CONTENTS

Open front screen

Section 1 .....Technical Data

Section 2 .....Maintenance

Section 3 .....Troubleshooting

Section 4.....Starting System

Section 5.....Charging System

Section 6 .....Ignition System

Section 7 .....Fuel System

Section 8 .....Governor System

Section 9 .....Cooling System

Section 10 .....3.0L Base Engine Service

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FOREWORD

It is important to note that this manual contains various Warnings, Cautions and Notes that must be carefully observed in order to reduce the risk of personal injury during service or repair. Improper service or repair may damage the engine or render it unsafe. It is also important to warn of all hazardous consequences that might result from careless treatment of the engine. Failure to observe these items could influence terms of warranty.

WARNING

Failure to heed could result in death, injury, or property damage.

CAUTION

Less severe than WARNING, but has the potential to cause injury or damage. Also used to notify of situations that could lead to eventual failure, injury or damage.

IMPORTANT: Denotes situation which could influence safety of proper performance of the vehicle or a component.

NOTICE: Significant item of information.

"Must Read" Symbols

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

- Proper service and repair are important to the safety of the service technician and the safe, reliable operation of all engines. The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.
- If part replacement is necessary, the replacement part must be of the same part number or an equivalent part. Do not use a replacement part of lesser quality. Before using a replacement part, service procedure, or tool which is not recommended by the engine manufacturer, it must first be determined that neither personal safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure, or tool selected.
- Special service tools shown in this service manual that have tool product numbers beginning with "J" or "BT" are available for worldwide distribution from:

Kent-Moore Tools
28635 Mound Road
Warren, Mi. 48092
1-800-345-2233
Mon.-Fri. 8:00 a.m. - 5:00 p.m. EST
Telex: 244040 KMTR VR
Fax: 1-800-578-7375

English and Metric Fasteners

CAUTION

Late model engines use a combination of English and Metric threaded fasteners. The components effected are starter motor, engine mounts, and flywheel housing mounting. Verify that the proper fasteners are used whenever removing or replacing one of these components.

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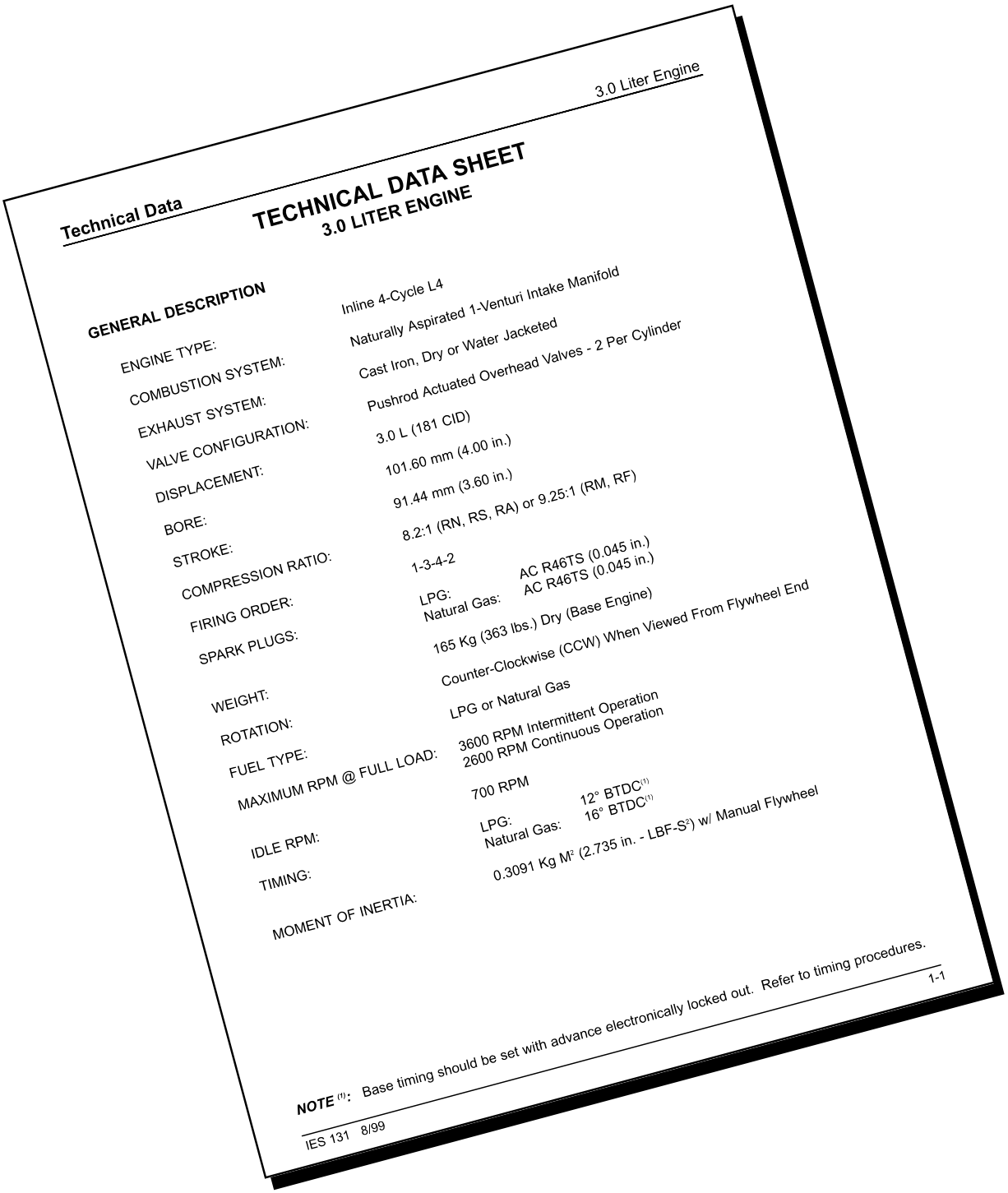
Section 1



Technical Data — 3.0 Liter Engine

TECHNICAL DATA SHEET
3.0 LITER ENGINE

GENERAL DESCRIPTION

ENGINE TYPE:	Inline 4-Cycle L4
COMBUSTION SYSTEM:	Naturally Aspirated 1-Venturi Intake Manifold
EXHAUST SYSTEM:	Cast Iron, Dry or Water Jacketed
VALVE CONFIGURATION:	Pushrod Actuated Overhead Valves - 2 Per Cylinder
DISPLACEMENT:	3.0 L (181 CID)
BORE:	101.60 mm (4.00 in.)
STROKE:	91.44 mm (3.60 in.)
COMPRESSION RATIO:	8.2:1 (RN, RS, RA) or 9.25:1 (RM, RF)
FIRING ORDER:	1-3-4-2
SPARK PLUGS:	LPG: AC R46TS (0.045 in.) Natural Gas: AC R46TS (0.045 in.)
WEIGHT:	165 Kg (363 lbs.) Dry (Base Engine)
ROTATION:	Counter-Clockwise (CCW) When Viewed From Flywheel End
FUEL TYPE:	LPG or Natural Gas
MAXIMUM RPM @ FULL LOAD:	3600 RPM Intermittent Operation 2600 RPM Continuous Operation
IDLE RPM:	700 RPM
TIMING:	LPG: 12° BTDC(1) Natural Gas: 16° BTDC(1)
MOMENT OF INERTIA:	0.3091 Kg M^2 (2.735 in. - LBF-S^2) w/ Manual Flywheel

NOTE **(1):** Base timing should be set with advance electronically locked out. Refer to timing procedures.

IES 131 8/99 — 1-1

Technical Data

TABLE OF CONTENTS

3.0L Engine 1-1
General Description 1-1
Fuel System 1-2
Air Intake System 1-2
Exhaust System 1-3
Cooling System 1-3
Lubrication System 1-4
Engine Electrical 1-4
Installation Limits 1-4

TECHNICAL DATA SHEET
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NOTE (1): Base timing should be set with advance electronically locked out. Refer to timing procedures.

FUEL SYSTEM

NATURAL GAS FUEL:

FUEL MIXER INLET PRESSURE: +140 mm Wg ± 12.7 mm Wg (+5.5 in. WC ± 0.5 in. WC) @ Idle
GAS PRESSURE @ LPR INLET: 177 - 356 mm Wg (7 - 14 in. WC)

Mixer:	IMPCO FB125M
Recommended Regulator[2]:	IMPCO IMP-53
Regulator Fuel Inlet Sizes:	1" NPT inlet & outlet ports
Air/Fuel Mixture:	2% Oxygen @ Rated Power and Speed

PROPANE (LPG) Liquid:

FUEL MIXER INLET PRESSURE: -51 mm Wg ± 12.7 mm Wg (-2.0 in. WC ± 0.5 in. WC) @ Idle
GAS PRESSURE @ LPR INLET: Full Tank Pressure

Mixer:	IMPCO CA100M (air valve CV1-16-2)
Recommended Regulator[2]:	IMPCO Model EB w/VFF30 Vacuum Fuelock Filter [3]
Fuel Inlet Sizes:	VFF30 - 1/4" NPT liquid fuel inlet & outlet ports EB Regulator - 1/4" NPT liquid fuel inlet - 1" NPT fuel outlet
Air/Fuel Mixture:	0.5 to 1.5% CO @ Rated Power and Speed

PROPANE (LPG) Vapor:

FUEL MIXER INLET PRESSURE: -51 mm Wg ± 12.7 mm Wg (- 2.0 in. WC ± 0.5 in. WC) @ Idle
GAS PRESSURE @ LPR INLET: 177 - 356 mm Wg (7 - 14 in. WC)

Mixer:	IMPCO CA100M (air valve CV1-16-2)
Recommended Regulator[2]:	IMPCO IMP-53 mounted upside-down w/spring removed [2]
Regulator Fuel Inlet Sizes:	1" NPT inlet & outlet ports
Air/Fuel Mixture:	0.5 to 1.5% CO @ Rated Power and Speed

AIR INTAKE SYSTEM

MINIMUM INTAKE AIR FLOW RATE:	4.11 m^3/min. (145 CFM)	
MAXIMUM ALLOWABLE INTAKE RESTRICTION:	w/Clean Element :	254 mm Wg (10 in. WC)
	w/Dirty Element:	508 mm Wg (20 in. WC)
MAXIMUM ALLOWABLE TEMPERATURE:	Maximum Allowable Temperature Rise between Ambient and Engine Air Inlet is 16.7°C (30°F).	

NOTE [2]: All regulators should be mounted within 457.2 mm (18 in.) of the mixer for best operation.

NOTE [3]***:*** A balance line should be installed between the regulator and mixer if engine is to be operated in dirty or dusty environment. (Balance line fittings are 1/8" NPT)

EXHAUST SYSTEM

EXHAUST GAS FLOW RATE AT MAXIMUM POWER:	272 CFM @ 2600 RPM 447 CFM @ 3600 RPM
MAXIMUM EXHAUST GAS TEMPERATURE @ FULL LOAD:	527°C (980°F) @ 2600 RPM 677°C (1250°F) @ 3600 RPM
MAXIMUM ALLOWABLE BACK PRESSURE:	18.7 kPa (2.5 PSI)
MINIMUM ALLOWABLE EXHAUST PIPE SIZE:	38 mm (1-1/2 in.)

COOLING SYSTEM

MAX COOLANT TEMPERATURE @ TOP TANK OF RADIATOR:	98°C (210°F) @ 2600 RPM		
WATER PUMP ROTATION:	(viewed from front)	w/V-Belt Drive - Clockwise (CW)	
MAXIMUM RESTRICTION AT PUMP INLET:	10 kPa (1.5 PSI)		
THERMOSTAT:	LPG:	Opening Temperature:	82°C (180°F)
		Fully Open Temperature:	96°C (205°F)
	NG:	Opening Temperature:	71°C (160°F)
		Fully Open Temperature:	85°C (185°F)
COOLING WATER CAPACITY (block only):	3.8 L (4.0 qts.)		

LUBRICATION SYSTEM

OIL PRESSURE (MIN. HOT):	28 kPa (4 psi) @ 700 RPM 207 - 414 kPa (30 - 60 psi) @ 2000 RPM
OIL TEMPERATURE:	Upper Limit: 130°C (266°F) Recommended: 99 - 110°C (210 - 230°F) Lower Limit: 80°C (176°F)

NOTE: Oil Cooler Required w/Standard Oil Pan (Stationary Applications Only)

CRANKCASE CAPACITY:	Standard Pan: 4.7 L (5.0 qts.) Optional Pan: 26.5 L (28 qts.) Oil Filter: 0.9464 L (1 qt.)
ENGINE OIL SPECIFICATION:	API - SG/SH, SAE 10W30 - All Temperatures SAE 15W40 - Above -18°C (0°F) SAE 30W - Between 5° and 27°C (40° and 80°F) SAE 40W - Above 27°C (80°F)

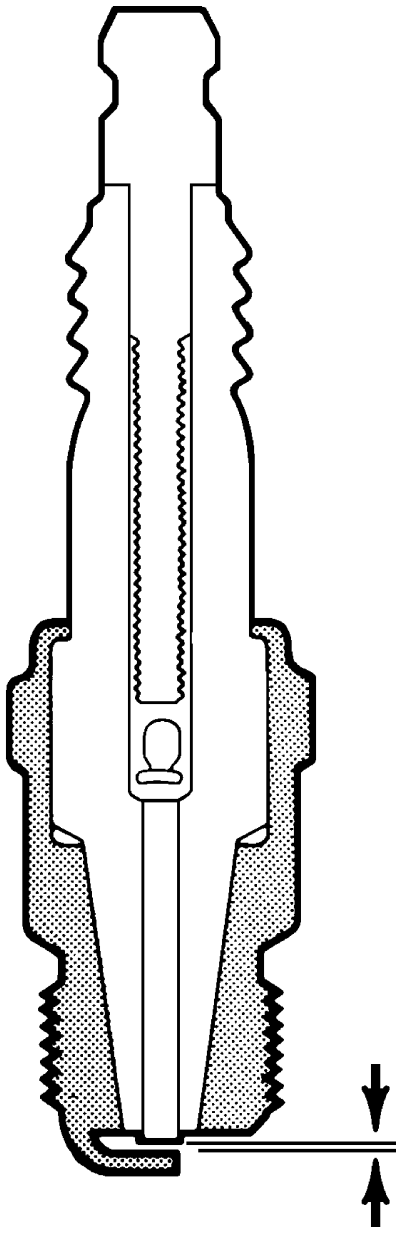
ENGINE ELECTRICAL

IGNITION TYPE:	Delco EST w/Electronic Advance
STARTER MOTOR:	Delco SD300 / 12 volt Negative Ground (-) (12.75” Flywheel) Delco PG260 / 12 volt Negative Ground (-) (14.00” Flywheel)
FLYWHEEL TEETH:	12.75 in. Flywheel 153 14.00 in. Flywheel 168
BATTERY REQUIREMENT:	12 volt - 485 CCA (90 AH)
ALTERNATOR:	12 volt - Mando 51 Amp

INSTALLATION LIMITS

MAXIMUM ANGULARITY LIMITS ON ENGINE:	Front of engine down:	8.5°
	Rear of engine down:	18°
	Side to side:	20°

Section 2



Maintenance

TABLE OF CONTENTS

Maintenance 2-1
Accessory Drive Belts 2-1
Engine Crankcase Oil 2-1
Changing Engine Oil and Filter 2-2
Cooling System 2-2
Engine Compression Check 2-3
Scheduled Maintenance Chart 2-4

MAINTENANCE

All Crusader Industrial Power Products require a certain amount of maintenance. Suggested maintenance requirements are contained in this section. The owner should, however, develop his own maintenance schedule using the requirements listed in this Section and any other necessary requirements resulting from optional additions to the engine system.

ACCESSORY DRIVE BELTS

WARNING

Engine must be shut off and the ignition key removed before inspecting drive belts.

V-Belt Systems

Check belt tension by pressing down on the midway point of the longest stretch between two pulleys. The belt should depress 1/2 in. (13 mm). If depression is more than allowable, adjust tension.

Serpentine Belt Systems

Serpentine belt systems use a spring-loaded tensioner which keeps the belt properly adjusted automatically.

ENGINE CRANKCASE OIL

Figures 2-1 and 2-2

Oil Recommendations

Prior to changing oil, select an oil based on the prevailing daytime temperature in the area in which the engine is operated. The chart in figure 2-1 is a guide to selecting the proper crankcase oil. Refer also to Section 1 for additional information.

IMPORTANT: Oils containing "solid" additives, non-detergent oils, or low-quality oils are not recommended for use in Crusader Industrial Power Products.

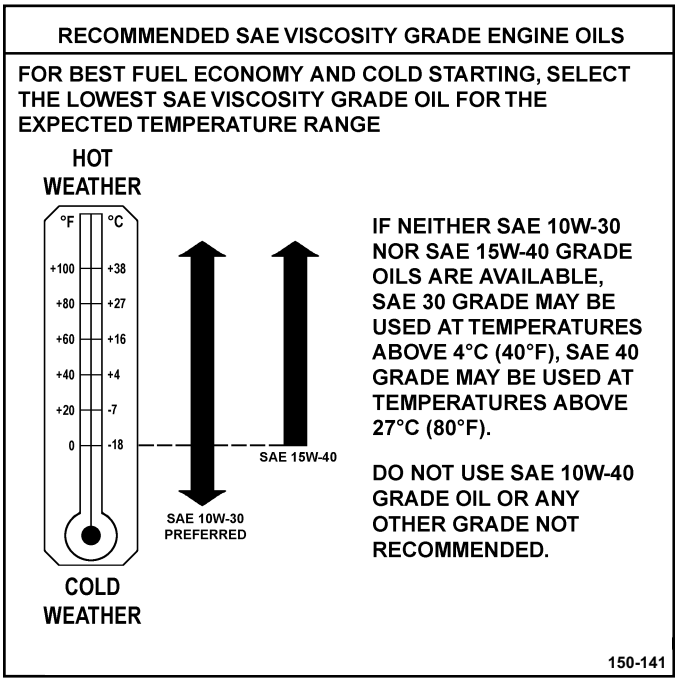


Figure 2-1 *Engine Oil Viscosity Recommendation*

Use of Supplemental Additives

Engine oils meeting Crusader Industrial Power Products' recommendations already contain a balanced additive treatment. The use of supplemental additives which are added to the engine oil by the customer are unnecessary and may be harmful. Cruasder does not review, approve, or recommend such products.

Synthetic Oils

Synthetic engine oils are not recommended for use in Crusader Industrial Power Products. Synthetics may offer advantages in cold-temperature pumpability and high-temperature oxidation resistance. However, synthetic oils have not proven to provide operational or economic benefits over conventional petroleum-based oils in Crusader Industrial Power Products. Their use does not permit the extension of oil change intervals.

Checking/Filling Engine Oil Level

IMPORTANT: Care must be taken when checking engine oil level. Oil level must be maintained between the "ADD" mark and the "FULL" mark on the dipstick. To ensure that you are not getting a false reading, make sure the following steps are taken before checking the oil level.

1. Stop engine if in use.
2. Allow sufficient time (approximately 5 minutes) for the oil to drain back into the oil pan.
3. Remove dipstick. Wipe clean and reinstall. Push dipstick all the way into the dipstick tube.
4. Remove dipstick and note the oil level.
5. Oil level must be between the "FULL" and "ADD" marks (figure 2-2).

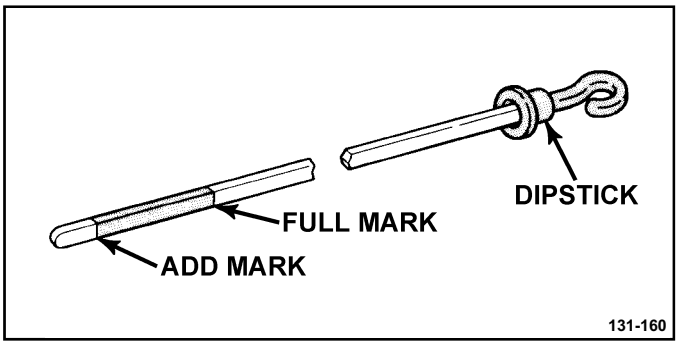


Figure 2-2 *Engine Oil Dipstick (Typical)*

6. If the oil level is below the "ADD" mark, proceed to Steps 7 and 8, and reinstall dipstick into the dipstick tube.
7. Remove oil filler cap from the valve rocker arm cover.
8. Add required amount of oil to bring level up to, but not over, the "FULL" mark on dipstick.

CAUTION

Overfilled crankcases (oil level being too high) can cause a fluctuation or drop in oil pressure and rocker arm "clatter" on engines. The overfill condition results in the engine crankshaft splashing and agitating the oil, causing it to foam (become aerated). The aerated oil causes the hydraulic valve lifters to "bleed down." This, in turn, results in rocker arm "clatter"and loss of engine performance due to the valves not opening properly.

CHANGING ENGINE OIL AND FILTER

IMPORTANT: When changing the oil, always change the oil filter.

1. Start engine and run until it reaches normal operating temperatures.

IMPORTANT: Change oil when engine is warm from operation as It flows more freely, carrying away more impurities.

2. Stop engine.
3. Remove drain plug and allow all the oil to drain.
4. Remove and discard oil filter and its sealing ring.
5. Coat sealing ring on new filter with clean engine oil, and install new filter. Tighten filter securely (following filter manufacturer's instructions). Do not overtighten.
6. Fill crankcase with oil.
7. Start engine and check for oil leaks.

COOLING SYSTEM

CAUTION

Alcohol- or methanol-based antifreeze or plain water are not recommended for use in the cooling system at anytime.

Crusader Industrial Power Products recommends that the cooling system be filled with a 50/50 mixture of ethylene glycol antifreeze and water.

Crusader Industrial Power Products can use any type of permanent antifreeze or any brand antifreeze solution that meets GM Specification 1825M or 1899M which will not damage aluminum parts.

Checking Coolant Level

Do not remove cooling system pressure cap when engine is hot. Allow engine to cool and then remove cap slowly allowing pressure to vent. Hot coolant under pressure may discharge violently.

1. Check coolant level in coolant recovery tank. Add specified coolant as required.
2. Periodically remove the pressure cap from the filler neck to ensure the coolant recovery system is functioning properly. Coolant must be at the top of the filler neck. If coolant is low, check gasket in cap for damage. Replace if necessary. Inspect coolant recovery system for leaks.

ENGINE COMPRESSION CHECK

1. Disconnect the primary lead from the distributor.
2. Remove all spark plugs.
3. Block the throttle plate and choke plate (if equipped) into the wide-open position.
4. Make sure the battery is fully charged.
5. Starting with the compression gauge at zero, crank the engine through four compression strokes.
6. Make the compression check at each cylinder and record each reading.
7. If some cylinders have low compression, inject about one tablespoon (15 ml or about three squirts from a pump-type oil can) of engine oil into the combustion chamber through the spark-plug hole. Recheck compression.
8. Minimum compression recorded in any one cylinder should not be less than 70% of the highest cylinder, and no cylinder should read less than 100 psi (690 kPa). For example, if the highest pressure in any one cylinder is 150 psi (1035 kPa), the lowest allowable pressure for any other cylinder would be 105 psi (725 kPa), since 150 x 70% = 105 (1035 x 70% = 725).
   - Normal condition - compression builds up quickly and evenly to the compression specified on each cylinder.
   - Piston rings leaking - low compression on first stroke tends to build up on following strokes but does not reach normal. Improves considerably with addition of oil.
   - Valves leaking - low compression on first stroke. Does not tend to build up on following strokes. Does not improve much with addition of oil.
   - If two adjacent cylinders have lower than normal compression, and injecting oil into cylinders does not increase the compression, the cause may be a head gasket leak between the cylinders.

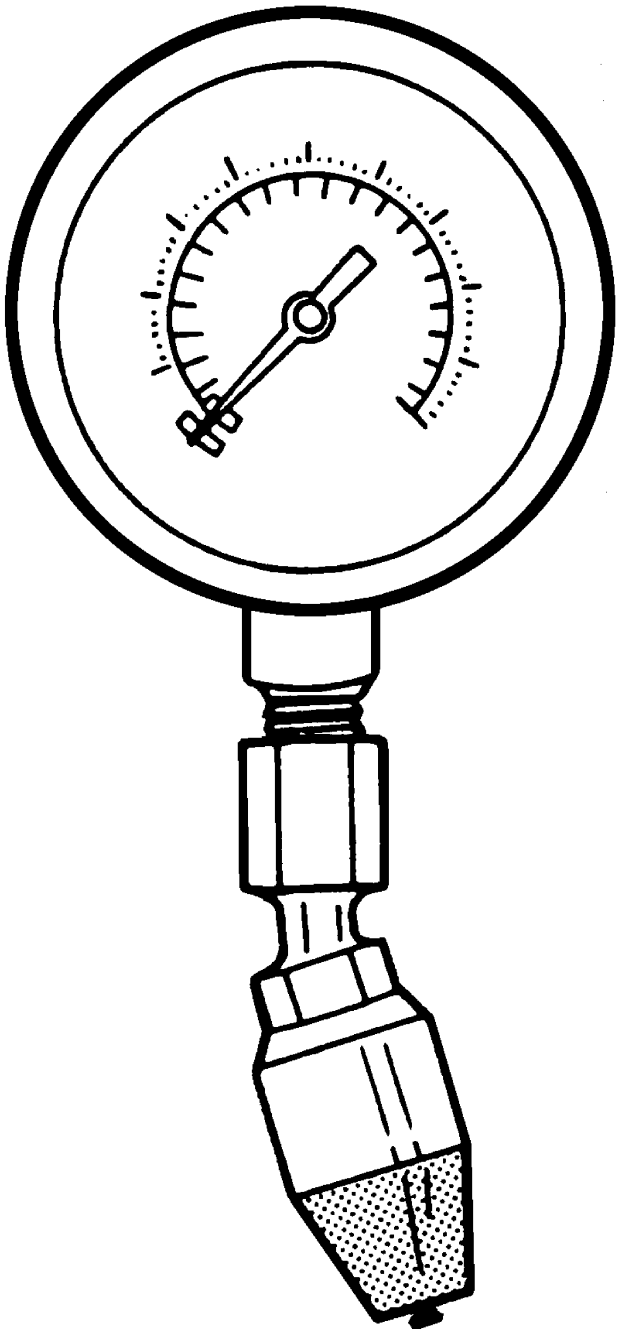
SCHEDULED MAINTENANCE CHART

Maintenance Items	Interval (Hours)								
	Daily	250	500	750	1000	1250	1500	1750	2000
Check engine oil level	X								
Check engine for obvious water, oil fuel, or exhaust leaks	X								
Check engine for loose, missing, or damaged parts and/or fasteners	X								
Change engine oil and filter: Standard oil pan - All applications Optional large capacity oil pan - standby operation Optional large capacity oil pan - Continuous operation	*Every 100 hours or 60 days of operation* *Every 250 hours or 120 days of operation* *Every 750 hours or 120 days of operation (28-32 Qt. Capacity Pan)* *Every 500 hours or 120 days of operation (15 Qt. Capacity Pan)*								
Check accessory drive belts for cracks, fraying, wear, and tension		X	X	X	X	X	X	X	X
Inspect hoses for cracks, swelling, weather checking, or deterioration		X	X	X	X	X	X	X	X
Inspect electrical system - check for loose, dirty, or damaged wires		X	X	X	X	X	X	X	X
Inspect battery - check for case damage or corrosion on cables		X	X	X	X	X	X	X	X
Inspect ignition system				X			X		
Check ignition timing - adjust as necessary									X
Replace spark plugs									X
Inspect and lubricate throttle cable linkage			X		X		X		X
Check air cleaner element		X	X	X		X	X	X	
Replace air cleaner element					X				X
Check fuel mixer - adjust as necessary									X
Check coolant level (self contained cooling system models only)		X	X	X	X	X	X	X	
Change coolant (self contained cooling system models only)									X
Check engine alignment - adjust an necessary				X			X		

131-168

Figure 2-3 *Maintenance Intervals*

Section 3



Troubleshooting

TABLE OF CONTENTS

Engine Performance 3-1

Engine Starting Problems 3-1

Charging System Problems 3-2

Instrument Problems 3-2

Engine Noise 3-3

Oil Pressure Diagnostics 3-5

Oil Pressure Problems 3-6

Water In Engine 3-7

Engine Overheating 3-8

Vacuum Gauge Diagnostics 3-9

TROUBLESHOOTING

ENGINE PERFORMANCE

Symptom	*Cause*
1. Poor engine idle.	A. Clogged air breather. B. Improper idle-fuel mixture adjustment. C. Cap or spark-plug wires arcing. D. Low grade fuel. E. Incorrect ignition timing. F. Spark plugs (fouled, burned, cracked porcelain). G. Spark plug wires broken or faulty insulation. H. Defective coil. I. Cracked or dirty distributor cap. J. Dirty carburetor. K. Leak at intake manifold or carburetor base. L. Low compression. (Check for blown head gasket). M. Loose or worn distributor. N. Head gasket, exhaust manifold, cracked head or valve seat.
2. Poor engine acceleration.	A. Idle mixture screw. B. Incorrect ignition timing. C. Incorrect distributor advance curve. D. Cracked or dirty distributor cap or rotor. E. Vacuum leak on the intake manifold or carburetor base. F. Spark plugs (fouled, burned, wrong heat range, cracked porcelain). G. Dirty carburetor. H. Low compression.

ENGINE STARTING PROBLEMS

The following information will help to locate the starting problem:

1. Determine which engine system is causing the problem. To make an engine run, basic components - fuel, spark (ignition) and compression - are required. If all three components are present, the engine should run. If any one of the three is missing, weak or arriving at the wrong time, the engine will not run.
2. Determine if there is fuel present.
3. Check ignition system operation. Using appropriate spark tester, check for spark at coil and at each spark plug. If there is a spark at the spark plug wires, remove the spark plugs and make sure they are the correct type and heat range, and not fouled or burned.
4. Run a compression check on the engine to make sure it is mechanically sound.

ENGINE STARTING PROBLEMS (CONTINUED)

Symptom	*Cause*
1. No spark.	A. Distributor cap or spark plug leads arcing. B. Spark plugs fouled, burned or cracked porcelain. C. Spark plug wires are broken or have faulty insulation. D. Battery, electrical connections, damaged wiring. E. Ignition switch. F. Faulty ignition components. G. Cracked or dirty distributor cap. H. Shorted tachometer. (Disconnect tachometer and try again).
2. Engine will not crank over.	A. Battery charge low, damaged wiring or loose electrical connections. B. Circuit breaker tripped (if equipped). C. Bad ignition switch. D. Bad starter solenoid. E. Defective starter motor.

CHARGING SYSTEM PROBLEMS

Symptom	*Cause*
1. Gauges indicate no battery charge.	A. Loose or broken drive belt. B. Loose or corroded electrical connections. C. Faulty ammeter or voltmeter. D. Battery will not accept charge. E. Faulty alternator or regulator.
2. Noisy alternator.	A. Loose mounting bolts. B. Worn, frayed or loose drive belt. C. Loose drive pulley. D. Worn or dirty bearings. E. Faulty diode trio or stator.

INSTRUMENT PROBLEMS

Symptom	*Cause*
1. Malfunctioning instruments or gauges.	A. Faulty wiring, loose or corroded terminals. B. Bad key switch. C. Faulty gauge. D. Faulty sender.

ENGINE NOISE

No definite rule or test will positively determine the source of engine noise. Therefore, use the following information only as a general guide to engine noise diagnosis.

1. Use a timing light to determine if noise is timed with engine rpm or one-half engine rpm. Noises timed with engine rpm are related to crankshaft, rods, pistons, piston pins or flywheel. Noises timed to one-half engine rpm are valve-train related.
2. The use of a stethoscope can aid in locating a noise source. However, because noise will travel to other metal parts not involved in the problem, caution must be exercised.
3. If noise is believed to be confined to one particular cylinder, ground the spark plug leads one at a time. If noise lessens noticeably or disappears, it is isolated to that particular cylinder.
4. Try to isolate the noise to location in engine, front to back, top to bottom. This can help determine which components are at fault.
5. Sometimes noises can be caused by moving parts coming in contact with other components. Examples are: flywheel, crankshaft striking (pan and pan baffle), rocker arm striking valve cover or loose flywheel cover. In many cases, if this is found to be the problem, a complete engine teardown is not necessary.
6. When noise is isolated to a certain area and component, removal and inspection will be required. Refer to proper sections of service manual for pertinent information.

Symptom	***Cause***
1. Noise around the valve cover area.	A. Rocker arm striking valve cover. B. Rocker arm out of adjustment. C. Worn rocker arm. D. Bent push rod. E. Collapsed lifter.
2. Noise around the cylinder area.	A. Sticking valve. B. Carbon build-up. C. Connecting rod installed wrong. D. Bent connecting rod. E. Piston. F. Piston rings. G. Piston pin. H. Cylinder worn.
3. Noise around camshaft area (throughout engine).	A. Loss of oil pressure. B. Valve lifters. C. Cam bearings.
4. Noise in camshaft area area (front of engine).	A. Camshaft timing gear. B. Timing chain. C. Fuel pump. D. Valve lifter. E. Cam bearings.

ENGINE NOISE (CONTINUED)

Symptom	*Cause*
5. Noise in camshaft area (center of engine).	A. Valve lifter. B. Cam bearings.
6. Noise in camshaft area (rear of engine).	A. Distributor gear. B. Valve lifter. C. Cam bearings.
7. Noise in crankshaft area (throughout engine).	A. Loss of oil pressure. B. Main bearings. C. Rod bearings.
8. Noise in crankshaft area (front of engine).	A. Crankshaft timing gear. B. Timing chain. C. Main bearing. D. Rod bearing.
9. Noise in crankshaft area (center of engine).	A. Crankshaft striking pan or pan baffle. B. Main bearing. C. Rod bearing.
10. Noise in crankshaft area (rear of engine).	A. Loose flywheel cover. B. Loose flywheel. C. Drive plate. D. Main bearing. E. Rod bearing.
11. Engine spark knock.	A. Advanced timing. B. Low quality fuel. C. Engine running hot. D. Carbon deposits in engine.
12. Popping through carburetor.	A. Wrong ignition timing. B. Carburetor set too lean. C. Faulty accelerator pump (gasoline). D. Vacuum leak. E. Valve adjustment. F. Valve timing. G. Burned or stuck valve.
13. Hissing.	A. Vacuum leak. B. Leaking exhaust (manifolds or pipes). C. Loose cylinder heads. D. Blown head gasket.
14. Whistle.	A. Vacuum leak. B. Dry or tight bearing in an accessory.

ENGINE NOISE (CONTINUED)

Symptom	*Cause*
15. Sparks jumping.	A. Defective high-tension cables. B. Cracked coil tower. C. Cracked distributor cap.
16. Squeaks or squeals.	A. Drive belt slipping. B. Dry or tight bearing in an accessory. C. Parts rubbing together.

OIL PRESSURE DIAGNOSTICS

The following table contains important information for the checking of oil pressure.

Condition	*Information*
1. Measuring oil pressure.	Use a good automotive oil pressure test gauge. Do not rely on the oil pressure gauge in the instrument panel.
2. Check engine oil level.	Oil level should be between the "ADD" and "FULL" marks.
3. Oil level in crankcase above "FULL" mark.	May cause loss of engine speed, oil pressure gauge fluctuation, drop in oil pressure and hydraulic valve lifter noise at high RPM.
4. Oil level in crankcase at or below “ADD” mark.	Low oil pressure, oil pressure gauge fluctuation, internal below engine noise and/or damage.
5. Change in oil pressure.	This may be a normal condition. Oil pressure may read high in the cooler times of the day and when engine is not up to operating temperature. As the air temperature warms up and the engine is running at normal operating temperature, it is normal for oil pressure to drop off slightly.
6. Low engine oil pressure at idle or high rpm.	With modern engines and engine oils, low oil pressure readings at idle or high rpm do not necessarily mean there is a problem. If valve lifters do not "clatter" (at idle), there is a sufficient volume of oil to lubricate all internal moving parts properly. The reason for the drop in oil pressure is that engine heat causes an expansion of the internal tolerances in the engine and, the oil will thin out somewhat from heat.
7. Engine-to-engine variance.	It is not uncommon to see different oil pressure readings between like engines, as long as they fall within specifications. Differences in oil pressure can be attributed to differences in engine tolerances, gauges, wiring, senders, etc.

OIL PRESSURE PROBLEMS

Symptom	*Cause*
1. Low oil pressure.	A. Low oil level in crankcase. B. Defective oil-pressure gauge and/or sender. C. Oil broken down, contains water, wrong viscosity, engine running too hot or too cold, excessive idling with cold water (condensation). D. Relief valve stuck open, pickup tube restricted, worn parts in oil pump, air leak on suction side of oil pump or pickup tube. E. Oil passage plugs leaking, cracked or porous cylinder block. F. Excessive bearing clearance.
2. High oil pressure.	A. Wrong viscosity, oil full of sludge or tar. B. Defective oil pressure gauge and/or sender. C. Clogged or restricted oil passage. D. Oil pump relief valve stuck closed.

IMPORTANT: Oil pressure slightly higher than normal does not always indicate a problem. Tolerance stack-up ln the engine, oil viscosity or weather conditions could cause high oil pressure.

3. Excessive oil consumption.	A. Oil leaks. B. Oil diluted or of the wrong viscosity. C. Oil level too high. D. Drain holes in cylinder head plugged causing flooding of valve guides. E. Defective valve seals. F. Intake manifold gasket leaking, worn valve stem or valve guides. G. Defective oil cooler (if so equipped). H. Glazed, scuffed, worn, stuck, improperly installed; ring grooves worn; improper break-in; wrong end gap. I. Piston out-of-round, scored, tapered, glazed; excessive piston-to-cylinder clearance; cracked piston.

NOTE: Normal consumption is approximately one quart of oil in 3-10 hours of operation at W.O.T.

WATER IN ENGINE

Determine location of water in engine. This information is necessary to determine where the water came from and how it got into the engine. The most common problems are water on top of pistons and/or water in crankcase oil.

1. After locating the water, remove all the water from the engine by removing all spark plugs and pump cylinders by cranking engine over. Next change oil and filter. Start engine and see if problem can be duplicated. If so, there is more than likely a mechanical problem. If problem cannot be duplicated, it is either an operator error or a problem that exists only under certain environmental conditions.
2. If water is confined to cylinders, it is usually entering through the intake system, exhaust system or head gasket.
3. If the water is confined to crankcase, it is usually caused by a cracked or porous block or condensation.
4. If the water is located in both the cylinders and the crankcase, it is usually caused by water in the cylinders getting past the rings and valves.
5. Checking for rust in the intake manifold or exhaust manifolds is a good idea. Rust in these areas will give clues if the water entered through these areas.

Symptom	***Cause***
1. Water found on top of the pistons.	A. Cracked exhaust manifold (water cooled). B. Improper manifold-to-elbow gasket installation (water cooled). C. Loose cylinder head bolts. D. Blown cylinder head gasket. (Check for warped cylinder head or cylinder block). E. Cracked valve seat. F. Porous or cracked casting (check engine).
2. Water found in the crankcase oil.	A. Water seeping past piston rings or valves. B. Engine running cold (defective thermostat) causing condensation. C. Intake manifold leaking near a water passage. D. Cracked or porous casting.

ENGINE OVERHEATING

Symptom	*Cause*
1. Mechanically related.	A. Engine rpm below specification for W.O.T. (engine laboring). B. Wrong ignition timing. C. Spark plug wires crossed (wrong firing order). D. Lean fuel mixture. E. Wrong heat range spark plugs. F Exhaust restriction. G. Valve timing off caused by a jumped or improperly installed timing chain and/or gears. H. Blown head gasket(s). I. Insufficient lubrication to moving parts of engine.
2. Cooling system related.	A. Loose or broken drive belt. B. Water shut-off valve partially or fully closed (if equipped). C. Clogged or improperly installed water strainer (if equipped). D. Water inlet hose kinked or collapsed. E. Water pickup clogged. F. Defective thermostat. G. Obstruction in cooling system such as casting flash, sand, or rust. H. Engine circulating pump defective. I. Low coolant level. J. Antifreeze not mixed properly. K. Heat exchanger cores plugged.

VACUUM GAUGE DIAGNOSTICS

Gauge Reading	*Probable Cause*
1. Steady reading ranging between 15 to 21 in. at idle rpm.	A. Normal.
2. Extremely low reading but steady at idle rpm.	A. Vacuum leak. B. Incorrect timing.
3. Fluctuates between high and low at idle rpm.	A. Blown head gasket between two adjacent cylinders.
4. Fluctuates 4 or 5 in. very slowly at idle rpm.	A. Carburetor needs adjustment. B. Spark plug gap too narrow. C. Valves are sticking.
5. Fluctuates rapidly at idle rpm and steadies as the rpm is increased.	A. Valve guides are worn.
6. Continuously fluctuates between low and normal reading at regular intervals at idle rpm.	A. Burned or leaking valve.

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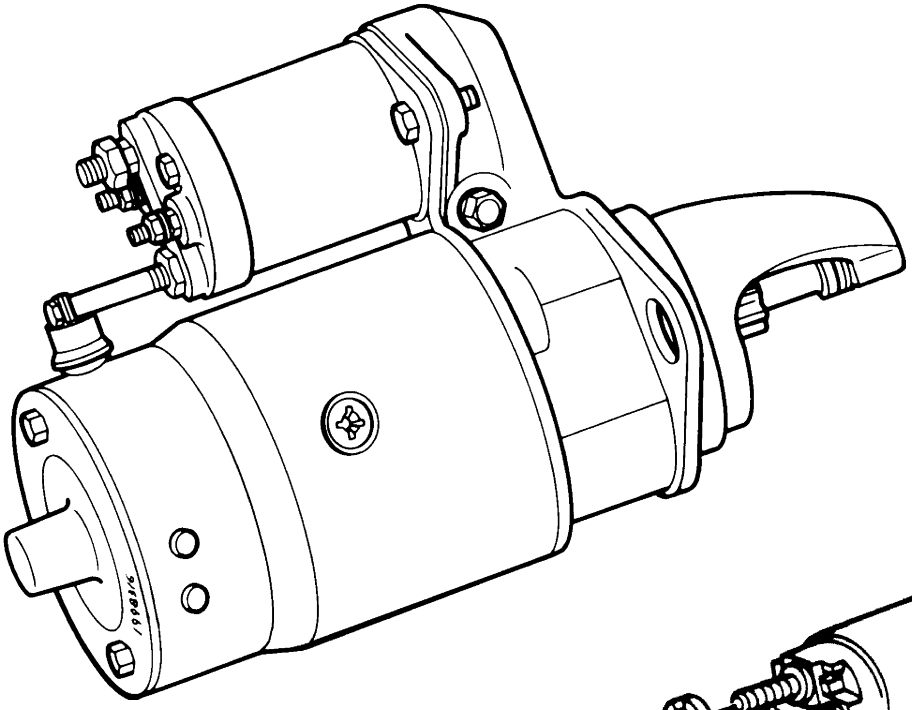
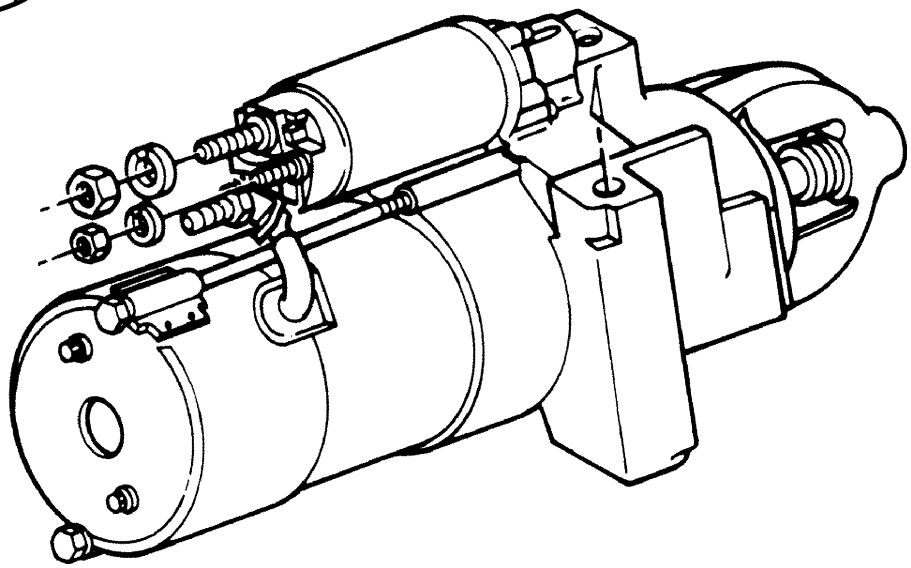
Section 4

SD300 Starter Motor





PG260 Starter Motor

Starting System

TABLE OF CONTENTS

General Information 4-1
Cranking Circuit 4-1
Starter Motor 4-1
Diagnosis 4-1
Starter Motor Noise Diagnosis Chart 4-2

SD300 Starter Motor 4-3
Identification 4-3
Starter Motor Maintenance 4-3
Starter Motor Removal 4-3
Starter Motor Disassembly 4-3
Cleaning and Inspection 4-4
Armature Tests 4-4
Field Coil Tests 4-4
Loose Electrical Connections 4-5
Starter Motor Assembly 4-6
Starter Motor Adjustments 4-6
Starter Motor Installation 4-8
Solenoid Removal 4-8
Solenoid Switch Installation 4-8
Solenoid Switch Testing 4-8

PG260 Starter Motor 4-9
Identification 4-9
Lubrication 4-9
Solenoid Replacement 4-9
Starter Replacement 4-10
No Load Test 4-10
Starter Motor Disassembly 4-11
Cleaning, Inspection, and Testing 4-11
Starter Motor Assembly 4-13
Checking Pinion Clearance 4-15
Torque Specifications 4-16
General Specifications 4-16