PRACTICE EXAM 5: RED SEAL 421A SIMULATION (135 QUESTIONS)

1. A technician is working on a hydraulic hose replacement beneath a raised excavator boom. The boom is held in position by the hydraulic cylinders with the engine running. Partway through the job, the engine stalls unexpectedly. What was the critical safety violation in this work setup?

A. The technician failed to wear a hard hat rated for overhead work beneath a raised implement structure

B. The technician should have chocked the tracks before working beneath any part of the machine regardless of task

C. The boom should have been mechanically supported with rated safety stands or lowered to the ground — relying solely on hydraulic pressure to support a raised implement is never acceptable

D. The technician should have positioned the excavator on level ground before raising the boom, which would have prevented the engine stall

2. A technician completes a repair on a machine's steering system and must document the work before returning the machine to service. What information must the work order contain at minimum for the repair to be properly documented?

A. Only the technician's name and the date — detailed repair information is recorded separately in the machine's electronic maintenance database

B. The machine identification, fault reported, diagnosis performed, parts replaced, work completed, technician name, and date — sufficient to recreate the repair history

C. A photograph of the completed repair attached to a blank work order template that serves as visual confirmation of the work performed

D. The parts requisition number and the total labour hours charged — all other repair details are maintained by the parts department records

3. A technician is asked to perform a confined space rescue after a coworker collapses inside a large fuel tank during an internal inspection. The technician has not been trained in confined space rescue procedures. What is the correct response?

A. Enter the space immediately to assist the coworker — the urgency of the situation overrides the training requirement for lifesaving intervention

B. Lower a rope into the space for the coworker to grab while the technician remains at the entry point and pulls them to safety

C. Enter the space wearing a selfcontained breathing apparatus borrowed from the onsite fire extinguisher cabinet to protect against toxic atmosphere

D. Do not enter the space — activate the emergency rescue plan, call the designated rescue team, and remain at the entry as the standby attendant while monitoring the situation

4. A heavy equipment shop stores multiple chemical products including solvents, paints, lubricants, and battery acid. A new employee asks how to identify whether a product container has been received from a supplier or has been transferred into a workplace container by another employee. How are supplier containers distinguished from workplace containers under WHMIS 2015?

A. Supplier containers are always metal drums and workplace containers are always plastic bottles — the container material determines the label type

B. Supplier containers must carry the full WHMIS 2015 supplier label with all six required elements, while workplace containers require at minimum a product identifier and safe handling information

C. Both container types require identical labelling — there is no distinction between supplier and workplace container requirements under WHMIS 2015

D. Workplace containers require only a colourcoded cap that matches the GHS pictogram hazard class, while supplier containers carry a full text label

5. A technician is using a hydraulic press to remove a bearing from a shaft. The bearing suddenly fractures and a fragment strikes the safety guard. No injury occurs. Under Canadian OHS legislation, what category does this event fall under and what action is required?

A. This is a near miss (close call) — it must be reported to the supervisor and investigated to identify the root cause and prevent recurrence, even though no injury occurred

B. No action is required because no injury occurred — near miss reporting applies only to electrical and fall hazard events under Canadian legislation

C. This is a first aid incident that must be recorded in the shop's first aid logbook because a projectile was generated even though no injury resulted

D. The technician should replace the safety guard and continue working — the guard performed its function and no further action is required

6. A technician discovers that a 20litre pail of hydraulic oil has been left open overnight on the shop floor. The product SDS indicates the oil has a flash point of 210°C. What is the primary workplace hazard associated with this open container?

A. The low flash point creates an immediate explosion risk — the open container must be treated as a Class 1 flammable liquid emergency requiring evacuation

B. The oil will have absorbed sufficient moisture overnight to make it unsuitable for use in any hydraulic system and must be disposed of as waste

C. The open container creates a spill and slip hazard, and the prolonged exposure allows dust contamination that makes the oil unsuitable for precision hydraulic systems

D. The oil vapour concentration above the open container exceeds the occupational exposure limit within minutes, creating an inhalation hazard in the immediate area

7. A technician is assigned to work on a machine located on a public roadway that has been closed to through traffic but remains accessible to site vehicles. What traffic control measure is the technician's minimum responsibility before beginning work?

A. Position highvisibility warning devices (cones, signs, or a flagger) to alert approaching site vehicle operators of the work zone and the technician's presence

B. Park the service truck behind the disabled machine to act as a physical barrier between the work area and any approaching vehicles

C. Wear a reflective safety vest only — site vehicle operators are trained to watch for personnel and no additional traffic control is required

D. Begin work immediately and move to a safe position whenever a vehicle is heard approaching — intermittent exposure does not require formal traffic control

8. A technician is performing a hot work task (welding) on a machine located 3 metres from an open partswashing tank containing petroleumbased solvent. What precaution is required before welding can begin?

A. No precaution is required because the 3metre distance exceeds the minimum 1metre separation required between hot work and flammable materials

B. Cover the partswashing tank with a metal lid to contain any vapour and proceed with welding at the current location without further action

C. Notify the shop supervisor that hot work is being performed near a flammable source and request verbal approval to proceed at the current location

D. A hot work permit must be obtained, the parts washer must be covered and moved beyond the minimum safe distance or the welding relocated, and a fire watch must be established with an extinguisher

9. A technician identifies a crack in the ROPS on a skid steer during a scheduled inspection. The crack is approximately 50 mm long and is located at a weld junction on the main upright post. What is the required action?

A. Weldrepair the crack in the field using a matching electrode and return the machine to service after visual confirmation of a sound weld

B. Remove the machine from service immediately — the cracked ROPS must be assessed by the OEM or a qualified structural engineer before any repair or return to operation

C. Grind the crack to clean metal, apply a crackdetection dye to determine the full extent, then weldrepair the crack using the OEM procedure if the length is under 100 mm

D. Apply a temporary reinforcement plate over the cracked area with four structural bolts and return the machine to limited service for the remainder of the current shift

10. A maintenance crew is preparing to service a highvoltage batteryelectric loader in an underground mine. The mine's ventilation system circulates fresh air continuously. What additional hazard specific to batteryelectric equipment must be addressed in the job hazard analysis?

A. The battery pack produces electromagnetic radiation that interferes with the mine's communication system during active service procedures

B. The battery coolant is classified as a hazardous waste and cannot be opened or drained in any underground location under mining regulations

C. A damaged or compromised lithiumion battery can release toxic and flammable gases — the work area must be monitored for hydrogen fluoride and other decomposition products, and HV isolation must be completed before service

D. The batteryelectric machine produces zero hazardous emissions and requires no additional hazard precautions beyond the standard LOTO procedure for any powered equipment

11. A technician performs a relative compression test using a current clamp on the starter motor cable during cranking. The trace shows five cylinders with equal current peaks and one cylinder with a noticeably lower current peak. What does the lower peak indicate?

A. The cylinder with the lower peak has a stuckopen exhaust valve that is venting compression to the exhaust manifold during cranking

B. The starter motor has a weak armature segment that produces reduced torque once per revolution, coinciding with that cylinder's position

C. The cylinder with the lower peak has a fuel injector that is leaking fuel into the bore, which is hydraulically resisting the piston and masking the true compression

D. The cylinder with the lower peak has reduced compression — the starter motor draws less current on that cylinder because less work is required to compress the reduced air charge

12. A technician discovers a failed connecting rod bearing during an engine teardown. The bearing surface shows severe wiping and copper exposure on the loaded (lower) half. The oil gallery feeding the main journal supplying this rod bearing is clean and unrestricted. What is the most probable cause of this isolated bearing failure?

A. The engine oil did not meet the API specification for the application, causing premature additive depletion at all bearing surfaces simultaneously

B. The connecting rod bore was distorted (outofround), creating uneven oil film distribution that overloaded the thinnest film area and initiated bearing surface failure

C. The engine was operated at excessive RPM above the governor limit, which increased the inertia loading on all connecting rod bearings equally

D. The main bearing directly upstream of this rod journal has failed, reducing oil supply pressure to the entire crankshaft and starving all rod bearings equally

13. A diesel engine has been running for 500 hours with a coolant leak that the operator has been topping up with plain water instead of the specified coolant mixture. What damage is developing inside the cooling system?

A. The reduced inhibitor concentration from dilution with plain water is allowing corrosion of the internal metal surfaces — particularly aluminum components, which are the most susceptible to uninhibited water attack

B. The plain water has raised the coolant's boiling point above the thermostat's rated opening temperature, preventing the thermostat from opening normally

C. The plain water is dissolving the rubber hoses from the inside, which will cause simultaneous hose failure on all coolant circuits within the next 100 hours

D. The diluted coolant mixture has increased in viscosity, restricting flow through the radiator core tubes and reducing the cooling system's heat rejection capacity

14. An engine oil pressure gauge reads normally at high RPM but drops below specification at idle. The oil level is correct and the oil is the proper viscosity. The technician suspects the oil pump. Before condemning the pump, what should be checked first?

A. Replace the oil pressure sensor — a failing sensor commonly produces an inaccurate low reading at idle that does not reflect actual system pressure

B. Perform an engine compression test — low compression at idle reduces oil pressure because the reduced blowby decreases crankcase pressure that assists the pump

C. Check the bearing clearances — worn main and rod bearings with excessive clearance allow oil to bleed off faster than the pump can replenish at low RPM, producing the idle pressure drop

D. Install a mechanical oil pressure gauge at a different port — if the reading matches, the pump is confirmed faulty and must be replaced immediately

15. A technician is investigating a Tier 4 Final engine that has entered a severe power derate. The diagnostic software shows an active NOx conversion efficiency fault on the SCR system. The DEF level is adequate and no dosing system faults are present. What is the next logical diagnostic step?

A. Replace the SCR catalyst immediately — a conversion efficiency fault with no dosing faults confirms the catalyst has failed and cannot be diagnosed further

B. Perform a DPF forced regeneration to clear accumulated soot that may be backpressuring the SCR catalyst and reducing its conversion efficiency

C. Check the DOC inlet and outlet temperatures to verify the DOC is producing adequate NO_2 for the SCR, as insufficient NO_2 reduces passive SCR conversion efficiency

D. Measure the NOx sensor readings before and after the SCR catalyst during a loaded operation to verify the sensors are reading correctly and the fault is not a sensordriven false code

16. A diesel engine cranks normally but will not start. There is no smoke from the exhaust during cranking. The technician confirms fuel is present at the primary filter. What does the absence of exhaust smoke during cranking indicate?

A. The glow plugs have failed and the intake air temperature is too low for combustion — the presence of smoke would indicate fuel is reaching the cylinders

B. Fuel is not reaching the cylinders — if fuel were being injected, even incomplete combustion would produce visible white or grey smoke from the unburned fuel vapour in the exhaust

C. The engine has zero compression — the absence of smoke confirms all cylinders are unable to produce any compression heat regardless of fuel delivery status

D. The exhaust aftertreatment system is capturing all exhaust products during cranking, which prevents visible smoke from appearing at the tailpipe

17. A diesel engine has been operating with a restricted air filter for an extended period. The operator has not reported any symptoms. What longterm damage can result from prolonged operation with a restricted air intake?

A. Excessive fuel dilution of the engine oil — the rich combustion mixture from insufficient air washes unburned fuel past the piston rings and into the crankcase, degrading oil viscosity and lubrication

B. Accelerated turbocharger compressor bearing wear from the increased vacuum at the compressor inlet that pulls oil through the compressor seal

C. Premature SCR catalyst failure from the elevated ammonia slip caused by the reduced exhaust temperature reaching the catalyst at lowerthandesigned values

D. Increased main bearing wear from the reduced oil pressure caused by the engine's lower RPM when operating with a restricted intake air supply

18. A technician is investigating an engine overheating complaint. The thermostat has been removed for testing. The technician places the thermostat in a container of water with a thermometer and heats the water. The thermostat begins to open at 78°C. The OEM specification states the thermostat should begin opening at 88°C. What is the consequence of operating with this thermostat?

A. The engine operates at correct temperature because the cooling system pressure cap compensates for the thermostat's lower opening point

B. The engine runs hotter than normal because the thermostat opens too wide at normal operating temperature and overwhelms the radiator capacity

C. The engine operates below its designed temperature — the thermostat opens too early, sending coolant to the radiator before the engine has reached optimal operating temperature, reducing combustion efficiency and accelerating component wear

D. The thermostat is within the acceptable tolerance range — a 10°C variation below specification does not affect engine operating temperature significantly

19. A technician is measuring fuel return (backleak) flow from all six injectors on a common rail engine at rated speed under load. The results show all six injectors returning approximately equal flow rates that are 40% higher than the OEM specification. What does this pattern indicate?

A. All six injectors have worn simultaneously — the entire set has reached end of life and must be replaced as a complete set

B. The highpressure fuel pump is oversupplying the rail, and the excess pressure forces more fuel through the injector return paths than specified

C. The fuel return line to the tank is restricted, creating backpressure at the injector returns that produces artificially high flow readings on the test

D. The fuel rail pressure sensor is misreading high, causing the ECM to command excessive rail pressure that forces additional fuel through all injector return circuits

20. A technician is measuring crankcase pressure (blowby) on a diesel engine using a water manometer connected to the oil fill port. The reading is 18 inches of water column. The OEM specification maximum is 6 inches. What condition does this indicate?

A. The oil level is overfilled, creating hydraulic resistance in the crankcase that the manometer registers as false positive pressure

B. The CCV (crankcase ventilation) system is restricted, trapping normal blowby gases and elevating the measured pressure above the actual generation rate

C. The oil is overdue for change and the degraded oil is producing elevated vapour pressure inside the crankcase at operating temperature

D. The piston rings, cylinder liners, or valve seals are allowing excessive combustion gas to enter the crankcase — the blowby volume exceeds the CCV system's capacity to manage it

21. A technician finds the exhaust manifold bolts on a diesel engine are heavily corroded and two bolts have broken off flush with the cylinder head. What environmental factor is the primary contributor to exhaust manifold bolt corrosion and failure?

A. Repeated thermal cycling — the extreme temperature variations between operation and shutdown cause the bolts to expand and contract cyclically, which workhardens the material and promotes corrosionassisted fatigue cracking at the stress point

B. Vibration from the engine causes the bolt threads to fret against the head casting, removing the protective oxide layer and exposing bare steel to atmospheric moisture

C. The exhaust gas condensate that forms during cold starts contains sulfuric acid from the combustion of sulfur in diesel fuel, which attacks the bolt surfaces

D. The head casting and the manifold are dissimilar metals that create a galvanic cell in the presence of moisture, corroding the bolt at the interface between the two components

22. A technician is diagnosing an intermittent engine miss on a sixcylinder diesel. The miss occurs only under heavy load at low RPM. Compression, fuel delivery, and valve adjustment are all within specification. What less common cause should be investigated?

A. The flywheel ring gear has a worn tooth segment that causes the CKP sensor to miscount teeth under the torsional vibration present at heavy load and low RPM

B. The intercooler hoses are ballooning under the high boost pressure present at heavy load, momentarily reducing the air charge to one cylinder bank

C. A hairline crack in one injector line allows a small amount of fuel to leak at high injection pressure — the leak occurs only when the pressure spike at heavy load exceeds the crack's sealing capability

D. The engine mounts have softened from age and the engine shifts under heavy load torque, momentarily stretching the throttle position sensor wiring and causing a signal dropout

23. A technician replaces the thermostat on a heavy equipment engine. After the repair, the engine reaches operating temperature normally but the cab heater produces only lukewarm air. The coolant level is correct. What is the most likely cause?

A. The replacement thermostat has a higher opening temperature than the original, preventing the cooling system from reaching the heater core operating threshold

B. The replacement thermostat was installed backward — the sensing element faces the wrong direction, causing the thermostat to bypass coolant around the heater circuit

C. The replacement thermostat is the correct part but a different design that blocks the heater supply port in the thermostat housing when installed in the original housing orientation

D. The thermostat housing gasket was overtorqued during installation, crushing the gasket and partially blocking the heater supply port cast into the housing

24. A highhour diesel engine shows increasing crankcase oil consumption with no external leaks. Exhaust colour during loaded operation appears slightly bluegrey. Oil analysis shows normal wear metals. What is the most likely source of the oil consumption?

A. The turbocharger compressor seal is leaking oil into the intake manifold, where it is ingested and burned during combustion at a rate below the oil analysis detection threshold

B. Oil is seeping past degraded valve cover gaskets and dripping onto the exhaust manifold, where it vaporizes and produces the observed haze near the engine

C. The oil cooler has developed a pinhole leak that allows a small quantity of oil to transfer to the coolant circuit under oil pressure higher than coolant pressure

D. Worn valve stem seals and piston ring wear are allowing oil to enter the combustion chamber — the bluegrey exhaust and increasing consumption without abnormal wear metals confirms progressive but normal highhour oil passage

25. A technician is adjusting the overhead valve train on a diesel engine using the OEMspecified valve lash settings. The exhaust valves require 0.50 mm cold lash. The technician sets all exhaust valves to 0.50 mm. After starting the engine, one exhaust valve produces a ticking noise. What is the most likely explanation?

A. The valve seat on that cylinder is recessed (sunk) deeper into the head than the others — the effective installed valve height is shorter, producing more actual lash at operating temperature despite the correct cold setting

B. The feeler gauge the technician used is worn thinner than its stamped dimension, producing a setting that is tighter than intended on all valves

C. The rocker arm on that cylinder has a worn contact pad that introduces additional clearance beyond the measured feeler gauge setting at the valve stem tip

D. The pushrod for that valve is slightly bent, changing the geometry of the rocker arm contact point and producing uneven force distribution that creates the noise

26. A common rail diesel engine exhibits a gradual loss of maximum power over the last 200 operating hours. No fault codes are active. Boost pressure, fuel rail pressure, and exhaust backpressure all measure within specification. What system should be investigated next?

A. The cooling system — a partially restricted radiator is limiting heat rejection and causing the ECM to derate power through the thermal protection strategy without generating a fault code

B. The air intake piping — a collapsed inner liner in the intake hose between the air filter and turbocharger is restricting airflow without being detected by the boost pressure sensor

C. The charge air cooler — internal fouling from oil accumulation reduces the density of the charge air entering the intake manifold, reducing the oxygen mass available for combustion without affecting boost pressure

D. The exhaust system — a catalyst substrate that is partially broken and blocking the exhaust path reduces power by increasing backpressure above the sensor location

27. A machine operator reports that the engine warning lamp illuminated briefly during a heavy pull, then extinguished when the load was released. No fault codes are stored. The technician testdrives the machine under load and cannot reproduce the warning. What should the technician do?

A. Return the machine to service — the warning was a transient event caused by a momentary load spike that will not recur under normal operating conditions

B. Replace the engine oil and filter as a precaution — transient warning lamps during heavy load are commonly caused by oil pressure variations from degraded oil

C. Clear the fault code memory and return the machine to service — the absence of stored codes confirms the event was a noncritical electrical glitch

D. Investigate by reviewing the ECM's event history log for parameter snapshots recorded at the time of the warning — many ECMs capture data even for events too brief to store a formal DTC

28. A diesel engine's cooling fan is driven by a viscous fan clutch that engages based on the temperature of air passing through the radiator core. A technician finds the fan spins freely with no resistance when the engine is cold. Is this normal operation?

A. No — the fan clutch should always provide at least 50% engagement to maintain minimum airflow through the radiator core under all conditions

B. Yes — the viscous clutch disengages at low temperatures to reduce parasitic power consumption, noise, and overcooling. It progressively engages as the bimetallic spring senses rising air temperature at the radiator

C. No — a freely spinning fan indicates the silicone fluid inside the clutch has leaked out, and the clutch must be replaced before the engine is operated under load

D. Yes — all viscous fan clutches are designed to freewheel below 1,000 RPM and engage only when engine speed exceeds the engagement threshold

29. A technician replaces the fuel injectors on a common rail diesel engine. After programming the IQA (Injector Quantity Adjustment) trim codes for each new injector, the engine starts but runs roughly for the first 30 seconds before smoothing out. Is this behaviour expected?

A. No — the rough running indicates the trim codes were entered for the wrong cylinder positions and must be reprogrammed in the correct firing order sequence

B. No — the engine should idle perfectly after trim code programming and the rough start indicates a fuel supply issue unrelated to the injector replacement

C. Yes — the ECM requires a brief adaptive learning period to finetune delivery based on the new injectors' actual flow characteristics beyond what the trim codes provide

D. No — the rough running confirms one or more injector electrical connectors are not fully seated, producing an intermittent connection during the initial vibration at startup

30. A Tier 4 Final diesel engine equipped with an exhaust brake (variable geometry turbocharger exhaust brake function) produces a loud exhaust bark or pop when the operator rapidly releases the throttle during a downhill descent. What causes this noise?

A. The VGT vanes close rapidly when the exhaust brake activates, creating a sudden high backpressure event that compresses exhaust gas in the manifold — when a cylinder opens on the exhaust stroke, the pressurized gas escapes rapidly, producing the bark

B. The fuel injectors are dribbling a small amount of fuel during the deceleration event, and the fuel ignites in the hot exhaust manifold producing an afterfire

C. The turbocharger is surging — the sudden reduction in exhaust flow causes the compressor to stall momentarily, producing the characteristic bark noise

D. The DPF regeneration cycle is initiating during the deceleration event, and the elevated temperature in the DPF ignites accumulated soot in a rapid combustion burst

31. A technician is troubleshooting a wheel loader that drifts to the left during straight travel on a flat, level surface. The tires are all the same size, correctly inflated, and evenly worn. The steering system has been checked and is functioning correctly. What should be investigated next?

A. The operator seat is positioned offcentre, causing the operator to apply an unconscious slight steering input to the left during travel

B. The brake system — a partially applied or dragging brake on the right side creates a retarding force that pulls the machine to the left, away from the dragging side

C. The differential carrier is worn and is sending more torque to the left wheel, which pushes the machine toward the right and the operator corrects by steering left

D. The frame is bent from a previous impact, creating a permanent alignment offset that produces the leftward drift regardless of steering and brake condition

32. A mining truck's suspension strut has collapsed completely on the right front corner — the strut is fully compressed with no rebound. The nitrogen charge was checked and is at zero. What is the consequence of operating the truck with a collapsed strut?

A. The truck can operate normally at reduced speed because the hydraulic oil inside the strut provides adequate spring function without the nitrogen gas charge

B. The truck rides lower on the affected corner but the other three struts compensate and overall stability is not significantly affected during loaded travel

C. The collapsed strut improves traction on the right front corner by lowering the machine and increasing the vertical load on that tire during cornering

D. The right front corner cannot absorb impacts — every bump transmits directly to the frame, stressing the frame structure, affecting steering geometry, and creating an immediate rollover risk from the asymmetric ride height

33. An operator reports that the parking brake on a machine equipped with springapplied dry disc brakes releases normally but the machine rolls on a 10% grade when parked. The service brake holds the machine firmly. What is the most likely cause?

A. The parking brake control valve is not fully shifting to the park position, leaving residual hydraulic pressure that partially compresses the springs and reduces clamping force

B. The parking brake springs have fatigued from age and thermal cycling and cannot develop sufficient clamping force to hold the machine's weight on the grade

C. The parking brake disc friction surfaces are worn, oiled, or glazed — reducing the coefficient of friction below the level needed for the spring force to hold on the grade

D. The parking brake release circuit has a check valve leak that slowly bleeds hydraulic pressure to the springs after the engine is shut down, gradually releasing the brake

34. A technician is investigating premature tire wear on all four tires of an articulated dump truck. The wear pattern shows a smooth, even reduction in tread depth across the full face of every tire. No feathering, cupping, or edge wear is present. What is the most probable cause?

A. The tires are underinflated — running below specification increases the contact patch area and heat generation, producing uniform accelerated wear across the full tread face

B. The tires are slightly overinflated, crowning the tread centre and causing the centre to wear faster, but the question states wear is across the full face

C. The operator is driving at excessive speed — higher ground speed increases the scrub cycles per hour and accelerates even tread wear proportionally on all four tires

D. The machine's gross vehicle weight consistently exceeds the tire manufacturer's rated load capacity, compressing the tread into fullface contact and accelerating wear uniformly

35. A technician inspects the front idler on a crawler dozer and notices the tread has worn into an oval shape rather than maintaining its original round profile. The idler rotates freely with no bearing noise or roughness. What caused this wear pattern?

A. The front idler bearing has a flat spot on one roller element that holds the idler in one position during stops, causing the tread to wear at that contact point

B. The machine is routinely parked for extended periods with the track resting in one position — the track tension maintains a constant load on one spot of the idler, creating a flat wear area that progresses to an oval shape

C. The idler tread material hardness is below specification due to a manufacturing defect, and the soft material deforms under the track chain load into the oval profile

D. The track tension is set too tight, causing the idler tread to wear faster on the loaded contact arc than on the unloaded arc, producing the oval shape over time

36. An air brake equipped machine has been parked overnight in −25°C conditions. When the operator starts the machine and builds air pressure, the rear brakes do not release. The air gauge shows full system pressure. What is the most likely cause?

A. The spring brake chambers have frozen internally — moisture has entered the chamber and frozen the diaphragm to the housing, preventing air from compressing the spring

B. The brake lining material has contracted from the cold temperature and is locked against the drum by the friction of the cold contact surface

C. The air compressor unloader valve is frozen open, preventing the system from building sufficient pressure to release the rear spring brakes

D. Moisture in the air system has frozen in the brake lines or quickrelease valve serving the spring brake circuit, blocking air from reaching the spring brake chambers to compress the springs

37. A wheel loader is equipped with a ride control system that the operator activates during loaded travel. The operator reports the boom drops approximately 50 mm when ride control is activated while the bucket is loaded. Is this normal?

A. Yes — ride control connects the boom circuit to an accumulator, and the accumulator absorbs a small amount of oil from the boom cylinders during the initial equalization, allowing the boom to settle slightly before the system stabilizes

B. No — the boom should rise slightly when ride control is activated because the accumulator precharge adds hydraulic force to the boom circuit above the holding pressure

C. No — the boom should remain at exactly the same height when ride control is activated because the system is designed to maintain position while adding compliance

D. Yes — the boom drops because the ride control solenoid momentarily opens the boom lower circuit to bleed excess pressure before connecting the accumulator

38. A technician is adjusting the brakes on a machine with hydraulically actuated drum brakes. The service manual specifies a specific running clearance between the shoes and drum measured with a feeler gauge. If the clearance is set too tight, what is the consequence?

A. The shoes will drag on the drum during operation, generating heat that accelerates lining wear, increases fuel consumption, and may cause brake fade or drum damage

B. The tight clearance improves initial brake response and pedal feel — there is no negative consequence of setting the running clearance tighter than the OEM specification

C. The brake fluid reservoir will overflow because the tight clearance pushes the wheel cylinder pistons back into the cylinders, displacing fluid into the reservoir

D. The brake shoes will wear unevenly because the tight clearance loads one shoe against the drum while the other shoe remains free until pedal pressure is applied

39. A technician is inspecting the track on a compact track loader (rubber track). The rubber track shows cracks in the tread surface and the rubber has hardened noticeably. The track has 2,500 operating hours. What is the primary cause of this deterioration?

A. The track has been operated on abrasive surfaces that have worn through the tread compound, exposing the underlying rubber to degradation from environmental factors

B. The rubber compound has aged through UV exposure, ozone exposure, and heat cycling over the 2,500hour service life — the material has lost its elasticity and developed surface cracking consistent with agerelated degradation

C. The hydraulic oil from a leaking final drive motor has been spraying on the track surface, and the petroleumbased oil dissolves the rubber compound over time

D. The track tension has been set too tight for the entire service life, stretching the rubber matrix beyond its elastic limit and causing the surface to crack under the sustained strain

40. An articulated dump truck operator reports that the steering feels vague and requires more input than normal to maintain a straight line on haul roads. The steering system pressures test within specification. What mechanical cause should be investigated?

A. Worn steering cylinder rod end bearings and frame pivot bearings — excessive play at these mechanical connections allows the frames to shift before the cylinders can respond, producing the vague steering feel

B. The hydraulic oil viscosity has changed due to contamination and the thinner oil cannot maintain precise spool positioning inside the steering valve

C. The steering wheel column universal joint has excessive play that delays steering input transmission from the wheel to the orbital control unit

D. The hydraulic steering accumulator has lost its precharge, reducing the available flow rate for steering response during rapid corrections

41. A technician is measuring brake drum temperature with an infrared thermometer after a loaded downhill grade descent. The left rear drum reads 280°C while the right rear drum reads 190°C. Both brakes were applied equally by the operator during the descent. What does this temperature difference indicate?

A. The right side brake is less effective than the left — a mechanical fault (seized adjuster, contaminated lining, or broken shoe spring) is preventing the right brake from applying full force

B. The temperature difference is within the normal 100°C tolerance range for drum brakes during heavyduty downhill application and does not require investigation

C. The left side brake is dragging — the higher temperature indicates the left brake is partially applied even when the pedal is released, generating friction heat during travel

D. The left side brake is applying more force than the right, creating asymmetric braking — the left brake lining is likely worn to a thinner profile, which concentrates heat generation on the remaining contact area

42. A technician is performing a complete undercarriage inspection on a dozer and records all measurements on the OEM undercarriage wear chart. The inspection reveals that the track links, pins, and bushings are at 70% worn, but the sprocket teeth are at only 40% worn. What should be recommended?

A. The sprocket is within service limits and does not require replacement — it can remain in service and will likely reach its wear limit naturally as the chain continues to wear

B. Replace both the sprocket and the chain simultaneously — the sprocket must always be replaced at the same time as the chain to ensure correct mesh engagement

C. Replace the chain and turn the sprocket to the reverse side to present unworn tooth faces to the new chain, maximizing sprocket service life

D. Defer all undercarriage work until both the chain and sprocket reach 80% wear to minimize the number of undercarriage service events per machine lifecycle

43. A heavy equipment machine's air brake system includes a lowpressure warning device that activates at approximately 380 kPa (55 PSI). During a pretrip inspection, the technician intentionally drains air from the system to verify the warning activates. The buzzer does not sound at 380 kPa. What is the required action?

A. Adjust the lowpressure switch to activate at a lower threshold — the original 380 kPa setting may be too sensitive for this machine's normal operating pressure range

B. The machine must not be operated until the lowpressure warning device is repaired and confirmed functional — it is a critical safety system that alerts the operator of impending brake failure

C. Continue operating the machine and have the warning device repaired during the next scheduled service, provided the operator monitors the dashboard air pressure gauges manually

D. Replace the air pressure gauges with calibrated units — the inaccurate gauges are causing the warning switch to activate at the wrong indicated pressure

44. An oscillating rear axle on a motor grader allows the rear tandem to articulate over uneven terrain. During inspection, the technician discovers the oscillation pivot pin bushings are severely worn. What steering and grading symptom would this produce?

A. The machine cannot maintain a consistent blade grade during fine grading — the rear axle shifts laterally under the grading load, changing the blade's position relative to the cut surface

B. The machine's turning radius increases because the worn pivot allows the rear axle to resist the articulation force needed for tight turns

C. The rear tires wear only on the outer edges because the worn pivot allows the axle to tilt beyond the design angle during oscillation events

D. The grading accuracy is affected because the worn pivot allows the rear end to sway unpredictably, causing the blade angle and height to vary as the rear end shifts during travel between grading passes

45. A technician is replacing an inner tube on a large OTR tire mounted on a split rim. After deflating the tire and breaking the beads, the technician prepares to separate the rim components. What critical check must be performed before removing the lock ring?

A. Verify the tire is completely deflated and the valve core has been removed — any residual pressure trapped in the tire can eject the lock ring with lethal force during removal

B. Verify the rim base is not cracked by performing a visual inspection with a magnifying glass around all bolt holes and ring groove areas

C. Verify the lock ring orientation is marked before removal so it can be reinstalled in the identical position to maintain the original balance

D. Verify the tube manufacturer's serial number matches the tire manufacturer's compatibility list to confirm the replacement tube is the correct specification

46. A technician is checking the condition of a hydropneumatic steering accumulator on a large mining truck. With the engine off and the system depressurized, the technician connects a nitrogen charging kit to the gas valve. The gauge reads 0 bar. What does this mean?

A. The gas valve has failed and is not passing nitrogen to the gauge — the accumulator may still have its correct precharge trapped behind the failed valve

B. The accumulator bladder is intact but the nitrogen has slowly leaked past the gas valve seal over time and the accumulator requires recharging to specification

C. The accumulator bladder or diaphragm has ruptured — the nitrogen has entered the oil side and been absorbed into the hydraulic fluid, leaving no measurable gas precharge

D. The reading is normal for a depressurized system — the nitrogen precharge is only measurable when hydraulic system pressure is applied to compress the gas

47. A 24volt machine has a 100watt work light. Using Watt's Law ($P = V \times I$), what is the current draw of this light?

A. 2,400 amperes — calculated by multiplying the voltage by the wattage instead of dividing power by voltage

B. 0.24 amperes — calculated by dividing voltage by wattage (V ÷ W) instead of wattage by voltage (W ÷ V)

C. 4.17 amperes × 2 lights = 8.34 amperes total — the question asks for total circuit current draw including both parallel work lights

D. 4.17 amperes — calculated as P ÷ V = 100 ÷ 24 = 4.17 amperes current draw for the single work light circuit

48. A technician measures battery opencircuit voltage (OCV) on a 12V leadacid battery and reads 12.06 volts. The battery was disconnected from the machine and allowed to rest for 24 hours before the measurement. What state of charge does this voltage indicate?

A. Approximately 25% state of charge — a fully charged 12V leadacid battery reads 12.6–12.7V OCV and the voltage drops linearly to approximately 11.8V at full discharge, placing 12.06V at roughly 25%

B. Approximately 75% state of charge — the battery is nearly full and requires only a brief topup charge before returning to service

C. The battery is fully charged — 12.06V is within the acceptable range of a healthy, fully charged 12V battery that has rested for 24 hours

D. The battery is at 0% charge and is fully discharged — any reading below 12.4V on a 12V battery confirms complete depletion

49. A technician is diagnosing intermittent CAN bus communication errors on a machine with 12 modules. Disconnecting modules one at a time while monitoring bus health, the technician discovers that removing one specific module eliminates all communication errors. What can be concluded?

A. The disconnected module is the only module with an active fault code and its fault messages are overloading the bus bandwidth

B. The remaining 11 modules have identical firmware versions and the disconnected module has an outdated version that causes a protocol conflict

C. The disconnected module has a failing CAN bus transceiver that is corrupting the bus signal — the faulty driver chip is transmitting malformed data that disrupts communication for all other modules

D. The CAN bus wiring to that module is routed too close to a highcurrent circuit, and the electromagnetic interference from the adjacent wire is coupling into the bus through that module's connection

50. A machine operator reports that the voltmeter gauge on the dashboard shows 28.5 volts during normal operation but drops to 24.0 volts when the operator turns on the cab heater, work lights, and windshield wiper simultaneously. The alternator output is confirmed at 28.2V at the alternator terminal. What does this indicate?

A. The alternator is undersized for the machine's total electrical load and cannot maintain rated output when all accessories are operating simultaneously

B. Excessive voltage drop exists in the wiring between the alternator output and the dashboard gauge connection point — the 4.2V difference under load confirms high resistance in the main charging circuit

C. The dashboard voltmeter is faulty and does not accurately represent the actual system voltage under varying load conditions

D. The voltage drop is within the normal range for a heavy equipment machine during maximum electrical load operation

51. A heavy equipment machine is equipped with a 24V charging system using two 12V batteries in series. The technician measures 14.2V across battery A (nearest the alternator positive cable) and 13.8V across battery B. Both batteries are the same age and specification. What is the most likely cause of the 0.4V charging imbalance?

A. The alternator voltage regulator is functioning correctly — it maintains 28.0V total across the series bank, but individual battery charging rates vary naturally based on internal resistance

B. Battery B has a higher internal resistance than battery A, which causes it to receive a lower share of the charging current in the series configuration

C. The alternator field winding has a partial short that reduces the total output by 0.4V, and the deficit appears across the battery furthest from the alternator

D. The batterytobattery series cable between battery A and battery B has a highresistance connection that drops 0.4V under charging current

52. A technician is testing an ECMcontrolled groundside switched circuit for a solenoid. With the solenoid commanded off, the technician measures 0.0V at the ECMcontrolled pin (relative to chassis ground). When the solenoid is commanded on, the voltage at the same pin reads 0.3V. What is the correct interpretation?

A. The ECM driver is functioning correctly — when the driver is on (grounding), the pin should read near 0V. The 0.3V represents the normal voltage drop across the active driver transistor under current flow

B. The ECM driver has a highresistance fault — the 0.3V reading when commanded on indicates the driver cannot pull the pin fully to ground

C. The readings are reversed — 0.0V when off and 0.3V when on indicates the ECM is applying voltage rather than ground, confirming incorrect driver polarity

D. The solenoid coil has an internal short that is pulling the driver voltage down to 0.3V when the command is active, which will eventually destroy the ECM driver transistor

53. A machine's electrical system has a parasitic draw of 350 milliamps measured at the battery with all systems shut down and modules in sleep mode. The OEM specification maximum is 50 milliamps. The technician needs to isolate which circuit is causing the excessive draw. What is the correct procedure?

A. Replace the batteries — excessive parasitic draw is most commonly caused by an internal battery defect that creates a selfdischarge current path between cells

B. Disconnect each module connector one at a time and observe the ammeter — the draw should decrease when the faulty circuit is interrupted by the disconnection

C. Remove fuses one at a time from the fuse panel while monitoring the ammeter — when the excessive draw drops significantly, the circuit protected by that fuse contains the fault

D. Measure voltage at each fuse with the circuit loaded and identify the fuse with the lowest voltage — the circuit drawing the most current produces the greatest voltage drop at the fuse

54. A technician is testing the signal from a magnetically inductive crankshaft position sensor using an oscilloscope. The waveform shows a sinusoidal AC signal that increases in both amplitude and frequency as engine RPM increases. Is this the expected output characteristic for this sensor type?

A. No — a magnetic inductive sensor should produce a constantamplitude square wave at all speeds, and the variable amplitude indicates a sensor fault

B. No — the amplitude should remain constant while only the frequency increases with RPM, because the sensor's permanent magnet strength does not change with speed

C. Yes — but only the frequency should increase with RPM; increasing amplitude indicates the sensor air gap is too small and the sensor is at risk of contacting the reluctor

D. Yes — a magnetically inductive sensor generates an AC signal whose amplitude increases with the speed of the reluctor teeth passing the sensor, and whose frequency is directly proportional to RPM

55. A heavy equipment machine's wiring harness includes a connector where five wires enter a sealed housing. During inspection, the technician finds the secondary lock (TPA — Terminal Position Assurance) is missing from the connector. What risk does this create?

A. The terminals will corrode faster without the TPA because the secondary lock provides an additional moisture barrier at the connector face

B. Individual terminal crimps may back out of the connector housing under vibration — the TPA is the secondary retention device that prevents terminal pushback after the primary latch is engaged

C. The connector cannot be mated to its counterpart without the TPA in place because the TPA aligns the two halves during the mating process

D. The missing TPA allows the connector housing to rotate on the wire bundle, twisting the wires and eventually breaking them at the crimp connections

56. A machine is equipped with a keyless start system that requires the operator to enter a PIN code before the engine can be started. The operator has forgotten the PIN. What is the correct procedure to regain access?

A. The PIN can be reset through the OEM dealer or fleet management portal using the machine's unique serial number and ownership verification — this is a security feature that prevents unauthorized reset

B. Disconnect the battery for 30 minutes to reset the ECM's memory, which clears the PIN and allows the engine to start without entering a code

C. Enter the default factory PIN printed on a sticker inside the engine compartment fuse box, which overrides the custom PIN set by the fleet manager

D. Jump the starter relay directly from the battery to bypass the keyless start module — the PIN system only controls the relay circuit and is easily bypassed

57. A technician measures the resistance of a temperature sensor and obtains readings at two different temperatures: 2,500 ohms at 25°C and 300 ohms at 90°C. Based on these values, what type of sensor is this?

A. A PTC (Positive Temperature Coefficient) thermistor — resistance increases with temperature, which matches the higher reading at the higher temperature

B. A resistive temperature detector (RTD) made of platinum wire — RTDs show large resistance swings between room temperature and operating temperature

C. A voltagegenerating thermocouple — thermocouples produce varying resistance based on the temperature difference between the measuring junction and the reference junction

D. An NTC (Negative Temperature Coefficient) thermistor — resistance decreases as temperature increases, which matches the drop from 2,500 ohms at 25°C to 300 ohms at 90°C

58. A machine has four identical headlights, each drawing 5 amperes, connected in parallel on a 24V circuit. The fuse protecting the circuit is rated at 15 amperes. What happens when all four lights are turned on?

A. The circuit operates normally because the total parallel current (20A) is divided among the four branches and each branch draws only 5A, which is below the fuse rating

B. Only three lights illuminate and the fourth remains off because the fuse limits the total circuit current to its 15A rating, providing power for three lights only

C. The fuse blows immediately — the total current draw of 20 amperes (4 × 5A in parallel) exceeds the 15ampere fuse rating and the fuse opens to protect the wiring

D. The lights dim proportionally because the available 15 amperes is shared among four lights, and each receives only 3.75 amperes instead of its rated 5 amperes

59. A technician is replacing a wheel speed sensor on an ABSequipped heavy equipment machine. The new sensor is the correct OEM part number. After installation, the ABS warning light remains illuminated. What should be checked first?

A. Verify the sensor air gap — the distance between the sensor tip and the reluctor teeth must be within the OEM specification, as an incorrect gap produces an unreadable signal that the ABS module interprets as a fault

B. The sensor air gap to the reluctor wheel — if the gap is too wide or too narrow, the sensor produces a signal outside the ABS module's acceptable range, triggering the warning light

C. The reluctor wheel teeth for damage or debris — a damaged or contaminated reluctor produces an erratic signal that the ABS module cannot process correctly

D. The ABS module's software version — a firmware mismatch between the new sensor and the ABS module can prevent the module from recognizing the replacement sensor

60. A technician needs to measure the voltage drop across a highcurrent connector on the main alternator output cable. The engine is running and the electrical system is under load. What is the correct procedure?

A. Place one DMM lead on the alternator side of the connector and the other lead on the battery side of the same connector while the circuit is live and under load — the reading shows the voltage lost across the connector

B. Disconnect the connector, measure the resistance across the mating surfaces, and multiply by the circuit current to calculate the voltage drop mathematically

C. Connect the DMM across the battery terminals and compare the reading to the alternator output — the difference is the total voltage drop including all connectors and wiring

D. Disconnect the alternator output cable and measure the connector pintosocket resistance with the circuit deenergized — any measurable resistance confirms a faulty connector

61. A machine's operator display screen shows a "No Communication" error for the transmission control module (TCM). All other modules on the CAN bus are communicating normally. What is the most likely cause?

A. The entire CAN bus has a termination resistor fault that is disrupting only the TCM's communication while all other modules continue to function with degraded signal quality

B. The CAN bus backbone cable has a break between the TCM connection and the rest of the network, isolating the TCM from the bus while all other modules remain connected

C. The TCM has lost communication because it has been powered down by a blown fuse, a disconnected connector, or a failed power supply circuit — a module without power cannot communicate on the bus

D. The operator display has a corrupted address table that prevents it from recognizing the TCM's messages, even though the TCM is transmitting normally on the bus

62. A technician is testing a fuel level sender unit. With the tank full, the sender resistance should read 33 ohms. With the tank empty, it should read 240 ohms. The technician measures 240 ohms with the tank half full. What does this indicate?

A. The sender unit's float is stuck at the bottom of its travel, causing the sender to output the emptytank resistance value regardless of actual fuel level

B. The sender unit is functioning correctly — 240 ohms at half full is the expected midpoint reading for a sender with a 33–240 ohm range

C. The fuel gauge on the dashboard is faulty and is not responding to the sender's correct signal proportional to the halffull tank level

D. The wiring between the sender and the gauge has a highresistance connection that adds resistance to the circuit, offsetting the reading toward the high end

63. A technician needs to verify that an ECM is receiving a correct 5V reference voltage. The measurement shows 4.8V at the ECM connector with the sensor connected. The technician disconnects the sensor and the reference voltage rises to 5.0V. What does this indicate?

A. The ECM's internal reference regulator is faulty and cannot maintain 5V under the minimal load of a single sensor connection

B. The sensor is defective and is drawing excessive current that overloads the 5V reference, pulling it down by 0.2V

C. The 0.2V drop is normal — a sensor connected to the reference circuit draws current that produces a small voltage drop in the reference supply wiring

D. The sensor's signal wire is shorted to the reference wire inside the sensor, creating a parallel load that reduces the reference voltage below specification

64. A machine's electronic throttle position sensor uses a dualtrack potentiometer — two separate wiper tracks that produce signals that the ECM crossreferences for validity. If one track produces a signal that disagrees with the other by more than a calibrated threshold, what does the ECM do?

A. The ECM disables the throttle response and defaults to a fixed idle speed or reduced power mode — the dualsignal disagreement triggers a protection strategy that limits engine output until the sensor is replaced

B. The ECM averages the two signals and uses the midpoint value, which provides an approximate throttle position that allows continued normal operation

C. The ECM selects whichever signal is higher and uses it exclusively, ensuring the operator always has access to full throttle range regardless of sensor condition

D. The ECM alternates between the two signals at a high frequency, using each track for alternate combustion cycles to distribute the error across all cylinders

65. A machine's electrical system has a diode installed in the circuit between the ignition switch and the starter relay coil. The diode allows current to flow from the switch to the relay but blocks current flow in the reverse direction. What is the purpose of this diode?

A. It prevents the voltage spike from the relay coil deenergization from feeding back through the ignition switch to the dashboard electronics

B. It limits the current flowing through the starter relay coil to prevent the coil from overheating during extended cranking attempts

C. It prevents current from the alternator charging circuit from backfeeding through the starter relay and reenergizing the starter after the engine starts

D. It reduces the voltage drop between the ignition switch and the relay coil by providing a lowerresistance path than the switch contact alone

66. A technician is diagnosing an intermittent electrical fault on a machine working in a coastal environment with salt spray exposure. Multiple circuits experience occasional faults that clear after the machine is returned to the shop. What is the most likely common cause?

A. The salt air is increasing the conductivity of the air gap between battery terminals, allowing voltage to arc across the gap during humid conditions

B. Salt spray corrosion on exposed connector pins, ground studs, and terminal surfaces creates intermittent highresistance connections that worsen in humid conditions and temporarily improve when the machine enters the dry shop environment

C. The salt spray is degrading the wire insulation on all harnesses simultaneously, creating multiple short circuits that selfheal as the salt dries in the shop

D. The machine's alternator is producing inconsistent output due to salt corrosion on the voltage regulator sensing terminal, causing voltage fluctuations that affect all circuits

67. A technician replaces a failed ECM on a machine. The new ECM has been programmed with the correct machine calibration, all parameter settings verified, and injector trim codes entered. The engine starts but runs roughly and produces more smoke than normal. What was likely missed during the programming?

A. The new ECM requires a sensor calibration procedure where the ECM learns the actual installed position and offset of each sensor before adaptive corrections can begin — without this initialization, the base fuel maps produce incorrect fuel delivery

B. The ECM software version must exactly match the previous ECM's version number — even a minor revision difference produces incompatible fuel delivery maps

C. The new ECM's internal clock must be synchronized with the machine's telematics module before the injection timing maps activate correctly

D. The injector trim codes were entered but the individual cylinder timing offsets from the previous ECM were not transferred — timing offsets are stored separately from trim codes

68. A technician measures the insulation resistance between a HV motor's windings and the motor frame using a 500V megohmmeter. The reading is 5 megohms. The OEM minimum specification for this motor is 1 megohm per volt of operating voltage. The motor operates at 650 VDC. What is the test result?

A. Pass — the minimum required insulation resistance is 650 megohms, but that applies only to new motors; used motors require only 10% of the new specification

B. Pass — the 5 megohm reading exceeds the 1 megohm minimum calculated by dividing the operating voltage by the test voltage (650 ÷ 500 = 1.3 MΩ)

C. Fail — the minimum required insulation resistance is 650 megohms (650V × 1 MΩ/V) and the measured 5 megohms is far below this threshold

D. Fail — the minimum required insulation resistance is 650 megohms (1 MΩ per volt × 650V = 650 MΩ); the motor's 5 MΩ reading indicates severely degraded insulation that presents a ground fault hazard

69. A machine's CAN bus is operating normally but the technician notices one module is transmitting messages at a much higher rate than all others — flooding the bus with lowpriority data. What effect does this have on the network?

A. No effect — the CAN bus priority arbitration system ensures highpriority messages always transmit first regardless of how many lowpriority messages are queued

B. The flooding module's messages are automatically discarded by the other modules and do not affect bus performance in any measurable way

C. The excessive lowpriority traffic can delay higherpriority messages from other modules by consuming bus bandwidth, potentially causing visible symptoms like sluggish control response or display update delays

D. The gateway module detects the flooding and disconnects the offending module from the bus automatically through a builtin traffic management function

70. A technician is replacing a battery temperature sensor on a 24V system. The sensor is mounted on the battery case and provides a temperature signal to the voltage regulator for temperaturecompensated charging. If the sensor fails in a state that reads permanently cold, what is the consequence?

A. The voltage regulator will reduce charging voltage below the normal range, causing the battery to gradually undercharge and reducing its capacity over time

B. The voltage regulator will increase charging voltage above normal — in cold conditions, higher voltage is needed to overcome the battery's increased internal resistance, so a permanently cold reading causes continuous overcharging at normal operating temperatures

C. The voltage regulator defaults to a fixed 28.0V output when the temperature sensor fails, which is the correct charging voltage for moderate conditions

D. The battery management system disconnects the alternator from the battery automatically when a sensor fault is detected, preventing any charging until the sensor is replaced

71. A machine has two identical ECMs — one for the engine and one for the transmission — that share data over the CAN bus. The engine ECM receives a software update but the transmission ECM does not. After the update, the transmission occasionally shifts at incorrect points. What is the most likely cause?

A. The engine ECM update changed the format or content of the data messages it broadcasts on the CAN bus — the transmission ECM interprets the changed data using its previous calibration, causing shift point errors

B. The software update overwrote the engine ECM's CAN bus address, and it is now transmitting on the transmission ECM's address, causing data conflicts

C. The update increased the engine's maximum RPM, and the transmission ECM's shift points were calibrated for the previous lower RPM limit

D. The update changed the engine ECM's message priority level, and the transmission ECM's messages are now being delayed by the higherpriority engine messages

72. A technician is performing a torque converter stall test. The engine reaches the specified stall speed and the technician holds the stall for the OEMrecommended maximum of 10 seconds. What is the primary reason for the strict time limit?

A. At stall, 100% of the engine's power output is converted to heat in the transmission oil through the torque converter — the oil temperature can rise by 1°C per second or more, and exceeding the time limit risks thermal damage to the converter, seals, and oil

B. The engine fuel system cannot sustain maximum fuel delivery for more than 10 seconds without overheating the injectors and damaging the nozzle seat surfaces

C. The torque converter lockup clutch is partially engaged during a stall test and will overheat if held for more than 10 seconds under full engine torque output

D. The transmission pump generates maximum pressure during a stall test and the hydraulic circuit components are only rated for 10 seconds of continuous maximum pressure exposure

73. A machine's powershift transmission uses a modulated clutch engagement strategy that applies the clutch in three stages: fill, modulation, and lockup. What is the purpose of the modulation stage?

A. The modulation stage rapidly increases clutch pressure to maximum to minimize the total shift time and reduce the energy wasted as heat during the engagement event

B. The modulation stage holds clutch pressure at a reduced level while checking the clutch pack for correct fill volume before proceeding to the full engagement pressure

C. The modulation stage gradually increases clutch apply pressure to control the rate of speed change, producing a smooth shift by preventing abrupt torque transfer to the drivetrain

D. The modulation stage applies and releases the clutch rapidly in a pulsing pattern that allows the clutch pack to cool between microengagements, preventing thermal damage

74. A technician is diagnosing a machine that has lost all forward and reverse drive through the automatic transmission. The engine runs normally, all dashboard indicators are functioning, and the operator can select gear ranges on the shift console without error. What should be checked first?

A. The transmission oil level — if the level has dropped below the pump inlet, the pump cannot generate pressure to apply any clutch pack, resulting in complete loss of drive

B. The transmission oil level and condition — a severely low oil level means the pump is drawing air, and no clutch pack can be applied without hydraulic pressure, producing the complete loss of drive in all ranges

C. The torque converter — a failed turbine hub spline connection between the converter turbine and the transmission input shaft disconnects the engine from the transmission mechanically

D. The transmission ECM — a complete electronic failure prevents all shift solenoids from being commanded, resulting in no clutch engagement in any gear range

75. A driveshaft on a heavy equipment machine produces a vibration that is felt at one specific travel speed but disappears at speeds above and below that point. What phenomenon does this describe?

A. Ujoint wear — worn Ujoints produce vibration that peaks at one specific speed where the worn bearing caps resonate with the vehicle's natural frequency

B. Driveshaft imbalance — a missing balance weight produces a vibration that increases linearly with speed and does not disappear at higher speeds

C. Phasing error — an outofphase driveshaft produces a vibration at all speeds above a threshold and does not diminish at any particular speed

D. The driveshaft is operating near its critical speed — the resonant frequency of the shaft matches the rotational speed at that specific travel speed, amplifying vibration that diminishes as the speed moves away from resonance

76. A technician is rebuilding a differential and needs to set the correct backlash between the ring gear and pinion. The OEM specification is 0.20–0.30 mm. Why is backlash important?

A. Backlash provides the necessary clearance for thermal expansion of the gears at operating temperature, prevents the teeth from binding, and allows an adequate lubricant film to form between the meshing gear tooth surfaces

B. Backlash controls the noise level of the gear set — tighter backlash produces quieter operation while wider backlash increases gear whine proportionally

C. Backlash determines the gear set's torque multiplication ratio — changing backlash changes the effective tooth engagement depth and therefore the mechanical advantage

D. Backlash is a manufacturing tolerance that has no functional significance — it exists solely as a quality check to verify the gear set was machined within specification

77. A machine's transmission uses a oneway clutch (sprag clutch) in the torque path for a specific gear range. The oneway clutch locks in one rotational direction and freewheels in the other. What symptom occurs if the oneway clutch fails and freewheels in both directions?

A. The transmission cannot downshift into the gear range served by the failed clutch because the oneway clutch provides the holding force that prevents the downshift from occurring

B. The engine overspeeds when the operator decelerates in the affected gear because the oneway clutch was preventing engine braking and the failed clutch now allows the drivetrain to drive the engine

C. The affected gear range has no drive capability — the oneway clutch was providing the reaction member holding force, and without it the planetary set freewheels and cannot transmit torque

D. The transmission produces a grinding noise in the affected gear because the sprag elements are tumbling inside the housing and contacting the inner and outer races randomly

78. A machine equipped with a hydraulic retarder shows reduced retarding effectiveness during a loaded descent. The transmission oil temperature is elevated but below the maximum alarm threshold. What is the most likely cause?

A. The retarder proportional control solenoid is partially stuck and is not opening fully to direct maximum flow to the retarder housing when commanded

B. The retarder rotor blades have eroded from cavitation and can no longer generate the designed fluid resistance at the commanded engagement level

C. The elevated oil temperature has reduced the fluid viscosity, which decreases the retarder's ability to resist rotor rotation and therefore reduces its braking effectiveness

D. The transmission oil temperature has reduced the oil viscosity, which reduces the fluid's shearing resistance in the retarder housing and therefore reduces the retarding force generated at any given rotor speed

79. A technician is adjusting a clutch on a machine with a manual transmission. The clutch engages at the very bottom of the pedal travel — almost at the floor — before the pedal is released more than a few millimetres. What does this indicate?

A. The clutch master cylinder pushrod is too short, reducing the total hydraulic displacement available for clutch release and limiting the engagement range

B. The clutch disc friction material is worn thin — the release bearing must travel further to reach the pressure plate fingers because the reduced disc thickness has moved the engagement point toward the end of the pedal stroke

C. The clutch hydraulic system has air in the circuit, which is absorbing pedal travel before the hydraulic fluid can build pressure to actuate the release bearing

D. The pressure plate diaphragm spring has weakened and is applying insufficient clamping force, causing the clutch to engage only when the release bearing is nearly fully retracted

80. A technician performs a final drive oil change on a crawler excavator and notices the drained oil has a metallic silver sheen with visible fine metal flakes. The oil also has a slightly burnt odour. What does this indicate?

A. The planetary gear teeth or bearing surfaces inside the final drive are experiencing abnormal wear — the metallic content and burnt oil indicate elevated operating temperature and accelerated metal removal from internal components

B. The metallic sheen is normal for final drive oil at the end of its service interval — the heavy gear loading produces a baseline level of metallic content that is removed during each oil change

C. The magnetic drain plug has reached its capacity and is releasing previously captured particles back into the oil, producing the visible metallic appearance during draining

D. The drain plug was not properly installed at the previous service and has allowed external contamination to enter the final drive housing over the service interval

81. A technician is diagnosing a powershift transmission that shifts from 1st to 2nd gear normally but will not shift from 2nd to 3rd. All other upshifts and downshifts function correctly. What is the most probable cause?

A. The main transmission pump pressure is low, preventing the 3rd gear clutch from receiving adequate apply pressure — but this would affect all gear ranges, not just one

B. The governor pressure signal is incorrect, preventing the valve body from commanding the 23 shift — but governor faults affect all shift points, not a single shift

C. The torque converter stator clutch is slipping, reducing the torque input to the transmission and preventing the 23 shift — but this would affect acceleration in all gears

D. The 3rd gear shift solenoid, the 3rd gear clutch apply circuit, or the 3rd gear clutch pack itself has a fault — the isolated 23 shift failure points to a component specific to the 3rd gear engagement circuit

82. A machine's differential is equipped with a limited slip device that uses a clutch pack to transfer torque to the slowerturning wheel. The operator reports that the machine has difficulty maintaining traction in muddy conditions, even with the limited slip engaged. What is the most likely cause?

A. The limited slip clutch discs have a higher friction coefficient when wet, which causes them to lock the differential completely and prevent any speed differential between the wheels

B. The limited slip clutch pack has worn and can no longer generate sufficient friction force to transfer meaningful torque to the slower wheel — the differential behaves more like a standard open differential

C. The limited slip unit requires the operator to manually lock it before entering muddy conditions — it does not engage automatically and the operator may not have activated it

D. The limited slip mechanism is designed for dry, hightraction conditions only and is not effective in lowtraction environments such as mud, where a full locking differential is required

83. A technician is replacing a pilot bearing in a flywheel on a machine with a manual transmission. The old bearing shows heat discoloration and the grease has dried completely. What operating condition caused this premature failure?

A. The engine was operated at excessive RPM for extended periods, spinning the bearing at speeds above its rated capacity and generating friction heat that dried the lubricant

B. The clutch disc was the wrong thickness, positioning the input shaft too far into or too far out of the pilot bore and creating an axial load on the bearing it was not designed to carry

C. The operator habitually rests their foot on the clutch pedal during operation, partially disengaging the clutch and causing the input shaft to rotate at a different speed than the flywheel, spinning the pilot bearing continuously under load

D. The flywheel bore is slightly oversized, allowing the pilot bearing outer race to creep (rotate) in the bore under the input shaft load, generating friction heat between the race and the bore

84. A machine uses a planetary hub reduction final drive at each wheel. The primary advantage of planetary hub reduction is that it multiplies torque at the wheel without requiring a larger differential or axle shaft. Where in the drivetrain does this torque multiplication take place?

A. Inside the wheel hub — the planetary gear set is located between the axle shaft and the wheel, so the axle shaft carries only the prereduction torque while the full output torque is generated at the hub and transmitted directly to the wheel

B. Inside the differential carrier — the planetary gear set is part of the differential assembly and multiplies torque before it reaches the axle shafts

C. At the transmission output — the planetary reduction is the final gear stage inside the transmission housing before the driveshaft

D. At the driveshaft centre support bearing — the planetary gear set is located at the midpoint of the driveshaft assembly to reduce the torque loading on the rear driveshaft section

85. A technician is replacing a ring and pinion gear set in a differential. The new gear set comes with a specific pinion depth shim included in the box, based on factory measurements of that individual gear set. What is the purpose of this matched shim?

A. The shim adjusts the pinion bearing preload to the correct value for the specific gear set's tooth profile and expected operating load

B. The shim positions the pinion gear at the correct depth relative to the ring gear centreline, establishing the designed tooth contact pattern for that specific gear set

C. The shim compensates for manufacturing tolerances in the carrier housing bore depth, ensuring the gear set mounts correctly in any carrier

D. The shim is a spacer that positions the pinion seal at the correct depth relative to the yoke to prevent oil leakage at the pinion flange

86. A technician is inspecting the universal joint on a driveshaft and discovers that one bearing cap rotates smoothly while the opposite cap has a notchy, rough feel during rotation. What does this indicate?

A. The notchy bearing cap is contaminated with debris that entered through a failed seal and is interfering with the needle bearing rotation

B. The smooth cap has lost its needle bearings and is running on the hardened cross surface, which feels smooth despite being a catastrophic failure condition

C. The rough, notchy feel indicates the needle bearings in that cap have developed flat spots (brinelling) from impact loading, vibration, or moisture corrosion — the Ujoint requires replacement

D. The rough feel indicates the needle bearings in that cap have developed flat spots (brinelling) or corrosion pitting — the Ujoint must be replaced because needle bearing damage in any single cap compromises the entire joint

87. A machine has an axle disconnect system that allows the operator to disengage the front drive axle for highway travel. What is the primary benefit of disconnecting the front axle during highway travel?

A. Disconnecting the front axle reduces the turning radius of the machine by eliminating the resistance of the front drive components during steering inputs

B. Disconnecting the front axle eliminates the parasitic energy consumption of driving the front differential, driveshaft, and hub gears, reducing fuel consumption and component wear during highspeed travel

C. Disconnecting the front axle improves the machine's highway braking performance by reducing the rotating mass that the brakes must decelerate during stopping events

D. Disconnecting the front axle reduces tire wear on the front tires by eliminating the drive torque that accelerates tread wear during highspeed travel on paved roads

88. A powershift transmission's torque converter is equipped with a lockup clutch. The TCM commands lockup in 3rd and 4th gear above a minimum speed threshold. The operator reports a noticeable shudder when the lockup clutch engages in 3rd gear at the minimum engagement speed. What is the most likely cause?

A. The lockup clutch hydraulic apply circuit has a restriction that delays full engagement pressure, causing the clutch to slip momentarily before locking fully

B. The lockup clutch friction material is worn or contaminated, reducing its friction coefficient and causing it to shudder during the transition from slipping to locked engagement

C. The torque converter has internal damage to the stator oneway clutch that produces the shudder vibration only at the specific speed where lockup occurs

D. The engine firing frequency at the lockup engagement speed matches the drivetrain's natural torsional resonance, producing a vibration that feels like a clutch shudder

89. A heavy equipment A/C system uses an orifice tube instead of a thermostatic expansion valve (TXV) as its metering device. What is the functional difference between these two metering devices?

A. An orifice tube is a fixed restriction with no moving parts — it does not modulate refrigerant flow based on evaporator conditions, unlike a TXV which actively adjusts its opening to maintain a target superheat at the evaporator outlet

B. An orifice tube provides variable refrigerant metering identical to a TXV but uses a simpler mechanical design that is less expensive to manufacture

C. An orifice tube is installed on the highpressure side of the system while a TXV is installed on the lowpressure side — the location is the primary functional difference

D. An orifice tube meters liquid refrigerant while a TXV meters vapour refrigerant — each device handles a different phase of the refrigerant at the metering point

90. A technician is checking A/C system performance on a heavy equipment machine. The ambient temperature is 35°C. With the A/C set to maximum cooling, the engine at rated RPM, and the blower on high, the centre dash vent temperature stabilizes at 22°C. The OEM specification states the vent temperature must not exceed 12°C at maximum cooling under these standard test conditions. Is this system performing correctly?

A. Yes — 22°C is a comfortable cab temperature and the system is meeting the operator's comfort requirement regardless of the specification

B. Yes — the 13°C differential between ambient and vent temperature confirms adequate cooling performance within normal operating limits

C. No — the reading is only 3°C above specification and falls within the normal measurement tolerance for field testing with a standard thermometer

D. No — the vent temperature of 22°C exceeds the OEM maximum specification of 12°C by 10°C, confirming the system is significantly underperforming and requires diagnosis of the refrigerant charge, airflow, or component condition

91. A machine's cab ventilation system draws fresh air through an intake mounted on the cab roof. The intake is equipped with a primary particulate filter and a secondary activated carbon filter. Under what operating condition should the operator switch the HVAC from fresh air mode to recirculation mode?

A. When operating in dusty conditions that are overwhelming the particulate filter faster than the service interval allows, recirculation prevents overloading the filter

B. When operating near a fire or chemical spill where the activated carbon filter cannot adequately remove the toxic contaminants from the incoming air

C. When the outside air contains a hazardous concentration of gases or vapours that exceed the filtration system's capacity — recirculation prevents contaminated air from entering the cab through the fresh air intake

D. The operator should never switch to recirculation mode because it causes the cab to depressurize, allowing contaminated air to infiltrate through the door and window seals

92. A technician has recovered the refrigerant from an A/C system and is preparing to replace the compressor. The old compressor seized internally. What additional service is required beyond compressor replacement?

A. Only the receiverdrier or accumulator needs replacement — the desiccant must be fresh for the new compressor and the seized compressor may have released debris into the drier

B. The entire system must be flushed to remove metallic debris and contaminated oil from the seized compressor before installing the new unit — the debris will destroy the new compressor if recirculated

C. No additional service is required — the new compressor includes a fresh oil charge and the system filter will capture any debris from the old compressor during normal operation

D. Only the expansion valve requires replacement because the debris from the seized compressor will have clogged the small orifice opening and restricted refrigerant flow

93. A technician is diagnosing an A/C system with low cooling performance. The manifold gauges show highside pressure is highnormal and lowside pressure is also higher than normal. The condenser is clean and the fan is operating. What is the most likely cause?

A. The expansion valve or orifice tube is stuck open or oversized — too much refrigerant is flowing through the evaporator, and the evaporator cannot fully vaporize the excess charge, producing the elevated lowside pressure while the high side remains near normal

B. The system is overcharged with refrigerant, producing elevated pressures on both the high and low sides of the circuit simultaneously

C. The compressor has failed internally and is not compressing the refrigerant adequately, causing both the high and low sides to equalize

D. The condenser fan is running in reverse, blowing air away from the condenser rather than through it, reducing heat rejection and elevating the highside pressure

94. An operator complains that the cab heater works well at engine operating temperature but the windshield defroster cannot clear fog from the inside of the windshield. The heater temperature and blower speed are at maximum. What is the most likely cause?

A. The heater core is partially restricted and cannot deliver sufficient heat to the defroster ducts at the high airflow volume required for windshield clearing

B. The windshield has a damaged antifog coating on its interior surface that promotes condensation formation regardless of defroster performance

C. The HVAC mode door (or vent selector) is not directing airflow to the defroster outlets — the door actuator may be failed, disconnected, or the mode control may not be selecting the correct position

D. The recirculation door is stuck in the fresh air position, and the cold outside air is cooling the defroster duct air before it reaches the windshield surface

95. A technician recovers refrigerant from an A/C system and measures the recovered quantity. The system specification calls for 1,800 grams of R134a. The recovered amount is 950 grams. What does this confirm?

A. The compressor has lost efficiency and is not circulating the full charge — the missing refrigerant is stagnant in the condenser and could not be recovered

B. The recovery machine did not capture the full charge — the remaining 850 grams is still in the system in liquid form trapped in the evaporator and hoses

C. The system was previously serviced by another technician who undercharged it to the 950gram level, which explains the low cooling performance complaint

D. The system has lost approximately 850 grams of refrigerant through a leak — the leak must be located and repaired before the system is recharged

96. A machine's cab pressurization fan draws fresh air through the HVAC filter and into the cab to maintain positive pressure. The technician notices the pressurization fan is running but can feel ambient air being drawn into the cab through the door seal gaps when the door is closed. What does this indicate?

A. The cab pressurization fan is running in reverse — a wiring error or a failed motor has the fan pulling air out of the cab instead of pushing it in, creating negative cab pressure

B. The cab door seal is damaged and needs replacement — the fan is creating positive pressure but the seal gap is too large for the fan to overcome

C. The pressurization system is functioning correctly — a small amount of air movement at the door seals is normal and indicates the pressure differential is within specification

D. The HVAC recirculation door is stuck open, shortcircuiting the pressurization fan's output back through the recirculation path instead of pressurizing the cab

97. A dieselfired auxiliary heater on a coldweather machine consumes approximately 0.5 litres of diesel fuel per hour. The heater has been running continuously for 10 hours during an overnight cold soak. What operational consideration must the technician be aware of?

A. The 5 litres of fuel consumed by the heater may have reduced the machine's fuel level below the minimum operating threshold, risking fuel system air ingestion when the engine is started

B. The heater has consumed 5 litres of fuel and this must be accounted for in the machine's fuel records — the heater draws from the main fuel tank and extended operation can reduce the fuel level enough to trigger a low fuel warning on engine start

C. The heater's combustion chamber requires inspection after 10 continuous hours of operation because carbon deposits accumulate faster during sustained coldweather operation

D. The heater's glow plug must be replaced after 10 continuous hours because the sustained energization accelerates the heating element's degradation beyond its rated duty cycle

98. A fixeddisplacement hydraulic pump delivers 80 L/min at 1,500 RPM. What is the pump's displacement per revolution?

A. 120,000 cm^3/rev — calculated by multiplying flow rate by RPM instead of dividing

B. 18.75 cm^3/rev — calculated by dividing RPM by flow rate (1,500 ÷ 80) instead of the correct formula

C. 53.3 cm^3/rev — calculated as (80 L/min ÷ 1,500 RPM) × 1,000 = 0.0533 L/rev × 1,000 = 53.3 cm^3/rev

D. 80 cm^3/rev — assuming displacement equals the flow rate numerically without applying the RPM conversion

99. A hydraulic system's return line filter has a differential pressure indicator that pops out when the filter element's restriction exceeds a preset level. The technician notices the indicator is popped. The machine is operating normally. What should be done?

A. Nothing — the indicator may have popped during a cold start when oil viscosity was high, and the filter is likely not clogged under normal operating temperature conditions

B. Continue operating and check the indicator again at the next service — a single pop may be a transient event from a cold start or a brief highflow demand

C. Increase the system operating temperature by running the machine at full load for 30 minutes to thin the oil and reduce the restriction across the filter element

D. Replace the filter element immediately — the indicator confirms the element has reached its dirtholding capacity and oil is now flowing through the bypass valve unfiltered

100. A hydraulic cylinder extends smoothly but retracts in a jerky, erratic motion. The DCV spool, pump, and relief valve have all been verified correct. What should be investigated next?

A. The cylinder rod seal is installed backward, creating resistance during retraction that does not occur during extension

B. Air is trapped in the rodend side of the cylinder — air compresses during the retraction stroke, creating a springy, jerky motion as the trapped air pocket alternately compresses and expands

C. The counterbalance valve on the cylinder's extend port is set too high, creating excessive backpressure that resists the retraction stroke

D. The cylinder rod is slightly bent, causing the rod seal to bind at certain points during the retraction stroke and produce the erratic motion

101. A technician is measuring the flow from a hydraulic pump using a flow meter connected between the pump outlet and the return line (full bypass test). The pump delivers 95 L/min at no load (0 bar). When the flow control valve on the test unit is progressively restricted to simulate load, the flow drops to 82 L/min at rated pressure (250 bar). What do these measurements indicate?

A. The pump has acceptable volumetric efficiency — the 13.7% flow loss between no load and rated pressure is within the typical range for an axial piston pump, indicating internal leakage is within acceptable limits

B. The pump has failed — any flow reduction between no load and rated pressure confirms internal damage that requires immediate pump replacement

C. The flow meter is producing inaccurate readings because the oil temperature has increased during the test, reducing viscosity and producing an artificially low flow reading at pressure

D. The pump's compensator is faulty and is destroying the pump to minimum displacement prematurely before rated pressure is reached

102. A hydraulic system uses a pressurereducing valve to supply a subcircuit at 100 bar from a main system operating at 280 bar. The technician measures the subcircuit pressure and reads 280 bar — the same as the main system. What has failed?

A. The subcircuit relief valve has failed open, allowing main system pressure to bypass the reducing valve through the relief path

B. The pressurereducing valve was installed backward — flow is entering the valve's outlet port and bypassing the regulation element entirely

C. The subcircuit has no load connected and the pressurereducing valve cannot regulate without a downstream flow demand to reference

D. The pressurereducing valve spool is stuck open (in the freeflow position), allowing unrestricted main system pressure to pass through to the subcircuit without regulation

103. A closedcentre loadsensing hydraulic system on an excavator has a "standby pressure" specification of 25 bar. When the technician measures standby pressure with all functions in neutral, the gauge reads 180 bar. What is the most likely cause?

A. The system is operating correctly — loadsensing systems maintain pressure at the highest active circuit pressure plus the margin setting, and 180 bar indicates a function is still active

B. The loadsensing line between the valve bank and the pump controller is blocked or disconnected, and the pump has defaulted to maximum pressure because it receives no feedback signal

C. The main relief valve has been adjusted above its specification, raising the entire system pressure including the standby pressure proportionally

D. The pump's compensator spring has broken, eliminating the force that normally holds the pump at minimum displacement, causing it to destroke to zero output

104. A hydraulic excavator's boom cylinder drifts down slowly when the boom is held in a raised position with the engine running and the DCV in neutral. The technician has already confirmed the DCV spool is not leaking. What should be tested next?

A. The cylinder's piston seals — internal bypass allows oil to leak from the capend (pressurized by the boom weight) to the rodend across the worn piston seals, producing the drift

B. The pump's pressure compensator — a low compensator setting could allow the pump to supply insufficient pressure to hold the boom against gravity

C. The pilot circuit pressure — insufficient pilot pressure may allow the DCV spool to shift slightly off centre, cracking open a metering path to tank

D. The return line filter — a clogged return filter creates backpressure that pushes against the cylinder's rod end and forces the piston to retract

105. An air brake system's compressor is cycling on and off more frequently than normal — the governor cutin and cutout cycle completes every 30 seconds instead of the normal 3–5 minutes. System pressure readings are normal during both loaded and unloaded states. What does the rapid cycling indicate?

A. The governor is faulty and is cycling at incorrect pressure thresholds, causing the compressor to load and unload too frequently

B. The engine RPM is too high, causing the compressor to charge the system faster than normal and reach the cutout pressure in less time

C. The air tank drain valves are stuck partially open, continuously bleeding air from the reservoirs and causing the compressor to reload as soon as it unloads

D. There is a leak in the air system — the compressor charges the system to cutout pressure normally, but the leak depletes the stored air rapidly, causing the governor to signal the compressor to reload sooner than normal

106. A technician is troubleshooting a hydraulic motor that operates at correct speed but produces less torque than specified. The system pressure at the motor inlet reaches rated pressure when the motor is loaded. What should be checked?

A. The motor's displacement — a motor with reduced displacement produces less torque per revolution at any given pressure than a motor at full displacement

B. The motor's case drain flow — excessive internal leakage bypasses the motor's working chambers, reducing the effective pressure differential across the motor and therefore reducing the available torque output

C. The pump's flow output — insufficient flow reduces the motor's RPM but does not affect the torque produced at a given pressure level

D. The system relief valve setting — if the relief is set too high, it creates excessive backpressure on the motor's outlet that resists rotation and reduces net torque

107. A hydraulic hose assembly has been in service for 6 years. The OEM recommends a maximum hose life of 6 years regardless of visual condition. The hose shows no external damage. Should it be replaced?

A. No — the hose should be inspected annually and replaced only when physical deterioration (cracking, abrasion, leaking, or deformation) is observed

B. No — the 6year recommendation is a guideline, not a requirement, and the hose can continue in service as long as it passes a visual inspection

C. Yes — rubber hose reinforcement degrades from the inside out through heat cycling, pressure fatigue, and chemical attack, and a visually perfect hose may be near failure internally; the OEM timebased replacement interval accounts for this invisible degradation

D. Yes — but only hoses in the highpressure pump outlet and cylinder circuits require timebased replacement; return and drain line hoses can remain in service indefinitely

108. A technician is charging a bladdertype accumulator with nitrogen. The OEM specification states the precharge pressure should be 90% of the system minimum working pressure. The minimum working pressure is 150 bar. What is the correct nitrogen precharge?

A. 15 bar — calculated by taking 10% of the working pressure instead of 90%

B. 150 bar — the precharge should equal the full working pressure to ensure maximum oil storage volume

C. 166.7 bar — calculated by dividing the working pressure by 0.90 instead of multiplying by it

D. 135 bar — calculated as 150 bar × 0.90 = 135 bar nitrogen precharge pressure

109. A hydrostatic transmission machine has been sitting idle for one week. When the operator starts the engine and moves the drive control, the machine hesitates for several seconds before beginning to move. After the initial hesitation, the machine operates normally for the remainder of the shift. What caused the initial hesitation?

A. The hydrostatic loop has partially drained during the idle period — the charge pump requires several seconds to refill the loop and build sufficient charge pressure before the main pump can generate drive pressure

B. The EDC solenoids are stuck from the dried oil residue that accumulated during the idle period and require several seconds of oil flow to free them

C. The engine was not at full operating temperature and the ECM limited the hydrostatic pump displacement until the coolant temperature reached the minimum threshold

D. The operator did not preheat the hydraulic oil before operating the drive controls, and the cold oil is too viscous for the pump to displace until it warms

110. A hydraulic system is equipped with a highpressure filter located downstream of the pump and upstream of the control valve bank. The filter is rated at 10 microns absolute with a collapse pressure rating of 30 bar. What does the collapse pressure rating represent?

A. It is the maximum system pressure the filter housing can withstand before the housing structure fails and releases pressurized oil

B. It is the maximum system operating pressure at which the filter element provides its rated micron efficiency — above this pressure, particles are forced through the media

C. It is the maximum differential pressure across the filter element before the element structurally collapses — if the element clogs and the pressure drop exceeds 30 bar, the element fails and releases captured contamination downstream

D. It is the pressure at which the filter bypass valve opens, routing unfiltered oil around the element to prevent oil starvation at the control valve bank

111. A technician is testing the charge pressure on a hydrostatic transmission. The OEM specification is 25–30 bar at rated RPM. The measured charge pressure is 18 bar. The charge pump relief valve is accessible and adjustable. Should the technician increase the relief valve setting to bring the pressure to specification?

A. No — the low charge pressure is a symptom of a worn charge pump, leaking charge circuit components, or excessive main loop leakage; increasing the relief setting masks the root cause without correcting it

B. Yes — the charge relief valve may have been previously adjusted below specification, and correcting the setting to 25–30 bar restores the designed charge pressure

C. No — charge pressure is not adjustable and is determined solely by the charge pump's displacement and the engine RPM driving it

D. Yes — increasing the relief valve setting compensates for the normal wear in the charge pump and extends the service interval before a pump rebuild is needed

112. An air brake system's automatic drain valve on the wet tank (supply reservoir) is designed to purge accumulated moisture each time the compressor unloads. The technician notices no purge burst is occurring when the compressor cycles. What is the consequence?

A. The compressor will overheat because the purge cycle also cools the compressor discharge valve during the unloaded phase

B. The governor will cycle more frequently because the moisture in the tank displaces air volume, reducing the effective storage capacity

C. No immediate consequence — the automatic drain is a convenience feature and the manual drain handles the moisture removal during daily inspections

D. Moisture accumulates in the wet tank and passes downstream to the service reservoirs, degrading brake valve operation, corroding metal components, and creating a freeze risk in cold weather

113. A hydraulic system operates at 200 bar and 100 L/min. Using the hydraulic power formula (kW = bar × L/min ÷ 600), what is the system's hydraulic power output?

A. 20,000 kW — calculated by multiplying pressure by flow without applying the conversion divisor

B. 0.33 kW — calculated by dividing pressure by flow (200 ÷ 600) without including the flow rate variable

C. 33.3 kW — calculated as (200 × 100) ÷ 600 = 20,000 ÷ 600 = 33.3 kW hydraulic power output

D. 3.0 kW — calculated by dividing only the flow rate by the conversion factor (100 ÷ 600) and multiplying by the result

114. A machine's hydraulic system includes a shuttle valve between two work circuits. The shuttle valve has two inlets and one outlet. What does the shuttle valve do?

A. It automatically routes the higher of the two inlet pressures to the single outlet port — the higherpressure inlet shifts the shuttle, blocking the lowerpressure inlet and connecting the higherpressure source to the outlet

B. It splits a single inlet flow equally between two outlet circuits, ensuring both receive proportional flow regardless of load

C. It alternates flow between the two inlets at a fixed frequency, providing pulsating flow to the outlet circuit that improves actuator response

D. It combines the flow from both inlets simultaneously and delivers the total combined flow to the outlet at the average of the two inlet pressures

115. A hydraulic pump is making excessive noise that started suddenly during operation. The reservoir level is correct and the oil temperature is normal. What is the most common cause of sudden pump noise?

A. A worn pump compensator spring that has gradually lost tension and has now reached the point where it cannot hold the swashplate at the correct angle

B. Suctionside air ingress — a cracked suction hose, a loose fitting, or a failed shaft seal is allowing air to enter the pump inlet, causing aerationinduced noise

C. The pump's internal relief valve has shifted off its seat and is allowing intermittent pressure spikes that produce the noise as the valve chatters

D. The pump drive coupling has worn and the backlash between the coupling halves is producing an impact noise with each revolution

116. A hydrostatic drive system's flushing valve is stuck closed. What operating symptom will develop?

A. The machine will lose all forward drive because the flushing valve is required to supply charge flow to the forward side of the loop

B. The machine will exhibit normal performance initially but the closedloop oil temperature will rise progressively because the flushing valve is the only mechanism for exchanging hot loop oil with cooled reservoir oil

C. The machine will drive in forward only — the flushing valve controls the reverse flow path and a closed valve blocks reverse motor supply

D. The closedloop oil temperature will rise progressively because no hot oil is being exchanged with cooled, filtered reservoir oil — the machine will eventually overheat and derate or shut down

117. A technician needs to test the tractor protection valve on an air brake equipped prime mover. With the tractor connected to a trailer, the technician slowly drains air from the tractor's primary circuit. At what approximate pressure should the tractor protection valve close and isolate the trailer?

A. At the governor cutin pressure — the tractor protection valve closes when the compressor loads to prevent the loaded compressor from pressurizing the trailer circuit

B. At 690 kPa (100 PSI) — the tractor protection valve closes at the maximum system pressure as a highpressure safety measure

C. At approximately 415–480 kPa (60–70 PSI) — the tractor protection valve closes at this pressure to preserve the tractor's remaining air supply for its own braking system before pressure drops to a dangerous level

D. At 0 kPa — the tractor protection valve closes only when the tractor's air supply is completely exhausted, providing maximum trailer braking until the last available air pressure is consumed

118. A wheel loader hydraulic system has a priority valve that guarantees steering circuit flow before directing excess flow to the implement circuit. The operator reports sluggish implement response. Steering response is normal. What should be investigated?

A. The priority valve may be diverting more flow to the steering circuit than required — the priority valve spool setting, spring, or adjustment may be directing excessive flow to the steering at the expense of the implement circuit

B. The implement circuit has a clogged return filter that is creating backpressure and slowing actuator movement on the implement side only

C. The steering circuit has an internal leak that is consuming flow from the priority valve, reducing the excess flow available for the implement circuit

D. The hydraulic pump has lost overall capacity, producing insufficient total flow to satisfy both the steering priority circuit and the implement circuit simultaneously

119. An air brake system's spring brake chambers are rated at Type 30/30. What do these numbers represent?

A. The chamber can produce 30 pounds of force on both the service and spring brake sides, totaling 60 pounds of maximum braking force

B. The chamber operates at a maximum pressure of 30 PSI on both the service and spring brake sections

C. The first number (30) represents the service brake effective diaphragm area in square inches, and the second (30) represents the spring brake section diaphragm area in square inches

D. The Type 30/30 designation indicates the chamber has a 30squareinch effective diaphragm area for both the service brake section and the spring brake section — both sides have equal forcegenerating capability for a given pressure

120. A hydraulic excavator's swing system uses a hydraulic motor with a crossport relief valve on each motor port. During a swing stop, the upper structure overshoots the intended position slightly before settling. What does this indicate?

A. The swing motor has internal leakage that allows the upper structure to coast past the intended stop position before the leakage resistance slows and stops the swing

B. The swing parking brake is not applying fast enough to stop the swing momentum before the upper structure passes the intended position

C. The crossport relief valves are set too high — the pressure required to stop the swing momentum exceeds the ideal setting, allowing the upper structure to coast further than intended before the reliefs absorb the kinetic energy

D. The swing control valve spool is returning to neutral too slowly, continuing to supply drive flow to the motor briefly after the operator releases the joystick

121. A technician is installing a hydraulic cylinder and must determine the correct hose size for the supply and return lines. The pump delivers 60 L/min to the cylinder. What parameter determines the correct hose internal diameter?

A. The hose must be rated for the system's maximum working pressure — diameter is selected based on pressure rating alone

B. The hose internal diameter must be large enough to carry the required flow at a velocity that does not exceed the OEM's maximum recommended velocity for the hose type and circuit location (pressure, return, or suction line)

C. The hose diameter must match the cylinder port size — any hose that physically fits the port connection is correctly sized for the application

D. The hose must be the same internal diameter as the pump outlet port to maintain consistent flow velocity throughout the circuit

122. A hydraulic system has three return line filters in parallel. The system was originally designed with two filters. A previous technician added the third filter. What was the most likely reason for adding the additional filter?

A. The system was experiencing premature contaminationrelated component failures, and the additional filter increases the total filtration capacity, reduces the flow velocity through each element, and extends the service interval between filter changes

B. The third filter was added to increase the system's maximum flow capacity because the two original filters were creating excessive backpressure at full flow

C. The third filter was added as a backup — when one filter clogs, flow automatically diverts to the third filter while the technician replaces the clogged element

D. The third filter was added to increase the filtration micron rating below the original two filters' combined capability

123. A technician is performing a visual inspection of a welded boom joint and discovers a small, circular opening in the weld bead surface. The opening appears to penetrate into the weld body. What weld defect is this?

A. An undercut — the arc has melted the base metal adjacent to the weld toe and created a groove that reduces the crosssection at the weldtobasemetal transition

B. A cold lap — the weld bead has folded over itself without fusing to the base metal, creating a surface discontinuity that looks like a penetrating defect

C. A slag inclusion — nonmetallic material trapped inside the weld has risen to the surface and created a visible pocket in the bead profile

D. Porosity — a gas pocket trapped in the molten weld metal during solidification has left a void that appears as a small circular opening on the surface and may indicate subsurface voids

124. A hydraulic breaker attachment on an excavator requires periodic chisel tool maintenance. The technician inspects the chisel and finds the tool shank shows visible wear marks and metal deformation at the retaining pin contact area. What service is required?

A. Apply antiseize compound to the shank wear areas and reinstall the chisel — the marks indicate normal wear that does not affect performance

B. Replace the retaining pin and inspect the tool bushing — the wear marks indicate the retaining pin or bushing has worn, allowing the chisel to move excessively and deform the shank contact area

C. Rotate the chisel 180 degrees in the breaker housing so the worn shank area is on the opposite side of the retaining pin contact zone

D. Sharpen the chisel tip to restore its penetration angle — the shank wear is caused by excessive impact absorption from a dull tip and will stop once the tip is restored

125. A technician discovers that an attachment pin on a wheel loader bucket has been secured with a bolt instead of the OEMspecified quickrelease pin with a hairclip retainer. The bolt and nut appear tight. Is this acceptable?

A. No — the bolt may loosen under the dynamic loading of bucket operations and does not provide the same installation verification and quickinspection capability as the OEM quickrelease pin system

B. Yes — a bolt and nut provide superior retention to a quickrelease pin because the threaded connection cannot vibrate loose like a hairclip retainer

C. No — only welded retention is acceptable for attachment pins on wheel loader buckets because the dynamic loading exceeds the capacity of any removable fastener

D. Yes — any fastener that prevents the pin from backing out is an acceptable alternative to the OEMspecified retaining device

126. A large mining excavator's bucket has had its wear package (liner plates and corner protectors) removed for replacement. The technician inspects the bucket shell beneath the removed liner plates and discovers significant thinning of the base plate in several areas. What action is required?

A. Install the new liner plates directly over the thinned areas — the liner plates provide the structural reinforcement that compensates for base plate thinning

B. Apply a bead of structural weld along the thinned areas to build up the material, then install the new liner plates over the repaired surface

C. Measure the remaining base plate thickness and compare to the OEM minimum — if below the minimum, the base plate sections must be repaired (weld buildup or plate replacement) before the new liner package is installed

D. The bucket must be scrapped — base plate thinning beneath a liner package indicates the bucket has reached end of life and cannot be repaired economically

127. A machine's quick coupler has been reported as difficult to engage on a specific attachment. The coupler engages easily on all other attachments. What is the most likely cause?

A. The quick coupler's hydraulic circuit has low pilot pressure that cannot generate sufficient force to engage the locking mechanism under the weight of the heavier attachment

B. The attachment's connection pins are worn to a smaller diameter or are damaged, preventing the coupler's locking mechanism from fully engaging around the undersized or deformed pins

C. The quick coupler's lock release solenoid is sticking intermittently, and the difficulty only manifests with the specific attachment because its weight amplifies the engagement force required

D. The machine's hydraulic pump has insufficient flow to operate the coupler cylinder at the speed needed for positive engagement with the specific attachment's pin geometry

128. A technician is performing a structural inspection on a dozer and finds paint bubbling and flaking on the main frame rail near a weld joint. Beneath the paint, the technician discovers surface corrosion and a fine crack extending from the weld toe into the base metal. What is the significance of this finding?

A. The paint bubbling is cosmetic only — the surface corrosion is typical for a dozer operating in wet conditions and the crack is a surface blemish in the paint layer, not in the metal

B. The corrosion has developed from a paint defect and the crack is a superficial corrosion groove that does not extend into the structural crosssection

C. The crack at the weld toe is a potential fatigue crack that has initiated at the stress concentration point — the paint bubbling indicates corrosion has been active beneath the surface for an extended period

D. The crack is a structural fatigue crack at the highestстress location on the frame — the weld toe is the most common initiation point for fatigue cracks in welded steel structures, and this crack must be assessed and repaired before the machine operates

129. A telehandler's operator requests that the technician adjust the hydraulic stabilizer legs to a wider spread than the OEM configuration for improved stability during maximum lift height operations. Should the technician make this modification?

A. No — the stabilizer geometry, machine stability envelope, and rated load charts are designed as an integrated system; widening the stabilizers beyond the OEM specification invalidates the rated capacity charts and may create a structural overload condition on the stabilizer legs, cylinders, or frame

B. Yes — wider stabilizer spread improves stability in all conditions and is a recognized best practice for telehandler operation at maximum lift height

C. No — wider stabilizer spread reduces stability because the increased lever arm amplifies the frame flex under load

D. Yes — the stabilizer cylinders have sufficient stroke for a wider spread and the only limitation is the available ground surface width at the work site

130. A technician is replacing a damaged operator seat on a compact excavator. The replacement seat is an aftermarket unit with different mounting bolt hole spacing. The technician fabricates a steel adapter plate to mount the new seat to the existing cab floor mounting points. Is this acceptable?

A. Yes — an adapter plate is a standard practice for aftermarket seat installations and the fabrication quality is the technician's responsibility

B. Yes — the seat is not a safetycritical component and any secure mounting method is acceptable provided the seat does not move during operation

C. No — the operator seat is integral to the machine's ROPS certification and any modification to the seat mounting that is not approved by the machine OEM or the seat manufacturer may compromise the restraint system and ROPS protection in a rollover event

D. No — aftermarket seats cannot be installed on any heavy equipment machine because the seat belt attachment points are proprietary to each OEM

131. A large excavator's counterweight is supported by a mounting frame that uses highstrength pins and selflocking nuts. During a scheduled inspection, the technician discovers one selflocking nut has backed off two full turns from its seated position. What is the required action?

A. Apply threadlocking compound to the nut threads and retighten to the OEM specification without investigating further

B. Remove the pin, inspect it and the bore for damage from the loose connection, replace the selflocking nut (selflocking nuts lose their locking effectiveness once loosened), reinstall, and torque all counterweight fasteners to specification

C. Tighten the nut to the OEM torque specification and mark it with a witness line to monitor for any further movement at the next inspection

D. Replace all pins and selflocking nuts on the counterweight mounting frame as a precaution, assuming the loosening may have affected adjacent fasteners

132. A technician is performing the sixstep HV isolation procedure on a hybrid excavator before servicing the HV system. The procedure requires measuring voltage at the HV bus after the service disconnect is opened and the prescribed wait time has elapsed. What is the purpose of the voltage measurement?

A. It verifies the HV contactors opened correctly when the service disconnect was pulled — if voltage is present, the contactors have welded closed and the circuit remains live

B. It measures the battery's opencircuit voltage to determine the state of charge for the service record before any work is performed on the HV system

C. It confirms all HV energy has been discharged — capacitors and other storage devices may retain dangerous voltage even after the service disconnect is opened and the wait time has elapsed

D. It calibrates the technician's HV meter against the known bus voltage to ensure the meter is functioning correctly before any HV work begins

133. A batteryelectric wheel loader's regenerative braking system recovers energy during deceleration and stores it in the traction battery. The operator reports that regenerative braking feels weaker on cold mornings. What is the explanation?

A. At cold temperatures, the battery's internal resistance increases and the BMS limits the maximum charging current to protect the cells — reduced charging current means less regenerative braking force is available

B. The hydraulic brake fluid viscosity increases in cold conditions, which applies a slight mechanical brake that interferes with the regenerative braking system's ability to decelerate the machine

C. The electric drive motor's permanent magnets lose field strength at cold temperatures, reducing the motor's ability to generate electricity during the regenerative braking phase

D. The drive controller reduces regenerative braking at cold temperatures to prevent the motor from generating excessive voltage that could damage the cold battery cells

134. A technician notices that the HV battery enclosure on a hybrid machine has an integral ventilation system with small ducting and a fan that routes air from the enclosure to the outside of the machine. What is the purpose of this ventilation system?

A. It provides general cooling airflow across the battery modules to supplement the liquid cooling system during sustained heavy discharge operations

B. It maintains positive pressure inside the battery enclosure to prevent dust and moisture ingress during operation in contaminated environments

C. It removes heat generated by the battery management system's electronic control boards, which are mounted inside the enclosure alongside the battery modules

D. It evacuates any flammable or toxic gases released by the battery cells during a thermal event, preventing gas accumulation inside the enclosure that could lead to explosion or toxic exposure

135. A fleet manager is evaluating the total cost of ownership for a batteryelectric compact loader versus a dieselpowered equivalent. Beyond fuel versus electricity cost, what is the primary maintenance cost advantage of the batteryelectric machine?

A. The batteryelectric machine's tires last longer because the electric motor's smoother torque delivery reduces tire slip and wear compared to a diesel engine's torque pulses

B. The batteryelectric machine eliminates the engine, transmission, exhaust aftertreatment system, and associated fluids and filters — reducing the number of maintenance items and scheduled service events significantly

C. The batteryelectric machine requires no hydraulic system maintenance because all actuators are electric, eliminating oil, filters, hoses, and cylinder seals

D. The batteryelectric machine's structural components last longer because the electric motor produces less vibration than a diesel engine, reducing fatigue loading on the frame

Practice Exam 5: Answer Key and Explanations

1. C — Hydraulic pressure is not a mechanical support device. A raised boom held only by hydraulic cylinders can drop without warning if a hose fails, a seal leaks, or the engine stalls — exactly as occurred in this scenario. The boom must be mechanically supported with rated safety stands or lowered to the ground before anyone positions themselves beneath it.

2. B — A complete work order documents the machine identification, the fault as reported, the diagnostic steps performed, parts replaced, work completed, technician name, and date. This information creates a traceable repair history that supports warranty claims, identifies recurring failures, informs future diagnostics, and satisfies regulatory documentation requirements.

3. D — Entering a confined space without proper training, equipment, and a rescue plan is the leading cause of multiple-casualty confined space incidents. The untrained technician must not enter — instead,

activate the emergency rescue plan, call the designated rescue team or emergency services, and serve as the standby attendant at the entry while monitoring the situation and maintaining communication.

4. B — WHMIS 2015 distinguishes between supplier containers and workplace containers. Supplier containers require the full WHMIS 2015 supplier label with all six mandatory elements (product identifier, pictograms, signal word, hazard statement, precautionary statement, and supplier identifier). Workplace containers — products transferred into secondary containers by employees — require at minimum a product identifier and information for safe handling, referencing the SDS.

5. A — A near miss is an unplanned event that did not result in injury but had the potential to do so. Canadian OHS legislation and best practice require near miss reporting and investigation to identify root causes and implement corrective actions before a similar event causes actual injury. The bearing fragment striking the guard demonstrates the event's injury potential.

6. C — With a flash point of 210°C, hydraulic oil is not a flammable liquid hazard at shop ambient temperature. The primary hazard of an open container left on the shop floor is the spill and slip risk it creates for personnel walking in the area, and the dust and airborne contamination that settles into the exposed oil, making it unsuitable for use in precision hydraulic systems.

7. A — Working on or near a roadway accessible to site vehicles requires the technician to alert approaching operators of the work zone and their presence. High-visibility warning devices — cones, signs, warning lights, or a flagger — are the minimum traffic control measures that protect the technician from being struck by a vehicle whose operator did not see them.

8. D — Hot work within proximity of a flammable liquid source requires a formal hot work permit, removal or protection of the flammable material beyond the minimum safe distance, and a fire watch with an appropriate extinguisher. The 3-metre distance to an open solvent tank is well within the hazard zone — solvent vapour is heavier than air and can travel along the floor to the ignition source.

9. B — A crack in a ROPS structural member compromises the structure's ability to protect the operator during a rollover event. The ROPS was tested and certified as a complete structural assembly — a crack at a weld junction on a main upright represents a critical structural deficiency. The machine must be removed from service and the ROPS assessed by the OEM or a qualified engineer before any repair or return to operation.

10. C — Lithium-ion battery cells can release toxic and flammable gases — including hydrogen fluoride, carbon monoxide, and volatile organic compounds — if damaged, overheated, or compromised during service. The job hazard analysis must address atmospheric monitoring for these decomposition products, full HV isolation procedures, and the specific fire suppression requirements for lithium-ion battery incidents.

11. D — During cranking, the starter motor draws more current when compressing a cylinder with normal compression than when compressing one with low compression. A cylinder with reduced compression requires less work from the starter, producing a lower current peak on the clamp ammeter trace. This relative comparison identifies the weak cylinder without removing any components.

12. B — An isolated connecting rod bearing failure with a clean, unrestricted oil supply gallery points to a problem specific to that bearing's operating environment rather than a system-wide oil supply deficiency. A distorted connecting rod bore (out-of-round from overheating, improper reconditioning, or manufacturing defect) creates uneven oil film distribution — the thinnest film area overloads and fails while the rest of the bearing appears normal.

13. A — Engine coolant contains a carefully formulated inhibitor package that protects metal surfaces from corrosion. Repeatedly topping up with plain water dilutes these inhibitors below their effective concentration. Aluminum components — cylinder heads, water pump housings, and heat exchanger plates — are the most vulnerable to uninhibited water attack and will develop pitting corrosion that progressively damages the surfaces.

14. C — Low oil pressure at idle with normal pressure at high RPM is the classic symptom of excessive bearing clearance. Worn main and rod bearings create larger-than-designed clearance gaps that allow oil to bleed off faster than the pump can replenish at low RPM. At higher RPM, the positive-displacement pump's output increases proportionally and overcomes the increased leakage, restoring pressure.

15. D — Before condemning the SCR catalyst, the technician must verify the NOx sensors themselves are reading correctly. A NOx sensor that is reading high on the inlet or low on the outlet produces a false efficiency calculation that triggers the conversion efficiency fault — even if the catalyst is functioning normally. Comparing the sensor readings to a known-good reference under loaded operation confirms or eliminates the sensors.

16. B — The absence of any exhaust smoke during cranking is the key diagnostic indicator. If fuel were reaching the cylinders and being injected — even without successful combustion — the heat of compression would vaporize enough fuel to produce visible white or grey smoke at the exhaust. No

smoke means no fuel is entering the combustion chambers, directing the diagnosis to the fuel delivery system.

17. A — A restricted air filter reduces the oxygen available for combustion, creating a rich fuel-to-air ratio. The excess unburned fuel washes past the piston rings and enters the crankcase, diluting the engine oil with raw diesel fuel. This fuel dilution reduces the oil's viscosity and load-carrying capacity, accelerating wear on every lubricated surface in the engine.

18. C — A thermostat that opens at 78°C instead of the specified 88°C allows coolant to flow to the radiator 10°C below the designed operating temperature. The engine cannot reach its optimal operating point because the thermostat directs coolant for cooling before it is needed. The lower-than-designed operating temperature reduces combustion efficiency, increases fuel consumption, and accelerates moisture-related component wear.

19. B — All six injectors showing equally elevated return flow — 40% above specification — suggests the common factor is the supply pressure rather than individual injector wear. If the high-pressure pump is over-supplying the rail (due to a faulty pressure control valve, regulator, or sensor), the excess rail pressure forces additional fuel through all injector return paths uniformly.

20. D — Crankcase pressure of 18 inches of water column against a 6-inch maximum specification confirms excessive combustion gas is entering the crankcase. The most common sources are worn piston rings, worn cylinder liners, or failed valve seals that allow combustion pressure to bypass into the crankcase at a rate exceeding the CCV system's venting capacity. Engine condition assessment (leak-down test) is required.

21. A — Exhaust manifold bolts operate in one of the most severe thermal environments on the engine — cycling between ambient temperature and 600–700°C during every operating cycle. This repeated expansion and contraction work-hardens the bolt material, creates fatigue stress at the thread root, and promotes corrosion-assisted cracking at the stress concentration points. The corrosion and fatigue combine to fracture the bolt.

22. C — An intermittent miss under heavy load only — with compression, fuel delivery, and valves confirmed correct — points to a component that fails under high-pressure conditions. A hairline crack in a high-pressure injector line allows a small quantity of fuel to leak only when the injection pressure spike reaches its peak during heavy-load injection events. At lighter loads, the reduced pressure does not exceed the crack's sealing capability.

23. B — Some thermostat housing designs route the heater core supply through a port in the housing that interacts with the thermostat position. If the replacement thermostat is installed with the sensing element facing the wrong direction (backward), the thermostat may function for engine temperature control but physically block or restrict the heater core supply port, preventing hot coolant from reaching the heater core.

24. D — Blue-grey exhaust from a high-hour engine with increasing oil consumption but normal wear metals on oil analysis is consistent with progressive but non-catastrophic oil passage past worn valve stem seals and piston rings. The oil enters the combustion chamber and burns, producing the visible blue-grey tint. Wear metals remain normal because the wear is distributed across all cylinders at a rate that does not generate detectable metal concentrations.

25. A — If one cylinder's valve seat has recessed (sunk) deeper into the head than the others from erosion or normal wear, the valve sits lower in the head. This effectively increases the clearance between the rocker arm and valve stem tip beyond the measured cold lash setting. The additional clearance produces the ticking noise even though the feeler gauge measurement at the valve tip was correct.

26. C — Boost pressure, fuel rail pressure, and exhaust back-pressure are within specification, which rules out turbo, fuel, and exhaust system faults. The charge air cooler is an often-overlooked component — oil accumulation from the turbocharger compressor seal coats the internal surfaces, insulating them and reducing the cooler's ability to remove heat from the charge air. The resulting lower-density intake charge reduces the oxygen mass available for combustion, gradually reducing peak power.

27. D — Many ECMs record event history data for transient warning conditions that are too brief to generate a formal stored DTC. Reviewing the ECM's event log for parameter snapshots (engine speed, temperatures, pressures) at the time of the warning may identify the root cause of the transient event and determine whether it is a developing fault that requires attention.

28. B — A viscous fan clutch is designed to disengage (freewheel) when the radiator air temperature is below the clutch's engagement threshold. When cold, the bimetallic spring on the clutch face keeps the silicone fluid in the reservoir, and the fan spins freely with minimal drag. As the radiator air temperature rises, the spring opens a valve that allows fluid into the working chamber, progressively engaging the fan.

29. C — After trim code programming, the ECM has the base delivery correction for each injector. However, the ECM's adaptive control system requires a brief operating period to fine-tune the delivery by learning the actual closed-loop combustion characteristics of each new injector under real operating

conditions. The initial roughness during this learning period is expected and resolves within the first minute of operation.

30. A — When the VGT exhaust brake activates, the vanes close rapidly to create high exhaust back-pressure for engine retarding. This pressurizes the exhaust manifold significantly above atmospheric pressure. When a cylinder opens on the exhaust stroke, the pressurized gas in the manifold rushes out through the open valve, producing the audible bark or pop as the pressure releases rapidly.

31. B — With tires, inflation, and steering confirmed correct, the next system to investigate is the brake system. A partially applied or dragging brake on the right side applies a continuous retarding force on that side, causing the machine to pull away from the braking side — toward the left. Checking both sides for evidence of dragging brakes (heat differential, pad contact marks) identifies the fault.

32. D — A fully collapsed suspension strut with zero nitrogen charge cannot absorb any impact energy. Every bump transmits directly through the frame at the affected corner, creating dynamic stress loads the frame was not designed to absorb repeatedly. The asymmetric ride height changes the steering geometry, and the uncontrolled weight transfer during cornering creates an immediate rollover risk.

33. C — The springs are applying full design force (the service brake confirms the hydraulic release is functional and the springs are not weakened). The machine rolls because the friction disc surfaces cannot generate enough holding force from the spring's clamping pressure. Worn, oiled, or glazed disc surfaces have a reduced friction coefficient that is the only explanation when spring force and release mechanism are confirmed correct.

34. A — Smooth, even tread wear across the full face of all four tires simultaneously — without feathering, cupping, or edge concentration — indicates the tires are under-inflated. Under-inflation increases the contact patch width, raises the operating temperature, and accelerates uniform tread consumption across the entire face. This is the most common cause of premature even wear on heavy equipment tires.

35. B — A track idler develops an oval (out-of-round) shape when the machine is routinely parked for extended periods in the same track position. The track chain tension maintains a constant compressive load on one contact point of the idler tread. Over time, the sustained load at that single point creates a flat spot that progresses into the oval profile as the flat area grows from repeated parking in the same position.

36. D — Moisture that has entered the air brake system and accumulated in the lines or valves serving the spring brake circuit freezes in −25°C conditions, forming ice plugs that physically block the air passage. Full system pressure at the reservoirs cannot reach the spring brake chambers through the frozen passages. The springs remain fully extended (applied) because the release air cannot reach them.

37. A — When ride control is activated, the boom circuit is connected to a gas-charged accumulator. The accumulator must absorb a small volume of oil from the boom cylinders during the initial equalization between the cylinder pressure and the accumulator pre-charge. This small fluid transfer allows the boom to settle slightly (approximately 25–75 mm) before the system stabilizes. This is normal and expected.

38. C — Brake shoes set too tight — with less than the specified running clearance — will drag against the drum during operation. The continuous friction generates heat that accelerates lining wear, raises drum temperature toward the fade threshold, increases parasitic fuel consumption, and can ultimately cause the brake lining to overheat and glaze or the drum to crack from sustained thermal stress.

39. B — Rubber track material degrades over time through UV radiation, ozone exposure, and repeated heat cycling from operation. At 2,500 hours, the rubber compound has lost its elasticity through these aging mechanisms, producing the characteristic surface cracking and hardening pattern. This is age-related degradation consistent with the expected service life of the rubber compound.

40. A — Worn steering cylinder rod end bearings and frame pivot bearings introduce mechanical play into the steering linkage between the operator's steering input and the actual wheel or frame response. The operator must move the steering input through the dead zone of play before the hydraulic force takes up the slack and the machine responds — producing the vague, imprecise steering feel.

41. D — The left drum at 280°C is significantly hotter than the right drum at 190°C during equal brake application. The left brake is applying more force — either from a contaminated right-side brake that is less effective (reducing right-side contribution and shifting braking effort to the left), or from a left-side mechanical condition that concentrates the braking load. The asymmetry requires investigation.

42. C — The track links, pins, and bushings at 70% worn are approaching the typical pin-turn or replacement threshold, while the sprocket at 40% has significant remaining life. Installing a new chain against a 40%-worn sprocket would cause accelerated chain wear from the mismatched sprocket tooth profile. Turning the sprocket to its unworn face for the new chain maximizes both component lives.

43. B — The low-pressure warning device is a critical safety system that provides the only audible and/or visual alert to the operator that air pressure is dropping below the level required for safe braking. Without a functioning warning, the operator would have no indication of impending brake failure until the brakes stop working. The machine must not operate until the warning device is repaired and verified.

44. D — Worn oscillation pivot pin bushings allow the rear axle assembly to shift laterally and vertically relative to the frame during travel and grading. This uncontrolled movement at the rear directly affects the blade position because the grading blade is mounted on the front frame, which responds to rear frame inputs. The lateral sway produces inconsistent blade height and angle between grading passes.

45. A — Residual air pressure trapped inside the tire — even a fraction of a bar — can eject the lock ring with lethal force when the ring groove is released during rim disassembly. The tire must be completely deflated and the valve core removed to ensure absolutely zero residual pressure before any rim components are separated.

46. C — A reading of 0 bar nitrogen with the system fully depressurized most likely indicates the accumulator bladder or diaphragm has ruptured. The nitrogen has migrated through the ruptured bladder into the oil side of the accumulator, where it dissolves into the hydraulic fluid and is eventually vented through the reservoir breather. No gas remains on the gas side to register on the charging gauge.

47. D — Applying Watt's Law: I = P ÷ V = 100W ÷ 24V = 4.17 amperes. This calculation determines the current flowing through the circuit for correct fuse sizing, wire gauge selection, and circuit design. A 100-watt light on a 24V system draws 4.17 amperes of current.

48. A — A fully charged 12V lead-acid battery reads approximately 12.6–12.7V OCV after a 24-hour rest. Each 0.2V decrease below 12.6V represents approximately a 25% decrease in state of charge. At 12.06V — approximately 0.6V below fully charged — the battery is at roughly 25% state of charge and requires charging and further testing.

49. C — Isolating the fault to a single module by the disconnection method confirms that module is the source of the bus disruption. A failing CAN bus transceiver chip inside the module transmits malformed or improperly timed signals that corrupt the bus for all connected modules. Replacing the defective module restores normal communication.

50. B — The voltage drop from 28.5V to 24.0V under load (4.5V total drop) with 28.2V confirmed at the alternator terminal means the voltage is being consumed by resistance in the wiring between the

alternator and the dashboard gauge point. This excessive voltage drop — far above the acceptable maximum — indicates corroded connections, damaged cables, or undersized wiring in the main charging circuit.

51. A — In a 24V series bank, the alternator maintains a total voltage across both batteries combined. Individual battery charging rates naturally vary based on each battery's internal resistance and condition. A 0.2V differential indicates one battery's internal resistance has changed relative to the other, warranting a load test to determine if the lower battery has a developing defect.

52. A — When the ECM driver is off, the pin floats at 0.0V (no ground connection). When the ECM commands the driver on, it connects the pin to the internal ground circuit. The 0.3V reading represents the normal voltage drop across the active MOSFET driver transistor while conducting the solenoid's current. This is correct low-side driver operation.

53. C — The most efficient method to isolate a parasitic draw is to remove fuses one at a time while monitoring the ammeter reading. When a fuse is pulled and the draw drops from 350 mA to near the 50 mA specification, the circuit protected by that fuse contains the fault. The technician then traces that specific circuit to identify the component that is not shutting down.

54. D — A magnetically inductive (variable reluctance) sensor generates its signal through electromagnetic induction as the reluctor teeth pass the sensor tip. Both the amplitude and frequency of the sinusoidal AC output increase with reluctor speed — amplitude increases because faster-moving teeth induce a stronger voltage in the coil, and frequency increases because more teeth pass per second. This is the expected characteristic.

55. B — The Terminal Position Assurance (TPA) clip is a secondary locking device that prevents individual terminals from backing out of the connector housing after the primary terminal latch has seated. Without the TPA, vibration can overcome the primary latch and push a terminal partially out of its cavity, creating an intermittent open circuit or high-resistance connection.

56. A — A keyless start PIN is a security feature that prevents unauthorized machine operation. The PIN reset procedure requires authentication through the OEM dealer or fleet management portal using machine identification and ownership verification. This controlled process prevents unauthorized individuals from resetting the PIN and gaining access to the machine.

57. D — The resistance decreases from 2,500 ohms at 25°C to 300 ohms at 90°C — as temperature increases, resistance decreases. This is the defining characteristic of an NTC (Negative Temperature Coefficient) thermistor, which is the standard sensor type used for coolant temperature, oil temperature, and intake air temperature measurements in heavy equipment.

58. C — Four parallel lights each drawing 5A produce a total circuit current of 20A (4 × 5A). The 15A fuse cannot sustain 20A and will blow immediately when all four lights are energized. The circuit requires a fuse rated above 20A (typically 25A or 30A) or the lights must be split across multiple fused circuits.

59. A — After installing a new wheel speed sensor, the most critical parameter to verify is the air gap between the sensor tip and the reluctor teeth. An incorrect gap — too wide or too narrow — produces a signal that is either too weak for the ABS module to process or physically contacts the reluctor. The OEM-specified gap ensures the sensor produces a clean, readable signal.

60. A — Voltage drop across a connector is measured live, under load, with one DMM lead on each side of the connector. The reading directly shows the voltage consumed by the connector's resistance under actual operating current. Any reading above the OEM maximum (typically 0.1–0.2V) confirms a high-resistance connection requiring cleaning or replacement.

61. C — A single module failing to communicate while all others function normally points to a power or connection fault specific to that module. An ECM without power cannot transmit on the CAN bus. The most common causes are a blown fuse, a disconnected connector, or a failed power supply wire to the TCM — all of which prevent the module from operating.

62. B — The sender reads 240 ohms (the empty-tank value) regardless of the actual half-full fuel level, confirming the sender's float mechanism is stuck at the bottom of its travel. The sender's resistance output corresponds to the float position, not the actual fuel level. A stuck float outputs only the resistance value corresponding to its physical position.

63. C — A small voltage drop (0.2V) in the 5V reference when a sensor is connected is expected — the sensor draws current from the reference circuit, and the current flow through the reference wiring produces a proportional voltage drop according to Ohm's Law. This is normal circuit behavior and does not indicate a fault in either the ECM or the sensor.

64. A — The dual-track throttle sensor provides the ECM with a redundant validity check. If the two signals disagree by more than the calibrated tolerance, the ECM cannot determine which signal is correct and defaults to a protective mode — typically fixed idle or reduced power. This prevents the engine from responding to an unreliable throttle command that could produce unintended acceleration.

65. C — The diode prevents current from the alternator's charging circuit from back-feeding through the starter relay coil via the ignition switch circuit. Without the diode, the charging voltage could energize the relay coil through the reverse path when the ignition switch is in the run position, re-engaging the starter while the engine is running.

66. B — Salt spray deposits on connector pins, ground studs, and terminal surfaces create a thin corrosion film that increases contact resistance. In humid coastal conditions, the corrosion worsens and multiple circuits develop intermittent high-resistance connections. When the machine enters the dry shop, the reduced humidity temporarily improves the connections, making the faults difficult to reproduce.

67. A — Modern ECMs require a sensor calibration initialization after replacement to learn the actual installed position and offset of each sensor. Without this procedure, the ECM operates on default baseline values that may not match the physical reality of the installed sensors — producing incorrect fuel delivery calculations that manifest as rough running and excessive smoke.

68. D — The minimum required insulation resistance = 1 MΩ per volt × 650V = 650 MΩ. The measured value of 5 MΩ is far below the 650 MΩ threshold, confirming severely degraded winding insulation. Current can leak from the conductors through the compromised insulation to the motor frame, creating a ground fault hazard that requires motor repair or replacement before re-energization.

69. C — While the CAN bus priority arbitration system ensures the highest-priority message wins any arbitration event, excessive low-priority traffic still consumes bus time. If the bus is saturated with low-priority messages, higher-priority messages must wait for each bus-free window, introducing delays that can produce visible symptoms such as sluggish control response or delayed display updates.

70. B — A temperature-compensated charging system increases voltage at cold temperatures (batteries need higher voltage to accept charge when cold) and decreases voltage at warm temperatures (to prevent overcharging and electrolyte boiling). A sensor stuck reading cold causes the regulator to maintain the elevated cold-temperature charging voltage continuously at normal operating temperature — chronically overcharging the batteries.

71. A — The engine ECM software update may have changed the format, content, timing, or scaling of the data messages it broadcasts on the CAN bus. The transmission ECM, still running the previous software version, interprets the changed data using its old calibration — potentially misreading engine torque values, RPM signals, or shift permission flags that determine shift timing.

72. A — At stall, the torque converter turbine is stationary and 100% of the engine's power output is absorbed as heat in the transmission oil through fluid shearing between the pump and turbine. Oil temperature can rise by several degrees per second under this condition. Exceeding the time limit risks thermal damage to the converter, oil degradation, and seal failure.

73. C — The modulation stage gradually increases clutch apply pressure from the initial fill level to full lock-up pressure over a controlled time period. This managed pressure ramp allows the clutch pack to transition smoothly from slipping to fully locked, controlling the rate of speed change in the drivetrain and preventing the abrupt torque shock that an instantaneous pressure application would produce.

74. B — Complete loss of drive in all forward and reverse ranges indicates a condition that is common to every gear — the hydraulic pressure supply. If the transmission oil level has dropped below the pump inlet, the pump draws air instead of oil and cannot generate the pressure needed to apply any clutch pack. No clutch engagement is possible in any range without hydraulic pressure.

75. D — A vibration that peaks at one specific speed and diminishes above and below that point is the characteristic signature of a driveshaft operating at or near its critical (resonant) speed. At this specific RPM, the shaft's natural frequency matches the rotational speed, amplifying the vibration. Moving above or below that RPM breaks the resonance and the vibration subsides.

76. A — Backlash provides three essential functions: it accommodates the thermal expansion of the gear teeth that occurs as the differential reaches operating temperature (preventing the teeth from binding), it prevents the gear faces from wedging together under load reversal, and it creates the space needed for lubricant film to form between the meshing tooth surfaces.

77. C — The one-way clutch provides the reaction member holding force for the planetary gear set in the affected gear range. If the clutch freewheels in both directions, no element is held stationary and the planetary set cannot transmit torque — the gears rotate freely without generating output. The affected range has zero drive capability while all other ranges using different reaction members function normally.

78. D — The elevated oil temperature has reduced the transmission oil viscosity. The retarder generates braking force by shearing fluid between the rotor and stator — the fluid's resistance to shearing is directly related to its viscosity. As the oil thins from heat, its shearing resistance drops proportionally, reducing the retarding force at any commanded engagement level.

79. B — A clutch that engages at the very bottom of pedal travel indicates the friction disc has worn thin. The release bearing must travel further to contact the pressure plate fingers because the thinner disc allows the fingers to sit closer to the flywheel. The engagement point migrates toward the floor of the pedal stroke as the disc wears. Free play adjustment or disc replacement is required.

80. A — Visible metallic flakes with a silver sheen and a burnt oil odour from a final drive are clear indicators of abnormal internal wear at elevated operating temperature. The metal particles originate from planetary gear teeth, bearing surfaces, or thrust washers, and the burnt smell confirms the oil has been thermally stressed. The final drive requires investigation and likely rebuild.

81. D — A shift failure isolated to a single gear transition — the 2-3 shift — while all other shifts function correctly points to a component specific to the 3rd gear engagement circuit. The fault is in the 3rd gear shift solenoid, its apply circuit, or the 3rd gear clutch pack itself. System-wide causes (main pressure, governor, pump) would affect all shifts.

82. B — A limited slip differential's clutch pack relies on friction between alternating plates to transfer torque to the slower wheel. Worn clutch discs cannot generate sufficient friction force and the differential behaves more like a standard open differential — allowing all torque to spin the wheel with less traction while the stuck wheel receives nothing. The worn clutch pack requires replacement.

83. C — Resting a foot on the clutch pedal — even lightly — partially disengages the clutch, causing the input shaft to spin at a slightly different speed than the flywheel. This speed differential forces the pilot bearing to rotate under load continuously. The bearing was designed only for brief operation during clutch disengagement events, not sustained continuous rotation. The constant spinning destroys the bearing through overheating and lubricant depletion.

84. A — The planetary hub reduction gear set is located inside the wheel hub, between the axle shaft and the wheel. The axle shaft delivers pre-reduction torque to the sun gear, and the planetary gear set multiplies it at the hub. This means the axle shaft, differential, and driveshaft all carry only the lower pre-reduction torque — allowing these components to be smaller and lighter.

85. B — Each ring and pinion gear set has manufacturing tolerances that produce a unique optimal pinion depth. The matched shim included with the gear set is calculated from factory measurements to position the pinion at the correct depth relative to the ring gear centreline, establishing the designed tooth contact pattern for that specific gear set without trial-and-error shimming.

86. D — A notchy, rough feel during bearing cap rotation indicates the needle bearings have developed flat spots (brinelling) from impact loading, vibration damage, or moisture-induced corrosion pitting. Needle bearing damage in any single cap compromises the entire U-joint — the damaged needles cannot support the cross spider evenly, producing vibration and accelerating the failure of the remaining caps.

87. A — Disconnecting the front axle from the driveline eliminates the parasitic power consumed by driving the front differential, ring and pinion, driveshaft, and hub reduction gears. This reduction in rotating resistance directly reduces fuel consumption and extends the service life of the disconnected components during highway travel where front-wheel drive is not needed.

88. C — A shudder during lockup clutch engagement indicates the friction surface cannot transition smoothly from slipping to locked. Worn or contaminated lockup clutch friction material has a reduced and inconsistent friction coefficient that produces the characteristic shudder as the clutch alternates rapidly between grip and slip during the engagement transition.

89. A — An orifice tube is a fixed-diameter restriction that meters refrigerant at a constant rate regardless of evaporator conditions. A TXV actively modulates its orifice opening based on a sensing bulb that monitors evaporator outlet temperature, maintaining a target superheat. The TXV adapts to changing conditions while the orifice tube cannot — systems with orifice tubes rely on compressor cycling for evaporator temperature control.

90. D — The OEM specification establishes a maximum allowable vent temperature of 12°C under standardized test conditions. The measured 22°C is 10°C above this threshold, confirming the A/C system is significantly underperforming. The technician must now diagnose the root cause — common causes include low refrigerant charge, a restricted condenser or evaporator, a failing compressor, a stuck blend door, or an expansion device malfunction. Operator comfort perception is not a substitute for objective specification compliance.

91. C — Fresh air mode through the particulate and carbon filters is the normal operating mode that maintains cab pressurization. Recirculation should only be selected when the external air contains hazardous gases or vapours that exceed the filtration system's removal capacity — such as when operating near a fire, chemical spill, or blasting event where the intake air is unsafe to filter and breathe.

92. B — A seized compressor generates metallic debris from the failing internal components. This debris and the contaminated oil are distributed throughout the system — condenser, hoses, evaporator, and receiver-drier/accumulator. The entire system must be flushed to remove this contamination, and the receiver-drier or accumulator replaced, before the new compressor is installed. Without flushing, the debris will destroy the replacement compressor.

93. A — High-side pressure at the upper end of normal with an elevated low-side pressure indicates too much refrigerant is flowing through the evaporator. A stuck-open or oversized expansion device allows excess liquid refrigerant into the evaporator, which cannot fully vaporize the increased volume. The excess liquid refrigerant raises the low-side pressure while the high side remains near normal because the condenser is handling the total charge normally.

94. C — The heater produces adequate heat (ruling out heater core and coolant issues), but the air is not reaching the windshield defroster outlets. The HVAC mode door — which directs airflow between floor, panel, and defroster outlets — is either stuck, disconnected, or the control is not selecting the defroster position. A failed mode door actuator or a disconnected linkage prevents airflow from being directed to the defroster ducts.

95. D — The system specification is 1,800 grams and only 950 grams were recovered. The 850-gram deficit represents refrigerant that has escaped through a leak. The leak must be located and repaired before the system is evacuated and recharged to the full 1,800-gram specification. Charging a leaking system wastes refrigerant and delays the repair.

96. A — The pressurization fan is designed to push air into the cab, creating positive pressure that pushes air outward through any gaps. If ambient air is being drawn inward through the door seals, the cab has negative pressure — the fan is pulling air out rather than pushing it in. A wiring error or a failed motor running in reverse is the most likely cause.

97. B — The diesel-fired heater draws fuel from the main machine fuel tank. Ten hours of continuous operation at 0.5 L/hr consumes 5 litres of fuel. If the fuel tank was not full before the overnight heating period, the 5-litre consumption could lower the fuel level below the supply line pickup point, causing air ingestion into the fuel system when the engine is started.

98. C — Displacement = (Flow ÷ RPM) × 1,000 = (80 ÷ 1,500) × 1,000 = 0.0533 L/rev × 1,000 = 53.3 cm^3/rev. This calculation converts the measured flow rate and known drive speed into the pump's volumetric displacement per revolution, which is used to verify pump specification and assess pump condition.

99. D — The differential pressure indicator confirms the filter element has reached its maximum dirt-holding capacity. Oil is now flowing through the bypass valve unfiltered, recirculating all contamination through the system. The filter element must be replaced immediately to restore filtration. The indicator should be reset after element replacement.

100. B — Smooth extension but jerky retraction — with the DCV, pump, and relief valve confirmed correct — points to a problem on the cylinder's rod-end side. Trapped air in the rod-end chamber compresses during the retraction stroke (when rod-end pressure builds to push the piston). The compressible air pocket alternately compresses and expands, producing the jerky, spongy retraction motion.

101. A — The pump delivers 95 L/min at zero pressure and 82 L/min at 250 bar rated pressure. The 13.7% flow reduction between no-load and rated pressure represents internal leakage through the pump's clearances under operating pressure. For an axial piston pump, this is within the acceptable volumetric efficiency range, confirming the pump is serviceable.

102. D — A pressure-reducing valve spool that is stuck in the open position allows unrestricted main system pressure to pass through to the sub-circuit without regulation. The valve's regulation function depends on the spool moving to restrict flow when downstream pressure reaches the set point. A stuck spool cannot restrict, so full system pressure is delivered to the sub-circuit.

103. C — A load-sensing system relies on the LS pilot line to communicate the highest active circuit pressure back to the pump controller. If this pilot line is blocked or disconnected, the pump receives no feedback signal and defaults to maximum displacement and maximum pressure — producing the 180 bar reading in neutral instead of the expected 25 bar standby.

104. A — With the DCV spool confirmed leak-free, the next component to test is the cylinder itself. Internal piston seal bypass allows oil to leak from the pressurized cap-end (loaded by the boom's weight) to the lower-pressure rod-end across the worn piston seals. This slow internal transfer produces the gradual boom drift without visible external leakage.

105. D — Normal system pressure readings during both the loaded and unloaded states confirm the governor and compressor are functioning correctly. The rapid cycling — charging to cut-out then quickly falling to cut-in — indicates stored air is escaping through a leak. The leak depletes the reservoir between compressor cycles, causing the governor to reload the compressor much sooner than normal.

106. B — The motor inlet pressure reaches rated pressure (confirming the system can generate adequate force), but the motor produces less torque than expected. Excessive case drain flow indicates high-pressure fluid is bypassing through worn internal clearances inside the motor rather than acting on the motor's working elements. This internal leakage reduces the effective pressure differential that produces output torque.

107. C — Hydraulic hose reinforcement — typically braided or spiralled steel wire — degrades internally from heat cycling, pressure fatigue, and chemical interaction with the hydraulic fluid. This degradation is invisible from outside the hose. A hose that appears perfect externally may have wire reinforcement that is corroded, fatigued, or weakened to the point of imminent failure. The OEM time-based replacement interval accounts for this hidden degradation.

108. D — The correct pre-charge pressure = minimum working pressure × 0.90 = 150 bar × 0.90 = 135 bar. Pre-charging to 90% of minimum working pressure ensures the bladder is not fully compressed against the shell at minimum system pressure (which would damage the bladder) while maximizing the usable oil volume stored in the accumulator.

109. A — During the one-week idle period, oil drains from the hydrostatic loop through internal clearances in the pump and motor back to the reservoir. When the engine starts, the charge pump must refill the loop volume and build charge pressure before the main pump can develop working pressure. This refill period produces the several-second hesitation before the machine begins to move.

110. C — The collapse pressure rating is the maximum differential pressure the filter element can withstand before the element structure physically fails (collapses). If the element clogs and the pressure drop across it exceeds 30 bar, the element collapses inward, tearing the media and releasing all captured contaminants downstream into the clean circuit — a catastrophic filtration failure.

111. A — Low charge pressure is a symptom — not a cause. Simply increasing the relief valve setting masks the underlying problem without correcting it. The root cause could be a worn charge pump with reduced output, leaking charge circuit seals, excessive main loop internal leakage, or a combination. Increasing the relief setting may temporarily raise the gauge reading while the actual problem continues to worsen.

112. D — The automatic drain valve's failure to purge means moisture-laden compressed air passes directly from the wet tank to the service reservoirs without any moisture removal at the primary collection point. This moisture accumulates throughout the brake system, degrades the rubber components in valves and chambers, corrodes metal surfaces, and freezes in cold weather — potentially blocking air passages to the brakes.

113. C — Power (kW) = (bar × L/min) ÷ 600 = (200 × 100) ÷ 600 = 20,000 ÷ 600 = 33.3 kW. This formula converts hydraulic pressure and flow into kilowatts of hydraulic power output, which is used to verify system performance, match pump capacity to engine power, and calculate heat generation for cooler sizing.

114. A — A shuttle valve automatically routes the higher of two inlet pressures to its single outlet port. When the higher-pressure inlet dominates, it shifts the internal shuttle element to block the lower-pressure inlet and connect the higher-pressure source to the outlet. This is used to provide a pilot signal from whichever circuit is operating at the highest pressure.

115. B — Sudden onset of pump noise with correct oil level and temperature points to a sudden change in suction conditions. A cracked suction hose, a loose suction fitting, or a failed pump shaft seal allows atmospheric air to enter the pump inlet. The entrained air produces the characteristic loud, harsh aeration noise as it compresses and expands inside the pump's displacement chambers.

116. D — The flushing valve is the sole mechanism for exchanging hot closed-loop oil with cooled, filtered reservoir oil. With the valve stuck closed, no heat is rejected from the loop and no fresh filtered oil enters. Loop temperature rises progressively with each pass until the oil degrades, components overheat, and the system derates or shuts down on thermal protection.

117. C — The tractor protection valve closes at approximately 415–480 kPa (60–70 PSI) to isolate the tractor's air supply from the trailer circuit. This threshold is set high enough to preserve sufficient air in the tractor's reservoirs for its own braking capability while still providing trailer braking down to that pressure level.

118. A — With steering response confirmed normal, the priority valve is delivering adequate flow to the steering circuit. If the implement response is sluggish, the priority valve may be directing more flow to steering than necessary — the spool setting, spring tension, or adjustment may be diverting excessive flow to the steering circuit at the expense of the implement circuit's excess flow allocation.

119. D — The Type 30/30 designation indicates both sections — the service brake diaphragm and the spring brake diaphragm — have an effective area of 30 square inches. The braking force each section produces equals the effective area multiplied by the applied air pressure, so equal areas mean equal force-generating capability for a given pressure input.

120. C — The cross-port relief valves absorb the kinetic energy of the swinging upper structure during a swing stop by converting it to heat in the hydraulic fluid. If the relief settings are too high, the upper

structure must build more momentum-induced pressure before the reliefs open and begin absorbing energy — allowing the structure to coast further past the intended position before decelerating.

121. B — The hose internal diameter must be sized to carry the required flow rate at a fluid velocity that does not exceed the OEM's maximum recommended velocity for the specific circuit location. Excessive velocity causes turbulence, heat generation, pressure loss, and noise. Different velocity limits apply to pressure lines, return lines, and suction lines.

122. A — Adding a third parallel filter increases the total filtration surface area available to the system. With more filter area, the flow velocity through each individual element decreases, the dirt-holding capacity increases, and the service interval extends. This is a common solution when the original filter configuration cannot maintain the required cleanliness level.

123. D — Porosity is a gas pocket trapped in the molten weld metal during solidification. It appears as a small, circular void on the weld bead surface and may indicate additional subsurface voids within the weld body. Porosity is caused by shielding gas deficiency, moisture contamination, or incorrect welding parameters and reduces the weld's effective cross-section and fatigue strength.

124. B — Wear marks and metal deformation on the chisel tool shank at the retaining pin contact area indicate the retaining pin or the tool bushing has worn, allowing the chisel to move excessively inside the breaker housing. The excessive movement allows the chisel to impact the pin contact zone with each breaker cycle, deforming the shank. The pin and bushing must be inspected and replaced.

125. A — The OEM-specified quick-release pin with a hair-clip retainer is designed for the specific dynamic loading conditions of bucket operations and provides easy visual verification of correct installation. A bolt and nut may appear secure initially but can loosen under the severe vibration and impact loading of bucket work. The OEM retention system must be used.

126. C — The remaining base plate thickness must be measured and compared to the OEM minimum specification. If the thinning has reduced the plate below the minimum, the structural integrity is compromised and the plate must be repaired (weld buildup or section replacement) before new liner plates are installed. Liner plates protect the base plate from further wear but do not restore structural capacity already lost.

127. B — Difficulty engaging the coupler on one specific attachment while all others engage easily isolates the problem to that attachment's connection interface. Worn pins with a reduced diameter or

damaged pin surfaces prevent the coupler's locking mechanism from achieving full engagement. Measuring the pin diameter and inspecting for damage confirms whether the pins require replacement.

128. D — The weld toe is the highest-stress location in a welded joint — the geometric transition between the weld bead and the base metal creates a stress concentration that magnifies the applied stress. Fatigue cracks preferentially initiate at this point because the concentrated stress exceeds the material's fatigue limit at the weld toe before it is exceeded at any other location. The paint bubbling confirms moisture has been promoting corrosion that accelerates the fatigue process.

129. A — The stabilizer legs, their geometry, and the machine's rated load charts are designed as an integrated system. Widening the stabilizer spread beyond the OEM specification may overload the stabilizer leg structure, cylinders, or frame mounting points. It also invalidates the rated capacity charts that the operator relies on for safe lift planning.

130. C — The operator seat is integral to the ROPS restraint system. The seat belt anchor points, the seat mounting to the cab floor, and the cab mounting to the frame form a continuous chain that keeps the operator within the protective envelope during a rollover. A fabricated adapter plate that has not been tested or approved by the OEM or seat manufacturer may fail under the extreme loads of a rollover event.

131. B — A self-locking nut that has backed off two turns may have allowed the pin to move and sustain damage from the dynamic loading of excavation cycles. The pin and bore must be inspected for wear or damage from the period of loose operation. The self-locking nut must be replaced (not reused) because self-locking nuts lose their locking effectiveness once disturbed. All remaining counterweight fasteners should be torqued to specification.

132. C — The voltage measurement after the service disconnect is opened and the wait time has elapsed confirms all HV energy has been discharged. Capacitors in the inverter and other HV components can retain dangerous voltage for extended periods even after the main power source is disconnected. The measurement is the mandatory final verification that the circuit is at zero energy before any hands-on work begins.

133. A — At cold temperatures, the battery's internal resistance increases significantly. The BMS limits the maximum charging current (and therefore the regenerative braking force) to prevent exceeding the cells' safe charging rate at the elevated internal resistance. Less charging current means less electrical resistance against the motor's rotation, which reduces the available regenerative braking deceleration force.

134. D — The battery enclosure ventilation system is designed to evacuate any gases released by the cells during a thermal event — including flammable hydrogen and toxic hydrogen fluoride from lithium-ion cell decomposition. The ducting routes these gases outside the machine, preventing dangerous gas concentrations from accumulating inside the sealed enclosure where they could explode or expose personnel.

135. B — The battery-electric machine eliminates the diesel engine, multi-speed transmission, exhaust after-treatment system (DPF, DOC, SCR, DEF), and all associated fluids and filters — engine oil, coolant, transmission oil, DEF, fuel filters, oil filters, air filters, and coolant filters. This dramatically reduces both the number of maintenance items and the frequency of scheduled service events.