480C LOADER BACKHOE SERVICE MANUAL

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Bur 7-43650

Printed in U.S.A.
Issued December 1991

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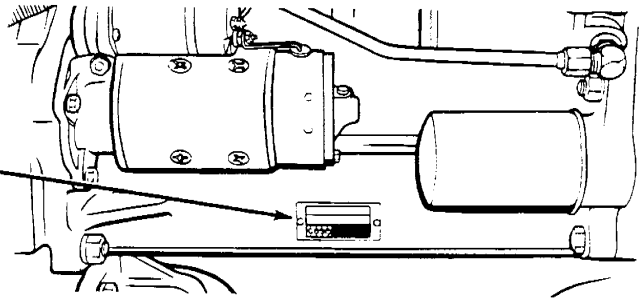
Section 1010

GENERAL ENGINE SPECIFICATIONS 480C TRACTORS

THE MODEL AND ENGINE SERIAL NUMBER IS STAMPED ON A PLATE, LOCATED ON THE RIGHT SIDE OF THE ENGINE, BELOW THE CRANKING MOTOR.



DIESEL ENGINES

General

Type ..... Case Open Chamber, 4 Cylinder, 4 Stroke Cycle, Valve-in-Head
Firing Order 1-3-4-2
Bore ..... 3-13/16 Inches
Stroke ..... 4-1/8 Inches
Piston Displacement ..... 188 Cubic Inches
Compression Ratio ..... 16-1/2 to 1
No Load Governed Speed ..... 2000 to 2040 RPM
Rated Engine Speed ..... 1900 RPM
Engine Idling Speed ..... 625 to 675 RPM
*Valve Tappet Clearance (Exhaust) ..... (Hot and Cold) .014 Inch
(Intake) ..... (Hot and Cold) .012 Inch

*Hot Settings Are Made After the Engine Has Operated At Thermostat Controlled Temperature For At Least Fifteen Minutes.

Piston and Connecting Rods

Rings per Piston 4
Number of Compression Rings 2
Number of Oil Rings 2
Type Pins ..... Full Floating Types
Type Bearing ..... Replaceable Precision, Steel Back, Copper-Lead or Aluminum Alloy Liners

Main Bearings

Number of Bearings 5
Type Bearings ..... Replaceable Precision, Steel Back, Copper-Lead or Aluminum Alloy Liners

Engine Lubricating System

Crankcase Capacity (Without Filter) 4
(With Filter Change) 5
Oil Pressure ..... 50 to 70 Pounds with Engine Warm and Operating at Rated Engine Speed
Type System ..... Pressure and Spray Circulation
Oil Pump ..... Gear Type
Oil Filter ..... Full Flow Spin-on Type

Fuel System

Fuel Injection Pump ..... Roosa-Master
Pump Timing ..... 8 Degrees Before Top Dead Center
Fuel Injectors ..... Pencil Type (Opening Pressure 2800 PSI)
Fuel Transfer Pump ..... Vane Type, Integral Part of Injection Pump
Governor ..... Variable Speed, Fly-Weight Centrifugal Type, Integral Part of Injection Pump
Fuel Filters ..... Full Flow Spin on Type

Section
1027

DETAILED SPECIFICATIONS

188 Diesel Engines

FRACTION to DECIMAL to MILLIMETER CONVERSION TABLE

Fraction	Decimal	MM	Fraction	Decimal	MM	Fraction	Decimal	MM
1/64	.0156	0.397	23/64	.3593	9.128	45/64	.7031	17.859
1/32	.0312	0.794	3/8	.3750	9.525	23/32	.7187	18.256
3/64	.0468	1.191	25/64	.3906	9.922	47/64	.7343	18.653
1/16	.0625	1.587	13/32	.4062	10.319	3/4	.7500	19.050
5/64	.0781	1.984	27/64	.4218	10.716	49/64	.7656	19.447
3/32	.0937	2.381	7/16	.4375	11.113	25/32	.7812	19.844
7/64	.1093	2.778	29/64	.4531	11.509	51/64	.7968	20.240
1/8	.1250	3.175	15/32	.4687	11.906	13/16	.8125	20.637
9/64	.1406	3.572	31/64	.4843	12.303	53/64	.8281	21.034
5/32	.1562	3.969	1/2	.5000	12.700	27/32	.8437	21.431
11/64	.1718	4.366	33/64	.5156	13.097	55/64	.8593	21.828
3/16	.1875	4.762	17/32	.5312	13.494	7/8	.8750	22.225
13/64	.2031	5.159	35/64	.5468	13.890	57/64	.8906	22.622
7/32	.2187	5.556	9/16	.5625	14.287	29/32	.9062	23.019
15/64	.2343	5.953	37/64	.5781	14.684	59/64	.9218	23.415
1/4	.2500	6.350	19/32	.5937	15.081	15/16	.9375	23.812
17/64	.2656	6.747	39/64	.6093	15.478	61/64	.9531	24.209
9/32	.2812	7.144	5/8	.6250	15.875	31/32	.9687	24.606
19/64	.2968	7.541	41/64	.6406	16.272	63/64	.9843	25.003
5/16	.3125	7.937	21/32	.6562	16.669	1	1.0000	25.400
21/64	.3281	8.334	43/64	.6718	17.065			
11/32	.3437	8.731	11/16	.6875	17.462			

INCH to MILLIMETER CONVERSION TABLE

Inch	MM	Inch	MM	Inch	MM	Inch	MM
1	25.400	6	152.000	10	254.000	60	1,524.000
2	50.800	7	177.800	20	508.000	70	1,778.000
3	76.200	8	203.200	30	762.000	80	2,032.000
4	101.600	9	228.600	40	1,016.000	90	2,286.000
5	127.000	10	254.000	50	1,270.000	100	2,540.000

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RUN-IN-INSTRUCTIONS

Engine Lubrication

When the engine rebuild is complete, fill the engine crankcase with Case HDM oil and install new engine oil filter. **NOTE:** If Case HDM oil is not used, use only a Series 3 DS or CD Service Classification oil that has the proper viscosity rating for prevailing air temperature. Refer to vehicle Operators Manual.

After the first 20 hours of operation, change the engine oil while the engine is hot and replace the the engine oil filter. DO NOT DRAIN OIL UNTIL THE ENGINE HAS BEEN OPERATED 20 HOURS.

Change the engine oil and filter at the recommended intervals thereafter as outlined in the Operator's Manual.

Break-In Procedure for Rebuilt Engines (With a Dynamometer)

The following procedure must be implemented when using a PTO dynamometer to break-in the engine. The dynamometer will insure control of the engine load at each speed and will eliminate over stressing new parts during break-in.

During the break-in, continually check the oil pressure, coolant level, and coolant temperature.

STEP	TIME	ENGINE SPEED	DYNAMOMETER SCALE LOAD*
1	**10 Minutes	1000 RPM	None
2	**10 Minutes	1800 RPM	None
3	20 Minutes	1800 RPM	1/3
4	20 Minutes	1800 RPM	1/2
5	***30 Minutes	100 RPM below rated speed	3/4
6	Retorque the cylinder head bolts using the procedure described in Section 2015 of this service manual.		

*Based upon normal dynamometer scale load at rated speed for the particular vehicle model. Reduce this scale load as indicated.

**The most ideal break-in procedure would be to constantly vary the throttle between 750 to 1000 RPM for the first 10 minutes and from 1000 RPM to 1800 RPM for the next 10 minutes. The purpose of this changing RPM is to vary the lubrication and coolant flow.

***30 minutes at 3/4 load is a minimum amount of time the engine should be run. It is recommended that whenever possible the engine (especially turbocharged diesels) should be run for four (4) hours or more at the above speed and load before checking the full engine horsepower or before using the engine for heavy field work.

Break-In Procedure for Rebuilt Engines (Without a Dynamometer)

STEP	TIME	ENGINE SPEED	LOAD
1	*10 Minutes	1000 RPM	None
2	*10 Minutes	1800 RPM	None
3	30 Minutes	2/3 Rated RPM	Light Load
4	1 Hour	Full RPM (not over 2000 RPM)	80 to 90%
5	Retorque the cylinder head bolts using the procedure described in Section 2015 of this service manual.		

*If engine must then run at or near full load to operate the machine - for first hour remove load and run at high idle for a few minutes at 15 minute intervals.

Run-In Procedure (Agricultural Tractors)

For the first 8 hours of field operation stay one gear lower than normal. For the next 12 hours DO NOT "lug" the engine. Prevent "lugging" by shifting to a lower gear. The engine must not be "lugged" below its Rated Engine RPM during the early hours of life.

Run-In Procedure (Construction Equipment)

For the first 8 hours, operate the engine at full throttle maintaining a normal load. DO NOT baby the engine, but avoid prolonged converter or hydraulic stall. Engine must not be "lugged" below its Rated Engine RPM (Do not exceed 10 seconds of stall).

Run-In Procedure (Power Units)

For the first 1/2 hour, operate engine at 2/3 rated RPM with a light load or no load. For the next (1) hour, run engine at 80 to 90% load at rated RPM (but not over 2000 RPM). Then full load and rated RPM as required in application.

DETAILED ENGINE SPECIFICATIONS

Cylinder Sleeves

	U.S. Value	Metric Value
Type	Replaceable Wet	
Material	Cast Iron	
I.D. of sleeve	3.8125 to 3.8115″	96.838 to 96.812mm
Maximum Serviceable Limit	3.8165″	96.939mm
Sleeve out-of-round (installed in block)	.001″ max.	.025mm
Maximum Serviceable Limit	.004″	.102mm
Taper (installed in block)	.001″	.025mm
Maximum Serviceable Limit	.004″	.102mm
Clearance to bottom of piston skirt, 90° to piston pin	.0035 to .0055″	.090 to .140mm
Maximum Serviceable Limit	.0100″	.254mm
Sleeve Protrusion above cylinder block (Max.)	.005″	.127mm

Piston

Type	Cam ground	
Material	Aluminum Alloy	
O.D. at bottom of skirt, 90° to piston pin	3.807 to 3.808″	96.698 to 96.723mm
Minimum Serviceable Limit	3.806″	96.672mm
I.D. of piston pin bore including wear	1.2500 to 1.2508″	31.750 to 31.770mm
Width of 2nd ring groove	.097 to .098″	2.464 to 2.489mm
Maximum Serviceable Limit	.100″	2.540mm
Width of 3rd ring groove	.1885 to .1895″	4.788 to 4.813mm
Maximum Serviceable Limit	.1915″	4.864mm

Piston Rings

No. 1 Compression	Chrome Grooved Keystone	
End gap in 3.8125 I.D. (96.838mm I.D.) sleeve	.015 to .025″	.381 to .635mm
Maximum Serviceable Limit	.035″	.889mm
No. 2 Compression	Rectangular Grooved Back	
End gap in 3.8125 I.D. (96.838mm I.D.) sleeve	.015 to .025″	.381 to .635mm
Maximum Serviceable Limit	.035″	.899mm
Side Clearance	.0035 to .0055″	.090 to .140mm
Maximum Serviceable Limit	.008″	.203mm

Piston Rings (Cont'd)

	U.S. Value	Metric Value
No. 3 Oil Control Ring	Three Piece	
End gap in 3.8125 I.D. (96.838mm I.D.) sleeve	.015 to .055"	.381 to 1.397mm
Maximum Serviceable Limit	.065"	1.651mm
Side clearance	.000 to .008"	.000 to .203mm
Maximum Serviceable Limit	.010"	.254mm

Piston Pin

Type	Full Floating	
O.D. of pin	1.2495 to 1.2498"	31.737 to 31.745mm
Fit in piston	.0002 to .0010"	.005 to .025mm
Fit in rod bushing	.0004 to .0015"	.010 to .038mm

Connecting Rod

Bushing	Replaceable Bronze	
Bushing I.D. installed (ream to size)	1.2502 to 1.2504"	31.755 to 31.760mm
Maximum Serviceable Limit	1.2510"	31.775mm
Bearing liners	Replaceable	
Rod width at crank end	1.3035 to 1.3055"	33.109 to 33.160mm
Journal I.D. without bearing liners	2.1870 to 2.1875"	55.550 to 55.563mm
Bearing oil clearance	.0010 to .0040"	.025 to .102mm
Undersize bearings for service	.002,.010,.020,.030"	.051,.254,.508,.762mm
Side clearance	.005 to .011"	.127 to .279mm

Crankshaft

Type	Hardened Steel Balanced	
Main bearing liners	Replaceable	
End play, center main bearing cap	.001 to .015"	.025 to .381mm
Center main bearing thrust surface thickness	.1025 to .1045"	2.603 to 2.654mm
Connecting rod journal std. O.D.	2.0605 to 2.0615"	52.337 to 52.362mm
.002" (.051mm) O.D. undersize, grind to	2.0585 to 2.0595"	52.286 to 52.311mm
.010" (.254mm) O.D. undersize, grind to	2.0505 to 2.0515"	52.083 to 52.108mm
.020" (.508mm) O.D. undersize, grind to	2.0405 to 2.0415"	51.289 to 51.854mm
.030" (.762mm) O.D. undersize, grind to	2.0305 to 2.0315"	51.575 to 51.600mm
Connecting rod journal maximum taper	.001"	.025mm
Journals out-of-round	.0005"	.013mm
Undersize main bearing liners for service	.002,.010,.020,.030"	.051,.254,.508,.762mm
Main bearing oil clearance	.0012 to .0042"	.031 to .107mm

Crankshaft (Cont'd)

	U.S. Value	Metric Value
Main bearing journal std. O.D.	2.8730 to 2.8740″	72.974 to 73.000mm
.002″ (.051mm) O.D. undersize, grind to	2.8710 to 2.8720″	72.923 to 72.949mm
.010″ (.254mm) O.D. undersize, grind to	2.8630 to 2.8640″	72.720 to 72.746mm
.020″ (.508mm) O.D. undersize, grind to	2.8530 to 2.8540″	72.466 to 72.492mm
.030″ (.762mm) O.D. undersize, grind to	2.8430 to 2.8440″	72.212 to 72.238mm
Main bearing journal bore I.D. without liners	3.066 to 3.067″	77.876 to 77.902mm
Main journal width between cheeks:		
2nd and 4th	1.185 to 1.189″	30.099 to 30.201mm
3rd	1.3740 to 1.3770″	34.900 to 34.976mm
5th	1.745 to 1.755″	44.32 to 44.58mm
Connecting rod journals width between cheeks	1.3105 to 1.3145″	33.287 to 33.388mm

Camshaft

Type	Parabolic	
Bushings	5, Replaceable	
Bushing Lubrication:		
Front bushing	Pressure lubricated from oil pump	
Intermediate bushing	Gravity flow lubricated	
Rear bushing	Pressure lubricated with rear oil metering.	
Oil clearance	.002 to .007″	.051 to .178mm
I.D. of bushing installed	1.752 to 1.753″	44.501 to 44.526mm
Maximum Serviceable Limit	1.755″	44.577mm
Bushing width:		
1st (front)	1.213 to 1.223″	30.810 to 31.064mm
2nd, 3rd and 4th	.490 to .500″	12.446 to 12.700mm
5th (rear)	1.213 to 1.223″	39.810 to 31.064mm
O.D. of each bearing surface	1.749 to 1.750″	44.425 to 44.450mm
Minimum Serviceable Limit	1.748″	44.399mm
Thrust washer thickness	.147 to .149″	3.734 to 3.785mm
Minimum Serviceable Limit	Maintain end clearance	
Camshaft end play	Taken up by thrust washer	
Camshaft end clearance	.003 to .007″	.076 to .178mm

Valve Push Rod Lifters

Material	Hardened Steel	
Type	Mushroom	
O.D. of lifter stem	.5605 to .5610″	14.237 to 14.249mm
I.D. of block bore, including wear	.5625 to .5650″	14.287 to 14.351mm

Gear Train

	U.S.Value	Metric Value
Backlash:		
Crankshaft gear to camshaft gear	.0002 to .006″	.005 to .152mm
Camshaft gear to idler gear	.0004 to .006″	.010 to .152mm
Idler gear to fuel pump gear	.0005 to .007″	.013 to .178mm
Crankshaft gear to oil pump gear	.002 to .008″	.051 to .203mm
Crankshaft gear to fuel pump gear	.0005 to .019″	.013 to .483mm
O.D. of idler gear shaft	1.3745 to 1.3755″	34.912 to 34.938mm
Minimum Serviceable Limit	1.3740″	34.900mm
I.D. of idler gear with bushing	1.376 to 1.377″	34.950 to 34.976mm
Maximum Serviceable Limit	1.377″	34.976mm
Idler gear thrust washer shims	.005,.006,.007,.009″	.127,.152,.178,.229mm
Idler gear end play	.003″	.076mm

Oil Pump

Positive displacement pump	Gear Type	
Backlash, pump gear to crankshaft gear	.002 to .008″	.051 to .203mm
Drive gear to pump body maximum clearance	.0035 to .010″	.089 to .254mm
Pump gears to body radial maximum clearance	.002 to .008″	.051 to .203mm
Pump gears to pump cover maximum clearance	.0015 to .008″	.038 to .203mm
Oil pressure	50 to 75 PSI	344.7 to 482.6 kPa
Relief valve spring:		
Free length	2.125″	53.975mm
Compressed 1.44″ (36.58mm)	18 to 19 lbs.	8.16 to 8.62 kg

Cylinder Head

Warpage (Max.)	.006″	.152mm

Intake Valve

Tappet clearance (COLD and HOT)	.012″	.305mm
Face angle	44°	44°
Face run-out (max.)	.002″	.051mm
Length	6.339 to 6.364″	161.011 to 161.646mm
O.D. of stem	.3409 to .3419″	8.659 to 8.684mm
Minimum Serviceable Limit	.3399″	8.634mm
O.D. of head	1.599 to 1.609″	40.615 to 40.869mm
Seat angle	45°	45°
Seat contact width	.0704″ to .1057″	1.788 to 2.685mm
Seat run-out (max.)	.002″	.051mm

Exhaust Valve

	U.S. Value	Metric Value
Tappet clearance (COLD and HOT)	.014″	.356mm
Face angle	44⁰	44⁰
Face run-out (max.)	.002″	.051mm
O.D. of head	1.398 to 1.408″	35.509 to 35.763mm
O.D. of stem	.3399 to .3409″	8.634 to 8.659mm
Minimum Serviceable Limit	.3389″	8.608mm
Length	6.340 to 6.364″	161.036 to 161.646mm
Insert seat angle	45⁰	45⁰
Seat contact width	.0608 to .0962″	1.544 to 2.443mm
Seat run-out (max.)	.002″	.051mm
Insert height	.2475 to .2525″	6.286 to 6.413mm
O.D. of insert	1.4495 to 1.4505″	36.817 to 36.843mm
I.D. of insert	1.245 to 1.255″	31.623 to 31.877mm

Intake Valve Guides

Length	3.250″	82.550mm
O.D.	.6565 to .6575″	16.675 to 16.701mm
I.D. (installed and reamed)	.3429 to .3439″	8.710 to 8.735mm
Maximum Serviceable Limit	.3449″	8.761mm
Protrusion above cylinder head	.875″	22.225mm
Valve stem clearance in guide	.001 to .003″	.025 to .076mm
Maximum Serviceable Limit	.004″	.102mm

Exhaust Valve Guides

Length	3.125″	79.375mm
O.D.	.6565 to .6575″	16.675 to 16.701mm
I.D. (installed and reamed)	.3429 to .3439″	8.710 to 8.735mm
Maximum Serviceable Limit	.3449″	8.761mm
Protrusion above cylinder head	.875″	22.225mm
Valve stem clearance in guide	.002 to .004″	.051 to .102mm
Maximum Serviceable Limit	.005″	.127mm

Valve Spring

Free length	2.375″	60.325mm
Total coils	8.25	
Wire diameter	.162″	4.115mm
I.D.	.958 to .978″	24.333 to 24.841mm
Compressed to 1.521″ (38.63mm) (valve open)	110 to 118 lbs.	49.90 to 53.52 kg
Compressed to 1.875″ (47.63mm) (valve closed)	53 to 59 lbs.	24.04 to 26.76 kg

Rocker Arm Assembly

	U.S. Value	Metric Value
O.D. of shaft	.622 to .623″	15.799 to 15.824mm
I.D. of arm bore	.624 to .626″	15.850 to 15.900mm
Shaft spring:		
Free length	2.5″	63.500mm
Compressed to 1.75″ (44.45mm)	7.5 to 8.5 lbs.	3.40 to 3.86 kg
Lubrication	Engine oil, camshaft metering	
Shaft oil holes	Toward valve side of engine. Shaft cannot be rotated.	

SPECIAL TORQUES

Engine

	U.S. Value	Metric Value
Camshaft nut	80 to 90 ft. lbs.	109 to 122 Nm
Camshaft thrust plate mounting bolt	17 to 20 ft. lbs.	23 to 27 Nm
Connecting rod nuts	45 to 50 ft. lbs.	61 to 68 Nm
Crankshaft nut	125 to 135 ft. lbs.	169 to 183 Nm
Crankshaft pulley bolt	54 to 64 ft. lbs.	73 to 87 Nm
Cylinder head studs w/flange nuts (1/2")	90 to 100 ft .lbs.	122 to 136 Nm
Cylinder head cover stud nuts (3/8")	4 to 6 ft. lbs.	5 to 8 Nm
Cylinder head bolts (Gr. 8, 12 pt. hd.)	105 to 115 ft. lbs.	142 to 156 Nm
Cylinder head stud nuts (1/2")	95 to 105 ft. lbs.	129 to 142 Nm
Engine oil filter	Install until gasket contacts filter head, then hand tighten 1/2 turn. Loosen filter approximately 1 full turn and retighten until gasket contact is made, then hand tighten an additional 1/2 to 3/4 turn.	
Fan mounting bolts	35 to 42 ft. lbs.	48 to 57 Nm
Fuel pump drive gear nut	40 to 50 ft. lbs.	54 to 68 Nm
Flywheel to crankshaft bolt	65 to 70 ft. lbs.	88 to 95 Nm
Idler gear journal mounting bolts	35 to 42 ft. lbs.	48 to 57 Nm
Intake manifold (Aluminum) stud nuts	30 to 35 ft. lbs.	41 to 48 Nm
Intake and Exhaust Manifold stud nuts	25 to 30 ft. lbs.	34 to 41 Nm
Main bearing cap bolts	90 to 100 ft. lbs.	122 to 136 Nm
Oil pan capscrews (stamped steel)	10 to 12 ft. lbs.	14 to 16 Nm
Oil pan capscrews (cast iron)	24 to 28 ft. lbs.	33 to 38 Nm
Oil pan to seal retainer	15 to 20 ft. lbs.	20 to 27 Nm
Oil pan drain plug	29 to 31 ft. lbs.	39 to 42 Nm
Oil pump cover capscrews	6 to 8 ft. lbs.	8 to 11 Nm
Oil seal retainer bolts (Grade 8)	12 to 15 ft. lbs.	16 to 20 Nm
Oil pump suction tube nut	95 to 105 ft. lbs.	129 to 142 Nm
Rocker arm bracket bolts	25 to 30 ft. lbs.	34 to 41 Nm
Timing gear housing bolts	25 to 30 ft. lbs.	34 to 41 Nm
Water pump mounting bolts	25 to 30 ft. lbs.	34 to 41 Nm
Water pump body-to-cyl. mounting bolts	35 to 42 ft. lbs.	48 to 57 Nm

GENERAL TORQUE SPECIFICATION TABLE (Revised 2-74)

USE THE FOLLOWING TORQUES WHEN SPECIAL TORQUES ARE NOT GIVEN

NOTE: These values apply to fasteners as received from supplier, dry, or when lubricated with normal engine oil They do not apply if special graphited or moly-disulphide greases or other extreme pressure lubricants are used. This applies to both UNF and UNC threads

SAE Grade No.		2				5				8 ★			
Bolt head identification marks as per grade NOTE: Manufacturing Marks Will Vary													
		Torque				Torque				Torque			
Bolt Size		Foot Pounds		Newton-Meters		Foot Pounds		Newton-Meters		Foot Pounds		Newton-Meters	
Inches	Millimeters	Min.	Max.	Min.	Max.	Min	Max	Min.	Max.	Min.	Max.	Min.	Max
1/4	6 35	5	6	6.8	8.13	9	11	12.2	14.9	12	15	16.3	20.3
5/16	7 94	10	12	13.6	16.3	17	20.5	23.1	27.8	24	29	32.5	39.3
3/8	9 53	20	23	27.1	31.2	35	42	47.5	57.0	45	54	61.0	73.2
7/16	11.11	30	35	40.7	47.4	54	64	73.2	86.8	70	84	94.9	113.9
1/2	12 70	45	52	61.0	70.5	80	96	108.5	130.2	110	132	149.2	179.0
9/16	14 29	65	75	88.1	101.6	110	132	149.2	179.0	160	192	217.0	260.4
5/8	15.88	95	105	128.7	142.3	150	180	203.4	244.1	220	264	298.3	358.0
3/4	19.05	150	185	203.3	250.7	270	324	366.1	439.3	380	456	515.3	618.3
7/8	22.23	160	200	216.8	271.0	400	480	542.4	650.9	600	720	813.6	976.3
1	25.40	250	300	338.8	406.5	580	696	786.5	943.8	900	1080	1220.4	1464.5
1-1/8	25.58					800	880	1084.8	1193.3	1280	1440	1735.7	1952.6
1-1/4	31 75					1120	1240	1518.7	1681.4	1820	2000	2467.9	2712.0
1-3/8	34.93					1460	1680	1979.8	2278.1	2380	2720	3227.3	3688.3
1-1/2	38 10					1940	2200	2630.6	2983.2	3160	3560	4285.0	4827.4

★ Thick nuts must be used with Grade 8 bolts

NOTE: The Case Corporation reserves the right to make improvements in design or changes in specifications at any time without incurring any obligation to install them on units previously sold.

Section 1050

MAINTENANCE AND LUBRICATION

CASE CORPORATION

C. E. Div. 9-66025
August 1976

PRINTED IN U.S.A.

FLUIDS AND LUBRICANTS

COMPONENTS	CAPACITY U.S.	CAPACITY Metric	SPECIFICATIONS
Fuel tank	22 gallons	83 litres	Refer to Operator's Manual.
Engine crankcase Without filter change With filter change	 6 quarts 7 quarts	 5.7 litres 6.6 litres	Case HDM oil Engine oil, class CD, Above 32° F (0° C). . . . . SAE 30 10°-50° F (-12°-10° C) . . . SAE 20W Below 32° F (0° C) . . . . . SAE 10W
Hydraulic system (approx.) Loader/backhoe Loader only Loader/three point hitch Three point hitch only Reservoir refill	 23 gallons 15 gallons 19 gallons 14 gallons 11.5 gallons	 87 litres 57 litres 72 litres 53 litres 43 litres	Case TCH Fluid Alternate oil Engine oil, SD or CA Above 32° F (0° C) . . . . SAE 10W Below 32° F (0° C) . . . . . SAE 5W Type C-2 transmission/hydraulic fluid such as Tenneco Hytrans Fluid.
Power steering system Reservoir refill	3 quarts 1 quart	2.8 litres 0.9 litre	Case TCH Fluid.
Mechanical shuttle	2 quarts	1.9 litres	Case TCH Fluid.
Transaxle	20 quarts	19 litres	Case FDL gear lubricant or lubricant meeting API-GL-4, specification Above 0° F (-18° C) . . . . . SAE 90 Below 0° F (-18° C) . . . . . SAE 80
Grease fittings	As required		No. 2 moly disulfide grease.
Front wheel bearings	As required		No. 2 wheel bearing grease.
Cooling system	21 quarts	19.8 litres	Mix ethylene glycol type antifreeze and water for lowest anticipated temperature.
Battery	As required		Add colorless, odorless drinking water.
Brake master cylinders	As required		DOT 3 brake fluid.

MAINTENANCE CHART

NOTE: This chart is based on maximum service intervals. If operating in severe working conditions, service more often.

INTERVAL	SERVICE	INSTRUCTIONS
Run-in period. Every two hours until stable	Torque front and rear wheel bolts to 115-130 foot-pounds (157-176 N m). Torque transaxle mounting bolts to 250-300 foot-pounds (339-407 N m). Torque swing cylinder trunnion plate mounting bolts to 520-640 foot-pounds (732-867 N m). Torque drive shaft cap screws to 20-24 foot-pounds (27-32 N m).	
Run-in period after first 20 hours	Change engine oil and filter. Change hydraulic oil filter. Check fan belt tension.	 Section 4002 Section 8007
Every 10 hours of operation or daily, whichever occurs first	Grease loader pivot points. Grease backhoe pivot points. Grease extendable dipper, if so equipped. Grease three point hitch, if so equipped. Grease front axle pivot. Grease front axle king pins. Grease shuttle control bellcrank. Check engine oil level. Check hydraulic oil level. Check radiator coolant level. Clean air cleaner dust cup. Check the machine and the ground under it for signs of leaks. Check injection pump sediment bowl for water. If bowl has water, drain fuel tank, first stage fuel filter and sediment bowl.	 Section 2051

INTERVAL	SERVICE	INSTRUCTIONS
Every 100 hours of operation	Change engine oil.	
	Grease rear axle bearings.	
	Grease seat post.	
	Grease brake pedals and clutch shaft.	
	Grease brake pedals and clutch shaft on mechanical shuttle machines.	
	Check tire condition and pressure.	Section 6229
	Check battery fluid level.	Section 8005
	Check transaxle oil level.	
	Check mechanical shuttle oil level.	
	Check power steering oil level.	
	Clean spark arresting muffler if so equipped.	Section 2051
Every 200 hours of operation	Change engine oil filter.	Section 2555
	Check fan belt tension.	Section 8007
Every 500 hours of operation	Grease universal joints.	Section 6222
	Lubricate hydraulic pump shaft.	Section 4005
	Replace fuel filters.	Section 3010
	Check brake master cylinder fluid level.	
	Repack front wheel bearings.	Section 5021
	Inspect Roll-Over Protection Structure.	Section 9061
	Change hydraulic oil filter.	Section 4002
	Clean hydraulic reservoir breather.	Section 4002
Every 1000 hours of operation or once a year, whichever occurs first	Change hydraulic oil.	Section 4002
	Replace power steering oil filter.	Section 5005
	Change mechanical shuttle oil.	
	Change transaxle oil.	
	Clean transaxle breather.	

INTERVAL	SERVICE	INSTRUCTIONS
Every 2000 hours of operation or once a year, whichever occurs first	Drain, flush and refill cooling system.	Section 2050
As required	After a wheel has been removed and installed, check bolt torque every two hours until stable.	
	Service air filter element whenever restriction warning light remains on with engine running at full throttle.	Section 2051
	Change hydraulic oil filter whenever restriction warning light remains on.	Section 4002

Section 1051

TORQUE SPECIFICATIONS

CASE CORPORATION

C. E. Div. 9-66025
August 1976

PRINTED IN U.S.A.

U.S. AND METRIC TORQUE SPECIFICATIONS

Grade 5 Bolts, Nuts and Studs (Dry Threads)

Thread size	Ft-lbs	N m	Thread size	Ft-lbs	N m
1/4"-20 NC	5-10	7-13	3/4"-10 NC	235-285	319-386
1/4"-28 NF	10-15	13-20	3/4"-16 NF	270-330	366-447
5/16"-18 NC	15-20	20-27	7/8"-9 NC	360-440	488-597
5/16"-24 NF	15-20	20-27	7/8"-14 NF	395-490	536-664
3/8"-16 NC	25-35	34-47	1"-8 NC	520-640	705-867
3/8"-24 NF	30-40	41-54	1"-12 NF	575-705	780-955
7/16"-14 NC	45-55	61-74	1-1/8"-7 NC	720-820	976-1111
7/16"-20 NF	50-60	68-81	1-1/8"-12 NF	790-970	1071-1315
1/2"-13 NC	65-85	88-115	1-1/4"-7 NC	1010-1240	1370-1681
1/2"-20 NF	80-100	109-135	1-1/4"-12 NF	1115-1365	1512-1850
9/16"-12 NC	100-120	135-163	1-3/8"-6 NC	1315-1610	1783-2182
9/16"-18 NF	110-130	149-176	1-3/8"-12 NF	1510-1850	2047-2508
5/8"-11 NC	135-165	183-223	1-1/2"-6 NC	1745-2135	2366-2894
5/8"-18 NF	160-200	216-271	1-1/2"-12 NF	1880-2420	2549-3281

Grade 8 Bolts, Nuts and Studs (Dry Threads)

Thread size	Ft-lbs	N m	Thread size	Ft-lbs	N m
1/4"-20 NC	10-15	13-20	3/4"-10 NC	340-420	461-569
1/4"-28 NF	15-20	20-27	3/4"-16 NF	380-460	515-623
5/16"-18 NC	20-30	27-40	7/8"-9 NC	540-660	732-894
5/16"-24 NF	25-30	34-40	7/8"-14 NF	595-725	807-982
3/8"-16 NC	40-50	54-67	1"-8 NC	810-990	1098-1342
3/8"-24 NF	45-55	61-74	1"-12" NF	900-1100	1220-1491
7/16"-14 NC	60-80	82-102	1-1/8"-7 NC	1150-1400	1559-1898
7/16"-20 NF	70-90	95-122	1-1/8"-12 NF	1295-1585	1756-2148
1/2"-13 NC	100-120	136-162	1-1/4"-7 NC	1640-2000	2224-2711
1/2"-20 NF	110-130	149-176	1-1/4"-12 NF	1800-2200	2440-2982
9/16"-12 NC	135-165	183-223	1-3/8"-6 NC	2140-2620	2901-3552
9/16"-18 NF	155-190	210-257	1-3/8"-12 NF	2450-3000	3322-4067
5/8"-11 NC	200-240	271-325	1-1/2"-6 NC	2845-3475	3857-4711
5/8"-18 NF	215-265	292-359	1-1/2"-12 NF	3200-3900	4339-4880

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U.S. AND METRIC TORQUE SPECIFICATIONS

Hydraulic Fittings (Steel)

Dash Size	Tube O.D. Hose I.D.	Thread Size	37° Flare Torque		Straight Thread O-ring Torque	
			Ft-lbs	N m	Ft-lbs	N m
4	1/4"	7/16"-20	6-12	8-16	12-19	16-25
5	5/16"	1/2"-20	8-16	11-21	16-25	22-33
6	3/8"	9/16"-18	10-25	14-33	25-40	34-54
8	1/2"	3/4"-16	15-42	20-56	42-67	57-90
10	5/8"	7/8"-14	25-58	34-78	58-92	79-124
12	3/4"	1-1/16"-12	40-80	54-108	80-128	108-174
14	7/8"	1-3/16"-12	60-100	81-135	100-160	136-216
16	1"	1-5/16"-12	75-117	102-158	117-187	159-253
20	1-1/4"	1-5/8"-12	125-165	169-223	165-264	224-357
24	1-1/2"	1-7/8"-12	210-250	285-338	250-400	339-542

Split Flange Mounting Bolts (Grade 5, Dry Threads)

Flange Size	Thread Size	Torque	
		Ft-lbs	N m
1/2"	5/16"-18 NC	15-20	20-25
3/4"	3/8"-16 NC	20-25	26-33
1"	3/8"-16 NC	20-25	26-33
1-1/4"	7/16"-14 NC	35-45	47-61
1-1/2"	1/2"-13 NC	45-55	61-74
2"	1/2"-13 NC	55-65	74-88
2-1/2"	1/2"-13 NC	80-90	104-122
3"	5/8"-11 NC	140-150	190-203

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Section 2001

ENGINE DIAGNOSIS

188 and 207 Diesel Engines

CASE CORPORATION Rac. 9-78875 PRINTED IN U.S.A.

GENERAL INFORMATION

Before making any repairs or adjustments on an engine, a mechanic or technician must properly diagnose the trouble.

Locating the trouble and repairing it is only part of the job, a technician must find and eliminate the cause of the trouble as well. Too many repairs are made with no thought to removing the causes that made the repair necessary.

For any engine to start or perform properly, three main requirements must be present:

1. FUEL
2. COMPRESSION
3. COMBUSTION

When any of these requirements are not present or limited by some mechanical reason, the engine will not start and will fail to operate properly throughout the power range.

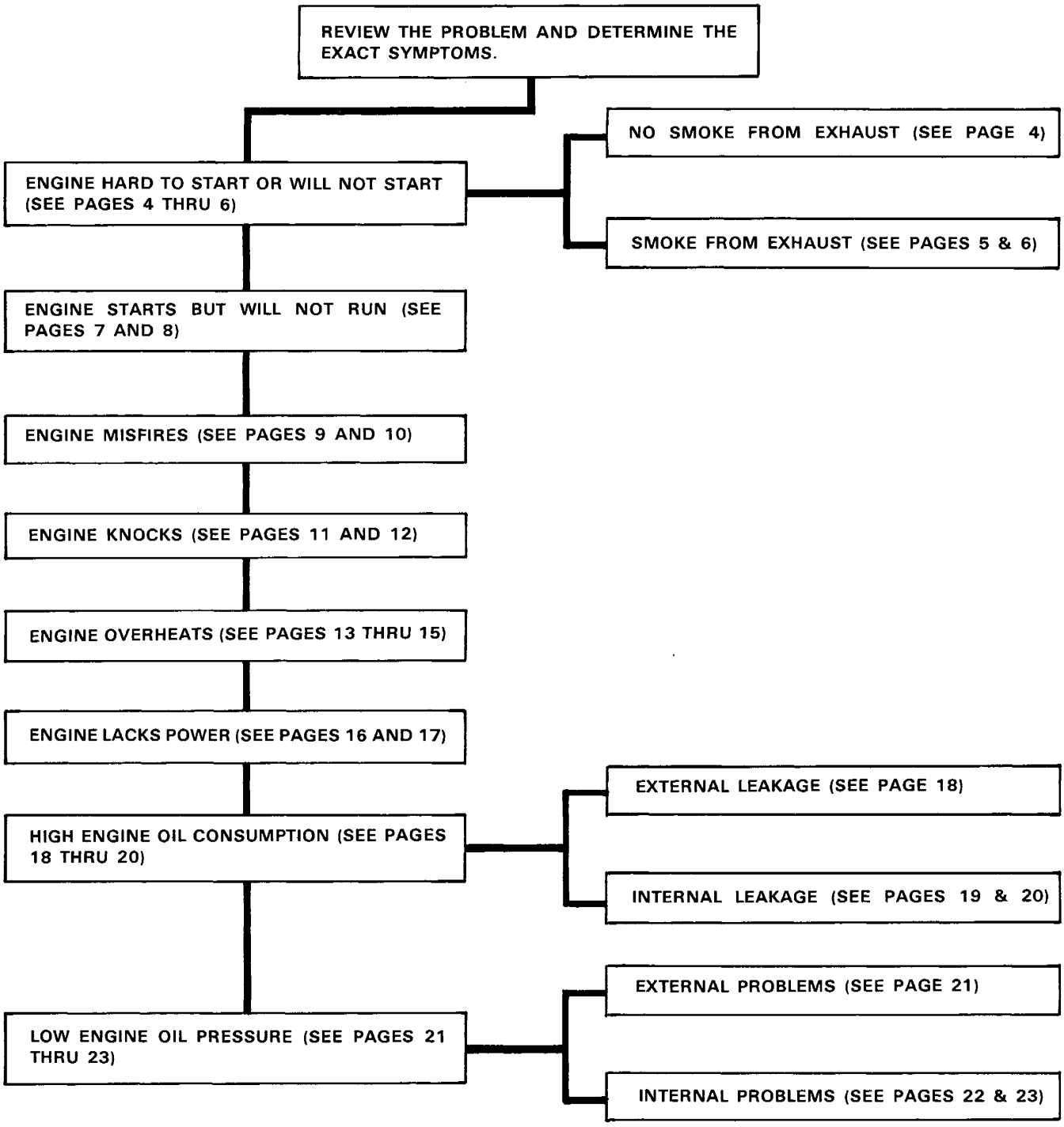
FUEL. Fuel system problems can be present anywhere from the fuel tank, through the filters and injection pump as well as the injectors. Correct injection pump timing is important in the overall fuel system performance.

COMPRESSION. Compression on an engine is related to the "breathing function". Proper compression is affected by the air cleaner condition, muffler restriction, valve condition and operation including proper valve adjustment, cylinder head gaskets, condition of sleeves, rings, pistons, camshaft, and camshaft timing.

COMBUSTION. Combustion is the result of adequate compression to develop enough heat in the air charge on the compression stroke to fire the fuel being injected into the engine cylinders. Proper spray pattern and atomization of the fuel by the injector is very important. Timing the fuel injection pump to the engine to a precise degree BTDC is a vital requirement for proper combustion.

The engine diagnosis contained in the following pages covers many trouble symptoms, the causes, and what will be necessary to repair or eliminate the problem. Under each symptom are listed the most common and reoccuring problems progessing to the not so common problems. Locate your problem symptom in the diagnosis chart and refer to the pages listed for the probable causes and remedies.

ENGINE DIAGNOSIS CHART



ENGINE HARD TO START OR WILL NOT START

No Smoke From Exhaust

1. Fuel Shut-Off Not Open Completely.

Improper cable adjustment, damaged cable, cable slipping in clamps, misadjusted or inoperative solenoid will not completely return fuel shut-off lever to open position. Check lever to be sure it is opening completely. A partially opened lever limits the amount of fuel to the injection pump and results in low engine horsepower.

2. Final Air Filter Plugged

A dirty filter will cause rich fuel mixture and low engine power. Check filter restriction indicator and service final air filter if required.

3. Slow Cranking Speed

Starter must crank engine 200 to 300 RPM in order to ignite the diesel fuel. Check engine RPM while cranking. If cranking is slow, check starter amperage draw to help determine the following defective areas: batteries, cables, solenoid and starting motor.

Slow cranking speed can be caused by the following internal and external engine defects: scuffing and scoring of pistons and sleeves, improper crankshaft or camshaft end play, defective rod or crank bearings, oil pump, water pump, hydraulic pump or air compressor.

4. Fuel Supply Shut-Off or No Fuel

Check that fuel tank shut-off valve is open. Check fuel supply in tank.

5. Air In Fuel System

Bleed fuel system until fuel flows steadily with no bubbles. Check for air leaks at fittings between tank and fuel pump.

6. Camshaft Damaged

A sheared key in the cam drive gear or a broken cam shaft will throw valve timing out of sequence affecting engine operation. Remove cylinder head cover and check valve timing in reference to crankshaft timing marks with a dial indicator.

7. Fuel Injection Nozzle Not Seated In Head.

A nozzle that is not seated in the cylinder head will let compression leak by and not produce enough heat to fire the injected fuel. Check for damaged nozzle gasket or seals, loose nozzle, or broken stud.

8. Fuel Line Plugged

A fuel line plugged with dirt will not let fuel through to the injection pump. Remove line at fuel filters and check for fuel flow through line.

9. Clogged Fuel Filter

Check and service fuel filters.

10. Wrong Fuel or Contaminated Fuel

Wrong fuel (low centane) or contaminated fuel (water and dirt) can cause the engine not to run or to have pre-combustion, causing serious damage to the engine. Drain fuel tank and refill with correct fuel.

11. Sticking Rack Control

A sticking rack control will not let the fuel injection pump accept any fuel.

12. Piston Rings Worn

As piston rings become worn, they lose tension and ability to seal and wipe lubrication oil off cylinder walls. Take a compression test to determine piston ring condition. If readings are low, squirt a small amount of oil into the cylinder and retest. If compression comes up because the oil helps the rings seal, it will be necessary to install new piston rings and possibly sleeve and pistons.

13. Injection Pump Malfunction

A malfunctioning injection pump will usually under-fuel the engine. Adjust or replace the injection pump. A common cause is a sheared key on the injection pump drive, preventing fuel to be delivered to injectors. Adjust or replace the injection pump.

ENGINE HARD TO START OR WILL NOT START
Smoke From Exhaust

1. Slow Cranking Speed

Starter must crank engine 200 to 300 RPM in order to ignite the diesel fuel. Check engine RPM while cranking. If cranking is slow, check starter amperage draw to help determine the following problem areas: batteries, cables, solenoid, and starting motor.

Slow cranking speed can be caused by the following internal and external engine defects: scuffing and scoring of pistons and sleeves, improper crankshaft or camshaft end play defective rod or crank bearings, oil pump, water pump, hydraulic pump or air compressor.

2. Fuel Shut-Off Not Open Completely.

Improper cable adjustment, damaged cable, cable slipping in clamps, misadjusted or inoperative solenoid will not completely return fuel shut-off lever to open position. Check lever to be sure it is opening completely. A partially opened lever limits the amount of fuel to the injection pump and results in low engine horsepower.

3. Low Compression

Low compression on several cylinders, makes the engine hard to start and rough running, also does not generate enough heat to properly fire on all cylinders. Make a compression test on the engine.

4. Final Air Filter Plugged

A dirty filter will cause rich fuel mixtures and low engine power. Check filter restriction indicator and service final air filter if required.

5. Fuel Injection Nozzles Malfunctioning

Low cracking pressure, improper spray pattern, or plugged spray orifice will affect proper combustion in engine cylinders. Remove and test the fuel injection nozzles.

6. Engine Timing Incorrect

Combustion will not occur in the cylinder at the correct moment (degrees BTDC) if the engine timing is incorrect. This can cause precombustion and serious damage to the engine. Check for proper engine timing.

7. Piston Rings Worn

As piston rings become worn, they lose tension and ability to seal and wipe lubricating oil off cylinder walls. Take a compression test to determine piston ring condition. If readings are low, squirt a small amount of oil into the cylinder and retest. If compression comes up because the oil helps the rings seal, it will be necessary to install new piston rings and possibly sleeve and pistons.

8. Valve Push Rods Bent

Bent push rods will affect valve operation and not allow cylinders to get a full charge of fuel and air, or not exhaust properly. This can usually be distinquished by excessive valve tappet noise. Remove cylinder cover and check for bent push rods.

9. Clogged Fuel Filter

Check and service fuel filters.

10. Fuel Injection Nozzle Not Seated In Head

A nozzle that is not seated in the cylinder head will let compression leak by and not produce enough heat to fire the injected fuel. Check for damaged nozzle gasket or seals, loose nozzle, or broken stud.

11. Tune-up Specifications Wrong

Check engine and unit serial number plates for correct specifications when performing engine tune-up.

12. Piston and Sleeves Scuffed and Scored

Scuffing starts as a very small surface disturbance of torn out metal particle. This helps break down lubrication which increases heat and spreads the scuffing to adjacent areas. Scuffing and scoring are caused by malfunctioning of the lubrication system or cooling system, incorrect timing, pre-combustion, lugging or overloading, improperly fitting parts and improper break-in procedure. Remove piston assemblies and inspect.

ENGINE HARD TO START OR WILL NOT START

Smoke From Exhaust (Cont'd)

13. Cylinder Head Gasket Blown

A blown cylinder head gasket will cause one or two cylinders to loose power and cause an engine to miss. Compression leaking into the water system can also cause the cooling system pressure to rise and blow engine coolant out the radiator overflow. Take a compression test to help determine a defective head gasket, or remove radiator cap, run engine and check for gas bubbles rising in coolant at radiator opening.

14. Piston Ring Installation Faulty or Broken Rings

At times, piston rings are installed wrong, upside down, wrong size, overlapping of expanders, or expanders are cut on three piece oil rings. Be sure to carefully read the instructions before installing piston rings. Damaged rings can cause scoring of the piston sleeves and cause the engine to use oil.

15. Valves Sticking

Sticking valves can be caused by improper replacement of valve guides, no lubrication, rust vapors, bent valves, or carbon. A sticking valve will cause an engine miss and the valve could also hit the piston causing internal damage.

16. Wrong Fuel or Contaminated Fuel

Wrong fuel (low centane) or contaminated fuel (water and dirt) can cause the engine not to run or to have pre-combustion, causing serious damage to the engine. Drain fuel tank and refill with correct fuel.

17. Injection Pump Malfunction

A malfunctioning injection pump will usually under-fuel the engine. A common cause is a sheared key on the injection pump drive, preventing fuel to be delivered to injectors. Adjust or replace the injection pump or parts as required.

18. Fuel Injection Line Cracked.

A cracked, chaffed or damaged fuel injector line will allow the fuel to escape externally and not inject fuel into the cylinder. This will cause an engine miss and low horsepower. Leaking fuel from a damaged injector line can easily be seen.

ENGINE STARTS BUT WILL NOT RUN

1. Fuel Shut-Off Not Open Completely

Improper cable adjustment, damaged cable, cable slipping in clamps, misadjusted or inoperative solenoid will not completely return fuel shut-off lever to open position. Check lever to be sure it is opening completely. A partially opened lever limits the amount of fuel to the injection pump and results in low engine horsepower.

2. Final Air Filter Plugged

A dirty filter will cause rich fuel mixtures and low engine power. Check filter restriction indicator and service final air filter if required.

3. Air In Fuel System

Bleed fuel system until fuel flows steady with no air bubbles. Check for air leaks at fittings between fuel tank and injection pump.

4. Low Fuel Supply

Check fuel supply in tank and refill if necessary.

5. Injection Pump Rack Control Sticking

A sticking rack control will not allow the fuel injection pump to accept any fuel.

6. Low Compression

Low compression on several cylinders, makes the engine hard to start and rough running, also does not generate enough heat to properly fire on all cylinders. Make a compression test on the engine.

7. Valve Push Rods Bent

Bent push rods will affect valve operation and not allow cylinders to get a full charge of fuel and air, or not exhaust properly. This can usually be distinquished by excessive valve tappet noise. Remove cylinder cover and check for bent push rods.

8. Camshaft Damaged

A sheared key in the cam drive gear or a broken camshaft will throw valve timing out of sequence, affecting engine operation. Remove cylinder cover and check valve timing in reference to crankshaft timing marks with a dial indicator.

9. Wrong Fuel or Contaminated Fuel

Wrong fuel (low centane) or contaminated fuel (water and dirt) can cause the engine not to run or to have pre-combustion, causing serious damage to the engine. Drain fuel tank and refill with correct fuel.

10. Clogged Fuel Filter

Check and service fuel filters.

11. Fuel Injection Nozzles Malfunctioning

Low cracking pressure, improper spray pattern, or plugged spray orifice will affect proper combustion in engine cylinders. Remove and test the fuel injection nozzles.

12. Cylinder Head Gasket Blown

A blown cylinder head gasket will cause one or two cylinders to loose power and cause an engine to miss. Compression leaking into the water system can also cause the cooling system pressure to rise and blow engine coolant out the radiator overflow. Take a compression test to help determine a defective head gasket, or remove radiator cap, run engine and check for gas bubbles rising in coolant at radiator opening.

13. Piston Rings Worn

As piston rings become worn, they lose tension and ability to seal and wipe lubricating oil off cylinder walls. Take a compression test to determine piston ring condition. If readings are low, squirt a small amount of oil into the cylinder and retest. If compression comes up because the oil helps the rings seal, it will be necessary to install new piston rings and possibly sleeve and pistons.

ENGINE STARTS BUT WILL NOT RUN (Cont'd)

14. Valves Sticking

Sticking valves can be caused by improper replacement of valve guides, no lubrication, rust vapors, bent valves, or carbon. A sticking valve will cause an engine miss and the valve could also hit the piston causing internal damage.

15. Injection Pump Malfunction

A malfunctioning injection pump will usually under-fuel the engine. A common cause is a sheared key on the injection pump drive, preventing fuel to be delivered to injectors. Adjust or replace the injection pump or parts as required.

16. Fuel Injector Line Cracked

A cracked, chaffed or damaged fuel injector line will allow the fuel to escape externally and not inject fuel into the cylinder. This will cause an engine miss and low horsepower. Leaking fuel from a damaged injector line can easily be seen.

17. Injection Pump Timing Incorrect

A fuel injection pump timed at wrong degrees, wrong stroke, or marks moved on pulley, will inject fuel into the cylinders at the wrong time, causing rough running, pre-combustion, low horsepower and other damage to the engine. Check for proper pump timing.

ENGINE MISFIRES

Low and High RPM

1. Wrong Fuel or Contaminated Fuel

Wrong fuel (low centane) or contaminated fuel (water and dirt) can cause the engine not to run or to have pre-combustion, causing serious damage to the engine. Drain fuel tank and refill with correct fuel.

2. Valve Push Rods Bent

Bent push rods will affect valve operation and not allow cylinders to get a full charge of fuel and air, or not exhaust properly. This can usually be distinquished by excessive valve tappet noise. Remove cylinder cover and check for bent push rods.

3. Fuel Injection Nozzles Malfunctioning

Low cracking pressure, improper spray pattern or plugged orifice will affect proper combustion in engine cylinders. Isolate faulty injector nozzle and remove.

4. Fuel Injection Nozzle Not Seated in Head

A fuel injection nozzle that is not seated in the cylinder head will let compression leak by and the cylinder does not produce enough heat to fire the injected diesel fuel. A damaged nozzle gasket or seals, loose nozzle, or broken stud can cause the nozzle not to be seated correctly.

5. Cylinder Head Gasket Blown

A blown cylinder head gasket will cause one or two cylinders to loose power and cause an engine to miss. Compression leaking into the water system can also cause the cooling system pressure to rise and blow engine coolant out the radiator overflow. Take a compression test to help determine a defective head gasket, or remove radiator cap, run engine and check for gas bubbles rising in coolant at radiator opening.

6. Low Compression

Low compression on several cylinders, makes the engine hard to start and rough running, also does not generate enough heat to properly fire on all cylinders. Make a compression test on the engine.

7. Fuel Injection Line Cracked

A cracked, chaffed or damaged fuel injector line will allow fuel to escape externally and inject fuel into the cylinder. This will cause an engine miss and low horsepower. Leaking fuel from a damaged injector line can easily be seen.

8. Injection Pump Malfunction.

A malfunctioning injection pump will usually under-fuel the engine. A common cause is a sheared key on the injection pump drive, preventing fuel to be delivered to injectors. Adjust or replace the injection pump or parts as required.

9. Injection Pump Timing Incorrect

A fuel injection pump timed at wrong degrees, wrong stroke, or marks moved on pulley, will inject fuel into the cylinders at the wrong time, causing rough running, pre-combustion, low horsepower and other damage to the engine. Check for proper pump timing.

10. Intake Manifold Gasket Damaged

A damaged intake manifold gasket can reduce the manifold pressure and cause an insufficient air-fuel mixture in the cylinders and result in low power.

11. Cylinder Head or Sleeve Cracked

A cracked head or sleeve will usually let engine coolant into the engine. This will cause an engine miss or pressure rise in the cooling system depending on how bad the leak is. Low coolant level, oil level, engine missing, and blowing water out the exhaust are evidence that coolant is getting into the engine combustion chambers.

ENGINE MISFIRES

Low and High RPM (Cont'd)

12. Valves Damaged

Damaged valves are caused by wear, improper grinding, hitting the pistons, wrong adjustment, loose seat, or broken valve spring. Defective valves can usually be heard through the intake or exhaust manifold. A low reading compression test usually indicates defective valves.

13. Valve Spring Worn (High RPM)

Weak valve springs will allow the valves to float at high speed. Broken valve springs will not close valve completely and valve could hit the piston doing internal engine damage. Always check and test valve springs when doing a valve job. Damping coils on spring should be assembled against the cylinder head.

14. Operating Temperature Low

The engine was designed for and will only develop full horsepower within its correct operating temperature range. Low operating temperature can result from a malfunctioning thermostat. Do not remove thermostat during the summer. Maintain 50% of permanent antifreeze all year for more efficient operation.

15. Engine Pre-combustion

Pre-combustion is the igniting of the fuel before the normal compression point occurs. This can cause severe knocking and engine power loss. High temperature and pressure from pre-combustion will cause other serious internal damage to the engine. The following are causes of pre-combustion:

A. Valves operating at higher than normal temperature because of excessive guide clearance or improper seal with valve seats.
B. Hot spots caused by an inefficient or damaged cooling system.
C. Injection nozzles set at incorrect cracking pressure.
D. Sharp edges in combustion chamber.
E. Timing incorrect.
F. Excessive lugging of engine.
G. Defective injection pump.
H. Wrong or contaminated fuel.

16. Valves Sticking

Sticking valves can be caused by improper replacement of valve guides, no lubrication, rust vapors, bent valves or carbon. A sticking valve will cause an engine miss and the valve could also hit the piston causing internal damage.

17. Bent Connecting Rod

A bent connecting rod will cause piston slap from scoring due to misalignment. The engine will run rough because of incomplete combustion and emit white exhaust smoke from the bad cylinder. Remove engine oil pan and inspect connecting rods for alignment. A comparison of piston heights at Top Dead Center with cylinder head removed may quickly indicate a bent rod condition. A difference of .020 inch in connecting rod can cause a noticeable miss at low RPM and cold engine conditions.

18. Tune-up Specifications Incorrect

Check engine and unit serial number plates for correct specifications when performing engine tune-up.

ENGINE KNOCKS

Low and High RPM

1. Engine Timing Incorrect

Combustion will not occur in the cylinder at the correct moment (degrees BTDC) if the engine timing is incorrect. This can cause pre-combustion and serious damage to the engine. Check for proper engine timing.

2. Flywheel Loose (Low RPM)

A loose flywheel will chuck or pound at low speed making the engine sound like it has a loose connecting rod. As speed increases, the knock will go away. Replace flywheel if badly worn.

3. Engine Pre-combustion

Pre-combustion is the igniting of the fuel before the normal compression point occurs. This can cause severe knocking and engine power loss. High temperature and pressure from pre-combustion will cause other serious internal damage to the engine. The following are causes of pre-combustion:

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D. Sharp edges in combustion chamber.
E. Timing incorrect.
F. Excessive lugging of engine.
G. Defective injection pump.
H. Wrong or contaminated fuel.

4. Rod Bearing Worn

A rod bearing going bad will have a sharp metallic sound which will increase as RPM increases. When the cylinder with the bad knock is grounded by cracking the injector line, the knock will stop or decrease considerably. Remove the engine oil pan and check rods with plasti-gauge.

5. Main Bearing Worn

A worn main bearing will have a thudding sound and increased engine vibration. Both symptoms will increase as engine speed increases. By grounding out (cracking injector line) the problem cylinder, the thudding sound will stop or decrease but the vibration will remain. Remove engine oil pan and check main bearing clearance will plasti-gauge. Also, low oil pressure can be the result of worn main bearings and excessive oil clearance.

6. Piston and Sleeves Scuffed and Scored

Scuffing starts as a very small surface disturbance of torn out metal particles. This helps break down lubrication which increases heat and spreads the scuffing to adjacent areas. Scuffing and scoring are caused by malfunctioning of the lubrication system or cooling system, incorrect timing, pre-combustion, lugging or overloading, improperly fitting parts and improper break-in procedure. Remove piston assemblies and inspect.

7. Piston Ring Installation Faulty or Broken Rings

At times, piston rings are installed wrong, upside down, wrong size, overlapping of expanders, or expanders are cut on three piece oil rings. Be sure to carefully read the instructions before installing piston rings. Damaged rings can cause scoring of the piston sleeves and cause the engine to use oil.

ENGINE KNOCKS

Low and High RPM (Cont'd)

8. Bent Connecting Rod

A bent connecting rod will cause piston slap from scoring due to misalignment. The engine will run rough because of incomplete combustion and emit white exhaust smoke from the bad cylinder. Remove engine oil pan and inspect connecting rods for alignment. A comparison of piston heights at Top Dead Center with cylinder heads removed may quickly indicate a bent rod condition. A difference of .020 inch in connecting rod can cause a noticeable miss at low RPM and cold engine conditions.

9. Valve Spring Weak

Weak valve springs will allow the valves to float at high speed. Broken valve springs will not close valve completely and valve could hit the piston doing internal engine damage. Always check and test valve springs when doing a valve job. Damping coils on spring should be assembled against the cylinder head.

10. Piston Pin or Bushing Worn

Piston pin or bushing knock will increase with speed. When grounding out the cylinder (cracking injector line) the knock will be twice as bad. Due to combustion, every other revolution will keep the piston pin and bushing tight giving no knock. Remove and inspect piston assembly producing the knock.

11. Camshaft Bearing Worn

A camshaft bearing knock is not a very sharp sounding knock. The knock will be only at one-half of crankshaft speed and will not become worse at different engine speeds. Low oil pressure could result from worn bearings and excessive oil clearance from lack of replacing cam bearing at engine overhaul.

12. Crankshaft End Play Excessive

Excessive crankshaft end play will be indicated by one thudding sound when increasing RPM and one thud when decreasing RPM. Due to the angle of the teeth on crank gear and cam gear, as speed changes it pushes the crankshaft back and forth. Check crankshaft end play with a dial indicator.

13. Foreign Material In Cylinders

Foreign material such as pieces of broken valve, bolts, nuts, washers, or pieces of castings, in the cylinder will cause a noise everytime the piston comes to Top Dead Center. The noise will not change by shorting out the cylinder. Due to the metal-to-metal contact, the vibration can be felt on the side of the engine. Remove cylinder heads and inspect.

14. Cylinder Ridge Not Removed

When performing an engine overhaul and installing new rings, the cylinder ridge must be removed. If the ridge was not removed, it would cause the engine to knock on all cylinders as the top piston ring hits the ridge on every stroke. If the top ring continued to hit the ridge, it would cause ring land breakage between top and second ring, causing piston and sleeve scuffing and scoring. Remove heads and check for cylinder ridge.

15. Improper Use of Ether (Low RPM)

Spraying either into the engine air intake without cranking the engine, will cause one or more cylinders to receive a large amount of ether due to open valves. Then, when the engine is cranked, volatile, uncontrolled explosions will occur in these cylinders breaking ring lands and damaging the piston. Be sure engine is cranking before using ether. Remove cylinder heads and inspect pistons for damage.

16. Camshaft End Play Excessive

Excessive camshaft end play will be indicated by one thudding sound when increasing engine speed and one thud when decreasing speed, but will not be as pronounced as crankshaft end play. Due to the angle of the teeth on crank gear and cam gear, as engine speed changes, it pushes and pulls the camshaft back and forth. Excessive camshaft end play can be caused by worn thrust washer, loose cam gear, or broken or missing camshaft thrust spring. Remove front timing cover and check camshaft end play with a dial indicator.

ENGINE OVERHEATS

1. Fan Belt Loose

Check fan belt for proper tension. Check that the belt is not covered with oil or worn badly and riding very deep in pulley groove. Check for pulley groove wear.

2. Low Coolant Level

Check coolant level in radiator and refill if necessary.

3. Water Pump Malfunction

Remove the radiator cap and observe the coolant to see if there is movement which indicates the water pump is pumping. Move the fan back and forth to check for any defective bearings. Check around the water pump for any signs of coolant leakage indicating a bad water pump seal. Remove water pump and rebuild or replace.

4. Thermostat Inoperative

If there is high coolant temperature and boiling coolant, remove thermostat and test it.

5. Engine Timing Incorrect

Combustion will not occur in the cylinder at the correct moment (degrees BTDC) if the engine timing is incorrect. This can cause pre-combustion and serious damage to the engine. Check for proper engine timing.

6. Tractor Mechanical Drag

A mechanical drag on a unit can cause low horsepower and engine overheating. Causes of some mechanical drags are defective brakes, bad bearings or gears in transmission.

7. Radiator Cap Inoperative

Test radiator cap to see that it relieves at the correct pressure. Inspect cap gasket for proper sealing. An inoperative cap can cause water pump cavitation and lower coolant boiling points.

8. Radiator Fins Bent

Bent or damaged fins can cause a cooling system to overheat because of restricted air flow through the radiator core. All of the fin area is needed to dissipate the engine heat from the radiator.

9. Radiator Fins Plugged With Dirt

Radiator fins must be clean so air can flow through the radiator fins and help dissipate the heat of the coolant. Items that affect radiator cooling are: oil and grease on fins, leaves, and attachments covering radiator air inlet.

10. Cylinder Head Gasket Blown

A blown cylinder head gasket will cause one or two cylinders to loose power and cause an engine to miss. Compression leaking into the water system can also cause the cooling system pressure to rise and blow engine coolant out the radiator overflow. Take a compression test to help determine a defective head gasket, or remove radiator cap, run engine and check for gas bubbles rising in coolant at radiator opening.

11. Injection Pump Malfunction

A malfunctioning injection pump will usually under-fuel the engine. A common cause is a sheared key on the injection pump drive, preventing fuel to be delivered to injectors. Adjust or replace the injection pump or parts as required.

12. Radiator Baffling Missing

The removal of or non-reinstalling of radiator baffling, whether foam rubber or sheet metal, will cause cooling air flow to escape around the radiator instead of drawing in cool external air through the radiator.

13. Engine Low On Oil

An engine low on oil could lose lubrication to internal parts and start scoring pistons, sleeves and damage engine bearings. Proper oil level is required to help dissipate some of the engine heat. Check engine oil level every eight hours of operation. Low engine oil can also give low oil pressure readings.

ENGINE OVERHEATS (Cont'd)

14. Wrong Fuel or Contaminated Fuel

Wrong fuel (low centane) or contaminated fuel (water and dirt) can cause the engine not to run or to have pre-combustion, causing serious damage to the engine. Drain fuel tank and refill with correct fuel.

15. Piston and Sleeves Scuffed and Scored

Scuffing starts as a very small surface disturbance of torn out metal particles. This helps break down lubrication which increases heat and spreads the scuffing to adjacent areas. Scuffing and scoring are caused by malfunctioning of the lubrication system or cooling system, incorrect timing, pre-combustion, lugging or overloading, improperly fitted parts and improper break-in procedure. Remove piston assemblies and inspect.

16. Water Pump Hose Worn

Water pump hoses can become worn from age and collapsing, cracking, chaffing against something or fan belts cutting through them. Inspect hoses for coolant leaks.

17. Bad Ground on Gauge or Sending Unit

A bad ground on gauges or sending units can many times be the only problem with a defective gauge. Take a jump wire and ground gauge or sending unit to machine, then recheck gauge. Pipe tape is often used to seal threads on oil sending units which destroys the biggest share of its' grounding ability.

18. Cylinder Head or Sleeve Cracked

A cracked cylinder head or sleeve will usually allow engine coolant into the engine, causing engine miss or pressure rise in the cooling system depending upon how bad the leak is. Coolant level low, oil level check, engine missing when first started, and water blowing out the exhaust are indications that coolant is getting into the engine combustion chambers.

19. Lack of Anti-Freeze

To illustrate the importance of having antifreeze in the cooling system year around, consider the following. Any ethylene glycol antifreeze with a 50% mixture and a 7 PSI cap will raise the coolant boiling point to 242 degrees. A 70% mixture will raise the boiling point to 253 degrees. With just water in the above cooling system, it would boil at 233 degrees.

20. Cylinder Sleeve O-Ring Damaged

A pinched, rolled, nicked, or hard sleeve O-ring can cause a coolant leak in the crankcase, contaminating the engine oil. This coolant leaking can go undetected for sometime causing engine heating and crankshaft damage. Remove engine oil pan and observe bottom of sleeves to detect slow coolant leak.

21. Radiator Leaking Externally

Inspect and repair or replace leaking radiator.

22. Tune-up Specifications Wrong

Check engine and unit serial number plates for correct specifications when performing engine tune-up.

23. Engine Pre-combustion

Pre-combustion is the igniting of the fuel before the normal compression point occurs. This can cause severe knocking and engine power loss. High temperature and pressure from pre-combustion will cause other serious internal damage to the engine. The following are causes of pre-combustion:

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E. Timing incorrect.
F. Excessive lugging of engine.
G. Defective injection pump.
H. Wrong or contaminated fuel.

24. Water Temperature Gauge Malfunction

The water temperture gauge, wiring, resisttor or sending bult could give false or no temperature readings. To diagnose, remove wire at sending unit and ground to tractor. Turn key switch on, if gauge comes up, sending unit is malfunctioning. If gauge does not come up, use voltmeter and ohmeter to check wiring circuit.