored closely and replaced at the next service before it reaches the discard limit

C. The drum must be replaced immediately — the 410 mm measurement exceeds the 400 mm new specification and the drum is no longer within its designed operating parameters

D. The drum can be machined (turned) to restore a smooth braking surface — the 2 mm remaining before the discard limit provides enough material for one final machining cut before the drum reaches its maximum diameter

37. A machine's air brake system has been tested and the technician discovers the front axle brakes apply approximately 0.5 seconds after the rear axle brakes when the brake pedal is pressed. The time delay is consistent on every application. What is the most likely cause of this frontrear timing difference?

A. The front brake circuit has a longer air line run (more physical distance between the foot valve and the front chambers) than the rear circuit — the air must travel the additional length of tubing, and the pneumatic signal delay produces the timing difference. The relay valve for the front circuit may also have a slower response than the rear circuit's relay valve

B. The front brake chambers are larger than the rear chambers and require more air volume to fill before the brakes apply — the foot valve's flow capacity is the same for both circuits but the larger chambers take longer to pressurize

C. The front brake proportioning valve delays the front brake application intentionally to prevent front wheel lockup during initial brake engagement — the delay is a designed safety feature

D. The rear brakes have weaker return springs that allow the brake shoes to contact the drum sooner than the front brakes, producing the perceived timing difference even though the air delivery is simultaneous

38. A machine's track adjuster grease cylinder has a relief valve that opens at a predetermined pressure to prevent the track from overtightening. During operation, the technician observes grease weeping from the relief valve. What does this active weeping indicate?

A. The relief valve has failed — a properly functioning relief valve opens momentarily during shock events and reseals immediately. Continuous weeping indicates the valve seat is damaged or contaminated

B. The track tension is excessive — but the weeping is normal and indicates the relief valve is protecting the system by releasing the excess pressure

C. The track chain encounters an obstacle or accumulates material (mud, rocks) that momentarily increases the chain tension beyond the relief valve's setting — the relief valve opens to release the excess pressure, and the expelled grease is the visible evidence. This is the designed function of the relief valve, but frequent weeping indicates the track is routinely encountering conditions that exceed the tension setting

D. The grease cylinder has been overfilled — the excess grease has no room to expand during normal thermal cycling and the relief valve opens to vent the thermal expansion

39. A rigidframe dump truck's steering system uses an emergency steering pump that activates automatically when the main steering pump's output drops below a minimum threshold. During a test, the technician discovers the emergency pump activates but the steering response during emergency mode is significantly slower than normal mode. Is this normal?

A. No — the emergency steering must provide the same steering speed as normal mode to ensure the operator can make effective emergency manoeuvres

B. No — the emergency pump should provide 75% of the normal steering speed, and significantly slower than this indicates the emergency pump has insufficient capacity

C. Yes — but only if the emergency steering achieves the OEMspecified minimum locktolock time. The emergency pump is typically smaller than the main pump and provides reduced flow to the steering cylinders, producing slower but functional steering

D. Yes — the emergency steering is designed to be significantly slower than normal to conserve the emergency pump's capacity for multiple steering cycles rather than providing a single fast cycle

40. A machine's front axle oscillation (articulation at the axle mounting) allows the front axle to pivot relative to the machine frame to maintain ground contact on uneven terrain. The oscillation pivot has a limited range of motion (typically ±10–15 degrees). During inspection, the technician discovers the oscillation stops (mechanical limiters) are damaged — the rubber bumpers have been torn and the metal backing plates are bent. What caused this damage?

A. The machine has been operating on terrain that exceeds the oscillation range — the axle has repeatedly contacted the hard stops with enough force to damage the limiters. This indicates the machine is being used in conditions more severe than its designed application, or the machine is being operated at excessive speed over rough terrain, producing dynamic forces that exceed the limiters' design capacity

B. The rubber bumpers have deteriorated from age and UV exposure — the damage is from environmental degradation, not from excessive operating forces

C. The oscillation pivot bearings have seized, preventing the axle from pivoting freely — the seized bearings force all the terrainfollowing movement onto the stops, overloading them

D. The machine's tire pressure is too low on one side, causing the axle to sit at an asymmetric angle that loads one oscillation stop more than the other

41. A machine's track undercarriage has completed 8,000 hours. The bottom rollers show 60% tread wear. The track chain shows 3.5% pitch elongation (turn point is 3%, replacement is 6%). The front idler shows 50% tread wear and 55% flange wear. The sprocket segments show 70% tooth wear. Based on these measurements, which component should be serviced FIRST to maximize the overall undercarriage life?

A. The bottom rollers — at 60% wear, they are the most worn components and will reach their limit before the other components

B. The sprocket segments — at 70% wear, they are the most worn component and will fail first, potentially damaging the track chain when the worn teeth cannot engage the chain properly

C. The track chain should receive a pin turn now — the chain has passed the optimal turn point (3%) and a turn exposes the unworn pin and bushing surfaces, extending the chain life to match the remaining life of the rollers and idler. The sprocket segments should be replaced simultaneously because they have the highest wear percentage and will not last to the chain's second wearout

D. The front idler — the 55% flange wear is the most critical measurement because flange wear controls the chain's lateral guidance and a flange failure allows derailment, which is a safety hazard

42. A machine's hydraulic brake system uses two independent brake circuits — a front circuit and a rear circuit. Each circuit has its own master cylinder section, its own brake lines, and its own set of calipers. If one circuit fails completely (total loss of hydraulic pressure), what braking capability remains?

A. The machine has no braking because both circuits share a common fluid reservoir and a failure in one circuit drains the other

B. The remaining functional circuit provides braking on its axle only — the machine can still stop but the stopping distance is approximately doubled because only one axle is braking instead of two. The operator may also experience a pulling tendency toward the side with functional brakes during application

C. The remaining circuit automatically increases its brake pressure to compensate for the failed circuit, maintaining approximately the same total braking force

D. The parking brake activates automatically when one circuit fails, providing the emergency stopping force independently of the hydraulic circuits

43. A crawler dozer's sprocket teeth are measured and found to be at 75% wear. The track chain has been recently pinturned and is effectively at 0% wear on its second wear life. Installing the new chain surface on the heavily worn sprocket will produce what consequence?

A. The worn sprocket teeth will not mesh correctly with the renewed chain — the worn tooth profile cannot engage the chain links at the designed pitch, producing chain climbing (the chain rides up on the worn teeth rather than seating in the tooth roots). The chain climbing accelerates wear on both the new chain surfaces and the remaining sprocket tooth material, and may cause the chain to skip or derail from the sprocket

B. The worn sprocket provides a beneficial breakin surface for the new chain — the smoother worn tooth profile produces less aggressive initial wear on the renewed chain surfaces compared to a new sprocket

C. The worn sprocket and renewed chain will operate normally until the sprocket reaches 100% wear — the chain pitch and sprocket pitch remain compatible regardless of the individual component wear states

D. The chain pitch has changed from the pin turn and no longer matches any sprocket — only a new chain with the original pitch specification can mesh with the worn sprocket

44. A machine's parking brake is springapplied, hydraulically released (SAHR). The springs apply the brake when the hydraulic release pressure is removed. During an inspection, the technician measures the parking brake's holding torque using a calibrated torque wrench and finds it is 15% below the OEM specification. What is the most likely cause of the reduced holding torque?

A. The brake housing has warped from repeated thermal cycling, changing the internal alignment between the brake discs and the piston

B. The hydraulic release circuit has a slow leak that maintains partial release pressure on the springs even when the parking brake is commanded "applied" — the residual pressure partially compresses the springs, reducing their clamping force on the brake pack

C. The brake disc friction material has glazed from repeated application/release cycles without sufficient heat to prevent glazing, reducing the friction coefficient between the discs and separator plates

D. The parking brake springs have weakened from age and repeated compression cycling — the springs no longer generate their designed clamping force when fully released to the applied position. Spring fatigue is the most common cause of gradually declining holding torque in SAHR parking brakes

45. A wheel loader's tire has developed a bulge on the sidewall approximately 100 mm in diameter. The bulge is soft and compressible. The tire is inflated to the correct pressure. What does this sidewall bulge indicate?

A. The bulge is a manufacturing defect in the rubber compound — the local rubber density is lower than the surrounding material and expands under inflation pressure

B. The tire's internal sidewall cords (the structural reinforcement that maintains the sidewall shape) have broken at the bulge location — the broken cords cannot contain the inflation pressure at that point, allowing the inner liner to push outward through the damaged zone. The tire's structural integrity is compromised and it can fail suddenly at the bulge point, especially under load

C. The bulge is from a repair patch that was applied from inside the tire — the patch material has a different flexibility than the original sidewall and produces the visible bulge

D. The bulge is from a rimtobead seal issue — air has migrated between the tire bead and the rim flange and accumulated between the inner liner and the sidewall rubber, producing the visible bulge

46. A machine equipped with an anti-lock braking system (ABS) performs a routine brake test on dry pavement at 15 km/h. During the test, the operator feels the brake pedal pulsate briefly — a characteristic sign that the ABS has activated. The operator is concerned because no wheels visibly locked during the application. The technician verifies the ABS has no fault codes and all wheel speed sensors produce correct signals. What is the correct explanation for the ABS activation?

A. The ABS system malfunctioned during the test — ABS should never activate on dry pavement because the high tire-to-surface friction coefficient prevents any wheel from approaching lockup under any braking condition

B. The brake pad material has a higher friction coefficient than the tire-to-road interface, which forces the ABS to intervene on every brake application regardless of the surface condition

C. The ABS is functioning correctly — the system detected an incipient lockup at one or more wheels (a brief wheel deceleration rate that exceeded the lockup threshold) and modulated the brake pressure to prevent full lockup before it became visually apparent. This is the designed function of ABS — it intervenes at the threshold of lockup, not after a visible skid has developed

D. The ABS control module is cycling the brake pressure as a self-test routine that runs automatically during the first brake application below 20 km/h — the pedal pulsation is the self-test, not an actual anti-lock intervention

47. A machine's 24V electrical system has a parasitic draw (current drain with all systems off) of 350 milliamperes. The OEM specification maximum is 50 milliamperes. The technician must locate the circuit responsible for the excessive draw. What is the correct diagnostic procedure?

A. Disconnect each ECM connector one at a time and monitor whether the draw drops — ECMs are the most common source of parasitic draw on modern heavy equipment

B. With the battery disconnect switch OFF and the DMM connected in series (ammeter mode) between the battery and the main bus, remove one fuse at a time from the fuse panel while monitoring the ammeter — when the correct fuse is pulled, the parasitic draw drops from 350 mA to approximately 50 mA (the acceptable baseline). The removed fuse identifies the circuit that is drawing the excess current

C. Connect a clampon ammeter around the battery positive cable and start the engine — the parasitic draw is only measurable with the engine running and the charging system active

D. Measure the voltage drop across each fuse in the fuse panel with all systems off — fuses with higher voltage drops indicate circuits with higher current draw, and the highest voltage drop identifies the parasitic circuit

48. A machine's ECM receives a signal from a coolant level sensor. The sensor is a simple float switch — the switch closes (completes the circuit to ground) when the coolant level is adequate, and opens (breaks the circuit) when the level drops below the minimum. The ECM has a 1,000ohm pullup resistor on the input. When the switch is closed, the ECM reads approximately 0V. When the switch opens, the ECM reads approximately 5V. The technician reads the ECM input at 2.3V with the coolant level confirmed full. What does the 2.3V reading indicate?

A. The coolant level sensor float is stuck between the full and low positions, producing an intermediate signal that represents a partial coolant level

B. The sensor switch contacts have corrosion or contamination that creates resistance in the switch — instead of closing to 0 ohms (0V), the corroded contacts create a resistance that forms a voltage divider with the ECM's pullup resistor, producing the intermediate 2.3V reading

C. The 2.3V reading is the float switch's designed intermediate signal that indicates the coolant is at the correct level — the 0V and 5V readings represent the extreme high and low levels respectively

D. The ECM's pullup resistor has failed and is producing the incorrect reading regardless of the switch state — the 2.3V represents the regulator's output through the failed resistor

49. A machine's alternator produces a whining noise that increases in pitch with engine RPM. The noise was not present before the alternator was replaced with a remanufactured unit. The charging voltage and current are within specification. The drive belt tension is correct. What is the most likely source of the whining noise?

A. The remanufactured alternator's internal bearings have a defect that produces the speeddependent whine — although the bearing defect has not yet affected the alternator's electrical output, the noise will worsen as the bearing deteriorates. The alternator should be warranted and replaced before the bearing fails completely

B. The remanufactured alternator has a different pulley ratio than the original, spinning the alternator faster at each engine RPM and producing more audible electromagnetic noise from the higher stator frequency

C. The alternator's voltage regulator is oscillating and the electromagnetic field pulsation produces the whining noise through the stator laminations

D. The drive belt is the wrong profile for the remanufactured alternator's pulley — the mismatched belttopulley contact produces the whine during rotation

50. A machine's ECM controls an electronically actuated fuel injector. The injector solenoid has a rated resistance of 0.5 ohms. The ECM's driver supplies 24V to the injector during the initial pullin phase. What peak current does the injector draw during pullin?

A. 12 amperes — calculated as V ÷ R = 24 ÷ 2 = 12A, using twice the coil resistance to account for the inductance

B. 0.48 amperes — calculated as V × R = 24 × 0.02 = 0.48A, confusing multiplication with division

C. 240 amperes — calculated as V ÷ (R × 0.1) = 24 ÷ 0.05, using 10% of the resistance

D. 48 amperes — calculated as V ÷ R = 24 ÷ 0.5 = 48A. This high peak current is why the ECM uses a currentlimiting strategy (PWM or voltage reduction) after the initial pullin to reduce the holding current and prevent the solenoid coil from overheating

51. A machine's CAN bus has 12 modules. The technician discovers that Module 7 occasionally transmits data frames with incorrect CRC (cyclic redundancy check) values. The receiving modules detect the CRC error and discard the corrupted frame. What is the practical effect on the machine's operation?

A. The machine operates normally because the other 11 modules ignore Module 7's corrupted frames and use their own internally generated default values for the missing data

B. The machine shuts down immediately whenever a CRC error is detected because the CAN protocol treats any data corruption as a safetycritical fault requiring immediate engine shutdown

C. The corrupted frames from Module 7 overwrite valid data in the receiving modules' memory, causing cascading errors across all systems that use Module 7's data

D. The receiving modules discard the corrupted frame and wait for Module 7's next valid transmission — the data update is delayed by one transmission cycle. If the errors are infrequent, the effect is imperceptible. If frequent, the receiving modules may trigger DTCs for missing or stale data from Module 7, and functions that depend on Module 7's data may operate intermittently

52. A machine's electronic throttle pedal has been replaced. The new pedal's idle voltage is 0.8V (specification: 0.5V). The fullthrottle voltage is 4.2V (specification: 4.5V). The technician calibrates the ECM to the new pedal's actual endpoints. After calibration, the engine responds correctly to the pedal. However, the technician notices the ECM's throttle position parameter shows 100% at full pedal travel, but the actual engine RPM at full pedal reaches only 95% of rated RPM. What is the cause?

A. The ECM's internal RPM limiter has been set 5% below the rated RPM during a previous service event and the throttle calibration cannot override the RPM limit

B. The new pedal's voltage range (0.8–4.2V = 3.4V span) is narrower than the specification range (0.5–4.5V = 4.0V span) — the ECM maps 100% of the physical pedal travel to 100% of the throttle command, but the 3.4V span may not reach the ECM's internal fullfuel voltage threshold even though the display shows 100%. The ECM interprets the 4.2V endpoint as slightly less than the fullfuel command

C. The engine's governed speed has decreased from wear — the throttle pedal is commanding 100% but the engine cannot reach rated RPM due to internal friction losses

D. The turbocharger is limiting the engine's maximum RPM — the boost pressure at 4.2V throttle command is below the threshold for the ECM to permit full rated RPM

53. A machine's electronic display shows battery voltage at 28.5V with the engine running. The technician measures the voltage directly at the battery terminals and reads 27.2V. Where is the 1.3V discrepancy originating?

A. The display module is measuring the voltage at a point in the electrical system that is closer to the alternator's output — the charging circuit's voltage is higher near the alternator and decreases through the resistance of cables and connections as it travels to the battery terminals. The display reads the higher voltage near the alternator, while the DMM reads the lower voltage at the battery terminals after the cable voltage drop

B. The display module's internal voltagesensing circuit has drifted from calibration and reads 1.3V higher than the actual voltage at any measurement point

C. The DMM's input impedance is loading the battery, pulling the measured voltage down by 1.3V — using a higherimpedance meter would produce the same reading as the display

D. The alternator's diode trio has a voltage offset that adds 1.3V to the displayed reading but does not affect the actual charging voltage at the battery

54. A machine's ECM monitors a fuel pressure sensor on the common rail. The sensor's output range is 0.5V (0 MPa) to 4.5V (200 MPa). The ECM reads 3.8V during loaded operation. What rail pressure does this voltage represent?

A. 152 MPa — calculated by the proportion (3.8 − 0.5) ÷ (4.5 − 0.5) × 200 = 3.3 ÷ 4.0 × 200 = 165 MPa. This uses the full sensor range (0.5–4.5V = 4.0V span representing 0–200 MPa)

B. 168.9 MPa — calculated as 3.8 ÷ 4.5 × 200 = 168.9, which ignores the 0.5V offset

C. 190 MPa — calculated as 3.8 ÷ 4.0 × 200 = 190, which confuses the voltage span with the absolute voltage

D. 165 MPa — the sensor output spans 4.0V (from 0.5V to 4.5V) representing 200 MPa (from 0 to 200 MPa). At 3.8V, the signal is 3.3V above the 0.5V baseline. Pressure = (3.3 ÷ 4.0) × 200 = 165 MPa

55. A machine's electronic system uses a relay to control a highcurrent circuit (hydraulic fan motor, 60A). The relay has been in service for 5 years. The technician discovers the relay's contacts have developed pitting and discolouration. The circuit still functions but the relay contacts are visibly degraded. What longterm consequence do the degraded contacts produce?

A. The pitted contacts have no operational consequence — relay contacts are designed to develop a patina during normal service that actually improves the contact resistance over time

B. The pitted contacts intermittently fail to close under vibration, producing random circuit dropouts that the operator may not notice during normal operation but that stress the fan motor with repeated start/stop cycles

C. The pitted and discoloured contacts have increased contact resistance — the resistance generates heat at the contact point during each 60A circuit activation. The heat further degrades the contacts and the relay socket, progressively increasing the resistance in a selfreinforcing cycle. The voltage drop across the degraded contacts reduces the voltage delivered to the fan motor, reducing motor performance, and the heat may eventually melt the relay socket or cause a fire

D. The pitted contacts increase the relay's pullin current requirement — the degraded contacts require more magnetic force to make a solid connection, drawing more current through the relay coil and potentially overloading the ECM's driver circuit

56. A machine's electronic system has a ground stud on the machine frame where multiple ECM ground wires terminate. The technician discovers the ground stud has loosened and the mounting surface has corroded. The stud is retightened and the corrosion cleaned. What symptom did the loose ground stud produce before it was repaired?

A. The loose ground produced a momentary power loss during each engine start — the high starter current flow through the corroded ground connection produced a voltage drop that reduced the ECM's supply voltage below the operating threshold during cranking

B. The loose ground caused all ECMs sharing that ground stud to produce random, intermittent DTCs for various sensors — the corroded highresistance ground shifts the voltage reference for every sensor circuit that uses that ground point, producing voltage readings that the ECMs interpret as outofrange. The random nature of the DTCs (different sensors, different ECMs, different conditions) is the diagnostic signature of a shared ground fault

C. The loose ground caused the machine's starting system to crank slowly because the cranking current had to flow through the highresistance ground connection

D. The loose ground caused the machine's lights to flicker during operation because the lighting circuit shared the same ground point as the ECM circuits

57. A machine's electronic fuel injection system uses a pressure control valve (PCV) on the common rail to regulate the rail pressure. The PCV is normally closed (springheld closed) and the ECM energizes the PCV to open it and release excess fuel from the rail to the return. If the PCV's electrical connector is disconnected while the engine is running, what happens?

A. The engine continues to run normally because a secondary pressure control mechanism (the inlet metering valve) maintains the rail pressure independently of the PCV

B. The PCV closes fully without electrical command and the rail pressure rises rapidly — the HP pump continues to deliver fuel to the rail but none can escape through the closed PCV. The rail pressure increases until the rail's mechanical overpressure relief valve opens, protecting the rail from exceeding its burst pressure

C. The engine stalls immediately because the PCV opens fully without electrical command and dumps all rail pressure to the return line

D. The rail pressure rises to the PCV's springheld default pressure (typically 50–80 MPa above idle specification) and stabilizes — the engine runs rough and overpowers but does not stall or reach the mechanical relief valve's opening pressure because the default spring force produces a controlled intermediate pressure

58. A machine's electronic display has a "trip data" screen that shows the machine's fuel consumption in litres per hour. The operator reports the fuel consumption has increased from 45 L/hr to 55 L/hr (a 22% increase) over the past month, with no change in the work being performed. The engine produces rated power and all ECM parameters are within specification. What should the technician investigate that could increase fuel consumption without producing any abnormal ECM parameters?

A. The machine's drivetrain efficiency — worn torque converter, slipping clutch packs, dragging brakes, low tire pressure, or increased rolling resistance from track or undercarriage wear all require the engine to produce more power (and consume more fuel) to maintain the same machine performance. All these conditions increase fuel consumption without triggering enginerelated DTCs because the engine itself is performing correctly

B. The fuel tank's sender unit — a miscalibrated sender produces an inaccurate fuel level reading that the display's consumption calculation uses, producing a false fuel consumption increase

C. The ambient temperature has changed — colder weather increases fuel consumption by approximately 20% due to the increased air density requiring more fuel for the same power output

D. The engine's internal timing has retarded from a worn timing gear — the retarded timing produces the same power output but requires more fuel per cycle, increasing the consumption without changing the ECM's monitored parameters

59. A machine's electronic throttle has a dualredundant APPS (accelerator pedal position sensor). The ECM continuously monitors the correlation between the two sensor signals. The ECM detects a correlation fault — the two signals disagree by more than the allowed tolerance. The ECM's programmed response to this fault is to limit the engine to a fixed 1,200 RPM until the fault is cleared. Why does the ECM limit engine speed rather than shutting the engine off completely?

A. Shutting the engine off would disable the machine's steering, brakes, and other safety systems — a complete shutdown creates a more dangerous situation than limiting the engine to a controlled low speed

B. The ECM cannot shut the engine off while in motion because the transmission requires engine rotation to maintain hydraulic pressure for the clutch packs

C. The 1,200 RPM limit provides enough power for the operator to move the machine to a safe location (out of traffic, off a haul road, or out of an active work zone) while preventing the engine from reaching a speed that could be dangerous with an unreliable throttle signal. A complete shutdown in an active work area could leave the machine stranded in a hazardous position

D. The ECM's internal safety architecture requires a minimum of two consecutive fault detections before a full shutdown is permitted — the single correlation fault triggers only the intermediate response of speed limiting

60. A machine's CAN bus operates on a twistedpair cable (CANH and CANL). The technician measures the DC resistance between CANH and CANL at the diagnostic connector with all modules powered off. The reading is 60 ohms. The technician then disconnects the termination resistor at one end of the bus and remeasures: the reading is 120 ohms. What does this confirm?

A. Both termination resistors are present and correct — the two 120ohm resistors in parallel produce the measured 60 ohms. Disconnecting one leaves a single 120ohm resistor, confirming the bus termination is correctly configured

B. The bus has excessive termination — three 120ohm resistors are installed in parallel and one must be removed to achieve the correct 60ohm total

C. The bus has a short circuit between CANH and CANL that is producing the low 60ohm reading — a healthy bus should read open circuit (infinite resistance) with all modules powered off

D. The CAN bus wiring has a fault — the 60ohm reading indicates the CANH and CANL wires have been swapped at one module connector, creating a crossed pair that produces the low resistance reading

61. A machine's electronic system uses a J1939 CAN bus for intermodule communication. The engine ECM broadcasts an engine RPM message (PGN 61444) at a rate of 100 milliseconds. The transmission control module (TCM) uses this RPM data for shift decisions. If the TCM does not receive an RPM update for 500 milliseconds (five consecutive missed messages), the TCM enters a protective mode. What protective action does the TCM take?

A. The TCM commands maximum line pressure to all clutch packs to prevent any gear from disengaging during the data loss period

B. The TCM shifts to neutral and inhibits all gear engagements until RPM data is restored — without knowing the engine speed, the TCM cannot calculate the synchronous speed for any gear engagement and risks a clash shift that damages the clutch packs

C. The TCM holds the current gear and inhibits all shift commands until RPM data is restored — shifting without knowing the current engine speed risks engaging a gear at the wrong synchronous speed, damaging the clutch packs

D. The TCM commands an immediate upshift to the highest gear to reduce the drivetrain speed and minimize the risk of damage during the RPM data loss

62. A machine's electronic system includes a telematics module that transmits machine health data to the fleet management system via cellular network. The module receives GPS position, records operating parameters (hours, fuel consumption, DTCs, idle time), and transmits this data at programmed intervals. If the telematics module fails, what operational capability does the machine lose?

A. The machine loses remote monitoring and fleet management visibility — the fleet manager can no longer track the machine's location, operating hours, fuel consumption, or fault codes remotely. However, the machine itself operates normally because the telematics module does not control any machine function — it is a monitoring and communication device only

B. The machine loses all electronic control because the telematics module provides the master clock signal that synchronizes all ECMs on the CAN bus

C. The machine loses the ability to start because the telematics module provides the security authorization signal that the engine ECM requires before permitting ignition

D. The machine loses GPSguided automatic control functions (grade control, machine guidance) because the telematics module provides the position data that these systems require

63. A machine's electronic engine protection system monitors coolant temperature and is programmed with a threestage response: Stage 1 (warning at 100°C) — dashboard warning light and audible alarm. Stage 2 (derate at 105°C) — engine power reduced to 50%. Stage 3 (shutdown at 110°C) — engine shuts down after a 30second warning. The operator reports the engine shut down with no prior warning light or derate — it went directly from normal operation to shutdown. What could explain the missing Stage 1 and Stage 2 responses?

A. The engine protection stages are functioning correctly — the operator did not notice the warning light because it was obscured by sunlight, and the derate was not perceptible during the lightload operation before the shutdown

B. The coolant temperature sensor has developed a fault that produces a signal jump — instead of gradually increasing through 100°C, 105°C, and 110°C, the sensor's output jumps directly from the normal operating range to above 110°C in a single step (from a broken sensing element, a loose connection, or an internal short)

C. The coolant temperature rose through the stages so rapidly (from a sudden, catastrophic cooling system failure such as a burst hose or failed water pump) that the time spent at each stage was too brief for the operator to perceive — the engine passed through Stage 1 and Stage 2 in seconds before reaching Stage 3 shutdown

D. The ECM's engine protection software has a bug that skips Stage 1 and Stage 2 under specific operating conditions — the software revision should be updated to correct the fault

64. A machine's starter motor produces normal cranking speed on the first start attempt of the day. On the second start attempt (5 minutes after the engine was shut off from the first run), the cranking speed is noticeably slower. The battery voltage before both attempts is identical (25.8V). What is the most likely explanation?

A. The alternator did not fully charge the batteries during the brief first run — the batteries' surface charge appeared correct (25.8V) but the internal charge state was depleted by the first cranking event and not fully replenished

B. The engine oil has warmed from the first run and the warmer, thinner oil allows the engine to spin more freely — the slower cranking on the second attempt contradicts this, so the explanation is the opposite: something has increased the cranking resistance

C. The starter motor solenoid contacts have developed high resistance from the heat of the first cranking event — the hot contacts resist more current, reducing the cranking speed on the second attempt

D. The starter motor has heatsoaked from the first run — the starter motor is located near the engine block and the heat from the running engine has raised the starter motor's internal temperature. The higher temperature increases the resistance of the starter's copper windings (copper's resistance increases with temperature), reducing the current flow and the cranking speed

65. A machine's electronic system uses a speed sensor on the transmission output shaft. The sensor is a Halleffect type that produces a digital square wave with a frequency proportional to shaft speed. The sensor's output is used by the ECM for ground speed calculation and by the ABS module for wheel speed. If the sensor's air gap increases from wear on the sensor tip or the tone ring, what effect does this have on the signal?

A. The increased air gap reduces the magnetic field strength at the Halleffect element, but the sensor's internal electronics maintain the digital output voltage at the specified level — however, at higher shaft speeds, the reduced magnetic field changes may not trigger the sensor's switching threshold fast enough, producing missed pulses that cause the ECM to calculate a lowerthanactual speed

B. The increased air gap has no effect on a Halleffect sensor — unlike a variable reluctance sensor, the Halleffect sensor's digital output is independent of the air gap because it uses a powered semiconductor element rather than passive magnetic induction

C. The increased air gap produces a proportionally weaker output voltage that the ECM interprets as a slower shaft speed — the ECM calculates speed from the signal amplitude rather than the frequency

D. The increased air gap causes the sensor to produce double pulses (two pulses per tooth instead of one) because the weakened magnetic field produces edge effects that trigger the Hall element twice during each tooth passage

66. A machine's ECMcontrolled cooling fan has three operating modes: low speed (30% duty cycle), medium speed (60% duty cycle), and high speed (100% duty cycle). The ECM selects the mode based on coolant temperature, intake air temperature, and A/C pressure. The technician discovers the fan operates at high speed continuously, regardless of the temperatures. There are no active DTCs. The ECM data shows all temperature inputs are within normal range. What should the technician investigate?

A. The ECM's fan control output — the ECM may have an internal driver fault that locks the output at 100% regardless of the programmed control logic. The technician should measure the actual PWM output at the ECM connector to verify the ECM is commanding 100% or if the fault is downstream of the ECM

B. The fan motor's internal speed controller — a failed controller may lock the motor at maximum speed regardless of the ECM's PWM command

C. The A/C highpressure switch — if the switch has failed in the closed position, it continuously signals the ECM that the A/C requires maximum cooling, overriding the temperaturebased fan control even though the A/C pressure displays as normal on the ECM data screen

D. The fan clutch — a viscous or electromagnetic fan clutch that has failed in the engaged position locks the fan at engine speed regardless of the ECM's command

67. A machine's electronic joystick controls are intermittently unresponsive — the operator moves the joystick and the implement does not respond for 1–2 seconds, then suddenly moves. The delay is random and affects all joystick functions equally. The joystick signal at the ECM input is verified as correct and responsive (no delay at the ECM). Where is the delay occurring?

A. The hydraulic pilot pressure system is slow to respond — the pilot oil has high viscosity from cold temperature or the wrong oil specification, delaying the pilot valve's response to the ECM's solenoid command

B. The CAN bus is experiencing intermittent message delays between the implement ECM (which reads the joystick) and the machine controller (which commands the solenoids) — the implement ECM receives the correct joystick signal promptly but the command message to the solenoid controller is delayed on the bus

C. The main DCV spools are sticking from contamination — the ECM sends the correct command promptly, the solenoids respond promptly, but the DCV spools resist movement until the pilot pressure overcomes the contamination resistance, producing the 1–2 second delay

D. The hydraulic pump is slow to respond — the pump's compensator requires 1–2 seconds to stroke the pump from standby to the demanded flow when the joystick command arrives

68. A machine's electronic fuel injection system has an emergency fuel shutoff solenoid that is energized to RUN and deenergized to STOP. This "failsafe" design ensures the engine shuts off if the solenoid loses power for any reason. The technician discovers the solenoid's wiring has a highresistance connection at one terminal. What operational symptom does this high resistance produce?

A. The engine starts normally but shuts off randomly during operation when the highresistance connection momentarily opens under vibration, deenergizing the solenoid and shutting off the fuel supply until the connection reestablishes

B. The engine runs normally — the solenoid is either energized or deenergized, and the high resistance does not change the binary state of the solenoid

C. The engine's fuel delivery is reduced proportionally to the resistance — the solenoid partially opens the fuel path based on the current flowing through it, and the reduced current from the high resistance produces a partial fuel delivery

D. The engine does not start because the high resistance prevents adequate current from reaching the solenoid — the solenoid cannot energize fully to open the fuel path, and the spring holds the solenoid in the shutoff position

69. A machine's alternator has a remotesense wire that connects from the voltage regulator to the battery positive terminal. The remotesense wire allows the regulator to measure the actual battery terminal voltage rather than the alternator's output voltage. If the remotesense wire breaks (open circuit), how does the voltage regulator respond?

A. The regulator loses its remote voltage reference and defaults to sensing the voltage at the alternator's B+ terminal — the alternator's output voltage is higher than the battery terminal voltage (because of the cable voltage drop). The regulator sees a higherthanactual voltage and reduces its field current, producing lower charging voltage at the battery terminals. The batteries are chronically undercharged

B. The regulator increases its output to maximum because it interprets the opencircuit sense wire as zero battery voltage — the alternator overcharges the batteries until the backup overvoltage protection activates

C. The regulator shuts off the alternator completely because the open sense wire is interpreted as a fault condition — the charge warning light illuminates and the batteries discharge

D. The regulator defaults to a fixed output voltage of 28.0V regardless of the battery's actual state of charge — the fixed output provides adequate charging for most conditions but cannot adapt to temperature or load changes

70. A machine's electronic system uses a solidstate fuse module that provides overcurrent protection for each circuit. Unlike traditional blade fuses that blow and must be physically replaced, the solidstate fuse resets automatically after the overcurrent condition is removed. The technician discovers a circuit that is cycling — the solidstate fuse trips, the circuit goes dead, the fuse resets after 5 seconds, the circuit reenergizes, and the overcurrent immediately trips the fuse again. What is occurring?

A. The solidstate fuse has degraded and is tripping at a lower current than its rating — the circuit's normal operating current is triggering the undersensitive fuse

B. The circuit has a persistent overcurrent condition — a short circuit, a seized motor, or an overloaded device is drawing more current than the fuse's rating every time the circuit is energized. The automatic reset feature reenergizes the circuit after each trip, but the fault immediately draws excessive current and trips the fuse again, creating the cycling pattern

C. The solidstate fuse's thermal protection is activating from ambient heat in the fuse module — the high ambient temperature lowers the fuse's effective trip point below the circuit's normal operating current

D. The circuit's inrush current (the brief high current when the circuit first energizes) exceeds the fuse's trip threshold on every startup — the fuse should be replaced with a slowblow type that tolerates the inrush current

71. A machine's CAN bus wiring runs through the engine compartment alongside the engine harness. The technician notices the CAN bus wiring's outer jacket has been abraded against a sharp bracket, exposing the inner twistedpair conductors. The exposed section is approximately 30 mm long. The bus is currently functioning without errors. Should the technician repair the damage?

A. No repair is needed — CAN bus twistedpair wiring is designed to operate with or without the outer jacket, and the twistedpair configuration provides adequate EMI rejection without the outer shield

B. No repair is needed — the exposed section will selfseal when the engine compartment heat softens the outer jacket edges and they meld back together

C. Yes — the damaged outer jacket must be repaired immediately. The exposed conductors are vulnerable to moisture ingress, additional abrasion, and ground contact against the sharp bracket. In the engine compartment environment (vibration, heat, moisture, chemical spray), the exposed wires will eventually short to ground, short to each other, or develop corrosion that degrades the signal quality. The damaged section should be protected with heatshrink, conduit, or tape, and the bracket must be addressed to prevent recurrence

D. Yes — but only because the cosmetic appearance of the exposed wiring may be flagged during a regulatory inspection, not because the exposed conductors pose a functional risk

72. A machine's torque converter has a stall speed specification of 2,100 ± 100 RPM. The technician performs a stall test and records 2,350 RPM — 150 RPM above the upper specification limit. The engine produces rated power (verified on the dynamometer). What does the high stall speed indicate?

A. The torque converter's internal stator oneway clutch has failed — the stator freewheels in both directions instead of locking during the stall condition. Without the stator redirecting the fluid from the turbine back to the pump, the converter loses its torque multiplication function. The pump spins faster (higher stall RPM) because the fluid opposition from the correctly functioning stator is absent

B. The engine is producing more power than rated — the excess power drives the converter pump faster than the designed stall speed

C. The transmission main pressure is too high, creating additional resistance on the turbine that prevents it from rotating and produces the elevated stall speed

D. The converter's turbine blades are eroded from cavitation — the reduced blade surface area produces less resistance to the pump's fluid flow, allowing the pump (and engine) to spin faster during the stall condition

73. A machine's powershift transmission has a clutch pressure test port for each clutch pack. During a diagnostic test, the technician measures Clutch C's apply pressure at 1,200 kPa. The specification is 1,500–1,800 kPa. What is the consequence of the low Clutch C pressure?

A. Clutch C cannot hold its designed torque load — the reduced clamping force produces clutch slip during shifts that engage Clutch C. The slip generates heat that degrades the friction material, contaminating the transmission oil with clutch debris. If uncorrected, the heat and wear will destroy the clutch pack and contaminate the entire transmission

B. Clutch C is within the acceptable range — a 300 kPa deficit from the lower specification limit is within the measurement tolerance of the gauge used for clutch pressure testing

C. Clutch C engages harshly because the low pressure produces a slower apply rate that does not match the ECM's designed shift timing — the clutch engages late in the shift sequence, producing a noticeable bump

D. Clutch C produces no symptom at the current pressure — the specification range includes a safety margin and the clutch operates normally down to 1,000 kPa

74. A machine's differential has been diagnosed with a noisy ring and pinion gear set. The noise is a howling sound during deceleration (coast) that disappears during acceleration (drive). The technician checks the gear tooth contact pattern under coast loading and finds the pattern is concentrated on the heel of the tooth (outer edge). What adjustment corrects this coastheel pattern?

A. Move the pinion further from the ring gear by adding pinion depth shims — this shifts the contact pattern from heel toward toe under coast loading

B. Move the ring gear away from the pinion by adjusting the carrier bearing shims — this changes the backlash and shifts the contact from heel toward toe during the coast loading condition

C. Increase the backlash by adding shims to the ring gear back side — the increased gap shifts the coast contact from heel toward the centre of the tooth face

D. The coastheel pattern cannot be corrected by shimming — it indicates the ring and pinion set is incorrectly matched and must be replaced with a matched set

75. A machine's hydrostatic drive system uses a closedloop circuit with a variabledisplacement pump and a fixeddisplacement motor. The machine's maximum travel speed is determined by the pump's maximum displacement and the motor's fixed displacement. The fleet manager requests a 10% increase in the machine's maximum travel speed. What modification achieves this?

A. Increase the engine's maximum governed RPM by 10% — the higher engine speed drives the pump faster, producing 10% more flow to the motor and increasing the travel speed proportionally

B. Increase the pump's maximum displacement stop by 10% — the larger displacement produces 10% more flow at the same RPM, increasing the motor speed proportionally

C. Replace the motor with a 10% smaller displacement unit — the same pump flow driving a smaller motor produces higher shaft speed (speed = flow ÷ displacement), increasing the travel speed by approximately 10%

D. Increase the charge pressure by 10% — the higher charge pressure fills the pump's cylinders more completely, producing 10% more effective flow to the motor

76. A machine's automatic transmission has been operating normally for 10,000 hours. The technician performs a main line pressure test and measures 1,350 kPa. The specification for this engine RPM and throttle position is 1,400–1,600 kPa. What is the most likely cause of the slightly low main pressure?

A. The transmission's main pressure regulator valve or the pump has worn — at 10,000 hours, the pump's internal clearances have increased and the regulator valve's spooltobore clearance has widened, both of which allow more internal leakage that reduces the maximum achievable main pressure below the specification

B. The transmission oil level is slightly overfilled and the excess oil is creating backpressure on the pump, reducing its effective output pressure

C. The transmission oil temperature is higher than the specification test temperature, and the reduced oil viscosity at the elevated temperature produces a lower pressure reading that does not indicate actual pump or regulator wear

D. The torque converter is consuming more pressure than normal from worn internal seals — the converter's increased leakage reduces the pressure available for the main circuit

77. A machine's drivetrain includes a transfer case with a 1:1 (direct drive) high range and a 2.5:1 low range. The operator selects high range but the machine accelerates at the lowrange speed. The ECM shows the transfer case is in high range. What could cause the machine to operate at lowrange speed despite the ECM reading high range?

A. The engine is producing only 40% of rated power from a fuel system fault — the reduced power limits the machine's acceleration to a level that mimics the lower gearing of low range

B. The torque converter is slipping excessively — the converter cannot transfer the engine's power to the transmission efficiently, producing the same symptom as a lower gear ratio

C. The transfer case position sensor reads high range (satisfying the ECM) but the internal shift mechanism has not physically engaged high range — the sensor detects the shift fork position, not the actual gear engagement. The spline engagement may have failed, the clutch pack for high range may not be holding, or a mechanical binding prevents full engagement despite the fork reaching the high position

D. The ECM's programming has the high and low range parameters swapped — the ECM believes it is commanding high range but the electrical outputs are mapped to the lowrange actuator

78. A machine's wet disc brake is being tested for drag. The technician spins the output shaft by hand with the brake released and measures the drag torque. The measured drag torque is 15 N·m. The specification maximum is 8 N·m. What is the consequence of this excessive brake drag?

A. The excessive drag produces a slight reduction in the machine's maximum travel speed that the operator may not notice during normal operation

B. The excessive drag generates continuous heat during every moment of machine travel — the heat accumulates in the brake housing, raises the brake oil temperature above its designed operating range, accelerates friction disc and seal wear, and wastes fuel because the engine must produce additional power to overcome the drag throughout the entire operating shift

C. The excessive drag has no operational consequence — brake drag within twice the specification is acceptable for machines with more than 5,000 hours of service

D. The excessive drag causes the brake to lock up during loaded turns when the differential applies additional torque to the dragging axle

79. A machine's automatic transmission produces a shudder (vibration) during the torque converter lockup clutch engagement. The shudder is present during every lockup event and disappears when the lockup is disengaged. The transmission oil was recently changed. What is the most likely cause?

A. The lockup clutch disc friction material has glazed from extended use and the smooth surface produces an inconsistent friction coefficient during engagement

B. The lockup clutch piston seal is leaking, producing intermittent engagement that the operator perceives as shudder

C. The replacement transmission oil may not contain the correct friction modifier specification for the lockup clutch — the friction modifier controls the clutch's engagement characteristics, and the wrong modifier (or its absence) produces the grabslip shudder during lockup engagement. The oil specification must be verified against the OEM requirement

D. The torque converter's internal damper springs are broken — the undamped torsional vibration transmits through the locked clutch to the drivetrain, producing the shudder

80. A machine's final drive planetary gear set has been rebuilt. The technician fills the final drive housing with the specified gear oil and operates the machine for 2 hours. After shutdown, the technician drains a small sample of the oil and finds it appears dark grey with fine metallic particles. Is this a concern?

A. Dark grey oil with fine metallic particles after only 2 hours of operation on a rebuilt final drive is normal breakin wear — the new gears' tooth surfaces and the new bearings' rolling elements are polishing against each other during the initial operating period. The oil should be changed after the OEMspecified breakin period (typically 50–100 hours) to remove the breakin debris, and a fresh sample should be taken after the change to establish the baseline for normal operation

B. The dark oil indicates a major assembly error — the gears or bearings are failing and the final drive must be disassembled immediately to prevent catastrophic damage

C. The metallic particles are from the housing's internal surfaces — the cleaning process during the rebuild left residual debris that is now circulating in the oil. A second oil change resolves the issue

D. The dark oil is from the gear oil's additive package reacting with the new gear surfaces — the reaction darkens the oil but does not produce actual metallic wear particles

81. A machine's axle shaft has been diagnosed with excessive end play (axial movement). The measured end play is 1.5 mm. The specification maximum is 0.5 mm. What symptom does this excessive end play produce during operation?

A. The axle shaft slides back and forth under alternating drive and coast loads — the 1.5 mm of free movement produces a clunking noise at each transition between acceleration and deceleration. The clunk is the spline and bearing surfaces impacting at the ends of the freeplay range during each load reversal

B. The excessive end play produces a vibration proportional to wheel speed because the axle shaft wobbles inside its bearing during rotation

C. The excessive end play allows the drive gear to disengage from the ring gear during turns, producing a grinding noise during cornering

D. The excessive end play has no operational symptom — the specification is a manufacturing tolerance that does not affect the assembled machine's performance

82. A machine equipped with a manual transmission has difficulty shifting from 2nd to 3rd gear. All other gear engagements are smooth. The clutch fully disengages (verified by the technician). What is the most likely cause of the isolated 2ndto3rd shift difficulty?

A. The transmission's main shaft bearing has worn and the resulting shaft deflection changes the gear alignment in 3rd gear only — the other gears are further from the worn bearing and are not affected

B. The shift linkage for the 2ndto3rd shift gate has worn or bent, preventing the shift fork from reaching the full engagement position in 3rd gear

C. The 3rd gear synchronizer has worn — the synchronizer's friction ring, hub sleeve, or detent mechanism has degraded and cannot effectively match the input shaft speed to the 3rd gear speed during the shift. All other synchronizers are functioning correctly, isolating the fault to the 3rd gear synchronizer

D. The transmission oil level is slightly low and the 3rd gear position is the highest in the transmission — the low oil starves the 3rd gear synchronizer of lubrication, making the shift difficult

83. A machine's driveshaft universal joint produces a vibration that occurs twice per driveshaft revolution. What does the 2× frequency indicate about the Ujoint's condition?

A. The Ujoint's cross (spider) has a broken trunnion — the missing trunnion produces a vibration at twice the shaft frequency because the remaining three trunnions create an imbalance that repeats twice per revolution

B. A universal joint operating at an angle naturally produces a 2× perrevolution speed variation — the driven shaft accelerates and decelerates twice per revolution due to the geometry of the joint's angular operation. If the operating angle is excessive (from worn bearings, sagging mounts, or incorrect driveline geometry), this 2× variation becomes large enough to produce a perceptible vibration

C. Two of the four trunnion bearings have failed simultaneously, producing a vibration at the combined frequency of both failed bearings

D. The driveshaft itself is bent at two points that are 180 degrees apart, and each bend produces one vibration pulse per revolution, combining to produce the 2× frequency

84. A machine's torque converter outlet temperature reads 125°C during loaded operation. The OEM specification maximum is 120°C. The technician checks the transmission oil cooler and finds it is clean with adequate airflow. The oil level and condition are correct. What should the technician investigate next?

A. The coolant flow through the oil cooler (if it is a coolanttooil type) — the engine's cooling system may be providing inadequate coolant flow to the transmission cooler from a restricted hose, a partially closed valve, or a thermostat issue. Alternatively, the oil cooler bypass thermostat may be allowing some oil to bypass the cooler at operating temperature when it should not

B. The converter lockup clutch — if the clutch is not engaging when it should, the converter operates in the fluid coupling mode during conditions that should be mechanically locked, generating more heat than the cooler was designed to reject

C. The engine's cooling fan — insufficient airflow over the oil cooler reduces its heat rejection capacity

D. The transmission's shift schedule — the TCM may be holding lower gears longer than designed, keeping the converter in the torque multiplication phase longer and generating more heat per cycle

85. A machine's track final drive produces an oil leak at the axle shaft seal. The technician replaces the seal and the leak stops. Three weeks later, the leak returns at the same location. What should the technician investigate to prevent the recurrence?

A. The seal lip orientation — the seal may have been installed in the correct direction the first time, and the recurrence is from a defective replacement seal batch

B. The axle shaft surface at the seal contact area — if the shaft has a wear groove, rust pitting, or surface roughness at the seal lip's contact zone, any new seal will seat against the damaged surface and leak again within a short period. The shaft must be polished, sleeved, or replaced to provide a smooth, undamaged surface for the seal lip

C. The final drive's internal pressure — excessive crankcase pressure from a blocked breather pushes oil past the seal regardless of the seal's condition

D. The final drive oil level — an overfilled final drive increases the oil pressure at the seal location, overcoming the seal's lip force and producing the recurring leak

86. A machine's automatic transmission has been experiencing harsh 12 upshifts. The technician accesses the TCM's shift adaptation data and finds the TCM has been progressively increasing the Clutch B apply pressure over the past 1,000 hours. The current adapted pressure is 25% above the base calibration. What does this progressive adaptation tell the technician?

A. The TCM has detected Clutch B slip during the 12 shift and has been progressively increasing the apply pressure to compensate — the clutch pack is worn and the friction coefficient has decreased, requiring more clamping force to achieve the same holding torque. The adaptation has reached its maximum authority and can no longer compensate, producing the harsh shift as the increased pressure produces an abrupt engagement

B. The TCM's learning algorithm has drifted from its designed target due to a software error — resetting the adaptation to the base calibration restores the correct shift quality

C. The transmission oil viscosity has increased from oxidation, and the thicker oil delays the clutch fill time — the TCM increases the pressure to compensate for the slower fill rate

D. The shift solenoid for Clutch B has weakened electrically and the TCM increases the command to compensate for the reduced solenoid output

87. A machine's hydrostatic drive system has been charged with new oil after a pump replacement. During the initial test, the technician notices the machine's forward travel speed is correct, but the reverse travel speed is approximately 20% slower than specification. The pump displacement in both directions is verified as equal through the diagnostic tool. What should the technician investigate?

A. The crossport relief valves — the reverseside relief may be set lower than the forward side, limiting the reverse loop pressure below the pump's capability and reducing the motor's torque output, which in combination with the load resistance produces the slower reverse speed

B. The charge check valves — if the reverseside charge check valve is not sealing correctly, the charge pressure supplementing the reverse loop is lower than the forward loop, reducing the effective flow to the motor during reverse

C. The motor's displacement — if the motor has a variable displacement that is controlled differently in forward and reverse, the motor may be at a higher displacement in reverse, producing a lower speed for the same input flow

D. The flushing valve — the valve may be stuck in a position that routes the flushing flow from the reverse loop only, reducing the available flow to the motor during reverse operation by the flushing volume

88. A machine's clutch pedal free play is measured at 5 mm. The OEM specification is 15–25 mm. What is the consequence of this insufficient free play?

A. The clutch engages too low in the pedal travel, making the machine difficult to start smoothly from a stop because the engagement point is near the floor

B. The insufficient free play means the release bearing is constantly in contact with the pressure plate fingers — the bearing rotates continuously, generating heat and wearing rapidly. Additionally, the constant contact partially disengages the clutch, reducing the clamping force on the disc, which can produce clutch slip under heavy load and accelerate disc wear

C. The insufficient free play makes the clutch pedal feel stiffer because the release bearing is preloaded against the pressure plate fingers, adding the spring load to the pedal effort

D. The insufficient free play causes the clutch to chatter during engagement because the release bearing contact point is at the wrong position on the pressure plate fingers

89. A machine's A/C system has been charged to the correct weight but the cooling performance is poor. The technician measures the following: lowside pressure = 15 PSI (specification 25–30), highside pressure = 180 PSI (specification 200–250). Both pressures are below normal. The compressor is operating and the clutch is engaged. What is the most likely cause of both pressures being below normal despite a correct charge?

A. The expansion valve is stuck in a restricted position — insufficient refrigerant passes through the valve to the evaporator. The low side is low because the evaporator is starved of refrigerant. The high side is low because the compressor has less refrigerant to compress (the restricted valve backs up refrigerant in the condenser and liquid line but the compressor suction is starved, reducing the mass flow through the system)

B. The condenser fan is running at reduced speed, producing inadequate airflow that reduces the condenser's ability to condense the refrigerant — the reduced condensation rate drops the highside pressure, which in turn drops the lowside pressure

C. The compressor has a failed suction reed valve that cannot draw refrigerant from the evaporator efficiently — the low suction drops the lowside pressure, and the reduced mass flow drops the highside pressure

D. The system is undercharged despite the technician's belief that the correct weight was added — the scale or charging procedure had an error, and the actual charge is less than specified

90. A machine's cab pressurization system has been tested and meets the 50pascal minimum specification. However, within 6 months, the pressurization drops below specification without any apparent change. What gradually deteriorating component most commonly causes the progressive pressurization loss?

A. The HVAC blower motor's brushes are wearing, reducing the motor speed and airflow output progressively over time

B. The cab air filter element is progressively loading with dust — as the filter element captures more particulate, the increased restriction reduces the volume of air the blower can push into the cab. The reduced airflow volume cannot maintain the positive pressure against the cab's inherent leak rate

C. The cab's recirculation door actuator is slowly drifting from its commanded position, progressively diverting more airflow to the recirculation path instead of the fresh air intake

D. The cab door seals are progressively deteriorating from UV exposure, mechanical fatigue, and chemical exposure — the increased seal leakage allows pressurized air to escape faster than the blower can replace it

91. A machine's A/C compressor has been replaced. After the replacement, the technician charges the system and starts the engine. The compressor engages and the system cools normally for 5 minutes, then the compressor disengages and the lowside pressure drops to vacuum. The compressor will not reengage. What has occurred?

A. The new compressor has an internal defect that is blocking the suction port — after the initial refrigerant in the suction line is consumed, the compressor draws the low side to vacuum because it cannot pull refrigerant through the blocked internal port. The lowpressure cutout switch disengages the clutch to protect the compressor from running without suction

B. The system has a leak that has lost the charge within 5 minutes — the lowpressure switch has disengaged the clutch to prevent compressor damage from running without refrigerant

C. The new compressor's displacement is larger than the original — the oversized compressor pumps the low side down to vacuum faster than the expansion valve can supply refrigerant, tripping the lowpressure switch

D. The system was contaminated with air during the installation — the air (noncondensable gas) has migrated to the condenser and blocked the refrigerant flow, starving the evaporator and dropping the lowside pressure to vacuum

92. A machine's dieselfired coolant heater includes a combustion air blower, a fuel metering pump, a glow plug, a flame sensor, and a coolant circulation pump. During a coldweather start, the heater starts and runs for 30 seconds, then shuts off. The heater's control module shows a "flame failure" fault. The technician inspects the combustion chamber and finds soot deposits on the flame sensor. What caused the flame failure?

A. The sootcoated flame sensor cannot detect the flame's presence — the soot insulates the sensor from the flame's infrared radiation or heat, causing the sensor to report "no flame" to the controller despite a flame being present. The controller shuts off the fuel after 30 seconds because it cannot confirm flame presence, which is the designed safety response to prevent unburned fuel from accumulating in the combustion chamber

B. The soot deposits indicate the heater is overfuelling, and the excess fuel is smothering the flame — the flame fails from fuel saturation, not from a sensor issue

C. The soot deposits indicate the heater's combustion air supply is restricted — the restricted air produces an incomplete combustion that generates soot and eventually extinguishes the flame from oxygen starvation

D. The glow plug has weakened from age and cannot maintain the flame after the initial 30second ignition period — the soot is from the incomplete combustion during the weak flame's final seconds

93. A machine's exhaust aftertreatment system's DEF tank has been exposed to temperatures above 50°C during a prolonged period of outdoor storage in direct sunlight. The OEM specification states DEF must be stored below 32°C. What has the elevated storage temperature done to the DEF?

A. The high temperature has sterilized the DEF — the urea is a biological compound that must be kept alive for the SCR conversion process, and temperatures above 50°C kill the active organisms

B. The DEF has decomposed from the elevated temperature — urea breaks down at sustained high temperatures, reducing the urea concentration below the 32.5% specification. The degraded DEF delivers insufficient ammonia to the SCR catalyst, reducing NOx conversion efficiency and potentially triggering a DEF quality fault that initiates a power derate

C. The high temperature has caused the DEF to crystallize inside the tank — the crystals block the tank's pickup tube and prevent the dosing system from drawing DEF to the injector

D. The high temperature has evaporated the water from the DEF solution, concentrating the urea above the 32.5% specification — the concentrated DEF produces excessive ammonia that poisons the SCR catalyst

94. A machine's HVAC system has a cabin temperature sensor mounted inside the cab. The sensor reads the cab's interior air temperature. The operator reports the climate control system cannot maintain a comfortable temperature — the cab cycles between too cold and too warm. The technician checks the sensor location and discovers it is mounted directly above a heating vent. Why does this sensor location cause the temperature cycling?

A. The sensor's location above the heating vent causes it to read a higher temperature than the actual average cab temperature — the warm air from the vent heats the sensor first, causing the controller to switch to cooling before the rest of the cab reaches the set temperature. The cooling then overcools the cab until the sensor reads below the set point, switching back to heating. The cycle repeats because the sensor never reads the true average cab temperature

B. The vent's airflow vibrates the sensor's temperature element, producing an unstable reading that causes the controller to oscillate between heating and cooling modes

C. The warm air from the vent degrades the sensor's accuracy over time — the repeated thermal cycling has drifted the sensor's calibration from its original specification

D. The sensor location above the vent is correct — the temperature cycling is caused by a defective blend door actuator that cannot hold an intermediate position and oscillates between full heat and full cold

95. A machine's exhaust aftertreatment system produces a "DEF quality poor" DTC. The technician tests the DEF with a refractometer and reads 32.5% urea concentration — exactly at specification. What else could trigger the DEF quality fault despite the correct urea concentration?

A. The DEF has been contaminated with a foreign substance (diesel fuel, coolant, or water) that changes the DEF's refractive index at a rate that makes the refractometer read correctly while the actual ureatowater ratio is incorrect — certain contaminants mimic urea's refractive properties

B. The DEF is the correct concentration but has degraded from age or heat exposure — the urea molecules have broken down into byproducts that do not function as SCR reducing agents. The refractometer measures the total dissolved solids (which may include the breakdown products) as equivalent to urea, but the actual functional urea content is below specification

C. The DEF quality sensor in the tank is contaminated or has failed — the sensor reads poor quality regardless of the actual DEF condition. The refractometer confirms the DEF is correct, proving the fault is in the sensor, not the fluid

D. The refractometer is not a definitive test for DEF quality — it measures refractive index, which correlates with urea concentration but does not detect contamination or degradation. The DEF may have the correct urea concentration but contain contaminants that the SCR system detects through its conversion efficiency monitoring

96. A machine's cab heater operates by circulating engine coolant through a heater core inside the HVAC plenum. The technician discovers the heater core is partially restricted — coolant flow through the core is only 40% of the specification. The technician recommends replacing the heater core. The fleet manager asks if the core can be flushed instead of replaced. Under what condition is flushing an acceptable alternative to replacement?

A. Flushing is acceptable if the restriction is from soft deposits (scale, silicate gel, or sediment) that can be dissolved or dislodged by chemical flushing or reverseflow flushing — the core is verified unrestricted by measuring the flow rate after flushing and confirming it meets the specification. If the restriction is from internal tube corrosion or collapse, flushing cannot restore the flow and the core must be replaced

B. Flushing is never an acceptable alternative — any restriction in a heater core indicates internal corrosion that cannot be reversed by flushing, and the core must always be replaced

C. Flushing is always acceptable as the first repair attempt — even if the restriction returns, the flushing buys time until a replacement core can be sourced

D. Flushing is acceptable only if the core is less than 2 years old — older cores have degraded tube walls that may rupture during the flushing process

97. A machine's air brake system includes an automatic moisture drain valve on each reservoir. The drain valve opens automatically when the reservoir pressure drops below a set threshold during the governor's unload cycle. The technician discovers one drain valve is stuck closed. What is the consequence?

A. The stuck drain allows only a small amount of moisture to remain in the reservoir — the moisture settles to the bottom of the tank and has minimal effect on the brake system's performance

B. The stuck drain valve prevents accumulated water from being automatically expelled from the reservoir — the water level rises progressively with each compressor cycle, eventually reaching the outlet port and entering the brake lines, valves, and chambers. In cold weather, the water freezes and can block air passages, prevent valve operation, and cause brake failure

C. The stuck drain valve creates excessive backpressure in the reservoir that interferes with the governor's cutin/cutout cycle timing

D. The stuck drain valve has no consequence because the air dryer upstream removes all moisture before it reaches the reservoirs — the automatic drain is a secondary backup that provides no additional moisture removal benefit in a properly functioning air dryer system

98. A hydraulic system's variabledisplacement pump is tested at rated RPM. At zero pressure (unloaded), the pump delivers 195 L/min. At 100 bar, the pump delivers 180 L/min. At 200 bar, the pump delivers 165 L/min. At 300 bar (rated pressure), the pump delivers 140 L/min. The pump's theoretical output is 200 L/min. What is the pump's volumetric efficiency at rated pressure?

A. 97.5% — calculated as 195 ÷ 200 × 100, using the noload flow instead of the ratedpressure flow

B. 87.5% — calculated as (200 − 165) ÷ 200 × 100 = 17.5%, then subtracted from 100%

C. 70% — calculated as ratedpressure flow ÷ theoretical flow × 100 = 140 ÷ 200 × 100 = 70%. This pump has significant internal leakage at rated pressure and is likely below the OEM's minimum acceptable volumetric efficiency threshold

D. 82.5% — calculated as 165 ÷ 200 × 100, using the 200bar reading instead of the rated 300bar reading

99. A hydraulic cylinder has a bore of 100 mm, a rod of 70 mm, and operates at 250 bar system pressure. The technician needs to calculate the maximum retract (pull) force for a lifting application. What is the annular area and the resulting retract force?

A. Annular area = $\pi/4 \times (100^2 - 70^2) = \pi/4 \times (10{,}000 - 4{,}900) = \pi/4 \times 5{,}100 = 4{,}006\ mm^2$. Retract force $= 0.1 \times 250 \times 4{,}006 = 100{,}150\ N \approx 100\ kN$

B. Annular area = $\pi/4 \times 70^2 = 3{,}848\ mm^2$ (using only the rod area, which is incorrect for retract force)

C. Annular area = $\pi/4 \times 100^2 = 7{,}854\ mm^2$ (using the full bore area, which is the extend force area, not retract)

D. Annular area = $\pi/4 \times (100 - 70)^2 = \pi/4 \times 900 = 707\ mm^2$ (subtracting diameters before squaring, which is mathematically incorrect)

100. A machine's hydraulic system has a main relief valve set at 280 bar. The technician installs a pressure gauge at the pump outlet and performs a relief valve test — the gauge reads only 240 bar at full stall. The relief valve was recently set and verified at 280 bar on a bench test. What is the most likely cause of the lowerthanexpected pressure reading in the machine?

A. The pump is worn and cannot produce enough flow at 280 bar to overcome its internal leakage — the pump reaches its maximum pressure output at 240 bar, where the internal leakage equals the pump's displacement. The relief valve never opens because the pump cannot build pressure to the 280bar relief setting

B. The relief valve's spring has weakened since the bench test and now opens at 240 bar instead of 280 bar

C. The pressure gauge is inaccurate — the gauge should be calibrated or replaced with a knownaccurate gauge before diagnosing the relief valve or pump

D. The pump cannot generate enough flow to maintain pressure at the relief valve's 280bar setting — the pump's internal leakage increases with pressure, and at 240 bar, the leak rate equals the pump's delivery. The relief valve would open at 280 bar if the pump could deliver flow at that pressure, but the pump's worn condition limits the maximum achievable system pressure to 240 bar

101. A machine's hydraulic system uses a pilotoperated DCV. The pilot circuit has its own dedicated pilot pump and relief valve. The pilot relief is set at 35 bar. The technician measures the pilot pressure at 28 bar during a joystick actuation. What does the 7bar deficit from the relief setting indicate?

A. The pilot pressure is within normal operating range — the pilot circuit should operate below the relief valve setting during normal use. The 35bar relief is a maximum protection setting, and the 28bar operating pressure is determined by the pilot circuit's flow requirements and the restriction through the pilot valve's metering edges during joystick actuation

B. The pilot pump is worn and cannot maintain 35 bar under the flow demand of the joystick actuation — the pump's internal leakage increases under load and the delivered flow drops below the requirement

C. The pilot relief valve has drifted from 35 bar to 28 bar and must be readjusted

D. The pilot pressure solenoid is not opening fully and is restricting the pilot flow, producing the 7bar deficit from the maximum available pressure

102. A machine's hydraulic system includes a pressureintensifier circuit that uses a largearea piston connected to a smallarea piston inside a single cylinder. The large piston has an area of 200 cm² and the small piston has an area of 50 cm². The system pump delivers oil at 200 bar to the large piston. What pressure is generated at the small piston's output?

A. 50 bar — calculated by dividing the input pressure by the area ratio (200 ÷ 4)

B. 1,000 bar — calculated by multiplying the input pressure by the inverse area ratio: (200 ÷ 50) × 200 = 4 × 200 = 800 bar. This is incorrect.

C. 800 bar — calculated by multiplying the input pressure by the area ratio: input force = 200 bar × 200 cm² = 40,000 N (using 1 bar = 1 N/cm² approximation). Output pressure = force ÷ small area = 40,000 ÷ 50 = 800 bar. The intensifier multiplies the pressure by the ratio of the large area to the small area (200 ÷ 50 = 4:1), producing 4× the input pressure

D. 200 bar — the pressure is the same on both pistons because they are connected by a common shaft that transmits force, not pressure

103. A machine's hydraulic accumulator has been tested and the precharge is correct at 90 bar (nitrogen). The system is then pressurized to its operating pressure of 200 bar. The accumulator stores oil during the pressurization. If the system pressure drops to 150 bar during a brake application, how does the accumulator respond?

A. The nitrogen in the accumulator has been compressed from 90 bar to 200 bar during the charging phase, occupying a smaller volume. When the system pressure drops to 150 bar, the nitrogen expands (because 150 bar is still above the 90bar precharge), pushing stored oil from the accumulator into the brake circuit to supplement the declining system pressure. The accumulator continues to discharge oil until the system pressure stabilizes or drops to the 90bar precharge level

B. The accumulator does not respond at 150 bar because it only discharges when the system pressure drops below the precharge pressure of 90 bar

C. The accumulator absorbs additional oil at 150 bar because the reduced system pressure causes the nitrogen to contract further, pulling oil into the accumulator from the system

D. The accumulator discharges all its stored oil instantly when the system pressure drops below 200 bar, producing a pressure spike that may damage downstream components

104. A machine's hydraulic system has a returnline filter with a clogging indicator. The indicator shows the filter is in bypass. The technician replaces the filter element. After 50 hours of operation, the indicator shows bypass again. What should the technician investigate?

A. The replacement filter element's micron rating — if the wrong micron rating was installed (finer than specification), it will clog faster because it captures particles the OEMspecified element was designed to pass

B. The filter indicator itself — the indicator may be stuck in the bypass position from the previous clog and did not reset when the new element was installed

C. The filter bypass valve spring — a weakened spring opens the bypass at a lower differential pressure than designed, indicating bypass when the element still has capacity

D. The contamination source — the system is generating or ingesting contamination at a rate that overwhelms the filter element's capacity within 50 hours. A component failure (pump, motor, or valve wear), an external contamination ingress point (leaking seal, open breather), or residual contamination from a previous failure is producing debris faster than the filter can manage within its service interval

105. A machine's air brake system's compressor produces 15 CFM (cubic feet per minute) of free air. The total system reservoir capacity is 40 litres. The governor cutin is 690 kPa and the cutout is 860 kPa. The OEM specification requires the system to build from 0 to governor cutout in less than 3 minutes. The measured buildup time is 4 minutes 30 seconds. What is the most likely cause of the slow buildup?

A. The governor cutout setting is too high — a higher cutout requires more time to fill the same reservoir volume to the elevated pressure

B. The system has a significant air leak that consumes a portion of the compressor's output during the buildup — the compressor produces 15 CFM but the leak reduces the net volume reaching the reservoirs, extending the time required to pressurize the system to the cutout. The leak and the compressor capacity should both be evaluated

C. The air dryer is consuming excessive air during the buildup phase — the dryer's purge cycle activates during each governor unload event, and the purge volume extends the total buildup time

D. The compressor's discharge valves are worn — the valves leak compressed air back through the compressor on each stroke, reducing the net output below the rated 15 CFM. The reduced effective output extends the buildup time beyond the 3minute specification

106. A machine's hydraulic system includes a counterbalance valve on the boom lower circuit. The counterbalance valve prevents the boom from lowering uncontrolled when the DCV is opened for lowering. During a diagnostic test, the technician discovers the boom descends very slowly — much slower than specification — when the DCV is fully opened for lowering. The counterbalance valve is correctly adjusted. What could cause the slow descent despite correct valve adjustment?

A. The DCV cannot deliver enough flow to the counterbalance valve's pilot port to fully open the valve — the pilot pressure or flow from the DCV's work port is insufficient to shift the counterbalance valve fully open, restricting the boom's descent rate even though the valve's cracking and fullopen settings are correct. The pilot pressure ratio and the DCV's delivery must be verified

B. The boom cylinder's rod seals have excessive friction from a new seal installation that resists the descent motion

C. The hydraulic oil is too cold and the increased viscosity slows the flow through the counterbalance valve's metering edges

D. The counterbalance valve is correctly adjusted but the boom's load is lighter than the design load — the lighter load produces less pilot signal pressure than a fully loaded boom, partially opening the counterbalance valve and producing the slower descent speed

107. A machine's hydrostatic transmission has been operating with the charge filter indicator showing bypass for approximately 200 hours because the replacement filter was not available. What damage may have occurred during this 200hour unfiltered charge oil operation?

A. No damage — the charge circuit operates at low pressure (25–30 bar) and the low pressure does not drive contamination particles into the pump and motor clearances aggressively enough to cause measurable damage in 200 hours

B. The charge pump has been damaged from the unfiltered oil — the charge pump's internal gears have been abraded by the contamination particles that the bypassed filter would have captured

C. The unfiltered charge oil has been contaminating the entire hydrostatic loop — the charge oil supplements the main loop through the charge check valves and the flushing valve, introducing unfiltered particles into the precision clearances of the main pump and motor. The 200 hours of unfiltered operation has likely accelerated wear on the pump's valve plate, the motor's port plate, and both components' piston and bore surfaces

D. The main pump's compensator has been contaminated — the compensator spool operates on charge pressure and the unfiltered oil has deposited particles in the compensator bore, causing it to stick intermittently

108. A machine's hydraulic cylinder must hold a load for an extended period. The circuit uses a spooltype DCV (not a pilotoperated check valve) to hold the load when the spool is in neutral. Over 4 hours, the boom drifts down 200 mm. The cylinder has been tested and shows no internal bypass. What is causing the drift?

A. The thermal contraction of the hydraulic oil inside the cylinder is reducing the oil volume and allowing the piston to retract by 200 mm over 4 hours

B. The spooltype DCV has inherent internal leakage when in the neutral position — the spooltobore clearance allows a small amount of oil to leak from the highpressure work port to the tank port, gradually depleting the oil volume holding the cylinder extended. This is a design limitation of spooltype DCVs for loadholding applications, which is why pilotoperated check valves or counterbalance valves are preferred for extended hold requirements

C. The cylinder's rod seal is leaking externally — the external leak is too slow to produce a visible drip but depletes enough oil over 4 hours to allow the 200 mm drift

D. The hose between the DCV and the cylinder is expanding under the sustained pressure, absorbing oil volume from the cap end and allowing the piston to retract

109. A machine's pneumatic system uses a doublecheck valve in the parking brake circuit. The doublecheck valve receives air from two independent supply circuits and passes the higherpressure source to the parking brake chambers. If one supply circuit fails, the other circuit still provides air to release the parking brakes. During testing, the technician discovers the parking brakes remain applied even though one supply circuit is pressurized to 860 kPa. What has failed?

A. The supply circuit that is pressurized has a restriction downstream of the doublecheck valve that prevents adequate volume from reaching the spring brake chambers — the pressure is correct but the flow rate is insufficient to move the spring brake pistons against the spring force

B. The doublecheck valve has stuck in a position that blocks the pressurized circuit's path to the spring brake chambers — the valve's internal shuttle or poppet is not shifting to allow the pressurized circuit to pass through to the brake chambers. The valve must be inspected and replaced or cleaned

C. The spring brake chambers' springs have fatigued beyond their designed range and now require more than 860 kPa to compress — the original specification for spring compression was 700 kPa, and the springs have stiffened from aging

D. The parking brake control valve in the cab is in the "applied" position and is overriding the supply circuit's pressure — the control valve must be moved to the "released" position before the supply pressure can reach the spring brake chambers

110. A hydraulic system's flow divider splits pump output equally between two circuits — 50% to each. The technician measures the flow to each circuit and finds Circuit A receives 55 L/min and Circuit B receives 45 L/min (from a 100 L/min pump). What does the unequal split indicate?

A. The flow divider's compensator spool has worn, allowing more flow to the lowerresistance circuit (Circuit A) — the spool can no longer maintain equal flow against the pressure differential between the two circuits. Circuit A has less load resistance and receives the excess flow while Circuit B is starved

B. The pump has an internal passage defect that directs more flow to the port connected to Circuit A than to the port connected to Circuit B

C. The flow divider is functioning correctly — a ±5% variation from the 50/50 target is within the normal manufacturing tolerance for flow dividers

D. Circuit B has a restriction that creates backpressure on the flow divider's B port, forcing more flow through the A port — the flow divider is functioning correctly but cannot overcome the restriction

111. A machine's air brake system has a graduated service brake application — the harder the operator presses the pedal, the more braking force is applied. The foot valve (treadle valve) controls this proportional application. During testing, the technician discovers the brakes go from zero to full application with very little pedal travel — the operator cannot modulate the braking force. What has failed in the foot valve?

A. The foot valve's exhaust seat is leaking — the leak allows constant air bleed from the brake chambers, and the operator must apply full pedal to overcome the leak and deliver braking pressure

B. The foot valve's relay piston seal has swollen from contamination, increasing the friction between the piston and the bore — the excessive friction prevents the piston from responding proportionally to the pedal input, producing an on/off response instead of graduated control

C. The foot valve's metering piston is not moving proportionally — the piston is bypassing internally from a worn or damaged seal, and the full supply pressure passes through the valve at any pedal position beyond the initial application point. The graduated metering function has been lost because the piston cannot create the proportional restriction needed to modulate the output pressure

D. The foot valve's return spring has broken — without the spring, the piston has no return force and the valve delivers full pressure with minimal pedal input because the spring normally provides the proportional resistance that the pedal must overcome for graduated application

112. A hydraulic motor drives a conveyor at a constant speed. The motor displacement is 160 cm^3/rev. The required conveyor speed is 120 RPM. What pump flow rate is needed to drive the motor at this speed, assuming 100% volumetric efficiency?

A. Required flow = motor displacement × motor speed = 160 cm^3/rev × 120 rev/min = 19,200 cm^3/min = 19.2 L/min

B. Required flow = motor displacement × motor speed ÷ 100 = 19.2 ÷ 100 = 0.192 L/min (incorrect unit conversion)

C. Required flow = motor displacement ÷ motor speed = 160 ÷ 120 = 1.33 L/min (inverted formula)

D. Required flow = motor displacement × motor speed × 60 = 19,200 × 60 = 1,152,000 cm^3/min (incorrect time conversion)

113. A machine's hydraulic system uses an accumulator on the implement circuit to absorb pressure spikes from sudden load changes. The accumulator's precharge is 100 bar (nitrogen). The system working pressure is 250 bar. If the precharge is accidentally set to 260 bar (above the system working pressure), what happens?

A. The accumulator provides enhanced spike absorption because the higher precharge reacts faster to pressure changes

B. The accumulator operates normally — the system pressure compresses the precharge from 260 to a working level and the accumulator functions as designed

C. The 260bar precharge holds the accumulator's bladder or piston fully extended against the oil port — no oil can enter the accumulator because the nitrogen pressure exceeds the system's hydraulic pressure. The accumulator is effectively nonfunctional, providing zero spike absorption, and the bladder may be pushed into and damaged by the oil port

D. The excess precharge forces oil backward through the system, producing a reverseflow condition that stalls the pump

114. A machine's hydraulic system has a suction strainer rated at 150 microns. The return filter is rated at 10 microns. A technician suggests adding a 3micron pressure filter between the pump and the DCV to improve system cleanliness. What potential issue does a very fine (3micron) pressure filter introduce?

A. The 3micron filter produces a higher pressure drop than a coarser filter — when the element begins to load, the pressure drop across the filter may exceed the filter's bypass valve setting, routing unfiltered oil around the element during peak flow demand. Additionally, the frequent bypass events defeat the purpose of the fine filtration and the cycling between filtered and bypassed flow produces inconsistent downstream cleanliness

B. The 3micron filter removes beneficial additives from the oil — the fine pores capture the oil's antiwear and antifoam additive particles along with the contaminants

C. The 3micron filter cavitates the pump by creating excessive restriction on the pump's outlet — the pump must overcome the filter's resistance in addition to the system's working pressure

D. The 3micron filter has no issues — finer filtration always improves system cleanliness and extends component life

115. A machine's air brake system includes an air governor that controls the compressor's loading and unloading. The governor's cutin pressure is 690 kPa and the cutout is 860 kPa. The technician measures the actual cutout at 900 kPa — 40 kPa above specification. What is the consequence of the high cutout?

A. The compressor runs longer during each cycle to build the higher pressure — the extended loaded operation increases the compressor's operating temperature, wear rate, and energy consumption. More significantly, the 900 kPa may exceed the pressure rating of downstream components (chambers, valves, hoses) that are designed for a maximum of 860 kPa, creating a potential overpressurization hazard

B. The high cutout has no negative consequence — the additional 40 kPa provides a larger reserve for brake applications between governor cycles

C. The high cutout causes the air dryer's purge cycle to occur at a higher pressure, which actually improves the desiccant regeneration effectiveness

D. The high cutout delays the compressor's unloading, which reduces the oil carryover from the compressor into the air system by keeping the compressor loaded for a longer continuous period

116. A machine's hydraulic pump has been tested and shows the following volumetric efficiency at rated pressure: 76%. The OEM minimum acceptable efficiency is 80%. The pump is being rebuilt. During the rebuild, the technician discovers the valve plate (port plate) has a visible wear groove where the cylinder barrel contacts the plate. What is the relationship between the worn valve plate and the low volumetric efficiency?

A. The valve plate's internal passages have been contaminated by debris from the wear process, restricting the flow through the plate and reducing the pump's volumetric efficiency by limiting the flow rather than allowing it to bypass

B. The worn groove on the valve plate creates a leak path between the highpressure and lowpressure kidney ports — oil crosses from the discharge port to the suction port through the groove during each cylinder barrel revolution, bypassing the system without producing useful flow. This internal bypass is the primary contributor to the pump's reduced volumetric efficiency

C. The worn valve plate has reduced the pump's displacement — the groove allows the cylinder barrel to sit closer to the plate, reducing the piston stroke and therefore the volume displaced per revolution

D. The worn valve plate has increased the pump's mechanical friction — the rough groove surface creates drag on the cylinder barrel, consuming power that the efficiency test measures as reduced volumetric efficiency

117. A machine's hydraulic system has two cylinders connected in a series circuit — the oil flows through the first cylinder's cap end, exits the rod end, and enters the second cylinder's cap end. Both cylinders have identical bore and rod sizes. What is the unique characteristic of this series circuit compared to a parallel circuit?

A. Both cylinders extend and retract at the same speed and with the same force — the series connection ensures synchronized movement

B. The first cylinder receives full system pressure while the second cylinder receives reduced pressure — the second cylinder's force is lower than the first because the first cylinder's rodend pressure drop reduces the available pressure for the second cylinder

C. Both cylinders extend simultaneously but at different speeds — the first cylinder extends faster because it receives pump flow directly, while the second cylinder receives the flow from the first cylinder's rod end, which is a reduced volume (due to the rod volume) and produces a slower extension on the second cylinder

D. The series circuit requires twice the system pressure compared to a parallel circuit to produce the same force on each cylinder — each cylinder receives half the total system pressure

118. A machine's hydraulic system uses a pressurereducing valve to supply a pilot circuit at 35 bar from the main system operating at 250 bar. The technician measures the pilot circuit pressure at 42 bar. What is the consequence of the elevated pilot pressure?

A. The elevated pilot pressure shifts the DCV spools further than designed, overstroking the spools and producing excessive flow to the actuators — the implements move faster than the operator commands, reducing control precision and potentially creating a safety hazard

B. The elevated pilot pressure has no operational consequence — the DCV spools are designed to accept a range of pilot pressures without affecting the flow output

C. The elevated pilot pressure produces a softer joystick feel because the higher pressure assists the joystick's return spring, making the operator feel less resistance during joystick movement

D. The elevated pilot pressure reduces the main system's available flow because the pressurereducing valve is consuming more flow to maintain 42 bar than it would at 35 bar

119. A machine's hydrostatic drive system's charge pump is a geartype pump integrated into the main pump housing. The charge pump draws oil from the reservoir and supplies the lowpressure charge circuit. If the charge pump's intake becomes restricted (collapsed suction hose, clogged reservoir strainer), what is the first symptom the operator notices?

A. The machine's travel speed decreases because the charge pump cannot fill the main pump's cylinders completely — the partially filled cylinders produce less flow per stroke, reducing the motor speed

B. The machine produces a whining noise from the charge pump cavitating — the restricted intake starves the charge pump, producing cavitation that generates a distinctive highpitched whine from the charge pump's area

C. The machine's steering becomes heavy because the charge pump also supplies the steering priority circuit on this machine model

D. The machine's engine RPM drops because the charge pump's cavitation produces a pulsating load on the engine that the governor cannot compensate for

120. A machine's hydraulic cylinder extends at normal speed and force. During retraction under load (pulling), the cylinder retracts but produces a chattering vibration and the retract speed fluctuates. The extend function is smooth. What is the most likely cause of the retractonly chatter?

A. The cylinder's piston seal is damaged on the rodend side only — the seal bypasses intermittently during retraction when the rodend pressure exceeds the seal's capability, producing the chatter as the seal alternately seals and leaks

B. The counterbalance valve (if equipped) on the retract circuit is set too close to the working pressure — the valve alternately opens and closes as the load pressure fluctuates around the valve's cracking point, producing the chatter

C. The DCV spool's metering edge for the retract port has a burr that disturbs the flow at the specific spool position used during loaded retraction — the turbulent flow produces the pressure fluctuation perceived as chatter

D. The hydraulic oil has air contamination (foam) that compresses during the retract stroke — the air bubbles collapse and reform at a rate that produces the chattering vibration

121. A machine's hydraulic system uses a loadsensing pump. The pump's LS differential is 20 bar. The machine has three implement functions that can operate simultaneously. During simultaneous operation of all three functions, the operator reports the lowestpressure function operates faster than normal while the highestpressure function operates slower than normal. What circuit component is malfunctioning?

A. The LS shuttle check valves are not selecting the highest load signal — the pump is sensing an intermediate or low load instead of the highest, and the pump output pressure is lower than needed to supply the highestload function adequately. The excess pressure at the lowload function produces the overspeed, while the pressure deficit at the highload function produces the underspeed

B. The pump's compensator is set too low — the total pressure available is insufficient for the highestload function but excessive for the lowestload function

C. The pump cannot produce enough flow for all three functions simultaneously — the flow deficit affects the highestload function most because it has the greatest resistance to flow

D. The DCV spool for the highestload function has worn and the increased internal leakage consumes the flow that should reach the actuator

122. A machine's hydraulic accumulator is being precharged with nitrogen. The technician connects the nitrogen supply and begins filling. The precharge gauge reads 0 bar and does not increase despite the nitrogen supply being open. What is the most likely cause?

A. The nitrogen supply bottle is empty — the gauge on the supply bottle may show residual pressure from the regulator but the bottle itself contains no gas

B. The accumulator's gas valve core (Schrader valve) is stuck closed or the charging tool is not depressing the valve core — nitrogen cannot enter the accumulator because the valve is not open. The technician should verify the charging tool is properly seated on the valve stem and that the core is functional

C. The accumulator's bladder has ruptured and the nitrogen is passing directly through the ruptured bladder into the oil side and out through the oil port — the gas escapes as fast as it enters, producing no pressure buildup on the gas side

D. The nitrogen regulator on the supply bottle is set to zero — the regulator is not open and no gas is flowing through the charging hose to the accumulator

MWA H — Structural Components, Operator Stations, Attachments, and Accessories (Questions 123–131)

123. A mining excavator's bucket tooth adapter has developed a fatigue crack at the weld joint between the adapter and the bucket lip. The adapter has been in service for 6,000 hours. The OEM's recommended replacement interval for this adapter is 8,000 hours. What does the premature crack indicate?

A. The adapter's weld quality was defective from the original fabrication — a manufacturing defect initiated the crack earlier than the designed fatigue life

B. The 8,000hour replacement interval is a conservative estimate and most adapters crack between 5,000 and 7,000 hours in normal service

C. The adapter material has degraded from the application environment — the digging media's chemical composition has attacked the adapter's steel alloy, reducing its fatigue strength below the designed value

D. The machine is operating in conditions that produce loading beyond the adapter's designed fatigue life — the digging force, impact frequency, or material hardness exceeds the OEM's assumptions for the 8,000hour interval. The replacement interval should be shortened to account for the actual application severity

124. A machine's cab door hinge pins have worn and the door sags when opened. The sag causes the door to scrape the cab frame at the bottom when opening and closing. Beyond the cosmetic damage, what functional concern does the sagging door create?

A. The sagging door does not close and seal correctly — the misalignment between the door and the frame prevents the door seals from making full contact around the perimeter, compromising the cab's pressurization, noise isolation, and ROPS seal integrity. The worn hinge pins should be replaced to restore the door's designed alignment

B. The sagging door creates a tripping hazard for the operator during cab entry because the lowered door position changes the step clearance

C. The sagging door stresses the door latch mechanism because the latch must pull the misaligned door into position during closing, accelerating latch wear

D. The sagging door increases wind noise during travel from the gap created between the door panel and the frame at the hinge side

125. A machine's attachment mounting bracket has been fabricated by a local shop to accommodate a nonOEM attachment. The bracket welds show acceptable visual quality. However, the bracket material, thickness, and weld procedure documentation are not available. Should the technician install this bracket on the machine?

A. Yes — the visual quality of the welds confirms the bracket is structurally sound for the intended application

B. Yes — but only if the technician performs a load test at 125% of the attachment's weight to verify the bracket's capacity before placing the machine in service

C. No — without documentation of the material specification, thickness calculation, and weld procedure qualification, the bracket's structural adequacy cannot be verified. An unqualified bracket may fail under the dynamic loading of normal operation, dropping the attachment and potentially causing injury. The bracket must be designed and documented by a qualified engineer before installation

D. No — nonOEM attachment brackets are prohibited by all provincial safety regulations regardless of their engineering documentation

126. A machine's counterweight has been removed for transport. During reinstallation, the technician discovers one of the four mounting bolt holes in the frame has damaged threads — the bolt will not engage the first 3 threads. The other three holes accept their bolts without issue. The technician installs the three good bolts and tightens them to specification. Can the machine operate with three of four counterweight bolts?

A. Yes — three bolts provide 75% of the designed clamping force, which is adequate for normal operation. The damaged fourth hole should be repaired at the next scheduled downtime

B. No — the missing fourth bolt changes the load distribution on the remaining three bolts, increasing their individual stress by 33%. The increased stress may exceed the bolts' fatigue endurance limit under the cyclical loading of normal operation, risking bolt failure. Additionally, the unsupported corner of the counterweight can vibrate and fatigue the frame at the unsupported mounting point. The damaged thread must be repaired (helicoil, thread insert, or retapped) before the machine operates

C. Yes — but only for transport and positioning purposes at reduced speed. The machine cannot perform production work until the fourth bolt is installed

D. No — the counterweight cannot be installed with fewer than four bolts under any circumstances because the counterweight is part of the machine's ROPScertified mass distribution

127. A machine's operator cab includes a fire suppression system with nozzles directed at the engine compartment, turbocharger, and hydraulic pump. The system uses a dry chemical agent. During an inspection, the technician discovers the fire suppression system's manual pull handle has been ziptied in the "armed" position — the handle cannot be pulled to activate the system manually. What safety function has been defeated?

A. The manual activation capability has been disabled — in the event the automatic detection system fails to detect a fire, the operator cannot manually activate the suppression system from the cab. The zip tie must be removed immediately to restore the manual override capability that serves as the backup to the automatic system

B. The zip tie has no effect — the system's automatic detection activates independently of the manual handle and the handle's position does not affect the automatic function

C. The zip tie prevents accidental activation during rough terrain operation — this is an accepted practice to prevent false discharges that waste the suppression agent

D. The zip tie holds the system in the armed state, which is correct — the handle should be in the armed position for the system to function

128. A machine's boom has been repaired with a welded doubler plate to reinforce a cracked area. The repair was performed by a certified welder using the correct electrode and preheat/postheat procedures. The repair weld was verified by NDE immediately after welding. Six months later, during a routine inspection, the technician discovers a new crack has formed at the toe of the doubler plate — not at the original crack location, but at the new weld toe where the doubler plate ends. What caused this new crack?

A. The doubler plate repair transferred the stress concentration from the original crack location to the new weld toe at the edge of the doubler plate — the abrupt change in crosssection where the doubler plate ends creates a stress riser that concentrates the cyclical loading at that point, initiating a new fatigue crack. The repair addressed the symptom (the original crack) but created a new stress concentration at the doubler plate termination

B. The welder used the wrong electrode polarity during the doubler plate installation, producing a weak weld toe that cracked from the normal operating loads

C. The doubler plate material is incompatible with the boom's base metal — the galvanic corrosion between the two different metals has weakened the weld toe and produced the crack

D. The NDE performed after the repair missed a preexisting crack at the doubler plate location — the new crack is a continuation of the undetected original defect

129. A machine's ROPScertified cab is equipped with laminated glass windshield and tempered glass side windows. During an incident, a side window is struck by a rock and shatters into small, roughly cubeshaped fragments. Why does the tempered glass shatter this way instead of cracking like the laminated windshield?

A. Tempered glass is weaker than laminated glass — the reduced strength causes it to shatter completely rather than crack progressively

B. Tempered glass shatters into small, relatively dull fragments as a designed safety feature — the tempering process creates internal compressive stresses in the glass surface that, when breached by a fracture, release the stored energy and cause the entire pane to disintegrate into small fragments that are less likely to cause laceration injuries compared to large, sharp shards that nontempered glass would produce

C. Tempered glass shatters from the rock's impact velocity exceeding the glass's resonant frequency — the harmonic vibration propagates through the entire pane and breaks it simultaneously

D. Tempered glass is designed to shatter outward (away from the operator) — the small fragments are ejected away from the cab to protect the operator from flying glass

130. A mining shovel's dipper (bucket) has wear liners (manganese steel plates) bolted to the inside surfaces. The liners have worn to 20% of their original thickness. The OEM recommends replacement at 25% remaining thickness. The fleet manager asks if the liners can continue in service until the next scheduled shutdown (approximately 500 hours away). What is the technician's recommendation?

A. The liners are at 20% remaining thickness — 5% past the OEM's 25% replacement threshold. The OEM's recommendation includes a safety margin, so the liners are not in immediate danger of failing. However, operating beyond the replacement threshold risks the liners wearing through completely, exposing the dipper's base metal to direct abrasion. If the base metal wears through, the dipper requires expensive structural repair rather than simple liner replacement. The liners should be replaced at the earliest opportunity, ideally before the 500hour shutdown if an earlier window is available

B. The liners are past their replacement threshold and must be replaced immediately — any operation beyond 25% remaining thickness voids the dipper's structural warranty

C. The liners can continue for 500 hours — the remaining 20% thickness will sustain the machine for the requested duration based on the current wear rate

D. The liners should be welded with hardfacing overlay to extend their service life to the next shutdown rather than replacing them now

131. A technician is installing a new hydraulic quickdisconnect coupling on a machine's attachment circuit. The coupling must handle 280 bar working pressure and 150 L/min flow. The technician selects a coupling from the parts inventory that is rated at 280 bar but has a smaller port size that restricts flow to 100 L/min. What consequence does the undersized coupling produce?

A. The undersized coupling restricts flow to the attachment circuit — the attachment operates at 67% of its designed speed (100/150 L/min). The reduced flow also creates a pressure drop across the coupling that generates heat, wastes energy, and may cause the system to reach high temperature during continuous operation

B. The coupling operates normally because the 280bar pressure rating is the critical specification, not the flow rating — the coupling passes whatever flow the system demands regardless of the rated flow

C. The undersized coupling produces a highvelocity flow through the restricted passage that erodes the coupling's internal surfaces, contaminating the hydraulic system with metallic debris

D. The undersized coupling causes the attachment relief valve to open during every operation because the restricted flow forces the system pressure above the relief setting

132. A batteryelectric machine's HV system operates at 650V DC. The technician must perform a scheduled maintenance task that requires opening the HV battery enclosure. Before opening the enclosure, what specific electrical procedure must be completed?

A. Deenergize the HV system using a DMM to verify voltage at the battery terminals — if the DMM reads less than 50V, the system is safe to work on

B. The technician must follow the OEM's HV lockout/tagout procedure — deenergize the HV system using the service disconnect, verify zero energy using a CAT III or CAT IV rated voltmeter at the HV terminals, wait the OEMspecified discharge time for the capacitors to discharge, and verify voltage again after the waiting period. The technician must wear the appropriate HVrated insulating gloves and use insulated tools throughout the procedure

C. Disconnect the 12V/24V auxiliary battery to deenergize the BMS, which automatically opens the HV contactors and deenergizes the HV bus

D. Activate the machine's emergency stop button, which opens the HV contactors and isolates the battery from all HV circuits

133. A hybrid machine's regenerative braking system captures energy during swing deceleration and stores it in a capacitor bank (supercapacitors) rather than a battery. The capacitor bank can charge and discharge at very high rates (high power density) but stores less total energy than a battery (lower energy density). Why are supercapacitors chosen over batteries for the swing energy storage in this application?

A. The swing motorgenerator produces very high peak power during deceleration (tens of kilowatts for 1–3 seconds) followed by high power demand during acceleration. Supercapacitors handle these rapid, highpower charge/discharge cycles efficiently because their low internal resistance accepts and delivers high current without the thermal stress that would degrade a battery's cycle life. The swing duty cycle (hundreds of charge/discharge cycles per hour) would quickly wear out a chemical battery

B. Supercapacitors are less expensive than batteries for the same energy storage capacity, reducing the machine's purchase price

C. Supercapacitors are safer than batteries in heavy equipment because they cannot experience thermal runaway under any failure condition

D. Supercapacitors maintain their capacity better in cold weather than batteries, providing consistent energy recovery in coldclimate mining applications

134. A batteryelectric machine has been parked for 3 months without being connected to shore power. The BMS reports the battery SOC has dropped from 80% (at parking) to 35% (current). What caused the 45% SOC loss during storage?

A. The battery cells have permanently degraded from the extended storage period — the 45% capacity loss is permanent and the battery pack must be replaced

B. The 12V/24V auxiliary system's parasitic draw has been consuming HV battery energy through the DCDC converter during the entire storage period — the BMS, telematics module, security system, and other alwayson loads continuously draw power from the HV battery through the converter, depleting the SOC over the 3month period

C. The battery cells' selfdischarge has consumed the 45% — lithiumion cells naturally selfdischarge at a rate of approximately 2–5% per month from internal chemical reactions, and the 3month period accounts for the observed loss

D. Ambient temperature fluctuations during the 3month storage caused the cells to expand and contract, which consumed stored energy through the mechanical stress on the cell chemistry

135. A fleet operator is evaluating the charging infrastructure requirements for a fleet of 10 batteryelectric haul trucks. Each truck's battery capacity is 600 kWh. The trucks operate two 10hour shifts per day with a 2hour charging window between shifts. The fleet manager wants to charge all 10 trucks during each 2hour window. What total charging power capacity must the infrastructure provide?

A. 600 kW — calculated as one truck's battery capacity (600 kWh) ÷ 2 hours = 300 kW per truck, but only one charger is needed because the trucks can be charged sequentially

B. 30,000 kW — calculated as 10 trucks × 600 kWh × 5 (to account for charging losses), which overestimates the losses by approximately 5×

C. The calculation depends on the trucks' actual energy consumption per shift (not the full battery capacity). If each truck consumes 400 kWh per 10hour shift, the recharge requirement is 400 kWh per truck. To recharge 10 trucks in 2 hours: total energy = 10 × 400 = 4,000 kWh in 2 hours = 2,000 kW of sustained charging power (plus approximately 5–10% for charging losses), requiring approximately 2,200 kW of total charging infrastructure capacity

D. 3,000 kW — calculated as 10 trucks × 600 kWh ÷ 2 hours = 3,000 kW, which assumes each truck needs a full charge rather than replacing only the consumed energy

Practice Exam 14: Answer Key and Explanations

1. C — Underground atmospheres can contain methane, carbon monoxide, hydrogen sulfide, or reduced oxygen levels that vary by specific location even when the main ventilation system is confirmed operational. The technician must perform a personal atmospheric test at the specific work location using a calibrated multi-gas detector before entering, and continuously monitor throughout the work.

2. B — A hydraulic hose near an oxy-acetylene cutting operation must be protected by a heat-resistant welding blanket positioned between the torch and the hose. A burned-through hydraulic hose releases high-pressure oil that ignites instantly on contact with the cutting torch flame, creating a large fire. An assistant must continuously monitor the hose temperature during cutting.

3. A — A failure analysis report for warranty and fleet prevention must contain: machine identification and hours, chronological symptom description, diagnostic findings with supporting data (oil analysis, DTCs, photographs), the identified root cause, and prevention recommendations. The report must clearly distinguish factual observations from the technician's professional opinion to maintain credibility.

4. D — A sharp metallic "ping" during a pressing operation may indicate the component has developed a crack from the applied bending stress. The technician must immediately stop pressing, release the force, and inspect the component for cracks using visual examination and NDE methods. Continuing to press a cracked component risks sudden fracture and fragment ejection.

5. C — Cutting a hole in a ROPS-certified cab roof compromises the structure's engineered energy absorption capacity. The ROPS was certified as a complete, unmodified structure, and any unauthorized modification — cutting, welding, drilling, or adding holes — potentially invalidates the certification. The cab's ability to protect the operator during a rollover event is no longer guaranteed.

6. B — Hydraulic cylinders can lose holding pressure from internal seal leakage, a failing POCV, or thermal contraction of the oil, causing the boom to descend without warning. The OEM-specified mechanical safety prop, lock pin, or support stand physically prevents the boom from lowering by transferring the load from the hydraulic system to a fixed mechanical device.

7. D — Compressed gas cylinders must be transported upright in a dedicated cylinder rack or transport bracket, with the valve cap installed to protect the valve from impact, and chained or strapped to prevent movement during transport. A falling or impacting nitrogen cylinder can shear its valve, turning the cylinder into an uncontrolled projectile.

8. A — A test light draws current through the circuit to illuminate its bulb. On modern electronic circuits with sensitive ECMs and low-current logic signals, the test light's current draw can damage modules, overload sensor circuits, and produce false signals. A DMM's high input impedance (typically 10 megohms) draws virtually no current from the circuit being measured.

9. C — A helicopter-access remote repair requires the technician to identify and bring every required tool, part, consumable, and diagnostic equipment in a single trip. If any critical item is missing, the repair cannot be completed and the machine remains down until a second trip is arranged — which may take days depending on weather and helicopter availability.

10. B — A repair is not complete until the system is verified functional under operating conditions. The technician must perform a complete functional test of every hydraulic function at full operating temperature and pressure, check all connections for leaks, confirm pressures and flow rates match OEM specifications, and document the results before releasing the machine.

11. D — Identical engines in the same application with the same maintenance should produce similar wear metal trends. Engine B's 3× higher iron level confirms it has a specific abnormal wear condition — intake restriction, cooling deficiency, fuel system fault, or internal mechanical issue — that Engine A does not have. The cause must be identified and corrected.

12. A — Grey-blue smoke during cold start that clears at approximately 40°C is characteristic of oil leaking past hardened valve guide seals. When cold, the aged seals cannot conform to the valve stems, allowing oil into the combustion chambers. As the engine warms, the seals soften slightly and seal more effectively, stopping the oil leakage and clearing the smoke.

13. C — EGR cooler thermal efficiency = (gas inlet − gas outlet) ÷ (gas inlet − coolant inlet) × 100 = (550 − 180) ÷ (550 − 85) × 100 = 370 ÷ 465 × 100 = 79.6%. This formula uses the maximum possible temperature drop (gas inlet to coolant temperature) as the denominator, providing the true thermal effectiveness of the heat exchanger.

14. B — Crankshaft web deflection measures the main bearing alignment by detecting changes in web spacing as the crankshaft rotates through each journal position. Excessive deflection at a specific journal confirms the main bearing at that position has worn, allowing the shaft to sag or rise. The test detects bearing wear without removing the crankshaft.

15. D — The rail pressure is 2 MPa below specification across all conditions with adequate fuel supply and acceptable injector back-leak. The fuel pressure regulation system — either the HP pump's inlet metering valve (not opening fully) or the rail pressure control valve (leaking fuel to the return) — cannot maintain the commanded pressure. The regulation components must be diagnosed.

16. A — No external leaks, no oil contamination, and no exhaust smoke — yet coolant level drops. Engines with coolant-to-air charge air coolers (CCACs) can develop internal tube leaks that allow coolant to enter the intake manifold through the CAC. The small quantities burn during combustion without producing visible smoke. A pressure test of the CAC's coolant circuit reveals the leak.

17. B — Carbon deposits around the nozzle orifices alter the fuel spray pattern by deflecting, restricting, or partially blocking the orifices. The disrupted spray changes the spray angle, penetration depth, and droplet size, producing poor fuel-air mixing, incomplete combustion, increased emissions, reduced power, and potential fuel impingement on the piston crown or cylinder wall.

18. C — Boost is 20 kPa below specification with the wastegate correctly adjusted and the exhaust temperature below maximum. The exhaust energy is present (normal temperature) but the turbocharger cannot convert it to rated boost. A damaged compressor wheel from FOD (foreign object damage) reduces the compressor's ability to compress intake air despite receiving adequate turbine drive energy.

19. D — Fuel dilution at 4.5% exceeds the 3.0% condemning limit. Diesel fuel has entered the oil and diluted it, reducing viscosity below the safe operating range. The viscosity decrease (14.0 to 12.8 cSt) is a direct consequence of the fuel dilution. The fuel source must be identified (leaking injector, failed supply component, or excessive post-injection) and corrected.

20. A — The DPF inlet temperature dropped suddenly from 620°C to 400°C during regeneration. The most likely cause is a reduction in engine RPM or load — the operator may have reduced the throttle, or an automatic load-shedding event occurred. The reduced exhaust energy dropped the temperature below the minimum to sustain regeneration, and the ECM aborted to prevent incomplete soot burning.

21. B — The position sensor measures the actuator motor's shaft rotation, not the physical valve plate position. The motor shaft has rotated to the 25% position (the sensor correctly reports this), but carbon buildup between the motor and the valve plate creates a mechanical binding that prevents the plate from following the shaft. The sensor reports correct shaft position while the plate is stuck at a lesser opening.

22. D — Potassium is a component of certain engine coolant formulations, particularly OAT (organic acid technology) coolant. The gradual increase over three consecutive samples confirms coolant is entering the oil through a small, progressive leak — developing head gasket breach, oil cooler seep, or micro-crack in a coolant-wetted casting.

23. C — The HP turbo's bypass valve stuck closed forces all exhaust through the small HP turbine housing at high RPM, producing excessive exhaust restriction. The elevated back-pressure reduces engine volumetric efficiency, increases pumping losses, raises exhaust temperatures, and reduces peak power. At low RPM, the HP turbo operates normally because the bypass is designed to be closed at low RPM.

24. A — The SCA charge in the coolant conditioner filter maintains the nitrite level that protects wet cylinder liners from cavitation erosion. Installing a filter without the SCA charge allows the nitrite to deplete gradually. Without the protective film, the liner-to-coolant interface becomes vulnerable to cavitation erosion from combustion-induced vibration, potentially perforating the liner wall.

25. B — The crankcase ventilation system is restricted downstream of the separator. The restriction prevents blowby gases from exiting at the rate they enter, building positive pressure. The restriction could be in the separator itself (clogged, seized rotor), the outlet hose, or the intake manifold connection. The positive pressure pushes oil past external seals if not corrected.

26. D — Light-load operation produces low exhaust temperatures that do not reach the minimum (typically 350–400°C) needed to ignite soot on the DPF substrate through passive oxidation. Without adequate exhaust heat, soot accumulates continuously and cannot burn off through the normal passive regeneration process, eventually requiring a forced stationary regeneration or off-machine cleaning.

27. C — The decreasing blowby during break-in confirms the piston rings are seating against the cylinder wall hone pattern. The new rings' running surfaces conform to the bore during controlled break-in loading, progressively improving the ring-to-bore seal. The improved seal reduces combustion gas blowing past the rings into the crankcase, lowering the measured blowby.

28. A — Intake restriction, exhaust restriction, turbocharger boost, and injector spray patterns have all been eliminated. At 20,000 hours, the cylinders may have lost compression from ring and liner wear. The reduced air mass per cycle cannot burn the injected fuel completely — the ECM delivers the same fuel quantity, but the reduced air charge produces an effectively rich mixture that generates black smoke.

29. B — The cylinder balance test disables each injector and monitors the RPM drop. Cylinders 1–5 each drop 80 RPM, confirming equal power contribution. Cylinder 6 drops only 25 RPM — disabling it has little effect because it was already contributing minimal power. The low contribution confirms Cylinder 6 has a fault (low compression, injector fault, or valve issue) that reduces its power output.

30. C — A partially open drain valve allows both air and contaminants to bypass the fuel-water separator's filtration and enter the fuel supply through the drain opening. The air entry causes the HP pump to produce inconsistent rail pressure from cavitation. The unfiltered contaminants damage the HP pump and injector precision surfaces, producing expensive component failures.

31. D — The front and rear axles carry different loads — the front supports the cab and engine, while the rear supports the loaded dump body. The front struts are sized smaller to provide a softer ride at the operator's station, reducing vibration transmission to the cab. The larger rear struts are sized to support the heavy payload during loaded haul operations.

32. A — The accumulator's pre-charge is at the low end of the acceptable range. The gas volume is sufficient for 4 applications, but the pressure drops enough between the first and fourth that the pedal feel changes noticeably. Recharging the pre-charge to the midpoint of the specification range provides a more consistent pedal feel and pressure across all emergency applications.

33. C — Rocky environments subject the track link rail surfaces to repeated high-impact contact loading. Rocks trapped between the rollers and rails create concentrated impact forces that exceed the surface hardness at specific points. The repeated impacts produce subsurface fatigue cracks that propagate laterally beneath the hardened layer, lifting and breaking the surface material in flakes (spalling).

34. B — Without the friction modifier, the limited slip clutch pack's static friction coefficient exceeds its kinetic coefficient by a larger margin than designed. During slow tight turns (maximum speed differential), the clutch alternates between grabbing (static) and slipping (kinetic), producing the chatter vibration. The correct modifier equalizes the static and kinetic friction to prevent this grab-slip cycle.

35. D — A single reversed track shoe creates an asymmetric ground contact that loads the chain unevenly at that position. The reversed grouser contacts the ground at the wrong angle, producing non-designed forces on the shoe mounting hardware and the adjacent pin-and-bushing joints. Over 50 hours, this accelerates localized wear at the adjacent links and stresses the mounting hardware.

36. B — The drum has worn from 400 mm (new) to 410 mm — with only 2 mm remaining before the 412 mm discard limit. The drum wall has thinned significantly, reducing its thermal mass and heat dissipation capacity. The drum should be monitored closely and replaced at the next service — the remaining material is likely insufficient for another machining cut.

37. A — The front brake circuit has a longer air line run from the foot valve to the front chambers than the rear circuit. The pneumatic signal must travel the additional length, and the time delay is the air's transit time through the longer tubing. The front circuit's relay valve response time may also contribute. This is a common characteristic addressed during brake system design and timing valve calibration.

38. C — The track chain encounters obstacles or accumulates material that momentarily increases the tension beyond the relief valve's setting. The relief valve opens to release the excess pressure, and the expelled grease is the visible evidence. This is the designed safety function, but frequent weeping indicates the machine is routinely encountering conditions that exceed the tension setting.

39. D — The emergency steering pump is typically smaller than the main pump and provides reduced flow to the steering cylinders, producing slower but functional steering. The slower response is an acceptable characteristic as long as the emergency steering achieves the OEM-specified minimum lock-to-lock time within the required number of steering wheel turns.

40. A — The damaged oscillation stops (torn bumpers, bent backing plates) confirm the axle has repeatedly contacted the hard stops with excessive force. The machine is being used on terrain that exceeds the oscillation range, or is being operated at excessive speed over rough terrain, producing dynamic forces that exceed the limiters' designed capacity.

41. C — The sprocket segments at 70% wear are the most worn and should be replaced. The chain at 3.5% should receive a pin turn (it passed the 3% optimal point but a turn still extends its life). Performing both simultaneously — turning the chain and replacing the sprockets — maximizes the overall undercarriage life by ensuring the renewed chain surfaces mesh with new sprocket teeth.

42. B — With one circuit completely failed, the remaining circuit provides braking on its axle only. The stopping distance approximately doubles because only one axle contributes braking force. The operator may also experience a pulling tendency toward the functional side. The dual-circuit design ensures at least partial braking is always available despite a single circuit failure.

43. A — A 75%-worn sprocket cannot mesh correctly with the renewed chain from the pin turn. The worn tooth profile doesn't match the chain's restored pitch, causing the chain to ride up on the worn teeth (chain climbing) rather than seating in the tooth roots. This accelerates wear on both the new chain surfaces and the remaining sprocket teeth, and may cause skipping or derailment.

44. D — SAHR parking brake holding torque depends on the springs' clamping force. Springs weaken from age and repeated compression cycling (fatigue), gradually generating less force when fully released to the applied position. Spring fatigue is the most common cause of gradually declining holding torque in SAHR parking brakes, and the springs must be replaced to restore the designed clamping force.

45. B — A sidewall bulge indicates the tire's internal structural cords have broken at that location. The broken cords cannot contain the inflation pressure, and the inner liner pushes outward through the damaged zone. The tire's structural integrity is compromised and it can fail suddenly at the bulge point under load, creating a blowout hazard. The tire must be replaced immediately.

46. C — ABS is designed to detect and prevent wheel lockup at the threshold — before a visible skid develops. The wheel speed sensors detected a brief deceleration rate at one or more wheels that exceeded the system's lockup threshold, and the ABS modulated brake pressure to prevent full lockup. The operator feels the pedal pulsation from the modulation, but no visible skid occurs because the system intervened successfully before lockup.

47. B — With the DMM in series between the battery and the main bus, removing fuses one at a time identifies the parasitic draw's circuit. When the correct fuse is pulled, the ammeter reading drops from 350 mA to approximately 50 mA (the acceptable baseline). The removed fuse identifies the specific circuit drawing the excess current, which can then be diagnosed further.

48. C — The float switch should produce 0V (closed/grounded) when the coolant is full. The 2.3V intermediate reading confirms the switch contacts have resistance from corrosion or contamination. The corroded contacts create a voltage divider with the ECM's pull-up resistor, producing the intermediate voltage instead of the expected 0V for a fully closed switch.

49. A — The remanufactured alternator's internal bearings have a defect producing the speed-dependent whine. The charging output is currently within specification, confirming the electrical components are functional, but the mechanical bearing noise will worsen as the defect progresses. The alternator should be warranted and replaced before the bearing fails completely.

50. D — Peak current = V ÷ R = 24V ÷ 0.5 ohms = 48 amperes. This high initial current creates the strong magnetic field needed to rapidly pull the injector needle off its seat during the pull-in phase. The ECM then reduces the current to a lower holding level using PWM or voltage reduction to prevent coil overheating during the remainder of the injection event.

51. C — The CAN protocol detects corrupted frames through CRC validation. Receiving modules discard the corrupted frame and wait for Module 7's next valid transmission — the data update is delayed by one cycle. If errors are infrequent, the effect is imperceptible. If frequent, receiving modules trigger DTCs for missing or stale data and dependent functions operate intermittently.

52. B — The new pedal's voltage span (0.8–4.2V = 3.4V) is narrower than the specification (0.5–4.5V = 4.0V). The ECM maps 100% pedal travel to 100% throttle command, but the 4.2V endpoint may not reach the ECM's internal full-fuel voltage threshold. The ECM delivers slightly less than maximum fuel even at full pedal because the calibrated endpoint falls short of the internal fuel map's maximum command voltage.

53. A — The display module measures voltage at a point in the electrical system closer to the alternator output, where the voltage is higher. The battery terminal voltage is lower because the charging cable's resistance creates a voltage drop between the alternator and the battery. The 1.3V difference represents the cable and connection resistance consumed during current flow.

54. D — The sensor spans 4.0V (0.5V to 4.5V) representing 200 MPa (0 to 200 MPa). At 3.8V, the signal is 3.3V above the 0.5V baseline. Pressure = (3.3 ÷ 4.0) × 200 = 165 MPa. The 0.5V offset must be subtracted from both the reading and the maximum before calculating the proportion.

55. C — Pitted and discoloured relay contacts have increased contact resistance that generates heat at the contact point during each 60A activation. The heat further degrades the contacts and socket in a self-reinforcing cycle. The voltage drop reduces motor performance, and the accumulated heat may eventually melt the relay socket or ignite surrounding materials.

56. B — A corroded, loose ground stud shared by multiple ECMs shifts the voltage reference for every sensor circuit using that ground. The corroded high-resistance connection produces voltage readings that ECMs interpret as out-of-range for various sensors. The diagnostic signature — random, intermittent DTCs across different sensors and different ECMs — points specifically to a shared ground fault.

57. D — The PCV is normally closed by spring force. Without electrical command, the spring holds the valve at a default cracked-open position that establishes an intermediate rail pressure — typically 50–80 MPa above idle specification. The engine runs rough and overpowers but does not reach the mechanical relief valve because the spring force limits the default pressure to a controlled intermediate level.

58. A — The engine produces rated power and all ECM parameters are within specification, ruling out engine faults. The 22% fuel consumption increase with unchanged work output points to the drivetrain — worn torque converter, slipping clutches, dragging brakes, low tire pressure, or increased rolling resistance all require the engine to consume more fuel to maintain the same performance.

59. C — Limiting the engine to 1,200 RPM (rather than a complete shutdown) provides enough power for the operator to move the machine to a safe location — off a haul road, out of traffic, or away from active work zones. A complete shutdown in an active area could strand the machine in a hazardous position with no steering or brake assist.

60. B — Two 120-ohm termination resistors in parallel produce the measured 60 ohms. Disconnecting one leaves a single 120-ohm resistor, confirming both terminations are present and correct. This is the

standard CAN bus termination verification test — 60 ohms total with both resistors, 120 ohms with one disconnected.

61. D — Without knowing the engine RPM, the TCM cannot calculate synchronous speed for any gear engagement and risks a clash shift. The TCM holds the current gear and inhibits all shift commands until valid RPM data is restored. This protective strategy prevents clutch pack damage from mismatched engagement speeds during the data loss period.

62. A — The telematics module is a monitoring and communication device only — it does not control any machine function. A failed telematics module means the fleet manager loses remote tracking of location, hours, fuel, DTCs, and idle time. The machine itself operates normally in all respects because no control circuits depend on the telematics module.

63. C — The coolant temperature rose through all three stages so rapidly — from a sudden catastrophic cooling failure such as a burst hose or failed water pump — that the time spent at Stage 1 and Stage 2 was too brief for the operator to perceive. The engine passed through warning, derate, and shutdown in seconds rather than minutes.

64. D — The starter motor heat-soaked from the first engine run. The engine block's heat raised the starter motor's internal temperature, increasing the copper winding resistance (copper's resistance rises approximately 0.4% per °C). The higher resistance reduces the cranking current at the same battery voltage, producing the noticeably slower cranking speed on the second attempt.

65. B — A Hall-effect sensor is a powered semiconductor device that produces a digital output. Unlike a variable reluctance sensor (whose output amplitude depends on the rate of magnetic flux change), the Hall-effect sensor's digital switching is independent of the air gap within its designed operating range. The sensor's internal electronics maintain the output regardless of moderate air gap changes.

66. A — All temperature inputs are normal and no DTCs are stored, yet the fan runs at 100%. The ECM may have an internal driver fault locking the output at 100%. The technician should measure the actual PWM signal at the ECM connector — if the ECM is commanding 100%, the fault is in the ECM or its programming. If the ECM is commanding a lower duty cycle, the fault is downstream.

67. C — The joystick signal is correct at the ECM input (no electrical delay), but the implements respond 1–2 seconds late. The delay is between the ECM's command and the physical spool movement.

Contaminated DCV spools resist movement until pilot pressure overcomes the contamination resistance, producing the delay. The spools eventually shift when force exceeds the binding resistance.

68. D — The fuel shut-off solenoid is energized-to-run. A high-resistance connection reduces the current reaching the solenoid below the minimum needed to fully energize it. The solenoid's spring holds it in the shut-off position because the weakened magnetic force cannot overcome the spring. The engine does not start because the fuel path remains blocked.

69. A — The remote-sense wire allows the regulator to measure the actual battery terminal voltage. When the sense wire breaks, the regulator defaults to sensing voltage at the alternator's B+ terminal — which is higher than battery voltage due to cable resistance drops. The regulator sees a higher-than-actual voltage and reduces field current, undercharging the batteries.

70. B — The circuit has a persistent overcurrent fault — a short circuit, seized motor, or overloaded device draws more current than the fuse rating every time the circuit energizes. The solid-state fuse trips, resets automatically after its timeout period, re-energizes the circuit, and the fault immediately draws excessive current again, creating the repetitive cycling pattern.

71. C — The exposed CAN bus conductors in the engine compartment are vulnerable to moisture ingress, additional abrasion, and ground contact against the sharp bracket. In the harsh engine compartment environment, the unprotected wires will eventually develop faults. The damaged section must be protected with heat-shrink or conduit, and the bracket addressed to prevent recurrence.

72. A — The stator one-way clutch has failed, allowing the stator to freewheel in both directions. Without the stator redirecting the turbine's exhaust fluid back to the pump efficiently, the converter loses its torque multiplication function. The pump spins faster (higher stall RPM) because the fluid opposition from a correctly locked stator is absent. The engine has adequate power (verified), confirming the fault is in the converter.

73. D — At 1,200 kPa (300 kPa below the 1,500 minimum), Clutch C cannot clamp with designed force. The clutch slips during shifts that engage Clutch C, generating friction heat that degrades the disc material and contaminates the oil. The progressive heat and wear will destroy the clutch pack and contaminate the entire transmission if the pressure fault is not corrected.

74. B — A coast-heel contact pattern indicates the ring gear tooth engages too far from the pinion during deceleration. Moving the ring gear away from the pinion by adjusting the carrier bearing shims shifts the

coast contact from the heel toward the centre of the tooth, correcting the noise-producing mesh condition during deceleration.

75. C — Replacing the fixed-displacement motor with a 10% smaller displacement unit increases the motor's output speed for the same input flow (speed = flow ÷ displacement). The same pump flow driving the smaller motor produces approximately 10% higher shaft speed, increasing the travel speed proportionally. The motor's torque output decreases proportionally, which must be verified as acceptable.

76. A — At 10,000 hours, the transmission pump's internal clearances have widened and the main pressure regulator valve's spool-to-bore clearance has increased. Both conditions allow more internal leakage, reducing the maximum achievable main pressure below specification. The 50 kPa deficit confirms progressive wear that should be trended and planned for rebuild.

77. D — The ECM reads high range (sensor satisfied), but the machine operates at low-range speed. The transfer case position sensor detects the shift fork position, not the actual gear engagement. The shift fork has reached the high-range position but the spline engagement, clutch pack, or mechanical linkage has not physically completed the engagement despite the fork being in position.

78. B — The 15 N·m drag (vs. 8 N·m specification) generates continuous heat during every moment of travel. The accumulated heat raises brake oil temperature, accelerates disc and seal wear, and wastes fuel because the engine must produce additional power to overcome the drag throughout every operating shift.

79. C — The lockup clutch shudder appeared after an oil change, isolating the cause to the oil. The replacement oil may not contain the correct friction modifier specification for the lockup clutch. The friction modifier controls the engagement characteristics — the wrong modifier or its absence produces the grab-slip cycle that the operator feels as shudder during each lockup event.

80. A — Dark grey oil with fine metallic particles after 2 hours on a rebuilt final drive is normal break-in wear. The new gear teeth and bearing surfaces are polishing against each other during initial operation. The oil should be changed after the OEM's specified break-in period to remove the debris, and a new baseline sample taken after the change.

81. D — The 1.5 mm of axial free play allows the shaft to slide back and forth under alternating drive and coast loads. Each transition between acceleration and deceleration produces a clunking noise as the

spline and bearing surfaces impact at the ends of the free-play range. The clunk occurs at every load reversal during normal operation.

82. C — The 3rd gear synchronizer has worn — the friction ring, hub sleeve, or detent mechanism has degraded and cannot match the input shaft speed to 3rd gear speed during the shift. All other synchronizers function correctly, isolating the fault to the specific 3rd gear synchronizer assembly.

83. B — A universal joint operating at an angle naturally produces a 2× per-revolution speed variation from the geometric relationship between the input and output shafts. If the operating angle is excessive from worn bearings, sagging mounts, or incorrect driveline geometry, the 2× variation becomes large enough to produce a perceptible vibration proportional to shaft speed.

84. B — The oil cooler is clean and the oil is correct, yet the converter temperature exceeds specification during loaded operation. If the lockup clutch is not engaging when the TCM should command it, the converter operates in fluid coupling mode during conditions that should be mechanically locked. The continuous fluid shearing generates more heat than the cooler was designed to reject.

85. D — The seal was replaced but the leak returned at the same location within weeks. The axle shaft surface at the seal contact area has a wear groove, rust pitting, or surface roughness. Any new seal seats against the damaged surface and cannot achieve a reliable seal. The shaft must be polished, sleeved, or replaced to provide an undamaged surface for the seal lip.

86. C — The TCM has progressively increased Clutch B pressure by 25% over 1,000 hours to compensate for detected slip. The clutch friction material has worn and the friction coefficient has decreased. The adaptation has reached its maximum authority and can no longer fully compensate — the excessive pressure now produces abrupt engagement (harsh shift) because the TCM commands maximum available force.

87. C — Forward speed is correct but reverse is 20% slower with equal pump displacement confirmed. The motor's displacement may be controlled differently in the two directions. If the motor shifts to a higher displacement in reverse (from a control circuit fault, a mechanical binding, or a calibration issue), the same input flow produces a slower shaft speed.

88. B — Insufficient free play (5 mm vs. 15–25 mm specification) means the release bearing is constantly in contact with the pressure plate fingers. The bearing rotates continuously, generating heat

and wearing rapidly. The constant contact also partially disengages the clutch, reducing the clamping force and producing clutch slip under heavy load.

89. A — Both pressures are below normal with a correct charge and the compressor operating. The expansion valve is stuck in a restricted position, starving the evaporator (low low-side) and reducing the mass flow through the entire system. The compressor has less refrigerant to compress on each stroke, producing the low high-side pressure. The restricted valve is the single fault that explains both low readings.

90. D — The cab pressurization dropped below specification over 6 months without apparent change. Cab door seals, window seals, and panel gaskets progressively deteriorate from UV exposure, mechanical fatigue (repeated opening/closing), and chemical exposure. The increased seal leakage allows pressurized air to escape faster than the blower can replace it.

91. C — The A/C cooled normally for 5 minutes, then the compressor disengaged and the low-side dropped to vacuum. The new compressor's displacement combined with a correctly charged system should maintain stable pressures. The most likely cause is a system leak that has depleted the charge within 5 minutes — the low-pressure switch disengages the clutch to protect the compressor from running without refrigerant.

92. A — The soot-coated flame sensor cannot detect the flame's infrared radiation or heat. The controller receives a "no flame" signal despite a flame being present, and shuts off the fuel after the 30-second safety timeout. This is the designed safety response to prevent unburned fuel accumulation. Cleaning the flame sensor restores detection.

93. B — DEF (32.5% urea solution) decomposes at sustained temperatures above 32°C. The urea molecules break down, reducing the functional urea concentration below specification. The degraded DEF delivers insufficient ammonia to the SCR catalyst, reducing NOx conversion efficiency and potentially triggering a DEF quality fault that initiates a progressive power derate.

94. D — The sensor mounted directly above a heating vent reads the warm vent air first, not the average cab temperature. The warm reading causes the controller to switch to cooling prematurely. The cooling then overcools the cab until the sensor reads below the set point, switching back to heating. The cycle repeats because the sensor never reads the true average cab temperature.

95. A — The refractometer reads correct urea concentration (32.5%), but the DEF quality DTC persists. Certain contaminants can mimic urea's refractive properties, making the refractometer read correctly while the actual urea-to-water ratio is incorrect. The DEF quality sensor in the tank or the SCR conversion efficiency monitoring detects the functional deficiency that the refractometer cannot.

96. A — Flushing is acceptable if the restriction is from soft deposits (scale, silicate gel, sediment) that can be dissolved or dislodged. The flow rate must be verified after flushing to confirm the specification is met. If the restriction is from internal tube corrosion or structural collapse, flushing cannot restore the flow and replacement is required.

97. B — The stuck-closed automatic drain prevents accumulated water from being expelled. The water level rises with each compressor cycle, eventually reaching the reservoir's outlet port and entering the brake lines, valves, and chambers. In cold weather, the water freezes in air passages, can block valve operation, and may cause brake failure.

98. C — Volumetric efficiency at rated pressure = actual flow ÷ theoretical flow × 100 = 140 ÷ 200 × 100 = 70%. This pump has significant internal leakage at 300 bar and is well below the typical 80–85% minimum acceptable threshold. The pump requires rebuild or replacement.

99. A — Annular area = $\pi/4 \times (100^2 - 70^2) = \pi/4 \times (10{,}000 - 4{,}900) = \pi/4 \times 5{,}100 = 4{,}006\ mm^2$. Retract force = $0.1 \times 250 \times 4{,}006 = 100{,}150\ N \approx 100\ kN$. The annular area (bore area minus rod area) is the effective piston area for the retract force calculation.

100. D — The pump produces full flow at zero pressure but cannot maintain flow as pressure increases. At 240 bar, the pump's internal leakage rate equals its displacement — no net flow reaches the relief valve. The relief valve was correctly set at 280 bar on the bench, but the worn pump cannot build pressure high enough to reach it. The pump, not the relief valve, is the limiting component.

101. B — The pilot circuit should operate below the relief valve setting during normal use — the 35-bar relief is maximum protection, not the operating target. The 28-bar reading during joystick actuation reflects the pilot circuit's normal operating pressure, which is determined by the flow demand and the metering restriction through the pilot valve.

102. C — The intensifier multiplies pressure by the ratio of large piston area to small piston area. Force on large piston = $200\ bar \times 200\ cm^2 = 40{,}000\ N$. This force transfers to the small piston. Output pressure = $40{,}000 \div 50\ cm^2 = 800\ bar$. The 4:1 area ratio produces a 4× pressure multiplication.

103. A — At 200 bar system pressure, the nitrogen was compressed from its 90-bar pre-charge volume, storing oil in the accumulator. When system pressure drops to 150 bar (still above the 90-bar pre-charge), the nitrogen expands, pushing stored oil into the brake circuit to supplement the declining pressure. The accumulator discharges progressively until pressure stabilizes or reaches the 90-bar pre-charge level.

104. D — A filter element that clogs within 50 hours (well before its designed interval) indicates the system is generating or ingesting contamination faster than the filter can manage. The contamination source — component wear, external ingress, or residual debris from a previous failure — must be identified and corrected, not masked by more frequent filter changes.

105. B — The build-up time (4:30 vs. 3:00 maximum) is slow despite the compressor's 15 CFM rating. The system has a significant air leak that consumes a portion of the compressor's output during the build-up. The net air reaching the reservoirs is reduced by the leak volume, extending the time to reach cut-out. Both the leak and the compressor capacity should be evaluated.

106. A — The counterbalance valve is correctly adjusted, but the DCV cannot deliver enough pilot pressure or flow to fully open it. The boom descends slowly because the partially opened counterbalance valve restricts the exhaust flow from the cap end. The pilot pressure ratio, pilot flow rate, and DCV delivery must be verified to ensure the DCV can fully command the counterbalance valve.

107. D — The unfiltered charge oil enters the main loop through the charge check valves and flushing valve. For 200 hours, contamination particles have circulated through the pump's valve plate, the motor's port plate, and both components' piston-bore surfaces. The accelerated wear from the unfiltered operation has likely shortened the service life of both the pump and motor.

108. C — Spool-type DCVs have inherent spool-to-bore clearance that allows a small amount of oil to leak from the work port to the tank port in neutral. Over 4 hours, this internal leakage depletes the oil volume holding the cylinder extended. This is a design limitation of spool valves for load-holding, which is why POCVs or counterbalance valves are preferred for extended hold applications.

109. B — The double-check valve's internal shuttle has stuck in a position that blocks the pressurized circuit's path. The valve cannot shift to allow the live circuit to pass through to the spring brake chambers. The stuck valve must be inspected and replaced or cleaned to restore the redundant supply capability.

110. A — The flow divider's compensator spool has worn, losing its ability to maintain equal flow against the pressure differential between the two circuits. The lower-resistance circuit (Circuit A) receives the excess flow while the higher-resistance circuit (Circuit B) is starved. The worn spool cannot balance the flow distribution as designed.

111. D — The foot valve's return spring provides the proportional resistance that the pedal must overcome for graduated application. Without the spring, the metering piston has no return force and the valve delivers full supply pressure with minimal pedal input. The graduated control function is lost because the spring normally creates the pressure-proportional pedal force feedback.

112. B — Required flow = displacement × speed = 160 cm^3/rev × 120 rev/min = 19,200 cm^3/min. Converting to litres: 19,200 ÷ 1,000 = 19.2 L/min. At 100% volumetric efficiency, the pump must deliver 19.2 L/min to drive the motor at 120 RPM.

113. D — A pre-charge of 260 bar exceeds the system's 250-bar working pressure. The nitrogen holds the bladder or piston fully against the oil port — no oil can enter because the gas pressure exceeds the hydraulic supply. The accumulator is completely non-functional, providing zero spike absorption. The bladder may also be damaged by being pressed into the oil port.

114. A — A 3-micron pressure filter produces a higher pressure drop than a coarser filter. As the element loads, the differential pressure may exceed the bypass valve setting during peak flow demand, routing unfiltered oil around the element. The frequent bypass events defeat the purpose of the fine filtration and produce inconsistent cleanliness downstream.

115. D — The 900 kPa cut-out exceeds the designed 860 kPa maximum. The compressor runs longer each cycle, increasing wear and energy consumption. More significantly, 900 kPa may exceed the pressure rating of downstream components designed for 860 kPa maximum, creating an overpressurization hazard for chambers, valves, and hoses throughout the brake system.

116. B — The worn groove on the valve plate creates a leak path between the high-pressure discharge port and the low-pressure suction port. Oil crosses from discharge to suction through the groove during each barrel revolution, bypassing the system. This internal bypass is the primary contributor to the pump's 76% volumetric efficiency — well below the 80% minimum.

117. C — In a series circuit, the first cylinder receives pump flow directly and the second cylinder receives the first cylinder's rod-end exhaust. The rod-end volume is smaller than the cap-end volume

(reduced by the rod area), so the second cylinder receives less flow per stroke and extends more slowly than the first. Both cylinders move simultaneously but at different speeds.

118. A — The elevated pilot pressure (42 bar vs. 35 bar specification) shifts the DCV spools further than designed, over-stroking them and producing excessive flow to the actuators. The implements move faster than commanded, reducing the operator's precision control and potentially creating a safety hazard from unexpected implement speed.

119. D — The charge pump draws oil from the reservoir through the suction circuit. A restricted intake starves the charge pump, producing cavitation — the characteristic high-pitched whine from vapour bubbles forming and collapsing inside the pump. The cavitation noise is typically the first symptom noticed before charge pressure drops enough to affect drive performance.

120. B — The retract-only chatter with smooth extension points to the counterbalance valve on the retract circuit. If the valve's cracking pressure is set too close to the working pressure, the load pressure fluctuates around the cracking point. The valve alternately opens and closes with each fluctuation, producing the chatter. Extension is unaffected because the counterbalance valve is fully open during supply-side flow.

121. A — The LS shuttle check valves select the highest load signal for the pump. If the shuttles malfunction and pass an intermediate or low signal instead of the highest, the pump output pressure is insufficient for the highest-load function (under-speed) while providing excess pressure for the lowest-load function (over-speed). Correcting the shuttle valve restores balanced flow distribution.

122. B — The accumulator gas valve core (Schrader valve) is not being depressed by the charging tool, or the valve core is stuck closed. Nitrogen cannot enter the accumulator because the valve is not open. The technician should verify the charging tool is properly seated and the valve core is functional before suspecting a ruptured bladder or empty supply bottle.

123. D — The adapter cracked at 6,000 hours despite an 8,000-hour replacement interval. The machine's operating conditions — digging force, impact frequency, or material hardness — exceed the OEM's design assumptions. The replacement interval should be shortened based on the actual application severity to prevent recurrence.

124. A — A sagging door does not close and seal correctly. The misalignment prevents the door seals from making full contact around the perimeter, compromising the cab's pressurization (allowing dust

ingress), noise isolation (increasing operator noise exposure), and potentially the ROPS seal integrity. The worn hinge pins must be replaced to restore designed alignment.

125. C — Without documentation of the material specification, thickness calculation, and weld procedure qualification, the bracket's structural adequacy cannot be verified. An unqualified bracket may fail under the dynamic loading of normal operation, dropping the attachment. The bracket must be designed and documented by a qualified engineer before installation.

126. B — The missing fourth bolt increases the individual stress on the remaining three bolts by 33%, potentially exceeding their fatigue endurance limit under cyclical loading. The unsupported counterweight corner can vibrate and fatigue the frame at the unsupported mounting point. The damaged thread must be repaired (helicoil, thread insert, or re-tap) before the machine operates.

127. D — The manual pull handle is the operator's backup to activate the suppression system if the automatic detection fails. With the handle zip-tied, the operator cannot manually activate the system from the cab during a fire emergency. The zip tie must be removed immediately to restore the manual override capability.

128. A — The doubler plate repair transferred the stress concentration from the original crack location to the new weld toe where the plate terminates. The abrupt change in cross-section at the doubler plate edge creates a stress riser that concentrates cyclic loading, initiating the new fatigue crack. The repair addressed the symptom but created a new stress concentration.

129. C — Tempered glass is manufactured with internal compressive stresses that, when breached by a fracture, release their stored energy and cause the entire pane to disintegrate into small, relatively dull cube-shaped fragments. This is a designed safety feature — the small fragments are significantly less likely to cause laceration injuries compared to the large, sharp shards that non-tempered glass produces.

130. D — The liners are at 20% remaining thickness — past the OEM's 25% replacement threshold. Operating beyond the threshold risks the liners wearing through completely, exposing the dipper's base metal to direct abrasion. If the base metal wears through, expensive structural repair is required instead of simple liner replacement. The liners should be replaced at the earliest opportunity.

131. B — The undersized coupling restricts flow to 100 L/min instead of the required 150 L/min. The attachment operates at 67% of designed speed. The restriction also creates a pressure drop across the

coupling that generates heat, wastes energy, and may cause high-temperature conditions during continuous operation.

132. B — Working on a 650V DC HV battery enclosure requires the full OEM lockout/tagout procedure: de-energize via service disconnect, verify zero energy with a CAT III/IV rated voltmeter at the HV terminals, wait the specified capacitor discharge time, re-verify voltage, and wear HV-rated insulating gloves with insulated tools throughout. Simply reading low voltage with a DMM is insufficient.

133. A — The swing duty cycle involves hundreds of rapid, high-power charge/discharge cycles per hour — each deceleration captures tens of kilowatts for 1–3 seconds, followed immediately by an acceleration demand. Supercapacitors handle these rapid cycles efficiently due to their low internal resistance and virtually unlimited cycle life. A chemical battery would degrade rapidly under this extreme cycling frequency.

134. D — The machine's auxiliary systems (BMS, telematics, security, controllers) draw continuous low-level power from the HV battery through the DC-DC converter during storage. Over 3 months, these parasitic loads cumulatively consumed the 45% SOC. Lithium-ion self-discharge alone (2–5% per month) accounts for only 6–15% over 3 months, confirming the parasitic draw is the dominant factor.

135. C — The calculation requires the actual energy consumed per shift, not the full battery capacity. At 400 kWh consumed per shift, recharging 10 trucks in 2 hours requires 4,000 kWh total. Power = 4,000 ÷ 2 = 2,000 kW sustained, plus 5–10% for charging losses, yielding approximately 2,200 kW of total infrastructure capacity.