RLC & SWS Products

General Testing & Procedure Manual

Digitally Published: December 2017

ABOUT THIS MANUAL

This service manual was written expressly for Toro service technicians. The Toro Company has made every effort to make the information in this manual complete and correct.

Basic shop safety knowledge and mechanical/electrical skills are assumed. The Table of Contents lists the systems and the related topics covered in this manual.

We are hopeful that you will find this manual a valuable addition to your service shop. If you have any questions or comments regarding this manual, please contact us at the following address:

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The Toro Company reserves the right to change product specifications or make changes to this manual without notice.

CHAPTERS

SAFETY

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SAFETY

DANGER: This safety symbol means danger. When you see this symbol, carefully read the instructions that follow. Failure to obey the instructions could cause serious permanent injury, disability, or death.

WARNING: This safety symbol means warning. When you see this symbol, carefully read the instructions that follow. Failure to obey the instructions can result in serious injury.

CAUTION: This safety symbol means caution. When you see this symbol, carefully read the instructions that follow. Failure to obey the instructions can result in minor to moderate injury and/or damage to property or equipment.

Think Safety First

Avoid unexpected starting of engine…
Always turn off the engine, remove the ignition key and disconnect the spark plug wire(s) before cleaning, adjusting, or repair.

Avoid lacerations and amputations…
Stay clear of all moving parts whenever the engine is running. Treat all normally moving parts as if they were moving whenever the engine is running or has the potential to start.

Avoid burns…
Do not touch the engine, muffler, or other components, which may be hot during operation, while the unit is running or shortly after it has been running.

Avoid fires and explosions…
Use extreme care in handling fuel. It is flammable and its vapors are explosive. Extinguish all cigarettes, cigars, pipes, and other sources of ignition. Avoid spilling fuel and never smoke while working with any type of fuel or lubricant. Wipe up any spilled fuel or oil immediately. Never remove the fuel cap or add fuel when the engine is running. Always use approved, labeled containers for storing or transporting fuel and lubricants. Do not add or drain fuel in an enclosed space. Do not store the machine or fuel container where there is an open flame, spark, or pilot light, such as on a water heater or other appliance.

Avoid asphyxiation…
Do not operate an engine in a confined area without proper ventilation.

Avoid injury from batteries…
Battery acid is poisonous and can cause burns. Avoid contact with skin, eyes and clothing. Battery gases can explode. Keep cigarettes, sparks and flames away from the battery.

Avoid injury due to inferior parts…
Use only original equipment parts to ensure that important safety criteria are met.

Avoid injury to bystanders…
Always clear the area of bystanders before starting or testing powered equipment.

Avoid injury due to projectiles…
Always clear the area of sticks, rocks or any other debris that could be picked up and thrown by the powered equipment.

SAFETY

Think Safety First (Cont.)

Avoid modifications…
Never alter or modify any part unless it is a factory approved procedure.

Avoid unsafe operation…
Always test the safety interlock system after making adjustments or repairs on the machine. Refer to the Electrical section in this manual for more information.

Avoid electrical shock…
Never touch electrical wires or components while the engine is running. They can be sources of shock. De-energize the system if you are having to do repairs. If testing electrical components ensure you are working in a dry environment.

Hydraulic System...
Release all pressure in the hydraulic system before performing any work on the system. Keep your body and hands away from pin-hole leaks or nozzles that eject hydraulic fluid under high pressure. Do not use your hands to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate the skin and cause serious injury. Seek medical attention right away if hydraulic fluid gets in the skin.

Personal Protective Equipment…
Use appropriate personal protective equipment (PPE) for protecting yourself from potential hazards in the environment in which you will work. PPE may include but is not limited to the following:

- hard hat
- respirator or dust mask
- hearing protection
- safety shoes
- long pants
- safety glasses, goggles, and/or face shield
- chemical suit
- chemical-resistant gloves
- rubber boots, steel-toed boots, or other substantial footwear
- tight-fitting gloves without drawstrings or loose cuffs

Tools…
All tools should be in proper working order. Do not use tools that are broken or in disrepair. Use the proper tool for the proper application.

Lifts, Hoists, and Jacks…
All lifts, hoists, and jacks should be used in accordance with the manufacturer information. Inspect lifts, hoists, and jacks prior to use. Do not over load lifts, hoists, and jacks. Do not work under a suspended load. Ensure chock blocks are used on equipment that can move. Use lifts or jacks and jack stands that are rated to support the total weight of the machine and any attachments. Do not rely on jacks to support the machine. If you are unsure of the operation of any lifts, hoists, and jacks do not use.

Think Safety First (Cont.)

Fire Extinguishers…

The proper class of fire extinguisher should be used in case of fire.

Class A extinguishers are for ordinary combustible materials such as paper, wood, cardboard, and most plastics. The numerical rating on these types of extinguishers indicates the amount of water it holds and the amount of fire it can extinguish. Geometric symbol (green triangle).

Class B fires involve flammable or combustible liquids such as gasoline, kerosene, grease and oil. The numerical rating for class B extinguishers indicates the approximate number of square feet of fire it can extinguish. Geometric symbol (red square).

Class C fires involve electrical equipment, such as appliances, wiring, circuit breakers and outlets. Never use water to extinguish class C fires - the risk of electrical shock is far too great! Class C extinguishers do not have a numerical rating. The C classification means the extinguishing agent is non-conductive. Geometric symbol (blue circle).

Class D fire extinguishers are commonly found in a chemical laboratory. They are for fires that involve combustible metals, such as magnesium, titanium, potassium and sodium. These types of extinguishers also have no numerical rating, nor are they given a multi-purpose rating - they are designed for class D fires only. Geometric symbol (Yellow Decagon).

Class K fire extinguishers are for fires that involve cooking oils, trans-fats, or fats in cooking appliances and are typically found in restaurant and cafeteria kitchens. Geometric symbol (black hexagon)

ABC fire extinguishers are a dry chemical type used for multiple purposes. See above information for description.

Ensure fire extinguishers are serviceable and replace any that are discharged or out of inspection dates.

Understanding Schematic Symbols

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Understanding Schematic Symbols

Understanding Hydraulic Schematics

The key to understanding hydraulic schematics is to break them down into individual circuits. For example, when troubleshooting a lift/lower problem, it is unnecessary to look at the cutting drive or steering circuits.

Schematic Circuit Diagrams are usually preferred for troubleshooting because of their ability to show current and potential system functions. Schematic symbols are used for each component, their controls, and connections. Toro uses the following symbols in hydraulic schematics (Figure 1):

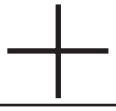
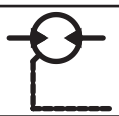
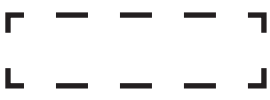
	VENTED RESERVOIR		RESTRICTOR
	PRESSURIZED RESERVOIR		ADJUSTABLE RESTRICTOR
	CONNECTED LINE		CYLINDER (SINGLE ACTING)
	CROSSED LINES		CYLINDER (DOUBLE ACTING)
	FIXED DISPLACEMENT PUMP		FIXED DISPLACEMENT MOTOR
	VARIABLE DISPLACEMENT PUMP		VARIABLE DISPLACEMENT MOTOR
	BI-DIRECTIONAL PUMP		BI-DIRECTIONAL MOTOR
	CHECK VALVE		VALVE ACTUATORS
	BYPASS CHECK VALVE		FILTER / STRAINER
	RELIEF VALVE		SHUT-OFF VALVE
	CONTROL VALVES		HEATER
	VALVE ENCLOSURE		COOLER

Figure 1

Understanding Schematic Symbols

Understanding Electrical Schematics

The key to understanding electrical schematics is to break them down into individual circuits. For example, when troubleshooting a no crank problem, it is unnecessary to look at the cutting unit or lift circuits.

Schematic Circuit Diagrams are usually preferred for troubleshooting because of their ability to show current and potential system functions. Schematic symbols are used for each component, their controls, and connections. Toro uses the following symbols in electrical schematics (Figure 2):

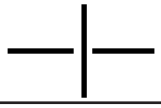
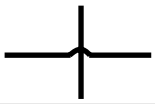
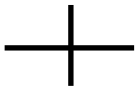
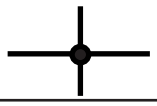
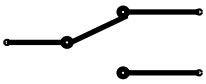
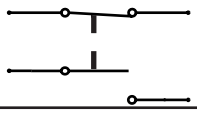
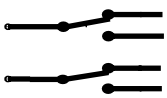
	WIRE		NORMALLY CLOSED PUSH BUTTON
	UNCONNECTED WIRE		POTENTIOMETER
	UNCONNECTED WIRE		VARIABLE SENDING UNIT
	UNCONNECTED WIRE		RELAY
	CONNECTED WIRE		FUSE
	GROUND		CIRCUIT BREAKER
	BATTERY		RESISTOR
	SWITCH SPST		DIODE
	SWITCH SPDT		CONNECTOR
	SWITCH DPST		LIGHT BULB
	SWITCH DPDT		LED
	NORMALLY OPEN PUSH BUTTON		COIL

Figure 2

BEARINGS

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BEARINGS

Why OEM is Important

Toro conducts bearing tests for specific applications and mechanisms. Toro bearings are designed and manufactured to exceed industry standards.

Bearing Types

Ball Roller Bearing

Roller bearings are a family of bearings that use balls or cylindrical rolling elements between two rings (races) to carry a load. Different rolling elements have advantages and these advantages determine the correct bearing for each application. Roller bearings may be unsealed or sealed (Figure 1).

Figure 1

Bearing Types (Cont.)

Tapered Roller Bearing

Tapered bearings are designed to handle both radial and axial loads. The tapered cylinder bearings contact the races over a larger surface area, and are more durable than ball bearings (Figure 2).

Figure 2

Needle Roller Bearing

Needle bearings are designed to carry heavier loads than ball bearings. The elongated cylinder bearings contact the races over a larger surface area, and are capable of supporting heavier loads (Figure 3).

Figure 3

BEARINGS

Inspection

Bearing inspection should take place in an environment that is free of debris. Foreign objects entering a bearing will cause premature bearing failure. If the bearings or bushings are sealed, do not attempt to clean or lubricate them.

Clean bearings in solvent and dry them by hand. Do not spin bearings with compressed air; this can damage them. Once the bearings are dry, inspect the rolling elements for signs of wear or grooves.

Lightly coat each bearing with oil and rotate the outer race by hand. Any roughness means the bearing is bad and must be replaced.

BLADES

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Inspection

CAUTION

The blades are sharp; contacting a blade could result in serious personal injury. Always wear eye protection and gloves when handling blades.

Perform the following checks before sharpening blades:

Sail Area

Sand and other soil particles can wear away metal at the base of the sail. If the blade is weakened it may crack or eject broken blade pieces from the deck. Inspect the blade area where the sail bends upwards. If there is excessive wear, the blade must be replaced (Figure 1).

Figure 1

Cutting Edge

Check the condition of the edge and verify there is enough material left on the blade to allow it to be sharpened. Repeatedly sharpening blades compromises their strength, and diminishes the quality of cut.

Inspection (Cont.)

Cracks or Damage

Cracks weaken the blade, and cracked blades must be replaced. Check for nicks or gouges in the blade that would prevent the blade from being successfully sharpened (Figure 2). Also, look for wear or damage in the blade mounting hole or surrounding area.

Figure 2

Twisted Blade

Inspect the ends of the blades. Verify that the blades have not twisted and that the back end of the blade is not lower than the cutting edge of the blade (Figure 3).

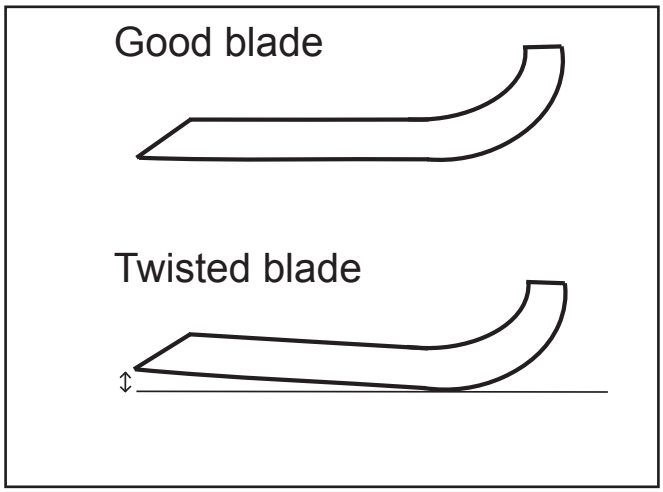

Figure 3

Sharpening

DANGER

Always wear proper personal protective equipment when grinding blades. This should include the following, safety glasses with side shields or goggles, face shield, hearing protection, and gloves.

Ensure if using a powered grinder that all equipment guards are set to prevent your hands from contacting the grinder.

CAUTION

Ensure there are no flammable materials near a power grinder, sparks and flying debris can start a fire.

Grind the top surface of the blade only and try to maintain the original cutting edge angle. Do not grind the bottom surface or a chisel shape will result. The lowest portion on the blade that contacts the grass must be the cutting edge or the grass will not be cleanly cut and the machine will need excessive horsepower.

Balance

After the blade has been sharpened the balance must be checked. This can best be accomplished using a commercial balancer. An unbalanced blade causes vibration damaging adjoining parts.

1. Check the balance of the blade by placing the center hole of the blade over a nail or a screwdriver shank clamped horizontally in a vise.
2. If either end of the blade rotates downward, file that end (do not file the cutting edge or the end near the cutting edge) (Figure 4). The blade is properly balanced when neither end drops

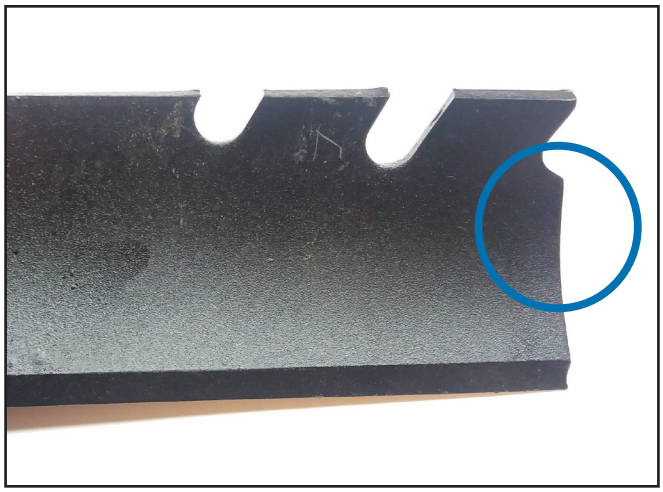

Figure 4

Blade Bolt Torque

CAUTION

When installing a blade on a multi-bladed machine, moving one blade may cause other blades to move. Use caution to prevent injury.

When installing the blade, the sails should point up towards the mower housing. Ensure blade bolt/nut is torqued to the service manual specification. It is recommended that a torque wrench is used, rather than an impact wrench.

Blade Hub Inspection

Ensure the blade stiffener is the proper OEM part for the specific mowing unit.

Height-of-Cut

Height-of-cut is the measurement from the ground to the top of the grass blade after it is cut, or from the ground to the cutting edge of the mower blade (these should be the same).

Height Check Procedure

1. Move mower to a level surface.
2. On products using inflatable tires, check the tire pressure. Make certain that the pressure is the correct level for operation and the tires are very close to equal pressure.
3. Make a simple sketch of the mower housing to use for recording measurements. Show the outline of the mower and the blade(s). Leave a space to write the measurements. Each blade must be measured at the 12, 3, 6, and 9 o'clock positions.
4. If the desired height-of-cut is known, make measurements at this setting. If this is not known, set the mower in the middle of its height-of-cut range.

NOTE: When taking the measurements, rotate the blade and use the same blade tip for measuring. Mark the blade with a piece of tape. There may be a slight difference between the two ends of the same blade. If the mower has multiple blades, repeat the process with each blade.

CAUTION

When installing a blade on a multi-bladed machine, moving one blade may cause other blades to move. Use caution to prevent injury.

5. When using the measuring tool, position the blade tip.
6. Place the tip of the tool under the tip of the blade and press the base of the tool on the floor.
7. Read the measurement and note it on your sketch.
8. Repeat in all four positions.

QUALITY-OF-CUT

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Deck Leveling

A properly leveled mowing deck is essential to a high quality cut. To achieve proper alignment the mower deck has front-to-back and side-to-side adjustments.

CAUTION

When installing a blade on a multi-bladed machine, moving one blade may cause other blades to move. Use caution to prevent injury.

Front-to-Back (Deck Pitch or Rake)

The deck should be adjusted so the front of the blade circle is just slightly lower than the rear of the blade circle.

Procedure

1. Rotate a blade so that it is in line with the direction of travel.
2. Measure and record the distance from the blade to the floor, (use the rotary mower height gauge or a tape measure).
3. Measure the distance on the back end of the blade, record measurement.
4. The cutting unit needs to be set so that the front of the blade is 1/16 to 1/8 in. (1.6 to 3mm) lower than the rear of the blade.

NOTE: If the measurements are not correct, make the necessary adjustments.

Side-to-Side

Each blade tip should be at the same height above a level surface when measured on either side of the mower.

Procedure

1. Place the unit on a level surface.
2. Rotate the end blade on one cutting until it is 90 degrees to the direction of travel. Do so with the cutting unit at the height-of-cut being used, or in the middle of the height-of-cut range.
3. Measure from the blade to the floor (use the rotary mower height gauge or a tape measure).
4. Rotate the blade (on the other side of the deck) until it is 90 degrees to the direction of travel and measure from the blade to the floor. The measurements from one side should equal the measurement on the other side. If the measurements are not the same, make the necessary adjustments to get the measurements equal within 1/8 in. (3 mm).

Deck Leveling (Cont.)

Blade Tip-to-Tip

1. Rotate the blades until the two adjacent blade ends align with each other.

NOTE: They should be within 1/16 in. (3 mm); if the blades line up, no additional adjustments are required.

2. Check for bent blades or damaged deck components, if the blades are not in alignment.

Deck Cleanliness and Inspection

The efficiency of a rotary cutting unit is directly related to the air flow withing the deck. The underside of the cutting deck should be examined periodically. The airflow is significantly affected if the deck is not cleaned out periodically.

Tire Pressure

NOTE: Ensure to add air to the tire to the recommended tire pressure on the side wall of the tire or as directed by the manufacturer.

Tires on a rotary mower should be at or near the manufacturer recommended pressure. Check all mower tires and be sure they are properly inflated. Low tire pressure will not only deter from the level of traction the mower is capable of, it will also leave a less even cut.

Engine Speed

DANGER

While testing the machine with the engine running, hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Keep bystanders away from the machine.

WARNING

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Avoid inhaling of exhaust fumes, and never run an engine in a closed building or confined area.

It is important for the engine to run at full RPM. This will allow the engine to rotate the blades at optimal speed. The blades of rotary mowers are designed to create a suction like force that lifts the grass in a vertical formation; when the engine is at full speed, it creates optimal suction, allowing for a greater quality cut.

QUALITY-OF-CUT

Ground Speed

There are three basic problem areas resulting from too fast a ground speed. It is unsafe, damaging to the equipment and will result in a poor quality of cut.

Ground speed is the speed with which the operator moves the mowing unit. The ground speed of a rotary mower must be limited to a point that the blade can cut and discharge the grass effectively while maintaining a good quality of cut. If the cutting unit is becoming overloaded, the ground speed should be lowered, the cutting width should be reduced, or the cutting height should be increased so the engine can regain its normal operating speed.

Blade Condition

The blade should always be straight and sharp. A sharp blade produces a clean, neat cut and helps ensure healthy grass plants. A dull blade tears and shreds grass, producing a poor quality of cut and damaging the grass plants.

Sharpening Angle

When sharpening the blades maintain the original cutting angle, grinding the top side of the blade only.

BELTS

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Symptoms of Belt Failure

- Loose edge cords
- Significant cracking between the notches
- Excessive polishing or glazing of sidewalls

How Belts Break

Worn or Dirty Pulleys

DANGER

Hands, feet, and clothing could get caught in moving parts, causing serious personal injury.

Dirt or debris in the clutch can cause the belt clutch system to function improperly. Deposits of belt material on the pulley surfaces, engine shaft, and brushing can completely disable the system if extreme buildup occurs. To service a pulley system, disassemble the system and clean the surfaces with a suitable solvent.

Improper Belt Fit

Three checks to determine fit

1. Deflection (tension): Consult product service manual to determine deflection specification.
2. Side clearance on the Engine Pulley: This is measured with feeler gauges. Consult product service manual to determine side clearance specification.
3. The top of the belt should ride close to the outside of the pulley. It should not ride in or out of the pulley more than 1/16 in. Pictured belt demonstrates an incorrect (too large) fit (Figure 1).

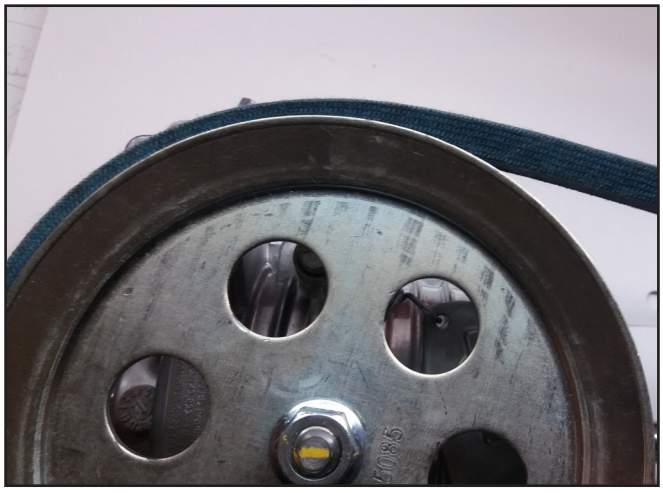

Figure 1

How Belts Break (Cont.)

Clutch Function Problems

Common wear areas

- Flyweight pivots and rollers
- Pulley sheave bushings
- Torque sensitive cam buttons

Alignment Issues

Misalignment falls under two categories: angular and parallel. Angular misalignment results when the engine is cocked in the frame and the crank and jackshaft are not parallel (Figure 2).

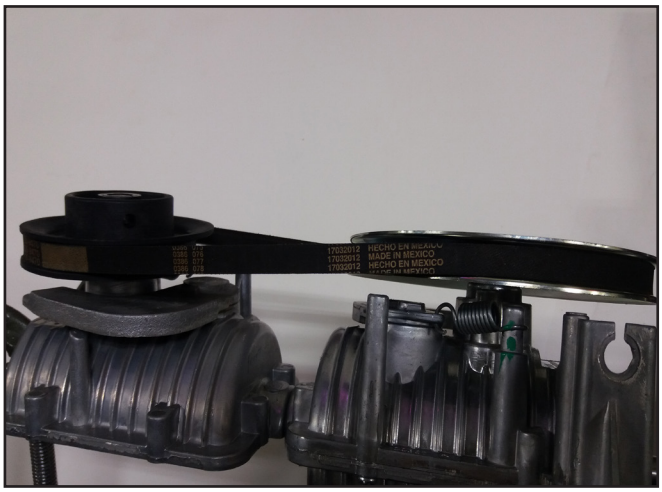

Figure 2

In parallel misalignment, the engine crankshaft and the jackshaft are parallel but the pulley offset is incorrect. Check specific procedures and specifications from the service manual to service the issue. Verify sheave alignment with a straight edge (Figure 3).

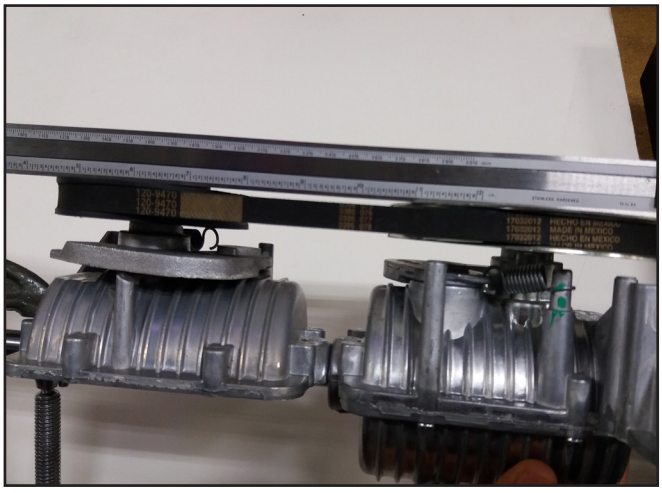

Figure 3

Belt Wear Diagnosis

Friction Burn

Cause
Frozen or jammed sheaves in the drive system, misalignment, or objects in contact with belt.

Correction
Ensure all sheaves move freely, check sheaves for proper alignment, clear any objects that may contact the belt (Figure 4).

Figure 4

Envelope Delamination

Cause
Improper belt fit, contact with oil.

Correction
Ensure belt is correct size. Clean sheaves and tensioners of oil (Figure 5).

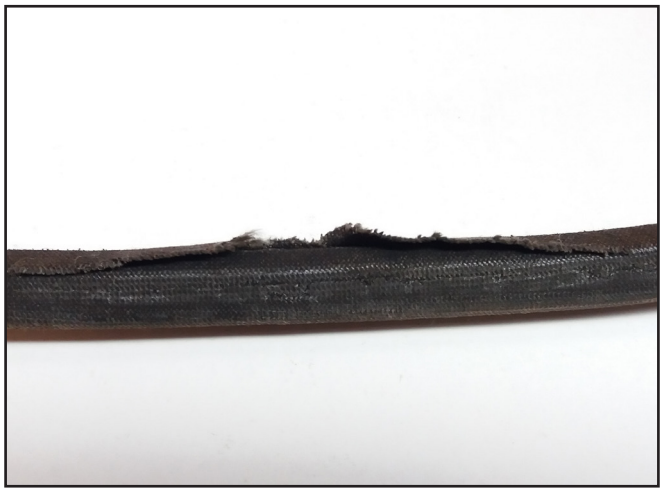

Figure 5

Belt Wear Diagnosis (Cont.)

Tensile Break

Cause
Severe shock load, foreign objects between sheave and belt, damage from improper installation (Figure 6).

Correction
Ensure idlers are not binding, check for foreign objects, release tension before installed replacement belt.

Figure 6

BELTS

What to Look For	What it Means
Oil and grease	Belts exposed to oil and grease will fail prematurely.
Dirt	Dirt accelerates belt wear and dirt build-up on a sheave impairs traction.
Added Loads	Added loads shorten belt life. Check that no additional loads have been added since the original drive was selected.
Belt Guards	Belt guards help keep the belt clean safe from external factors.
Cracking	It is not necessary to replace a belt because of bottom cracks; however, the cracks can be reduced by using larger sheaves and larger reverse bend sheaves.
Belt Dressing	Belt dressing should not be used to fix a slip or squeak and will accelerate the belt failure time.
Vibration	If there is belt vibration it means the belt is whipping up and down.
Tension	Be sure the tension of the belt is at the recommended value so the belt does not experience stress.
Heat	Belts that operate in high temperature should be frequently checked and special heat-resistant construction should be considered if belt life is not satisfactory.
Belt Turn Over	Belt turn over indicates drive misalignment, worn sheaves or excessive vibration.
Change in Ride Out	A change in ride out indicates uneven wear or worn sheaves.
Lateral Vibration	A belt should not touch anything but a belt guide and pulley. If it does make contact with other components; check for a loose belt, belt condition, and belt length.
Belt Wear	Wear on the sidewalls of the belt indicates consistent slippage, excessive dust, or rough sheaves.
Foreign Matter	Foreign matter in the sheaves or on the belts can cause a broken belt or excessive vibration wear.

What to Listen For

Squeal

Squeal noise occurs during either motor acceleration or when the motor is operating near or at full load. Squealing indicates belt slippage and should be investigated. The likely cause for a squealing noise is improper belt tension.

If the belt is properly tensioned, examine the drive for overloading.

Chirp or Squeak

Chirping sounds indicate dry bearings and occurs on all types and all styles of belts. Dust is often a contributing factor in drying of bearings. Never apply dressing or oil to a belt in an effort to eliminate chirps or squeaks; realignment of an idler may help.

Why to Use OEM Belts

Toro belts are manufactured to meet engine and application requirements.

ENGINE

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Engine Diagnostic Tools

DANGER

While testing the machine with the engine running, hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Keep bystanders away from the machine.

WARNING

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Never touch electrical wires or components while the engine is running. They can be sources of electrical shocks. Always use test equipment as directed by the manufacturer.

Spark Plug Tester

Checking for misfire

Spark plug misfire occurs when the sparks jumping the gap of the electrodes are inconsistent in their timing. The following steps will check for spark plug misfire:

1. Disconnect the spark plug lead from the spark plug.
2. Connect the spark plug tester to the spark plug lead.
3. Connect the spark plug tester to the spark plug; this creates a link from the lead to the spark plug.
4. Start the engine and watch the gap in the spark plug tester to check for inconsistent timing.

Checking for issues with the ignition

If there is no alligator clip, an ignition tester may be needed to perform the test. If there is an alligator clip at the end of the spark plug tester, the ignition can be checked for problems by performing the following steps:

1. Disconnect the spark plug lead from the spark plug.
2. Connect the spark plug tester to the spark lead.
3. Ground the spark tester's alligator clip.
4. Crank the engine using the recoil or electric starter. Check for a spark in the tester's gap.

Spark Test

In-line Engine Running

Use an Illuminating Spark Tester to determine if the engine is intermittently losing spark while running. This test will show if there is a spark, however it does not show the quality of the spark.

Ground to Block

Toro equipment uses the engine mounting bolt as an electrical ground. Verify that all grounding connections to the block are secure and free of corrosion.

Leak Down Test

DANGER

Hands, feet, and clothing could get caught in moving parts, causing serious personal injury.

WARNING

Filings, chips, shavings, particles of metal, etc., can be thrown when compressed air is used for cleaning purposes. Do not point the nozzle at anyone.

Use when an engine has

- Excessive oil in the air intake
- Low power
- Hard starting
- Oil consumption

Supplies needed:

- Compressed air source
- Leak down gauge kit
- Spark plug socket
- Basic hand tools
- Machine service manual

Leak Down Test (Cont.)

Procedure

1. Remove the air filter, dipstick, and radiator cap (liquid cool engines only) and place the throttle and choke wide open.
2. Remove the spark plugs and rotate the engine to put the piston to top dead center (TDC) on compression stroke. Insert a long screwdriver or extension into the spark plug hole and turn the engine by hand with a socket on the crankshaft. When the screwdriver stops rising or falling, TDC on compression stroke is reached. Do not turn the engine backward if TDC is missed.
3. Connect the gauge into the hole. Set the parking brake and hold the flywheel or crankshaft to prevent the engine from turning when air compresses into the cylinder. Start with the regulator turned counterclockwise to zero the incoming pressure.
4. Connect compressed air source and turn the regulator clockwise to pressurize air into the cylinder.
5. Record leakage percentage for the cylinder.
6. Listen and watch, wherever air is escaping will indicate where the problem is located. Disconnect the gauge and move to the next cylinder.

Liquid Coolant Engine Tools

DANGER

Hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Do not remove the radiator cap when the engine operates, or immediately after it stops. If not, hot water can spout out from the radiator. Only remove the radiator cap when it is at a sufficiently low temperature to touch with bare hands. Slowly loosen the cap to release the pressure before you remove it fully.

WARNING

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Avoid inhaling of exhaust fumes, and never run an engine in a closed building or confined area.

Leak Dye Tester

Leak dye is an ultra violet glowing fluid that goes in the engine coolant to help locate difficult-to-pinpoint internal leaks in the cooling system.

Procedure

1. Add dye to the cooling system (follow dye instructions).
2. Run the engine to operating temperature.
3. Inspect the cooling system externally with a black light for leaks (leaks will glow).

Liquid Coolant Engine Tools (Cont.)

Coolant System Pressure Tester
When heated, coolant pressurizes the system through expansion, which can expose leaks. Pressure tests operate similarly without having to make the engine extremely hot. The pressure tester attaches to the top of the radiator or coolant reservoir, allowing air pressure into the system; this simulates a heated engine.

Procedure

1. Install the tester on the radiator neck.
2. Pressurize to the level specified in the service manual.
3. If the pressure decreases, look for external leaks.
4. If no external leaks are found, use coolant leak detection dye before assembly.

Compression Test

DANGER

While testing the machine with the engine running, hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Keep bystanders away from the machine.

WARNING

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Avoid inhaling of exhaust fumes, and never run an engine in a closed building or confined area.

Use compression tester if the engine has

- Low power
- Detonation
- Oil consumption / smoking
- Coolant consumption / smoking
- Starting problems
  - Electric starter failures
  - Broken recoil studs

Compression Test (Cont.)

Gasoline Engine Procedure

1. Remove all spark plugs.
2. Ensure the carburetor or the fuel injection pump throttle plate is in the wide open position.
3. Disable the ignition system as directed by machine service manual.
4. If the engine is equipped with electronic fuel injection, it should also be disabled to prevent fuel from spraying into the engine.
5. Screw the compression gauge into one of the spark plug holes.
6. Crank the engine and let the engine rotate for about four to six compression strokes (movement of compression gauge).
7. Compare each gauge reading for each cylinder to the manufacturer's specifications.

Diesel Engine Procedure

DANGER

Do not open a fuel system under high pressure. The fluid under high pressure that stays in fuel lines can cause serious injury. Do not disconnect or repair the fuel lines, sensors, or any other components between the fuel pump and injectors on engines with a common rail fuel system under high pressure.

1. Remove all injectors or glow plugs. Refer to the manufacturer's manual for instructions.
2. Install the compression gauge.
3. Disconnect the fuel shut-off solenoid to disable the fuel injection pump.
4. Crank the engine and take note of the highest reading on the gauge.

Fuel Quality

DANGER

Fuel is very flammable and explosive under some conditions. Do not smoke or let flames or sparks in your work area.

Percent Ethanol

Most ethanol-infused fuel has a concentration of about 5-10 percent ethanol. There is also a market for fuel containing 85 percent ethanol and 15 percent gasoline; this is known as E85. The 15 percent gasoline is to ensure that the engine will start in cold weather and to enhance flame luminosity. While Ethanol has a high octane rating (resulting in greater engine efficiency and performance), it has lower energy content; this means that about one-third more ethanol is required to travel the same distance as gasoline.

Alcohol Tester

1. Fill the test tube with water to the line indicated on the tester.
2. Add fuel to the gas line indicated on the tester.
3. Insert stopper and shake for 30 seconds.
4. Place the tester on a flat surface and let stand until liquid separates.
5. Determine the ethanol content by looking at the line of the separation (view at eye level to accommodate the meniscus).

Odor / Swab

The objective of the swab test is to determine if the fuel is fresh, marginal, or bad by checking its color. This should only be a beginning step in the process of determining the fuel's quality. The swab test can identify if the fuel is dirty, but it cannot detect fuel damage in the form of moisture.

Gasoline

1. Submerge swab into fuel for 10 seconds.
2. Shake swab; let dry for two to three minutes (do not exceed three minutes).
3. Compare to gasoline test chart.

Diesel

1. Submerge swab into fuel for 10 seconds.
2. Shake swab; let dry for two to three minutes (do not exceed three minutes).
3. Compare to diesel test chart.

Auxiliary Fuel Tank

DANGER

While testing the machine with the engine running, hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Keep bystanders away from the machine. Fuel is very flammable and explosive under some conditions. Do not smoke or let flames or sparks in your work area.

Auxiliary fuel tanks allow troubleshooting of fuel delivery by isolating the engine from the fuel supply system. An in-line fuel filter should be used on the auxiliary tank output.

Procedure

1. Disconnect and seal the fuel line at the fuel pump inlet.
2. Connect auxiliary tank fuel line to the fuel pump inlet.
3. Place tank level at, or lower than the engine.
4. Start the engine.
    a. If the issue is resolved, there is an issue with the fuel supply. Contact Toro technical support for assistance.
    b. If the issue persists, it is not caused by the fuel supply.
5. Relocate the auxiliary tank fuel line to the carburetor inlet. Place tank above the carburetor so fuel is gravity fed.
6. Start the engine.
    a. If the issue is resolved, there is an issue with the fuel pump performance. Contact Toro technical support for assistance.
    b. If the issue persists, it is not caused by the fuel supply.

Electric Start

Electric starters use a motor and a gear wheel attached to a solenoid to engage the engine flywheel. A starter that does not engage the motor is indicative of a low or dead battery. If the battery is a fully charged battery, the starter may have a mechanical failure. See engine service manual for electric starter tests.

Valve Lash

Valve lash is the clearance between the rocker and valve tip. Excess valve lash causes premature wear on valves and poor performance while too little valve lash causes improper valve seating and poor performance.

Charging System

The charging system's purpose is to charge the battery while the engine is running and functions as the source of electrical energy while the engine runs. The primary component of a charging system is a generator (alternator). An alternator's purpose is to convert mechanical energy into electrical energy. See engine service manual for charging system tests.

Clear Fuel Line

Use the clear fuel line to determine if there are fuel delivery issues. Use the line for testing purposes only.

Digital Tachometer

NOTE: Tools should always be used as directed in the owner's manual.

Use a tachometer to set low and high idle engine speed. Using an inductive-type tachometer will ensure an accurate reading. Be sure to follow the tool manufacturer's recommendations. Use an inductive tachometer to compare coil output from side to side by measuring RPM.

Ultrasonic Cleaner

Use ultrasonic cleaner to break down and remove debris from the carburetor passages.

Procedure

1. Completely disassemble the carburetor.
2. Start the ultrasonic cleaner with the parts inside.
3. Rotate the parts.
4. Start the ultrasonic cleaner again.
5. Inspect the air bleeds, jets, fuel restrictors, transition ports and the idle outlet ports.
6. Reassemble the parts and be sure to install new gaskets and seals. Check if the inlet needle should also be replaced

Thermal Test Gun

This tool allows a check of the temperature radiating directly from the thermostat housing. Check the specifications of the product being tested for appropriate engine temperature. Allow the engine to run for several moments to heat to running temperature and then aim the thermal tester at the thermostat housing and wait for the reading to level off.

EFI Diagnostic Tools

Refer to OEM testing documentation for instrument specific instructions.

Diagnostic Codes

EFI issues can be diagnosed using either the blink codes on the device, or by connecting a computer to the ECU module. The computer software allows real time sensor readings, recording of sensor data, reading/clearing fault codes, and reading sensor history.

Noid Light

Noid lights are used to check electrical impulses from wiring harnesses to the fuel injectors.

Fuel Pressure Test Kit

This kit measures fuel pump pressure in fuel-injected engines to diagnose rich or lean running conditions, starting issues and run ability issues.

Diesel Injector Testing

DANGER

Do not open a fuel system under high pressure. The fluid under high pressure that stays in fuel lines can cause serious injury. Do not disconnect or repair the fuel lines, sensors, or any other components between the fuel pump and injectors on engines with a common rail fuel system under high pressure.

WARNING

Never use gasoline for testing as it could result in explosion or fire.

Before testing

- Nozzle needle and body are lap fitted to each other.
- Diesel fuel oil for testing must be clean.
- Keep hands away from nozzle spray.
- Clean all the nozzles and allow them to dry.
- Dip nozzles in clean fuel oil and insert them into the injector body.

Pressure test procedure

1. Operate the pump lever forcefully for about six to eight pumps per second.
2. If nozzle does not chatter, loosen the cap nut, rotate the nozzle and tighten.

NOTE: Hole type nozzles do not chatter like pintle type nozzles.

3. Adjust the pressure accordingly.
4. When pressure gauge is in use, increase and decrease pressure slowly.
5. Increase the pressure until slight chattering and read the pressure reading.
6. Operate the lever slowly (one to two pumps per second); all nozzles should spray/chatter at this point.

Diesel Injector Testing (Cont.)

Leakage test:
Operate the lever until the gauge reaches 20 bars (285 PSI) below specified pressure. If the nozzle tip is dry or a film forms, the nozzle is good. If a droplet forms or drips from the nozzle, the tip needs replacing (Figure 1).

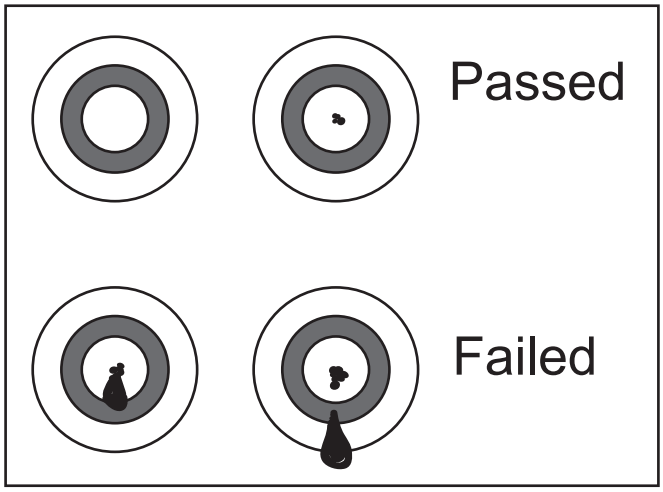

Figure 1

Chatter / spray pattern test:

Close the gauge shut off and rapidly pump the lever (four to six per second); observing the spray pattern. The test fails if the pattern is choppy (A), a stream (B), or uneven (C). Passing pintle and throttle nozzle patterns should be even and well atomized. Hole type nozzles should be full and finely atomized (D) (Figure 2).

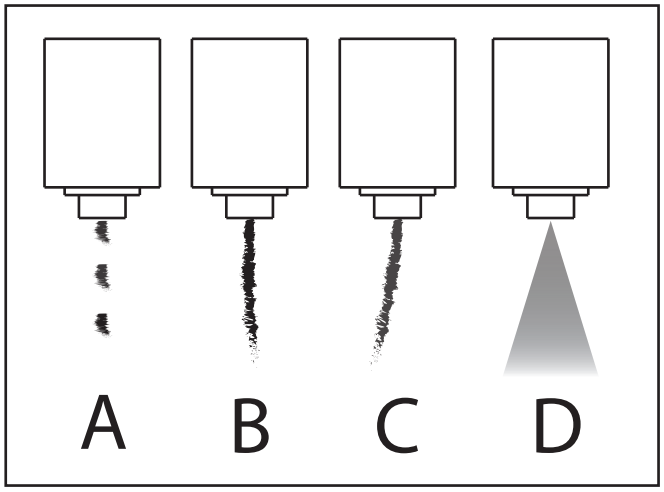

Figure 2

HYDRAULIC SYSTEM

Table of Contents

Hydraulic Principles

When a confined liquid is under pressure, the pressure distributes in all directions and on all faces of the container. This is the principle used to extend the ram on a hydraulic cylinder.

By applying a force to move the piston on one end, an equal sized piston on the other end will move the same distance with the same amount of force.

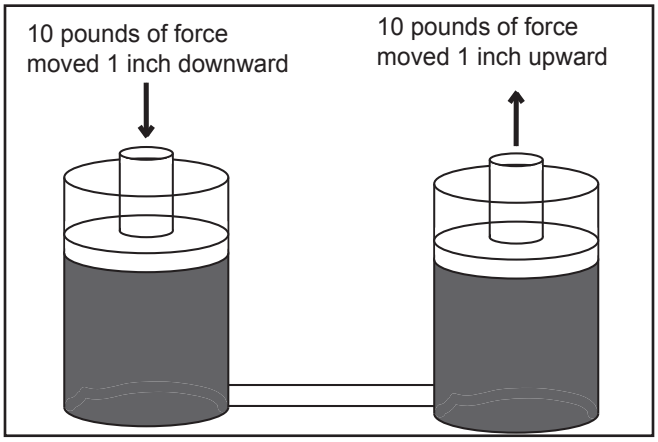

Figure 1

By making the containers different sizes, the mechanical advantage in work force increases.

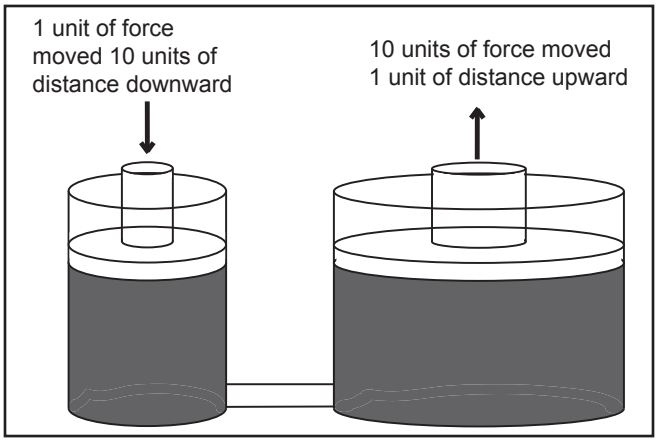

Figure 2

Circuits and Components

There are four basic components required in all hydraulic circuits: a tank (reservoir) to hold the fluid; a pump to force the fluid through the system; valve(s) to control the flow; and an actuator to convert the fluid energy into mechanical force to do the work (Figure 3).

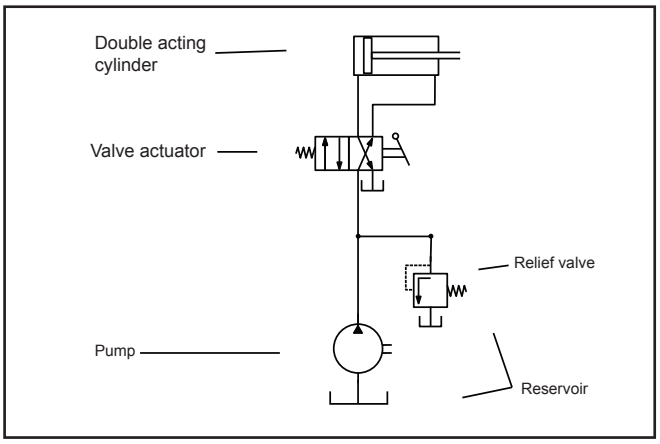

Figure 3

Gear Pump:

The gear pump (Figure 4). increases the oil flow to the cylinder and the ram's actuation rate (in comparison to the hand pump). As the gears in the pump rotate, suction forms in the inlet port of the pump. The fluid draws into the pump and moves in the spaces between the gear teeth to the discharge port of the pump. At the discharge side of the pump, the gear teeth mesh and the oil discharges from the pump.

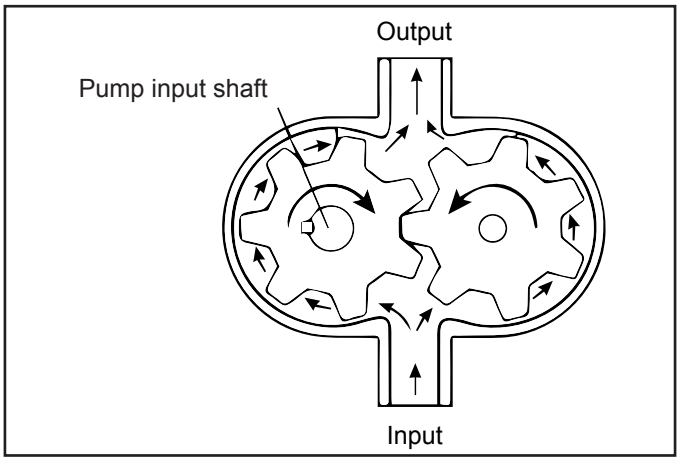

Figure 4

Circuits and Components (Cont.)

Gerotor Pump

Gerotor pumps (Figure 5) are internal gear pumps. They are generally used as fuel or oil pumps.

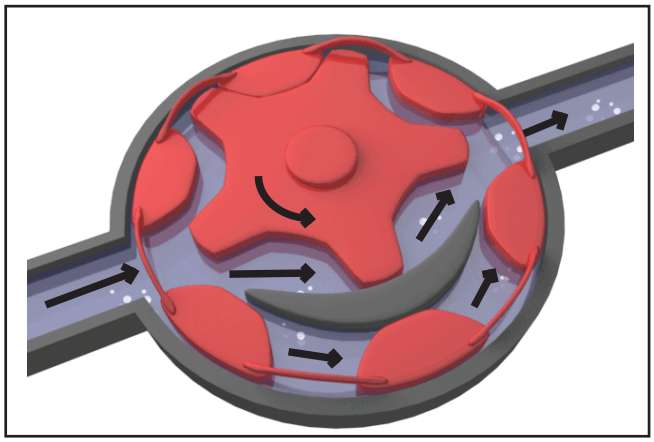

Figure 5

Gear Motor

The gear motor (Figure 6) is used to create rotational movement to drive attachments. The oil flow through the motor is essentially the same as through the pump; the gear teeth carry the oil around the outside of the motor and flows out the pump outlet

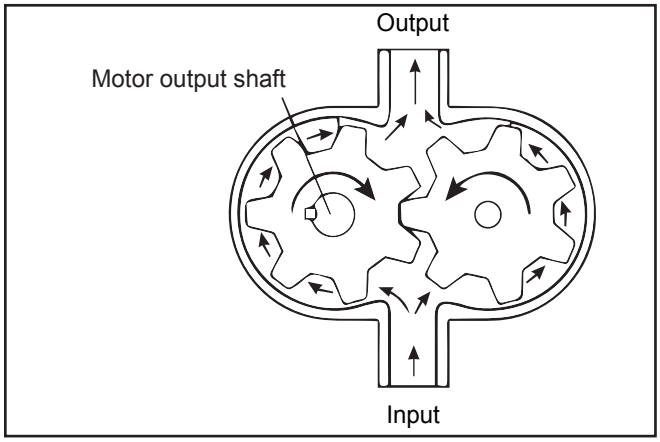

Figure 6

Circuits and Components (Cont.)

Spool Valve

Spool valves are directional control for flow between hydraulic circuit paths. Each position of the spool within the cylinder represents a different hydraulic function. A valve may be electrically or mechanically controlled (Figure 7).

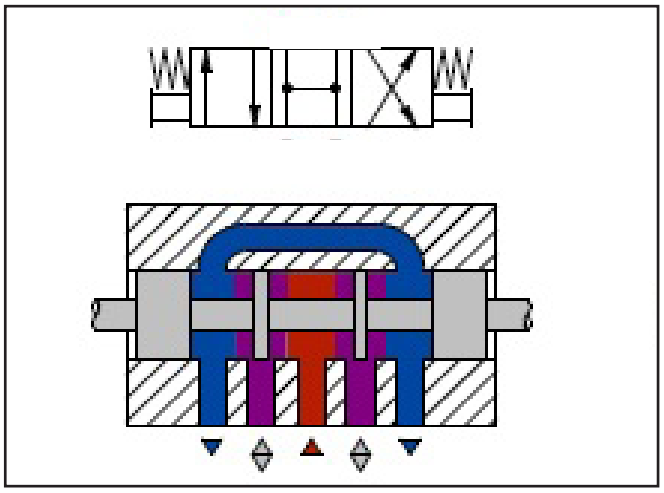

Figure 7

Relief Valve

A relief valve (A) (Figure 8), is a normally closed valve with one port connected to the pressure line and the other line connected to the reservoir. The flow direction arrow points away from the pressure line and toward the reservoir. When pressure in the system overcomes the spring pressure, fluid is directed through the valve to the reservoir. The schematic symbol for a relief valve is shown at (B) (Figure 8).

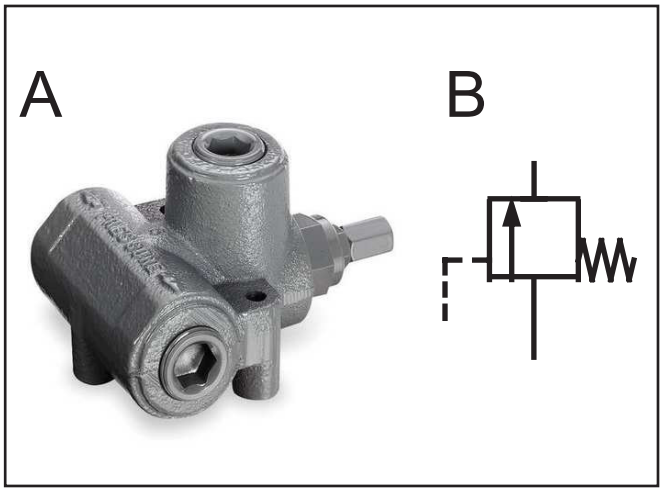

Figure 8

Circuits and Components (Cont.)

Reservoir

The reservoir (A) (Figure 9) is a chamber to hold the fluid in the hydraulic system. The schematic symbol for a reservoir is shown at (B).

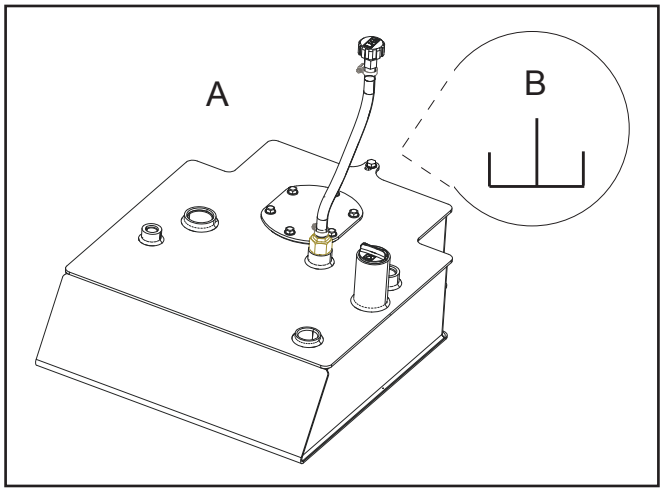

Figure 9

Hydrostatic Parts

Piston group
A piston (A) (Figure 10) is a sliding piece moved by or against fluid pressure. A piston group is a grouping of pistons mounted to the input shaft and driven by the engine. Pistons are fit within a cylindrical chamber or vessel along which it moves back and forth .

Swashplate
The swash plate (B) (Figure 10) pivots on two support pins and controls the pump output. As the operator moves the traction control pedal to increase travel speed, the swash plate angle increases.

Housing
Housing (C) (Figure 10) refers to a piston block with numerous precision-machined bores that house the pump pistons.

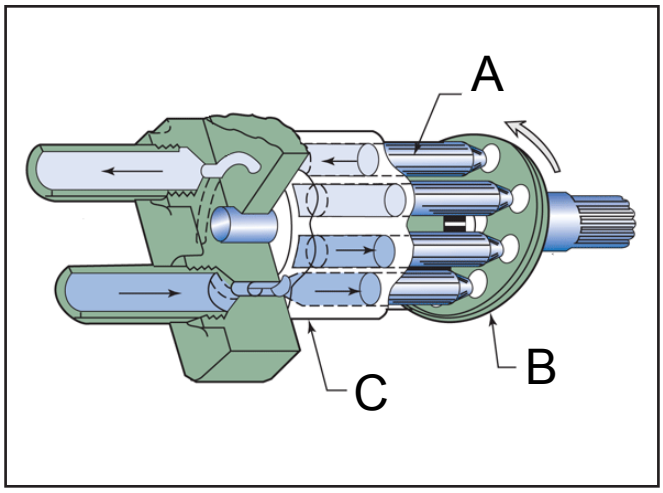

Figure 10

Hoses and Fittings

Hydraulic hoses are subject to extreme conditions such as pressure differentials during operation and exposure to weather, sun, chemicals, high temperature operating conditions and mishandling during operation or storage. Hoses that move during operation are more susceptible to these conditions.

Inspecting Hoses

Inspect hoses frequently for signs of wear, damage, or deterioration. Check hoses for leakage and replace when leaks are found.

WARNING

Keep body and hands away from pinhole leaks or nozzles that eject hydraulic fluid under pressure. Use paper or cardboard, not hands, to search for leaks. Serious injury may occur if hydraulic fluid is injected into the skin. When disconnecting or replacing a hydraulic hose, be sure to relieve all pressure from the system by stopping the engine and lowering or supporting the implement. Verify new hoses are straight (not twisted) before tightening the fittings.

Hoses and Fittings (Cont.)

Inspecting Fittings

O-ring Face Seal (ORFS) (Figure 11)

1. Ensure both threads and sealing surfaces are free of burrs, nicks, scratches, or foreign material.
2. Verify the O-ring is installed and properly seated in the groove.

NOTE: It is recommended that the O-ring be replaced any time the connection is opened.

3. Lubricate the O-ring with a light coating of oil.
4. Tighten fitting to proper torque.

Figure 11

Hoses and Fittings (Cont.)

SAE Straight Thread O-ring Port Fittings (Non-Adjustable) (Figure 12)

1. Ensure both threads and sealing surfaces are free of burrs, nicks, scratches, or foreign material.
2. Always replace the O-ring seal when this type of fitting shows signs of leakage.
3. Lubricate the O-ring with a light coating of oil.
4. Install the fitting into the port and tighten it down until finger tight.
5. Tighten fitting to proper torque.

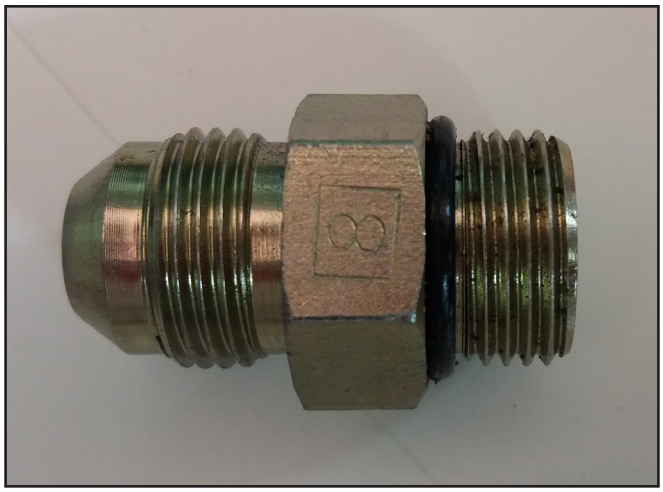

Figure 12

Hoses and Fittings (Cont.)

SAE Straight Thread O-ring Port Fittings (Adjustable) (Figure 13)

1. Ensure both threads and sealing surfaces are free of burrs, nicks, scratches, or foreign material.
2. Always replace the O-ring seal when this type of fitting shows signs of leakage.
3. Lubricate the O-ring with a light coating of oil.
4. Turn back the jam nut as far as possible. Make sure the backup washer is not loose and is pushed up as far as possible.
5. Install the fitting into the port and tighten it finger tight until the washer contacts the face of the port.
6. Unscrew by the required amount to put the fitting in the desired position, but not more than one full turn.
7. Hold fitting in the desired position with a wrench and turn the jam nut with another wrench to proper torque.

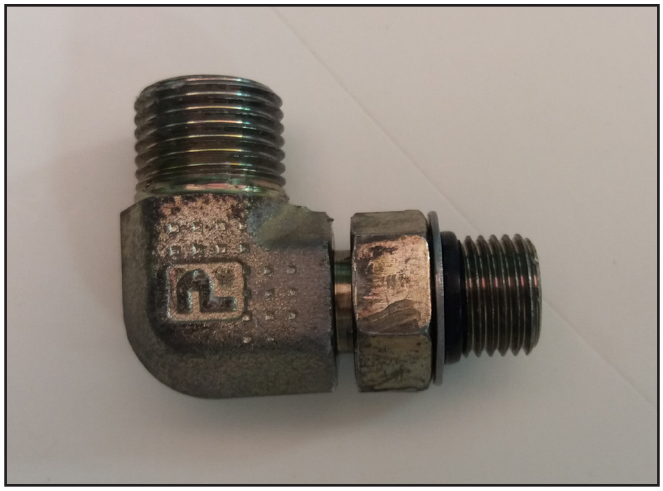

Figure 13

Hydrostatic Transmission

Pump with Remote Wheel Motor

In this type of hydrostatic system, the unit's engine mounts and drives the hydrostatic pump. The pump connects to the drive motor by hoses or steel lines. These motors can mount directly to the wheels or to a drive axle.

A hydrostatic drive consists of a hydrostatic pump, which pumps oil to a drive motor. The most significant feature of a hydrostatic system is the pump. The pump is a variable displacement pump, meaning the output of the pump can be varied and is not controlled solely by the engine RPM like a fixed displacement pump. This requires that the pump be a piston pump.

Tools Needed for Hydraulic Work

Test Gauges

Use gauges of proper pressure rating when performing hydraulic tests. Find the specified pressure for the circuit being tested, and then select a gauge that will measure the pressure in the middle part of its range. This will give the most accurate reading and prevent possible damage to the gauge.

Low pressure gauge 1000 PSI, high pressure gauges 5000 PSI and 10000 PSI, and associated hoses and fittings.

Hydraulic Test Kit

NOTE: Pumps used on Toro equipment are positive displacement type. If a tester is installed in a portion of the circuit not protected by a relief valve and the pumps output flow is completely restricted or stopped, damage to the pump or other components could occur.

Hydraulic Fittings

Fittings are used to seal hydraulic tubing to prevent leakage and/or contamination. There are several configurations for hydraulic fittings depending on their usage. The different configurations are used for specific applications, e.g., connecting hoses or lines to components, connecting hoses or lines together, or connecting different size lines or hoses together.

Hydraulic systems checklist

- Check that the fittings are finger tight and inserted far enough to ensure that they are not cross-threaded before tightening them with a wrench.
- Check the position of the tester hoses so that rotating machine parts will not make contact with them and result in hose damage.
- Check the oil level in the reservoir.
- Check the control linkage for improper adjustment, binding or broken parts.
- Check for a soft or collapsed suction hose.

Relief Valve Setting Test

1. With the control valve set in the run position, close off the restrictor valve to observe the pressure when the relief valve opens.
2. If this pressure is below specifications, check or repair the relief valve.

Tools Needed for Hydraulic Work (Cont.)

Flow Meter

Flow is the measurement of the volume of a liquid that passes a fixed point in a unit time. This can be measured in liters per minute (lpm), U.S. gallons per minute (US gpm), or U.K. gallons per minute (UK gpm) (Figure 14).

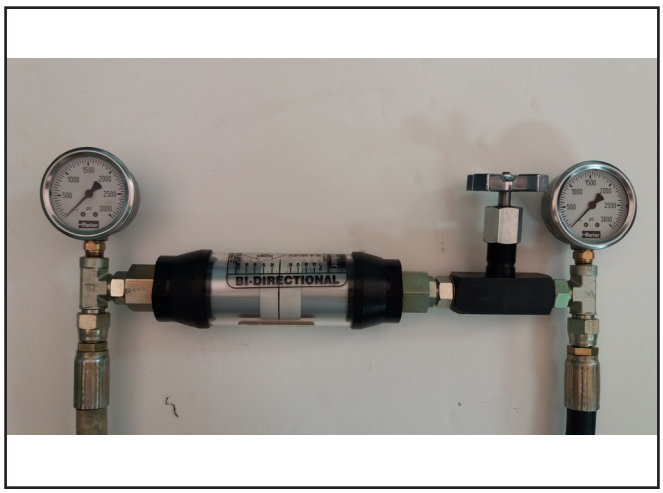

Figure 14

Hydraulic Tester Components (With Pressure and Flow Capabilities)

- Inlet hose: Hose connected from the system circuit to the inlet side of the tester.
- Load valve: If required, upon turning the valve to restrict flow, a simulated working load is created in the circuit.
- Low pressure gauge: A low range gauge provides accurate readings at low pressure (0-1000 PSI). This gauge has a protector valve which cuts out when pressure is about to exceed the normal range for the gauge. The cutout pressure is adjustable.
- High pressure gauge: A high range gauge accommodates pressure beyond the capacity of the low pressure gauge, 0 - 5000 PSI.
- Flow meter: Flow meter measures actual oil flow in the operating circuit. The reading is given in gallons per minute (GPM) with a gauge rated at 15 GPM. It is most commonly connected to the circuit in a series configuration. When properly connected in series, all fluid flowing through that portion of the circuit flows through the flow meter and can be measured.
- Outlet hose: this is a hose from the outlet side of the hydraulic tester to be connected the hydraulic circuit. Higher capacity flow meters are also available from various sources. This particular one has 600 and 5000 PSI pressure gauges, a 10 GPM flow meter and a temperature gauge.

Pump and Wheel Motor System Flow Test

DANGER

While testing the machine with the engine running, hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Keep bystanders away from the machine.

WARNING

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Avoid inhaling of exhaust fumes, and never run an engine in a closed building or confined area.

Pump Flow Test

1. Raise the drive tires off the ground.
2. Block the remaining tires on the ground to prevent accidental vehicle movement.
3. Open the restriction valve all the way.
4. Make certain all external pump directional control stops are removed or backed off on the machine linkage to obtain full pump directional control arm travel.
5. Start the engine and engage the drive pulley if necessary.

Pump and Wheel Motor System Flow Test (Cont.)

Pump Flow Test (Cont.)

6. Consult pump service manual for maximum RPM. Bring the engine to maximum operating speed for your pump.

CAUTION

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Avoid inhaling of exhaust fumes, and never run an engine in a closed building or confined area.

7. With the directional control lever (on the machine) for the pump being tested, move the control arm in full forward motion (It may be necessary to lock the control arm into full forward position to prevent false readings).

8. Operate without any load for approximately 30 seconds to 1 minute. This allows the system oil temperature to rise.

NOTE: Raising the system oil temperature will make a difference in the readings received. It has been determined that to complete this test accurately, the oil temperature must be near system operating temperatures. Suggested temperature range is 160°- 210°F (71.1° - 98.9°C).

9. Tighten the flow meter restriction valve until the gauge reads 300 PSI (21 bar). Record the flow reading on the bi-directional flow meter.

10. Increase the pressure to 1100 PSI (76 bar) for all models. Record the flow reading on the bi-directional flow meter

Consult the pump service manual for the acceptable GPM “flow drop”. If the difference exceeds the values specified in the service manual the pump is not operating efficiently and should be repaired or replaced.

Pump and Wheel Motor System Flow Test (Cont.)

Motor Efficiency

1. Lock the motor to prevent rotation; there should be no flow through the motor and this should be indicated by the flow meter.
2. If there is flow, and it is above an acceptable level, this indicates leakage through the motor.

Brake Systems

How they work

Hydraulic brake systems use hydraulic force many times greater than that of the pedal. Varying the relative location of the brake master cylinder rod pivot as it relates to the lever can change the multiplication as well as varying the size of the master cylinder and wheel cylinder pistons.

Basic maintenance

Regularly check the brake fluid level in the master cylinder. Before checking the brake fluid level, wipe the cover of the master cylinder so no foreign material can fall inside the reservoir. Periodically, inspect the brake pads and brake shoes for wear and replace as needed.

Common failure

A brake fluid leak can affect the brake master cylinder by allowing air into the system, creating a soft pedal and eventual brake failure. A large brake fluid leak leads to a major failure of the brake system. Most master cylinders have a built in safety device, the separate primary and secondary hydraulic systems.

Brake Systems (Cont.)

Common problems and fixes

Squealing brakes

Most of the time, squealing brakes can be a warning that the brake pads are worn out and need to be replaced. Other causes include overheating brake pads or rotors and rusting on the brake lining material.

WARNING

Most braking systems contain microscopic fibers that are hazardous; while cleaning, service brakes in a well-ventilated area.

Brake fade

Brake fade occurs when a machine's brakes stop working even though the pedal condition is good and there are no obvious problems with the braking system. This condition may present itself when the brake system is overheated. When the brake rotor is over heated, it cannot absorb any additional heat (the energy can no longer convert to heat). This will cause brake failure no matter how hard the brake pedal is applied.

Brake fade may occur when braking down long grades and in conditions where the machine is traveling at high rates of speed or carrying heavy loads and frequent braking occurs over a short period.

UHT System Flow Test

DANGER

While testing the machine with the engine running, hands, feet, and clothing could get caught in moving parts, causing serious personal injury. Keep bystanders away from the machine.

WARNING

Hot engine parts can cause severe burns. Do not touch engine while operating or just after stopping. Avoid inhaling of exhaust fumes, and never run an engine in a closed building or confined area

Purpose

The flow test determines if the UHT test is faulty by isolating the pump section from the wheel motor.

Tools needed for installation

- 20 GPM flow meter
- Two, 3,000 PSI pressure gauges
- Two hose assemblies
- One straight thread fitting
- One diagnostic plug

Safety Issues

- Ensure machine is properly secured
- Do not attempt any adjustments with engine running
- Be aware of high temperatures
- Be sure that all hoses are securely attached

Installation

1. Unplug the plug wire to the seat switch and install temporary bypass wire to the plug in wire.
2. Raise the rear of the unit enough to remove the tire and wheel assembly from the side being tested.
3. Install jack stands under rear portion of machine for stability

UHT System Flow Test (Cont.)

4. Remove the tire.

WARNING

Block the remaining tires on the ground to prevent accidental vehicle movement.

5. Install an oil drip pan under the transmission.
6. Clean any dirt or debris from around the ports
7. Remove the hex head plugs from the “A” and “B” ports on the pump.
8. Plug in the “A”, move the pump bypass lever to the open position.
9. Install the straight thread fitting in the “B” port on the pump.
10. Move the pump bypass lever to the closed position.
11. Connect the flow meter hydraulic hoses and make sure the fittings are tight. Completely open restriction valve on the meter.
12. Start the engine and bring up to max RPM when using the Parker Flow Tester. Depending on the flow tester, adjust engine RPM to correspond.
13. Disengage the park brake and move the machine’s directional control level on the machine being tested all the way in the forward position. Continue to operate in full forward position for about a minute to allow the system oil pressure to rise. Oil temperature should fall between 110°F (43°C) and 140°F (60°C).

UHT System Flow Test (Cont.)

14. Tighten the restriction valve until the difference between the pressure gauge reading is 300 PSI. Record the flow reading from the bidirectional flow meter.

15. Tighten the restriction valve until the difference between the pressure gauge is 1,000 PSI. Record the flow reading.

To determine the flow rate: subtract the first reading at 300 PSI from the second reading at 1,000 PSI. The difference in flow rate should not be more than 1 gpm. If the difference is greater, this could be an indicator of defective pump.

Troubleshooting Hydraulics

When troubleshooting a hydraulic problem

1. Know the hydraulic system for the machine: Study the schematics, operator manual, and service manual. Know how the system works and what the relief valve setting and the pump output should be.

2. Talk to the operator: How did the machine act just as it started to malfunction? Was any unauthorized service performed or did anyone else attempt to repair the machine? How was the machine used and when was maintenance last performed?

3. Operate the machine: Operate the machine in conditions simulating when the malfunction occurred. Verify what the operator described. Are the gauges and warning lights operating correctly. Do the controls feel spongy or stick. Check for any unusual sounds, smells, or smoke. At what speed or operating cycles does this occur?

4. Inspect the machine: Check the hydraulic fluid level and condition. Is the fluid dirty or filters plugged? Check for overheating. Does the oil have a burnt odor? Is the oil cooler plugged or lines caked with dirt? Look for bent or collapsed fluid lines. Check for leaks, loose fasteners, cracked welds, binding pivot points, damaged linkage, etc.

5. List possible causes: Note what was reported by the operator and verified by a technician. List what was found during your inspection. Remember that there may be more than one cause leading to the failure or malfunction.

6. Determine which cause is most likely the problem: Look at the list of most possible causes and determine which are the most likely. Use the troubleshooting charts in the service manual.

7. Test your findings: Operate the machine with a hydraulic tester connected to the suspected malfunctioning circuit. It may be necessary to replace or adjust a component to verify findings.

Fluid and Filters - Why using OEM Matters

Oil Function

Oil in the hydraulic system performs four main functions in a hydraulic system:

- The oil transmits the energy through the system.
- The oil lubricates all the moving parts of the system.
- The oil acts as heat transfer and carries it away.
- The oil seals small clearances in the system.

Water, dirt, and metal interfere with oil's ability to perform these functions. Contaminated oil causes the majority of hydraulic system failures. New oil is considered "dirty" until properly filtered through the system. Any dirt not captured by the filter and retained in the reservoir will not allow the heat to transfer to the reservoir walls and dissipate. Heat can break down the oil's lubricity, causing part damage.

ELECTRICAL

Table of Contents

Table of Contents (Cont.)

Electrical Principles

Electricity

Electricity is a form of energy created by the movement of electrons. By directing these electrons through a circuit, work can be performed. Electricity can produce light, heat, magnetism or mechanical work.

Basic System Requirements

Every electrical system requires some combination of basic and accessory components (Figure 1):

- Power Source
- Load Device
- Switch
- Fuse
- Conductors “Accessory Components”

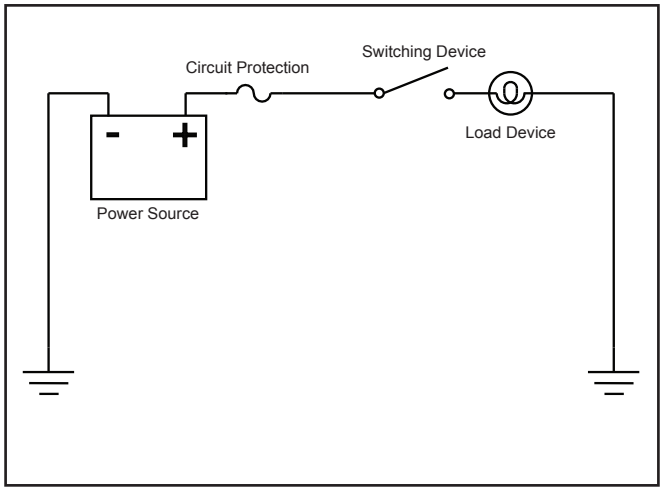

Figure 1

Here are the same basic requirements on a machine equipped with an Electronic Control Unit, Electronic Control Module, or Standard Control Module. The ECU/ECM/SCU acts as a switching device, replacing multiple relays. The device looks at inputs (switches), and based on the condition of those inputs, turns on and off various outputs (Figure 2).

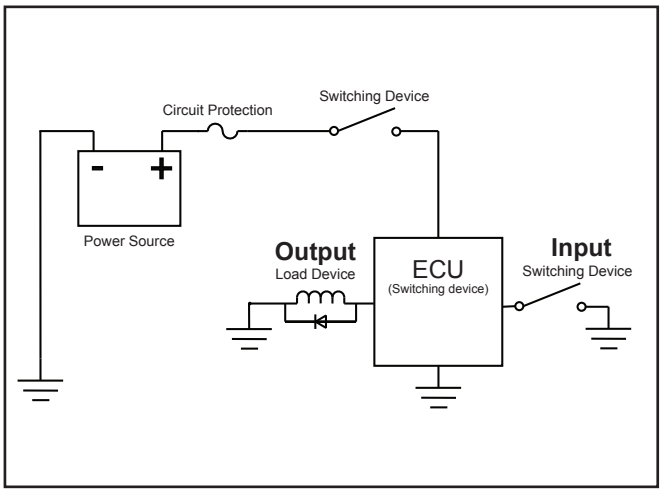

Figure 2

Electrical Principles (Cont.)

Basic Circuits

Series Circuit (Figure 3)

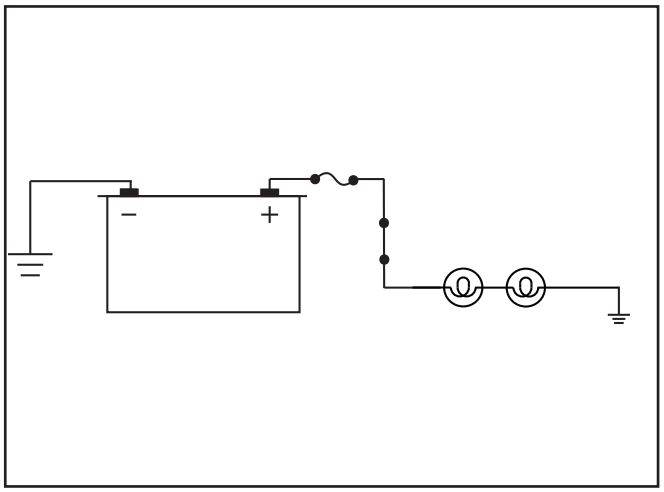

Figure 3

A series circuit may include more than one load. Characteristics of a series circuit:

- The current is constant throughout the circuit.
- The current must pass through each component in the circuit.
- The total resistance of the circuit controls the current in the circuit.
- The total resistance of the circuit is the sum of all the resistances in the circuit.
- The sum of the voltage drops across the resistors will equal the applied voltage.

Resistance in a series circuit equals the sum of all resistances (R_{TOTAL} = R1+R2+R3+ etc...)

Electrical Principles (Cont.)

Basic Circuits (Cont.)

Parallel Circuit (Figure 4)

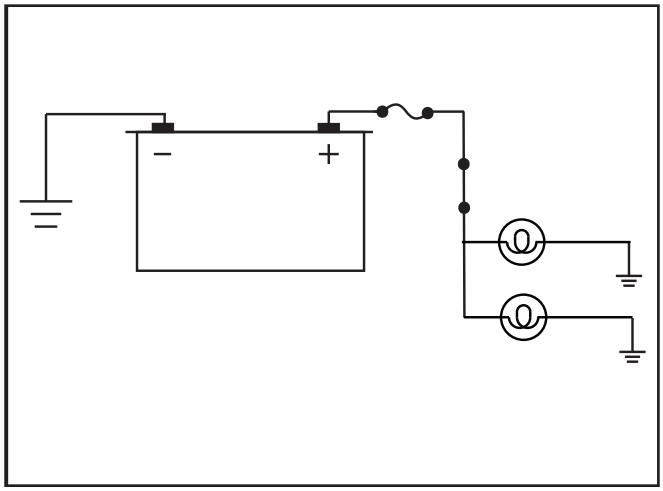

Figure 4

A parallel circuit has two or more loads connected so that current can divide and flow through the load. Most electrical circuits are parallel. Characteristics of a parallel circuit:

- The current has many paths.
- The resistance in each load will determine the current flow for that resistance.
- The total resistance will always be less than the smallest resistance in the circuit.
- The voltage drop across all loads will be battery voltage.

The formula for calculating resistance in a parallel circuit is as follows: $R_{total} = \frac{(R1 \times R2)}{(R1 + R2)}$

Basic Electrical Elements

Current is the directed *flow* of electrons through the circuit. The unit of current measurement is the ampere (A). Current is measured with an ammeter.

Voltage is the electrical *pressure* that causes the electrons to flow. The unit of current measurement is the volt (V). Voltage is measured with an voltmeter.

Resistance is the *restriction* to current flow. The unit of resistance measurement is the ohm (Ω). Resistance is measured with an ohmmeter.

Electrical Principles (Cont.)

Ohm's Law

The three electrical elements have a direct effect on each other. The formula to calculate this effect is Ohm's Law. The letters represent the properties in the system. If any two of the values are known, apply the proper mathematical formula to find the third (Figure 5).

V = Voltage,
I = Current,
R = Resistance.

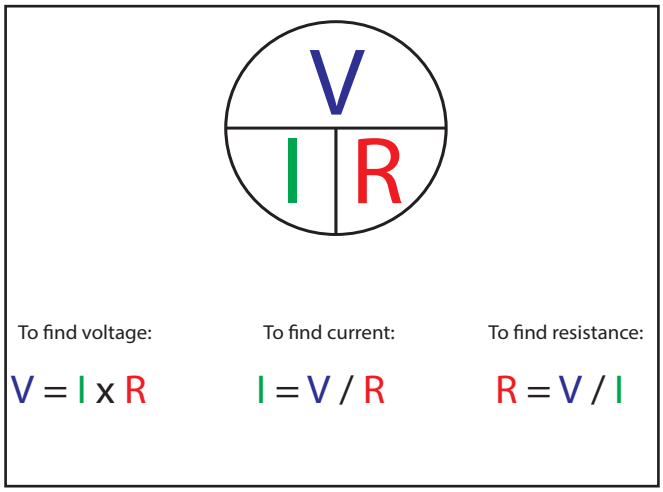

Figure 5

Electrical Testing Tools

Test light

Test lights are useful for checking for power in a circuit. However, they cannot give actual voltage readings and should not be used on electronic circuits (Figure 6).

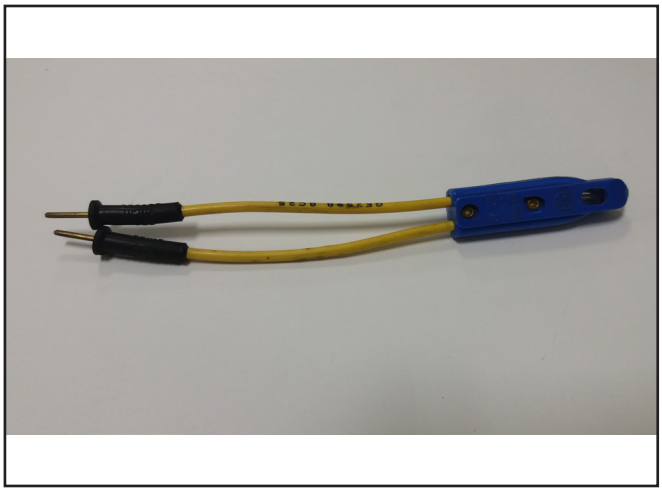

Figure 6

Analog Multimeter

Features:

- Voltage (Pressure) testing
- Amperage (Flow) testing
- Resistance (Restriction) testing
- Diode (Check valve) testing

Analog meters are less precise than digital meters, however, analog meters more accurately display rapid value changes (Figure 7).

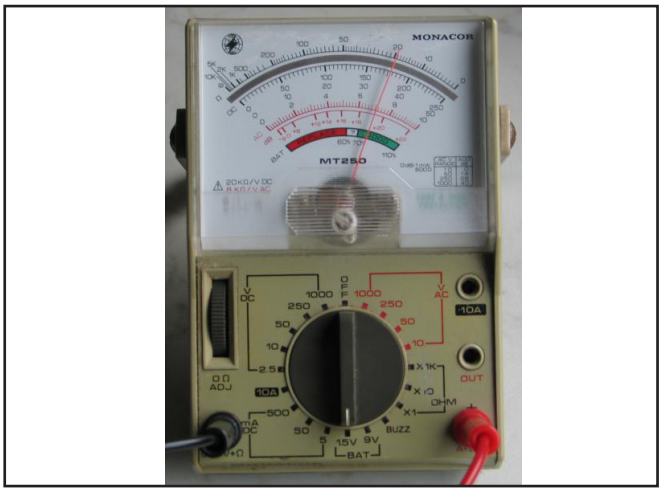

Figure 7

Electrical Testing Tools (Cont.)

Digital Multimeter

Features:

- Voltage (Pressure) testing
- Amperage (Flow) testing
- Resistance (Restriction) testing
- Diode (Check valve) testing

Many of these meters are auto-ranging. Digital multimeters are high impedance to protect sensitive circuitry (Figure 8).

Figure 8

Electrical Testing Tools (Cont.)

WARNING

Do not use the meter if the meter or test leads look damaged, or if you suspect that the meter is not operating properly. Never touch electrical wires or components while the engine is running. They can be sources of electrical shocks. Always use test equipment as directed by the manufacturer. When using the probes, keep your fingers behind the finger guards on the probes.

Using a Multimeter

Measuring Voltage with a Voltmeter

1. Set the meter to DC volts.
2. Connect the meter across load.
3. Close the switch and activate the circuit.
4. Read voltage on the meter (Figure 9).

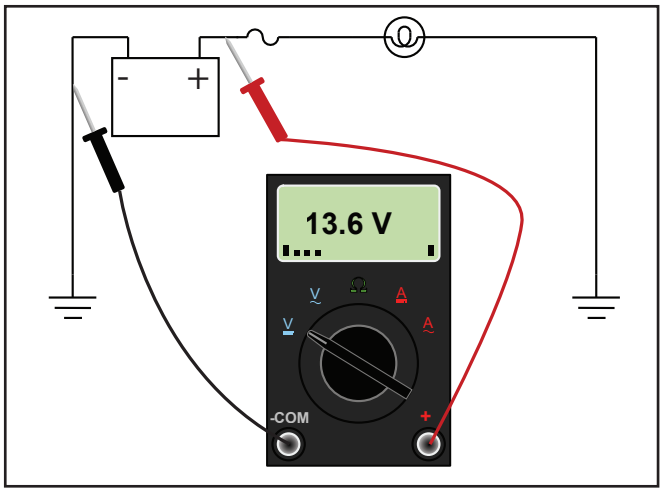

Figure 9

Electrical Testing Tools (Cont.)

Using a Multimeter (Cont.)

Measuring Resistance with an Ohmmeter

1. Isolate (or remove) the load from the circuit.
2. Set the meter to ohms (Ω).
3. Connect the meter across the load.
4. Read resistance on the meter (Figure 10).

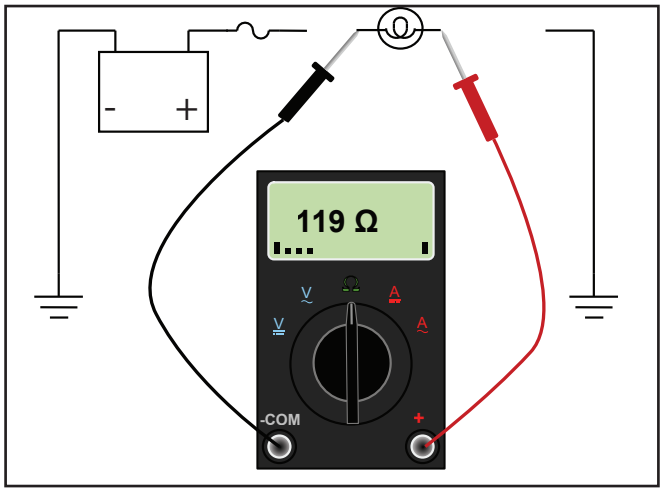

Figure 10

Electrical Testing Tools (Cont.)

Using a Multimeter (Cont.)

Measuring Current with an Ammeter

1. Set the meter to DC amps.
2. Open the circuit and connect the meter in series.
3. Activate the circuit.
4. Read the amperage on meter (Figure 11).

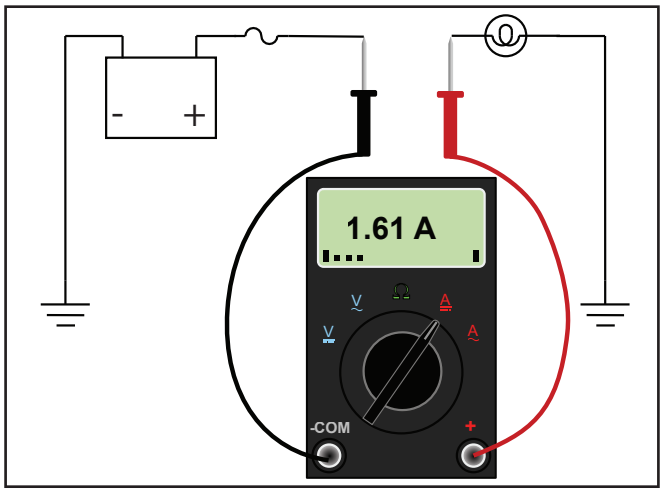

Figure 11

Electrical Testing Tools (Cont.)

Using a Multimeter (Cont.)

High Amperage Circuit Testing
Generally, testing electric circuits over 10 Amps will exceed most multimeter's capacity. A clamp meter can test high amperage circuits without having to disconnect any wires.

Measuring Current with Clamp on Ammeter.

1. Clamp the meter around the wire. If the meter can read current direction, line up the arrow in the direction of current flow.
2. Activate the circuit.
3. Read amperage on the meter (Figure 12).

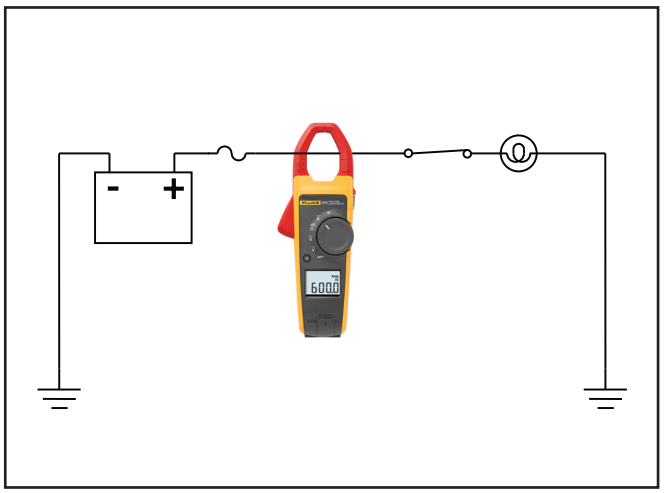

Figure 12

Circuit Protection

Description

Device that interrupts current flow if current flow becomes excessive.

Types:
- Fuses
- Circuit Breakers
- Fusible links

Fuse and circuit breaker test

1. Visually inspect for a broken wire in the middle of the fuse (Figure 13).

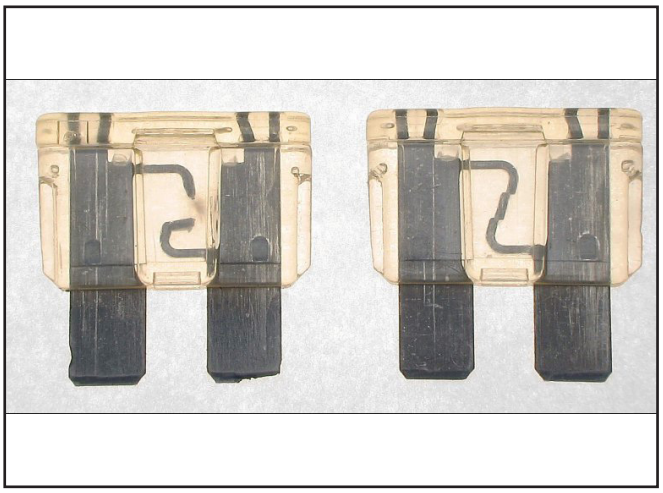

Figure 13

2. Check fuses and circuit breakers with an ohmmeter if disconnected from the circuit, blown fuses will read OL (Open Loop).
3. Check fuses and circuit breakers with a voltmeter while connected to the circuit. Look for continuity when closed, infinity when open.

Circuit Protection (Cont.)

Fusible link test

Fusible links are wires, that are smaller gauge wire than main conductor. For example, a 12 AWG conductor might have an 8 AWG fusible link. If the main circuit is overloaded, the fusible link will overheat and break the circuit.

1. Visually inspect for broken or bubbled cables.
2. Use continuity test for suspected burnt or broken fusible links.

Jumper Links

Jumper links are used to bypass switches by creating a temporary short in an electrical circuit.

Battery Tests

Specific Gravity Test (Use Table)

The specific gravity or weight of the battery electrolyte indicates state of the battery charge. A battery hydrometer measures the specific gravity of the electrolyte. Hydrometers are calibrated to measure specific gravity at an electrolyte temperature of 80º F. To determine the correct specific gravity reading when the temperature of the electrolyte is other than 80ºF use the following table:

Battery electrolyte temperature	Minimum voltage “under load” @ end of test
70º F (21º C)	9.6 VOLTS
60º F (16º C)	9.5 VOLTS
50º F (10º C)	9.4 VOLTS
40º F (4º C)	9.3 VOLTS
30º F (-1º C)	9.1 VOLTS
20º F (-7º C)	8.9 VOLTS
10º F (-12º C)	8.7 VOLTS
0º F (-18º C)	8.5 VOLTS

Amperage load should equal one-half the cold cranking amperage of the battery.
3 x Amp-Hr rating for 12-volt batteries.

TEST	TEST RESULTS	CONDITION	CORRECTIVE ACTION
SPECIFIC GRAVITY TEST @ 80º F (26º C)	GRAVITY BELOW 1.250 - 1.280	CHARGED	PERFORM LOAD TEST
	GRAVITY BELOW 1.240	DISCHARGED	RECHARGE, PERFORM LOAD TEST
	MORE THAN 50 GRAVITY POINTS (0.050) VARIATION BETWEEN CELLS	(A) SHORTED CELL (B) ACID LOST (C) OLD BATTERY	REPLACE
LOAD TEST	MINIMUM TERMINAL VOLTAGE	(A) DISCHARGED (B) OLD BATTERY	(A) RECHARGE (B) REPLACE

Battery Tests (Cont.)

Toro Key-Lectric Tester

To test WPM chargers and batteries, use the Key-Lectric system tester (part #67-7970).

Charger test

1. Connect the white charger plug to the tester. (Figure 14)

Figure 14

2. Press the tester toggle switch to “CHARGER”, and read LED result.

Battery test

1. Charge the battery for 48-72 hours before test.

2. Disconnect the battery from mower.

3. Connect the tester spade plugs to the battery.

4. Press the tester toggle switch to “BATTERY”, and read LED result (Figure 15).

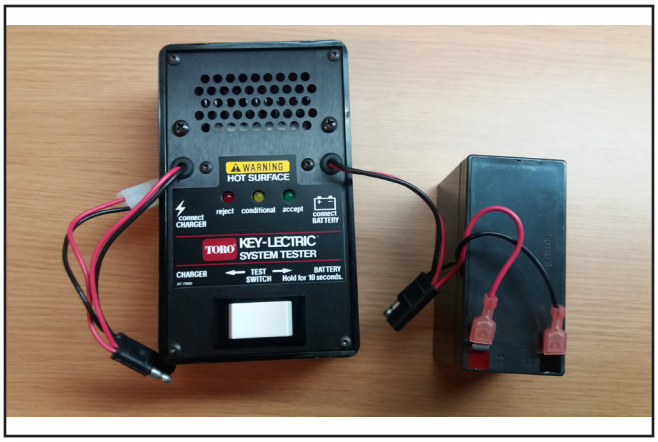

Figure 15

Voltage Tests

Understanding voltage drop testing and when to perform a voltage drop test.

When encountering poor performance from an electrical component, a test of the circuit may indicate that the amperage flow is lower than required to operate the system. The area of excessive resistance must be located and repaired. Performing a voltage drop test will help locate the area of excessive resistance.

Testing for voltage drop

1. Connect the voltmeter red lead (+) to the power (or “most” positive) side of the component, circuit or connection to be tested.
2. Connect the voltmeter black lead (-) to the ground (or “least” positive) side of the component, circuit or connection to be tested. Set the meter scale to exceed the expected test voltage, (auto-range on digital voltmeters).
3. Turn “on” the circuit (remember, current must be flowing through the circuit for resistance to be found) and read the voltage.

Voltage Tests (Cont.)

Feed Side Voltage Drop Test (Figure 16).

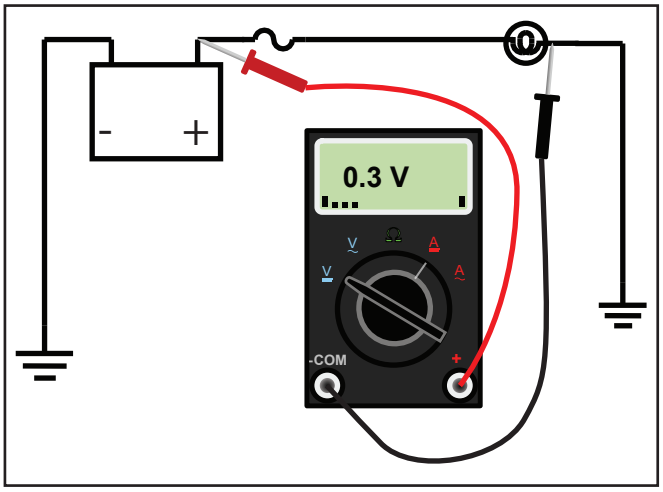

Figure 16

Ground Side Voltage Drop Test (Figure 17).

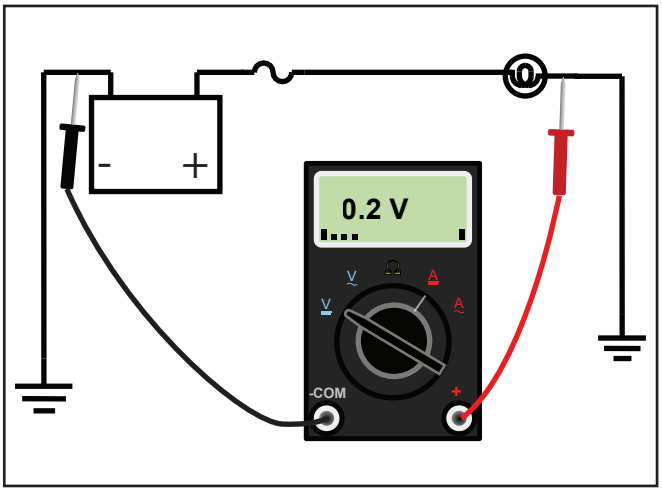

Figure 17

Resistance Tests

Magnetic Switches (Proximity or Reed Switches)

Description

Magnetically operated switches used for controlling current flow in the circuit.

Types

- Seat switch
- Cutting unit lift arm switch
- Magnetic reed switches are tested with an ohmmeter and using a magnet to close the switch.

Magnetic Switch Test

1. Set the multimeter to check resistance (ohms).
2. Move the magnet away from the switch. The meter should read OL (open loop).
3. Move the magnet close to the switch. The meter should read less than 1 ohm (closed).

Resistance Tests (Cont.)

Key Switch

Description

Mechanical switch used to control unit starting, running and accessories (Figure 18).

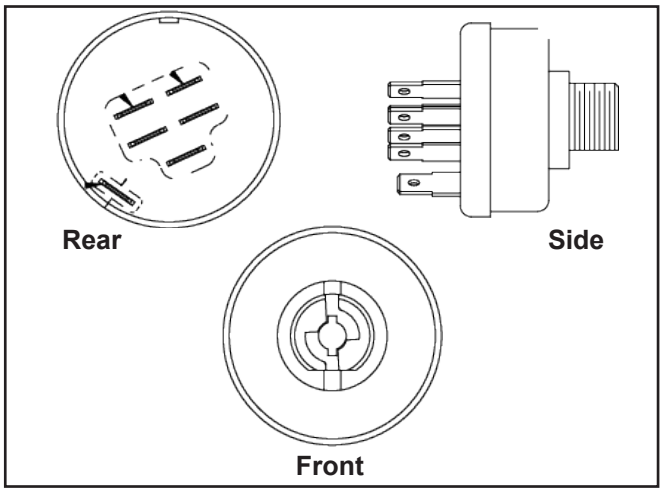

Figure 18

Key Switch Test

1. Set the multimeter to check resistance (ohms).
2. Refer to the unit wiring diagram to verify what terminals should be connected.
3. Look for continuity when closed and infinity when open.
4. When the switch is in the circuit, the switch is tested with a voltmeter.

Resistance Tests (Cont.)

Pressure Switches

Description

Pressure operated switches used for controlling current flow for lights and gauges.

Types

- Engine oil pressure switch
- Hydraulic oil pressure switch
- Filter restriction senders switch

Pressure Switch Test

1. Set the multimeter to check resistance (ohms).
2. Look for continuity when closed, infinity when open.
3. Pressure switches can be normally open and close at a certain pressure, or normally closed and open at a certain pressure.

Resistance Tests (Cont.)

Speed Sensors

Description

Switches that sense movement or speed, can be operated by a magnet, or sense a moving shaft.

Types

- Reel speed sensors
- Ground speed sensors

Speed Sensor Test

1. Set multimeter to check resistance (ohms).
2. Connect the ohmmeter and observe the resistance change when the shaft or gear is moved (Figure 19).

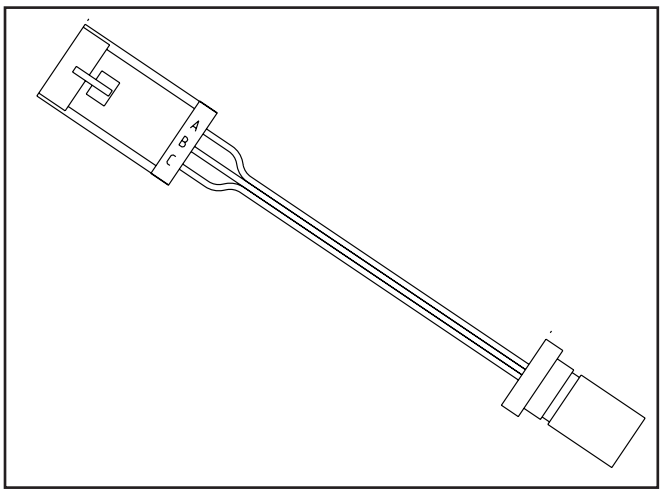

Figure 19

Resistance Tests (Cont.)

Temperature Senders and Switches

Description

Temperature controlled switches and senders.

Types

- Engine coolant temperature switch and sender
- Hydraulic system temperature switch and sender

Temperature Switch Test:

1. Set multimeter to check resistance (ohms).
2. Check if the switch is open or closed using the ohmmeter.
3. Submerse the sensing bulb in hot water and watch for switch change.

NOTE: The switch actuation temperature is usually noted on the switch (Figure 20).

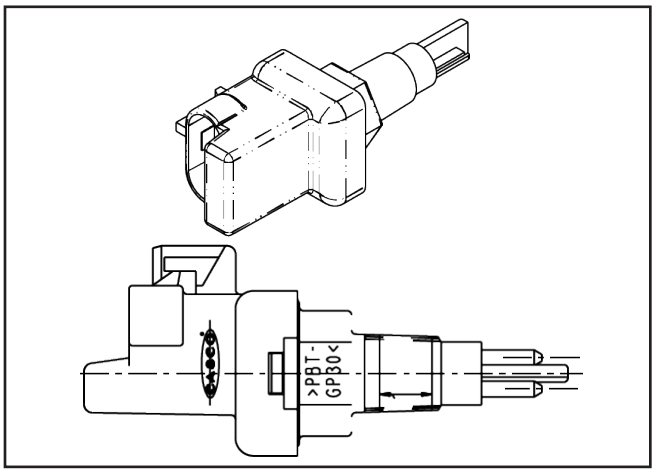

Figure 20

Resistance Tests (Cont.)

Temperature Senders and Switches (Cont.)

Temperature Sender Test

1. Set multimeter to check resistance (ohms).
2. Measure the resistance of the sender.
3. Submerse the sensing bulb in hot water and watch for resistance change.

Resistance Tests (Cont.)

Potentiometers

Description

Variable resistance switches.

Types

- Height-of-cut (H.O.C.)
- Reel Speed

Potentiometer Test

1. Connect the ohmmeter to the two outside terminals to find the total potentiometer resistance.
2. Connect the ohmmeter to the center and one outside terminal to find varying resistance as the potentiometer is turned.

Resistance Tests (Cont.)

Solenoids

Description

Solenoids control hydraulic valves, fuel injection pumps and some small mechanical functions.

Solenoid Test

1. Set the multimeter to check resistance (ohms).
2. Measure resistance across the solenoid leads.

NOTE: Solenoids can have different size ratings, see the Service Manuals for specifications.

Resistance Tests (Cont.)

Stator

Description

Stators keep an electromagnetic field aligned in an alternator. Stators are wound in a hollow ring shape, and are the stationary part of the alternator.

Stator Test

1. Set the multimeter to check resistance (ohms).
2. Connect the ohmmeter to the stator windings and check the stator for continuity.
3. Connect the ohmmeter to the stator windings and the housing and check the stator for shorts.

Resistance Tests (Cont.)

Rotor

Description

Rotors combined with stators make up alternator systems. Rotors are the spinning part of the alternator.

Rotor Test

1. Set the multimeter to check resistance (ohms).
2. Connect the ohmmeter leads to both slipper rings.
3. Check the rotor windings for continuity.
4. Connect the ohmmeter leads to one slipper ring and the rotor housing. Check the rotor for shorts between the windings and the housing.

Resistance Tests (Cont.)

Ignition Coils

Description

Ignition coils step up battery voltage to allow spark plugs to fire. Ignition coils have two circuits to test; a primary and a secondary.

Ignition Coil Test

1. Determine the correct resistances for the specific ignition coil.
2. Locate the ignition coil and remove any plastic covers.
3. Disconnect the wiring harness from the ignition coil.
4. Set the multimeter to check resistance (ohms).
5. Primary circuit
    a. Connect the multimeter leads to the coil's positive and negative terminals to test the primary circuit.
    b. The meter should read between 0.4 ohms and 2 ohms.

NOTE: Readings outside of this range indicate the coil should be replaced.

6. Secondary circuit
    a. Connect the multimeter leads to the coil's positive terminal and the high output terminal to test the secondary circuit.

NOTE: The meter should read between 2k ohms and 10k ohms. Readings outside of this range indicate the coil should be replaced.

Resistance Tests (Cont.)

Ignition Coils (Cont.)

Using a Spark Tester

1. Disconnect the spark plug boot from the spark plug.
2. Insert the spark tester into the spark plug boot.
   a. If using an inline tester, connect the rubber boot end of the tester to the spark plug (Figure 21).

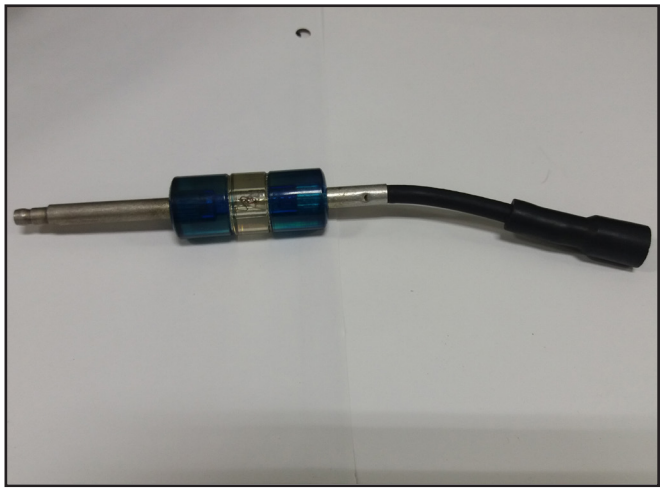

Figure 21

   b. If using an adjustable tester, ground the tester by connecting the clamp to the chassis.
3. Attempt to start engine and watch for regular strong spark within spark tester.

PTO Clutch

Description

PTO clutch controls the engagement and disengagement of the Power Take Off (PTO) pulley.

PTO Clutch Test

1. Disengage the PTO, set the parking brake, turn the ignition key to OFF, and remove the key.
2. Disconnect the clutch wire connector.
3. Set the multimeter to check resistance (ohms).
4. Connect the meter lead wires to the wire in the clutch connector (Figure 22).

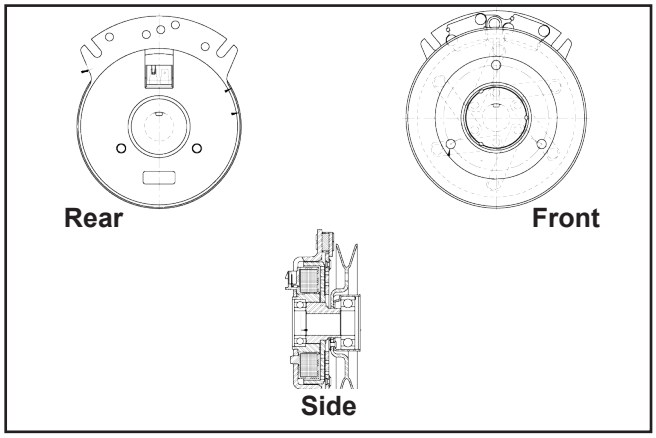

Figure 22

5. Refer to the service manual for acceptable resistance range.

NOTE: If the reading is above or below the specified range, the clutch has failed and needs to be replaced. If the reading is between these two limits, measure the clutch current draw.

PTO Clutch (Cont.)

Measuring Clutch Current Draw

1. Disengage the PTO, set the parking brake, and turn the ignition to OFF.
2. Disconnect the clutch wire connector.
3. Set the multimeter to check current (amps) on a 10 amp scale.
4. Connect the positive meter lead to the tractor terminal of the clutch wire.
5. Connect the negative meter lead to the corresponding wire terminal.
6. Connect a short jumper lead from terminals labeled (B) and (D) .
7. Turn the ignition switch to the “RUN” position and turn the PTO switch to the “ON” position.
8. Refer to the service manual for acceptable current range.

NOTE: If the meter is reading outside of the acceptable range, check the electrical system for problems (i.e., the battery, ignition switch, PTO switch, or wiring harness may be malfunctioning).

Voltmeter Gauge

Description

Voltmeter gauge indicates the voltage across the battery.

Voltmeter Test

1. Set the meter to measure voltage.
2. With the meter still connected to the wiring harness, turn the key to the “RUN” position.
3. Verify the conditions specified in the service manual.

NOTE: If the conditions are not met, replace the voltmeter as it not serviceable.

Hourmeter

Description

Hourmeter keeps track of the actual engine hours.

Hourmeter Test

1. Set the meter to measure voltage.
2. Verify that 12 volts is present across the two terminals when the engine is running.
3. If the previous step is verified and the meter is not running, replace the meter. If 12 volts is not present, check the connections and the engine oil pressure switch. The meter is a permanently sealed unit and is not repairable.

Troubleshooting

- Know the electrical system for the machine: Study the schematics, operators manual, and service manual. Know how the system works and what voltage and resistance measurements are expected.
- Talk to the operator: How did the machine act just as it started to malfunction? Was any unauthorized service performed or did anyone else attempt to repair the machine? How was the machine used and when was maintenance last performed?
- Operate the machine: Operate the machine in conditions simulating when the malfunction occurred. Verify what the operator described. Are the gauges and warning lights operating correctly. Check for any unusual operation, sounds, smells, or smoke. When during the operating cycle does this occur?
- Inspect the machine: Check for bypassed safety interlock switches or other components. Check the battery. Is it fully charged? Is there corrosion at the terminals? Look for corroded, loose or damaged wires and connections, including ground connections.
- List possible causes: Note what was reported by the operator and verified by a technician. List what was found during the inspection. Remember that there may be more than one cause leading to the failure or malfunction.
- Determine which cause is most likely the problem: Look at the list of most possible causes and determine which are the most likely. Use the troubleshooting charts in the service manual.
- Test the findings: Operate the system with a multi-meter connected to the suspected malfunctioning circuit. Use the diagnostic lamps and/or diagnostic display if the unit is equipped with an electronic control system (ECU/ECM/SCM). It may be necessary to replace or adjust a component to verify the findings.