SECTION 0

ENGINE INFORMATION

ELECTRO-MOTIVE

ENGINE MAINTENANCE MANUAL

ENGINE INFORMATION

DESCRIPTION

The turbocharged diesel engines are "V" type two-cycle engines incorporating the advantages of low weight per horsepower, positive scavenging air system, solid unit injection, and high compression.

OPERATION

In a two-cycle engine each cylinder completes a power cycle in one revolution of the crankshaft. The piston does not function as an air pump during one crankshaft revolution as is the case in a four-cycle engine which requires two revolutions of the crankshaft to complete one power stroke in each cylinder. A separate means is provided in a two-cycle engine to supply the needed air and to purge the combustion gases from the cylinder.

The engine is equipped with a turbocharger, shown schematically in Fig. 0-1, to efficiently provide the air needed for combustion and scavenging. The turbocharger provides an air supply greater than that provided by the positive displacement blowers used on other model engines.

During engine operation the turbocharger utilizes heat energy in the exhaust from the engine as well as power from the camshaft gear train to drive the turbine. However, when exhaust heat energy is sufficient to drive the turbine alone, the gear drive is disengaged by an overrunning clutch. The turbine then drives a centrifugal blower which furnishes air to the engine.

The air from the centrifugal blower is raised to a higher pressure and likewise to a higher temperature. It is desirable to reduce the air temperature to increase its density before it enters the air box surrounding the cylinders. The air temperature is reduced by passing it through the aftercoolers as shown in Fig. 0-1. Thus cooled air of greater comparable weight and having more oxygen is available to the engine.

Referring to Fig. 0-l, and assuming that the piston is at the bottom of its stroke and just starting up, the air intake ports and the exhaust valves will be open. Air under pressure enters the cylinder through the liner ports, pushes the exhaust gases left from the previous power stroke out through the exhaust valves and fills the cylinder with a fresh supply of air. When the piston is 45° past bottom dead center, the air intake ports will be closed by the piston as indicated on the timing diagram. Shortly after the air intake ports are closed, the exhaust valves will also be closed, and the fresh air will be trapped in the cylinder. Closing the exhaust valves after the intake air ports provides for the greatest efficiency in cylinder scavenging of combustion gases.

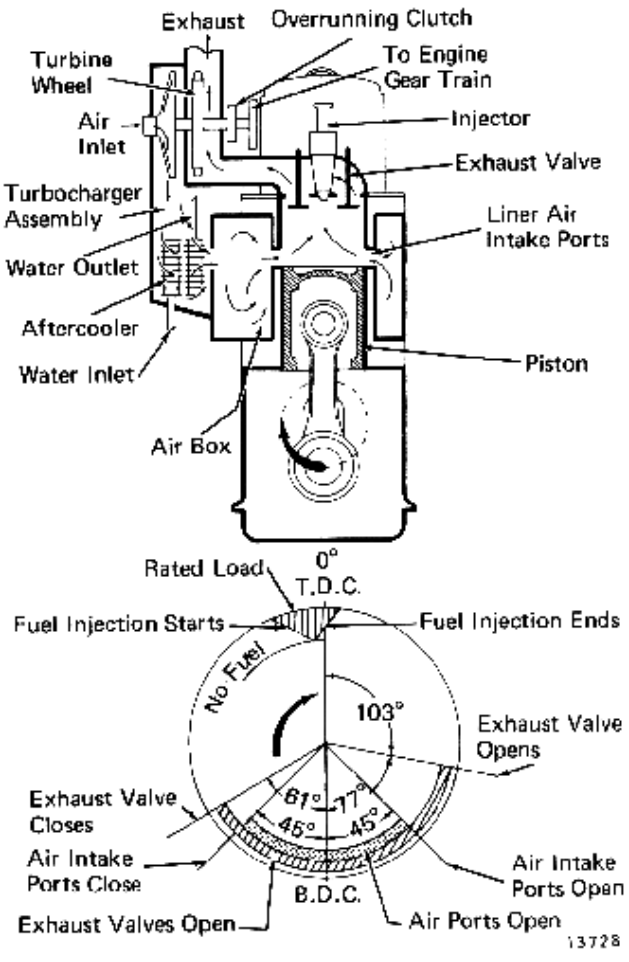

Fig. 0-1 - Schematic Illustration Of Engine Operation

As the piston continues upward, it compresses the trapped air into a very small volume. Just before the piston reaches top dead center, the fuel injector sprays fuel into the cylinder. Ignition of the fuel is practically instantaneous, due to the temperature of the compressed air trapped in the top of the cylinder. The fuel burns rapidly as the piston is forced down on the power stroke of the piston. As shown in the timing diagram, the piston continues downward in the power stroke until the exhaust valves open.

The exhaust valves are opened ahead of the air intake ports to permit most of the combustion gases to escape and reduce the pressure in the cylinder. When the air intake ports are uncovered by the piston at 45° B.B.D.C. as it continues downward, air from the air box under pressure can immediately enter the cylinder, scavenging the remaining combustion gases from the cylinder and providing fresh air for combustion. The piston is again at the original starting point of the description and the cycle of events is repeated.

ARRANGEMENT

Cylinder location and the designation of the ends and banks of the engine, as referred to throughout the manual, are shown in Fig. 0-2. The governor, water pumps, and lube oil pumps are mounted on the "front" of the engine. The turbocharger and flywheel are located at the coupling end or "rear" of the engine. Left and right will be in respect to looking toward the "front" of the engine when standing at the "rear."
For identification and location of internal engine components refer to engine cross-section preceding

SERIAL NUMBERS

Major components of the engine are identified by serial numbers for historical record. When reference is made regarding a part having a serial number, the serial number should be included in the information as well as other identification used concerning the part. Following are major engine items identified with a serial number, and its location on the part.

ENGINE -- serial number is shown on the engine nameplate located at the right bank of the engine, and stamped on the left bank of the engine at the accessory end below the cover frame base.

CRANKCASE -- serial number is on the right side of the main bearing caps, right side of each end "A" frame, and at the top of the left bank at the rear end.

OIL PAN -- serial number is located on the left side of the oil pan below the top rail at the rear end.
CRANKSHAFT - serial numbers are located on the web of either the first or last throws (8 & 12-cyl.) and on the web of both the first and last throws (16 & 20-cyl.).

CYLINDER HEAD - serial number is located at the front center section of the top face.

CYLINDER LINER - serial number is located below the water inlet connection.

PISTON - serial number is located at the bottom inside diameter below the oil control ring.

PISTON CARRIER - serial number is located below the thrust washer platform on the outside diameter.

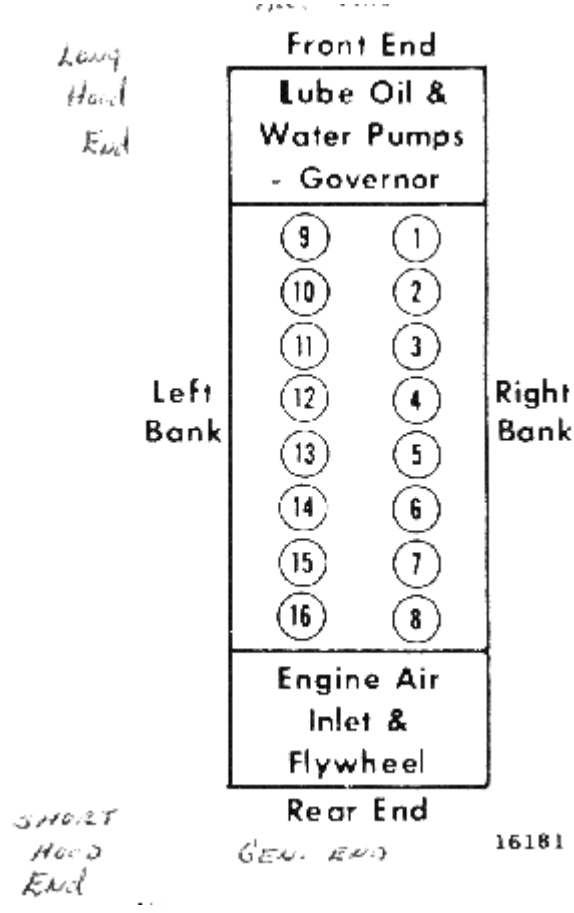

Fig. 0-2 - Engine Arrangement

PISTON PIN - serial number is located at end of pin on same end as small identification hole.

FORK CONNECTING ROD - serial numbers are located in three different locations as the fork rod assembly consists of two basket halves and the rod. On basket half with dowel, number is located above basket-to-rod bolt hole. On other half, it is located below basket-to-basket bolt holes. On the rod, number is located to the left of center above serrations on the dowel side of rod.

BLADE ROD - serial number is located at end of slipper opposite the long toe.

CAMSHAFT ASSEMBLY - serial number of the assembly is located at the end of the accessory end stubshaft.

ENGINE GEARS - serial number is located on the rim of the gear.

GOVERNOR - serial numbers are provided on the governor nameplate.

WATER PUMP - serial number is located on the housing flange rim and is preceded by an "R" or "L" to show pump installation, at the right or left bank.

LUBRICATING OIL PUMP -- serial number is located at the front end cover and is preceded by the letter "L" to identify it as a lubricating pump.

SCAVENGING OIL PUMP - serial number is located at end cover and is preceded by the letter "S" to identify it as the scavenging pump.

FUEL INJECTORS - serial number is located on the same side as the injector rack, and is provided by injector manufacturer.

PAINTING

If an engine is to be removed from service and completely overhauled and the interior repainted, the parts to be painted must be cleaned in a vat of caustic solution to remove old paint, grease and oil from the pores of the metal. The caustic solution must be thoroughly removed by washing the parts in clean hot water, and drying with an air hose. (Aluminum parts must not be washed in the caustic solution.) If caustic cleaning is not done before painting, the paint will peel off the interior of the engine and contaminate the lube oil lines. Mask off parts not being painted.

Use zinc free crankcase primer sealer on the following: interior of crankcase, oil pan, air duct, top deck, cylinder head cover frames (except on seal surface), accessory and camshaft drive housings. Do not paint machined surfaces, liners, heads or seal surfaces.

To refinish the engine exterior, remove grease and oil with alkaline cleaner. Mask off water, fuel and oil fittings. If required, apply coat of primer. Then apply finish coat.

SERVICE DATA
ENGINE INFORMATION

SPECIFICATIONS

Clearance and dimensional limits listed below are defined as follows:

1. *New limits are those to which new parts are manufactured. (Drawing tolerances.)*
2. *Minimum, maximum, and tolerance measurements are provided as service limits. At time of rebuild or any time unscheduled maintenance is performed, the service limits should not be exceeded. Engine components within these limits may be reused 'with the assurance that they will perform satisfactorily until the next scheduled overhaul.*

Bore	230.19 mm (9-1/16")
Stroke	254.0 mm (10")
Angle between banks	45°
Compression ratio	14.5:1
Displacement per cyl.	10 570 cm^3 (645 cu. in.) Rotation
(facing rear end)	Counterclockwise
Firing order -	
8-cyl.	1, 5, 3, 7, 4, 8, 2, 6
12-cyl.	1, 12, 7, 4, 3, 10, 9, 5, 2, 11, 8, 6
16-cyl.	1, 8, 9, 16, 3, 6, 11, 14, 4, 5, 12, 13, 2, 7, 10, 15
20-cyl.	1, 19, 8, 11, 5, 18, 7, 15, 2, 17, 10, 12, 3, 20, 6, 13, 4, 16, 9, 14
Exhaust valves (per cyl.)	4
Main bearings -	
8-cyl.	5
12-cyl	7
16-cyl	10
20-cyl	12
Governor (Woodward)	PGR
Scavenging	Uniflow
Type of scavenging blower	Turbo-Centrifugal
Cooling system	Pressurized
Water pumps	Centrifugal
Lubricating oil system	Full pressure
Oil Pumps -	
Main oil pump and piston cooling pump	Two pumps in one housing siamesed inlet, double discharge
Scavenging oil pump	Helical gear type
Fuel injection	Unit injector with needle valve
Fuel pump	Positive displacement
Engine starting -	
12-cyl. w/AC generator, 16 & 20-cyl.	Dual electric motors
8 / 12-cyl. w/DC generator	Generator field

RATINGS

Low idle speed	255 RPM
Idle speed	318 RPM
Full speed	900 RPM
Output	
8-cyl.	1650 HP
12-cyl.	2300 HP
16-cyl.	3000 HP
20-cyl.	3600 HP

CAPACITIES

Oil pumps	900 RPM LPM	GPM
Main lube oil -		
8-cyl.	397	105
12-cyl.	594	157
16-cyl.	700	185
20-cyl.	867	229
Piston cooling		
8-cyl.	182	48
12-cyl.	250	66
16-cyl.	348	92
20-cyl.	413	109
Scavenging -		
8-cyl.	776	205
12-cyl.	1056	279
16 & 20 cyl.	1476	390
Fuel pump		
8-cyl.	8	2.1
12, 16, & 20-cyl.	17	4.5
Water pump		
8-cyl.	1 892	500
12-cyl.	2 498	660
16-cyl.	3 218	850
20-cyl.	4 164	1 100
Soak back pump		
8, 12, 16, & 20-cyl.	11	3

WEIGHTS

The weights as listed below are approximate maximum weights for the numbered cylinder engine shown. The weights are provided as an aid in determining the handling procedure to be used. Weights represent kilograms/pounds per unit, as described.

	8-Cyl.		12-Cyl.		16-Cyl.		20-Cyl.		
DESCRIPTION		Kg	Lb	Kg	Lb	Kg	Lb	Kg	Lb
Engine assembly	10 002	22,050	12 839	28,306	16 522	36,425	19 545	43,091	
Crankcase (includes bearings & caps)	2 626	5790	3 561	7851	5 319	11,727	6 473	14,273	
Oil pan	612	1350	710	1566	953	2100	1 315	2900	
Crankshaft	775	1710	943	2080	1 442	3180	1 530	3375	
Viscous damper	99	218	99	218	99	218	141	310	
Accessory drive gear	42	92	42	92	44	98	44	98	
Crankshaft gear	51	112	51	112	51	112	51	112	
Ring gear	132	290	132	290	132	290	67	147	
Coupling disc	147	325	147	325	147	325	177	390	.
Cylinder power pack assembly w/fork rod	185	408	185	408	185	408	185	408	
w/blade rod	165	363	165	363	165	363	165	363	
Cylinder head assembly	66	145	66	145	66	145	66	145	
Cylinder liner	58	127	58	127	58	127	58	127	
Piston	18	40	18	40	18	40	18	40	
Connecting rod (fork)	23	50	23	50	23	50	23	50	
Connecting rod (blade)	11	25	11	25	11	25	11	25	
Camshaft w/stubshaft assembly	55	122	78	175	100	220	120	265	

SERVICE DATA (CONT'D)

DESCRIPTION	8-Cyl. Kg	8-Cyl. Lb	12-Cyl. Kg	12-Cyl. Lb	16-Cyl. Kg	16-Cyl. Lb	20-Cyl. Kg	20-Cyl. Lb
Camshaft drive gear	40	89	40	89	40	89	40	89
Camshaft drive housing	154	340	154	340	154	340	154	340
Idler gear stubshaft assembly	43	94	43	94	43	94	43	94
Low idler gear (No. l)	28	62	28	62	28	62	28	62
Spring drive gear assembly	77	170	77	170	77	170	77	170
Accessory drive cover assembly	60	132	60	132	60	132	60	132
Overspeed trip housing assembly	19	42	19	42	19	42	19	42
Governor	50	110	50	110	50	110	50	110
Governor drive gear assembly	24	53	24	53	24	53	24	53
Governor drive housing assembly	18	40	18	40	18	40	18	40
Water pump	49	109	49	109	49	109	49	109
Water manifold assembly	16	35	20	45	31	68	39	87
Main lube & piston cooling oil pump assembly	62	136	66	146	89	197	89	197
Scavenging oil pump assembly	73	162	74	164	101	222	101	222
Lube oil strainer assembly	92	203	92	203	92	203	92	203
Fuel oil filter assembly	22	49	22	49	22	49	22	49
Turbocharger assembly	816	1800	816	1800	816	1800	816	1800
Auxiliary drive assembly	37	81	37	81	37	81	37	81
Aftercooler duct	76	167	76	167	76	167	84	185
Aftercooler core, header, and cover	90	199	90	199	90	199	90	199
Oil separator assembly	33	73	33	73	33	73	33	73
Soak back oil motor/pump assembly	34	75	34	75	34	75	34	75
Turbocharger oil filter assembly	13	28	13	28	13	28	13	28
Exhaust manifold chamber	86	190	86	190	86	190	86	190
Expansion joint	14	32	14	32	14	32	14	32
Adapter and turbo screen	34	74	34	74	34	74	34	74
Starting motor	-	--	35	78	35	78	35	78
Starting motor mounting bracket	26	58	26	58	26	58	26	58

SERVICE DATA (CONT'D)

TORQUE VALUES

NOTE

When torque values are listed as "initial" and "final", torquing procedures in the manual text *MUST* be followed.

TOP DECK

	N-m	FT-LBS
Camshaft stubshaft bearing bracket bolts		
5/8" hex head	285	210
1/2" socket head	102	75
Cylinder head crab nuts (studs and nuts lubricated)*		
Initial	407	300
Final	2440	1800
Injector crab nuts (lubricated)*	68	50
Cylinder head-to-liner nuts (lubricated)*		
Initial	102	75
Final	325	240
Top deck head frame bolts		
(300M bolts with hardened washers)	54	40
Overspeed trip mechanism	32	24
Injector fuel lines	54	40
Camshaft bearing blocks	43	32
Rocker arm shaft nuts (lubricated)*		
Initial	203	150
Final	407	300
Fuel manifold blocks	54	40
Cylinder test valve packing nut	88	65
Water outlet elbow-to-head bolts	41	30
Exhaust manifold-to-crankcase (lubricated)**		
Initial	68	50
Final	176	130
Exhaust manifold connector bolts	108	80
Exhaust manifold inspection cover (when equipped)	108	80

ACCESSORY END

Accessory drive housing-to-crankcase and oil pan	88	65
Overspeed trip housing-to-crankcase	88	65
Water pump mounting bolts	88	65
Water pump elbows	88	65
Scavenging oil pump mounting bolts	88	65
Scavenging oil pump elbows	88	65
Lube oil pump mounting bolts	88	65
Lube oil pump elbows	88	65
Oil strainer housing mounting bolts	88	65
Governor drive housing mounting bolts	88	65
Governor-to-drive housing	88	65
Overspeed trip cover-to-overspeed trip housing	41	30
Fuel manifolds-to-filter	47	35
Oil strainer elbows-to-strainer housing	54	40
Accessory drive oil seal cover	54	40
Accessory drive flange retaining bolt		
Initial	136	100
Final	678	500

	N-m	FT-LBS
Accessory drive flange locking spring bolt	88	65
Governor drive gear assembly		
Stubshaft-to-crankshaft	102	75
Stubshaft dowel bolts	23	17
Oil jumper-to-stubshaft	47	35
Retainer plate-to-stubshaft	47	35
Governor drive flange-to-drive gear	47	35

TURBOCHARGER END

Piston cooling manifold flange-to-crankcase	37	27
Idler gear stubshaft bracket-to-crankcase -		
l/2"	122	90
3/8"	37	27
5/16" (dowel bolts)	23	17
No. I idler gear thrust plate-to-crankcase	251	185
Camshaft drive housing-to-crankcase	88	65
Camshaft drive housing-to-crankcase lockwire anchor bolts	88	65
Oil manifold-to-oil manifold	50	37
Oil manifold-to-crankcase	43	32
Camshaft drive gear-to-camshaft		
l/2"	122	90
5/16" (dowel bolts)	23	17
Turbocharger mounting bolts		
3/4"	238	175
1/2"	88	65
Air ducts-to-turbocharger	81	60
Air ducts-to-crankcase	88	65
Auxiliary drive-to-turbocharger 3/8"	32	24
Auxiliary drive-to-camshaft drive housing 1 / 2"	88	65
Aftercooler-to-air duct	61	45
Aftercooler support pad bolts	176	130
Turbocharger-to-manifold (lubricated)**	122	90
Water piping-to-aftercooler	47	35
Water piping-to-engine	47	35
Oil separator expansion joint bolts	122	90
Oil slinger-to-crankshaft gear	23	17
Oil retainer-to-camshaft drive housing	41	30

CRANKCASE AND OIL PAN

Main bearing nuts (lubricated)*		
Initial	475-542	350-400
Final	1 017	750
Crankcase-to-oil pan		
Initial	136	100
Final	610	450
Connecting rod-to-piston pin (lubricated)*	610	450
Basket-to-connecting rod (lubricated)*		
Initial	13	10
Final	258	190
Connecting rod basket	102	75
Piston cooling oil pipe bolts	27	20

SERVICE DATA (CONT'D)

	N-m	FT-LBS
Water jumper-to-liner	41	30
Water jumper saddle strap nuts	20	15
Torsional damper-to-crankshaft (lubricated)*	678	500
Bolt-on crankshaft stubshaft (lubricated) *(where applicable)	678	500
Bolt-on crankshaft stubshaft retention bolts	81	60
Accessory drive gear to crankshaft (lubricated)*	407	300
Accessory drive gear oil slinger	33	24
Coupling disc-to-crankshaft (8, 12, & 16-cyl.) (lubricated)*	2 441	1800
(20-cyl.) (lubricated)*	1 830	1350
Coupling disc rim bolts	400	295
Handhole cover bolts	27-41	20-30
Engine mounting bolts	617	455

WATER PUMP

	N-m	FT-LBS
Impeller-to-shaft	108	80
Drive gear-to-shaft	359	265
Stationary bushing	11.3	(100 in.-lbs)

*Lubricate with Texaco Threadtex No. 2303
**Lubricate with Fel-Pro C5A or equivalent