

**RED SEAL EXAM PREP**

# **421A Heavy Duty Equipment Technician**

Free 50-Question Mock Exam

Practice for the Red Seal / Certificate of Qualification exam

Pass mark: 70% · Aligned to the published occupational standard topic weightings  
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## Mock Exam — answer all questions, then check the key

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**Q1.** A loader with electronic climate control keeps steaming up the windshield in wet weather. Coolant level is correct, there is no sweet smell in the cab and the floor mat is dry, and the blend door tracks its commands. The module keeps selecting recirculated air with the compressor switched off. Which input should the technician check?

- A) The engine coolant temperature sensor feed to the module
- B) The humidity sensor input to the heating control module
- C) The cab pressure switch feeding the pressurizer control
- D) The evaporator temperature sensor signal at key-on

**Q2.** While diagnosing a no-cooling complaint, a technician considers jumpering the low-pressure switch connector to force the compressor clutch to engage on a system reading well below normal charge. What is the main risk of running the compressor this way?

- A) Clutch coil burnout from bypassing its resistor circuit
- B) Compressor seizure from oil starvation at low refrigerant flow
- C) Evaporator icing from continuous uncontrolled clutch engagement
- D) Condenser overpressure from unrestricted refrigerant circulation

**Q3.** A wheel loader equipped with oil-cooled wet disc brakes develops brake drag after a brake system repair. The repair included replacing brake cooling oil seals but not the disc packs. What is the MOST likely cause of the drag?

- A) Residual apply pressure is keeping the pistons clamped, or the piston return spring is damaged or missing
- B) The brake cooling oil pressure is too high — exceeding 20 PSI will apply the brake discs
- C) Wet disc brakes inherently drag slightly — this is normal and acceptable
- D) The brake cooling oil is too viscous, creating drag between the spinning and stationary discs

**Q4.** A technician finds a diode in a machine charging circuit that is shorted (zero resistance in both directions). The diode is in the alternator diode bridge. What symptom will this cause?

- A) Reduced charging output and battery drain when parked
- B) No effect — one shorted diode in a 3-phase bridge has minimal impact
- C) Overcharging — short circuit removes regulation
- D) No charging — alternator cannot produce current

**Q5.** A heavy equipment air brake system has a low air pressure warning light that activates at 80 psi but the system should have 120 psi. A compressor cycle test shows the compressor builds from 100 to 120 psi in 30 seconds and cuts out at 120 psi. What component is MOST likely leaking?

- A) Governor — cutting out prematurely at 120 psi
- B) Air compressor — cannot maintain pressure after cut-out
- C) Air dryer — moisture bypass is diluting the air supply
- D) A system air leak downstream of the compressor

**Q6.** A hydraulic oil sample is reported as ISO 4406 cleanliness code 22/20/17. What does this three-number code represent, and is this acceptable for a servo-hydraulic system with tight-tolerance components?

- A) The code indicates the oil has passed cleanliness testing — higher numbers indicate cleaner oil
- B) Particle count ranges at 4µm, 6µm, and 14µm — heavily contaminated oil, not acceptable for servo systems
- C) The three numbers represent viscosity, oxidation level, and water content — 22/20/17 is within normal limits for any hydraulic system
- D) ISO 4406 only applies to transmission oils — hydraulic systems use a different cleanliness standard

**Q7.** A technician notices a hydraulic hose with a small pinhole leak. What is the SAFEST way to check for the leak?

- A) Run a bare hand along the hose to feel for moisture
- B) Use a rag to wipe the hose while the system is running
- C) Increase system pressure to confirm location
- D) Use a piece of cardboard or wood to detect the spray

**Q8.** What does the lock-up clutch in a torque converter do once it engages?

- A) Couples the engine to the turbine mechanically
- B) Lets the stator freewheel at high turbine speed
- C) Multiplies engine torque at the turbine output
- D) Holds the converter charged with cooled oil

**Q9.** A mounting bolt is missing from a dozer's certified ROPS. The shop has a grade 5 bolt of the same thread, length and head size on the shelf. What is the correct action?

- A) Fit the OEM-specified bolt at the OEM torque value
- B) Fit the grade 5 bolt torqued to grade 5 specifications
- C) Fit the grade 5 bolt now and install the OEM bolt later
- D) Fit the grade 5 bolt with a lock washer and thread locker

**Q10.** A hydrostatic drive machine has a closed-loop circuit. The machine exhibits drift in one direction when the joystick is in neutral. There are no external leaks. What is the most likely cause, and what test confirms it?

- A) The charge pump is producing too much pressure — excess charge pressure pushes the motor in one direction
- B) The crossport relief valves are set too high — high relief settings allow the motor to be driven by external load
- C) The hydraulic oil is too hot — high oil temperature reduces viscosity, causing the motor to drift under load
- D) Internal bypass in the variable pump or motor — confirmed by measuring case drain flow from each

**Q11.** In a PARALLEL circuit, what is always the same across all branches?

- A) Resistance
- B) Current
- C) Power
- D) Voltage

**Q12.** A wheel loader with hydraulic-boosted service brakes has a spongy pedal that requires excessive travel to achieve normal braking. Fluid level is full and no external leaks are present. What is the MOST likely cause?

- A) Air entrained in the hydraulic brake system circuit
- B) Brake disc/pads are worn beyond service limits
- C) Hydraulic boost pressure is too low — booster assist is inadequate
- D) Master cylinder primary cup has deteriorated — fluid bypasses the seal

**Q13.** On a hybrid excavator, which of the following qualifies as an 'insulated tool' of the kind CSA Z462 requires where contact with energized parts is possible?

- A) A tool marked with the double-triangle 1000 V symbol
- B) A wrench with moulded rubber grips from the shop cart
- C) A chrome wrench wrapped in electrical tape by the tech
- D) A tool with a plastic-coated handle for corrosion control

**Q14.** A turbocharged diesel engine has progressively increasing crankcase pressure (blowby) over 1,000 service hours. Engine oil consumption has also increased proportionally. What is the MOST likely cause?

- A) Coolant leak into oil — increasing volume causes pressure buildup
- B) Progressive piston ring wear — combustion gases bypassing rings into crankcase
- C) Turbocharger seal failure — boost pressure entering crankcase
- D) PCV (crankcase ventilation) valve stuck closed

**Q15.** A hydrostatic-drive machine has failed in the field and must be winched onto a float. What must be done to the drive system before it is towed?

- A) Drain the closed loop so no oil is forced through it
- B) Back the charge relief valve out to unload the loop
- C) Open the loop bypass valves so the motors can turn
- D) Set the drive levers to neutral and lock the console

**Q16.** A technician is lubricating all grease fittings on an articulated dump truck during a 250-hour service. One fitting accepts very little grease before pressure rises significantly. No grease appears at the joint seal. What should the technician do?

- A) Apply extra pressure — force the grease past the blockage
- B) Investigate for a blocked fitting or a fully packed joint
- C) Skip this fitting — the joint is adequately lubricated from last service
- D) Replace the grease fitting — Zerk fittings fail over time

**Q17.** A crawler dozer fitted with a Level I FOPS is being reassigned from roadside utility work to overhead demolition. What does this change of application require under ISO 3449?

- A) A site-specific drop test of the existing canopy
- B) A Level II FOPS rated for heavy falling objects
- C) A second Level I canopy stacked above the first
- D) A thicker polycarbonate front windshield fitted

**Q18.** A dozer cranks slowly and the operator reports a burning smell. The braided engine-to-frame ground strap is found broken, and a hydraulic hose running from the engine-mounted pump to a frame-mounted valve is scorched at both of its end fittings. What accounts for the damage to the hose?

- A) The starter draws far more current than its rating when its ground path opens
- B) Cranking current is returning to the battery through the hose fittings and braid
- C) Static charge collected on the hose once the strap stopped bonding the engine
- D) The hose sheath was scorched by chafing where it is clamped against the frame

**Q19.** What is the primary purpose of a hydraulic oil cooler on heavy equipment?

- A) To increase hydraulic fluid viscosity during cold starts
- B) To keep hydraulic oil within its designed temperature range
- C) To pressurize the hydraulic reservoir
- D) To separate water from hydraulic fluid

**Q20.** What is the purpose of the EGR (Exhaust Gas Recirculation) system on a modern diesel engine?

- A) To reduce NOx emissions by lowering peak combustion temperature
- B) To preheat the intake air during cold starts
- C) To improve fuel economy by recovering exhaust energy
- D) To increase engine power by recirculating exhaust gases for a second combustion cycle

**Q21.** The Komatsu HB215LC hybrid excavator stores swing-regeneration energy in an ultracapacitor rather than a battery PRIMARILY because ultracapacitors:

- A) Charge and discharge much faster than batteries can
- B) Operate below the 60 V DC high-voltage threshold
- C) Store far more total energy for a given unit weight
- D) Are unaffected by vibration and high ambient heat

**Q22.** A machine's parking brake solenoid must be energized to release the spring-applied brake. The solenoid resistance is  $25\ \Omega$  and system voltage is 24V. What is the current draw and power consumption of this solenoid?

- A)  $I=24A$ ,  $P=576W$
- B)  $I=600mA$ ,  $P=14.4W$
- C)  $I=0.96A$ ,  $P=23W$
- D)  $I=1.2A$ ,  $P=28.8W$

**Q23.** A diesel engine equipped with a diesel particulate filter (DPF) triggers an active regeneration cycle. What conditions are required for active regeneration to begin, and why does regeneration fail in city/stop-and-go driving?

- A) Active regen needs sustained load and exhaust temperature — short city cycles interrupt it before completion
- B) Active regen is triggered only by a technician scan tool command — it does not occur automatically
- C) Active regen requires the DPF to be fully clogged — partial loading does not trigger the cycle
- D) Active regen requires engine at idle for 20 minutes — city driving provides this, so city operation actually helps regen

**Q24.** A technician inspects a planetary gear set and finds a cracked sun gear. The planetary system had been operating with occasional impact loads from ground engagement. What is the MOST likely failure mechanism?

- A) Spalling fatigue — cyclic contact stress exceeded material endurance limit
- B) Corrosion fatigue — the gear operated in wet/salty conditions
- C) Thermal fatigue — heat cycles from braking caused surface cracking
- D) Impact fracture — sudden high-stress loading exceeded material yield strength

**Q25.** A cylinder head bolt specification reads: tighten to 55 N.m, then turn an additional 90 degrees. Which of the torque procedures named in RSOS A-3.06 does that describe?

- A) Torque pattern, a numbered tightening sequence
- B) Torque stages, in rising torque steps
- C) Torque check, re-verifying a set fastener
- D) Torque turn, torque then measured rotation

**Q26.** On a wheel loader AC system equipped with a thermostatic expansion valve (TXV), where is the receiver-drier located?

- A) In the low-pressure line between the TXV outlet and the evaporator
- B) In the low-pressure vapor line between the evaporator and compressor
- C) In the high-pressure vapor line between the compressor and condenser
- D) In the high-pressure liquid line between the condenser and the TXV

**Q27.** A diesel engine cooling system is operating at 103°C (normal thermostat spec: 85-95°C). The fan clutch is engaged and the cooling system has no external leaks. What should the 421A technician check FIRST?

- A) Check for combustion gases in coolant using a block tester (combustion gas check)
- B) Pressure test the cooling system — verify coolant is reaching proper pressure to raise boiling point
- C) Replace the thermostat — at 103°C it is clearly defective
- D) Check for a plugged radiator core or restricted coolant flow

**Q28.** A machine ECM is experiencing high-voltage damage events. Investigation reveals voltage spikes up to 80V on the electrical system. The machine has an inductive load (solenoid) that is switched frequently. What component is **MOST** likely the source of the voltage spikes?

- A) ECM processor is failing and generating noise on the bus
- B) Battery positive cable has high resistance — causing voltage buildup
- C) Alternator — producing unregulated output voltage
- D) Inductive kickback from the frequently switched solenoid

**Q29.** A dozer at operating temperature cranks slowly. A clamp on the starter feed shows cranking draw well above the starter's specified figure. The starter has been removed and bench tested, and its free-running speed and current draw are within specification. What does this pattern point to?

- A) Batteries that cannot sustain the cranking load
- B) Shorted windings inside the starter motor armature
- C) Resistance in the starter feed and ground path
- D) Mechanical drag in the engine or its accessories

**Q30.** A hydraulic system has a counterbalance valve installed on the rod side of a lift cylinder to prevent uncontrolled lowering under negative loads. The cylinder now lowers extremely slowly even with full spool travel. What adjustment is needed?

- A) Decrease the counterbalance valve setting — valve is set too high and is restricting free return flow
- B) Increase the counterbalance valve setting — valve is holding at too high a pressure
- C) Decrease the counterbalance valve pilot ratio — valve is not opening fast enough with available pilot pressure
- D) Replace the counterbalance valve — slow lowering indicates internal failure

**Q31.** A worn axial piston pump has been replaced on a wheel loader. What must be done before the engine is started for the first time?

- A) Back the main relief off, then reset it after the first run
- B) Run the engine at full throttle to prime the new pump fast
- C) Set the pump to maximum displacement before the first start
- D) Fill the pump case with clean oil and bleed the suction line

**Q32.** A technician reviews oil analysis results for a heavy equipment engine. The report shows: silicon = 28 ppm (normal <10), iron = 45 ppm (normal <30), lead = 8 ppm (normal <5). What do these results indicate together?

- A) Fuel dilution — diesel fuel contains trace silicon from fuel system wear
- B) Coolant leak — high Si indicates antifreeze glycol contamination
- C) Dirt ingestion causing accelerated iron wear and bearing wear
- D) Normal wear patterns — all values within range for this hour interval

**Q33.** A quick-release valve is installed close to the brake chambers. Its function is to:

- A) Limit maximum brake application pressure
- B) Provide a secondary pressure source for emergency braking
- C) Exhaust brake air rapidly at the chamber to reduce brake release time
- D) Balance pressure between front and rear axle brakes

**Q34.** A dozer equipped with a certified ROPS was involved in a rollover, and the ROPS posts are visibly bent. What must happen before the machine returns to service?

- A) Straighten the posts using controlled heat and jacks
- B) Reinforce the bent areas with welded fish plates
- C) Replace the ROPS per the manufacturer's requirements
- D) Sleeve the bent posts with heavy-wall structural tubing

**Q35.** A pump is rated 100 L/min at 2,000 rpm and 200 bar. At those conditions a 421A tech measures 85 L/min of actual output. What is the volumetric efficiency, and what does the reading mean?

- A) 15% — efficiency is stated as the share of the flow that is lost
- B) 85% — pressure rather than flow decides volumetric efficiency
- C) 85% — the output a new pump of this size is expected to deliver
- D) 85% — about 15% of pump displacement is lost to internal leakage

**Q36.** The engine has started, but the starter motor keeps cranking after the key is released. What should the technician do immediately?

- A) Let it run - the overrunning clutch protects the starter drive
- B) Rev the engine so the flywheel throws the pinion out of mesh
- C) Disconnect the battery ground cable to stop the starter at once
- D) Hold the key in the start position until the starter disengages

**Q37.** Engine oil pressure drops suddenly at operating temperature. The FIRST component to inspect is:

- A) Crankshaft ventilation system
- B) Oil filter bypass valve
- C) Engine oil cooler
- D) Oil pump and relief valve

**Q38.** After rebuilding a hydraulic brake caliper, the brake drags during initial operation. The caliper pistons were replaced and the slides were lubricated. During diagnosis, the brake hose is found to be deteriorated internally. How does a deteriorated brake hose cause brake drag?

- A) A deteriorated hose restricts brake fluid flow, reducing hydraulic pressure to the caliper and causing partial engagement
- B) A deteriorated hose allows air ingestion into the system, creating a partial air lock that holds the caliper pistons applied
- C) The collapsed inner lining acts as a one-way check valve — fluid enters under pedal pressure but cannot return
- D) Internal hose deterioration reduces hose flexibility, causing it to transmit vibration that continuously applies the brake pedal

**Q39.** After replacing a receiver-drier on a skidder, the technician pulls the system into a deep vacuum and holds it there before recharging. What is the main purpose of this evacuation step?

- A) To verify the clutch coil operates under low-load conditions
- B) To boil off moisture and remove air from inside the system
- C) To distribute refrigerant oil evenly through the system lines
- D) To seat the compressor shaft seal before adding refrigerant oil

**Q40.** After installing a wheel on an articulated dump truck, the technician torques the nuts to specification in a star (criss-cross) sequence. The required follow-up is to:

- A) Coat each stud with thread-locking compound while warm
- B) Loosen and fully re-seat the wheel after the first shift
- C) Re-check the nuts only at the next 250-hour service
- D) Re-torque the nuts after the first short period of operation

**Q41.** A boom cylinder with a 2:1 area ratio extends roughly five times slower than it retracts at the same pump flow. Relief pressure is correct and a bypass test shows no leakage past the piston. The most likely cause is:

- A) Relief valve pressure set too high for the boom circuit
- B) A regenerative extend circuit active in the control valve
- C) Worn piston seals letting fluid bypass inside the cylinder barrel
- D) A restriction in the cap-end supply circuit to the boom cylinder

**Q42.** A diesel engine is equipped with an EGR (Exhaust Gas Recirculation) system. The technician finds the EGR valve stuck fully open. What performance symptoms will the operator likely notice?

- A) High oil consumption — EGR increases blow-by
- B) Engine will not start — EGR must be closed for cold start
- C) Rough idle, poor throttle response, and black exhaust smoke
- D) Engine overheating — EGR recirculates hot exhaust gases into the intake

**Q43.** A large loader tire has been assembled onto a multipiece rim and secured in an approved inflation cage. Under WorkSafeBC's OHS Regulation, what must the person inflating it do?

- A) Set the regulator to the required pressure and step away
- B) Stay clear while the beads seat, then approach to top up
- C) Watch the lock ring closely while the pressure comes up
- D) Stay clear of the trajectory and watch the pressure

**Q44.** During an in-frame overhaul of a wet-sleeve diesel engine, the coolant side of the cylinder liners shows deep, clustered pitting. What caused this damage?

- A) Cavitation erosion from liner vibration and depleted coolant SCA
- B) Electrolysis from stray electrical current in the cooling system
- C) Scale deposits from hard water used to top up the coolant level
- D) Acid etching from combustion gas leaking past the head gasket

**Q45.** In a powershift transmission, clutch engagement is controlled by:

- A) Hydraulic pressure from the control valve
- B) Engine vacuum and a centrifugal governor
- C) A mechanical foot clutch pedal
- D) Manual lever directly linked to the clutch packs

**Q46.** A technician is checking a grader frame for bend, twist and misalignment. Which set of tools does the 421A standard name for inspecting structural components?

- A) Laser alignment tools, calipers and straight edges
- B) Flow meters, wear gauges and pressure gauges
- C) Dial indicators, plumb bobs and a water level
- D) Borescopes, coating thickness gauges and chalk lines

**Q47.** A technician is performing a torque converter coupling phase test. When does the torque converter enter coupling phase and what happens to torque multiplication at that point?

- A) Coupling phase is a failure mode — normal converters do not enter coupling phase
- B) Coupling phase begins at ~90% of impeller speed — multiplication drops to 1:1
- C) Coupling phase begins when stator locks — torque ratio increases to maximum
- D) Coupling phase begins at stall — provides maximum torque when the turbine is stationary

**Q48.** During a hydraulic pump flow test, the pump output flow is 15% below specification at rated pressure. However, at low pressure, the flow is normal. This indicates:

- A) Relief valve opening too early
- B) Excessive internal bypass in the pump
- C) Air cavitation in the suction line
- D) A blocked hydraulic filter

**Q49.** The safety protocols listed in sub-task A-1.04 include maintaining a zero energy state. As the standard words it, that requirement is scoped to:

- A) Only equipment above 1,000 volts DC
- B) Any machine with a 24 V starting circuit
- C) All-electric equipment and attachments
- D) Hybrid equipment only, during charging

**Q50.** What does a diesel engine's "fuel trim" (injection quantity correction) data on a scan tool indicate when it shows a consistently high positive correction on all cylinders?

- A) The engine is in cold-start enrichment mode
- B) The throttle position sensor is reading high
- C) The ECM is adding fuel to compensate for insufficient delivery
- D) Injectors are delivering too much fuel — trim is reducing injection

## Answer Key & Explanations

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### Q1. Answer: B

A steaming windshield has two very different causes and this stem separates them deliberately. A leaking heater core puts warm coolant vapour into the cab, and the occupational standard names steaming windshield and coolant smell together as heating system symptoms for that reason. Here there is no coolant smell, the level is holding and the floor is dry, so the core is not the source. What is left is the dehumidification logic. An electronic system defogs by selecting fresh outside air and running the A/C compressor, because a cold evaporator condenses moisture out of the air before it is reheated and sent to the glass. If the humidity sensor reports falsely dry air, the control module sees no reason to do either, so it stays on recirculation with the compressor off and traps the moisture the operators bring in on wet clothing. The standard names humidity sensors, temperature sensors and heating control modules as electronic control components.

### Q2. Answer: B

**Refrigerant carries the oil, so running a low-charge system starves the compressor of lubrication.** The low-pressure switch exists precisely to prevent this: with little refrigerant circulating, oil stops moving through the system and the compressor can score and seize. Jumpering the switch is acceptable only very briefly as an electrical diagnostic, never as a way to operate a low system.

### Q3. Answer: A

**Wet disc brake drag: residual apply pressure or failed return spring preventing full piston retraction.** Wet disc brakes use separate apply and cooling oil circuits. After the brake pedal is released, the apply circuit must fully depressurize to allow the piston to retract. A trapped pressure pocket (check valve, restricted return line, or pressure metering valve not returning to zero) keeps the piston partially applied and the discs partially clamped. A damaged or missing return spring cannot push the piston back. Test: measure apply circuit pressure at brake with pedal fully released — should be 0 PSI. Also measure brake cooling oil temperature — drag generates excess heat.

### Q4. Answer: A

**A shorted diode in an alternator rectifier bridge has two effects — AC current passes to the battery instead of being rectified.** 1) Reduced output: the shorted diode allows reverse current flow, reducing the effective rectification. 2) Battery drain when alternator is not spinning: the shorted diode creates a path for battery current to flow backwards through the stator winding to ground. This discharges the battery when parked. Symptom: dead battery after overnight + reduced charge rate when running.

### Q5. Answer: D

**Compressor builds to 120 psi correctly, but system drops to 80 psi triggering the warning — this is a downstream leak, with air escaping faster than the compressor maintains when stationary.** The compressor output is confirmed good (builds pressure, cuts out at spec). The pressure drop after cut-out is caused by air escaping through a leak in the system (brake chambers, supply lines, fittings, drain valves). Perform a static leak test: engine off, brakes released, monitor pressure drop rate. Should not exceed 2 psi/minute for service brakes.

**Q6. Answer: B**

**ISO 4406: three numbers = particle count ranges at  $\geq 4\mu\text{m}$ ,  $\geq 6\mu\text{m}$ ,  $\geq 14\mu\text{m}$ . Higher number = dirtier oil.** Each increment of 1 in the ISO code represents doubling the particle count. Code 22 means 20,000–40,000 particles per mL at  $\geq 4\mu\text{m}$ . Servo valves have bore clearances of just 1–5 $\mu\text{m}$  — even particles much smaller than visible can cause valve erosion and stiction, so servo systems typically require ISO 16/14/11 or cleaner. Typical cleanliness requirements: servo valves = ISO 16/14/11; piston pumps = ISO 17/15/12; gear pumps = ISO 20/18/15. Code 22/20/17 would rapidly destroy precision components.

**Q7. Answer: D**

**Use cardboard or wood only.** High-pressure hydraulic fluid injection through skin (hydraulic injection injury) is a medical emergency. Never use bare hands. Pressure >100 PSI can inject fluid through skin without visible puncture.

**Q8. Answer: A**

**The lock-up clutch takes the fluid out of the drive path.** A torque converter always slips a little, and slip becomes heat and burnt fuel. When conditions allow it - enough speed, light enough load, oil warm - the transmission control applies a clutch that locks the converter cover to the turbine, giving a solid connection with no slip at all. Torque multiplication is the stator's work and is over long before that point, and the stator freewheels in the coupling phase whether the clutch is applied or not. A worn or cycling lock-up clutch shows up as shudder on apply, high converter-out oil temperature and lost fuel economy.

**Q9. Answer: A**

**ROPS mounting hardware is part of the certified structure, so only the specified fastener at the specified torque is acceptable.** The mounting bolts are what transfer rollover loads from the structure into the frame, and their grade, size and torque are set by the manufacturer's service information, not chosen in the shop. A bolt that matches only in thread, length and head size is not the specified bolt, and neither a lock washer, thread locker nor a "temporary" fit changes that. Provincial OHS rules also tie ROPS integrity to the manufacturer or an engineer: for example, Alberta's OHS Code requires any addition, modification, welding or cutting of a ROPS to be done in accordance with the instructions of, and re-certified by, the equipment manufacturer or a professional engineer, and BC's regulation requires a ROPS to be certified by its manufacturer or a professional engineer, including after any modification or repair.

**Q10. Answer: D**

**Hydrostatic drive drift in neutral = internal bypass in pump or motor.** In a closed-loop circuit, both ports of the motor should be blocked (or at equal charge pressure) in neutral — no net flow = no rotation. If one side of the closed loop loses fluid or pressure faster than the other (internal pump or motor bypass), a pressure imbalance develops, driving the motor slowly. Measure case drain flow from pump and motor separately at identical conditions — excessive case drain = excessive internal bypass in that component.

**Q11. Answer: D**

**Voltage is equal across all parallel branches.** Each branch connects directly between the same two nodes (positive and negative), so all branches see identical voltage. Current divides based on each branch's resistance — lower resistance = more current.

**Q12. Answer: A**

**Air in a hydraulic brake circuit is compressible — unlike brake fluid — causing spongy, high-travel pedal.** Air can enter through: micro-leaks in connections (suction side), air bubbles from aeration (low fluid level at some point), or improper bleeding procedure. Systematic bleeding from the furthest wheel cylinder to the nearest purges air. If bleeding does not correct, suspect a faulty master cylinder seal allowing air to be drawn back in.

**Q13. Answer: A**

**An insulated tool is manufactured and individually dielectrically tested, then marked with the double-triangle symbol and its voltage rating, commonly 1000 V.** The marking is the evidence that the tool was proof tested; without it, nothing about a handle covering has been verified. Comfort grips, corrosion coatings and wraps of electrical tape are insulating in appearance only: they are not continuous over the shank, they were never tested, and tape unwinds under torque. Insulated tools must also be inspected before every use, because a nick, crack or embedded metal chip in the coating destroys the protection.

**Q14. Answer: B**

**Progressive blowby and oil consumption over time = worn piston rings.** As rings wear, combustion pressure bypasses into the crankcase (blowby increases) and oil is drawn past worn rings into the combustion chamber (oil consumption increases). These two symptoms together are classic ring wear indicators. Confirm with a cylinder compression test and cylinder leakdown test.

**Q15. Answer: C**

**A closed loop has no path around it unless you open one.** In a hydrostatic drive the pump and motors are joined in a sealed circuit. Towing the machine turns the motors, and with the pump stopped the oil they push has nowhere to go and nothing replenishing it - the result is a hydraulic lock or, worse, motors turning with no charge oil and no lubrication. Every hydrostatic machine therefore has a tow or bypass valve that opens the two loop sides to each other; the service information gives how far to open it and also caps towing speed and distance, and requires the spring-applied parking brake to be released or mechanically caged. Reset the valve afterwards: a bypass valve left open is a common no-drive complaint after a recovery.

**Q16. Answer: B**

**A grease fitting that builds pressure immediately without taking grease indicates a blockage — do not overpressure; investigate why grease is not moving.** Possible causes: 1) Fitting check ball is stuck (clean or replace fitting). 2) Grease passage in the pin is blocked with hardened old grease. 3) The joint is completely packed (correct — no more grease needed). 4) The pin is seized. Applying excessive force can damage seals. Diagnose before applying pressure: remove the fitting and verify it passes air.

**Q17. Answer: B**

**Overhead demolition demands Level II falling-object protection, not Level I.** ISO 3449:2005 Clause 4 sets two levels: Level I resists a round test object dropped from a height sufficient to develop 1,365 J, suitable for the small debris of highway maintenance, landscaping and other construction site services (Clause 3.4), while Level II resists a cylindrical test object developing 11,600 J from heavy objects such as trees and rocks, for machines used in site clearing, overhead demolition or forestry (Clause 3.5). Stacking canopies or upgrading glazing does not create a certified Level II structure - the structure must be tested and labelled to the level claimed, and Clause 5.2.2 requires windows and other non-structural fittings to be removed for the test precisely because they do not contribute to FOPS strength. In Canada these levels carry legal force through provincial occupational health and safety regulation: Alberta OHS Code Part 19, Section 272(2) requires a falling objects protective structure installed on or after July 1, 2009 to comply with SAE J167 (2002), SAE J/ISO 3449 (2005) or SAE J1042 (2003), and Section 272(3) permits equipment certified by a professional engineer as providing equivalent or better protection instead. Watch the scope limit: ISO 3449 Clause 1 states it is not intended to apply to excavators - a hydraulic excavator operator guard is tested to ISO 10262, which uses the same 1,365 J and 11,600 J acceptance levels.

**Q18. Answer: B**

**Current returns to its source through every conductive path available to it, sharing itself out in inverse proportion to the resistance of each path.** The ground strap is the low-resistance route from the engine block back to the battery, and while it is sound almost all of the cranking current takes it. Broken, that current does not stop flowing - it returns through whatever else still joins the engine to the frame: the steel end fittings and wire reinforcement of a hose, a control cable, a fuel line. Those parts were never sized for hundreds of amperes and they touch over small areas, so they heat where they make contact, which is why the scorching is at the fittings rather than along the hose. The same fault explains the slow cranking: the return path now has far more resistance than it should, so voltage is lost across it and the starter turns on whatever reaches it, rather than drawing more than its rating. Nothing here is a static charge, which cannot deliver that kind of energy, and chafing abrades a sheath rather than burning it at both metal ends. Replace the strap, verify the repair with a voltage-drop measurement from the engine block to the battery negative post while cranking, and inspect every line and cable that carried the current before the machine goes back to work.

**Q19. Answer: B**

**Hydraulic oil cooler: prevents overheating, viscosity breakdown, and component wear.** Hydraulic systems generate heat through inefficiency (pressure drops, internal leakage). Excessive heat breaks down oil viscosity and additive packages, accelerates oxidation, and damages seals. Normal operating range is typically 60–80°C. The cooler maintains this range by transferring heat to ambient air or coolant.

**Q20. Answer: A**

**EGR: introduces cooled exhaust gas into the intake, lowering combustion temp = lower NOx.** NOx (nitrogen oxides) forms at extremely high combustion temperatures. Recirculating inert exhaust gas into the intake dilutes the oxygen content and absorbs heat, reducing peak combustion temperature and NOx formation. EGR is part of the EPA Tier 4/Euro 6 emissions compliance strategy along with SCR/DEF.

**Q21. Answer: A**

**Ultracapacitors excel at power density — rapid charge and discharge.** Excavator swing cycles repeat every few seconds, so the storage device must absorb braking energy and release it for acceleration almost instantly. Capacitors store energy electrostatically (ion migration) rather than through chemical reactions, allowing much faster power transfer than a battery. Their weakness is low total energy density, which is why they suit short, frequent cycles rather than long-duration storage.

**Q22. Answer: C**

**Ohm's law:  $I = V/R = 24/25 = 0.96A$ . Power =  $V \times I = 24 \times 0.96 = 23W$ .** This is useful for sizing the circuit protection (fuse) and wiring. The fuse must be rated above the solenoid's normal draw so it does not blow in service, but no higher than the circuit's wire can safely carry, because the fuse is there to protect the conductor. Use the fuse rating the machine manufacturer specifies for that circuit. The 23W is also used to assess solenoid heat — solenoids designed for continuous duty at this power are typically fine, but intermittent solenoids may overheat if held energized continuously.

**Q23. Answer: A**

**Active regen requires sustained engine load and exhaust temperatures above ~250°C to initiate, and ~550–650°C for soot combustion.** In city driving, the engine rarely reaches sustained load, exhaust temperatures are low (~150–250°C), and frequent stops interrupt the process before completion. The ECM increases fueling (post-injection or 7th injector) to raise exhaust temperatures and burn off accumulated soot. If interrupted repeatedly, soot continues to accumulate. Eventually, the DPF reaches critical restriction — requiring a parked regen or workshop service. Solution: regular highway driving or proper parked regeneration when lamp illuminates.

**Q24. Answer: D**

**A cracked sun gear with a history of impact loads indicates impact fracture, not fatigue.** Fatigue failures are progressive — multiple surface pits and cracks developing over many cycles. Impact fracture from a single or few severe overload events produces a clean, brittle fracture pattern (chevron marks pointing to origin). Ground engagement impact loads (hitting rocks, stumps) can momentarily exceed the gear material's yield strength. Root cause: operator technique or application beyond machine design limits.

**Q25. Answer: D**

A-3.06 names torque stages, torque to yield, torque turn and torque pattern as distinct procedures, and each answers a different question. Torque stages is a series of increasing torque values, such as 40 then 80 then 120 N.m. Torque pattern is the order the fasteners are tightened in, usually working outward from the centre. Torque turn is the method being specified here: a snug torque that seats the joint and takes friction variation out of the equation, followed by a measured angle of rotation that stretches the fastener a controlled amount. The angle, not the torque number, is what sets the final clamp load.

**Q26. Answer: D**

**Receiver-driers sit on the high side; accumulators sit on the low side.** In a TXV system, the receiver-drier is installed in the high-pressure liquid line between the condenser outlet and the TXV inlet, where it stores liquid refrigerant, filters debris and holds desiccant to absorb moisture. An accumulator at the evaporator outlet is used only on orifice-tube systems, and the two are not interchangeable.

**Q27. Answer: D**

**Overheating with fan engaged = not enough heat rejection capacity — a cooling capacity issue.** Fan engaged eliminates fan clutch as the cause. Check: 1) Radiator core plugging (external fin blockage reduces airflow). 2) Internal scale buildup in radiator tubes (reduces heat transfer). 3) Coolant flow rate (water pump worn). 4) Thermostat opening correctly. Start with the radiator core — inspect the fins for external blockage, then verify coolant is flowing through the core before condemning any component.

**Q28. Answer: D**

**Inductive kickback (back-EMF) occurs when current through an inductor (solenoid, relay coil, motor) is suddenly interrupted — inductors resist current change and produce high-voltage spikes when switched off.** The spike is proportional to inductance and the rate of current change, and can reach 10-100× supply voltage for milliseconds. Solution: install a flyback diode (freewheeling diode) across the solenoid terminals in parallel, oriented to clamp the spike.

**Q29. Answer: D**

**A starter draws current in proportion to the load it turns, so draw above specification with the crank speed down means the motor is being loaded, not starved.** Put extra resistance anywhere in the feed or the return path and less voltage reaches the motor: it draws less current than its specification, makes less torque, and cranks slowly. A battery down on charge or capacity produces the same pattern for the same reason. Both of those faults read below the specified draw, which is the opposite of what the clamp shows here, and both are chased down with a voltage-drop test on each side of the circuit and a battery load test. Draw above specification is the other half of the picture: something is making the armature work harder than it should, so it turns more slowly, and as the speed falls the counter-voltage the armature generates falls with it and lets still more current through. That load sits either inside the starter or outside it, and the bench test separates the two, because a starter with shorted armature windings shows excess draw while running free on the bench and this one ran to specification. What is left is drag on the engine side: a failing main or rod bearing, a driven accessory such as a hydraulic pump or air compressor beginning to seize, or an internal failure that has started to bind. Bar the engine over by hand with the starter out, and turn each driven accessory separately, before any parts are ordered.

**Q30. Answer: A**

**A counterbalance valve set too high requires higher pilot pressure to open — restricting lowering speed.** Counterbalance valve setting should be 1.3× the maximum load-induced pressure. If set above this, the valve cracking pressure requires excessive pilot pressure to open. Lower the setting to allow adequate pilot-to-open pressure at normal operating conditions, while still preventing uncontrolled drop.

**Q31. Answer: D**

**A piston pump lubricates itself with the oil standing in its own case.** A new or rebuilt pump arrives dry. Started dry, the slipper faces, the barrel bore and the port plate run metal to metal for the few seconds it takes to ruin them - and the failure looks exactly like the wear that caused the original replacement, so the cause is easily missed twice. Fill the case with clean, filtered fluid of the specified grade through the upper case-drain port, fill and bleed the suction line so the inlet is flooded, then run at low idle with no load until flow is established and case pressure is normal. Clean the reservoir and change every filter at the same time: debris left from the failed pump will find the new one.

**Q32. Answer: C**

**High silicon = dirt contamination. High iron = accelerated component wear (contamination-induced). High lead = bearing wear.** These three together tell a clear story: dirt entered through the air intake (or oil fill), caused abrasive wear on iron components, and the abrasive material has reached and damaged lead-alloyed bearings. Immediate actions: 1) Change oil and filter immediately. 2) Investigate air filtration — find and repair the air filter, breather, or cover sealing problem. 3) Check air filter condition and sealing.

**Q33. Answer: C**

**Quick-release valve exhausts air locally at the brake chamber.** When the driver releases the brake pedal, air must exhaust. Without a quick-release valve, air would have to travel all the way back to the foot valve to exhaust — slow release means slow brake release (brake drag). The quick-release valve vents air at the chamber immediately.

**Q34. Answer: C**

**A ROPS that has absorbed a rollover is spent and must be replaced or repaired only under manufacturer certification.** The structure protects by controlled deformation, so bent members have already used their energy-absorbing capacity. Heating, straightening, sleeving, or plating alters the certified material properties and voids the certification. Only the manufacturer or an authorized engineer can recertify a protective structure.

**Q35. Answer: D**

**Volumetric efficiency = actual flow ÷ theoretical flow × 100% = 85 ÷ 100 = 85%.** The missing 15 L/min never reaches the outlet: it slips back through internal clearances and turns into heat, which is why a worn pump also runs the oil hotter. Efficiency is quoted as the share delivered, never the share lost. A new pump of this class delivers well up in the nineties, so 85% is a worn pump — judge it against the minimum specified for that pump and against its own earlier test readings, since a falling trend tells you more than any single number. Pressure only sets the test condition; the measurement itself is a flow measurement.

**Q36. Answer: C**

**Open the circuit first, diagnose second.** A starter that keeps cranking after the key is released has a circuit that is still made: welded solenoid contacts, a stuck start relay, or an ignition switch that has not returned. The overrunning clutch stops the engine from driving the armature, but it does not stop the motor from running on its own supply, and a starter running unloaded at full speed overheats and throws its windings in seconds while the ring gear and battery pay for the delay. Pulling the ground cable opens the whole system with one connection. Then find why the circuit stayed closed - welded contacts weld again and are replaced, not filed.

**Q37. Answer: D**

**Sudden pressure loss = pump or oil pressure relief valve first.** A stuck-open relief valve bleeds off pressure prematurely. A failing oil pump cannot maintain adequate pressure at operating temperature. These are the primary high-probability causes before considering bearing clearances or pickup tube issues.

**Q38. Answer: C**

**Deteriorated brake hose: collapsed inner lining acts as a check valve — fluid goes in but can't return, so the pistons remain applied after the pedal is released.** The outer appearance of a brake hose can look fine while the inner lining delaminates and collapses. Under pedal application, pressure pushes past the blockage and applies the brakes. When the pedal is released, the return path is blocked by the collapsed lining — the caliper remains applied. Test: with the pedal released and the wheel still dragging, crack the caliper bleeder valve — if the piston releases immediately when the bleeder is opened, pressure was trapped upstream of the caliper. If it stays stuck, the fault is mechanical (seized piston, slides or binding pads). To confirm the hose itself, carefully loosen the fitting where the steel line enters the hose: pressure at the caliper but none at the hose inlet points to the hose.

**Q39. Answer: B**

**Evacuation removes air and boils trapped moisture out of the system.** Under deep vacuum, water's boiling point drops low enough that moisture vaporizes and is pumped out; holding the vacuum also confirms the system is leak-tight. Moisture left behind forms corrosive acids with refrigerant and oil and can freeze at the metering device, while residual air acts as a non-condensable gas that drives head pressure up.

**Q40. Answer: D**

**New wheel installations must be re-torqued after a short break-in period.** As the mating surfaces of the hub, wheel, and nuts seat under load and thermal cycling, clamping force can relax below spec, which is how wheel-off incidents start. Manufacturers typically call for a re-torque within roughly the first 10 service hours or 50 to 100 km of operation, then regular checks afterward. The star sequence ensures the wheel seats evenly and concentrically at every torque pass.

**Q41. Answer: D**

**Extend is normally slower than retract by the area ratio and no more.**  $\text{Speed} = \text{flow} \div \text{area}$ , so a 2:1 cylinder should extend about twice as slowly as it retracts. Five times slower is four extra times that the areas do not explain, and the bypass test has already ruled out the piston seal, so oil is being throttled on its way to the cap end — a collapsed hose liner, a partly closed line valve, a plugged fitting. Relief pressure sets force, not speed. A regenerative circuit routes rod-end oil back to the cap end and makes extension faster, not slower.

**Q42. Answer: C**

**A stuck-open EGR valve continuously recirculates exhaust gases, diluting the intake air and reducing the oxygen available for combustion.** At idle and light load, excessive exhaust gas dilution causes rough idle (oxygen-starved combustion). At load, less oxygen = less complete combustion = black smoke. The EGR is designed for partial, controlled recirculation at specific operating conditions — not continuous full recirculation.

**Q43. Answer: D**

**Inflation is done from outside the line the rim parts would take if the assembly let go, and the gauge is watched the whole time.** WorkSafeBC OHS Regulation section 16.16(4) reads: "A person inflating a tire must stay out of the potential explosion trajectory, if it is practical to do so, and actively monitor the tire's inflation pressure." Both halves carry weight. Standing where the lock ring can be watched puts the technician in the trajectory, which is exactly where the parts travel, and it is a position workers have been killed in. Setting a regulator and walking away leaves nothing monitoring the pressure, and an assembly taken past its pressure is how components get launched. Approaching once the beads have seated puts a body back in the trajectory for the rest of the fill. The cage answers a separate requirement — section 16.16(7) does not allow a multipiece rim to be inflated to operating pressure until it is mounted onto the mobile equipment or secured in a cage or engineered containment device — but a restraining device does not remove the duty to stay clear and watch the gauge.

**Q44. Answer: A**

**Coolant-side liner pitting = cavitation erosion — prevented by maintaining nitrite-based SCA levels.** Each combustion event makes the wet sleeve vibrate like a bell. As the liner wall snaps away from the coolant, vapour bubbles form; when it snaps back, the bubbles implode against the surface and hammer out pits that can eventually perforate into the cylinder. Nitrite in the supplemental coolant additive (SCA) package forms a sacrificial oxide film that absorbs the implusions. Test coolant with SCA strips at PMs and maintain roughly 1.5–3.0 units per gallon, or use an extended-life coolant per OEM.

**Q45. Answer: A**

**Powershift = hydraulically actuated, electronically controlled clutch packs.** Hydraulic pressure directed by the transmission control valve or solenoids engages one clutch pack while releasing another — no interruption in power delivery. The operator uses a selector switch or lever that signals solenoid valves which clutch packs to pressurize.

**Q46. Answer: A**

**The standard names laser alignment tools, calipers and straight edges for structural inspection.** Each answers a different question: the straight edge finds local bend across a surface, calipers capture bore and section dimensions against tolerance, and laser alignment reads frame geometry over a length no straight edge can span. Used together they turn a vague report of the machine tracking badly into measurements you can compare to the manufacturer's tolerance.

**Q47. Answer: B**

**Coupling phase begins when turbine speed reaches approximately 85-90% of impeller speed.** At this point, the fluid leaving the turbine is no longer striking the back face of the stator vanes — so the stator overrunning clutch releases and the stator freewheels. Without stator reaction, there is no torque multiplication — the converter acts as a simple fluid coupling with torque ratio of 1:1. This is the normal high-speed operating condition.

**Q48. Answer: B**

**Normal flow at low pressure, low flow at high pressure = internal pump bypass.** As pressure increases, worn clearances allow more oil to bypass internally. At low pressure, this bypass is minimal. This differentiates pump wear from a blocked filter (which would restrict flow at ALL pressures).

**Q49. Answer: C**

**The phrase reads 'maintain zero energy state when working on all-electric equipment and attachments.'**

Attachments are named explicitly, so an electrically driven attachment gets the same treatment as the base machine. Note the scope is the equipment type, not a voltage threshold.

**Q50. Answer: C**

**High positive fuel trim: ECM adding fuel = system delivering less than commanded.** The ECM monitors rail pressure, engine speed, and fueling response. If the engine demands more fuel than it's getting (lean condition), it commands higher injection. Causes: low fuel supply pressure, clogged fuel filter, restricted lift pump, or worn injectors with reduced flow.

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